Engineer On a Disk

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Professional Engineering Topics

2. ENGINEERING EDUCATION

2.1 PROBLEM SOLVING PHILOSOPHY

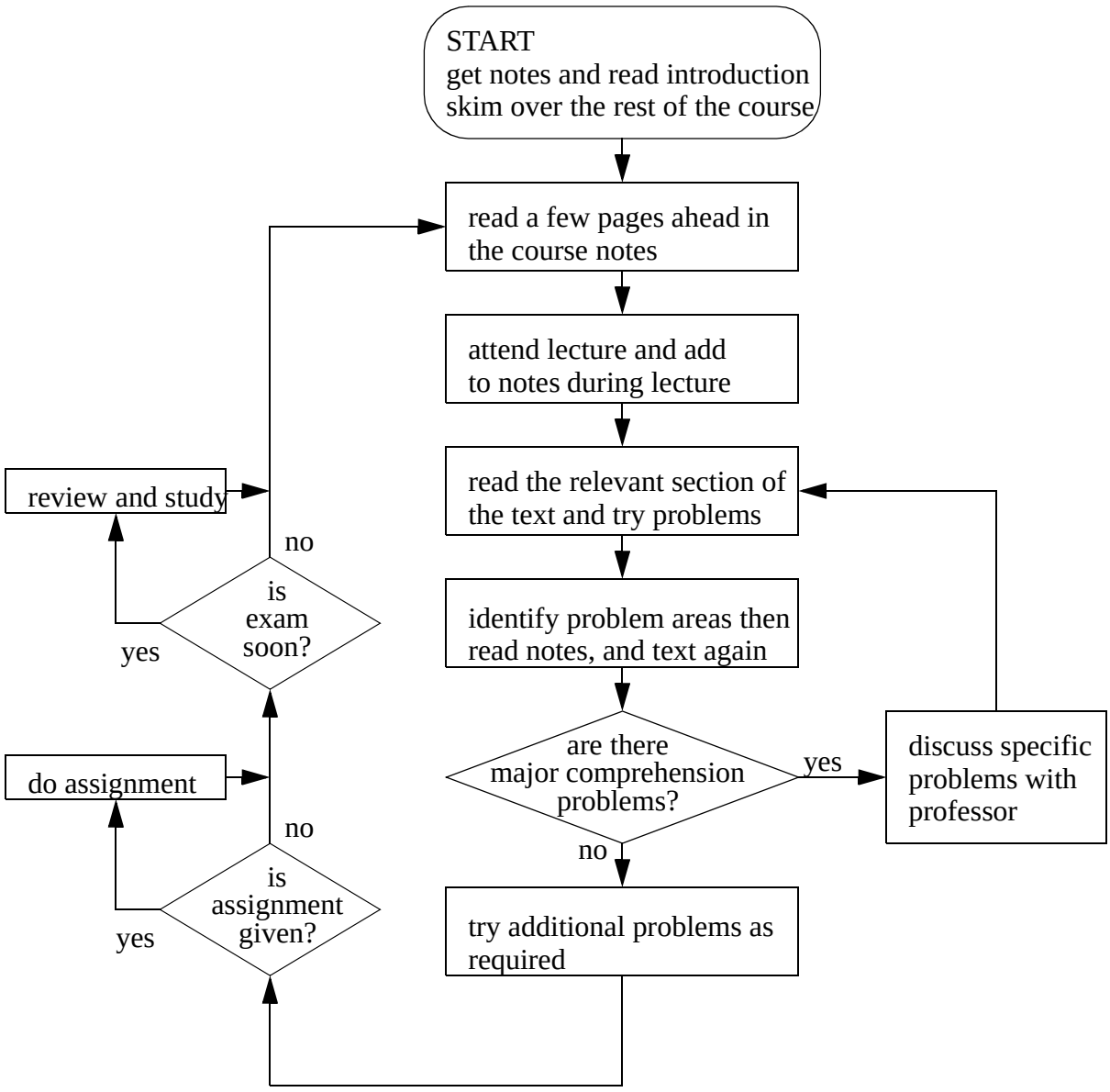
2.1.1 Tips When Solving Problems

1. Even when problems seem impossible keep trying, it will help you learn to solve problems (This is like learning a new sport, except here you are building strength and coordination for problem solving). Solving problems is mainly a skill of recognizing patterns and then using techniques you have seen before.
2. If there is a topic you do not understand in a previous section, it will make it hard to solve problems in more advanced sections.
3. As you solve problems, you will find that you work faster.
4. Avoid shortcuts, they always take longer.
5. Try alternate ways of solving problems, this will strengthen your skills.
6. If you are really stuck on a problem leave it until the next day, then try again.
7. Solve problems with variables, and units, this will reduce errors, and makes errors easier to find and fix.
8. Solving problems is the only way to do well.
9. Always look at your answer to see if it makes sense, and find ways to check the results.
10. Always use Free Body Diagrams, and list assumptions, this will reduce assumption based mistakes in simple problems, and give you clues for solving complicated problems.
11. Carefully read the question before starting. If it is confusing, underlining or writing out the details in point form can help.

2.2 STUDYING ENGINEERING COURSES

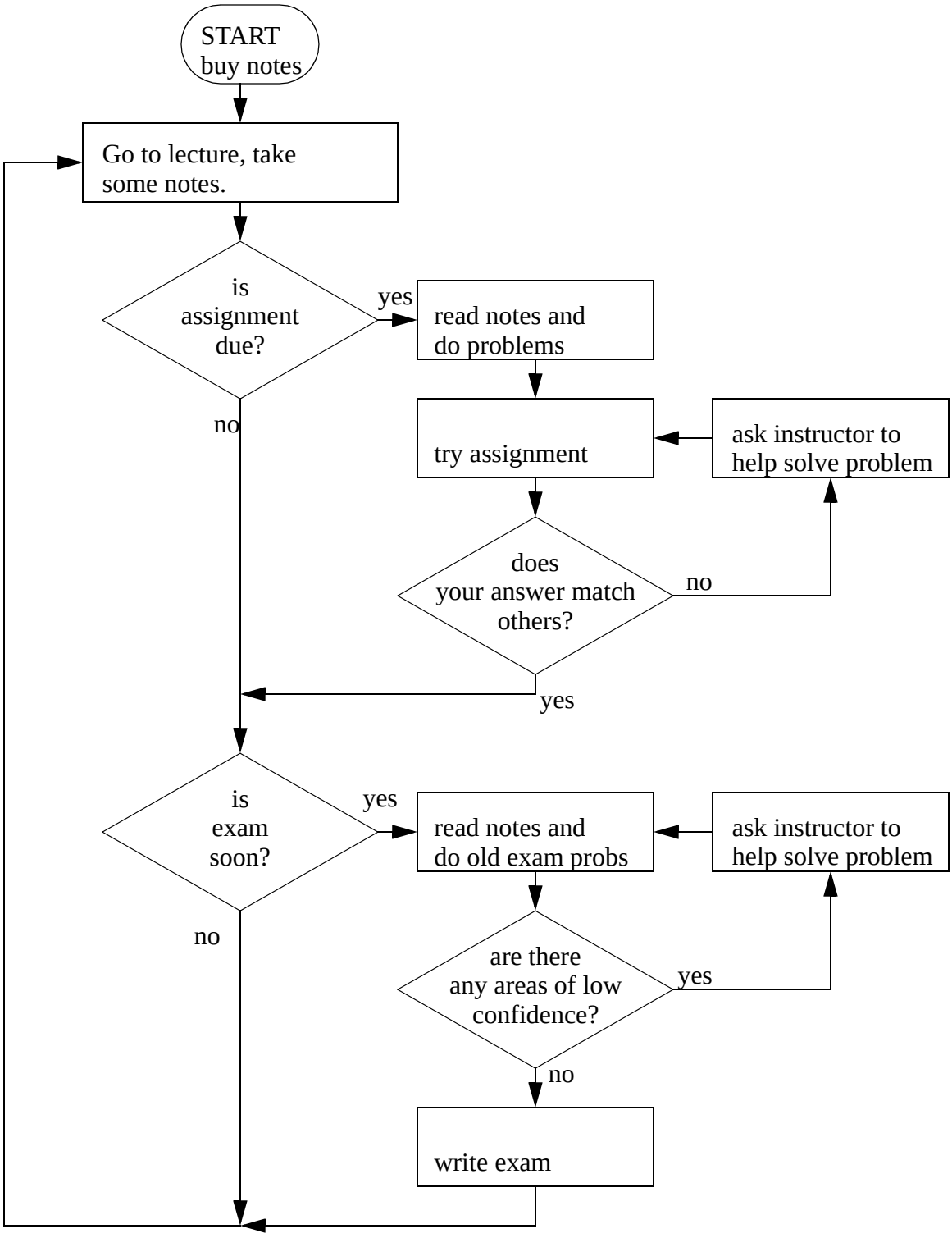
2.2.1 How To Get An ‘A’

• A student who will get an ‘A’ grade will typically focus on the material in the course, more than on the marks it is worth.



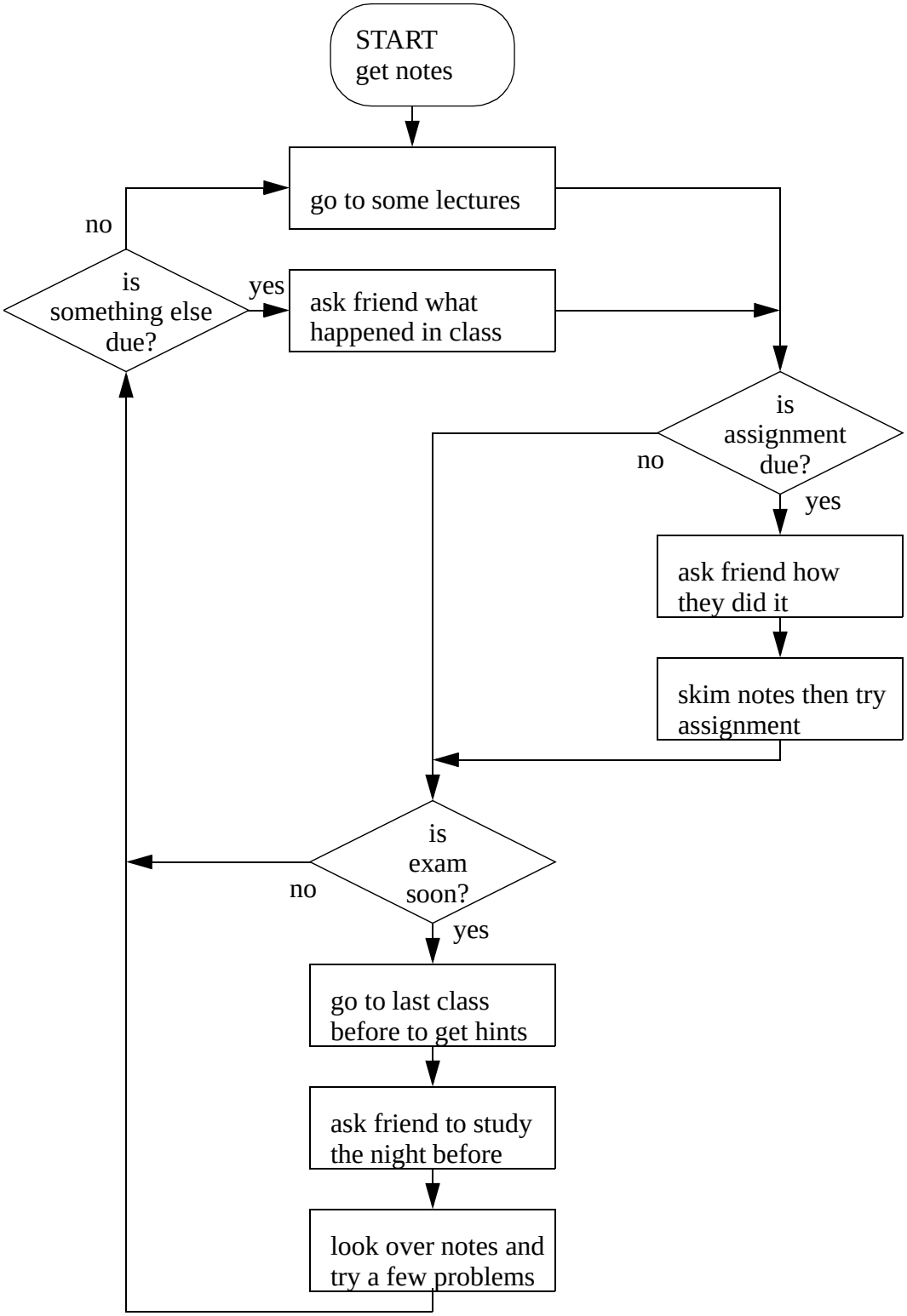
2.2.2 How to Get A ‘C’

• These students typically focus on the value of assigned work and then decide what to work on next. Their work habits are commonly described as ‘firefighting’. While this method appears to be the most efficient, the rush-to-submit often decreases the learning value significantly for the time spent.


START
buy notes
Go to lecture, take some notes.
is assignment due?
yes
read notes and do problems
no
try assignment
ask instructor to help solve problem
does your answer match others?
no
yes
is exam soon?
yes
read notes and do old exam probs
ask instructor to help solve problem
no
are there any areas of low confidence?
yes
no
write exam

2.2.3 How to get an ‘F’

• These students are rarely in class and count on others to keep them up to date. They typically measure their performance by asking other students how they are doing, and are often heard to say things like - “I can always ride the bell”, “they can’t fail us all”, “I don’t need to go to lectures”, and “It’s OK I took this course before”.


START
get notes
go to some lectures
no
is
something else
due?
yes
ask friend what
happened in class
is
assignment
due?
no
yes
ask friend how
they did it
skim notes then try
assignment
is
exam
soon?
no
yes
go to last class
before to get hints
ask friend to study
the night before
look over notes and
try a few problems

2.3 THE TOPICS OF MECHANICAL ENGINEERING

• The simple hierarchical list below tries to divide some of the fundamental topics found in engineering. It should be noted that this sort of division is somewhat subjective, although suitable for our purposes.

- Engineering
  - Design
    - technology
    - systems
  - Analysis
    - solid mechanics
      - rigid solids
        - statics
          - equilibrium
          - trusses
            - method of joints
            - method of sections
          - frames
            - method of members
          - friction
        - dynamics
          - translation
          - rotation
          - collision
      - flexible solids
        - statics
          - hookes law
        - dynamics
          - collision
        - vibrations
    - fluids
      - compressible flow
      - incompressible flow
        - hydraulics
    - thermodynamics
  - Methods
    - metrology
    - laboratory techniques
    - manufacturing processes

2.4 CALCULATIONS IN ENGINEERING

2.4.1 Units

• we will use both SI Units and Imperial units,

• Typical SI (System International) units are,
    m - meter (or mm, cm, km)
    s - second (or min, hr, day, yr)
    kg - kilogram (or g, tonnes)
    N - Newton (kg m/s^2)

• Typical Imperial Units are,
    lb - pounds (or tons, oz.)
    in - inches (or ft, yd, mile)
    s - second
    slug - mass (note: this is a proper unit of mass although we commonly use pounds)

• These units can be combined to describe any numbers we have.

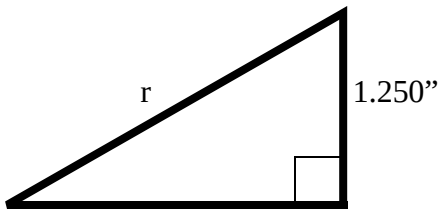
• Note: the reader is expected to be aware of the basic rules of numbers and units.

• see the section on units and watch some of the sample calculations for examples of proper application.

2.4.2 Significant Figures

• significant figures should be considered. One example of the effect of ignoring significant figures is given,

e.g., Find r,



$$r = \sqrt{(5.5\text{in})^2 + (1.250\text{in})^2}$$

what the calculator says

$$r = \sqrt{30.25\text{in}^2 + 1.5625\text{in}}$$

$$r = \sqrt{31.8125\text{in}^2} = 5.6402571in$$

the last digits are meaningless
because one dimension is measured as 5.5”

significant figures

$$r = \sqrt{30 + 1.6}$$

$$r = \sqrt{31.6(31.9)} = 5.6in$$

• Basic rules of calculations for engineering,

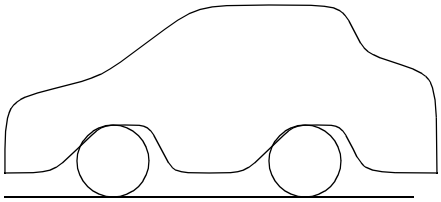
1. To count the number of significant figures, don’t count zeroes at the start of the number, but do count zeroes at the end.
2. When doing calculations, the number of significant figures should be considered. All numbers and results should have the same number of significant figures, or one/two extra for more accurate numbers.
3. Generally, the final result must have at most the same number of significant figures as the least significant number.
4. Typical engineering numbers have 3 or 4 significant figures as they are determined from real systems experimentally.
5. Be aware that different operations may increase or decrease accuracy.
6. Engineers use engineering notation for numbers in exponential form, for example 0.0003 should be $0.3\text{x}10^{-3}$ not $3\text{x}10^{-4}$.

2.5 FUNDAMENTAL THEORIES

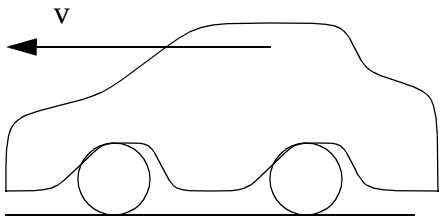
2.5.1 Newton’s Laws

• The fundamental laws,

1. Inertia - a particle at rest, or moving along a path will continue to sit still, or move in the same direction with a constant velocity, as long as there are no unbalanced forces applied.

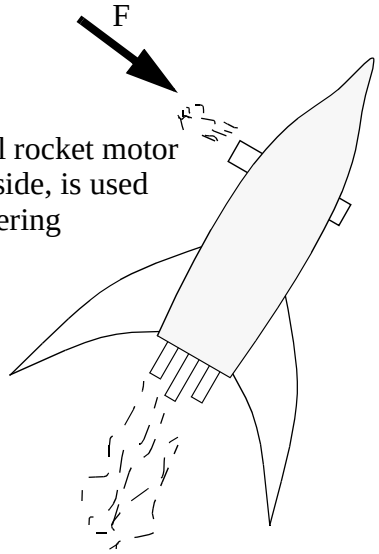


The car is still, and will stay still, unless pushed, or the wheels exert a force

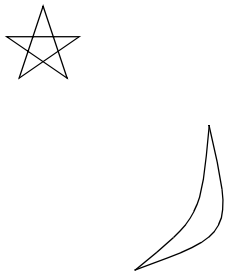


The car would continue to roll forward once pushed if air did not exert a resistance force

2. Acceleration - The application of a force to a particle will result in an acceleration in the direction of the force, and proportional to the force. The action and reaction forces balance to zero.

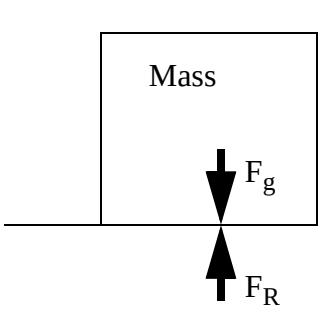


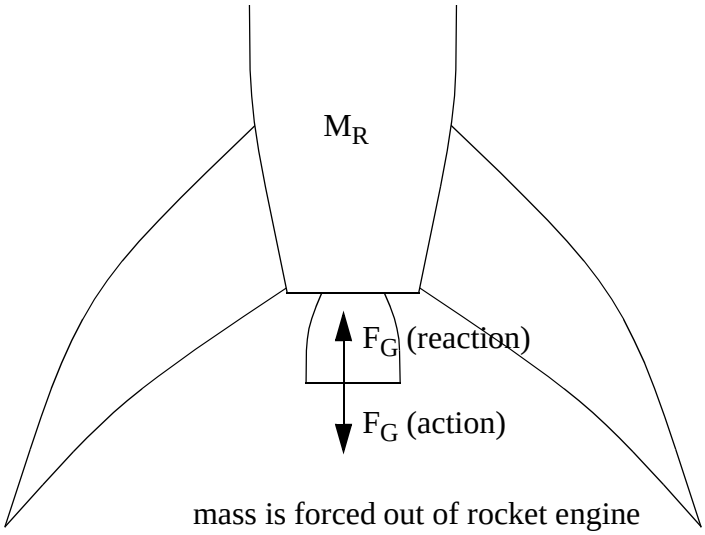
a small rocket motor at the side, is used for steering



rocket flying through space accelerates sideways when steering motor fired.

3. Action and Reaction - When a particle exerts a force on another, there is an equal force generated in the opposite direction. hat is action or reaction is relative)





• Newton's Law of Gravitational Attraction - basically the force of attraction between two bodies is a function of separation.

$$F = G\frac{M_1 M_2}{r^2}$$

where,

G = gravitation constant

M_1, M_2 = the two masses

r = the separation distance (between centres)

We can rearrange the equation to the form.

$$F_{thing} = \left(\frac{GM_{earth}}{r^2}\right)M_{thing}$$

where,

M_{earth} = the mass of the earth

r = the radius of the earth

M_{thing} = the mass of some thing

F_{thing} = the force exerted on the thing (and the earth)

The more popular form of this equation is,

$$F = gM$$

where,

$$g = 9.81\frac{N}{kg} = 9.81\frac{m}{s^2} = 32.2\frac{ft}{s^2}$$

READ	PROBLEMS	
	SUGGESTED	REQUIRED
SLI 1.1-1.6	1 to 9	

3. THE PROFESSIONAL PRACTICE OF ENGINEERING

3.1 ADMINISTRIVIA

3.1.1 OBJECTIVES

- to provide a free reference to engineering law and ethics that permits self study. This will only heighten the sense of professionalism in engineering.
- to take advantage of computers to enhance distribution. This reduce any real or perceived barriers to the topics. Also, in an unprecedented manner, this will allow the material to be updated and corrected as a living text, unlike that frozen on paper.
- by itself this will not be a complete reference, but a guide to those wishing to develop a good framework for the lifelong process of legally and ethically correct practice.
- I want to promote active participation of others who can help add new sections, alternate sections, alternative viewpoints, and corrections. A copyright notice has been added so that the document can be developed consistently. I would encourage additions in the terms of other web documents that are maintained at the authors home sites.

3.1.2 COURSE INFORMATION

This course has one main purpose - to prepare engineers for a professional licence. This capacity is clearly above and beyond technical competency, it is a responsibility to look beyond the technical decisions, to their impact on society. The nature of engineering is such that a licensed engineer will make many decisions that will not be checked regularly by others. As a result we must adopt legal and ethical principles to guide us. The professional practice examination (PPE) ensures that the candidate is aware of these issues before being issued a license, and the courts and engineering associations ensure that these levels of professional practice are maintained after licensing.

This course can be used for review, or if followed thoroughly, it will prepare the candidate to write the PPE. It is highly recommended that the candidate also purchase and read the recommended texts,

D.L. Marston, Law for Professional Engineers, third edition, McGraw-Hill Ryerson

G.C. Andrews and J.D. Kemper, Canadian Professional Engineering Practice and Ethics, second edition, 1999, Harcourt Canada.

(obsolete) C. Morrison, P. Hughes, Professional Engineering Practice; Ethical Aspects, McGraw-Hill Ryerson

Please keep in mind the following maxims while reviewing the material,

1. The ethics and legal aspects of professional engineering can often be subjective, and single clear-cut solutions should not be expected. In other words there are always two sides to every argument.
2. The distinction between ethics (society based) and morals (personally based) principles. We may be called upon to perform tasks as engineers that we are compelled to do, but object to morally.
3. Criminal law looks at absolute guilt, whereas civil courts look at proportion of responsibility. In civil court you may be found responsible for actions that you have not directly caused.
4. Engineers are assumed to be technically competent and are responsible for all technical decisions. Like surgeons, mistakes are of great concern.

3.2 THE PROFESSION OF ENGINEERING

3.2.1 DEFINITION OF ENGINEERING

Engineering is when an individual or group participates in an activity that involves technical skill, but also involves observing the effects to the general public.

Some elements worth discussing - an engineer must understand all of the scientific principles behind a technology. The engineer will understand the manipulation of these principles to provide function to members of the general public. Appreciating that the public is unaware of the technical and scientific details behind engineering, we must also endeavor to protect them from the results of our decisions.

In comparison we can think of the medical profession that must also use sciences such as physiology and pharmacology. Knowledge of these areas is used to benefit patients. One primary difference is that physicians are ultimately responsible to their patients, whereas engineers are responsible to the general public. A simple (naive) anecdote of this difference can be found is the over-prescription of antibiotics. Physicians are encouraged to overprescribe antibiotics to any patient who shows need to protect the patient. An engineer in the same situation would be encouraged to prescribe only as needed, to reduce the chance of breeding resistant forms of bacteria. To carry this example further, the physician is obliged to protect the patients privacy, but the engineer may disclose confidential information to protect the general public. There are also some important similarities between engineers and physicians. Both groups are self regulated by associations of their peers. These groups are legally recognized, and given certain limited powers to investigate and enforce legislation.

3.2.2 THE BASIC ELEMENTS OF PROFESSIONAL ENGINEERING

3.2.2.1 - Associations and Titles

CCPE (Canadian Council of Professional Engineers) - The provincial engineering associations are all members of the CCPE. This allows the associations to also have voice at a federal level, and for international affairs.

P.Eng. (Professional Engineer) - The designation given to an engineer licenced by a professional association. A typical examples of usage might be ‘Joe Smith, P.Eng.’, ‘Joe Smith, B.A.Sc., P.Eng’, ‘Dr. Joe Smith, P.Eng.’, etc.

E.I.T. (Engineer In Training) - A temporary designation to describe an engineer who is registered with an engineering association, but not yet licenced. The engineer registered this way will receive limited access to the local chapters and the services of the PEO.

C.E.T. (Certified Engineering Technician) -

The Engineers Ring - This ring is not an official symbol, but is commonly worn by those engineers that graduated from Canadian universities. Those who wear the ring do so remembering that it is a reminder of the horrific results of poor work.

• an engineer will need to show that they have a degree from an accredited university or other equivalent criteria have been met.

3.2.2.2 - Technical

CEAB (Canadian Engineering Accreditation Board) - a national review panel that examines engineering programs for adequacy. If a student graduates from an accredited program their technical adequacy will be accepted by any of the provincial associations.

Technical Internship - Every engineer is obliged to practice for some time under the observation of a licenced professional engineer before they apply for a licence. Letters of recommendation are required to verify that the candidate has been exposed to the practice in general, and that they are of good character. At present the maximum period is between 2 to 4 years.

Academic Requirements Committee (ARC) - In some cases engineers have not come from an accredited engineering program. They apply to a technical assessment committee. They will examine the candidates background, and accept the candidate as adequate, or more frequently make further requests. These are often in the form of special examinations, review of theses, etc.

3.2.2.3 - The Professional Practice Examination (PPE)

• This exam will review both the ethics and law knowledge of the engineer.

• The PPE must be passed within 2 years of application for a license.

• The PPE is only written once all of the academic requirements have been satisfied.

3.2.2.4 - The License

The Stamp - This is an unquestionable mark of support by an engineer. The stamp includes the engineers name, and the licensing association. When applied to a drawing, report, or other document, it indicates that the engineer has reviewed, and fully agrees with the contents. In some cases engineers are requested to stamp the work of others, this should only be done after careful consideration of the work, anything less is malpractice. There are three stamps commonly in use: the members seal; the licensees stamp; the specialists stamp.

Professional Engineer - A “professional engineer”, as opposed to an engineer is licensed to practice. The title engineer alone is used by many individuals, but the title professional engineer can only be used by a licenced engineer. The engineering associations actively prosecute individuals misrepresenting themselves as professional engineers.

Discipline Committees - When an engineer has been accused of professional misconduct, they will be called in front of a review panel to review technical and ethical details of the charges. The proceedings are published and sent to all association members. The committee can levee fines, revoke licenses, require testing, etc. This is separate from the other courts, and any results here do not preclude further court actions.

Engineering Corporations - Any company that puts itself forward as an “engineering” company must have the permission of the associations and must have a professional engineer in a controlling position.

Consulting Engineers - This is a step beyond a basic license. The intent is to distinguish between a recognized specialist, and a basic practitioner. The license holder is permitted to use the title “consulting engineer”.

Limited Licence - a person of some technical background might not qualify to become a professional engineer, but as a result of extensive experience (10 years or more) will be given a limited licence. This is typically limited in both scope of practice and use (eg. restricted to current employment).

Member of the PEO - a fully licenced engineer as opposed to a temporary or limited licensee.

Temporary License - a license that is granted to an engineer who would be fully qualified for a provincial license, but only requires one for a short term job. For example, an engineer from Alberta might require a temporary license to work on a project in Ontario. In some cases the limited license might be required to collaborate with a member of the PEO.

Branch of Registration - the primary discipline of education. Although an engineering license is not limited to a specific discipline, the practitioner is expected to only work in areas they are competent in.

Certificate of Authorization - a certificate will be issued to an engineer with a normal or temporary license to offer services to the public. This typically requires registration with the PO. If the certificate is for an individual, proof of liability insurance is required. If the certificate is for

an engineering corporation/partnership, the engineer directing the company will be listed.
Insurance - to offer services to the public a Certificate of Authorization must be held. Indirectly this means that the public can always count on a licenced engineer, and liability insurance. In Ontario this is $250,000 minimum per suit and $500,000 per year.

• The basic requirements for a licence are,
- permanent residence in Canada
- 18 years of age
- academic adequacy
- experienced
- of good character

3.2.2.5 - Discipline and Enforcement

• Problems that can be reviewed are,
- misconduct
- incompetence

• penalties may include,
- reprimands
- suspension of licence
- termination of licence
- fines
- imposed limitations or conditions
- etc.

• Decisions can be appealed to the civil courts

• The discipline committee will investigate allegations about any license holder and consider,
- decisions in other courts
- medical/psychological disabilities
- technical inadequacy via expert review
- investigations of events
- etc.

• negligence is an example of professional misconduct that is basically a failure to uphold professional standards, both technical and personal conduct.

• Complaints about an engineer are first submitted to a complaints committee. This committee can then refer the complaint to the discipline committee.

3.2.2.6 - Experience and Character

• Character is assessed by confidential letters of reference. These are obviously somewhat arbitrary, but the best letters are from senior colleagues familiar with the guidelines of professional practice (i.e., P.Eng's).

• Experience is required, previously this was 2years minimum (with one year allowed for graduate degrees). This is now increasing to four years. The main reason for this change is that after only two years the experience gained is not sufficient for the autonomy allowed by a license, and in some cases the public might be at risk.

• Experience is gauged as some employment in an engineering environment where the basic elements of professional practice are carried out. By necessity this would require that another professional engineer is "looking over the shoulder" of the candidate. This experience should also be primarily gained in the jurisdiction where the candidate intends to practice.

3.2.3 IN GENERAL

An engineer is obliged to an number of basic elements in their practice,
- conduct themselves in an ethical manner
- ensure technical adequacy of all work
- observe all legislative requirements
- follow standards and codes where available
- endeavor to maintain technological competency

3.2.3.1 - The Professional Image

• There are a few points that could be kept in mind when acting professionally (an alternative to Morrison & Hughes, pgs. 50-53),

1. When forming opinions - make sure you have sound reasons, have considered all options, and are confident in the results.
2. Don't Waver - don't allow theatrics and scare tactics to change your opinions, follow step #1 here.
3. Admit when you are wrong - this conflicts with #2.
4. Don't make sudden decisions - once a decision is made it is hard to be objective or take it back (see #1).
5. Try to listen first and be open to suggestions.
6. Stay calm.
7. Keep an arms length - don't mix personal obligations into professional conduct.
8. Think ahead - be prepared.

9. Don't try to become overinvolved - let things happen (technically and personality based) and only step in when it is required.

3.2.3.2 - The Overlap of Engineers and Architects

• In cases where engineers oversaw construction projects they were convicted for acting as architects. [Rex v. Bentall] In other cases this was not so. [Regina v. Margison and Associates, Limited]

• A Joint Practice Board was set up between the PEO and OAA (Ontario Association of Architects) to resolve disputes involving members and questions about the boundaries of the professions.

3.2.4 HISTORY OF PROFESSIONAL ENGINEERING IN ONTARIO

(****** If anybody wants to contribute information for other associations I would be delighted)

1922 The APEO (Association of Professional Engineers of Ontario) was formed under a provincial statute, but did not go as far as making licences mandatory.
1937 At the urging of members of the engineering profession the provincial government changes the engineering act to make licences mandatory, and setting up the APEO as a self regulating body allowed to impose regulations and maintain discipline.
1961 A referendum approved regional chapters. These act as local organizations that provide programs of interest and communicate as groups with council via the regional congresses.
1970 The role of the Council is redefined in the Professional Engineers Act, Chapter 366, Revised Statutes of Ontario 1970. (The Council governs the PEO). The membership was expanded to include one layperson, and one member of the Ontario Bar.
1984 The Professional Engineers Act, Statutes of Ontario is now the currently active legislation

3.2.4.1 - The Role of The PEO

• It's primary role is to "govern the practice of engineering to serve and protect the public"

*Note: The PEO is not a labor union for collective bargaining.

• Self governing

• responsible to the people of Ontario for,
- registration and licensing

- maintenance of professional standards
- social implications
- providing a code of ethics

• The engineering act is a “closed” practice statute including control of,
- engineering titles
- admission to the PEO
- setting of qualification standards
- professional misconduct
- the ability for the PEO to offer certain services

• the PEO allows entry of engineers, and then later can hold judgement if they are questioned technically or ethically.

• the engineering act can only be changed by the Ontario legislature, while the bylaws, that are administrative in nature, can be changed by membership referendum.

• the council membership is 23,
- 5 are appointed to represent disciplines (3 year term)
    - chemical and metallurgical
    - civil
    - electrical
    - mechanical, aeronautical and industrial
    - mining and geology
- 1 is an appointed member of the Ontario Bar (3 year term)
- 1 appointed layperson (3 year term)
- 10 elected regional members (2 year term)
- 2 elected members at large (2 year term)
- 4 executives,
    - president
    - past president
    - 1st vice president
    - 2nd vice president

• generally council,
- oversees administration of the PEO
- reviews all applications for registration
- defines misconduct
- provides specialist and consultant designations
- may put forward by-laws for membership referendum
- directs various boards and committees
- etc.

• council meets 4 times a year. An interim council consists of the,
- president
- past president

- 1st vice president
- 2nd vice president

• Each year for election of the president, 1st and 2nd vice president and councillor-at-large, a central nominating committee proposes candidates. Other nominations are welcome. Regional nominating committees suggest regional candidates.

• There are 5 regions (and congresses) that have 2 regional councillors and two delegates, as well as locally elected councils.
- eastern
- eastern central
- west central
- western
- northern

• Main departments of the PEO include,
- Director of Admissions/Registrar
- Director of Member Services
- Director of Legal and Professional Affairs
- Director of Finance (accounting)
- Executive Director (administration)
- General Secretary (administration)

• Other services offered by the PEO are,
- employment counselling - this group de-emphasizes placement and focuses on placement, advice, criticism, etc.
- salary surveys - frequently published statistics of earnings
- Dimensions - a monthly publication of the association sent to all members.
- publications of relevance to the mandate of the PEO are also available.
- awards
- ethics counselling - a sounding board for engineers in unclear situations.

• The Engineers Act of Ontario allows regulations to be made by the council. These regulations include details involved in issuing licenses, etc.

3.3 REFERENCE

3.3.1 ENGINEERING ASSOCIATIONS

3.4 ETHICS

• professional ethics have a number of purposes,
- maintain personal integrity
- maintain public respect and trust in the profession
- avoid legal problems (criminal and civil)

• The engineering code of ethics should guide the practitioner, but a violation of the code alone would not constitute professional misconduct.

• ethics cases come in different levels of severity, ranging from trivial to real. It is up to the ethical professional to focus as appropriate.

• Some common types of ethical dilemmas are,
1. The worst of two evils - for example, a factory is polluting the local village, but to close the facility would eliminate 50% of the regional employment
2. Ethic or Moral - for example, would you pick one member of your family to send away so that the rest might stay.
3. Suspected Hazard - some problems are suspected but not certain. Is the suspicion enough to act on?
4. Whistle Blowing -
5. Conflict of Interest -
6. Serving Two Masters - Sometimes and engineer is engaged to act as an intermediary by one of two parties in a dispute. Care must not be taken to lean towards the party that hired you.

3.4.1 Typical Misconduct Guidelines

• This is basically dictated by the “engineers standard of care”.

• Typical categories would include,
a) negligence
b) failure to consider the safety and well-being of the ultimate user or consumer
c) failure to correct a situation dangerous to the public
d) failure to follow guidelines, codes and standards
e) certifying work (e.g. stamped drawings) without verifying the content (this is ignorance as opposed to negligence)
f) if engineering directions are not followed point out the potential outcomes (no ostrich approach)
g) failure to follow the guidelines in the engineers act and regulations
h) only do work you are qualified to do

i) always disclose conflicts of interest (you must not profit from decisions, they must be entirely objective.
j) act in a “respectable way” - (don’t disgrace the profession)
k) observe the limitations of the engineering licence.
l) you should always disclose information when requested officially
m) don’t encourage or assist non-engineers to act as engineers.

• An engineer can be disciplined for acts of misconduct

3.4.2 Typical Ethics Guidelines,

• General principles include,

1. Be fair and loyal to those around you
2. Place public need ahead of all other responsibilities
3. Act with honor and integrity
4. Promote engineering and dissuade detractors
5. Don’t express opinions that are not well supported technically
6. Display professional credentials
7. Develop employer trust by guarding confidential secrets and disclosing any personal conflicts of interest
8. Disclose any interests that might be interpreted as prejudicial in making decisions
9. When employed, disclose any other employment and ensure that professional standards don’t decline.
10. Cooperate with other professionals when working on common projects
11. Act with courtesy and good faith
12. Do not secretly review the work of another engineer, unless they have been terminated
13. Avoid malicious damage of other professionals
14. Don’t give/get commissions to get work
15. Fair pay for work to advance the profession
16. Advance the profession through enabling and supporting others.
17. Disclose misconduct, unethical/unprofessional behavior, etc. when called to do so.

• An engineer cannot be disciplined for an unethical act alone.

3.4.3 Whistle Blowing (aka A Professional Engineers Duty to Report)

• There can be a natural conflict between the duty of an engineer to the general public and the objectives of an employer/client

• An engineer is often privy to confidential technical information about products, processes, etc. And, from time to time will become aware of dangers to an unsuspecting public. Sometimes

these are clear, other times not. In these circumstances the engineer will be obliged to act as an advocate and attempt to remedy the situation. If attempts to remedy the problem fail, the engineer is required to report these problems (whistle blow), regardless of personal considerations.

• The conflict here arises from the professional setback whistle-blowing will often create.

• A classic case of whistle-blowing is the space shuttle Challenger (mission 51-L) that exploded as a result of a failed solid rocket booster that ruptured the main fuel tank. Engineers at Morton-Thiokol and Nasa were aware of problems with o-ring seals on the booster. Attempts were being made in both organizations to correct the design flaw. At the time the shuttle exploded the situation had not reached the “whistle-blowing” stage. After the incident there were a number of public disclosures by engineers that resulted in their dismissals. They sued, and won awards for their dismissals (I don’t have details on the whistle blowing suits).

• The basic steps to be followed are,

1. Detection of problem.
2. Investigation of problem to form sound technical opinions.
3. Attempt to remedy with employer/client
4. If a “standoff” occurs, then contact the PEO and begin the whistle-blowing procedure. The PEO will generally try to remedy the situation before public disclosure.

• “leaking” information is not part of the whistle-blowing procedure.

3.4.4 OLD PPE QUESTIONS FOR PEO

The following questions are from old PPE (Professional Practice Examinations) collected over the years. These exams are not copyrighted, but credit for their development and distribution belongs to the PEO. Each candidate will typically receive one copy of a (complete) recent examination paper which will show common test formats and rules. In constructing this list of questions I wanted to give a good set of practice problems, without encouraging method studying, so I have not indicated which questions are repeated, or which year they appeared in.

If anybody has got additional examination questions not included here, I would appreciate a copy so that they may be added to the list. The dates of the previous tests included are,

May 2, 1987
September 12, 1987
May 14, 1988
September 10, 1988
April 29, 1989

September 9, 1989
April 28, 1990
September 8, 1990
April 27, 1991 (Ethics only)
December 14, 1991
April 25, 1992
September 5, 1992
September 4, 1993
April 23, 1994
September 7, 1996 (thanks A. Mahmud)
April 26, 1997 (thanks A. Mahmud)
September 6, 1997 (thanks A. Mahmud)
April 25, 1998 (thanks A. Mahmud)

3.4.4.1 - Ethics Questions

1. a) In Britain the practice of professional engineering is unregulated; in the United States it is state regulated; how is it regulated in Canada? Elaborate on your answer with references to the Professional Engineers Act and the Regulation made thereunder.
b) The association of Professional Engineers of Ontario is the self-regulating organization responsible for the practice of engineering in Ontario. What is the principle objective of the organization?
c) To become licensed to practice professional engineering in Ontario you must meet certain requirements. Discuss briefly the five most significant of these.
d) What is the difference between a limited licence and a temporary licence in the practice of professional engineering?
e) You are a practising professional engineer in a manufacturing company. Your division of the company has been transferred into Ontario from Manitoba. What must you do, if anything, to continue your engineering work under these circumstances?
f) How is the practice of professional engineering regulated in the Province of Ontario?
g) Describe how the practice of professional engineering is regulated in the Province of Ontario. Present your answer in the context of Federal and Provincial Legislation as well as Regulation 538/84 made under the Professional Engineers Act.
h) Our code of Ethics is section 91 of Ontario Regulation 538/84. What organization was responsible for preparing these regulations? Under what authority were they prepared?
i) What is a Certificate of Authorization? How is it obtained? How does it relate to an engineering practitioner's licence? How often must it be renewed?
j) What is the difference between a member of the A.P.E.O. and a licensee of the A.P.E.O.
k) The professional Engineers Act deals with temporary licence holders and limited licence holders. What qualifications must they have to receive their respective licenses?
l) The profession of engineering in the province of Ontario is said to be self governing. What makes it self-governing?
m) You are a professional engineer practising in British Columbia. You decide to take early retire-

ment and move to Ontario, where you hope to find some part-time engineering work. What action must you take before offering your services as a professional engineer in Ontario?

n) Because of the pace of change in today's society, many people believe that a professional engineer should be required to requalify in some formal way at regular intervals, say every five years, in order to continue to practice. Do you agree? Give reasons for your answer.

o) What is a certificate of authorization for? How is it obtained? Does it expire? If so, on what occasion? Is it transferable? Who or what holds it?

p) Section 86 of Ontario Regulation 538/84 deals with misconduct among professional engineers. Section 91 is the Engineer's Code of Ethics. What is the relationship between the subject matter of these two sections?

q) What is the principal objective of Professional Engineers Ontario (PEO)?

r) What is the purpose of a Certificate of Authorization?

s) What is your definition of a profession? Does the practice of engineering qualify as such?

t) The term "conflict of interest" is often used. What does it mean in the Professional Engineering context?

u) Are there situations where an Engineer's duty to the public may be in conflict with the Engineer's duty to the employer? Cite the appropriate section(s) of the code(s).

v) Differentiate between a limited licence and a temporary licence with respect to Professional Engineering qualifications.

x) Members of the PEO are governed by an Act and a Regulation. Briefly explain the difference between them.

y) Can a member avoid disciplinary actions by resigning his/her membership in the Association?

z) The principle object of the PEO is to regulate the practice of professional engineeringand govern its members in order to serve and protect the public interest. What does this mean and why is it important for engineers to follow it.

aa) When is a member required to use his/her seal? Give an example of when a member should not use his/her seal.

bb) Is a professional engineer required to follow the Act and Regulations if theP.Eng. is employed by the armed forces?

2. Four key professional engineering employees of a firm headed by Engineer A left the firm at the same time following disagreement on certain policies and promptly organized a new engineering firm, B, with the four engineers as the principals. Firm B contacted former clients of Firm A, including some former clients of Firm A which had projects under discussion with Firm A, but for which specific selection or negotiation had not taken place. In some instances one or more of the four engineers had been involved with the former clients of Engineer A while in his employ.

While Firm B was making these contacts to indicate the availability of the new firm for assignments, Engineer A was also making contact with these clients to indicate that his firm was still available for future commissions and retained its capacity to provide proper services despite the departure of the four engineers. He was told by some clients that Firm B had cast doubt on the ability of A to provide quality services under the new circumstances. In his discussions with the former clients Engineer A cast doubt on the ability of firm B to provide quality services.

Discuss the ethics of Engineer A and the four engineers of Firm B as indicated in this case. Such

split-offs from firms do occur in engineering businesses from time to time. What advice would you offer to the engineers forming the new company?

3. Engineers of company A prepared plans and specifications for machinery to be used in a manufacturing process and Company A turned them over to Company B for production. The engineers of Company B, in reviewing the plans and specifications, came to the conclusion that they contained certain miscalculations and technical deficiencies of a nature that the final product might be unsuitable for the purposes of the ultimate users, and that the equipment, if built according to the original plans and specifications, might endanger the lives of persons close to it. The engineers of company B called the matter to the attention of appropriate officials of their employer who, in turn, advised Company A of the concern expressed by the engineers of Company B. Company A replied that its engineers felt that the design and specifications for the equipment were adequate and safe and that Company B should proceed to build the equipment as designed and specified. The officials of Company B instructed its engineers to proceed with the work.

4. A government highway department prepared engineering data on alternate routes for a by-pass highway, including cost estimates for three possible routes. The highway department indicated it favored route “B”. An official of a city located close to the proposed route publicly criticized the proposed route “B” because he felt it would endanger the city’s water supply and be a detriment to the development of a lake as proposed recreation area.

A principal of a consulting engineering firm, which had performed the engineering work on a portion of the highway to which the by-pass would connect, issued a public letter, “To Whom Concerned”, which was published in the local press, discussing the alternative routes. His letter stated disagreement with the cost estimates of the highway department and pointed out alleged disadvantages of the proposed route. The letter then suggested a fourth route (“D”) which, he claimed, would be superior to those previously suggested. The newspaper story containing the full text of the letter from the consulting engineer also quoted the city official as favoring route “D” proposed by the consulting engineer.

Is it ethical for a consulting engineer to publicly express criticism of proposed highway routes prepared by engineers of the government highway department and to propose an alternative route?

5. You are a professional engineer employed in the quality control division of a manufacturing company. From time to time your company calls in consultants to run tests on new products before they go to market. One of your job responsibilities is to engage these consultants. Your husband, who is also a professional engineer, has recently left the firm of consultants most commonly called in on this work and has opened his own consulting practice to offer the same services as his old firm. You are a director of your husband’s company. Your husband has asked you to direct the next such consulting assignment to his new company. You are very tempted to do this because you know that he has all of the experience and background to do a good job and that he needs the work and therefore will get on with it promptly.

Can you ethically turn the next project over to his company? If not, what action must you take before his company will become eligible for such assignments?

6. A professor of engineering shares his time at the university between teaching and research projects under contract between the university and a government agency. He also owns an interest in a private research and development company in the community and devotes evening and week-end time to the interests of the company. The private R&D company and the university as well as others are invited by a federal agency to submit proposals for a project, the technical content of which is based in large part upon the research performed by the university for a different federal agency and in which the professor participated. The professor's background experience, and work on the technical subject matter will give the private R&D company and the university an advantage if he is to be actively involved in the project, either directly or as a consultant.

Can the professor ethically participate in the proposal preparation of the university, his R&D company or both under these circumstances and, if one of these proposers is the successful one, can he participate in executing the project?

7. A, the town engineer, and B, a consultant retained by the town, are collaborating on a study to determine final contours for the town's existing sanitary land fill site. Their instructions include considerations for ultimate land use, surrounding land use, environmental concerns and topography. They have concluded that using the existing parameters adopted by the town the site will be "full" in three years. Town Council have found this unacceptable because they have not been able to come up with a new site, so have asked A and B to revisit the project to extend the site's life but still stay within the environmental laws.

The final solution proposed by A and B and accepted by Council extends the life of the site for the requested ten years' time and stays just inside the limits of the environmental laws, but greatly exceeds the local parameters respecting minimum setbacks and maximum allowable slopes, and provides for a hill more than one hundred feet higher than the local parameters. These local parameters were established as desirable by Town Council but have no official (by-law) status.

Engineer C, who lives in the town, contends that this latest design concept is environmentally unsound. He says methane gas will move into adjacent private property and would also pollute nearby ground water. He questions whether A and B should have agreed to the higher intensity use of the site.

Did Engineers A and B act ethically in going along with Council's request? Did Engineer C act ethically in publicly challenging the design approach used by A and B?

8. A generation ago common practice was for employees to work for the same employer for a lifetime. Today the practice, particularly in the high tech. professions, trends toward job relocation three or more times during a career. Employers try to gain technical advantage over competitors by hiring experts out of another firm to add to their expertise.

Assume that you have been with Firm A for ten years and that you are now a senior professional engineer in A's research development division with joint credit for the development of a "hot" new process. You have an offer of employment from one of A's top competitors at a substantially greater compensation package, including major incentive bonuses related to growth in

sales. You suspect the motive behind this offer relates to your involvement in the “hot” new process. The improved emolument package is very attractive to you, but how can you handle the ethics of such a move?

Discuss this situation in the context of Ontario Regulations 538/84 section 86 and 91.

9. Professional Engineer A is employed by the Ontario division of a multinational chemical company. A wide variety of the solvents and paints manufactured by this Ontario division are from formulas developed in the company’s research laboratories in the U.S.A. As the chief engineer of the Ontario division, Mr. A has been requested by a Ministry of Labor inspector to provide the Ministry with information about all the ingredients used in the products turned out by the plant, particularly regarding their risk to the health of the factory workers.

Mr. A knows that a key ingredient in one of the products has been linked to a number of cancer cases among the employees of a U.S. customer. He does not have all details of the U.S. formulas, but his plant manager has told him to give the labor ministry inspector the report he requests from the information which he has in Ontario.

What course of action should he take?

10. Ms. “A”, P.Eng., is the chief quality control engineer of Corporation X which operates a chemical processing plant. The plant conforms fully to local requirements for maximum emission of toxic substances, as established ten years ten years ago. The facility is inspected annually and toxic emissions have always been well below acceptable levels.

However, based on recently published research, Ms. “A” is convinced that the cumulative effects of the low level of pollution from the plant entail a possible risk to public health. She is sure that the public officials would agree and that local requirements would be different if they had known of these studies at the time they were set.

She had taken the matter up with her supervisor and other engineering staff, and has recommended that Company X hold meetings with the local authorities to discuss the matter and, if appropriate, take corrective action. There is some support for her recommendations but because of the costs involved in the resulting modifications to the plant to change the process and the substantial number of lay-offs that would result, the company has decided to take no action.

Has Ms.A any further ethical responsibility in this matter? Discuss fully.

11. You are a Professional Engineer in a consulting engineering firm asked by the City of Devon to assess the effects of a tidal wave. Located at the end of a long, narrow inlet, Devon is in an ‘earthquake zone’. The last one occurred in 1950 when the City was really only a fishing port.

To make sure that the city has an adequate picture of the disaster that could result, it has asked your firm to examine the effects of the 200-year earthquake. Your findings are so startling that the City authorities are appalled. They feel that if the public were to realize the extent of impending damage, mass hysteria might result. As well, because many of the authorities are elected officials and have been in their positions for many years, people could ask why such a study was not carried out years ago, and why adequate planning by-laws were never formulated.

So, you are asked to keep the findings of the 200-year quake confidential, and undertake another study of the effects of the 100-year quake. Still, the results are frightening; and the City now asks you to study the 50-year quake.
Discuss this situation from an ethical point of view. What action will you take as a professional engineer? What advice will you give to the Town Council?

12. Mr. “A”, P.Eng., as a consultant to an urban developer client has prepared preliminary engineering and environmental impact studies for a project, and submitted these to the municipal planner for review and approval. The municipality has engaged consultant “B”, P.Eng., to assist their in-house planner in reviewing these submissions.
Mr. “A” has made several submissions but each time some aspects are found unsatisfactory and the submissions have been returned for change with redefined requirements. Finally Consultant “B”, in the presence of the municipal staff planner, offers to complete the submission for “A”, since he knows what is required.
The cost of work done by the municipality and the municipality’s consultant must be paid by Mr. “A”’s client.
How should Mr. “A” react to this proposal? Was it ethical for engineer “B” to make the proposal?

13. Mr. “A”, P.Eng., a full-time employee of a manufacturing company, has undertaken to prepare engineering plans for a motel complex on a part-time basis. The work includes foundation and structural plans suitable for building permit application. He sub-contracts the foundation design work to others expert in that field and superimposes the structural information on previously-prepared architectural drawings. He sealed these drawings with his professional seal and returned them to his client for permit application to the local building department.
Has he acted ethically in the procedures he has followed in this assignment?

14. A manufacturing company has contracted to develop and produce a completely automate mass transportation system. Public safety would be endangered by a failure of the system, if one were to occur. A series of engineered tests were carried out on the various major components during the development period, but a major subassembly did not perform satisfactorily on its test. The professional engineer who is manager of the department responsible for the project reported the failure to his superiors. He was told, however, that in order to meet the contract commitments the equipment would be shipped to the client without informing the client of the failure to pass the final tests. The engineer objected to this decision and learned subsequently that shipment to the client had been made.
What, if any, further action should the engineer take under these circumstances?

15. An injured workman is involved in a proceeding before a workmen’s compensation board relative to the amount of compensation to which he is entitled. The determination rests in large measure upon the conclusion of the board as to certain technical details related to the accident. The workman asks an engineer to appear before the board as an expert witness, but states that he is indigent and cannot afford to pay the engineer for his services.

The engineer is willing to assist the workman, but asks whether he may ethically do so: (a) on a contingent fee arrangement, whereby he would be paid a percentage of the amount received by the workman, or (B) as a compassionate and gratuitous action.
Is it ethical for an engineer to provide services as an expert witness for an indigent client on either a contingent fee or free basis?

16. A large multinational corporation is planning to build a new plant in Ontario, and services covering design and supervision of construction would be required. Three consulting engineering firms in Ontario were selected and interviewed.
Each firm in its proposal, stated that the fee would be that recommended by APEO for complete engineering services on a project such as the one described.
Later, the corporation asked each firm to state the amount by which it would reduce its fee if the corporation provided the following portions of the overall engineering services:
a) preliminary engineering studies and a report which contain a suggested layout for the plant;
b) all field engineers and inspectors required to supervise the construction of the plant.
A professional Engineer principal from each of the three firms got together and discussed the request and agreed on the amount (the same figure for all three) by which they would reduce the overall fee to allow for the data and field staff to be provided by the corporation.
Was it unethical for these three engineers to confer and agree on an amount to allow for these data and field staff?
Would it have been competitive bidding for each of the firms to determine independently an amount by which it would reduce the fee?

17. A person made an application top the Association of Professional Engineers for renewal of the Certificate of Authorization for his consulting engineering firm while his name was deleted from the register of the Association for non-payment of his annual fees. The application named him as being in charge of professional engineering in the company and as the official representative of the company under the requirements of the Professional Engineers Act. Was this person acting ethically in so doing? If he was not, which article of the Code was he violating/ If at the same time as he made this application he also forwarded his cheque to the Association for the outstanding fees, would this have altered the situation?

18. An Indian Band is planning a vacation resort development on a river which flows through its reservation. The site chosen is just upstream from the water supply intake for a major city. The intake is outside the boundary of the reservation. Because of fear of unacceptable pollution of the water in the vicinity of the intake, the city’s water commission intends to take whatever action is necessary to prevent the development and has so instructed the commission manager who is a professional engineer.
a) What ethical considerations are involved in this case?
b) As the commission manager, what advice would you give your commissioners to resolve this conflict of rights?

19. You are a professional engineer in private practice as a consultant. Before setting up your own business you worked for XYZ consultants. To meet the expanding needs of your business you have engaged the part time services of three technicians from XYZ who reported to you when you worked there. This morning the president of XYZ called to advise you that in his opinion the “moonlighting” work which his technicians are doing for you is adversely affecting their productivity on their full time job at XYZ.

Have you acted ethically by employing these technicians under the conditions stated?

20. You are a professional engineer. You have recently taken employment in the research and development department of a major manufacturing company. While familiarizing yourself with your company’s products you discover that one of these products does not meet the standards required by law. No research is being done on this product now so you have no direct connection with it nor responsibility for it. You have brought your finding to the attention of your supervisor only to be ignored.

What further action should you take?

21. You are a professional engineer presently employed but on the lookout for a more interesting and challenging job. You are attracted by a position offering advertised by A.E.C.L. and mention it to your fellow employee at lunch. She says that she has already applied for that position and that she was led to believe by the interviewer that her application was being seriously considered, although she has thus far received no offer of employment. You believe that your qualifications for this job are equal to or better than your friend’s, but now that you know of her interest in the position you are hesitant to pursue the matter further.

Would it be unethical of you to go after this job under these circumstances?

22. A consulting engineering firm is preparing to submit a proposal to clean-up an area contaminated by a chemical spill during a train derailment. Human welfare and the ecology will suffer unless this clean-up is done quickly and carefully. From past experience, the professional engineers in the firm know the amount of work involved in doing the job properly. The methodology which must be followed will result in an expenditure of about 5 million dollars. Before the proposal is submitted however, the federal government, which is the potential client, issues a press release to the effect that it has budgeted one million dollars for this work. You are the professional engineer in charge of the proposal preparation.

To reduce the level of work to one-fifth of what you think is necessary would compromise what you perceive as your ethical responsibility. What action will you take?

23. Engineer X is a professional engineering principal in a highly regarded consulting engineering firm in town. He is also an elected member and chairman of the public works committee of town council. He took on the chairmanship of this committee at the urging of other town council members because of his extensive knowledge and experience in public works design and construction. For many years Engineer X’s firm has done public works engineering projects for the municipality in competition with other firms. It would appear to be in the public interest

for people such as Engineer X to serve their community in this way, but under the circumstances, can Engineer X's firm ethically continue to compete for such assignments?

24. An extensive and costly flood-control and hydroelectric project has been under consideration by a Canadian Provincial Government for several years. Two different design approaches are being considered; one involves the use of a single high dam, the other a series of low dams.
At a meeting of a committee of the Provincial Legislature expert opinion was presented respecting both alternatives.
A professional engineer representing the Provincial Power Commission reported that studies he and his colleagues had made indicated that, from an engineering standpoint, the more efficient solution is the one involving a series of low dams.
Another professional engineer, representing a private power company, reported that his engineering analysis indicates a more effective and less expensive solution is obtained using one high dam.
Each engineer presented engineering data to support his conclusion and openly disagreed with the analysis and recommendations of the other.
Was there a violation of Ontario Regulation 538/84 Section 86 and/or 91 by one or the other engineer by criticizing the work and the statements of the other engineer in a public meeting? Discuss this situation.

25. After more than 15 years service as a professional engineer in one of the big three automobile manufacturers you have decided to change jobs, and have accepted employment as the only professional engineer in a small but growing small engines company. You report directly to the President, who is a good manager with excellent business development skills but he is not a professional engineer. Whereas in your previous job you had always reported to a more senior engineer, now as the only professional engineer in the company, all engineering decisions must be made by you. On a couple of recent decision you have noticed that your boss is more interested in cost control than quality of product. This has given you some concern about consumers' welfare. Do you have ethical and/or legal responsibility to take action to avoid future problems? What sections of regulation 538/84 apply?

26. You are the senior professional engineer in the electrical engineering division of a multi-disciplinary consulting engineering firm. Your firm has just been purchased by a major international construction company. The expressed intention in this acquisition is to provide design build services where possible but at the same time to continue to offer consulting engineering services to the public. You have been asked to co-chair a committee with a senior construction manager, who is also a professional engineer. The objective of this committee is to set down guidelines for the operation of the business so that the integrity of both the consulting engineering and the construction activities will not be jeopardized. Sketch out the points which you feel most need clear definition so that the professional engineers involved in the work will be in least danger of breaching Section 86 and 91 of Regulation 538/84.

27. You are a professional engineer. During a recent vacation you took your two sons on a canoe trip into Northern Ontario. One day while taking a break from paddling you were poking around under a railway bridge. One of your sons directed your attention to what appeared to be some misaligned ties on the bridge above your head. He wanted to know why that would be. Although structural engineering is not your specific field of interest it did appear to you to be somewhat peculiar and maybe could even lead to a future problem if the ties were not re-installed properly or at least examined by a qualified person. On the other hand there was no evidence of any recent change in the situation; it could have been that way for years. Do you have an ethical obligation to take any actions under these circumstances? Describe the major points which you feel need clear definition.

28. A rural municipality with a low assessment and a small road budget has been told by the Ministry of Transportation District Engineer that it must replace an old wooden crib bridge to maintain eligibility for certain road grants. The municipal council hired Mr. X, P.Eng. consulting engineer, who prepared designs for a concrete bridge to replace the old timber one. Because of the very bad soil conditions at the bridge location, extensive piling is required to support the foundation for the bridge. This results in an extremely costly structure. Mr. A., P.Eng., a summer resident of the area, learned of the concern of the municipal council over the high cost and, although he is not a consulting engineer, based on his general knowledge of the soil and topographic conditions in the area, suggested that the municipality might be wise to look into the use of a culvert as an alternative to the concrete bridge. As a result of Engineer A's suggestion, Consultant X was paid off by the municipality and Consulting Engineer Y was hired. In due course the culvert alternative was constructed at a fraction of the cost of the bridge design.

Discuss the ethics of the actions of Engineers A, X and Y in this situation.

29. Professional Engineer A is an experienced expert witness in a particular field. He has an established fee rate for such services. After reviewing the documents of a case concerning a criminal charge, he was asked if he would provide expert opinion in defense of the accused and if so to state his fee, which he did. It later came to light that the accused was being defended under LEGAL AID and that Engineer A's stated fee was higher than that which LEGAL AID would approve. A felt that without his evidence the accused might be convicted unjustly so he agreed to act at the reduced fee. Comment on A's ethics in this situation.

30. Professional Engineer A, employed by an aircraft manufacturer, conducted tests on a certain aircraft tail assembly configuration in the company's wind tunnel. He found that vibrations could occur with that configuration under certain circumstances which would lead to the destruction of the aircraft. Later, at a conference Engineer A hears Professional Engineer B who works for a different company, present a paper in which B describes a tail assembly configuration that A feels runs the risk of producing the same destructive vibrations that he discovered in his earlier tests.

What are the ethical obligations of Engineer A? Bear in mind confidentiality of proprietary knowledge, the engineers obligation to public welfare and the possibility that Engineer B may

unknowingly be responsible for a dreadful crash if Engineer A does not disclose what he has discovered.

31. The Provincial Ministry of Transportation proposes routing a new expressway diagonally across the city. A group of local citizens who believe they will be adversely affected by the routing, employed a consulting engineering firm to study the proposed route. Mr. X, a professional engineer with this firm, is the Project Manager and he concludes that the diagonal route proposed by the Ministry could have a negative impact, and recommends an alternative route as being a better choice. Mr. Y, a partner in the firm, appears before the local chapter of the APEA and explains the circumstances of the project. He answers all the questions put to him, and he asks this local chapter to publicly endorse the alternative route his firm is proposing.

Is it ethical for a colleague in the same firm as Mr. X to request the local chapter of the APEO to endorse the project in which he is directly involved?

32. Because of the rapid changes in technology in recent years, it has been suggested that a license to practice professional engineering in Ontario should expire and require renewal at regular intervals of say every four years. The renewal should be contingent on proof of competence. Competence to practise presumably would be determined on the basis of written examinations or on the satisfactory completion of formal continuing education courses at colleges and universities. Such procedures would make it difficult for engineers practising in areas remote from educational facilities and also for engineers working in a specialty unrelated to courses being offered.

Does the passing of a certain number of formal courses guarantee continuing competency? How do you feel about facing such tests of competency at regular intervals throughout your career? Relate your thoughts on this subject to our Code of Ethics.

33. You are a Professional Engineer partner in a consulting engineering firm. The economic downturn of the past eighteen months has hit your firm hard. You are faced with a reduced work load requiring serious staff cuts. Competition for new projects is very keen.

Mr. X an unlicensed person, with an excellent success record in the sale of manufactured products closely allied to your filed of engineering, has proposed to you that he be appointed Business Development Vice-President of your firm. He suggests a compensation package which would include a relatively low base salary, all expenses and a commission of 2% on all work that he brings to the firm.

You consider that you and your partners are good engineers but not good salesmen. You realize that under the present economic conditions, getting work into your company is most important, but is it ethical to have an unlicensed person soliciting contracts of an engineering nature for a consulting engineering firm? Is this arrangement compatible with the Code of Ethics? What about the compensation package?

34. You are a professional engineer in the new products division of a major manufacturing company. You have been assigned responsibility for a group of people investigating the feasibility

of a new product line.

The investigation so far looks good. You are convinced that the product can be built for a competitive price and the market studies which have been carried out identify a definite need. There is, however, one matter that concerns you. It is that your estimate of development costs, both in man hours and dollars greatly exceeds your budget. If you report this estimate to your supervisors you are concerned the project may be dropped. You are urged by some of the engineers in your project team to reduce your estimates so that this won't happen. They argue that no one can ever estimate accurately what costs will be. They say that historically, in the company, very optimistic estimates have been used and that cost overruns are accepted. On the other hand, you have put a lot of work into these estimates and believe that they accurately predict the costs. If you arbitrarily reduce the estimates, you fear your reputation will suffer when the real costs become known.

If you hold to your estimates, you fear a worthwhile project may be cancelled. This will mean layoffs to some of your project team-mates and in your view, a lost opportunity for the company. Discuss the ethics of this dilemma.

35. Several thousand people are killed and many times that number are injured every year in automobile accidents in Canada. Despite this dreadful annual carnage, people appear to believe that the benefits are worth the risk. Is society morally entitled to accept such benefits if these benefits entail risks to others?

You are a professional engineer working in the design office of an automobile manufacturer. You are aware of design changes that you believe would make the automobile safer. These changes, of course, would add to the cost of production and make your employer's product less competitive. Because of the production line process used in the auto industry, design changes cannot be quickly implemented. Are you as a professional engineer acting ethically by continuing to work for this employer if these design changes are not implemented immediately? Discuss this topic as it relates to our Code of Ethics.

36. Many employers of engineers are unfamiliar with Sections 86 and 91 of the Ontario Regulation 538/84 made under the Professional Engineers Act, which set the standard of conduct of the Professional Engineers whom they employ.

We believe these sections are very important to industry. Why? Are they compatible with the goals of industry? What are the possible consequences to an industrial employer of using an unlicensed person in an engineering role within the company?

37. Professional Engineer A is a director of a charitable organization that is engaged in constructing a subsidized housing complex. Engineer A observes that some workmen on the job are violating Department of Labor safety regulations regarding hard hats. He calls this to the attention of the general contractor's superintendent who indicates that the offenders are staff of the subcontractors and he is reluctant to interfere. Fellow directors of the charitable organization who are not engineers wish to let the matter drop. Should Engineer A concur with his fellow directors?

38. Mr. A, P.Eng. is township engineer in X township. With the help of Mr. B, P.Eng. an employee of the Ministry of Transportation of Ontario and a consulting engineering firm, he has completed a study of roadwork to be done over the course of the next five years for his municipality. These works have been given priority numbers from one to twenty-two based on their perception of urgency, number one being the most urgent and number twenty-two least urgent. In an attempt to spread the repair work across the municipality to show the taxpayers an even distribution of activity, the council has asked Mr. A, P.Eng. to juggle the listing so that all the electorate will see something being done in their area.

Mr. A, P.Eng. is having a problem with this instruction because it would mean delaying repairs to a bridge which if not done soon, could become dangerous to the travelling public. However, there is very little additional evidence that he can put to his township council to encourage them to accept his listing of priorities. Discuss the ethical responsibilities of Mr. A, P.Eng., in this circumstance.

39. Your conduct as a professional engineer is governed by the Professional Engineers' Act and the regulations thereunder which include a code of ethics. Discuss the act and the code as you see them applying to your professional life. It is necessary to have both an act and a code? Do they overlap?

40. You are a professional engineer working at a nuclear plant. You have built a home on a rural acreage with a twenty minute commute to your job. You and your family have settled very comfortably into the rural life-style of your community. It is, therefore, with some concern that you learn your municipality is giving favorable consideration to a proposal by a major automobile manufacturer to establish a plant across the road from your home.

The proposal is for two hundred acres of manufacturing use together with an urban development of some seven hundred and fifty homes to house a major part of the work force.

You see this as a serious intrusion into your quiet rural preserve. A number of your neighbors are organizing opposition to this potential disruption of their personal life. On the other hand, the municipal council members are pointing out in their press release that this will be a major source of taxation and employment for the young people in the township. With the decline in the agricultural industry, they see this as a real boost to the local economy. As a professional engineer, you have been approached by the Township Reeve to head up a council appointed committee to look into the pros and cons of the proposal and hopefully come up with sound arguments in support of the scheme. You are having difficulty with a conflict between your selfish personal interests and the needs of your community.

Discuss the ethics of this conflict and the way that you propose to handle it.

41. As a professional engineer with the XYZ manufacturing company, you are aware that your firm subcontracts a number of components. You are also aware that the supplier of one of the components is having difficulty meeting its delivery schedule. Upon investigating, you find that this supplier has lost its production superintendent and that the owner is trying to do this job as well as manage the company. You also learn upon further investigation that it is pressed

financially and generally in need of an injection of both capital and management know how. At the end of your third meeting with the owner, he asks you if you would be interested in becoming a silent partner. You would purchase an interest in the business and would be expected to advise on technical matters. You would not be expected to be available during regular working hours but would put in time on the weekends and in the evenings. The idea appeals to you, but can you do this sort of thing within the constraints of our code of ethics?

Discuss, based on our code of ethics and code of professional conduct, the course of action you would follow.

42. Mr. “C”, P.Eng. is a house building contractor. He owns land that is quite steeply sloping but he wants to build houses on it because of the spectacular views it affords.

He contracts with Mr. “D”, P.Eng. for the design of a suitable subdivision layout. When he priced out the expensive retaining walls required by this design, it became obvious the project would be uneconomical to build. Mr. “C” paid by Mr. “D” for his services and closed the file.

Some time later he was approached by Mr. “E”, P.Eng. who holds a franchise for a retaining wall system which has just received approval by the province. Mr. “E” presents Mr. “C” with a price for design and construction of the wall systems for the subdivision plan previously designed by Mr. “D”. This price makes the project economical so Mr. “C” decides to proceed with the work. He hires an old friend Mr. “F”, P.Eng. to oversee the works and obtain the necessary approvals. When Mr. “D” learns what is happening he is very upset. He believes that only he should be retained for the supervisory work and also he should have been consulted because it is his subdivision design that is being built.

Discuss the ethical aspects of this entire procedure. Did any of these Professional Engineers act unethically?

43. Professional Engineers of Manufacturing Company “X” have prepared plans and specifications for some new machinery to be used in their plant. Company “X” has contracted with Company “Y” to build these machines. Before starting construction of the machines Professional Engineers of Company “Y” checked the plans and specifications provided by Company “X” and believe they include miscalculations and technical deficiencies. They are concerned the product, if built in accordance with the plans and specifications supplied, might be dangerous to the users. These findings were reported back to company “X” which Company replied its Professional Engineers were satisfied the design and specifications were adequate and safe and that the construction should proceed. Based on this response the Senior Officials of Company “Y” directed that the work be done. You are one of the Professional Engineers of Company “Y”. You still think the machinery could be dangerous.

What is your ethical obligation in this case?

44. A professional engineer (P.Eng.) was asked by a friend who owns and operates a driving school to examine the dual braking system which had recently been installed in the school’s fleet of cars. The dual braking system allows the driving instructor to apply the brakes and stop the car if deemed necessary.

The P.Eng. found several deficiencies in the braking system which could lead to failure after a few

applications of the instructor's brake. The P.Eng. reported these findings to the owner friend, but took no other action.

Did the P.Eng. act correctly? Discuss the actions of the P.Eng. in this situation.

45. You are the holder of a Certificate of Authorization (C. of A.), from the Association of Professional Engineers of Ontario (APEO) and you are also the Senior Design Engineer in your company which designs hoisting equipment.

Your staff includes several professional engineers, draftsmen and mechanical and electrical technicians. You are on an extended business trip but maintain telephone contact with your company. Your assistant who is a P.Eng. informs you by telephone that a plan you both have worked on must be submitted immediately in order to meet a tender deadline.

Is it ethical for your assistant to submit the final drawings? How would you deal with this situation?

46. A Consulting Engineering firm has been hired by a City Council to do a preliminary analysis of the feasibility of introducing rail transit to its medium sized city. Under the direction of "C", P.Eng., a principal of the firm, a junior engineer "J", P.Eng., is processing the data through various computer models.

"A", P.Eng., an Engineering Associate in the Consulting firm, overhears "C" instructing "J" on the range in certain calibration parameters to be used in the calculations including, income levels, automobile ownership, fuel costs and parking charges. "A" suspects there is a bias in the ranges that "C" proposes. "A" thinks "The boss realizes that the politicians want to take advantage of provincial government grants and so he is using the compound optimum approach". Engineer "A" takes no action.

Is engineer "C" behaving in an ethical manner? Should Engineer "A" have said or done something?

47. Suppliers of goods and services sometimes show their appreciation to civic employees for their co-operation by giving gifts, particularly at Christmas time. You are a P.Eng. in the office of the commissioner of works for a large urban community. You have just received a gift which you do not consider major but recognize as being well in excess of the category of a "thank you" luncheon. The municipality is discussing publishing guidelines to staff respecting such things but so far has done nothing. How are you going to react to this supplier? What section(s) of the Codes of Professional Conduct and Ethics apply in this case?

48. Consulting Engineering firm XYZ is controlled by four principals. Under these principals there is a group of ten associates, all of whom hold shares in the firm, but at a lesser level than the principals. One of the principals took issue with a decision taken by the majority of the board members and promptly resigned from the firm. A few days later two of the associates also resigned from XYZ and joined the departing principal in the formation of a new consulting firm ABC.

The new firm ABC quickly produced a brochure to promote its services and as well as distribut-

ing it widely to likely prospects, began a campaign of personal calls on potential clients, including some with whom the individuals had worked while acting in an engineering capacity with firm XYZ. The remaining principals of XYZ were upset when they learned that the new firm was offering services to their clients. They filed a complaint with our association claiming that the principals of ABC were acting unethically.

Do you believe that they were behaving unethically? If you were a principal in the new firm ABC how would you proceed to develop clients?

49. In the past three years competition has become extremely keen in almost every industry as a result of the global economic down turn. Companies are surviving because of the competitive edge they can gain over others in the same market area. Engineers are moving from company to company primarily because they can bring new ideas with them. You are a P.Eng. in company A. You recently presented a paper at an industry conference in which you discussed work you had done on a specific product. The technical press gave your paper quite large coverage following this meeting. Since then you have been approached by three of your employer's competitors with employment offers. It is obvious to you that they want you because their employer's product is superior to theirs, largely because of your work on it, but it is not common knowledge just what the added ingredients are. One company in particular is being very aggressive with a very attractive proposal ties to increases in sales which this company assumes your added input will generate.

How do you deal with such matters from the point of view of our codes of conduct and ethics?

50. You are a P.Eng. in charge of production in a factory which galvanizes steel. In this process the bare steel parts are cleaned and then dipped in a large steel tank containing molten Zinc. The Zinc coats the steel and provides protection against corrosion. The factory has only recently been constructed and, in the main, the workers are inexperienced. In order to comply with the relevant health and safety regulations you have advised your superior that:

a) A safety committee must be formed
b) Safety procedures must be established, published and put into practice
c) Safety notices must be posted
d) Safety classes must be held
e) Safety training must be given to the workers
f) Safety clothing must be provided

Your superior tells you that since this is a new company struggling for survival in a weak economy, there are no funds to finance your safety proposals.

What is your ethical responsibility?

51. Professional Engineer "A" has embarked on a 5 day cross country tramp and camp trek with two younger relatives. The trek is expected to cover about 100 kilometers of rugged terrain. On the first afternoon of the trip they encounter a beaver dam that appears to be in poor condition. A heavy downpour could cause it to break out and send flood waters to the area downstream. The map shows that downstream there are a couple of beaver dams and a highway bridge, before the stream empties into Spruce Lake. Because of the steepness of the terrain P.Eng. "A"

is concerned that such a flood could wash out the other beaver dams and might even cause damage to the highway bridge. “A” comments that they should probably notify the Ministries of Transport and Resources when they get home.

Was it necessary for “A” to do differently to be ethical?

52. Customer “A” has hired a licensed gas contractor to install a high efficiency gas furnace in his home. Soon after the furnace is installed “A” discovers that the rated heat capacity of the furnace is below the estimated heat requirement for the house. The contractor says this is easily rectified by operating the furnace above the manufacturer’s rated capacity. The contractor makes the adjustments required to meet the estimated heat needs.

Customer “A” becomes concerned and writes a letter to the furnace manufacturer outlining the situation. This letter arrives on the desk of “B”, P.Eng.

Does “B” have an obligation to reply to “A” and to contact the gas contractor? If so, what are “B”’s ethical obligations to “A”? Does “B” have obligations under the code of conduct to either “A” and/or the gas contractor?

53. You are a P.Eng. responsible for the design an manufacture of an electrical switch, in a Canadian manufacturing plant. A group of users claim that the switch has malfunctioned and has started fires in their homes. A government agency in the United States has carried out tests on this product which indicate that under certain conditions the switch can malfunction and cause a fire.

All your in-house testing indicates that the switch is safe and reliable. The switch has passed all required Canadian standards tests. The users demand that the switch be withdrawn from the market.

Do you have an ethical responsibility to take further action? What further action do you take?

54. You are a Professional Engineer employed by a management consulting firm. Your present assignment is to find ways of speeding up the production line in a factory that manufactures skin lotion. As part of your investigative procedure you have been reviewing confidential company documents and, completely by accident, have found that the manufacturer is using small quantities of a known carcinogen in the lotion. You further find that there is no reference to the ingredient in the description of the product, or in the reporting literature which is provided to the government inspecting agency. This information, which you have stumbled upon, has no bearing on the assignment which you are doing.

Do you have an ethical obligation to take some action about this confidential information? If you do, what action would you take?

55. (Source T. Elio) Consulting Professional Engineer Smith is a member of a religious congregation. The parking lot and driveways associated with the facilities of this congregation are in deplorable condition and must be totally rebuilt. With the concurrence of P.Eng. Smith’s partners, P.Eng. Smith has volunteered to donate the time and expertise necessary to provide all the engineering services required including that for drainage, structures and surfacing and to pre-

pare the documents for tenders for the work at no cost to the congregation. Prior to making this undertaking, P. Eng. Smith sought and received the approval of the partners in the consulting company. The offer was accepted by the Church's Board. The Church Board asked P. Eng. Smith to submit a statement of account based on the normal fee for such work so that the treasurer could give P.Eng Smith a receipt for tax purposes.

Consulting Engineer Watkins from a different firm, heard of this arrangement and verbally attacked P.Eng. Smith for unethically depriving other members of the professional opportunity to compete for work.

Refer to our codes of Professional Conduct and Ethics. Based on these codes, in your opinion, have either P.Eng. Smith or P. Eng. Watkins or both acting improperly? Give the reasons for your conclusions.

56. Chi is a chemicalP.Eng. licensed with the PEO. For the last five years Chi has been working for a Federal government department in a remote post in the NorthwestTerritories studying atmospheric conditions and has recently been relocated to Ottawa. Since Chi's departure the post has been shut down. All infrastructure has been left in place and most of the supplies and equipment remain as well.

Chi's department has hired a consulting engineering company to study the costs of dismantling the post and remediating the environmental impact caused by the post's operations. The study projects the clean-up costs in the order of ten million dollars which far exceeds the department's budget for the project. The department decides to proceed with the lesser cost of dismantling all above-ground infrastructure and removing all visible equipment and supplies and restoring the ground surface to its original condition. The removal of buried equipment (including fuel tank) and subsurface remediation will not be undertaken since it is the major cost component.

Chi makes some enquiries and learns that the department has justified this omission on the basis that it is located in a remote area and its impact on the environment would be slight. Chi believes it should be cleaned up since Chi is aware that some surface tanks leaked while Chi was at the post and Chi suspects that th underground tanks may also have leaked.

What should Chi do? Should Chi have done anything while employed at the post?

57. The Provincial Ministry of Transportation proposes routing a new expressway diagonally across a large northern Ontario city. A group of local citizens who believe they will be adversely affected by the routing employed a consulting engineering firm to study the route. Lambda, a P.Eng. with the firm, and the Project Manager, concludes that their diagonal route proposed by the Ministry could have a negative impact and recommends an alternative route.

Rho, a partner in the firm, appears before the local PEO chapter and explains the circumstances of the project. Rho answers all of the questions asked. Rho requests the local chapter to publicly endorse the alternative route being recommended by the firm.

Has Rho violated PEO's codes in any way? What should be the actions of the local chapter?

58. Upsilon is a professional engineer who has been employed in the computer department of a large corporation for two years. The department comprises four engineers (including Upsilon)

and some non-technical staff. The department has been given the task of implementing a major computer software program throughout the company. Compubright, a major software firm, has been selected to provide the main component of the new system. Upsilon, and the rest of the computer department, have been working closely with representative from Compubright to modify its proprietary software to suit the specific needs of the company.

Towards the end of the implementation process two of the department's four engineers tender their resignation from the company. Upsilon learns from the two, in confidence, that they have left to join Compubright for more lucrative positions.

The departure of these two engineers substantially increases the work load for the rest of the department and there is no relief in sight since the company has been downsizing its operations. Upsilon is considering leaving the firm once the implementation is complete; particularly since Upsilon's position may become redundant at the end of the implementation. Compubright makes a generous offer to Upsilon with the condition that Upsilon must accept and leave the company prior to completing the implementation. other than this offer the job prospects for Upsilon appear dim.

Should Upsilon accept the offer? What obligations does Upsilon have to the firm? Discuss the conduct of the other two engineers with regards to PEO's Codes of Ethics and Conduct.

59. You are a senior professional engineer who, until last month, were one of two equal partners in a consulting engineering firm. Both of your names appeared on your company's Certificate of Authorization. After a number of prosperous years together you mutually agreed to dissolve the partnership to begin your own firms.

In your first month of business you received a call from a building management company seeking your engineering services. The company, Buildex, has recently purchased a building from Rentsom, Inc., a previous client of yours during your partnership.

The building in question requires some mechanical and electrical retrofitting due to aged equipment and facilities. You are aware of the required retrofit since you and your previous partner prepared the retrofit design last year for Rentsom (and were fully paid). Buildex explains that they have sought your services since your stamp appears on the retrofit design drawings of the permit application. The building department will not issue a permit to Buildex unless they have approval from you or Rentsom.

Buildex seeks your approval and your services for some modifications to the design and also reuqests your services for inspection of the contract work. This will be your first project as a sole proprietor and you are eager to accept it.

Are there any hazzards in accepting this project?

What actions should you perform regarding your professional ethics and conduct prior to proceeding?

Refer to the relevant clauses of the two codes in your answer.

60. You are a senior Professional Engineer registered in the Province of Ontario. You live in Ontario and work for a large interprovincial gas supply company which is based in Alberta. Your job duties include the review of technical Company reports for its Ontario operations. The company's solicitor requests you to review a report on a natural gas pipeline failure which was prepared by the company's Alberta based engineer. The failure occurred under a wheat-

field in Alberta not far from the Company's plant. At a later date you may be required to present your review to an Alberta court and to defend any comments you made regarding the report. To correctly review the report requires that you inspect the site of the failure.

Would you accept this assignment as part of your regular duties without reservations or restrictions?

Are there any actions you must take before working in Alberta?

Would your answer be any different if the report was prepared by a consulting firm which was no longer retained by the Company?

Cite relevant sections of the Code of Professional Conduct and Code of Ethics.

61. Iota is a professional engineer employed with Manutex Inc., a manufacturing firm. As part of its operations Manutex subcontracts a number of its components from other manufacturing firms. Iota is aware that Micron Inc., a long time supplier of one of the components, is having difficulty meeting its delivery schedule. Upon investigating, Iota finds that Micron has lost its production superintendent and that the owner is trying to do this job as well as manage the company. Upon further investigation Iota finds, that, as a result, Micron is having financial difficulties and is in need of an injection of both capital and management expertise.

At the end of the recent monthly meeting Micron's owner asks Iota to become a silent partner. As a silent partner Iota would purchase an interest in the business and would be expected to advise on technical matters. Iota would not be expected to be available during regular working hours but would put in time on the weekends and in the evenings. The idea is very appealing and would help Micron meet its obligations to Manutex. Can Iota accept this offer?

What is the course of action that Iota should follow?

62. Your firm is asked by a nearby city to assess the effects of a tidal wave. Located at the end of a long narrow inlet, the city is in an earthquake zone, although the last one occurred in 1 970 when the city was only a fishing port. To make sure they have an adequate picture of the disaster that could result, they ask your firm to examine the effects of an earthquake whose magnitude is likely to be exceeded only once in 200 years (a 200 year earthquake). Your findings are so alarming that the city authorities are shocked, and they believe that if the public were to realize the extent of impending damage, mass hysteria would result. Further, because many of the city authorities are elected officials and have been in their positions for many years, people could ask why such a study was not carried out years ago and why earthquake planning by-laws were never formulated.

As a result, you are asked to keep the findings of the 200 year earthquake confidential and to undertake another study with the reduced design magnitude of a 100 year earthquake. The results are still frightening, and the city asks you to further reduce the earthquake design magnitude to a 50 year earthquake. The city then incorporates the findings of your study of the 50 year earthquake in its disaster plan but makes no reference to the other two scenarios.

Discuss this situation from an ethical point of view. What action will you take as a professional engineer? What advice will you give to the city council?

63. a)Describe the significance of clause 72-(2)(g) from Ontario Regulation 941

b)Does the Professional Engineers Act apply to person other than Professional Engineers? Describe.

c)Frequently an engineer is asked to provide specific design details related to his/her discipline

(structural, electrical, mechanical, etc.) for a project that is being designed by an architect. It is not uncommon that these design details can readily be shown on the architectural drawings and often are. Are there any risks or responsibilities associated with this practice? What would you do if asked to provide your design on the same drawing as the architect's?

d)If a member has been convicted of a criminal action can the Association discipline that member for that conviction? If so,.under what circumstances?

e)The Act and Regulations describe six requirements that must be met in order for an applicant to become a Professional Engineer. List four of these and briefly explain their relevance.

64. The municipality of Penlan has recently been instructed by the Provincial Government Ministry's District Engineer that the municipality must replace a deteriorated wooden crib bridge to maintain roadway safety. The municipal council hired consulting engineer Gamma, P.Eng., who then prepared a design for a concrete bridge to replace the wooden bridge. Because of poor subsurface conditions at the bridge location, extensive work is required to make the bridge foundations satisfactory. This results in a very costly structure.

Beta, P.Eng., a resident of the municipality, has learned of the concern of the municipal council over the high replacement cost and suggests to the municipality that they may be wise to look into the use of a 'soil-steel' sure as an alternative to the concrete bridge. Beta does not hold a certificate of authorization but does work for a company that manufactures the 'soil steel' structures and is thus knowledgeable in this field.

As a result of Beta's suggestion, Gamma was paid in full for the design and released. Professional engineer Mu was then hired by the Penlan council. Mu prepared the alternative design and the 'soil-steel' structure was constructed at a fraction of the cost of the expected concrete design.

Discuss the ethics of the actions of professional engineers Gamma, Beta and Mu in this situation.

65. Fibretex Inc. is a Canadian based international company which manufactures products from wood fibres. One of its plants, located in a developing South American country, chemically processes wood fibre. Professional Engineer Kappa, (licensed in Ontario) has been transferred from Ontario to the post of manager of the plant. Shortly after arriving Kappa finds that the plant is using technology that is 20 years behind that of developed countries. Kappa is aware that the equipment was replaced in Canada as a result of more stringent regulations. It was found that the discharge from the older process caused the formation of a chemical in the receiving waters that interfered with the reproduction of certain aquatic organisms.

Knowing this, engineer Kappa conducted tests on the discharge of South American plant and found a similar composition of chemicals which led to the problem in the 80's. After researching the country's regulations Kappa found no reference to this situation and, in fact, no standards existed for this process. Upon reporting this to the superior, Vice-President Zeta, Kappa was told not to worry, "..the process met all of the standards in the host country and modifying the process would be costly and therefore an undue burden to the client."

Kappa was not comfortable with this position and sought advice from his friend and mentor Professor Sigma, P.Eng. Sigma counselled Kappa that, although Sigma empathized with Kappa's situation, ensuring that the country's standards be met should be sufficient.

What are Kappals obligations? What is Kappa required to do?Was Sigma's counsel wise? Is Sigma obligated to Kappa and the company in any way?

Refer to the Codes of Ethics and Conduct in your answer bearing in mind that Kappa is a member of PEO but is living and working in another country.

66. You are an Ontario P.Eng. who has been asked by an inventor to report on the safety, efficiency and reliability of a metering device for controlling chemical additions in a water treatment plant. Part of your task will be to review a report on a competitor's product that was prepared by a P.Eng. for that competitor.

a) Are there sections of the Ontario Professional Engineers Act which could prevent you from accepting this assignment?

b) If you undertake the assignment and find that the device can be hazardous, what action do you take?

67. Professional Engineer Omicron is an employee of.a government body. Omicron is responsible for the review of proposed engineering related works that are overseen by the government. At a party, a friend asks Omicron to provide engineering design services for a modification to his manufacturing plant. In consideration of Omicron's services the friend offers the use of his/her cottage resort, free of charge, for Omicron and family during their vacation. After some consideration Omicron accepts the offer and proposes that the design could be performed during Omicron's upcoming family vacation.

Omicron then seeks permission from his/her boss, also a Professional Engineer, and receives it on the basis that it not interfere with Omicron's work. Omicron proceeds with and completes the design work during the vacation period and presents it to the friend. Some weeks later the very design appears on Omicron's desk for approval. Apparently, and previously unknown to Omicron, a minor component of the design required approval by the government body that employed Omicron.

Was Omicron's action ethical? What should Omicron do? Given that Omicron works for a government body was the boss ethical in giving permission to Omicron?

68. You are an Ontario P.Eng. working in a mid sized consulting engineering company. You have a young family and have recently purchased a house in a neighborhood that both you and your spouse have dreamed to own. Adjacent to your neighborhood, and quite close to your home, is a vacant lot which has been designated for development. The developer is proposing a multi-storey mixed-use building. The local resident's association, of which you are the vice-chair, is strongly opposed to the development since it is expected it will have a negative impact on your quiet neighborhood. You share the concern and head the drive to prevent the development.

After a number of meetings with the civic council, the developer and the resident's association you learn that your firm has been engaged by the developer to design a major component of the building. Your boss has asked you to manage this project.

Discuss the ethical implications of this situation.

69. a) Can Professional Engineers advertise their services to the public? If so, what are the restrictions, if any?

b) What are the consequences, if any, to a lay person who claims to be a P.Eng. and performs professional engineering work?

c) What are the consequences, if any, to a professional engineer who does not keep his/her licence permanently displayed in his/her place of business?

d) Are there any risks involved in creating an electronic image of your stamp? Is the risk any different if you also create an electronic image of your signature with your stamp?

e) What does ’conflict of interest’ mean?

70. Eta is a Professional Engineer whose years of experience have resulted in Eta being called as an expert witness for a number of court cases. Eta has an established fee rate for this service which is in accordance with the PEO’s Schedule of Suggested Fees. Legal counsel has asked Eta to act as an expert witness in a criminal court case to provide opinions for the defendant. Eta reviews the file and prepares an offer of services, stating the fee, which counsel accepts. However, counsel advises Eta that the case is being defended under ’Legal Aid’ and the fee is higher than ’Legal Aid’ will approve.

Eta feels that the expert evidence is crucial to the defendant and, without it, it is likely the defendant will be convicted unjustly. Eta agrees to reduce the fee to that approved by ’Legal Aid’ and is retained by counsel.

During the trial it becomes apparent that the reduced fee will be insufficient to cover Eta’s costs. Counsel offers to pay the full fee, as per the original offer, if the defendant is successful. If unsuccessful, Eta will receive the reduced fee. Eta accepts this offer since there is now a chance to receive payment in accordance with the Schedule of Suggested Fees.

Discuss Eta’s decision with regard to the code of ethics and section 72 of O.Reg. 941.

71. a) Article 77-8 of the Code of Ethics obligates practitioners to "expose ... unprofessional, dishonest, or unethical conduct by any other practitioner". Knowing that such a report may damage that engineer’s reputation, discuss whether this article is consistent with sentence 77-7-iii.

b) One aspect of a profession is that it is self regulating. Describe what this means. How does the engineering profession achieve this?

c) Does a consulting engineer have any more privileges than a professional engineer who is not a consulting engineer? Are there any further obligations?

d) What are the consequences of a professional engineer sealing plans that were not prepared or reviewed by him/her?

e) Section 1 2 of the Professional Engineer’s Act prohibits a person from engaging in the practice of professional engineering unless licensed. Are there any consequences if a corporation engages in the practice of professional engineering?

72. You are an environmental engineer with P.Eng. status employed in the petroleum industry and have been active in promoting environmental issues in your community for some years.

You are aware that on the site proposed for a new low cost apartment complex there was a toxic spill 25 years ago. You have attended the local council meeting and know that there has been no mention of this toxic spill in any information given to council.

The community has been anxiously awaiting this development since it will bring much needed housing for lower income families.

Do you have an ethical responsibility to inform council of your understanding of the history of the site? Discuss this, and any other relevant issues, in relation to the Code of Ethics and Professional Misconduct.

73. Psi is a consulting engineer operating a consulting engineering practice. Psi’s client, Constructex, asks Psi to design a reinforced concrete porch for a large house he is building for his client. The project is 500 km from Psi’s office (still in Ontario) but is close to Constructex’s office. Psi accepts the job and prepares the design which receives the required approvals from the build-

ing department.

A few weeks later Psi receives a call from the building department requesting an inspection of the porch during construction.

The inspection of the porch will require either an air flight or a drive with a one night layover. The construction cost of the porch is estimated to be $2,000.00 and Psi's estimated cost to inspect the work is $1,500.00. When the design fee is added, the total design/inspection costs are greater than the construction cost.

Is it fair that Psi performs this inspection? Is it fair that Psi doesn't? What should Psi do?

74. You are a P.Eng. and have been assigned the position of manager for a new project. One of your first tasks is to estimate the time and cost to complete the project. You discuss your preliminary estimates with a few senior engineers who suggest you lower the estimates. In their experience many earlier projects would have been cancelled if their true costs had been known at the planning stage. The estimates for these earlier projects were reduced and they were successfully completed, even though the time and cost exceeded the estimates.

With this in mind, you review your estimates looking for errors or ways to reduce the costs and time. Your review justifies only minor changes which have little impact. You fear that some people in your department may be laid off if the project does not proceed. However, you are not comfortable with reducing your estimates. You must make a decision by the end of the week.

Discuss how you would proceed and what decision you would make. Refer to the applicable clauses in sections 72 and 77.

75. a) The Profession Engineers Act does not explicitly restrict professional engineers from practising outside of their discipline. In fact, some engineers do so. How does the Act deal with the matter?

b) The professional Engineers Act establishes a number of committees. Two of these are the complaints committee and the discipline committee. Briefly describe the function of these two committees.

c) Under what conditions can professional engineers advertise their services to the public? Are there any restrictions to the form and content of the advertisement?

d) Explain the implications of clause 72-2-g of Ontario Regulation 941. How does the clause affect professional engineers?

e) What is the professional engineer's stamp? When and why is it used?

76. You are a Consulting Professional Engineer. For more than 15 years you have worked exclusively on environmental matters. Recently you conducted an environmental assessment for a residential development proposed along the shore of Lake Latouche in the Town of SouthHead. Your client for this work was the Town of SouthHead. The project has been completed and you have received payment for your work.

A neighbouring, Eastni, also borders on part of Lake Latouche. Eastni has requested that you carry out an environmental assessment of Lake Latouche as it relates to the lands in Eastni.

Can you ethically undertake this work? Are there any restrictions on the use of data which you gathered when working for SouthHead?

At the same time, the Lake Latouche Cottager's Association wishes to retain you to represent it at a proposed Ontario Governmental Environmental Hearing. One of the directors of the Associ-

ation is an acquaintance of yours from your school years.
Can you represent the Cottager's Association? In the event that you do, what information can you use and how should you determine your fee structure?

77. Kappa hires Mu, a Professional Engineer, to design a freight/passenger elevator. Mu develops a design and meets with Kappa to discuss it. The two disagree over the resulting design. While Kappa feels that the design could be simplified, Mu believes that a simpler solution could endanger the public. Kappa demands that Mu turn over the drawings to Tau, a professional engineer who has agreed to complete the project as Kappa wishes. Kappa is willing to pay Mu for the drawings and the work completed thus far, but Mu refuses to give Kappa the drawings.
Is Mu obligated to give Kappa the drawings? Does Mu have any other obligations or responsibilities? Discuss Tau's agreement with Kappa as it relates to the Code of Ethics and definition of Professional Misconduct.

78. Upsilon is an engineer in training (EIT) with three years of engineering experience in an environmental consulting engineering firm. Eta, the professional engineer who supervises Upsilon, directs Upsilon to sample the contents of steel storage drums located on a client's property. Over the years, this client has brought a substantial amount of work to the firm and helped it stay in businessduring the lean recession years. From the look and smell of the drums, Upsilon suspects that and analysis of the samples will show hazardous waste in the drums. Upsilon knows that if the substance contains hazardous waste the regulatory authorities mst be notified.
Upsilon informs Eta of the likely contents of the drums and asks what to do next. Eta instructs Upsilon to report the presence of the drums and that samples had been taken, and not to do the analysis. eta suggests that the analysis would normally be done at this stage in the project but the local labs are all too busy. Since the client does other business with the firm, Eta intends to tell the client where the drums are located and that they may contain questionable material and to suggest that they be removed.
Did Eta's actions fulfil an engineer's professional obligations and responsibilities? Should Eta have done anything further? Does Upsilon have any obligations to fulfil, given that Upsilon is an EIT?

79. Lambda, the owner of a development company, is in the process of developing a structure on a parcel of land in a rural area of south western Ontario.
Lambda entered into an agreement with Consultex, a consulting engineering firm, to undertake the construction supervision on a 'payroll plus' basis. Consultex assigned P.Eng. Epsilon to the supervision. Epsilon assigned a small staff to the site to inspect and supervise the work. Epsilon made regular visits to the site to meet with the staff and supervise the work. Epsilon made regular visits to the site to meet with the staff and supervise the work.
Lambda was raised in a nearby rural area and was eager to help the local economy by involving local workers, including some of Lambda's relatives. Lambda called Epsilon to a meeting and urged that local help be added to the inspection/supervision team. Lambda willingly offered to bear all extra costs associated with the extra staff. Epsilon indicated that the work was adequately supervised and the increased costs could not be justified. Epsilon was concerned that such a commitment would create problems and drive up the engineering fees which could damage Consultex's reputation. Furthermore, Epsilon threatened to withdraw from the agreement, if Lambda insisted.

What problems might have arisen? Was Epsilon's action ethical? Relate your discussion to the Code of Ethics and definition of Professional Misconduct.

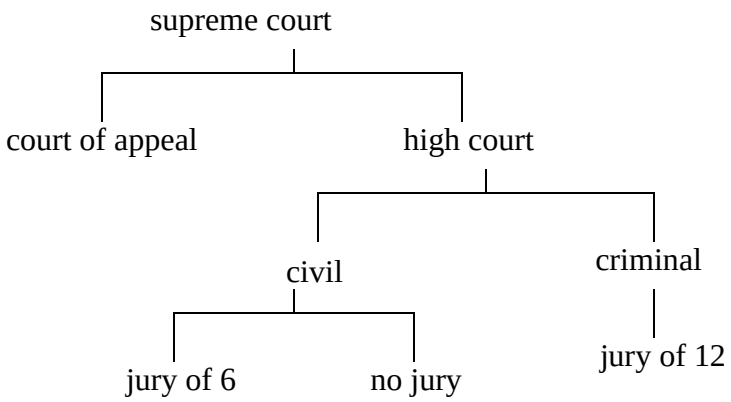
3.4.5 HOW TO APPROACH LAW/ETHICS PROBLEMS

1. Identify major events and issues.
2. State the applicable laws and precedents.
3. Apply legal principles and precedents to analyze the situation.
4. Consider possible outcomes.
5. Recommend an action.

3.5 LAW IN GENERAL

• The general rules of law are a combination of,
  - common law
  - statute law
  - negligence

• The court structure is given below,



• The Adversary System - a system of opposing legal parties.

• Lower courts are compelled to follow rulings made in higher courts.

• Statues are made by provincial and federal legislatures and override common law.

• criminal law is in the federal jurisdiction, and is not within the provincial jurisdiction - ultra vires

• The theory of precedent - a basis for legal decisions. When a decision has been made in a similar case before, that decision should be used again. In apparently similar cases there might be distinctions that cause a court to not follow precedents. Occasionally precedents are used from other states or England.

• Common Law - “judge made law” - previous court decisions are used as legal principles.

• Legislation - legislation can override the common law.
  - this is law passed in an elected legislature
  - can be a new law or a former common law

- the court then determines how to interpret and apply the legislation

• Arbitration is an alternative to a court based lawsuit. This allows maters to be argued (either by choice or as dictated by contract). Engineers may be asked to act as arbitrator, effectively this process makes the arbitrator a judge in an ad-hoc court empowered by statutes (e.g., The Arbitrations Act of Ontario). It is possible that the result will be taken to a formal court. [Re Thomas Hackett]

3.6 BUSINESS LAW

• Three basic forms,
- sole proprietorship
- partnership
- corporations

• proprietorship
- owner and company are one entity in the courts.
- profits and losses are the owners

• partnerships
- all partners are considered personally responsible for the profits and loses of the partnership, except in the case of silent partners.
- a silent partner must have no control in the day to day operation of the business and is essentially a financier.
- Joint ventures are partnerships limited to a single project.
- partnerships should be registered (The Partnership Act of Ontario) before they act as legal entities.
- partnerships will dissolve when one of the partners dies or becomes bankrupt or insolvent.
- partnership agreements are needed to determine responsibilities (financial, management duties, work) provisions for adding or expelling partners, etc.
- corporations can also be partners.
- limited partnerships are registered partnerships (Limited Partnerships Act of Ontario) where one or more partners can limit their liability to their own contribution. They cannot be advertised as part of the firm, represent themselves as a general partner, partake in business decisions, etc.

• corporation/limited company (“a fictitious person”)
- federal or provincial corporations
- a corporation has the same legal status as an individual. This principle is called the “corporate veil” [Salomon v. Salomon & Co. Ltd.]. This may be lifted in some cases when fraud is involved [Fern Brand Waxes Ltd. vs. Pearl]
- this provides a tax shelter for shareholders

    - this also acts as a liability shield
- Other circumstances will also set aside the corporate veil, such as common control of multiple corporations [Nedco Ltd. v. Clark et. al.]
- a corporation exists as long as it complies with its governing statute, and no legal steps have been made to dissolve it.
- quite often banks will require personal guarantees from shareholders for any corporate loans (this sidesteps the liability shelter of corporations).
- the taxes paid for profits/dividends made by a corporation can be lower than those paid out by a sole proprietorship.
- engineers can form engineering corporations
- corporations can be formed by,
    - federal statutes
    - provincial statutes
    - by following provincial acts (eg, Canada Business Corporations Act or Business Corporations Act of Ontario)
- federal and provincial corporations can trade outside their jurisdiction
- federal corporations (unlike many others) are well suited to Canada wide business, but beyond certain financial levels they must file public annual financial statements.
- provincial corporations may requires licences to conduct business in other provinces.
- “objects” are the purposes of the business which a corporation may opt to define or limit. Some businesses, such as engineering corporations are limited by statute already. (eg, the primary control must rest with an engineer holding a certificate of authorization)
- a private corporation has a limited number of shareholders (<50) with controlled transfer and ownership of shares.
- a public corporation offers shares for sale publicly (often to generate investment capitol). The shareholders elect a board of directors. The board of directors appoint officers to manage day to day affairs.
- in private corporations, shareholders agreements are often used to set up ownership, control new shares, sale of shares, etc. Minority shareholders can be very vulnerable if not protected by a shareholders agreement.
- The directors standard of care is a legal measure of the principles required to maintain a corporation as a distinct entity.
    - directors must act honestly and in good faith while working toward the interests of the corporation
    - directors are liable for up to 6 months of wages for the corporation if actions begin within 6 months of termination if the corporation is sued because of the director, the corporation become bankrupt or goes into liquidation.
    - directors can also be fined or jailed (The Combines Investigations Act) if they fail to submit certain returns.
    - can be prosecuted and are liable under the Canada Income Tax Act
    - directors can be prosecuted if the corporation is not properly identified during business transactions.
    - directors can be prosecuted if false statements are made on corporate reports, returns, notices or other official corporation documents.
    - Directors in corporations are required to disclose all conflicts of interest that per-

tain to any business in the company. Not doing so will make the directors liable for any profit or gain.

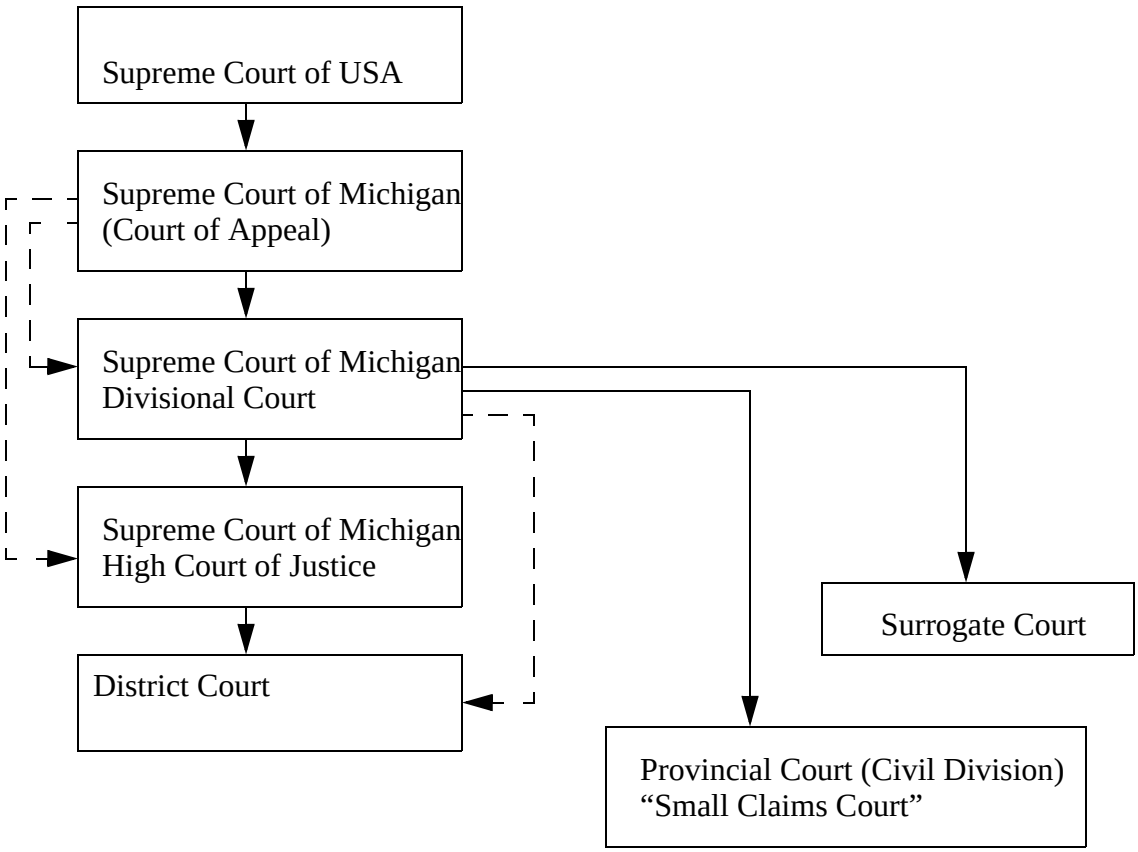
3.7 CIVIL LAW

• In a civil trial the claims of wrong doing are made by the plaintiff, and are made against the defendant(s).

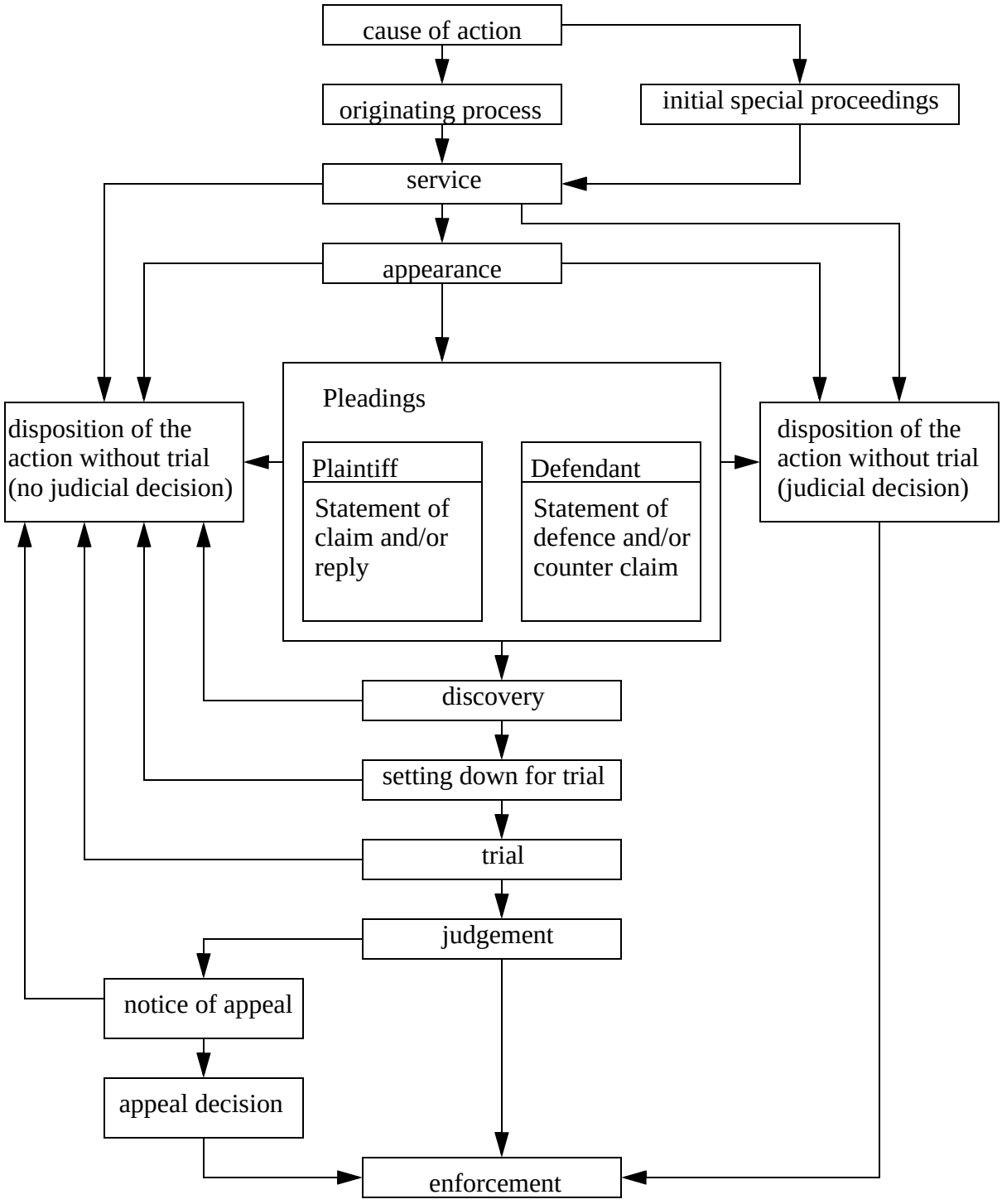
• Civil court decisions are based on an onus of proof, and a balance of probabilities.

• The civil court structure for the U.S. is pictured below,

• The civil court structure for Michigan is pictured below,



• The basic sequence of events for civil cases is shown in the chart below,



3.7.1 CONTRACTS

• each contract must contain certain elements,
    - offer
    - acceptance
    - intent
    - consideration
    - capacity to contract
    - lawful purpose/legality

• Breech of contract
    - fraud
    - misrepresentation
    - duress
    - undue influence

• A contract goes through a number of phases. As a matter of habit, I will illustrate general possibilities with a flowchart. This chart is by no means complete, but can give a simple picture of the life of a contract.

• Assignment of rights - unless limited in a contract, other parties can be assigned benefits. For example the use of a “collection agency” is a common method of dealing with bad debts using a third party.

• an offer may expire if not accepted in a reasonable amount of time. Expiry dates for offers are often included.

• simple offers can be revoked at any time (before acceptance), but in some cases we might want “irrevocable offers”. This involves submitting the offers under seal, or in other word giving contract consideration.

• The “option contract” is another type of irrevocable contract. Something of value is exchanged to in effect make the “option contract” a full contract that can lead to another contract. This type of contract could be used in mining to allow some investigation of a mine before buying mining rights.

• Care should be taken to state which jurisdiction the contract is in. If this is not stated in the contract it will be determined to be where the offer was accepted. [The Queen et. al. v. Commercial Credit Corp. Ltd.]

• mutual intent - a contract should outline what both parties agree on in a contract.

• Letters of Intent - a common device to start business decisions, often a prelude to entering into contracts. These “agreements to agree” are not contracts, and are not legally enforceable. [Bahama Consult Ltd. v. Kellogg Salada Canada Ltd.]

• Consideration is an important part of a contract, in effect both parties must be giving and getting something of value (not necessarily money) to make it worthwhile to enter into the contract. The only case where consideration is not “something of value”, is when the contract is sealed (the seal is seen as something of value). Seals may be the mechanical imprint of a corporation, or a small adhesive label, as is used to make an irrevocable offer a binding contract.

• Gratuitous promise - a promise without consideration that generally wont be upheld by a court. An example is a verbal amendment to a written contract where there is no consideration. Note that this promise is moral not contractual.

• “promissory or equitable estoppel” - In some cases when a contract is amended without consideration (a gratuitous promise), but one party would be inequitably punished by the strict enforcement of the contract, then the amendment may be accepted as valid. [Conwest Exploration Co. Ltd. et. al. v. Letain] [John Burrows Ltd. v. Subsurface Surveys Ltd. et. al.] [Owen Sound Public Library Board v. Mial Developments Ltd. et. al.]

• Capacity to enter into contracts prevents those not capable of meeting the requirements from being held liable.

• Minors do not have the capacity to contract, but if they contract, they can enforce the contract, the other party cannot hold the minor liable (unless it was for a necessity). The age of majority is 18 in most provinces, except in Nova Scotia, New Brunswick, Newfoundland, and British Columbia.

• Drunks and lunatics (like minors) can enter into contracts for necessities, but for non-necessities the contract is unenforceable if the party was obviously incapacitated and repudiates the contract in reasonable time.

• Corporations may not have the capacity to contract. This contract may be outside the corporate charter, not approved by the appropriate official. [Royal British Bank v. Turquand]

• The purpose of a contract must not be illegal or contrary to statutes. Some examples of such contracts are,
    - contracts that attempt to avoid loss of property in bankruptcy by transferring ownership (within one year to a relative or three months to a creditor).
    - a contract provision to limit settlements already statute specified, such as The Workmans Compensation Act of Ontario
    - contrary to the Combines Investigation Act
    - contrary to a lien act
    - when some form of license is required (e.g., P.Eng.) but not held. [Kocotis v. D’Angelo] [Calax Construction Inc. v. Lepofsky] In some cases this will only void part of the contract [Monticchio v. Torcema Construction Ltd. et. al.]

• a contract that is against public/common law may also be voided. For example, non-competition clauses that could lead to monopoly type situations, or make an engineer unable to earn a liv-

ing might not be enforced.

• The statute of frauds has been developed to reduce problems resulting from fraudulent testimony. Generally, written contracts are required in certain circumstances such as,
    - any aspect of land ownership or interest
    - any agreement not to be fully enacted within one year
    - debt guarantees

• unenforceable contracts will still be recognized to prevent inequities. For example, if a verbal sales contract is made and one party disputes the contract, it might be unenforceable, but they could force the returns of goods, money, etc.

• Innocent misrepresentation involves a mistake that is not intentionally misleading, but results in another party entering into a contract. If the mislead party comes forward in time, the contract can be rescinded, and they can recover costs incurred. [Township of McKillop v. Pidgeon and Foley]

• Fraudulent misrepresentation is similar to innocent misrepresentation, except an intent to deceive is involved, and the plaintiff can sue for deceit as well. [Derry v. Peek]

• Mistakes in a contract can be overturned in rare cases.

• Rectification can be done for a “common mistake” where an agreement had been reached but inaccurately recorded. If a clerical error has been made in a contract then the court may rectify it. An example of this is a figure of ‘$100 million’ is accidently typed as ‘$100’.

• Contract may be interpreted by the court using dictionary terms, witness accounts of the intentions, etc.

• “parol evidence rule” - conditions that have been agreed upon verbally, but don’t appear in a written contract cannot be entered as evidence. i.e., if it is not written it does not exist in the eyes of the court. This will only be overlooked when it can be seen that the condition was essential for the contract to be effective. [Pym v. Campbell]

• Implied terms are terms that would obviously be expected to be in a contract, but have been overlooked. [The Moorcock] [Markland Associates Ltd. v. Lohnes] [Pigott Construction Co. Ltd. v. W.J. Crowe Ltd.] [G. Ford Homes Ltd. v. Draft Masonry (York) Co. Ltd.]

• Discharge by performance - describes the end of a contract by satisfaction of the provisions of the contract.

• Discharge by agreement - if both parties agree a contract can be terminated or amended.

• Discharge by express terms - These can be written terms to end a contract

• If a contract has been breached by one party, the other party may,

- sue for damages
- consider the contract discharged [Piggot Construction Co. Ltd. v. W.J. Crowe Ltd.]

• In breach there are,
conditions - essential components of a contract (discharges a contract)
warranties - a non-essential obligation in a contract (only sue for damages)

• Repudiation - an obvious indication by one party (verbal or otherwise) that they do not intend to follow the terms of the contract. The other party may ignore the breach, treat it as breached and sue, or (in a reasonable time) notify the other party that they agree to discharge the contract. NOTE: in some cases repudiation may be warranted.

• Remedies for breached contracts may include,
- quantum meruit - a reasonable measure of the value of work used when it was not stated in a contract or when determining damages. [Alkok v. Grymek]
- specific performance - an award where monetary rewards are not suitable (such as land transfer). This will not be given for anything requiring supervision, such as design work.
- injunction - a restraint to stop another party from an action. This will only apply to contract clauses that are also preventative in nature.

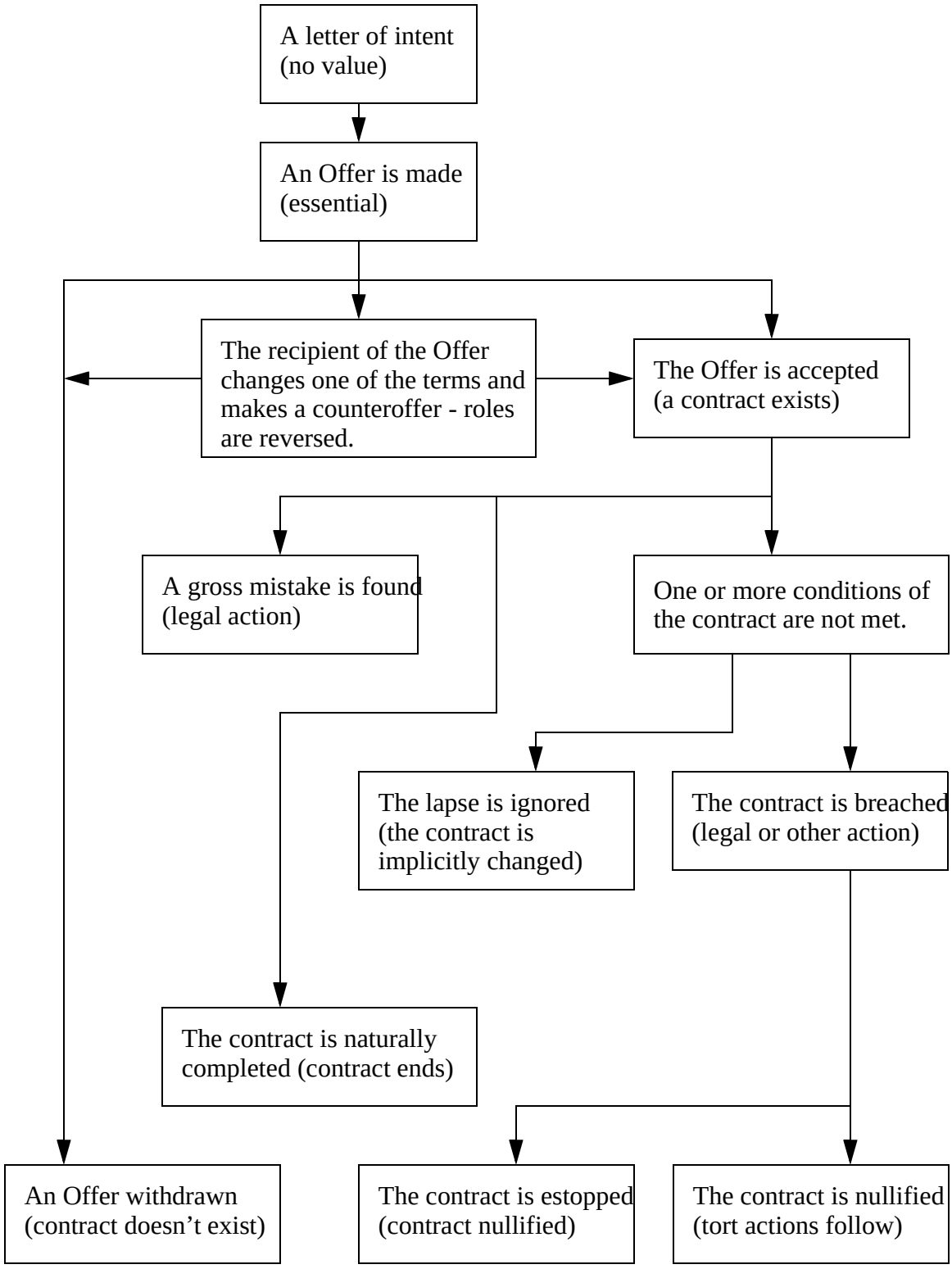
• The compensation for damages are determined by the court [Hadley v. Baxendale]

• Duty to Mitigate - when a party has been injured by a breach of contract they are obliged to minimize loses suffered. Failure to do this will reduce the damages awarded by the court.

• Penalty Clause - a clause that must be a contractual remedy that avoids a breach. If a condition of the contract is not met it can be used to recover damages. These damages must be a reasonable estimate of the incurred loss, or else the court will not uphold the term.

• Substantial compliance - when a contract has been fulfilled for the most part, except for some minor provisions of a contract, the court will award partial payment for work and services done. [Fairbanks Soap Co. Ltd. v. Sheppard]

• Fundamental Breach - when a contract contains an exemption clause (e.g., a maximum liability) and it has been fundamentally breached, then the limitation clauses no longer apply. [Harbutt's Plasticine Ltd. v. Wayne Tank and Pump Co. Ltd.] [Photo Production Ltd. v. Securicor Transport Ltd.] [Murray v. Sperry Rand Corporation et. al.] [Beaufort Realties (1964) Inc. and Belcourt Construction (Ottawa) Limited and Chomedey Aluminum Co. Ltd.]


A letter of intent (no value)
An Offer is made (essential)
The recipient of the Offer changes one of the terms and makes a counteroffer - roles are reversed.
The Offer is accepted (a contract exists)
A gross mistake is found (legal action)
One or more conditions of the contract are not met.
The lapse is ignored (the contract is implicitly changed)
The contract is breached (legal or other action)
The contract is naturally completed (contract ends)
An Offer withdrawn (contract doesn't exist)
The contract is estopped (contract nullified)
The contract is nullified (tort actions follow)

- Mailbox Doctrine - When making an offer the medium of communication is usually set by the communication used for the offer. For example, if an offer is mailed, by Mr. A to Mrs. B. The offer is made on the date that A put the letter in the mail. If B accepted the offer, and returned it by mail, then the offer was accepted as soon as it was put in the mail. In other words the contract came into existence when B put the response in the mail. In most other cases the acceptance is only valid when received.

- When an offer has been received, terms can be added or removed by the receiving party. As soon as the terms of the original offer have been modified the offer now becomes a counter offer. This is effectively a new offer, and must be approved by the original party.

- VOID - means that a contract never existed

- VOIDABLE - the contract has an option of being voided

- In a retail store a price tag is an “invitation to treat”, but it is not an offer.

- caveat emptor - buyer beware

- undue influence - when a dominance leading to coercion exists such as an emotional bond between two family members that is exerted to enter a contract.

- duress - unfair pressure or intimidation exerted to cause somebody to enter into an agreement can make the contract voidable [Mutual Finance Co. Ltd. v. John Wetton & Sons Ltd.]

- misrepresentation - this can be either innocent or fraudulent.

- unconscionable transaction -

- Unilateral Mistake - when an honest mistake is made and it is fundamental. If the recipient of the offer knows that there has been a mistake. The court could be persuaded to fix such mistakes. For example, if Mrs. A is buying a new car for $20,000 plus $500 shipping, but she notices that the contract is for $500, and signs eagerly knowing there was a mistake. Later the autodealer realizes a mistake was made and asks the court to correct the unilateral mistake. Some examples of successful and unsuccessful cases are, [Imperial Glass Ltd. v. Consolidated Supplies Ltd.] [Belle River Community Arena Inc. v. W.J.C. Kaufmann Co. et. al.] [Imperial Glass Ltd. v. Consolidates Supplies Ltd.] [Ron Engineering et. al. v. The Queen in right of Ontario et. al.] [Calgary v. Northern Construction Company Division of Morrison-Knudsen Company Inc. et. al.] The general principles are,
    - the source of the error was clerical
    - the errors were not obvious
    - the error was reported promptly
    - the error was honest and unintentional with good motives
    - the “contract” was an irrevocable offer not yet accepted
    - the intent was only to correct the offer, not withdraw it.

• Discharge by Frustration - problems arise that could not have been anticipated before the contract was signed. These can allow the contract to be voided. For example a contract to provide phone service to a new facility could be discharged if war caused the city to be destroyed. [Metropolitan Water Board v. Dick Kerr and Company Limited] [Davis Construction Ltd. v. Fareham Urban District Council] [Swanson Construction Company Ltd. v. Government of Manitoba; Dominion Structural Steel Ltd., Third Party]

3.7.1.1 - Engineering Contracts

• Engineers are often employed as agents, empowered to specific duties.

• Engineers that fail to specify payments in contracts will be awarded quantum meruit in court.

• When estimating costs in contracts the court may hold an engineer to a poor estimate. [Kidd v. Mississauga Hydro-Electric Commission et. al.]

• There are a number of forms available that are a suitable basis for engineering contracts. These can be found in many engineering associations.

• liability is normally limited in engineering contracts, this should be less than the liability insurance.

• Engineers are expected to understand common law principles, as well as applicable laws for the industry of practice.

• One example is the Hazardous Products Act.

• Engineers are also expected to follow codes, standards and other applicable guides.

3.7.1.2 - Tort Liability and Contract Liability - Concurrently

• We can consider the benefits of being sued for a contract, consider the case of a damage arising from a contract that is covered by a limitation period.

• Normally a contractual obligation negates a tort [Schewebel v. Telekes] but it is possible for an engineer to be held liable for damages in both contract and tort law [Halvarson Inc. v. Robert McLellan & Co. et. al.] [Dominion Chain Co. Ltd. v. Eastern Construction Co. Ltd. et. al.] [City of Kamloops vs. Nielsen et. al.] Other cases go against this trend. [Sealand of the Pacific Ltd. v. R.C. McHaffie Ltd. et. al.]

• A tort can generally be brought when it is outside of the duties described in the contract. [J.

Nunes Diamonds Ltd. v. Electric Protection Co.]

3.7.1.3 - Construction Contracts

• It is typical for an engineer and a contractor to have separate contracts with the owner. These duties expected of an engineer may be,
  - preparation of payment certificates
  - certificates of work completion
  - reschedule when delays occur
  - advising the owner when the contractors performance affects the contract terms
  - sets values for changes in the contract (i.e., the extras)
  - act in cases of emergency
  - inspecting soil conditions
  - inspecting work (and rejecting it if inadequate)

• When hired as an agent/representative, an engineer must remain impartial and independent (there is a small conflict here) from the owner. [Brennan Paving Co. Ltd. v. Oshawa] [Kamlee Construction Ltd. v. Town of Oakville] [Croft Construction Co. v. Terminal Construction Company] [Sutcliffe v. Thackerah et. al.]. If this is not done, actions may not hold up in court. [Grant Smith & Co. v. The King]

• Engineers (unless specifically excluded) are expected to inspect all major portions of construction. [Dabrous v. Zuliani et. al.]

• An engineer should not direct (supervise) work methods of contractors unless specifically contracted to do so, or obvious problems exist. [Demers et. al. v. Dufresne Engineering et. al.]

• An engineer working on a construction project should try to adhere to the contract, and keep a detailed journal of events, meetings, decisions, etc. These can be used later in court.

• Detailed drawings and specifications are needed to minimize misunderstanding. Improperly prepared drawings and specifications could lead to liability. [Trident Construction Ltd. v. W.L. Wardrop and Accoc. et. al.]

• The tendering process often involves “irrevocable offers” that are submitted. When one of these offers is accepted a contract typically exists between the successful bidder and the owner. Bid bonds are another way to ensure that a binding contract exists for the tendered bid. Note: this process should be directed by a lawyer.

• Typical categories of construction contracts are,
  - Stipulated-Price/Lump-Sum Contract - the basic bid amount will be paid on completion of the basic work. Additional work may be done, but this is at additional cost. This type of contract can be risky for the contractor (financial) and the owner (quality)

if problems arise.

- Unit-Price Contract - in cases where the nature of work may change after starting the bids can be per unit of work (e.g., per cubic meter of soil).
- Cost Plus Percentage - When it is not possible to estimate the cost of construction before (e.g., rushing to start a high-rise) the contractor can be paid the expenditures plus some percentage. This contract does not encourage cost reduction.
- Cost Plus Lump-Sum Fee - The same as Cost Plus Percentage except there is no incentive to spend more.
- Cost Plus Lump-Sum Fee Plus Bonus - Like the Cost Plus Lump-Sum Fee except that a bonus is offered for savings below an estimated price. This encourages reduced spending.
- Guaranteed Maximum Price Plus Bonus - This is like a Cost Plus Lump-Sum Fee Plus Bonus Contract, except a guaranteed maximum cost is used instead of an estimated price.
- Design Build - a contractor will likely work on a cost plus bonus, and will supply the engineering services. This allows projects to proceed quickly, as there are no delays waiting for plans and specifications. In this contract the engineer typically has a contract with the contractor, not the owner. Project managers are often hired by the owner to manage the projects on their behalf for a fee.

• It should be kept in mind that the contract between the owner and contractor should be consistent with the contracts between the contractor and subcontractor.

• Delay and interference can cause suits and should be handled carefully.

• Bonds are commonly used to ensure/secure bids, performance and labor and material payments. Here a third party bond agency indemnifies payment. If some contractual obligation is missed, the bond agency will pay, and pursue the party it has indemnified.

• A letter of credit is often used in place of a bond. It is effectively a “blank cheque” for the holder.

3.7.1.4 - Liens

• A construction lien directs an owner to hold back a percentage of the total cost for a period after completion (in Ontario it is 10% for 45 days). In this time anybody that is owed money for work, or materials on a property can place a lien on the property and prevent its sale. The holdback is used to pay them (even no there is no privity of contract between them).

• If an owner does not follow the lien act, for example not keeping a holdback, the owner may then become liable for the subcontractors losses.

• Before any holdback is released, or property is sold the local registry office must be checked for

registered liens.

• lien rights cannot be waived in contracts.

• Trust funds can also be set up for fixed sum payments. These cannot be used until the subject of the trust has been paid.

• Engineers can also make lien claims [Application of Erickson/Massey] [Englewood Plumbing & Gas Fitting Ltd. v. Northgate Development Ltd. et. al.] [Armbro Materials and Construction Ltd. v. 230056 Investments Limited et. al.]

3.7.2 EMPLOYMENT

• Basically defined by the Employment Standards Act,
  - Wage means compensation is calculated per hour
  - Salary means compensation is calculated per week/month

• There are two basic types of employee status,
  - independent contractor - can be terminated anytime as in contract
  - employee - requires notice, or compensation in lieu

• If employment ends there are four possible categories,
  - quits - no notice/compensation required
  - lawful dismissal - a notice is required, or compensation to cover the notice period
  - wrongful dismissal - an employee is terminated for unjust reasons or without adequate notice. compensation or reinstatement may be sought in civil law.
  - instructive dismissal - an employee is told to quit, or else be dismissed. compensation or reinstatement may be sought in civil law.

• When dismissing an employee a minimum of two weeks notice is required. Generally, if the employee has worked for more than 4 months, then 1 months notice are required for each year worked.

• Severance pay - Some employers will ask an employee to leave immediately, and not give notice. They are obliged to pay them the wages that they would have normally earned while working on notice.

• Reasons for wrongful dismissal include,
  - drunk every day
  - insubordination
  - theft
  - tardiness
  - incompetence

- sexual harassment
- willful destruction
- conflict of interest
- espionage
- loss of assignment

3.8 CRIMINAL LAW

• In criminal cases there are claims of violations of the criminal code that the Accused is answering. The Crown is responsible for seeking guilty verdicts.

• The crown must prove beyond a reasonable doubt that the accused is completely guilty.

• criminal courts have three options for decisions,
- innocent
- guilty
- hung

• if found guilty, sentences are set. these are set with the following principles,
- rehabilitation of the individual
- protection of the public
- specific and general deterrents

• victims are allowed to influence sentencing with victim impact statements.

3.8.1 A Duty of Honesty

• dishonesty in business dealings can lead to criminal convictions for,
- fraud
- bribes (giving or taking)
- undisclosed conflict of interest
- gifts to government employees that you have business dealings with

• Other areas of interest are,
- the income tax act
- combines investigations act
- etc.

3.8.2 The Combines Investigations Act

• Generally this act tries to dissuade,
- monopolies
- misleading advertising - knowingly making any statements about a product that are not true or based on fact.
- bid rigging - different bidders must not work together to artificially raise the price, or cause bidders to drop out.
- price fixing
- conspiracy to limit competition - hoard resources, reduce production, or work together to reduce competition.
- etc.

• trade associations are permitted but must avoid any actions that would reduce competition in,
- prices
- quality
- quantity
- markets/customers
- distribution

3.9 REFERENCE

3.9.1 ENGINEERING ASSOCIATIONS

4. INTELLECTUAL PROPERTY

4.1 PATENTS

• Patents are basically a unique registration method that allows inventors to disclose, and freely discuss inventions, while protecting the time and effort they invested in development. They generally have 17 years to profit from the patent.

• A patent can only be given for something physically planned, or demonstratable. These inventions must also have novelty and skill.

• Patent rights may be assigned or transferred legally.

• Patents may be infringed, if this occurs the patent holder may sue for damages (typically lost profit)

• Generally patent developed by employees don't become the property of the employer. In some cases the employee is specifically paid to be creative. In these cases the employer will hold the patent rights.

4.2 TRADEMARKS

• Small symbols, names or designs (marks) that are used to distinguish one product from others. A registered trademark uses the symbol 'T.M.' or an 'R' in a circle. This prohibits the unauthorized use anyplace else in Canada.

• Trademarks must,
  - not be a name (except for deceased more than 30 years)
  - not easily confused with other words commonly used for that product
  - similar to already registered trademarks

• The trademark owner may permit others to use the trademark and these may also be officially registered.

• a trademark registration is valid for 15 years, but can be renewed indefinitely.

• infringement on a trademark can be dealt with by restraining orders, civil suits, or in criminal courts.

4.3 COPYRIGHT

• A copyright is used to restrict the right to copy or perform certain creative works.

• copyrights generally exist until 50 years after the authors death (in most cases)

• copyrights can be registered (optional) but if the copyright is to be assigned or licensed to another party, it should be registered.

• engineering plans can be copyrighted.

4.4 INDUSTRIAL DESIGN

• This is a protected design that is novel and original and generally refers to a sculpture, shape, configuration or pattern that is esthetic. The functional components cannot be considered.

• This can be registered for 5 years and then 5 more.

• This design can be assigned to others with written permission. This typically leads to licensing the design.

• An employer owns all rights to industrial designs.

• This design is formally registered.

4.5 TRADE SECRETS

• A similar device to patents except there is no public disclosure, and it may include information, or other non-patentable things. Generally a trade secret permits a business advantage over the competition (“industrial know-how”)

• If somebody is given a trade secret (and it is made clear that it is both valuable and confidential), then they expose the trade secret, they can be sued for damages.

• The legal factors to determine secrecy are,
    - similar knowledge outside the business
    - measures taken to guard the secret
    - the competitive value of the information
    - the development cost for the information

- Employers can restrain or sue former employees with regard to trade secrets. Although courts will be reluctant to prevent a former employee from earning a living.

- Corporations may also be liable for trade secrets if they are entrusted with them, and then disclose them.

4.6 REFERENCES

Ullman, D.G., The Mechanical Design Process, McGraw-Hill, 1997.

5. NEGLIGENCE & LIABILITY

• The basic concept of a tort is that the negligence of one or more individuals has lead to loss or damages of another. The court seeks to compensate those who suffer as a result. This is independent of any contracts that might exist.

• A tort-feasor is a defendant that has been found liable for losses.

• Comparitive negligence - parties will both be found partially liable (hence lawyers sue everybody they can find) and be assigned a percentage of responsibility.

• Jointly and severally liable - when negligence has been proven to cause damage it is often the result of more than one action, each party found negligent will be assigned responsibility and will be respectively responsible for a percentage of the compensation. If one of the parties is unable to pay a share, the other parties will be expected to cover the shortfall.

• The essential elements of a successful tort suit are,
  - a duty of care - “how would your neighbor expect you to act?”
  - breach of expectations
  - resulting damage

• A standard of care - “what would a reasonable person do?” - reasonable is an important concept in tort suits.

• Typical torts arise from,
  - negligence
  - negligent misconduct
  - assault
  - battery
  - nuisance
  - interference

• “cause of action” - somebody who can demonstrate a loss or damage. Somebody too remote will not be successful

• Damages can be,
  - pecuniary - special damages that can be demonstrated as having a certain value
  - non-pecuniary - general damages that are hard to quantify

• Thin Skull - this principle suggests that if you are vulnerable, such as a weak heart, or thin skull, this cannot be used as a defense against liability.

• Assumption of risk - in some cases some risks are inherent and obvious, and thus are consented to by any party willingly participating or entering. For example, somebody swimming in the ocean would assume some risk of being caught in currents.

• Volenti - assumption of risk

• An engineer is liable for services, and may be responsible for more than his fee.

• When a consumer buys a product there is a contractual obligation but if the product is used by another (not the buyer) the manufacturer owes the ultimate consumer a duty of care.

• Professionals can be liable for incorrect advice, designs or reports. Also important is that a fee does not have to be paid for a professional to be liable.

• Strict liability occurs when the plaintiff proves that there was a defect that existed when the product was sold and it lead to injury.

• In some cases strict liability may make an employer/manufacturer/etc. liable regardless of negligence.

• Vicarious liability - an employer is liable for the actions of employees.

• Employees can also be held liable in tort suits.

• More than one party can be found to be negligent and are thus called “concurrent tort-feasor”.

• Product liability is determined by the courts,
  - if damage results when the product is used normally, and the manufacturer could have reasonably foreseen the results.
  - there are some statutes that provide certain conditions and warranties for sold goods.
  - this area is a mixture of both tort and contract law.

• Typical questions the court will consider are,
  - What is the use or purpose of the product?
  - What alternatives are available for the production?
  - How likely and how severe is an injury?
  - How obvious is the hazard?
  - Is the danger of the product common knowledge?
  - How avoidable was the injury if used normally?
  - Could the hazard have been eliminated without eliminating functionality?
  - What was the state of the art?
  - How much would it cost to make the product safer?
  - Would consumers buy a safer product?

• Manufacturers are obliged to warn consumers when there are potentially dangerous uses of a product. This duty to warn is stricter than normal.

• In tort cases, economic losses (e.g. lost business) can be counted as damages. But, these tend to be limited economically and in delay.

• The categories of economic loss may change in the future.

• There are time limitations between when a cause of action occurs and when the suit can be started. If a suit is started after the limitation period it is called “statute barred”. This can be changed by a clause in a contract.

• The tort of defamation involves an untrue statement that damages a reputation. If it is written it is called libel, or if it is verbal it is called slander.

• Occupiers’ Liability - anybody occupying property is responsible for anybody coming onto the property. Guests and trespassers should be protected against dangers the occupier is aware of. Business guests generally receive a higher duty of care and the occupier is expected to safe-guard them against dangers that should be reasonably recognized.

• The Tort of Nuisance - an occupant should be able to enjoy their land without interference. In some cases this will result in a lawsuit.

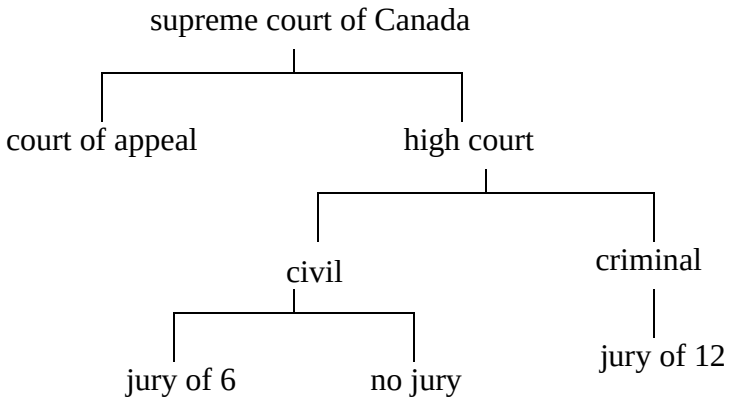
5.1 REFERENCES

Ullman, D.G., The Mechanical Design Process, McGraw-Hill, 1997.

5.2 LAW IN GENERAL

• The general rules of law in Canada are a combination of,
  - common law
  - statute law
  - negligence

• The court structure is given below,



• The Adversary System - a system of opposing legal parties.

• Lower courts are compelled to follow rulings made in higher courts.

• Statues are made by provincial and federal legislatures and override common law.

• criminal law is in the federal jurisdiction, and is not within the provincial jurisdiction - ultra vires

• The theory of precedent - a basis for legal decisions. When a decision has been made in a similar case before, that decision should be used again. In apparently similar cases there might be distinctions that cause a court to not follow precedents. Occasionally precedents are used from other provinces, england, or occasionally the USA.

• Common Law - “judge made law” - previous court decisions are used as legal principles.

• Legislation - legislation can override the common law.
  - this is law passed in an elected legislature
  - can be a new law or a former common law

- the court then determines how to interpret and apply the legislation

• Arbitration is an alternative to a court based lawsuit. This allows maters to be argued (either by choice or as dictated by contract). Engineers may be asked to act as arbitrator, effectively this process makes the arbitrator a judge in an ad-hoc court empowered by statutes (e.g., The Arbitrations Act of Ontario). It is possible that the result will be taken to a formal court. [Re Thomas Hackett]

5.3 BUSINESS LAW

• Three basic forms,
- sole proprietorship
- partnership
- corporations

• proprietorship
- owner and company are one entity in the courts.
- profits and losses are the owners

• partnerships
- all partners are considered personally responsible for the profits and loses of the partnership, except in the case of silent partners.
- a silent partner must have no control in the day to day operation of the business and is essentially a financier.
- Joint ventures are partnerships limited to a single project.
- partnerships should be registered (The Partnership Act of Ontario) before they act as legal entities.
- partnerships will dissolve when one of the partners dies or becomes bankrupt or insolvent.
- partnership agreements are needed to determine responsibilities (financial, management duties, work) provisions for adding or expelling partners, etc.
- corporations can also be partners.
- limited partnerships are registered partnerships (Limited Partnerships Act of Ontario) where one or more partners can limit their liability to their own contribution. They cannot be advertised as part of the firm, represent themselves as a general partner, partake in business decisions, etc.

• corporation/limited company (“a fictitious person”)
- federal or provincial corporations
- a corporation has the same legal status as an individual. This principle is called the “corporate veil” [Salomon v. Salomon & Co. Ltd.]. This may be lifted in some cases when fraud is involved [Fern Brand Waxes Ltd. vs. Pearl]
- this provides a tax shelter for shareholders

    - this also acts as a liability shield
- Other circumstances will also set aside the corporate veil, such as common control of multiple corporations [Nedco Ltd. v. Clark et. al.]
- a corporation exists as long as it complies with its governing statute, and no legal steps have been made to dissolve it.
- quite often banks will require personal guarantees from shareholders for any corporate loans (this sidesteps the liability shelter of corporations).
- the taxes paid for profits/dividends made by a corporation can be lower than those paid out by a sole proprietorship.
- engineers can form engineering corporations
- corporations can be formed by,
    - federal statutes
    - provincial statutes
    - by following provincial acts (eg, Canada Business Corporations Act or Business Corporations Act of Ontario)
- federal and provincial corporations can trade outside their jurisdiction
- federal corporations (unlike many others) are well suited to Canada wide business, but beyond certain financial levels they must file public annual financial statements.
- provincial corporations may requires licences to conduct business in other provinces.
- “objects” are the purposes of the business which a corporation may opt to define or limit. Some businesses, such as engineering corporations are limited by statute already. (eg, the primary control must rest with an engineer holding a certificate of authorization)
- a private corporation has a limited number of shareholders (<50) with controlled transfer and ownership of shares.
- a public corporation offers shares for sale publicly (often to generate investment capitol). The shareholders elect a board of directors. The board of directors appoint officers to manage day to day affairs.
- in private corporations, shareholders agreements are often used to set up ownership, control new shares, sale of shares, etc. Minority shareholders can be very vulnerable if not protected by a shareholders agreement.
- The directors standard of care is a legal measure of the principles required to maintain a corporation as a distinct entity.
    - directors must act honestly and in good faith while working toward the interests of the corporation
    - directors are liable for up to 6 months of wages for the corporation if actions begin within 6 months of termination if the corporation is sued because of the director, the corporation become bankrupt or goes into liquidation.
    - directors can also be fined or jailed (The Combines Investigations Act) if they fail to submit certain returns.
    - can be prosecuted and are liable under the Canada Income Tax Act
    - directors can be prosecuted if the corporation is not properly identified during business transactions.
    - directors can be prosecuted if false statements are made on corporate reports, returns, notices or other official corporation documents.
    - Directors in corporations are required to disclose all conflicts of interest that per-

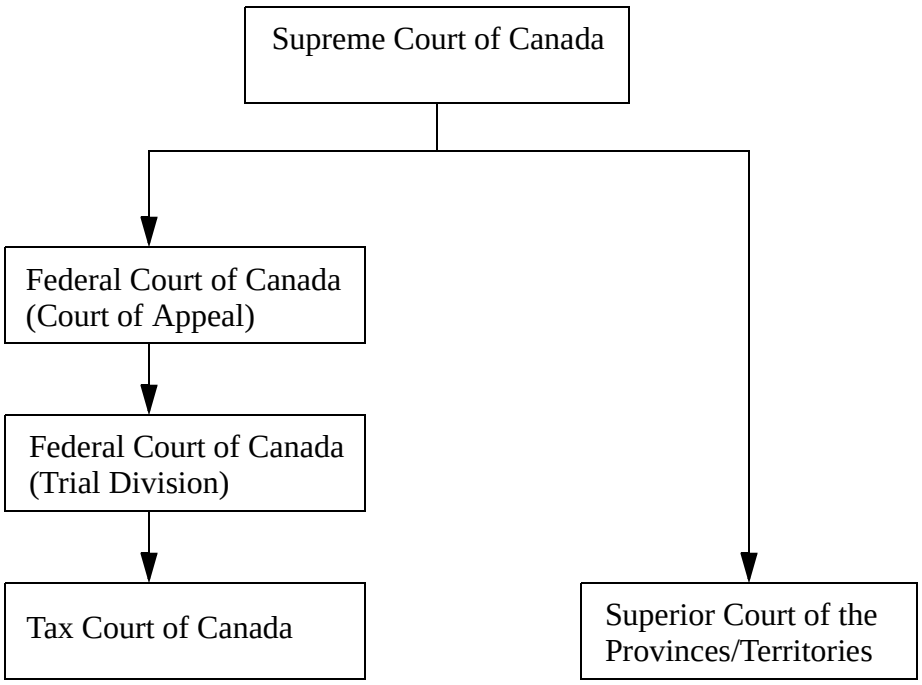
tain to any business in the company. Not doing so will make the directors liable for any profit or gain.

5.4 CIVIL LAW

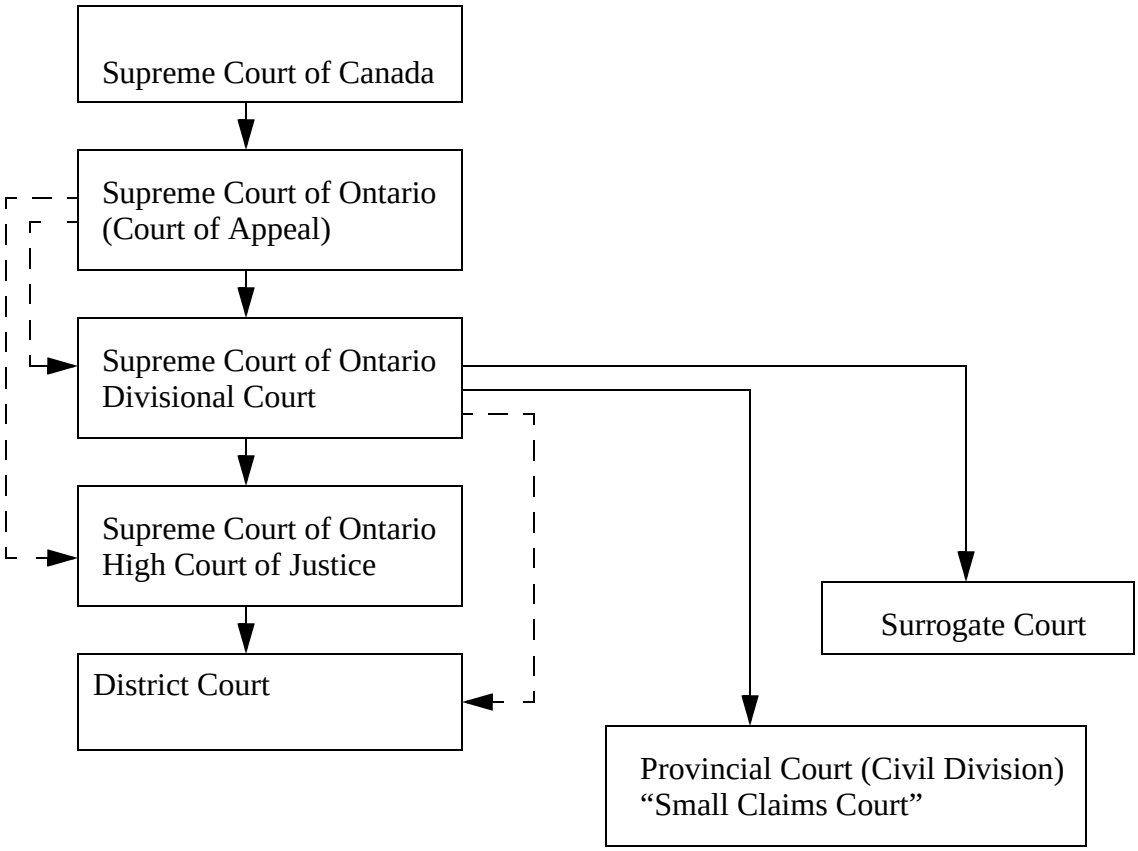
• In a civil trial the claims of wrong doing are made by the plaintiff, and are made against the defendant(s).

• Civil court decisions are based on an onus of proof, and a balance of probabilities.

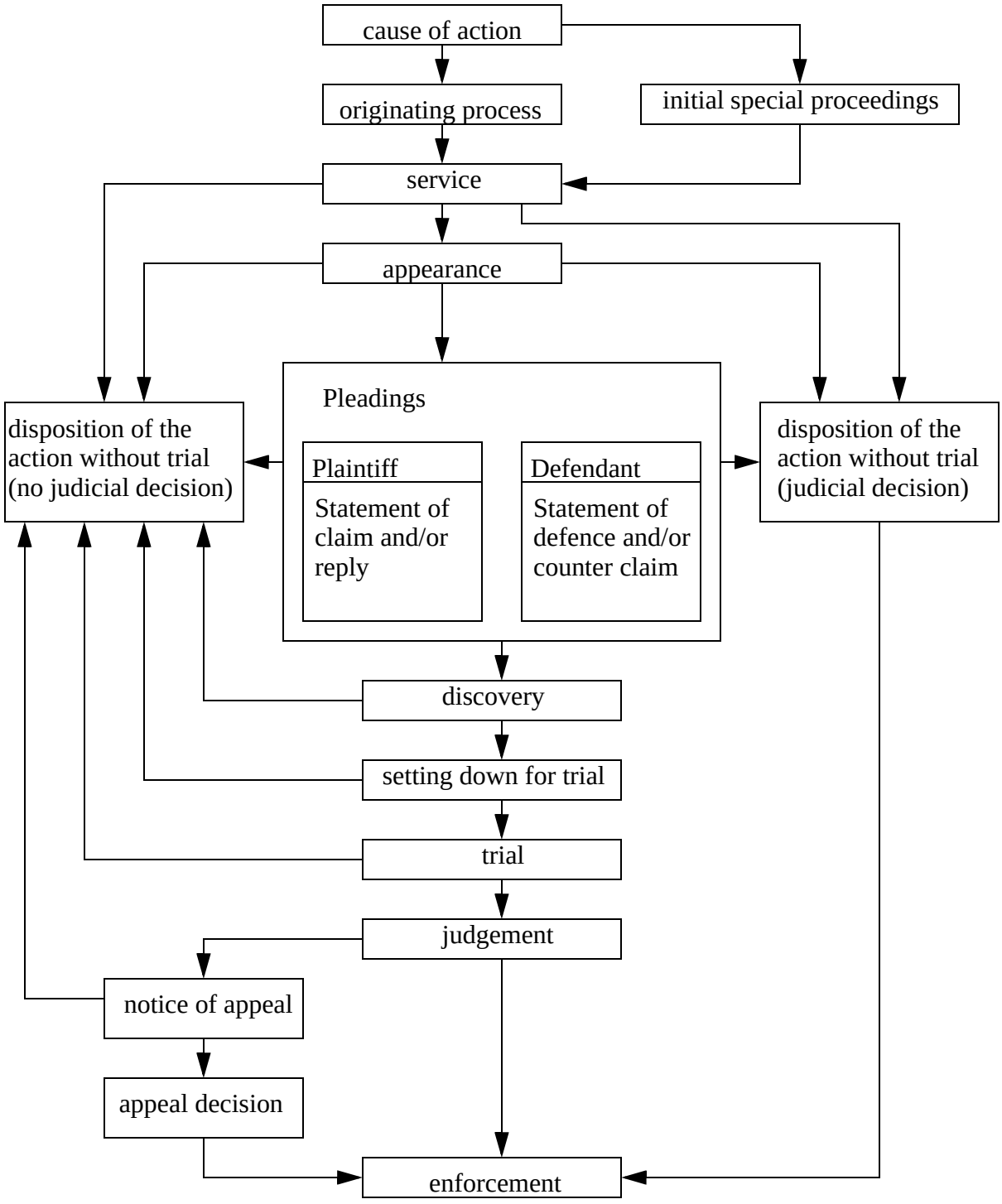
• The civil court structure for Canada is pictured below,



• The civil court structure for Ontario is pictured below,


Supreme Court of Canada
Supreme Court of Ontario (Court of Appeal)
Supreme Court of Ontario Divisional Court
Supreme Court of Ontario High Court of Justice
District Court
Surrogate Court
Provincial Court (Civil Division) "Small Claims Court"

• The basic sequence of events for civil cases is shown in the chart below,



5.4.1 CONTRACTS

• each contract must contain certain elements,
    - offer
    - acceptance
    - intent
    - consideration
    - capacity to contract
    - lawful purpose/legality

• Breech of contract
    - fraud
    - misrepresentation
    - duress
    - undue influence

• A contract goes through a number of phases. As a matter of habit, I will illustrate general possibilities with a flowchart. This chart is by no means complete, but can give a simple picture of the life of a contract.

• Assignment of rights - unless limited in a contract, other parties can be assigned benefits. For example the use of a “collection agency” is a common method of dealing with bad debts using a third party.

• an offer may expire if not accepted in a reasonable amount of time. Expiry dates for offers are often included.

• simple offers can be revoked at any time (before acceptance), but in some cases we might want “irrevocable offers”. This involves submitting the offers under seal, or in other word giving contract consideration.

• The “option contract” is another type of irrevocable contract. Something of value is exchanged to in effect make the “option contract” a full contract that can lead to another contract. This type of contract could be used in mining to allow some investigation of a mine before buying mining rights.

• Care should be taken to state which jurisdiction the contract is in. If this is not stated in the contract it will be determined to be where the offer was accepted. [The Queen et. al. v. Commercial Credit Corp. Ltd.]

• mutual intent - a contract should outline what both parties agree on in a contract.

• Letters of Intent - a common device to start business decisions, often a prelude to entering into contracts. These “agreements to agree” are not contracts, and are not legally enforceable. [Bahama Consult Ltd. v. Kellogg Salada Canada Ltd.]

• Consideration is an important part of a contract, in effect both parties must be giving and getting something of value (not necessarily money) to make it worthwhile to enter into the contract. The only case where consideration is not “something of value”, is when the contract is sealed (the seal is seen as something of value). Seals may be the mechanical imprint of a corporation, or a small adhesive label, as is used to make an irrevocable offer a binding contract.

• Gratuitous promise - a promise without consideration that generally wont be upheld by a court. An example is a verbal amendment to a written contract where there is no consideration. Note that this promise is moral not contractual.

• “promissory or equitable estoppel” - In some cases when a contract is amended without consideration (a gratuitous promise), but one party would be inequitably punished by the strict enforcement of the contract, then the amendment may be accepted as valid. [Conwest Exploration Co. Ltd. et. al. v. Letain] [John Burrows Ltd. v. Subsurface Surveys Ltd. et. al.] [Owen Sound Public Library Board v. Mial Developments Ltd. et. al.]

• Capacity to enter into contracts prevents those not capable of meeting the requirements from being held liable.

• Minors do not have the capacity to contract, but if they contract, they can enforce the contract, the other party cannot hold the minor liable (unless it was for a necessity). The age of majority is 18 in most provinces, except in Nova Scotia, New Brunswick, Newfoundland, and British Columbia.

• Drunks and lunatics (like minors) can enter into contracts for necessities, but for non-necessities the contract is unenforceable if the party was obviously incapacitated and repudiates the contract in reasonable time.

• Corporations may not have the capacity to contract. This contract may be outside the corporate charter, not approved by the appropriate official. [Royal British Bank v. Turquand]

• The purpose of a contract must not be illegal or contrary to statutes. Some examples of such contracts are,
    - contracts that attempt to avoid loss of property in bankruptcy by transferring ownership (within one year to a relative or three months to a creditor).
    - a contract provision to limit settlements already statute specified, such as The Workmans Compensation Act of Ontario
    - contrary to the Combines Investigation Act
    - contrary to a lien act
    - when some form of license is required (e.g., P.Eng.) but not held. [Kocotis v. D’Angelo] [Calax Construction Inc. v. Lepofsky] In some cases this will only void part of the contract [Monticchio v. Torcema Construction Ltd. et. al.]

• a contract that is against public/common law may also be voided. For example, non-competition clauses that could lead to monopoly type situations, or make an engineer unable to earn a liv-

ing might not be enforced.

• The statute of frauds has been developed to reduce problems resulting from fraudulent testimony. Generally, written contracts are required in certain circumstances such as,
    - any aspect of land ownership or interest
    - any agreement not to be fully enacted within one year
    - debt guarantees

• unenforceable contracts will still be recognized to prevent inequities. For example, if a verbal sales contract is made and one party disputes the contract, it might be unenforceable, but they could force the returns of goods, money, etc.

• Innocent misrepresentation involves a mistake that is not intentionally misleading, but results in another party entering into a contract. If the mislead party comes forward in time, the contract can be rescinded, and they can recover costs incurred. [Township of McKillop v. Pidgeon and Foley]

• Fraudulent misrepresentation is similar to innocent misrepresentation, except an intent to deceive is involved, and the plaintiff can sue for deceit as well. [Derry v. Peek]

• Mistakes in a contract can be overturned in rare cases.

• Rectification can be done for a “common mistake” where an agreement had been reached but inaccurately recorded. If a clerical error has been made in a contract then the court may rectify it. An example of this is a figure of ‘$100 million’ is accidently typed as ‘$100’.

• Contract may be interpreted by the court using dictionary terms, witness accounts of the intentions, etc.

• “parol evidence rule” - conditions that have been agreed upon verbally, but don’t appear in a written contract cannot be entered as evidence. i.e., if it is not written it does not exist in the eyes of the court. This will only be overlooked when it can be seen that the condition was essential for the contract to be effective. [Pym v. Campbell]

• Implied terms are terms that would obviously be expected to be in a contract, but have been overlooked. [The Moorcock] [Markland Associates Ltd. v. Lohnes] [Pigott Construction Co. Ltd. v. W.J. Crowe Ltd.] [G. Ford Homes Ltd. v. Draft Masonry (York) Co. Ltd.]

• Discharge by performance - describes the end of a contract by satisfaction of the provisions of the contract.

• Discharge by agreement - if both parties agree a contract can be terminated or amended.

• Discharge by express terms - These can be written terms to end a contract

• If a contract has been breached by one party, the other party may,

- sue for damages
- consider the contract discharged [Piggot Construction Co. Ltd. v. W.J. Crowe Ltd.]

• In breach there are,
conditions - essential components of a contract (discharges a contract)
warranties - a non-essential obligation in a contract (only sue for damages)

• Repudiation - an obvious indication by one party (verbal or otherwise) that they do not intend to follow the terms of the contract. The other party may ignore the breach, treat it as breached and sue, or (in a reasonable time) notify the other party that they agree to discharge the contract. NOTE: in some cases repudiation may be warranted.

• Remedies for breached contracts may include,
- quantum meruit - a reasonable measure of the value of work used when it was not stated in a contract or when determining damages. [Alkok v. Grymek]
- specific performance - an award where monetary rewards are not suitable (such as land transfer). This will not be given for anything requiring supervision, such as design work.
- injunction - a restraint to stop another party from an action. This will only apply to contract clauses that are also preventative in nature.

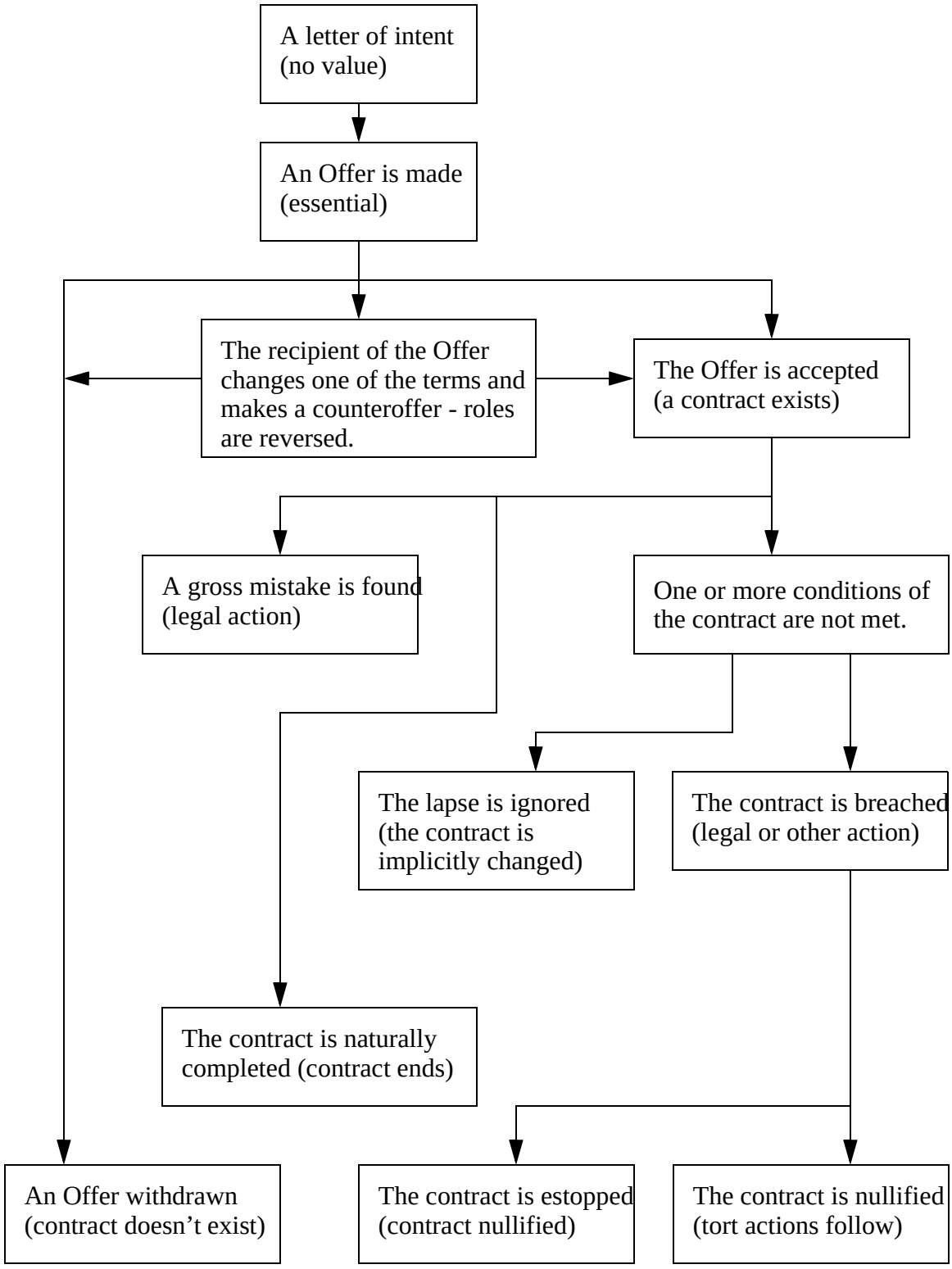
• The compensation for damages are determined by the court [Hadley v. Baxendale]

• Duty to Mitigate - when a party has been injured by a breach of contract they are obliged to minimize loses suffered. Failure to do this will reduce the damages awarded by the court.

• Penalty Clause - a clause that must be a contractual remedy that avoids a breach. If a condition of the contract is not met it can be used to recover damages. These damages must be a reasonable estimate of the incurred loss, or else the court will not uphold the term.

• Substantial compliance - when a contract has been fulfilled for the most part, except for some minor provisions of a contract, the court will award partial payment for work and services done. [Fairbanks Soap Co. Ltd. v. Sheppard]

• Fundamental Breach - when a contract contains an exemption clause (e.g., a maximum liability) and it has been fundamentally breached, then the limitation clauses no longer apply. [Harbutt's Plasticine Ltd. v. Wayne Tank and Pump Co. Ltd.] [Photo Production Ltd. v. Securicor Transport Ltd.] [Murray v. Sperry Rand Corporation et. al.] [Beaufort Realties (1964) Inc. and Belcourt Construction (Ottawa) Limited and Chomedey Aluminum Co. Ltd.]


A letter of intent (no value)
An Offer is made (essential)
The recipient of the Offer changes one of the terms and makes a counteroffer - roles are reversed.
The Offer is accepted (a contract exists)
A gross mistake is found (legal action)
One or more conditions of the contract are not met.
The lapse is ignored (the contract is implicitly changed)
The contract is breached (legal or other action)
The contract is naturally completed (contract ends)
An Offer withdrawn (contract doesn't exist)
The contract is estopped (contract nullified)
The contract is nullified (tort actions follow)

- Mailbox Doctrine - When making an offer the medium of communication is usually set by the communication used for the offer. For example, if an offer is mailed, by Mr. A to Mrs. B. The offer is made on the date that A put the letter in the mail. If B accepted the offer, and returned it by mail, then the offer was accepted as soon as it was put in the mail. In other words the contract came into existence when B put the response in the mail. In most other cases the acceptance is only valid when received.

- When an offer has been received, terms can be added or removed by the receiving party. As soon as the terms of the original offer have been modified the offer now becomes a counter offer. This is effectively a new offer, and must be approved by the original party.

- VOID - means that a contract never existed

- VOIDABLE - the contract has an option of being voided

- In a retail store a price tag is an “invitation to treat”, but it is not an offer.

- caveat emptor - buyer beware

- undue influence - when a dominance leading to coercion exists such as an emotional bond between two family members that is exerted to enter a contract.

- duress - unfair pressure or intimidation exerted to cause somebody to enter into an agreement can make the contract voidable [Mutual Finance Co. Ltd. v. John Wetton & Sons Ltd.]

- misrepresentation - this can be either innocent or fraudulent.

- unconscionable transaction -

- Unilateral Mistake - when an honest mistake is made and it is fundamental. If the recipient of the offer knows that there has been a mistake. The court could be persuaded to fix such mistakes. For example, if Mrs. A is buying a new car for $20,000 plus $500 shipping, but she notices that the contract is for $500, and signs eagerly knowing there was a mistake. Later the autodealer realizes a mistake was made and asks the court to correct the unilateral mistake. Some examples of successful and unsuccessful cases are, [Imperial Glass Ltd. v. Consolidated Supplies Ltd.] [Belle River Community Arena Inc. v. W.J.C. Kaufmann Co. et. al.] [Imperial Glass Ltd. v. Consolidates Supplies Ltd.] [Ron Engineering et. al. v. The Queen in right of Ontario et. al.] [Calgary v. Northern Construction Company Division of Morrison-Knudsen Company Inc. et. al.] The general principles are,
    - the source of the error was clerical
    - the errors were not obvious
    - the error was reported promptly
    - the error was honest and unintentional with good motives
    - the “contract” was an irrevocable offer not yet accepted
    - the intent was only to correct the offer, not withdraw it.

• Discharge by Frustration - problems arise that could not have been anticipated before the contract was signed. These can allow the contract to be voided. For example a contract to provide phone service to a new facility could be discharged if war caused the city to be destroyed. [Metropolitan Water Board v. Dick Kerr and Company Limited] [Davis Construction Ltd. v. Fareham Urban District Council] [Swanson Construction Company Ltd. v. Government of Manitoba; Dominion Structural Steel Ltd., Third Party]

5.4.1.1 - Engineering Contracts

• Engineers are often employed as agents, empowered to specific duties.

• Engineers that fail to specify payments in contracts will be awarded quantum meruit in court.

• When estimating costs in contracts the court may hold an engineer to a poor estimate. [Kidd v. Mississauga Hydro-Electric Commission et. al.]

• There are a number of forms available that are a suitable basis for engineering contracts. These can be found in many engineering associations.

• liability is normally limited in engineering contracts, this should be less than the liability insurance.

• Engineers are expected to understand common law principles, as well as applicable laws for the industry of practice.

• One example is the Hazardous Products Act.

• Engineers are also expected to follow codes, standards and other applicable guides.

5.4.1.2 - Tort Liability and Contract Liability - Concurrently

• We can consider the benefits of being sued for a contract, consider the case of a damage arising from a contract that is covered by a limitation period.

• Normally a contractual obligation negates a tort [Schewebel v. Telekes] but it is possible for an engineer to be held liable for damages in both contract and tort law [Halvarson Inc. v. Robert McLellan & Co. et. al.] [Dominion Chain Co. Ltd. v. Eastern Construction Co. Ltd. et. al.] [City of Kamloops vs. Nielsen et. al.] Other cases go against this trend. [Sealand of the Pacific Ltd. v. R.C. McHaffie Ltd. et. al.]

• A tort can generally be brought when it is outside of the duties described in the contract. [J.

Nunes Diamonds Ltd. v. Electric Protection Co.]

5.4.1.3 - Construction Contracts

• It is typical for an engineer and a contractor to have separate contracts with the owner. These duties expected of an engineer may be,
  - preparation of payment certificates
  - certificates of work completion
  - reschedule when delays occur
  - advising the owner when the contractors performance affects the contract terms
  - sets values for changes in the contract (i.e., the extras)
  - act in cases of emergency
  - inspecting soil conditions
  - inspecting work (and rejecting it if inadequate)

• When hired as an agent/representative, an engineer must remain impartial and independent (there is a small conflict here) from the owner. [Brennan Paving Co. Ltd. v. Oshawa] [Kamlee Construction Ltd. v. Town of Oakville] [Croft Construction Co. v. Terminal Construction Company] [Sutcliffe v. Thackerah et. al.]. If this is not done, actions may not hold up in court. [Grant Smith & Co. v. The King]

• Engineers (unless specifically excluded) are expected to inspect all major portions of construction. [Dabrous v. Zuliani et. al.]

• An engineer should not direct (supervise) work methods of contractors unless specifically contracted to do so, or obvious problems exist. [Demers et. al. v. Dufresne Engineering et. al.]

• An engineer working on a construction project should try to adhere to the contract, and keep a detailed journal of events, meetings, decisions, etc. These can be used later in court.

• Detailed drawings and specifications are needed to minimize misunderstanding. Improperly prepared drawings and specifications could lead to liability. [Trident Construction Ltd. v. W.L. Wardrop and Accoc. et. al.]

• The tendering process often involves “irrevocable offers” that are submitted. When one of these offers is accepted a contract typically exists between the successful bidder and the owner. Bid bonds are another way to ensure that a binding contract exists for the tendered bid. Note: this process should be directed by a lawyer.

• Typical categories of construction contracts are,
  - Stipulated-Price/Lump-Sum Contract - the basic bid amount will be paid on completion of the basic work. Additional work may be done, but this is at additional cost. This type of contract can be risky for the contractor (financial) and the owner (quality)

if problems arise.

- Unit-Price Contract - in cases where the nature of work may change after starting the bids can be per unit of work (e.g., per cubic meter of soil).
- Cost Plus Percentage - When it is not possible to estimate the cost of construction before (e.g., rushing to start a high-rise) the contractor can be paid the expenditures plus some percentage. This contract does not encourage cost reduction.
- Cost Plus Lump-Sum Fee - The same as Cost Plus Percentage except there is no incentive to spend more.
- Cost Plus Lump-Sum Fee Plus Bonus - Like the Cost Plus Lump-Sum Fee except that a bonus is offered for savings below an estimated price. This encourages reduced spending.
- Guaranteed Maximum Price Plus Bonus - This is like a Cost Plus Lump-Sum Fee Plus Bonus Contract, except a guaranteed maximum cost is used instead of an estimated price.
- Design Build - a contractor will likely work on a cost plus bonus, and will supply the engineering services. This allows projects to proceed quickly, as there are no delays waiting for plans and specifications. In this contract the engineer typically has a contract with the contractor, not the owner. Project managers are often hired by the owner to manage the projects on their behalf for a fee.

• It should be kept in mind that the contract between the owner and contractor should be consistent with the contracts between the contractor and subcontractor.

• Delay and interference can cause suits and should be handled carefully.

• Bonds are commonly used to ensure/secure bids, performance and labor and material payments. Here a third party bond agency indemnifies payment. If some contractual obligation is missed, the bond agency will pay, and pursue the party it has indemnified.

• A letter of credit is often used in place of a bond. It is effectively a “blank cheque” for the holder.

5.4.1.4 - Liens

• A construction lien directs an owner to hold back a percentage of the total cost for a period after completion (in Ontario it is 10% for 45 days). In this time anybody that is owed money for work, or materials on a property can place a lien on the property and prevent its sale. The holdback is used to pay them (even no there is no privity of contract between them).

• If an owner does not follow the lien act, for example not keeping a holdback, the owner may then become liable for the subcontractors losses.

• Before any holdback is released, or property is sold the local registry office must be checked for

registered liens.

• lien rights cannot be waived in contracts.

• Trust funds can also be set up for fixed sum payments. These cannot be used until the subject of the trust has been paid.

• Engineers can also make lien claims [Application of Erickson/Massey] [Englewood Plumbing & Gas Fitting Ltd. v. Northgate Development Ltd. et. al.] [Armbro Materials and Construction Ltd. v. 230056 Investments Limited et. al.]

5.4.2 EMPLOYMENT

• Basically defined by the Employment Standards Act,
  - Wage means compensation is calculated per hour
  - Salary means compensation is calculated per week/month

• There are two basic types of employee status,
  - independent contractor - can be terminated anytime as in contract
  - employee - requires notice, or compensation in lieu

• If employment ends there are four possible categories,
  - quits - no notice/compensation required
  - lawful dismissal - a notice is required, or compensation to cover the notice period
  - wrongful dismissal - an employee is terminated for unjust reasons or without adequate notice. compensation or reinstatement may be sought in civil law.
  - instructive dismissal - an employee is told to quit, or else be dismissed. compensation or reinstatement may be sought in civil law.

• When dismissing an employee a minimum of two weeks notice is required. Generally, if the employee has worked for more than 4 months, then 1 months notice are required for each year worked.

• Severance pay - Some employers will ask an employee to leave immediately, and not give notice. They are obliged to pay them the wages that they would have normally earned while working on notice.

• Reasons for wrongful dismissal include,
  - drunk every day
  - insubordination
  - theft
  - tardiness
  - incompetence

- sexual harassment
- willful destruction
- conflict of interest
- espionage
- loss of assignment

5.5 CRIMINAL LAW

• In criminal cases there are claims of violations of the criminal code that the Accused is answering. The Crown is responsible for seeking guilty verdicts.

• The crown must prove beyond a reasonable doubt that the accused is completely guilty.

• criminal courts have three options for decisions,
- innocent
- guilty
- hung

• if found guilty, sentences are set. these are set with the following principles,
- rehabilitation of the individual
- protection of the public
- specific and general deterrents

• victims are allowed to influence sentencing with victim impact statements.

5.5.1 A Duty of Honesty

• dishonesty in business dealings can lead to criminal convictions for,
- fraud
- bribes (giving or taking)
- undisclosed conflict of interest
- gifts to government employees that you have business dealings with

• Other areas of interest are,
- the income tax act
- combines investigations act
- etc.

5.5.2 The Combines Investigations Act

• Generally this act tries to dissuade,
- monopolies
- misleading advertising - knowingly making any statements about a product that are not true or based on fact.
- bid rigging - different bidders must not work together to artificially raise the price, or cause bidders to drop out.
- price fixing
- conspiracy to limit competition - hoard resources, reduce production, or work together to reduce competition.
- etc.

• trade associations are permitted but must avoid any actions that would reduce competition in,
- prices
- quality
- quantity
- markets/customers
- distribution

5.6 REFERENCE

5.6.1 ENGINEERING ASSOCIATIONS

5.6.2 Intellectual Property

5.6.2.1 - Patents

• Patents are basically a unique registration method that allows inventors to disclose, and freely discuss inventions, while protecting the time and effort they invested in development. They generally have 17 years to profit from the patent.

• A patent can only be given for something physically planned, or demonstratable. [Permutit Co. v. Borrowman] These inventions must also have novelty and skill [General Electric Company, Limited v. Fada Radio, Limited]

• Patent rights may be assigned or transferred legally.

• Patents may be infringed, if this occurs the patent holder may sue for damages (typically lost profit)

• Generally patent developed by employees don't become the property of the employer. [Willard's Chocolates Ltd. v. Bardsley] In some cases the employee is specifically paid to be creative. In these cases the employer will hold the patent rights. [British Reinforced Concrete Engineering Co. Limited v. Lind]

5.6.2.2 - Trademarks

• Small symbols, names or designs (marks) that are used to distinguish one product from others. A registered trademark uses the symbol 'T.M.' or an 'R' in a circle. This prohibits the unauthorized use anyplace else in Canada.

• Trademarks must,
  - not be a name (except for deceased more than 30 years)
  - not easily confused with other words commonly used for that product
  - similar to already registered trademarks

• The trademark owner may permit others to use the trademark and these may also be officially registered.

• a trademark registration is valid for 15 years, but can be renewed indefinitely.

• infringement on a trademark can be dealt with by restraining orders, civil suits, or in criminal courts.

5.6.2.3 - Copyright

• A copyright is used to restrict the right to copy or perform certain creative works.

• copyrights generally exist until 50 years after the authors death (in most cases)

• copyrights can be registered (optional) but if the copyright is to be assigned or licensed to another party, it should be registered.

• engineering plans can be copyrighted.

5.6.2.4 - Industrial Designs

• This is a protected design that is novel and original and generally refers to a sculpture, shape, configuration or pattern that is esthetic. The functional components cannot be considered.

• This can be registered for 5 years and then 5 more.

• This design can be assigned to others with written permission. This typically leads to licensing the design.

• An employer owns all rights to industrial designs.

• This design is formally registered.

5.6.2.5 - Trade Secrets

• A similar device to patents except there is no public disclosure, and it may include information, or other non-patentable things. Generally a trade secret permits a business advantage over the competition (“industrial know-how”)

• If somebody is given a trade secret (and it is made clear that it is both valuable and confidential), then they expose the trade secret, they can be sued for damages.

• The legal factors to determine secrecy are,
    - similar knowledge outside the business
    - measures taken to guard the secret
    - the competitive value of the information

- the development cost for the information

• Employers can restrain or sue former employees with regard to trade secrets. [Amber Size & Chemical Co. Ltd. v. Menzel] Although courts will be reluctant to prevent a former employee from earning a living.

• Corporations may also be liable for trade secrets if they are entrusted with them, and then disclose them.

5.6.3 TORT/NEGLIGENCE

• The basic concept of a tort is that the negligence of one or more individuals has lead to loss or damages of another. The court seeks to compensate those who suffer as a result. This is independent of any contracts that might exist.

• A tort-feasor is a defendant that has been found liable for losses.

• Jointly and severally liable - when negligence has been proven to cause damage it is often the result of more than one action, each party found negligent will be assigned responsibility and will be respectively responsible for a percentage of the compensation. If one of the parties is unable to pay a share, the other parties will be expected to cover the shortfall.

• The essential elements of a successful tort suit are,
- a duty of care - “how would your neighbor expect you to act?”
- breach of expectations
- resulting damage

• a standard of care - “what would a reasonable person do?” - reasonable is an important concept in tort suits.

• Typical torts arise from,
- negligence
- negligent misconduct
- assault
- battery
- nuisance
- interference

• “cause of action” - somebody who can demonstrate a loss or damage. Somebody too remote will not be successful

• damages can be,
- pecuniary - special damages that can be demonstrated as having a certain value
- non-pecuniary - general damages that are hard to quantify

• Thin Skull - this principle suggests that if you are vulnerable, such as a weak heart, or thin skull, this cannot be used as a defense against liability.

• assumption of risk - in some cases some risks are inherent and obvious, and thus are consented to by any party willingly participating or entering. For example, somebody swimming in the ocean would assume some risk of being caught in currents.

• volenti - assumption of risk

• an engineer is liable for services, and may be responsible for more than his fee [Dominion Chain Co. Ltd. v. Eastern Construction Co. Ltd. et. al.]

• When a consumer buys a product there is a contractual obligation but if the product is used by another (not the buyer) the manufacturer owes the ultimate consumer a duty of care. [Donaghue v. Stevenson]

• Professionals can be liable for incorrect advice [Hedley Byrne & Co. Ltd. v. Heller & Partners Ltd.], designs [Trident Construction Ltd. v. W.L. Wardrop and Assoc. et. al.] or reports [Brown & Huston Ltd. v. The Corporation of the City of York et. al.]. Also important is that a fee does not have to be paid for a professional to be liable. [Unit Farm Concrete Products Ltd. v. Eckerlea Acres Ltd. et. al.; Canama Contracting Ltd. v. Huffman et. al.]

• in some cases strict liability may make an employer/manufacturer/etc. liable regardless of negligence.

• vicarious liability - an employer is liable for the actions of employees. [Dutton v. Bognor Regis United Building Co. Ltd.]

• employees can also be held liable in tort suits. [Northwestern Mutual Insurance Co. vs. J.T. O'Bryan & Co.]

• More than one party can be found to be negligent and are thus called "concurrent tort-feasor". [Corporation of District of Surrey v. Carrol-Hatch et. al.]

• product liability is determined by the courts,
  - if damage results when the product is used normally, and the manufacturer could have reasonably foreseen the results.
  - there are some statutes (e.g., The Sale of Goods Act in Ontario) that provide certain conditions and warranties for sold goods.
  - this area is a mixture of both tort and contract law [Donaghue v. Stevenson]

• Manufacturers are obliged to warn consumers when there are potentially dangerous uses of a product. [George Ho Lem v. Barotto Sports Ltd., and Ponsness-Warren Inc.]. This duty to warn is stricter than normal. [Lambert v. Lastoplex Chemicals Co. Limited et. al.]

• In tort cases, economic losses (e.g. lost business) can be counted as damages. [Rivtow Marine Ltd. v. Washington Iron Works et. al.] But, these tend to be limited economically [MacMillan Bloedel Ltd. v. Foundation Co.] and in delay. [Bethlehem Steel Corporation v. St. Lawrence Seaway Authority]

• The categories of economic loss may change in the future [Junior Books Ltd. v. Veitchi Co. Ltd.]

• There are time limitations between when a cause of action occurs and when the suit can be started (6 years in Ontario, 20 years if the contract is signed with a seal). If a suit is started after

the limitation period it is called “statute barred”. This can be changed by a clause in a contract.

- There are also other limitation periods possible. For example, the Engineers Act of Ontario limits lawsuits to 12 months after the date the engineering work was done (or should have been). But the court may extend this in some situations. [Attorney-General of Canada v. Libling et. al.]. Note that this is different from general negligence where the limitation period is measured from the “cause of action” (e.g., when the house fell down, not when it was built). [Sparham Souter et. al. v. Town & Country Developments (Essex) Ltd. et. al.] Although the courts are still dealing with the ramifications of Sparham-Souter. [Robert Simpson Co. Ltd. v. Foundation Co.] [Viscount Machine and Tool Ltd. vs. Clarke] [Pirelli General Cable Works Ltd. vs. Oscar Faber and Partners] [City of Kamloops vs. Nielsen et. al.]

- The tort of defamation involves an untrue statement that damages a reputation. If it is written it is called libel, or if it is verbal it is called slander.

- Occupiers’ Liability - anybody occupying property is responsible for anybody coming onto the property. Guests and trespassers should be protected against dangers the occupier is aware of. Business guests generally receive a higher duty of care and the occupier is expected to safeguard them against dangers that should be reasonably recognized.

- The Tort of Nuisance - an occupant should be able to enjoy their land without interference. In some cases this will result in a lawsuit. [Newman et. al. v. Conair Aviation Ltd. et. al.] [Jackson et. al. v. Drury Construction Co. Ltd.]

5.7 CANADIAN CASES

5.7.1 Alkok v. Grymek

Location: Canada
Court:
Year: 1968
Importance: a quantum meruit award for damages
Details:

- A construction contract was formed and it was agreed that certain payments would be made at various dates in the project, as an architect certified work, and that sub-contractors had been paid.
- Some of the subcontractors had not been paid, there were defects, and the work was delayed.
- As a result the owner terminated the contract, and hired replacement contractors.
- In the resulting lawsuit the court found that the contractor had not violated the essential terms of the contract. This did not warrant a discharge, and the contractor received an award for work done (quantum meruit).

5.7.2 Amber Size & Chemical Co. Ltd. v. Menzel

Location: ?
Court:
Year: ?
Importance: sets principle for trade secret protection
Details:

- In a ruling the court stated - ex-employees should not divulge secrets given in confidence (this may only be implied), or take advantage financially.
- The four test questions were,
  - was there some secret process known and used.
  - did the employee know that it was a secret.
  - did the employee know the secret.
  - has the knowledge been misused since leaving the company.

5.7.3 Application of Erickson/Massey

Location: British Columbia
Court:
Year: 1971
Importance: an example of a lien for design-supervise services.
Details:

- An architect had prepared plans.
- He had applied to a court for a lien. This was refused.
- He then supervised the construction of the building.
- In appeal the lien was granted.

5.7.4 Armbro Materials and Construction Ltd. v. 230056 Investments Limited et. al.

Location: Ontario
Court:
Year: 1975
Importance: an example where a lien was allowed for an engineer.
Details:

- An engineer had prepared plans for subdivision roads, sewers, and water mains, with the condition that the plans had to be approved by local officials. The contract also called for supervision.
- The plans were approved, but financial constraints halted the project.
- The engineer applied for a lien.
- The court granted the lien saying that the plans were tied to the land, and constituted an improvement. This was differentiated from architects plans that are somewhat independent of the land.

5.7.5 Attorney-General of Canada v. Libling et. al.

Location: Ontario
Court:
Year: 1980
Importance: the limitation period for starting an action was challenged
Details:

- There were roof design problems.
- Attempts had been made to correct problems with the roof.
- The engineer that had designed the part of the roof in question had not been contacted about the problem for 11 years, and no longer had his records.
- The court heard all of the details but decided not to extend deadline.

5.7.6 Bahamaconsult Ltd. v. Kellogg Salada Canada Ltd.

Location: Ontario
Court:
Year: 1976
Importance: an example of a letter of intent

Details:

- A letter of intent about stock shares was issued.
- This letter discussed a sale of shares, and indicated that transfer of the shares, and finalizing of the sale were all that was left.
- Disagreement resulted in the sale not going through.
- In a lower court this letter of intent was upheld as a contract, but a higher appeal overturned the decision and ruled that certain elements were missing.

5.7.7 Beaufort Realties (1964) Inc. and Belcourt Construction (Ottawa) Limited and Chomeday Aluminum Co. Ltd.

Location: Canada
Court:
Year: 1980
Importance: another example of a fundamental breach
Details:

- A contractor had failed to pay a subcontractor.
- In court the contract was shown to have a clause that waived the subcontractors right to apply a lien.
- The court ruled that the failure to pay was a fundamental breach, and that the subcontractor would not be held to the lien waver.
- This was upheld in the supreme court.

5.7.8 Belle River Community Arena Inc. v. W.J.C. Kaufmann Co. et. al.

Location: Ontario
Court:
Year: 1977
Importance: a unilateral mistake was upheld
Details:

- The contractor had prepared a bid and incorrectly transferred a figure lowering the bid by $70,000 to $641,603.
- The irrevocable bid was submitted under seal.
- Upon discovering the mistake there was an attempt to withdraw the bid. Both sides acknowledged there was an error, but he was not allowed to withdraw the bid.
- When the plaintiff who had asked for the bids found out about the mistake, he attempted to accept the bid.
- When unable to accept the bid, another subcontractor was contracted and the original contractor sued for the difference in bids.
- The court rejected the suit saying that the motives of the plaintiff were less than honorable. And, the plaintiff had not formally accepted the contractors bid by returning it.
- The court also pointed out that trying to profit by the mistake of another was a key ele-

ment in the decision.

5.7.9 Bethlehem Steel Corporation v. St. Lawrence Seaway Authority

Location: Canada
Court:
Year: 1977
Importance: economic losses can only be claimed if some physical damage has occurred
Details:

- A ship ran into a bridge over a canal. The bridge was destroyed and the canal was obstructed for several days.
- In a lawsuit the ship owner was found negligent, and paid damages to the court.
- Two claims for damages were rejected. One being a request for lost profits for a ship. Another being the cost of shipping product across land to Toronto for subsequent shipping. Both were rejected because they were purely economic losses.

5.7.10 Brennan Paving Co. Ltd. v. Oshawa

Location: Ontario
Court:
Year: 1953
Importance: an example of an engineer given the power to certify
Details:

- An engineer was contracted for a construction project. One of the duties was to certify payment certificates.
- The court concluded that the certificates are valid if the engineer has acted in an independent and judicial manner.

5.7.11 British Reinforced Concrete Engineering Co. Limited v. Lind

Location: England
Court:
Year: ?
Importance: the company owns the patent when it is within the scope of the employees work
Details:

- The court ruled that the employer owned a design because the draughtsman was instructed to do the design.

5.7.12 Brown & Huston Ltd. v. The Corporation of the City ofYork et. al.

Location: Ontario
Court:
Year: 1983
Importance: engineers may be liable for negligence in report preparation
Details:

- Consulting engineers had been hired to prepared a soils and ground-water-level report, but had neglected to include some important information.
- A contractor was then hired to construct an underground pumping station. The contractor was required by the contract to personally examine the site for conditions to be encountered during construction.
- Based on the incomplete report, the contractor did not expect a water problem, and underbid on the job.
- The court determined that the contractor was 25% negligent in not requesting the missing information.
- The engineers were found 75% liable for their negligence.

5.7.13 Calax Construction Inc. v. Lepofsky

Location: Ontario
Court:
Year: 1974
Importance: an example of the legal capacity to contract based on licenses
Details:

- An unlicensed building contractor was unable to enforce a contract because without the license they did not have the legal capacity to enter into the contract.

5.7.14 Calgary v. Northern Construction Company Division of Morrison-Knudsen Company Inc. et. al.

Location: Alberta
Court:
Year: 1982
Importance: a case that was not allowed a dismissal for unilateral mistake
Details:

- A clerical error on a bid of $9,342,000 left out $181,000
- The next highest bid was $9,737,000
- When the bid was accepted, the contractor refused to carry out the work.
- The next highest bid was accepted and the first contractor sued.
- The court chose not to apply the unilateral mistake principle because the contract had been accepted and there was no deposit forfeit escape clause.

5.7.15 City of Kamloops v. Nielsen et. al.

Location: Canada
Court:
Year: 1984
Importance: the supreme court upheld [Sparham Souter] and rejected [Pirelli]
Details:

- Houses were being built with improper foundations
- The building inspector noticed the deficient foundations and issued a stop work order. This order was ignored and the building inspector did not enforce it.
- A plumbing permit was issued 8 months later.
- 2 years after the stop work order had been issued the house was finished and sold (an occupancy permit was never issued).
- The new owner discovered that the foundation had subsided, and sued.
- It was found that the city was 25% liable and the builder 75% liable for damages (costs involved with repair of the house, etc.).
- Part of this case involved the limitation date. The court upheld the [Sparham Souter] case and rejected Pirelli.

5.7.16 Conwest Exploration Co. Ltd. et. al. v. Letain

Location: Canada
Court:
Year: 1963
Importance: the application of equitable estoppel to allow a gratuitous promise.
Details:

- A time limited option contract was used to allow exploration before mining claims were Pursued.
- The contract stated that certain actions were required by a certain date to acquire mining claims.
- It became obvious that the tests would not be complete by the expiry date, and the owner implied that an extension would be allowed. (In effect this was a gratuitous promise).
- Later the owner held to the strict wording of the contract and enforced the expiry date as written.
- The supreme court agreed that enforcing the original contract strictly would be inequitable, therefore the contract was “estopped”, effectively allowing the extension, even though there was no consideration.

5.7.17 Corporation of District of Surrey v. Carrol-Hatch et. al.

Location: British Columbia
Court:
Year: 1979
Importance: an example of concurrent tort-feasor
Details:

- An architect had been hired to design a new police station.
- The architect hired an engineering firm to do the structural design.
- The engineers dug two shallow test pits and recommended deep soils tests to the architects. The architect rejected the recommendation and the engineers submitted a soils report to the owner based on the shallow test pits.
- The building was built, and eventually it settled causing damage.
- The architect was found 60% liable, and the engineer 40% because they had failed to inform the owner that more soils tests were required.

5.7.18 Croft Construction Co. v. Terminal Construction Company

Location: Ontario
Court:
Year: 1959
Importance: an engineers power to certify binding amounts, even with mistakes
Details:

- A construction contract stated that an engineer would calculate the values of payments to the contractor.
- The court ruled that the engineers figures would stand (even with mistakes) as long as there was no fraud or bad faith on the engineers part.

5.7.19 Dabous v. Zuliani et. al.

Location: Ontario
Court:
Year: 1976
Importance: negligence in inspection can lead to liability
Details:

- An architect contracted to design then supervise the construction of a house.
- During the construction a metal chimney was placed too close to wooden joints.
- The architect noticed the metal chimney problem, and ordered the problem corrected.
- A second similar chimney was installed and covered over before inspection. The architect did not ask to have the chimney exposed for inspection.
- After occupation the metal chimney caused the wood to catch fire, and caused damage.
- In court the architect was held liable because of a duty of care to inspect.

5.7.20 Davis Contractors Ltd. v. Fareham Urban District Council

Location: England
Court:
Year: 1956
Importance: a failed bid for discharge by frustration
Details:

- A construction contract was made to build 78 houses over 8 months.
- After 56 houses were built the contractor determined that the labor shortage was great enough to prevent completion.
- In the resulting suit against the contractor the court ruled that although the contractor overlooked the labor shortage and as a result is in an unfortunate situation, but of his own making. Therefore it refused to discharge the contract on the grounds of frustration.

5.7.21 Demers et. al. v. Dufresne Engineering et. al.

Location: Canada
Court:
Year: 1977
Importance: an engineer has a duty to direct contractors when obvious problems exist
Details:

- A contractor built a caisson (?) for a bridge pier, but did not use enough reinforcing steel.
- An engineer was able to see the construction method, but did not comment. His representative did add a small amount of vertical reinforcement.
- After completion the caisson failed and had to be replaced at a cost of $1.4 million.
- In the resulting court case the engineer was assumed to have approved the method by remaining silent. There was also implied consent because of the reinforcement added.
- The engineer was found 50% liable because of the implied approval.

5.7.22 Derry & Peek

Location: England
Court:
Year: ?
Importance: contract was rescinded because of fraudulent misrepresentation
Details:

- Fraudulent misrepresentation is defined as, made “(1) knowingly, or (2) without belief in its truth, or (3) recklessly, careless whether it be true or false.”

5.7.23 Dominion Chain Co. Ltd. v. Eastern Construction Co. Ltd. et. al.

Location: Ontario
Court:
Year: 1974, 1976
Importance: makes an engineer liable for negligence without a limit, also an example of joint and several liability
Details:

- Dominion Chain entered into contracts with an engineer and a contractor to construct a factory.
- Years after construction the improperly constructed roof began leaking.
- The owner sued, but the judge found the contractor was exempted by a clause in the contractors contract.
- The judges ruling included statements that,
  - an engineer is "responsible if he does or omits to do his professional undertakings with an ordinary and reasonable degree of care and skill," (Marston, pg.29)
  - an engineer "ought not to undertake the work if it cannot succeed, and he should know whether it will or not." (Marston, pg.29)
  - liability is "not limited to the amount of remuneration which under the agreement the architect or engineer was to receive, but are measured by the actual loss occasioned..." (Marston, pg.30)
- In the ruling the judge ruled that the fault for the damages were 25% the engineer and 75% the contractor (not liable). But, because the engineer was the only one left in the suit that he would be responsible for 100% of the damages.
- A court of appeal released the contractor because they were not joint tort-feasors. But, the court of appeal did state they could be liable in tort and contract.
- The supreme court also relieved the contractor of responsibility, based on contractual obligations alone.

5.7.24 Donoghue v. Stevenson

Location: England
Court:
Year: 1932
Importance: makes a manufacturer responsible to the eventual consumer of the product
Details:

- a bottle of ginger beer containing a decomposed snail was consumed, leading to an illness. This bottle of ginger beer was not purchased by the consumer, but was given to him by a friend. He Sued.
- The court rules that even though there was not privity of contract between the plaintiff and the defendant, a duty of care was owed to the plaintiff.

5.7.25 Dutton v. Bognor United Building Co. Ltd.

Location: England
Court:
Year: 1972
Importance: established the responsibility of employers for employee actions - vicarious liability
Details:

- A contractor built a foundation for a house. The foundation was on top of a rubbish deposit, and should have been deeper.
- As required by local by-laws, a building inspector was to approve the construction after appropriate inspection. The inspector did not object to the improper foundation.
- After the house was in use, and had been resold, the foundation settled and the house was severely damaged.
- The local building authority was sued (not the inspector) and found liable for the damages.

5.7.26 Englewood Plumbing & Gas Fitting Ltd. v. Northgate Development Ltd. et. al.

Location: Alberta
Court:
Year: 1965
Importance: allowed a lien for design work
Details:

- An architect was allowed to file a lien although he had not done any work on the property.

5.7.27 Fairbanks Soap Co. Ltd. Sheppard

Location: Ontario
Court:
Year: 1951
Importance: an example of substantial compliance
Details:

- A contractor supplied and installed equipment, but there were a few small defects (fixed at a small cost).
- The resulting lawsuit lead to a decision that the contractor had substantially complied and should be paid for work and materials supplied.

5.7.28 Fern Brand Waxes Ltd. v. Pearl

Location: Ontario

Court:
Year: 1972
Importance: the distinct nature of a corporation disappears when being used fraudulently
Details:

- the defendant, a director, officer and accountant of the corporation had made an authorized transfer of funds.
- these funds were used as a loan by the corporation as a loan to two other companies controlled by the director.
- some of the loaned money was used to buy shares in the corporation. (The court ruled this inappropriate).
- The court rules that the 2 other corporations had been used as instruments of the director, that the director had breached his trust, and that the companies could not shield his personal conduct.

5.7.29 Ford Homes Ltd. v. Draft Masonry (York) Co. Ltd.

Location: Ontario
Court:
Year: 1983
Importance: an example of an implied term
Details:

- a construction contract included the supply and installation of two staircases, but neglected to include a requirement that they meet the Building Code.
- A representative of the company visited the site, but turned down an offer to review architectural plans, which specified a minimum clearance.
- Based on measurements, a variety of staircases were suggested by the representative.
- The final staircase did not meet the minimum clearance in the building code, and was ordered replaced.
- The resulting lawsuit found that if the Building Code was not mentioned in the contract and the staircase was improperly designed thus being illegal, it would make the contract for an illegal action, therefore by implication the staircase would have to conform to the building code.

5.7.30 General Electric Company, Limited v. Fada Radio, Limited

Location: ?
Court:
Year: 1929
Importance: indicates patents must be novel and have use
Details:

- Basically stated that there must be some creative content, no matter how small. This includes alterations. They also focus on the concept of an improvement.

5.7.31 GeorgeHo Lem v. Barotto Sports Ltd. and Ponsness-Warren Inc.

Location: Alberta
Court:
Year: 1976
Importance: a manufacturer can be held liable if the consumer is not adequately warned about dangerous uses of a product
Details:

- Lem bought a machine for reloading used shotgun shells. The machine had clear instructions on how to load the shells. He also received personal instructions on the machine.
- When using the machine Lem did not follow instructions, and as a result produced some dangerous shells.
- One of the shells caused Lem's gun to burst, causing personal injury, and as a result he brought a lawsuit against the manufacturer and distributor.
- The court found that a high standard of care to prevent misuse was present, and found Lem fully responsible for his own injuries.

5.7.32 Grant Smith & Co. v. The King

Location: ?
Court:
Year: ?
Importance: fraudulent engineers certificates are set aside
Details:

- An engineer presented a certificate that had been prepared in collusion with a drilling contractor.
- In a lawsuit the certificates were ruled invalid because of the fraud.

5.7.33 Hadley v. Baxendale

Location: England
Court:
Year: 1854
Importance: established principle of remedies for damages
Details:

- A part in a mill was broken, and needed to be repaired.
- It was given to couriers for transport to the manufacturer.
- Not knowing of the urgency of the delivery the couriers delayed.
- The resulting delay meant that the mill was inoperative for a prolonged period and business was lost. As a result the courier was sued.

- The court said that the lack of notice about the urgency meant that the term for urgency had never been part of the “contract”, and therefore could not have been breached.
- The court also said that if there had been a breach of the contract, then the mill owner would have been due any losses that might have reasonably been expected at the start of the contract.

5.7.34 Halverson Inc. v. Robert McLellan & Co. et. al.

Location: Canada
Court:
Year: 1973
Importance: ruling that a contract overrides a tort
Details:

- An engineer was to modify a winch system.
- As a result of problems, the engineer was sued for negligence.
- The court ruled that the contract in the suit replaced the tort.

5.7.35 Harbutt’s Plasticine Ltd. v. Wayne Tank and Pump Co. Ltd.

Location: England
Court:
Year: 1970?
Importance: an example of fundamental breach
Details:

- A contract was prepared for the design and construction of storage tanks for stearine wax. Liabilities were limited to 2,300 pounds (approx $5,000).
- A plastic pipeline to carry the wax was wrapped with a heating element to allow the wax to flow in a liquid state.
- When put into use the pipe warped, cracked and ruptured. Wax spilled on the floor and ignited. The resulting fire destroyed the factory.
- The judge ruled that the design was so unsuitable that the contract was breached, and the liability limit did not apply. The damages awarded were 170,000 pounds.

5.7.36 Hedley Byrne & Co. Ltd. v. Heller & Partners Ltd.

Location: England
Court:
Year: 1963
Importance: this allows professionals to be sued for negligently given advice
Details:

- Byrne asked a bank to look into the credit status of another company that they were

doing business with.
- The bank then contacted another bank (Heller) that did business with the company.
- Heller reported that their financial position was favorable, but also stated that their advice was “without responsibility”.
- Based on their advice, Byrne did business with the company and lost 17,000 pounds.
- The court rules that the bank would have been liable, if not for the disclaimer.

5.7.37 Imperial Glass Ltd. vs. Consolidated Supplies Ltd.

Location: British Columbia
Court:
Year: 1960
Importance: an unsuccessful attempt to argue for a unilateral mistake
Details:
- During bid preparation an incorrect figure had been used for certain material suppliers, entirely because of mistakes by the bidder.
- It was obvious to the offeree that the bidder had misestimated.
- The mistake was not overturned.

5.7.38 Jackson et. al. v. Drury Construction Co. Ltd.

Location: Ontario
Court:
Year: 1974
Importance: an example of a tort of nuisance
Details:
- A contractor was blasting.
- The blast opened fissures in the bedrock allowing barnyard materials to seep into a well.
- The court awarded damages to the farmer.

5.7.39 John Burrows Ltd. v. Subsurface Surveys Ltd. et. al.

Location: Canada
Court:
Year: 1968
Importance: an example where equitable estoppel was disallowed
Details:
- A promissory note (a contract) was,

  “FOR VALUE RECEIVED Subsurface Surveys Ltd. promises to pay John Burrows Ltd. or order at the Royal Bank of Canada the sum of forty-two Thousand Dollars ($42,000.00) in nine (9) years and ten (10) months from April

1st, 1963, payable monthly on the first day of May, 1963, and on the first day of each and every month thereafter until payment, provided that the maker may pay on account of principal from time to time the whole or any portion thereof upon giving thirty (30) days' notice of intention prior to such payment.

In Default of payment of any interest payment or installment for a period of ten (10) days after the same became due the whole amount payable under this note is to become immediately due.

Subsurface Surveys Ltd. [signed by president]"

- Some payments were made more than 10 days late, but the contract was not strictly enforced.
- One interest payment was 36 days late (the parties had fallen out of favor with each other) and it was decided to call in the notice using the default clause, and Subsurface Surveys Ltd. was notified.
- In a resulting lawsuit it was claimed that the previous late payments were an implied modification of the contract and that an equitable estoppel was warranted.
- The court ruled that the indulgences taken by the plaintiff in making late payments were not evidence that the defendant intended to negotiate new contractual terms.

5.7.40 Junior Books Ltd. v. Veitchi Co. Ltd.

Location: England
Court:
Year: 1982
Importance: claims for economic loss may be extended to those with no contracts
Details:

- A floor was laid improperly, but was of no danger.
- Although the installer was a subcontractor (note no contract existed between them) the court found that he had a duty of care to provide skillful work. As a result the court found him liable for economic losses, and any repair costs.

5.7.41 Kamlee Construction Ltd. v. Town of Oakville

Location: Canada
Court:
Year: 1960
Importance: an example of an engineers power of certification
Details:

- An engineer was contracted for a construction project. The construction contract stated that the engineer had the final decision on the interpretation of the specifications and the quality of work.
- During the work the contractor disagreed with one of the engineers decisions, and the relationship between the partys was reduced to petty bickering.

- In the resulting lawsuit the court ruled that the engineers decisions would stand, provided he acted in a judicial manner and without influence from the owner.

5.7.42 Kidd v. Mississauga Hydro-Electric Commission et. al.

Location: Ontario
Court:
Year: 1979
Importance: an example of an engineers duty of care when preparing estimates
Details:

- A consulting engineer estimated the cost to do a study.
- When done, the engineer realized that the $14,447 for support staff was much higher than the $5,000 allowed in the estimate.
- In a lawsuit to recover the difference the court ruled against the engineer stating that the work was entered into based on the estimate (there were also no disclaimers given). And, the result was so far out of line that it implied the engineer had not properly estimated.

5.7.43 Kocotis v. D'Angelo

Location: Ontario
Court:
Year: 1958
Importance: improper licences can set aside a contract because of legality
Details:

- An electrician had done work and supplied materials. But, against local bylaws did not hold the required electrical contractors licence.
- Seeking payment a lawsuit arose.
- The judge stated that the purpose of the license was supposed to maintain quality on larger projects, and that by not having a license the electrician was clearly not legally capable of entering into the contract.

5.7.44 Lambert v. Lastoplex Chemicals Co. Limited et. al.

Location: Canada
Court: Supreme
Year: 1971
Importance: the high standard of care requires that all users are assumed to be idiots
Details:

- Lambert, a mechanical consulting engineer, purchased two cans of sealant for his basement floor.

- He read the labels before starting. These 3 labels indicated repeatedly that, among other horrible things, the product should be kept away from flames, fire, heat or cigarettes. Ventilation was also listed as essential.
- Lambert was using the sealant in his basement when a pilot light in an adjoining room started an explosion and a fire in an open can of sealant.
- In the resulting lawsuit another can of sealer made by a competitor had a warning label that also mentioned pilot lamps and more.
- The court ruled that the chemical company did not provide sufficient warning and that they were liable. It was also noted that even though the engineer ought to have known of the danger, the chemical company could not count on this.

5.7.45 MacMillan Bloedel Ltd. v. Foundation Co.

Location: British Columbia
Court:
Year: 1977
Importance: limits of recoverable economic loss
Details:

- Foundation's employees negligently cut a cable supplying MacMillan's office building.
- As a result of lost power, the employees were sent home.
- The estimated loss in wages was $48,841.
- The court indicated that the negligence was evident, but the "economic loss" would have been paid anyway. With no other evidence of loss, the case was dismissed.

5.7.46 Markland Associates Ltd. v. Lohnes

Location: Nova Scotia
Court:
Year: 1973
Importance: an example of implied contract terms
Details:

- The court ruled that a building contract did not clearly state, but implied,
  - that the work and materials would be of reasonable quality and meet standards.
  - the work was to be conducted in a normal manner.
  - the final product would be usable and meet needs.
  - the work would be done in reasonable time.

5.7.47 Metropolitan Water Board v. Dick, Kerr and Company, Limited

Location: England
Court:

Year: 1917
Importance: a discharge by frustration
Details:

- A contract was signed to build a reservoir from 1914 to 1920.
- In 1916 the work was ordered stopped because of the needs for WW-I.
- In light of the delay, the contractor did not want to continue the work.
- The water board wanted the contract resumed (as indicated in a force majeure clause) with the delay included.
- The case was taken to court, and the ruling was that the contract was different than the one entered into and as a result gave a discharge by frustration.

5.7.48 Monticchio v. Torcema Construction Ltd. et. al.

Location: Ontario
Court:
Year: 1979
Importance: departed from previous decisions that voided contracts because of lack of licenses made contract illegal
Details:

- A contractor (not properly licensed) entered into a contract to install drains.
- After completion, the contractor was not paid and began a lawsuit
- The judge ruled that while a license was required for the contracting work, it was not required for supply of materials. Therefore the supplier was reimbursed for the materials supplied.

5.7.49 The Moorcock

Location: ?
Court:
Year: ?
Importance: established implied terms in contracts
Details:

- The plaintiff paid for docking space for his boat, the Moorcock.
- As the tide went out the Moorcock settled on hard ground and was damaged.
- The court decided in favor of the defense (dock owner) in the ruling that there was an implied term in the contract that the boat would have been safe at low tide.

5.7.50 Murray v. Sperry Rand Corporation et. al.

Location: Ontario
Court:

Year: 1979
Importance: an example of fundamental breach
Details:

- A piece of farm machinery was purchased to harvest.
- The machine performance had been much worse than should have been expected.
- In the resulting lawsuit the defendant argued that there was an exemption clause in the contract.
- The court ruled that the supplier has fundamentally not met the obligations of the contract, and because of the fundamental breach it could not be protected by the exemption clause.

5.7.51 Mutual Finance Co. Ltd. v. John Wetton & Sons Ltd.

Location: ?
Court:
Year: ?
Importance: a contract can be revoked because of duress
Details:

- A family member had forged (criminal) a previous guarantee.
- The forger's father was ill and might be fatally effected by a disclosure of forgery.
- At this point the forger was threatened with disclosure, unless another guarantee was contracted.
- The court put the second guarantee aside, as it was made under duress.

5.7.52 Nedco Ltd. v. Clark et. al.

Location: Saskatchewan
Court:
Year: 1973
Importance: the corporate identity is not absolute and can be partially lifted
Details:

- Nedco Ltd. was owned by Northern Electric Company Limited.
- Northern Electric employees went on strike and picketed Nedco
- The court was asked to restrict picketing at Nedco because the two companies were separate entities.
- The court rules that Northern both owned and dominated Nedco, making it effectively part of Northern, and in these certain circumstances, the companies would be treated the same and picketing would be allowed.

5.7.53 Newman et. al. v. Conair Aviation Ltd. et. al.

Location: British Columbia
Court:
Year: 1972
Importance: an example of a tort of nuisance
Details:

- An aviation company was spraying crops, and the spray drifted onto the plaintiffs land.
- The court awarded damages.

5.7.54 Northwestern Mutual Insurance Co. v. J.T.O'Bryan & Co.

Location: British Columbia
Court:
Year: 1974
Importance: employees can be held liable in tort suits
Details:

- The Northwestern Mutual Insurance Co. had routinely asked that one of its agents delete a risk from a policy.
- The agent assured Northwestern that it had been deleted.
- Later, it was discovered that the risk had not been deleted and Northern had to pay for the risk.
- The court ruled that both the agent, and their employer were liable for the losses.

5.7.55 J. Nunes Diamonds Ltd. v. Dominion Electric Protection Co.

Location: Canada
Court:
Year: ?
Importance: draws a line between tort and contract liability
Details:

- Ruled that a tort action could be brought if it was independent of contractual obligations.
- There was special mention of non-performance not being mentioned in a clause.

5.7.56 Owen Sound Public Library Board v. Mial Developments Ltd. et. al.

Location: Ontario
Court:
Year: 1979
Importance: application of "equitable estoppel" for accepted late payments
Details:

- A construction contract was made that required payments needed to be made by the

owner within 5 days of an architects certificate specifying the value of payment.
- The contract also stated that if not paid within 7 days, the contractor could terminate the contract.
- Instead of making one payment promptly, the owner requested the corporate seal of a subcontractor affixed to a document that supports the architects certificate.
- The contractor then indicated he would obtain the seal.
- The contractor did not give the sealed document to the owner, and as a result was not paid within the allowed period.
- The contractor used the strict wording the terminate the contract.
- In the resulting suit the court maintained that the contractor had implicitly lead the owner to believe that the due date (including the termination clause) had been extended. Therefore an “equitable estoppel” of the clause was granted.

5.7.57 Permutit Co. v. Borrowman

Location: ?
Court:
Year: ?
Importance: a tangible (demonstrable) idea is required for a patent
Details:
- The court said that an idea must be reduced to a definite and useful form before it can be patented.

5.7.58 Photo Production Ltd. v. Securicor Transport Ltd.

Location: England
Court:
Year: 1980
Importance: an example of a failed fundamental breach (rejected the concept of fundamental breach)
Details:
- A security contract was set for watching a manufacturing company at night.
- During one of the patrols an employee started a fire that destroyed the factory.
- In the resulting lawsuit it was noticed that the security contract contained a clause that specifically exempted liability for (among other things) an employee that negligently starts a fire.
- The court ruled that the exemption clause reasonably predicted the potential loss, and that there was no fundamental breach.
- In effect this overturned the concept of fundamental breach.

5.7.59 Pigott Construction Co. Ltd. v. W.J. Crowe Ltd.

Location: Ontario
Court:
Year: 1961
Importance: refers to precedents of implied terms in contracts and a breach of a warranty (non-essential) term as grounds for damages, not termination.
Details:

- A construction contract was made, including some minor terms requesting expeditious work, and to provide heat during winter.
- The plaintiff argued that the two minor conditions had not been satisfied, and so the contract should be discharged.
- The court said that the breaches had not prevented substantial performance, and therefore are not a reason to discharge the contract, but are grounds for payment of damages.
- The court also stated that they would not imply terms into a contract unless it was obvious they should be there.

5.7.60 Pirelli General Cable Works Ltd. v. Oscar Faber and Partners

Location: England
Court:
Year: 1982
Importance: reverses the precedent set in [Sparham Souter]
Details:

- A chimney 160 feet high was built using precast concrete.
- An inner lining of a new material was used. The material was not suitable and cracks developed and the chimney had to be replaced.
- They stated that the period of limitation started from the date the damage occurred. They said that legislation is required, and that the Sparham-Souter decision may lead to unfairly long limitation periods.

5.7.61 Pym v. Campbell

Location: ?
Court:
Year: ?
Importance: parol evidence rule exception
Details:

- An agreement for sharing the ownership of a machine was made.
- Two individuals had agreed that invention ownership rights would be purchased, but an unwritten condition was that it would be approved by two engineers first.
- When consulted only one of the two engineers approved of the invention.
- As a result the case went to trial.

- The judge ruled that because of the condition, the contract had never been entered into, effectively sidestepping the parol evidence rule.

5.7.62 The Queen et. al. v. Commercial Credit Corp. Ltd.

Location: Nova Scotia
Court:
Year: 1983
Importance: example of mail/courier for a contract and governing law
Details:

- An offer of conditional sale was prepared by Commercial Credit as an agent to the parties in the contract.
- The offer was sent out of Nova Scotia to the offeree. And the acceptance returned by courier.
- Commercial Credit attempted to apply the Installment Payments Contract Act of Nova Scotia, but this was disallowed because the contract was made outside the province.

5.7.63 Ramsay and Penno v. The King

Location: ?
Court: ?
Year: ?
Importance: recognizes mistakes as separate from negligence
Details:

- the crown was sued alleging that poor dam design lead to flooding of lands
- the statement said that engineers are “not infallible, nor is perfection expected, and the most that can be required of them is the exercise of reasonable care and prudence in light of scientific knowledge at the time, of which they should be aware...” (Marston, pg. 30)

5.7.64 Regina v. Margison and Associates, Limited

Location: Ontario
Court:
Year: 1955
Importance: recognizes the legal overlap of engineers and architects duties
Details:

- An engineering firm was charged with acting as architects
- In reviewing the acts the court found too much overlap to distinguish between the duties of the engineers and the architects.

- The court ruled that clients should be free to contract who they wish.

5.7.65 Rex v. Bentall

Location: British Columbia
Court:
Year: 1939
Importance: an engineer can be convicted for doing architectural work
Details:

- An engineer had prepared plans for a theatre and then supervised construction.
- He was later convicted of practicing as an architect.

5.7.66 Rivtow Marine Ltd. v. Washington Iron Works et. al.

Location: Canada
Court:
Year: 1973
Importance: economic losses caused by a defective product can be recovered
Details:

- Rivtow chartered a barge that had a crane manufactured by Washington (a U.S. company)
- An identical crane manufactured by Washington had been used in a similar situation before, and it had collapsed. An investigation determined that there were structural defects in the crane Rivtow had chartered that were similar to those in the crane that had collapsed.
- The defendants were previously aware that design problems left the cranes prone to cracking, but they did not warn the plaintiff or attempt repairs.
- As a result of the failure to warn, the defendants were found liable for economic losses while the crane was being repaired.

5.7.67 Robert Simpson Co. Ltd. v. Foundation Co.

Location: Ontario
Court:
Year: 1981
Importance: upheld the time of action principle of [Sparham Souter]
Details:

- Some ceiling anchors were negligently designed, manufactured and installed. These were also misrepresented as adequate.
- More than 6 years after the work the problems were detected, therefore the court was asked to consider the limitation from the detection of damages.

- A lower court rejected the Sparham Souter principle, but a higher court heard an appeal that accepted the limitation period started when the damage was detected.

5.7.68 Ron Engineering et. al. v. The Queen in right of Ontario et. al.

Location: Ontario, Canada
Court:
Year: 1979, 1981
Importance: an example of the unilateral mistake principle
Details:

- A bid was submitted to The Water Resources Commission, along with a deposit cheque of $150,000.
- It was discovered before the tenders were opened that a bid of $2,748,000 was low by $750,058.
- An hour before the tenders were opened the contractor informed the commission, and also sent a telegram to the commission which arrived the following morning to tell them of the error.
- The next higher bid was $3,380,464 making the mistake obvious, but the bid was accepted.
- A lower court maintained the contract.
- An appeal lead to a successful overturn allowing the contract to be dismissed because of a unilateral mistake.
- The supreme court held the position that the construction contract could be overturned, but the tender contract meant that the deposit had to be forfeit, as described in a forfeit clause.

5.7.69 Royal British Bank v. Turquand

Location: England
Court:
Year: 1856
Importance: Only the appropriate officials in a company have the capacity to contract
Details:

- A corporation must observe contracts if the contracts were entered into normally, by a normally authorized employee/official, and the corporations records are in order.

5.7.70 Salomon v. Salomon & Co. Ltd.

Location: England
Court:
Year: 1897

Importance: recognition of a corporation as a distinct entity
Details:

- Salomon had been a leather merchant and boot manufacturer for a number of years.
- he incorporated a company and sold his business to it.
- the shareholders were Salomon and his family. Salomon was the majority shareholder, having received shares as part of his payment for the business, as well as debentures constituting security.
- all of the requirements for incorporation were met and the business was solvent.
- eventually the business became insolvent and was sued - Salomon claimed he should be satisfied ahead of the unsecured creditors by holding a secured debenture.
- In the court of appeal the corporation was viewed as a scheme only for limiting liability, and putting Salomon ahead of the creditors.
- But, the House of Lords upheld Salomon's corporation as properly formed, and a distinct entity, with no evidence of deception or fraud.

5.7.71 Schewebel v. Telekes

Location: Ontario
Court:
Year: 1967
Importance: an example of the contract overriding tort
Details:

- A notary public was to act for an individual in purchasing a home.
- The notary public was sued for negligence.
- The court ruled that the relationship between the two was contractual and thus the limitation is counted from the date of the breach or duty, and not discovery.

5.7.72 Sealand of the Pacific Ltd. v. R.C. McHaffie Ltd. et. al.

Location: British Columbia
Court:
Year: 1973
Importance: an example of a contract over a tort
Details:

- An architect had failed to determine the properties of an experimental material.
- The court ruled that the contract would overrule the tort and awarded damages.

5.7.73 Sparham Souter et. al. v. Town & Country Developments (Essex) Ltd. et. al.

Location: England

Court:
Year: 1976
Importance: sets the start of the limitation period to when damage occurred
Details:

- A building was negligently constructed.
- Some time later damage resulted and the law suit was allowed.
- The guideline is that the damage is said to have occurred when it should be obvious or detected by a reasonable level of skill or diligence.
- This decision was later overturned by a higher court, but it was used as the basis for other decisions. [XXXX]

5.7.74 Sutcliffe v. Thackrah et. al.

Location: England
Court:
Year: 1974
Importance: negligently prepared certificates make the certifier liable
Details:

- An architect was to prepare payment certificates.
- The court ruled that the architect had a duty of care when preparing certificates. And, if an overpayment was made without just cause, the architect was liable. The only just reason for overpayment would be the architect acting as arbiter.

5.7.75 Swanson Construction Company Ltd. v. Government of Manitoba; Dominion Structural Steel Ltd., Third Party

Location: Manitoba
Court:
Year: 1963
Importance: an example of a failed bid for discharge by frustration
Details:

- A bid was prepared for work, assuming the work was to be done in the warm summer months.
- The contract was accepted, but the work was delayed to the winter months.
- In court the contractor argued that the delay should constitute grounds for a discharge by frustration.
- The court did not discharge the contract saying that the delay was an event that might be reasonably expected during construction, and should have been considered in the bid.

5.7.76 Re Thomas Hackett

Location: Nova Scotia
Court:
Year: ?
Importance: the decision of an arbitrator can be overturned when improper
Details:

- A contract had stated that arbitration would be used without using the court system.
- The court overruled this point saying that a dispute can always be taken to court.

5.7.77 Township ofMcKillop v. Pidgeon and Foley

Location: ?
Court:
Year: ?
Importance: a contract was rescinded for innocent misrepresentation
Details:

- An engineer prepared plans and specifications for bidding.
- A contractor prepared a bid on the job based on the engineers plans and specifications.
- The specifications were found to underestimate to work significantly.
- As a result the contractor terminated the contract, and a lawsuit was initiated.
- The court concluded that the estimate was grossly in error (more than allowable by a disclaimer clause) and that because of the error, the contractor had entered into the contract.
- The court allowed the contractor the right to rescind the contract.

5.7.78 Trident Construction Ltd. v. W.L. Wardrop and Assoc. et. al.

Location: Manitoba
Court:
Year: 1979
Importance: Hedley Byrne decision applied to engineering, improperly prepared drawings and specifications leave an engineer liable
Details:

- An engineer designed a sewage disposal plant
- A contractor (no contract existed between the engineer and contractor) was to build the plant based on the engineers design.
- The contractor found the design unsuitable as a result the contractor brought a lawsuit against the engineer for his losses.
- The engineer was found liable for the design because he owed a duty of care to the contractor that would eventually build the plant.
- The judge specifically noted that contractors are so pressed for time preparing tenders that they could not be expected to check the engineers designs.

5.7.79 Unit Farm Concrete Products Ltd. v. Eckerlea Acres Ltd. et. al.; Canama Contracting Ltd. vs. Huffman et. al.

Location: Ontario
Court:
Year: 1983
Importance: an engineer can be liable for advice given without a fee
Details:

- A contractor was hired to construct a barn over a manure pit.
- In the past the contractor had used advice given by an engineer working for the government to assist farmers with plans.
- The contractor discussed the plans for the barn on the phone, and dropped the set on the engineers desk. The two did not meet, but he superficially reviewed the set and wrote a note “Good set of plans. I like the detail. Wish I could spend that amount of time on each project. Keep up the good work.” The engineer and the contractor never met to review the plans for the barn.
- The contractor assumed that the plans were adequate and built the barn.
- As a result of design deficiencies the manure pit walls failed.
- The court rules against the engineer (and Crown) noting that “good plans” was an implied approval and that the plans had been properly reviewed. There was also recognition that the contractor had been asking for advice.
- An appeal court then found liability 75% for the engineer and 25% for the contractor.

5.7.80 Viscount Machine and Tool Ltd. v. Clarke

Location: Ontario
Court:
Year: 1981
Importance: example of a limitation from the date of discovery
Details:

- A negligent land survey was done, but not discovered until a few years later.
- The judge allowed the limitation period to be from the date the damage was discovered.

5.7.81 Willard’s Chocolates Ltd. v. Bardsley

Location: ?
Court:
Year: ?
Importance: an employee may use an employers time and equipment to create an invention, but the employee owns the patent unless stated otherwise in the contract

Details:

-

5.7.82 GLOSSARY

actus reas - proof that a criminal defendant did all the things leading to a crime.
appellant - a party that is appealing a criminal or civil decision in a lower court.
caveat emptor - buyer beware.
consideration - something of value which must be given by the offerer to make a contract valid.
creatures of statute - created by a statute (e.g. PEO act) and able to exercise powers defined in statute.
creditor - is owed money by a debtor.
cross-examination - examining the other parties witness.
debtor - owes money to a creditor.
defendant - in criminal court, the defendant has been accused of a criminal act. In civil cases the defendant has been accused of wrong doing causing “injury”.
examination in chief - examining your own client.
expert evidence - a witness cannot give an opinion but an expert witness can.
Force Majeure - a force that interrupts the normal conduct of business, and as a result is a cause for delay, such as floods, wars, etc. There are typically clauses in contracts to cover these cases.
general damages - pain and suffering from the result of negligence.
guarantee - A promise of performance if all other avenues fail. For example if an insurance firm guarantees bill payment by a company, and the company fails to pay, the company must be pursued before the insurance company.
indemnity - A promise of performance. Consider the example of the insurance firm (see guarantee) that indemnified the debts of a company. If the company fails to pay their debts, the insurance firm can be approached without pursuing the company first.
leading questions - these questions are allowed during cross-examination only.
litigation - a civil lawsuit.
mens reas - a guilty mind.
non est factum - it is not his deed. This is a plea whereby a defendant either alleges that he did not execute the deed in question, or that he was laboring under a mistake as to its nature, when he executed the same.
onus of proof - in criminal court the prosecution is obliged to show through a balance of probabilities that the weight of evidence is against the defendant.
options contract - keeps a contract open for extension.
plaintiff - those that have made charges or brought a lawsuit. In the criminal courts this is often the crown, in the civil courts this is the injured party.
privity of contract - the legal relationship between two or more parties in a contract.
propriety of contract - this describes the legal relationship between parties in a contract.
resipsa loquitur - self evident.
respondent - a party that is arguing that a decision of a lower court be upheld. They oppose and appeal.
special damages - lost income, special care, equipment and other loses resulting from negligence.
stare decisis - a binding decision.
statute - these over-rule all levels of common law in all courts.
ultra-vires -

victim impact statements - these statements about the personal effects of crime can have an impact on the sentencing of a criminal.

5.7.83 OLD PPE QUESTIONS FOR PEO

The following questions are from old PPE (Professional Practice Examinations) collected over the years. These exams are not copyrighted, but credit for their development and distribution belongs to the PEO. Each candidate will typically receive one copy of a (complete) recent examination paper which will show common test formats and rules. In constructing this list of questions I wanted to give a good set of practice problems, without encouraging method studying, so I have not indicated which questions are repeated, or which year they appeared in.

If anybody has got additional examination questions not included here, I would appreciate a copy so that they may be added to the list. The dates of the previous tests included are,

May 2, 1987
September 12, 1987
May 14, 1988
September 10, 1988
April 29, 1989
September 9, 1989
April 28, 1990
September 8, 1990
April 27, 1991 (Ethics only)
December 14, 1991
April 25, 1992
September 5, 1992
September 4, 1993
April 23, 1994
September 7, 1996 (thanks A. Mahmud)
April 26, 1997 (thanks A. Mahmud)
September 6, 1997 (thanks A. Mahmud)
April 25, 1998 (thanks A. Mahmud)
August 21, 1999

5.7.83.1 - Law Questions

1. Define the following terms
   a) Fraudulent misrepresentation
   b) Vicarious liability
   c) Gratuitous promise
   d) Parol evidence rule
   e) The 5 legal essentials of a binding contract
   f) Libel
   g) Secret commission
   h) Common law
   i) Quantum meruit

j) Defamation
k) Innocent misrepresentation
l) Frustration of contract
m) Specific performance
n) Performance bond
o) Joint venture
p) Discharge by frustration
q) Mitigation of damages
r) Exemption clause
s) Limitation period
t) Concurrent tort-feasor
u) Bid bond
v) Slander
w) Consideration
x) Duress
y) Labor and material payment bond
z) The purpose of the holdback under the Construction Lien Act.
aa) Undue influence
bb) Letter of intent
cc) Cost-Plus construction contract
dd) Fraudulent misrepresentation
ee) Joint venture
ff) Contract ratification
gg) Statutory holdback
hh) Contract A (in tendering)
ii) Consequential damages
jj) Rule of contra proferentem
kk) Directors duty of care
ll) Duty to mitigate ,
mm) Indirect damages
nn) Contra proferentem
oo) Piercing the corporate veil
pp) Liquidated damages
qq) True construction approach
rr) The “liberal” approach to contract interpretation
ss) Alternative dispute resolution (“ADR”)
tt) Concurrent tortfeasors

2. A manufacturing company retained an architect to design a new plant. The manufacturer, as client, and the architect entered into a written client/architect agreement in connection with the project. The purpose of the plant construction was to enable the client to expand its manufacturing and warehousing facilities.

The structural design of the plant was prepared by an engineering firm which was retained by the architect. A separate agreement was entered into between the architect and the engineering firm to which the client was not a party.

The engineering firm turned the matter over to one of its employees, a professional engineer with

experience in structural steel design who proceeded to complete the structural design of the plant. The client had informed the architect that the second floor of the plant was to be used for manufacturing and warehousing purposes and that forklift trucks would be extensively used in both the manufacturing and warehousing sections on the second floor. The architect passed this information on to the engineering firm. The employee engineer designed a steel frame and specified that the second floor was to be a concrete-steel composite, consisting essentially of concrete poured onto a steel deck, and containing a light steel mesh. The steel deck, concrete thickness, and steel mesh specifications were specified in the engineer's design and were taken from design tables which the engineer located in his firm's library and which had been published by a company which manufactured and supplied the steel deck.

The construction of the plant was completed and shortly after manufacturing commenced at the plant, severe cracks appeared in the concrete on the second floor. After two months of operation the floor cracked and broke up so badly that the plant had to be shut down and a remedial slab, heavily reinforced with reinforcing bar, was poured on top of the damaged second floor.

The design of the remedial floor slab was carried out by another consulting engineering firm. After completing its investigation of the cause of the failure of the second floor, the second engineering firm stated that, in its opinion the engineer who had designed the second floor had used design tables from the steel deck manufacturer which were 12 years out of date and had also failed to use the tables that he obviously ought to have used knowing that the floor was intended for manufacturing and forklift truck loading. The second consulting engineering firm concluded that the depth of concrete and size of steel mesh in the floor as initially designed resulted in a floor that might have been appropriate for the design of an office or apartment building but not for manufacturing and warehouse purposes.

What potential liabilities in tort law arise from the preceding set of facts? In your answer, state the essential principles applicable in a tort action and apply these principles to the facts. Indicate a likely outcome of the matter.

3. Supercleen Limited, a manufacturing company, entered into an equipment supply contract with Red Fire Mines Limited, Supercleen agreeing to design supply and install a dust collection system at Red Fire Mine's northern Ontario smelter for a contract price of $200,000.00. The specifications for the dust collection system specified that the dust collection equipment was to remove 98% of prescribed exhaust particles from the exhaust gases in order to comply with the requirements of the environmental control authorities in the area in which the smelter was located.

In addition, the signed contract between Supercleen and Red Fire Mines also contained a provision limiting to $200,000.00, Supercleen's total liability for any loss, damage or injury resulting from Supercleen's performance of design, supply and installation services to Red Fire Mines pursuant to the contract.

The dust collection system as installed by Supercleen did not meet the specifications. In fact, only 60% of the prescribed exhaust particles were removed from the exhaust gases. As a result, Red Fire Mines was faced with the threat of substantial fines and possible shutdown by the environmental control authorities. Supercleen refused to remedy the defective equipment without being assured of compensation from Red Fire Mines of any costs in excess of $200,000.00 incurred in connection with such remedial work.

At the time of discovering that the system failed to meet the specifications, Supercleen had already received $180,000.00 from Red Fire Mines and Red Fire Mines refused to pay any-

thing further to Supercleen.

Red Fire Mines contracted another equipment supplier who, for an additional cost of $275,000.00 successfully designed and installed remedial equipment sufficient to clean the exhaust gases to the satisfaction of the environmental authorities and in accordance with the original contract specifications between Supercleen and Red Fire Mines.

Explain and discuss what claim Red Fire Mines Limited can make against Supercleen Limited in the circumstances.

4. An owner and a Contractor entered into a written construction contract which provided that payments were to be made by the Owner to the Contractor within five days subsequent to an Engineer's Certificate being issued and that, if the Owner should fail to pay the Contractor within such five day period any sums certified as due by the Engineer, the Contractor would be entitled to terminate the construction contract. The Contractor had been the lowest bidder on the project and, as the construction proceeded, became concerned that, because of its low bid, it would lose money on the contract.

During the first two months of the six-month construction schedule, the Engineer certified payments due by the Owner to the Contractor and such payments were made to the Contractor within five days of such certification.

At the end of the third month of construction, the Engineer certified a further sum as due to the Contractor. In spite of having received the Engineer's Certificate, the Owner requested that prior to payment the Contractor obtain the corporate seal of one of its subcontractors on a document supporting the Engineer's Certificate and the Contractor stated that it would obtain such corporate seal. However, the Contractor never did obtain the corporate seal; the five day payment period passed and ten days later the Contractor notified the Owner that it was terminating the contract on account of the Owner's failure to pay it within the five day period pursuant to the terms of the construction contract.

Was the Contractor entitled to terminate the contract in the circumstances? Explain.

5. Acme Manufacturing Limited designed and manufactured two identical cranes, which were sold by an Ottawa dealer two companies contracting logging barge services on the Ottawa River. The names of the purchasers were Movemore Ltd. and Unjammers Inc. Both cranes went into service at approximately the same time. After one month's service the crane purchased by Movemore Limited collapsed, killing the operator of Movemore's barge.

During the Worker's Compensation Board's investigation into the accident, it became apparent that the cause of the collapse was the negligent structural design of the crane. It also became apparent that the manufacturer and the dealer had been aware of the structural weaknesses for some time. Three weeks later, upon learning that a crane of similar design had been sold to Unjammers Inc., representatives of the Worker's Compensation Board notified Unjammers Inc., of the disaster involving the sister crane sold to Movemore Limited. At no time had Acme Manufacturing Limited or the Ottawa dealer notified Movemore Limited or Unjammers Inc. of any potential problems.

As a result, Unjammers Inc., at the height of its busiest season, was forced to return the crane to the factory for repairs.

What claim can Unjammers Inc. make against the crane manufacturer or against the dealer in the circumstances? Explain.

6. Jason Smith is a 25% shareholder and director of Skylift Inc., a company engaged in commercial helicopter services in Ontario.

A friend of Smith, James Johnson, sought Smith's technical and financial support in forming another commercial helicopter business in British Columbia and Smith agreed to so participate and acquired a 50% shareholder interest in the second company, known as Johnson's Skyhooks Limited.

Eventually Skylift Inc. became interested in purchasing all of the assets of Johnson's Skyhooks Limited. Jason Smith was in no way involved in promoting the purchase of Johnson's Skyhooks Limited until the proposed purchase was presented to the five man board of directors of Skylift Inc. for approval. At that meeting, Smith did not disclose his shareholder interest in Johnson's Skyhooks Limited and Smith cast the deciding vote in passing the directors' resolution to authorize the asset purchase. Shortly after the asset purchase had been finalized, the board of directors of Skylift Inc. became aware of Jason Smith's shareholder interest in Johnson's Skyhooks Limited and, on further investigation, concluded that the price paid for the assets of Johnson's Skyhooks Limited was unreasonably high.

What action might the board of directors and shareholders of Skylift Inc. take in the circumstances? State, with reasons, the likely outcome of the action.

7. A contractor specializing in farm buildings was engaged by an owner to design and construct a barn to be placed over a manure pit. The contract between the contractor and the owner provided that the contractor would be responsible for both the design and construction of the barn.

The contractor had previously designed and built barns over manure pits, but had never designed a manure pit of the size and shape required by this owner. In preparing the design, the contractor contracted an engineer who was employed by the Department of Agriculture of Ontario. The engineer was a government employee and not a consulting engineer. However, the engineer was employed by the government to assist farmers and contractors to work out their plans and although the engineer never received any payment from the contractor, the engineer had previously provided advice to the contractor in connection with the design of farm buildings.

The contractor and the engineer never met to discuss the plans but discussed the matter by telephone. Eventually, the contractor left a copy of the plans on the engineer's desk and the engineer reviewed the plans and forwarded the following hand written message to the contractor:

"Good set of plans. I like the detail. Wish I could spend that amount of time on each project. Keep up the good work."

After the manure pit was constructed in accordance with the plans, the walls of the manure pit cracked badly and had to be rebuilt.

The owner sought the advice of another engineer who redesigned the manure pit prior to the remedial construction taking place. The second engineer noted that the contractor's plans had two particular deficiencies:

(a) The plans showed the reinforcing rod to be in the middle of the wall. The rebar should have been closer to the inside of the wall for maximum support.

(b) There was a complete absence of any rebar schedule on the plans.

The second engineer concluded that the original plans were deficient insofar as the structural steel components and requirements vital to the integrity of the concrete wall were missing.

When the owner discovered that the original contractor had sought advice from the government employee engineer, the owner sued both the contractor and the government engineer on

account of the extra costs incurred by the owner in having the manure tank redesigned and reconstructed.

The government employee took the position that he really hadn't carefully reviewed the plans, but had simply looked through them. He said he didn't really understand that his advice on the detailed sufficiency of the plans was being sought.

Do you think the owner would be successful in a tort claim against the government employee engineer? In your explanation, discuss the tort law principles that a court would apply to determine whether and to what extent the government employee engineer would be liable.

8. a) The question of how long an engineer or a contractor can be sued for negligence is one that is of concern to professional engineers and to contractors. Describe the limitation periods during which engineers and contractors can be sued in tort.

b) In some construction contracts, an Engineer is authorized to be the sole judge of the performance of work by the Contractor. Where such a provision is stated, it is possible that the provision will not be enforceable on account of the manner in which the Engineer performs his duties? Explain.

c) Usually, an Engineer on a construction project is authorized to inspect the construction in order to ensure that the work proceeds in accordance with plans and specifications. Comment on the desirability of an Engineer actually instructing the Contractor on work methods and construction procedures which the Contractor should employ in carrying out the work.

d) Some construction contract contain a provision that failure of the contractor to complete work by a specific date will result in the contractor being required to make a specific payment to the owner for each day, week, or month that completion of construction is delayed. Is such a penalty provision always enforceable? Discuss.

e) Describe the circumstances in which "penalty clauses" are enforceable.

f) Briefly describe the basis upon which damages for breach of contract are calculated at common law. Explain also the meaning of "mitigating damages".

g) In a construction contract, it is common for an Engineer who is not a party to the contract to be authorized to judge the performance of the work by the contractor. Where the owner and contractor agree that the engineer shall be so authorized, it is possible that the engineer's decisions may be challenged by either the owner or the contractor on account of how the engineer performs his or her duties? Explain.

h) An Engineer may be asked to provide engineering services to friends, neighbors or community organizations of which the Engineer may be a member. Can engineers ever be liable for losses or damages arising when engineering services are provided without any fee being charged? Explain.

i) Briefly describe the legal essentials of a binding contract.

j) A contractor entered into a construction contract to build 45 houses at a mine site in northern Ontario within a twelve month period. At the end of the twelve month period, only 30 houses had been completed and the contractor abandoned the project claiming that the local labor shortage had made it impossible for him to perform pursuant to the terms of the contract. The contractor emphasized that he had never contemplated his labor shortage when he had provided the mine site owner with his quotation for the project. The contractor claimed that the contract had been frustrated.

Was the contractor justified, from a legal point of view, in abandoning the project? Explain.

k) Briefly describe how a bonus feature may be included in a guaranteed maximum price con-

struction contract to the advantage of both the owner and the contractor.

l)

9. A municipality, as owner, retained an architect to design a new police station. The architect entered into a contract with an engineering firm to perform structural design services in connection with the project.

In performing soils investigations, the engineering firm's employee engineer assigned to the project examined two shallow test pits and recommended to the architect that proper deep soils tests be taken. However, the architect rejected the engineer's recommendation, informing the engineer that expensive soils tests were not part of the owner's budget for the project.

The engineer submitted a "soils report" to the owner on the basis of the superficial examination of the shallow test pits. Neither the architect nor the engineer indicated to the owner that the engineer had recommended to the architect that a more thorough subsurface investigation be undertaken.

The design of the police station was completed and the building was constructed in accordance with the project drawings and specifications.

Within twelve months of completion of the engineering design service the new police station "settled" very badly on one code and extensive remedial foundation work was necessary to correct the settlement problems.

Upon investigation the reason for the settlement problems, another consulting engineering firm concluded that the design should never have proceeded without the more detailed and thorough subsurface investigation which the original project engineer had recommended to the architect.

What potential liabilities arise from the preceding set of facts? In identifying the potential liabilities in tort law, explain the application of tort law principles to the facts as given. Indicate a likely outcome of the matter.

10. A mining contractor signed an option contract which provided that if the mining contractor (the "optionee") performed a specified minimum amount of work of exploration services on the optionor's property within a nine month period, then the optionee would be entitled to exercise its option to acquire certain mining claims from the optionor.

Before the expiry of this nine month "option period", the optionee realized that it couldn't fulfill its obligation to expend the required minimum amount by the expiry date. The optionee notified the optionor of its problem prior to expiry of the option period and the optionor indicated that the option period would be extended. However, no written record of this extension was made, nor did the optionor receive anything from the optionee in return for the extension.

The optionee then proceeded to finally expend the specified minimum amount during the extension period. However, when the optionee attempted to exercise its option to acquire the mining claims the optionor took the position that, on the basis of the strict wording of the signed contract, the optionee had not met its contractual obligations. The optionor refused to grant the mining claims to the optionee.

Was the optionor entitled to deny the optionee's exercise of the option? Explain the contract law principles that apply to the positions taken by the optionor and by the optionee.

11. A professional engineer entered into a written employment contract with a Toronto-based civil engineering design firm. His contract of employment stated that, for a period of five years after the termination of his employment, he would not practice professional engineering either

alone, or in conjunction with, or as an employee, agent, or principal, or shareholder of an engineering firm anywhere within the City of Toronto.

During his employment with the design firm, the employee engineer dealt directly with many of the firm's clients. He became extremely skilled in preparing cost estimates, and he established a good reputation for himself within the City of Toronto.

The engineer terminated his employment with the consulting firm after three years, and immediately set up his own engineering firm in another part of the City of Toronto. His previous employers then commenced a court action for an injunction, claiming that he had breached his contract and should not be permitted to practise within the City limits.

Do you think the engineer's former employers should succeed in an action against him? I answering, state the principles a court would apply in arriving at a decision.

12. In 1967 a contractor entered into a design-build contract with an owner for the design and construction of a warehouse. The warehouse construction was completed in 1968. In 1985, the roof of the warehouse collapsed. The owner sued the contractor in 1986, alleging that the cause of the collapse was design negligence.

The contract between the owner and contractor contained no provision limiting the time during which an action could be brought against the contractor.

Was the owner entitled to sue the contractor in 1968 for design services performed more than 18 years before the roof collapse? Explain.

13. A developer/owner retained an architect to design an office tower complex in downtown Toronto. In the agreement between the developer/owner and the architect the architect agreed to be responsible for all aspects of design of the complex, including all structural, mechanical and electrical engineering design aspects.

The architect entered into a contract with a mechanical engineering firm for all mechanical engineering design services for the project, particularly the heating, ventilating and air conditioning systems.

The complex was designed and ultimately constructed at a cost of 125 million dollars.

The air conditioning system as designed and specified by the mechanical engineering firm did not perform satisfactorily, as evidenced by start-up and performance tests. Major design modifications and alterations to equipment already installed had to be undertaken at additional project costs in excess of two million dollars before the air conditioning system performed satisfactorily and the project could be completed. As a result, the completion date of the project occurred two months later than scheduled.

The developer/owner, when initially faced with the air conditioning performance shortfalls, retained a second mechanical engineering firm to investigate the reasons for the problem. The second mechanical engineering firm prepared an opinion report for the developer/owner which concluded that the employee engineer of the mechanical engineering firm that prepared the design had made significant errors in his design calculations that resulted in the deficient performance of the air conditioning system. The opinion report also stated that the suppliers of the air conditioning equipment had complied with the specifications included in the project contract documents.

What potential liabilities arise from the preceding set of facts? In identifying the potential liabilities in tort law, explain the application of tort law principles to the facts as given. Indicate a likely outcome of the matter.

14. A contractor, in designing and constructing a shopping centre in 1980, negligently designed and installed certain ceiling anchors. The shopping centre was sold to a new owner in 1987. The inadequacy of the ceiling anchors wasn't discovered until September of 1988 when the new owner undertook significant renovations and discovered that new ceiling anchors and new ceilings had to be installed.

Is the new owner entitled to recover any damages from the contractor? In your answer, describe any damages from the contractor? In your answer, describe the limitation periods during which engineers and contractors can be sued in tort.

15. A contractor submitted a bid on a construction project. The contractor's bid price of six million dollars was very low in comparison to the other bidders. In fact, the three other bidders had each bid amounts in excess of seven million dollars.

The contract was awarded to the lowest bidder. The contract conditions expressly entitled the contractor to terminate the contract if the owner did not pay monthly progress payments within ten days following certification by the project Engineer that a progress payment was due.

The low bidder commenced work on the project and soon determined that he would likely suffer a major loss on the project, as he had made significant judgement errors in arriving at his bid price. He also learned that, in comparison with the other bidders, he had "left a million dollars on the table".

After the fourth monthly progress payment was certified as due by the Project Engineer, the contractor was approached by the owner for additional information relating to bills from an equipment supplier, the cost of which comprised a portion of the fourth progress payment amount. The owner requested that the additional information be provided prior to payment of the fourth progress payment being due. Although the signed contract did not obligate the contractor to obtain such additional information, the contractor verbally informed the owner that he would provide the additional information. However, the contractor never did so.

Eleven days after the progress payment had been certified for payment, the contractor notified the owner that he was terminating the contract as the owner had defaulted in its payment obligations under the specific wording of the contract.

Was the contractor entitled to terminate the contract? Explain.

16. Jason Sharp, P.Eng., was retained by a Municipality in Southern Ontario to design and supervise the construction of a bridge. Mr. Sharp and the Municipality executed a contract for Mr. Sharp's design and supervisory services.

Mr. Sharp estimated that construction of the bridge would cost his client approximately $1,750,000. The Municipality pointed out to Mr. Sharp that budgetary restrictions were such that it would not be economically feasible for it to proceed with construction if the cost were to exceed $1,800,000.

Sharp entered into a contract with a firm of soils experts, Acme Underground Ltd., to advise him on sub-surface conditions at the site. Acme Underground Ltd. was made fully aware that its services were being requested in connection with the bridge design. On the basis of its subsurface investigations, Acme Underground Ltd. reported to Mr.Sharp that he should encounter no difficulty whatsoever with subsurface conditions, insofar as all drill holes indicated that the footings could easily be designed to rest on bedrock.

Sharp completed his detailed design, the plans and specifications were finalized and the construc-

tion of the bridge ultimately awarded to ABC Construction Limited at a cost of $1,650,000. The Municipality entered into a contract with ABC Construction Limited as General Contractor for the project. The form of the Contract had been prepared and approved by Mr.Sharp. In excavating, ABC Construction determined that the subsurface conditions were not as represented in the plans and specifications. Indeed, only two-thirds of the footings could be placed on bedrock at the design elevations. Another firm of soils experts, Subsurface Wizards Inc., was called in to investigate and ultimately concluded and reported that the Acme Underground employee who was responsible for the initial investigations hadn't drilled enough test holes to accurately predict the nature of the subsurface conditions.

After extensive additional test borings were carried out, a revised design of the structure was prepared which included the driving of piles and a new footing design to ensure a secure basis for the foundation. These changes in design resulted in an extra cost of $350,000 being requested by ABC Construction, much to the annoyance of the Municipality.

Sharp determined that ABC's price of $350,000 for the extra work was a reasonable price in light of the revised design.

What potential liabilities arise from the preceding set of facts? In identifying the potential liabilities in tort law, explain the application of tort law principles to the facts as given. Indicate a likely outcome of the matter.

17. National Stores Inc., the owner of a large chain of grocery stores in Ontario and Quebec, retained the services of an architect on a project. The purpose of the project was to build a grocery store for a new outlet in Kenora, Ontario. The architect and National Stores entered into a client/architect agreement for the project. Under the agreement, the architect was to design and to prepare the construction documentation necessary to build the store.

The architect produced a conceptual design and a set of general construction specifications for the construction. The general specifications included a requirement that an automatic sprinkler system be installed. More specifically, the sprinkler system was to conform to the National Fire Protection Association ("NFPA") standards.

In order to perform the detailed engineering aspects of the design, including the detailed design of the automatic sprinkler system, the architect retained an engineering firm. The architect and the engineering firm entered into a separate agreement to which National Stores was not a party. Under the contract, then engineering firm's design was to conform to the architect's general specifications.

The engineering firm assigned the design of the automatic sprinkler system to one of its employees, John Abel, who had recently received his engineering degree. Abel obtained a copy of the NFPA standards from his firm's library because he was not familiar with the requirements. Although he read certain section of the standards, Abel did not have enough time, given his other project responsibilities, to pay close attention to all the details. Abel completed the design of the automatic sprinkler system and it was reviewed by a professional engineer. Although the professional engineer did not perform a detailed check of the design, it appeared satisfactory to him.

Six months after the new store opened for business, it was damaged by fire very early one morning. After investigating the damage, local fire officials concluded that the fire started in a backroom storage area and quickly spread to engulf the store. The fire caused substantial damage to the store and to the inventory. In addition, National Stores had to close the store in order to repair it.

National Stores retained a consulting engineer to conduct an independent investigation. The consulting engineer determined that the design of the automatic sprinkler system was inadequate. Specifically the engineer's report indicated that the design did not conform to the NFPA standards, which required, among other things, that the coverage per sprinkler head was not to exceed 10 square meters. The engineer determined that 10% of the sprinkler heads were designed to cover an area as high as 25 square meters. The report also indicated that, in the engineer's expert opinion, had the sprinkler head spacing conformed to the NFPA standards, the fire should have been quickly extinguished and would not have spread to any great extent.

What potential liabilities in tort law arise in this case? In your answer, explain what essential principles of tort law are relevant and how each principle applies to the case. Indicate a likely outcome to the matter.

18. Hyper Eutectoid Steel Inc. ("HESI") is a company which produces various types of steel for industrial applications. In order to increase the strength of its steel products, HESI uses a process of quenching and tempering. During the quenching stage, hot steel is quickly cooled with water. During the tempering stage, the steel is then heat treated for an appropriate time. The process requires large amounts of water and heat.

Faced with rising costs for energy, HESI decided to install a heat recovery system. The system would include a heat exchanger by which heat could be recovered from the cooling water in the quenching stage. The recovered heat, then, would be used to heat the steel in the tempering stage.

HESI entered into an equipment supply contract with Energy Recovery and Recyclings Systems Inc. ("ERRS"). ERRS agreed to design, supply and install a heat recovery unit for a contract price of $600,000. After an analysis of HESI's processes ERRS determined and guaranteed in the contract that the heat recovery system would recover 40% of the heat in the cooling water and that this would result in substantial savings in energy costs.

The contract also contained a provision limiting ERRS's total liability to $600,000 for any loss, damage or injury resulting from ERRS's performance of its services under the contract.

The heat recovery system was installed and was operational; however, certain defects in the heat exchanger prevented the system from ever recovering more than 10% of the heat in the cooling water. After repeated unsuccessful attempts by ERRS to remedy the defect, HESI hired another supplier, who, for an additional $800,000, replaced the heat exchanger and was able to achieve the level of performance originally promised by ERRS. The total amount received by ERRS under its contract was $500,000.

Explain and discuss what claim HESI can make against ERRS in the circumstances. In answering, please include a summary of the development of relevant case precedents.

19. Rocky Rail Limited, the owner and operator of a railway network, retained the services of Train Engineers Design Inc. ("TEDI"), a consulting engineering firm, on a project in British Columbia. The purpose of the project was to expand Rocky Rail's service to certain areas of British Columbia.

TEDI and Rocky Rail entered into an engineering services agreement for the project. Under the contract, TEDI was to design a new rail line. The consulting firm's services were to include the design of mountain tunnels on the rail route as well as the design of the electrical system for the locomotives.

TEDI produced a design for the route and for the tunnels which included a preliminary design for

the electrical system. The preliminary design of the electrical system called for an overhead power source for the locomotives.

TEDI retained a second engineering consulting firm, Canadian Rail ElectricWorks ("CREW") to perform the detailed engineering design of the electrical system. TEDI and CREW entered into a separate agreement to which Rocky Rail was not a party.

Under the agreement, CREW was responsible for collecting all data and performing all field surveys necessary for it to design the electrical system. CREW assigned the collection of data and the performance of such surveys to Vera Able who had recently received her engineering degree. Able requested and received from TEDI all the relevant information that TEDI had in its possession that related to the design of the project, including geological and other profiles, cross section drawings of the tunnels and preliminary temperature data. Able, however. did not collect any data of her own. CREW used the information obtained by Able to design an overhead contact system to power the locomotives. The overhead contact system consisted of a copper cable suspended by means of "droppers" from the top of the tunnels.

Within two years of installation, the copper wire which made up the overhead contact system had undergone extensive damage. A metallurgical analysis revealed that the damage had been caused by stress corrosion cracking promoted by the presence of sulphur and ammonia compounds and excessive humidity in the tunnels.

Rocky Rail retained a consulting engineer to conduct an independent investigation of the corrosion. The consulting engineer determined that the design of the overhead contact system was inadequate. Specifically, the engineer's report indicated that the design did not take into account the presence of sulphur compounds and the percolation of water through the rock and that, accordingly the electrical system as designed by CREW was inadequate for the corrosive environment in which the trains were operating. The report also indicated that, in the engineer's expert opinion, a more corrosion resistant electrical system could and should have been designed.

What potential liabilities in tort law arise in this case? In your answer, explain what essential principles of tort law are relevant and how each principle applies to the case. Indicate a likely outcome to the matter.

20. A land owner retained an architect and a number of engineering firms to design various aspects of an office tower in Ottawa.

The owner entered into a design services contract with a specialist firm of vertical transportation engineers for the building's elevators. According to the contract, the specialist engineering firm was to provide all design services for a high quality elevator system. The owner promised to pay the firm $400,000 for its services.

During the course of the contract negotiations, the engineering firm proposed that the contract should include a provision limiting the engineering firm's total liability for any loss, damage or injury including consequential damages to $1 million, being the amount of the engineering firm's professional liability insurance coverage. The owner, not surprisingly, strongly objected initially to any provision limiting liability but ultimately agreed to the limitation because it was unable to locate another similar specialist that could provide the services within the time available for the design of the project. Accordingly, in spite of its initial reluctance, the owner did agree to the limitation provision when it signed the contract.

The office tower was designed and ultimately completed at a cost of $45 million. A large number of corporate tenants had entered into leases in anticipation of the tower's completion.

Two weeks before the project was scheduled for occupancy by tenants, it was discovered during start-up and performance tests that the elevator system that was designed and specified by the engineering firm did not perform adequately due to significant design errors made by the engineering firm. Specifically, the elevators would not service any of the floors below the 15th floor when they were loaded beyond one-quarter of their load capacities. As a result, the elevator system did not pass the inspection by the Ministry of Consumer and Commercial Relations and could not be put into operation.

Major design modifications and alterations to major equipment already installed had to be undertaken at an additional cost to the owner of $1.5 million before the elevator system performed satisfactorily and could be certified by the Ministry for use.

The modifications to the design and the equipment caused the completion date for the project to occur two months later than scheduled. As a result of the delay, the owner incurred additional expenses totalling $2 million due to late charges payable to tenants under the leases and the cost of extra financing to cover the project for an additional two months.

The owner sued the engineering firm for $3.5 million. The total amount that had been paid to the engineering firm by the owner pursuant to the design services agreement was $300,000.

To what is the owner legally entitled? Why? What legal principles are involved? In answering, please include a summary of the development of relevant case precedents.

21. Mammoth Undertaking Ltd. (Mammoth"), a development company, retained the firm of Sharpe Architects ("Sharpe") to design a six storey office building. Sharpe also agreed with Mammoth that Sharpe would provide or arrange for inspection services during the course of construction of the project in order to ensure that construction was carried out in accordance with the project plans and specifications.

Sharpe prepared a conceptual design and retained Abel Engineering ("Abel") to prepare the detailed structural design for the project and also to carry out inspection services to ensure that all structural aspects of the construction of the project were carried out in accordance with the project plans and specifications.

Abel prepared the structural design and eventually Mammoth awarded the contract for the construction of the project to a general contractor, Swift Construction Ltd. ("Swift").

Abel appointed one of its employee engineers, James Newman, a recent engineering graduate, as Abel's representative and inspector on the construction site.

Construction commenced during the month of October and soon thereafter Swift recommended to Mammoth that a substantial cost savings could be effected if the specified fill material around the foundation was changed to a more readily available material. Mammoth sought Sharpe's advice on the suitability of the proposed alternative fill material and indicated to Sharpe that it was most important that a decision be made as soon as possible in order to complete as much of the foundation and backfilling as possible prior to frost conditions setting in.

Sharpe, in turn, referred the matter to Abel through its representative Newman, requesting that Abel approve the proposed change as quickly as possible in the circumstances. Newman determined that the original fill material had been specified by an engineer who no longer worked for Abel and that the specification had been made on the basis of a careful investigation of soil conditions at the site. Newman contacted one of Abel's vice-presidents and was authorized to advise Sharpe as to the suitability of the alternative fill material after conducting an appropriate investigation.

Under pressure from both Mammoth and Swift to approve the proposed fill material without

delaying the construction schedule, Newman approved the change of materials without giving due consideration to the possible repercussions.

The substitute material did not drain as well as the material originally specified; in fact, it retained some water and, as it expanded during freeze up, it caused significant cracking in the foundation walls, necessitating remedial work resulting in substantial additional expense being incurred by Mammoth. In addition, the completion of the project was considerably delayed as a result.

Explain the potential liabilities in tort law arising from the preceding set of facts. In your explanation, discuss and apply the principles of tort law and indicate a likely outcome of the matter.

22. Provincial Life of Ontario Inc. ("Provincial"), an insurance company, retained an architect, to design a new corporate head office in North York, Ontario, Provincial, as client, and the architect entered into a written client/architect agreement in connection with the project. According to the agreement, the architect was to prepare the complete architectural and engineering design for the project.

In order to carry out the structural engineering aspects of the design, the architect engaged the services of a structural engineering firm. The architect and the structural engineering firm entered into a separate agreement to which Provincial was not a party.

To determine the nature of soil on which the project would be constructed, two shallow test pits, each about 1.25 meters deep, were dug on the site at locations selected by the architect. The architect telephoned the structural engineering firm's vice-president and requested that he send out a professional engineer from his firm to examine the soils exposed in the test pits.

Based on information received from the professional engineer sent to examine the soil, the vice-president of the structural engineering firm reported to the architect that the test pit had revealed a silty clay. The vice president also recommended to the architect that a soils engineer be engaged to carry out more thorough and proper soils tests. The architect rejected the recommendation stating that there was not "enough room in the budget" for more soils tests.

The architect succeeded in persuading the vice-president to send a letter to Provincial giving a "soils report" based on the examination of the shallow test pits. The vice-president stated in his letter to Provincial, that based on its examination of the test pits, the soil was a fairly uniform mixture of clay and silt which would be able to support loads up to 100KPa.

The structural engineering firm then completed its structural engineering design on the basis of the maximum soil load reported to Provincial.

The project was constructed in accordance with the plans and specifications. Subsequently, the building suffered extensive structural change, including severely cracked and uneven floors and walls.

On the basis of an independent engineering investigation by an engineer retained by Provincial, it was determined that the extensive structural change in the building had resulted from the substantial and uneven settlement of the building. The investigation also determined that the subsoil in the area of the building consisted of 30 to 40 meters of compressible marine clay covered by a surface layer of dryer and firmer clay two meters in depth. The investigation also revealed that the test pits that were dug had not penetrated the surface layer into the lower layer of compressible material.

What potential liabilities in tort law, arise from the preceding set of facts? Please state the essential principles applicable to a tort action and apply these to the facts above. Indicate a likely outcome of the matter.

23. ACE Construction Inc. is a company primarily engaged in the business of supplying heavy equipment used in construction. As part of the company's economic plan to expand its business, ACE became interested in the rock crushing industry.

ACE had become aware that International Metals Company Ltd. ("IMCO") required a contractor to crush, weigh and stockpile approximately 250,000 tons of ore. As ACE believed this was an excellent opportunity to venture into venture into the rock crushing business, it decided to tender on the IMCO contract.

In order to tender on the contract, ACE set out to purchase the necessary equipment to crush the material. ACE was contracted by a representative of Rock Busters Ltd., a company which sold such equipment. After visiting the IMCO site and determining the nature of the material to be crushed, the representative discussed the IMCO contract with ACE. After performing a number of calculations, the representative determined and guaranteed that the equipment Rock Busters would provide would be capable of crushing the material at a rate of 175 tons per hour. On the basis of the guarantee, Rock Busters and ACE entered into a contract. Rock Busters agreed that if ACE were successful in its tender to IMCO, RockBusters would provide the equipment for a price of $400,000. The contract also contained a. provision for limiting Rock Busters' total liability to $400,000 for any loss, damage or injury resulting from Rock Buster's performance of its services under the contract.

Based on the information provided by the representative, ACE prepared and submitted its tender to IMCO. IMCO accepted the tender and entered into a contract with ACE to crush the material.

The rock crushing equipment was set up at the IMCO site by employees of Rock Busters and crushing operations commenced. However, from the beginning there was trouble with the operation. One of the components of the crusher, called the cone crusher, consistently became plugged by the accumulation of material. Each time the cone crusher had to be shut down and the blockage cleared manually. In some cases, such blockages caused damage to the equipment. Rock Busters made several unsuccessful attempts to correct the defect by making modifications at the site and at its factory. The crushing equipment was never able to crush more than 30 tons of material per hour.

In order to meet its obligations under the IMCO contract, ACE hired another supplier to correct the defects in the Rock Busters equipment. For an additional $500,000 the supplier replaced the cone crusher with one manufactured by another company. The modified equipment was able to crush the material at the rate of 180 tons per hours. The total amount which had been paid by ACE to Rock Busters was $350,000.

Explain and discuss what claim ACE can make against Rock Busters in the circumstance. Would ACE be successful in its claim? Why? In answering, please include a summary of the development of relevant case precedents.

24. An owner and a contractor entered into a written construction contract. According to the contract, the contractor would be paid a lump sum price to construct a factory. The contractor was to complete the work by August 30, 1992.

The contract provided that if the owner delayed the contractor in performing the work, the contractor would be entitled to additional time in completing the work and to be reimbursed by the owner for reasonable costs incurred by the contractor as a result of the delay. Section 4.3 of the contract provided:

"Section 4.3: No claim for a time extension of for costs shall be made for delay unless a written notice describing the delay is given to the owner not later than 14 calendar days after the commencement of the delay."

Under the contract, the owner was to purchase and supply specialized manufacturing equipment which the contractor was to install in the factory. The owner was to arrange for and have the equipment delivered to the site by March 15, 1992. The owner delivered the equipment on March 22, 1992 and the contractor immediately commenced to install it. At a meeting at the site between the owner and the contractor on March 23, 1992 to discuss the status of the work, the contractor verbally indicated that it had incurred additional labor and equipment rental costs as a result of the owner's delay in delivering the manufacturing equipment. The contractor explained that because the manufacturing equipment was not available as scheduled, the contractor had incurred 8-person days in additional labor costs and two days' in rental costs for a crane. The contractor said that it would be seeking compensation for these additional costs. The owner assured the contractor that it would be paid for the delay and asked the contractor to provide the owner with a detailed written statement of the additional costs "within the next month or so."

On April 10, 1992, the contractor provided the owner with a detailed written statement indicating additional costs of $9,400 as a result of the delay. On May 10, 1992, the owner responded to the contractor's detailed statement and indicated that the contractor was not entitled to the additional costs claimed because the contractor had failed to give the owner a written notice of delay within the time required by section 4.3 of the contract.

Is the contractor entitled to the additional costs claimed? Explain.

25. Ontario Industrial Laundry Inc. ("OILI") is the owner of several laundry plants in Ontario. OILI's operations include handling laundry for various industrial and institutional facilities around the province. OILI decided to build a large new plant in Brampton. The new plant would replace a number of smaller and aging facilities OILI operated nearby.

OILI engaged an architectural firm, Clever and Really Useful Design Developments Inc. ("CRUDDI"), and entered into an architectural services agreement with it. Under the agreement, CRUDDI was to design the new plant and prepare construction documentation necessary to build it. According to the agreement, CRUDDI was to design "the most modern and technically up-to-date laundry in Canada."

CRUDDI hired a number of engineering consultants to provide the various engineering design services necessary for the project. Of these, Mechanical Engineering Systems and Services Inc. ("MESSI") was to design the air conditioning and handling system.

Although MESSI did not have a contract with OILI, it worked closely with a representative of OILI who specified that, as it was important to provide comfortable working temperatures in the plant, the air conditioning and handling system must be able to provide working temperatures in the range of 22° to 25° and a minimum of 18 air changes per hour.

OILI, on the basis of competitive tenders, awarded the contract for the construction of the new plant to Dominion Industries and Related Technologies ("DIRTI"). The contract price was $15,000,000. DIRTI completed the construction in accordance with the contract drawings and specifications.

Almost immediately after having commenced its operations in the new plant, OILI experience problems in the air conditioning and handling system. The temperature in the working areas was excessive, reaching 38°C in the summer months. In the compressor room, the temperature

reached 50°C and caused malfunctions. In addition, the circulation was poor and the air quality was offensive. The employees began suffering fatigue and other ailments and it became necessary for them to take frequent “heat breaks”.

CRUDDI and MESSI tried several times to remedy the problems but they were unsuccessful. OILI retained Top Industrial Designs Inc. (“TIDI”), another mechanical engineering company, to conduct an independent investigation. TIDI determined that the air conditioning and handling system was underdesigned. The air conditioner’s chilling unit had a capacity of only 230 tons; a large unit having a capacity in the order of 600 tons should have been specified. In addition, the exhaust and intake vents on the roof were located too close to each other and caused exhaust air to reenter the plant.

TIDI determined that the system would require $1.1 million in modifications in order to meet the plant’s specifications. It also indicated that, had the system been specified and constructed as it ought to have been in the first place, construction costs incurred by OILI would have been $400,000 higher, that is $15,400,000.

What potential liabilities in tort law arise in this case? In you answer, explain what principles of tort law are relevant and how each applies to the case. Indicate a likely outcome to the matter.

26. An owner and a contractor entered into a written contract for the construction of a $20,000,000 chemical plant in Sarnia, Ontario. The contract provided that the plant would be constructed in accordance with the plans and specifications that had been prepared by the owner’s engineering consultant. Under the contract, the owner, through the engineering consultant, was permitted to make changes to the design of the plant with the amount payable to the contractor being adjusted accordingly. However, the contract further provided that the contractor could not proceed with any change in the work without a written order signed by the owner and that no claim for additional compensation on account of a change would be valid without such a written order.

As the work progressed, the engineering consultant certified payments for amounts due to the contractor on the basis of the amount of work performed during each month. Several of the monthly payments included additional compensation for extra work performed by the contractor on account of relatively minor changes to the design of the plant. In total there were 55 such changes. In each case, the contractor had proceeded with the extra work and was paid additional compensation despite the fact that no written order was given by the owner authorizing the extra work of the additional compensation.

During the course of the work, the engineering consultant made a major change to the design of the plant. It was anticipated that the change would require and additional $1.7 to $2.0 million of work by the contractor and would require four months to complete. The contractor requested the owner’s approval before proceeding with the extra work. The owner indicated orally to the contractor that the contractor should proceed with the work and that a written order authorizing the change would be issued once the details of the design change were finalized.

The contractor commenced performing the additional work for the major design change in January, 1990 and invoiced the owner on a monthly basis. Although the owner never did issue a written order authorizing the additional work, the contractor was paid for the additional work that was performed in January, February and March of 1990. The contractor completed all of the extra work in April 1990 and submitted an invoice for payment which included $950,000 on account of extra work performed in April.

The owner refused to pay the $950,000 on the basis that no written order by the owner was given authorizing any extra work, as required by the written contract. Is the contractor entitled to the $950,000? Explain.

27. A supplier of information technology hardware, ABC Hardware ("ABC"), submitted a fixed price bid on a computer installation project for a large accounting firm. ABC's bid price of six million dollars was very low in comparison to the other bidders. In fact, the three other bidders had each bid amounts in excess of nine million dollars.

The contract was awarded to the lowest bidder. The contract conditions expressly entitled the contractor to terminate the contract if the owner did not pay monthly invoices within thirty days following receipt of an invoice.

ABC commenced supplying computer hardware on the project and soon determined that it would likely suffer, a major loss on the project, as it had made significant judgment errors in arriving at its bid price. ABC also learned that, in comparison with the other bidders, ABC had "left three million dollars on the table".

After the fifth invoice was delivered, ABC was approached by the accounting firm for additional information and explanation of bills from an equipment parts supplier, the cost of which comprised a portion of the fifth invoiced amount. The accounting firm requested that the additional information be provided prior to payment of the fifth invoice being due. Although the signed contract did not obligate ABC to obtain such additional information, a representative of ABC verbally informed the accounting firm that ABC would provide the addition information. However, ABC never did so.

Thirty-one days after the fifth invoice had been received, ABC notified the accounting firm that ABC was terminating the contract as the accounting firm had defaulted in its payment obligations under the specific wording of the contract.

Was ABC entitled to terminate the contract? Explain the relevant legal principle and how it should be applied in this situation.

28. A telecommunications development company leased an outdated and unused.underground.pipe system from an Ontario municipality. The developer's purpose in leasing the pipe was to use it as an existing conduit system in which to install a fibre optic cable system to be designed, constructed and operated in the municipality by the telecommunications developer during the term of the lease. AU necessary approvals from regulatory authorities were obtained with respect to the proposed telecommunications network.

The telecommunications development company then entered into an installation contract with a contractor. For the contract price of $4,000,000, the contractor undertook to complete the installation of the cable by a specified completion date. The contract specified that time was of the essence and that any contract was to be completed by the specified completion date, failing which the contractor would be responsible for liquidated damages in the amount of $50,000 per day for each day that elapsed between the specified completion date and the subsequent actual completion date. The contract also contained a provision limiting the contractor s maximum liability for liquidated damages and for any other claim for damages under the contract to the maximum amount of $1,000 000

Due to its failure to properly staff and organize its workforce, the contractor to meet the specified completion date. In addition, during the installation, the contractor's inexperienced workers damaged significant amounts of the fibre optic cable, with the result that, the telecommunica-

tions development company, on subsequently discovering the damage, incurred substantial additional expense in engaging another contractor to replace the damaged cable. Ultimately, the cost of supplying and installing the replacement cable plus the amount of liquidated damages for which the original contractor was responsible because of its failure to meet the specified completion date, totalled $1,800,000.

Explain and discuss what claim the telecommunications development company could make against the contractor in the circumstances. In answering, explain the approach taken by Canadian courts with respect to contracts that limit liability and include a brief summary of the development of relevant case precedents.

29. (a)An environmental consulting firm, E Inc., was retained by a large manufacturing company, Acme Ltd. E Inc. was retained to prepare an environmental compliance audit as Acme Ltd. was contemplating the possibility of a sale of two of its properties.

E Inc. carried out the environmental compliance audit with respect to each of the properties and submitted its reports on each property. Included at the outset of each report was the following statement:

"This report was prepared by E Inc. for the account of Acme Ltd. The material in it reflects E Inc.’s best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such third parties.E Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."

Some time later, Acme Ltd. sold each of the two properties to Acquisitions Inc. In negotiating the sale with Acquisitions Inc., E Inc.’s reports were shown to Acquisitions Inc., but Acquisitions Inc. had no dealings with E Inc. E Inc. had no knowledge of the sale to Acquisitions Inc. until approximately four years later when Acquisitions Inc. commenced a lawsuit against E Inc. Acquisitions Inc. claimed it had commenced the lawsuit in tort against E Inc. because it had encountered hazardous substances on one of the properties and had subsequently obtained the opinion of another environmental consulting firm who confirmed that the report in question by E Inc. contained negligent misstatements. Acquisitions Inc. claimed in its lawsuit that E Inc. was aware that the report might be shown to a prospective purchaser and, accordingly, E Inc. should be responsible for damages arising as a result of reliance by Acquisitions Inc. on the negligent misstatements in E Inc.’s report.

Should E Inc. be liable in the circumstances? Explain.

(b) - The Ontario Human Rights Code protects employees against certain types of behavior in the workplace. Briefly identify (list) five examples of inappropriate conduct in the workplace that are prohibited by the Ontario Human Rights Code.

(c)The question of how long an engineer or a contractor can be sued for negligence or breach of contract is one that is of concern to professional engineers and to contractors. Describe the limitation periods during which engineers and contractors can be sued in tort and in contract.

30. Live Rail Inc. ("Live Rail"), a company specializing in the manufacture and installation of railway commuter systems was awarded a contract by a municipal government to design and build a significant transit facility in British Columbia. The contract specified electrically pow-

ered locomotives. As part of the design, Live Rail was contractually obligated to design an overhead contact system in a tunnel. Live Rail subcontracted the subdesign of the overhead contact system to a consulting design firm, EverWorks Limited ('EverWorks').

Ever Works designed an overhead contact system in the tunnel, however, in doing so it did not carry out any testing nor did it gather any data of its own relating to the conditions inside the tunnel. It did not even request copies of underlying reports which, had they been examined, would have indicated that there was a large volume of water percolating through the tunnel rock and that the tunnel rock contained-substantial amounts of sulphur compounds. The project documentation that was turned over to Ever Works by Live Rail did not include the underlying reports, but did identify the existence and availability of the underlying reports.

The construction of the rail system through the tunnel was completed in accordance with the Ever Works' design. However, within eight months of completion, the overhead contact system in the tunnel became severely corroded and damaged due to the water seepage in the tunnel resulting in a very humid atmosphere that promoted stress corrosion cracking damage, accelerated by the presence of hydrogen sulphide, ammonia and nitrites.

As a result of the corrosion damage, the municipality had to spend substantial additional money on redesigning and rewiring the system.

What potential liabilities in tort law arise in this case? In your answer, explain what principles of tort law are relevant and how each applies to the case. Indicate a likely outcome to the matter.

31. A mining contractor signed an option contract with a land owner which provided that if the mining contractor (the "optionee") performed a specified minimum amount of exploration services on the property of the owner (the "optionor") within a nine month period, then the optionee would be entitled to exercise its option to acquire certain mining claims from the optionor.

Before the expiry of this nine month "option period", the optionee realized that it couldn't fulfil its obligation to expend the required minimum amount by the expiry date. The optionee notified the optionor of its problem prior to expiry of the option period and the optionor indicated that the option period would be extended. However, no written record of this extension was made, nor did the optionor receive anything from the optionee in return for the extension.

The optionee then proceeded to perform the services and to finally expend the specified minimum amount during the extension period. However, when the optionee attempted to exercise its option to acquire the mining claims the optionor took the position that, on the basis of the strict wording of the signed contract, the optionee had not met its contractual obligations. The optionor refused to grant the mining claims to the optionee.

Was the optionor entitled to deny the optionee's exercise of the option? Identify the contract law principles that apply, and explain the basis of such principles and how they apply, to the positions taken by the optionor and by the optionee.

32.An information technology firm assigned to one of its junior employee engineers the task of developing special software for application on major bridge designs. The employee engineer had recently become a professional engineer and was chosen for the task because of the engineer's background in both the construction and the 'software engineering' industries.

The firm's bridge software package was purchased and used by a structural engineering design firm on a major bridge design project on which it had been engaged by contract with a municipal government.

Unfortunately, the bridge collapsed in less than one year after completion of construction. Motorists were killed and injured.

The resulting investigation into the cause of the collapse concluded that the design of the bridge was defective and that the software implemented as part of the design did not address all of the parameters involved in the scope of this particular bridge design. The investigators concluded that although the design software would suffice for certain types of structures it was not appropriate in the circumstances of the particular subsurface conditions and length of span required for this particular application. The investigators' report also indicated that the design software package was not sufficiently explicit in warning users of the software of the scope of the design parameters addressed by the software. The investigators 'report also stated that even an experienced user of the software might reasonably assume that the software would be appropriate for application on this particular project and that too little attention had been paid to ensuring that adequate warnings had been provided to software users of the limitations on the application of the software.

What potential liabilities in tort law arise in this case? In your answer, explain what principles of tort law are relevant and how each applies to the case. Indicate a likely outcome to the matter.

33. (a) The Ontario Human Rights Code protects employees against certain types of behavior in the workplace. Briefly identify (list) five examples of inappropriate conduct in the workplace that are prohibited by the Ontario Human Rights Code.

(b) A professional engineer entered into a written employment contract with a Toronto-based civil-engineering design firm. The engineer's contract of employment stated that, for a period of five years after the termination of employment, the engineer would not practise professional engineering either alone, or in conjunction with, or as an employee, agent, principal, or shareholder of an engineering firm anywhere within the City of Toronto.

During the engineer's employment with the design firm, the engineer dealt directly with many of the firm's clients. The engineer became extremely skilled in preparing cost estimates, and established a good personal reputation within the City of Toronto.

The engineer terminated the employment contract with the consulting firm after three years, and immediately set up an engineering firm in another part of the City of Toronto. The engineer's previous employers then commenced a court action for an injunction, claiming that the engineer had breached the employment contract and should not be permitted to practise within the City limits.

Do you think the engineer's former employers should succeed in an action against the engineer? In answering, state the principles a court would apply in arriving at a decision.

(c) The question of how long an engineer or a contractor can be sued for negligence or breach of contract is one that is of concern to professional engineers and to contractors. Describe the limitation periods during which engineers and contractors can be sued in tort and in contract.

34. A $30,000,000 contract for the design, supply and installation of a cogeneration facility was entered into between a pulp and paper company ("Pulpco") and an industrial contractor. The cogeneration facility, the major components of which included a gas turbine, a heat recovery steam generator and a steam turbine, was to be designed and constructed to simultaneously generate both electricity and steam for use by Pulpco in its operations.

The contract provided that the electrical power generated by the cogeneration facility was not to be less than 25 megawatts. A liquidated damages provision was included in the contract speci-

fying a pre-estimated amount payable by the contractor to Pulpco for each megawatt of electrical power generated that was less than the amount specified. Other provisions specified additional liquidated damages at prescribed rates relating to other matters under the contract, including any failure by the contractor to meet the required heat rates or to achieve completion of the facility for commercial use by a stipulated date. However, the contract also included a "maximum liability" provision that limited to $5,000,000 the contractor's liability for all liquidated damages due to failure to achieve (i) the specified electrical power output, (ii) the guaranteed heat rate and (iii) the specified completion date. The contract clearly provided that under no circumstances was the contractor to be liable for any other damages beyond the overall total of $5,000,000 for liquidated damages. Pulpco's sole and exclusive remedy for damages under the contract was strictly limited to the total liquidated damages, up to the maximum of $5,000,000. The contract specified that Pulpco was not entitled to make any other claim for damages, whether on account of any direct, indirect, special or consequential damages, howsoever caused.

Unfortunately the contractor's installation fell far short of the electrical power generation specifications (achieving less than 25% of the specified megawatts) and the heat rate specifications provided in the contract. The contractor was paid $27,000,000 before the problems were identified on startup and testing. Because of its very poor performance, the contractor also failed to meet the completion date by a very substantial margin. Applying the liquidated damages provisions, the contractor's overall liability for all liquidated damages under the contract totalled $4,000,000. Ultimately Pulpco had to make arrangements through another contractor for new equipment items and parts to be ordered and installed in order to enable the cogeneration facility to meet the technical specifications, with the result that the total cost of the replacement equipment and parts reached an additional $115,000 000 beyond the original contract price of $30,000,000.

Explain and discuss what claim Pulpco could make against the contractor in the circumstances. In answering, explain the approach taken by Canadian courts with respect to contracts that limit liability and include a brief summary of the development of relevant case precedents.

35. (a) Briefly define, and explain the differences between, (i) sole proprietorship, (ii) partnership, and (iii) the corporation.

(b) Some construction contracts contain a provision that failure of the contractor to complete the work by a specific date will result in the contractor being required to make a specified payment to the owner for each day, week or month that completion of construction is delayed. Is such a penalty provision always enforceable? Discuss.

(c) The question of how long an engineer or a contractor can be sued for negligence or breach of contract is one that is of concern to professional engineers and to contractors. Describe the limitation periods during which engineers and contractors can be sued in tort or contract.

36.Ontario Industrial Laundry Inc. ("OILI") owns several laundry plants in Ontario.OILI's operations include handling the laundry for various customers around the province. OILI decided to build a large new plant in Brampton to replace a number of smaller and aging OILI facilities.

OILI engaged an architectural firm, Clever and Really Useful Design Developments Inc. ("CRUDDI"), and entered into an architectural services agreement with it. Under the agreement, CRUDDI was to design the new plant and prepare plans and specifications necessary to build it. According to the agreement, CRUDDI was to design "the most modern and techni-

cally up- to-date laundry in Canada."

CRUDDI hired several consultants to provide the various services necessary for the project. Of these, Mechanical Engineering Systems and Services Inc. ("MESSI") was to design the air conditioning and handling system.

Although MESSI did not have a contract with OILI, it worked closely with a representative of OILI who specified that, as it was important to provide comfortable working temperatures in the plant, the air conditioning and handling system must be able to provide working temperatures in the range of 22deg to 25deg C and a minimum of 18 air changes per hour.

OILI, on the basis of competitive tenders, awarded the contract for the construction of the new plant to Dominion Industries and Related Technologies Inc.' ("DIRTI"). The contract price was $15,000,000. DIRTI completed the construction in accordance with the contract drawings and specifications.

Almost immediately after having commenced its operations in the new plant, OILI experienced problems in the air conditioning and handling system. The temperature in the working areas was excessive, reaching 38deg C in the summer months. In the compressor room, the temperature reached 50deg C and caused malfunctions. In addition, the circulation was poor and the air quality was offensive. The employees began suffering fatigue and other ailments and it became necessary for them to take frequent "heat breaks".

CRUDDI and MESSI tried several times to remedy the problems but they were unsuccessful. OILI retained Top Industrial Designs Inc. ("TIDI"), another mechanical engineering company, to conduct an independent investigation. TIDI determined that the air conditioning and handling system was underdesigned. The air conditioner's chilling unit had a capacity of only 230 tons; a larger unit having a capacity in the order of 600 tons should have been specified. In addition, the exhaust and intake vents on the roof were located too close to -each other and caused exhausted air to re-enter the plant.

TIDI determined that the system would require $1.1 million in modifications in order to meet the plant's specifications. It also indicated that, had the system been specified and constructed as it ought to have been in the first place, construction costs incurred by OILI would have been $400,000 higher, that is, $15,400,000.

What potential liabilities in tort law arise in this case? In your answer, explain what principles of tort law are relevant and how each applies to the case. Indicate a likely outcome to the matter.

37. Arbour Pulp & Paper Company ("ARBOUR") entered into a written equipment supply contract with Recovery Exchangers and Turbines Inc. ("RECOVERY"). According to the agreement, RECOVERY was to design, manufacture and deliver a heat recovery steam generator to ARBOUR's pulp and paper mill in Ontario for a purchase price of $3.5 million. ARBOUR would arrange to install the equipment in its mill as part of a cogeneration system for the purpose of converting steam into electricity.

According to the agreement, RECOVERY was to begin manufacturing the equipment on February 1, 1992 and deliver the finished product to ARBOUR on or before March 30, 1993. The agreement provided that ARBOUR would pay the $3.5 million purchase price in monthly installments over the manufacturing period. The agreement contained the following provision:

"Each instalment of the purchase price shall become due and payable by ARBOUR on the last day of the month for which the instalment is to be made. If ARBOUR fails to pay any instalment within 10 days after such instalment becomes due, RECOVERY shall be entitled to stop performing its work under this contract or term invalidate this contract."

As the work progressed, RECOVERY invoiced ARBOUR for each monthly instalment. Although ARBOUR paid the first instalment on time, it was more than 20 days late in paying each of the second, third, fourth, fifth and sixth installments. RECOVERY never once complained about the late payments, even when ARBOUR apologized for the delayed payments and commented in meetings with RECOVERY that ARBOUR's current cash flow difficulties resulting from the impact of recessionary times, were the reasons for the late payments.

By the middle of September 1992, it became apparent to RECOVERY that due to serious cost overruns resulting from its own design errors and lack of productivity, it would stand to lose a substantial amount of money on the contract by the time the equipment would be completed. Although the instalment for August had been invoiced and was due on August 31, 1992, ARBOUR had not yet paid it by September 15, 1992. On September 15, 1992, RECOVERY terminated the contract.

Was RECOVERY entitled to terminate the contract? Explain.

38. Clearwater Limited, a process-design and manufacturing company, entered into an equipment-supply contract with Pulverized Pulp Limited. Clearwater agreed to design, supply, and install a cleaning system at Pulverized Pulp's Ontario mill for a contract price of $200,000.The specifications for the cleaning system stated that the equipment was to remove ninety-five percent of the prescribed chemicals from the mill's liquid effluent in order to comply with the requirements of the environmental control authorities in the area in which the mill was located. However, the contract clearly provided that Clearwater accepted no responsibility whatsoever for any indirect of consequential damage, such as lost profits, arising as a result of the contract.

The cleaning system installed by Clearwater did not meet the specifications, but this was not determined until after Clearwater had been paid $180,000 by Pulverized Pulp. In fact, only seventy percent of the prescribed chemicals were removed from the effluent.

As a result, Pulverized Pulp Limited was fined $10,000 and was shut down by the environmental control authorities. Clearwater made several attempts to remedy the situation by altering the process and cleaning equipment, but without success.

Pulverized Pulp eventually contracted with another equipment supplier. For an additional cost of $250,000, the second supplier successfully redesigned and installed remedial process equipment that cleaned the effluent to the satisfaction of the environmental authorities, in accordance with the original contract specifications between Clearwater and Pulverized Pulp.

Explain and discuss what claim Pulverized Pulp Limited can make against Clearwater Limited in the circumstances.

39. A long established manufacturing company, Acme Ltd., contemplating the possibility of a sale of some of its properties, retained an environmental consulting firm, E Inc., to prepare an environmental compliance audit.

The Vice-President of E Inc. responsible for the performance of the environmental compliance audit, herself a professional engineer, turned the matter over to one of her department's engineering employees. The engineering employee in question to whom the matter was referred had only recently qualified as a professional engineer. However, on the basis of previous assignments, the Vice- President had been very impressed by the young engineer's abilities. The Vice- President was also aware that her extremely busy schedule would likely limit the amount of time she could spend on the environmental compliance audit herself and, accordingly, selected the younger employee engineer in the hope that his involvement, particularly in

view of his impressive performance on previous matters, would decrease her supervisory time in connection with the audit.

The employee engineer carried out an environmental compliance audit with respect to each of the properties identified and E Inc. submitted its reports on each property. Included at the outset of each report was the following qualifying statement:

'This report was prepared by E Inc. for the account of Acme Ltd. The material in it reflects E Inc.'s best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such third parties, E Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report."

Some time later, Acme Ltd. sold two of its properties to Acquisitions Inc. In negotiating the sale with Acquisitions Inc., E Inc.'s reports were shown to Acquisitions Inc., but Acquisitions Inc. had no dealings with E Inc. E Inc. had no knowledge of the sale to Acquisitions Inc. until approximately four years later when Acquisitions Inc. commenced a lawsuit against E Inc. Acquisitions Inc. claimed it had commenced the lawsuit in tort against E Inc. because it had encountered hazardous substances on one of the properties and had subsequently obtained the opinion of another environmental consulting firm who confirmed that the report in question by E Inc. contained negligent misstatements which, in the opinion of the second consulting firm, had resulted from E Inc.'s representatives having spent too little time investigating the property for hazardous substances. Acquisitions Inc. claimed in its lawsuit that E Inc. was aware that the report might be shown to prospective purchasers and, accordingly, E Inc. should be responsible for damages arising as a result of reliance by Acquisitions Inc. on the negligent misstatements in E Inc.'s report.

What potential liabilities in tort law arise in this case? In your answer, explain what principles of tort law are relevant and how each applies to the case. Indicate a likely outcome to the matter. In your answer indicate if your conclusion would differ if the reports by E Inc. had not contained the qualifying statement identified above and, if your conclusion would differ, explain why.

40. (a)The Ontario Human Rights Code protects employees against certain types of behavior in the workplace. Briefly identify (list) five examples of inappropriate conduct in the workplace that are prohibited by the Ontario Human Rights Code.

(b)Engineers, as creative professionals, may require industrial (i.e. intellectual) property protection. Briefly identify 3 types of industrial property protection and the duration of protection provided by each.

(c)In some construction contracts, an engineer is authorized to be the sole judge of the performance of work by the contractor. Where such a provision is stated, is it possible that the provision will not be enforceable on account of the manner in which the engineer performs his or her duties? Explain.

(d)The question of how long an engineer or a contractor can be sued for negligence or breach of contract is one that is of concern to professional engineers and to contractors. Describe the limitation periods during which engineers and contractors can be sued in tort and in contract.

41. ACE Construction Inc. is a company primarily engaged in the business of supplying heavy equipment used in construction. As part of the company's economic plan to expand its business, ACE became interested in the rock crushing industry.

ACE had become aware that International Metals Company Ltd. ("IMCO") required a contractor to crush, weigh and stockpile approximately 250,000 tons of ore. As ACE believed this was an excellent opportunity to venture into the rock crushing business, it decided to tender on the IMCO contract.

In order to tender on the contract, ACE set out to purchase the necessary equipment to crush the material. ACE was contacted by a representative of Rock Busters Ltd., a company which sold such equipment. After visiting the IMCO site and determining the nature of the material to be crushed, the representative discussed the IMCO contract with ACE. After performing a number of calculations, the representative determined and guaranteed that the equipment Rock Busters would provide would be capable of crushing the material at a rate or 175 tons per hour. On the basis of the guarantee, Rock Busters and ACE entered into a contract. Rock Busters agreed that if ACE were successful in its tender to IMCO, Rock Busters would provide the equipment for a price of $400,000. The contract also contained a provision limiting Rock Busters' total liability to $400,000 for any loss, damage or injury resulting from Rock Busters' performance of its services under the contract.

Based on the information provided by the representative, ACE prepared and submitted its tender to IMCO. IMCO accepted the tender and entered into a contract with ACE to crush the material.

. The rock crushing equipment was set up at the IMCO site by employees of Rock Busters and crushing operations commenced. However, from the beginning there was trouble with the operation. One of the components of the crusher, called the cone crusher, consistently became plugged by the accumulation of material. Each time the cone crusher became plugged, the operation would have to be shut down and the blockage cleared manually. In some cases, such blockages caused damage to the equipment. Rock Busters made several unsuccessful attempts to correct the defect by making modifications at the site and at its factory. The crushing equipment was never able to crush more than 30 tons of materials per hour.

In order to meet its obligations under the IMCO contract, ACE hired another supplier to correct the defects in the Rock Busters equipment. For an additional $500,000 the supplier replaced the cone crusher with one manufactured by another company. The modified equipment was able to crush the material at the rate of 180 tons per hour. The total amount which had been paid by ACE to Rock Busters was $350,000.

Explain and discuss what claim ACE can make against Rock Busters in the circumstances. Would ACE be successful in its claim? Why? In answering, please include a summary of the development of relevant case precedents. In particular, point out how the law changed because of these relevant case precedents.

42. A supplier of information technology hardware, ABC Hardware ("ABC"), submitted a fixed price bid on a computer installation project for a large accounting firm. ABC's bid price of six million dollars was very low in comparison to the other bidders. In fact, the three other bidders had each bid amounts in excess of nine million dollars.

The contract was awarded to the lowest bidder. The contract conditions expressly entitled the contractor to terminate the contract if the owner did not pay monthly invoices within thirty days following receipt of an invoice.

ABC commenced supplying computer hardware on the project and soon determined that it would likely suffer a major loss on the project, as it had made significant judgment errors in arriving at its bid price. ABC also learned that, in comparison with the other bidders, ABC had "left

three million dollars on the table'.

After the fifth invoice was delivered, ABC was approached by the accounting firm for additional information and explanation of bills from an equipment parts supplier, the cost of which comprised a portion of the fifth invoiced amount. After a lengthy meeting on the subject, during which some clarification of the information was provided, the accounting firm requested that further additional information be provided prior to payment of the fifth invoice being due. Although the signed contract did not obligate ABC to obtain such additional information, a representative of ABC verbally informed the accounting firm that ABC would provide the additional information as requested, and prior to payment of the fifth invoice being due. However, ABC never did so.

Thirty-one days after the fifth invoice had been received, ABC notified the accounting firm that ABC was terminating the contract as the accounting firm had defaulted in its payment obligations under the specific wording of the contract.

43. A contractor decided to use a computer program to prepare its bid for tendering on a construction project. Having been approached by a software developer promoting its software package for bid preparation, the contractor dealt with the software developer and entered into a contract in the form of a license agreement authorizing the contractor to use the software. However, the contract between the contractor and the software developer also included an express provision which limited the software developer's liability on account of any damages that the contractor might suffer as a result of using the software to the amount of the license fee paid by the contractor for the use of the software. The licence fee for the software package was $25,000.

The contractor used the software program to prepare a bid for an important contract opportunity. Unformtunately, the software contained a software defect, a flaw which resulted in the bid price that the contractor submitted on the project being understated by $2,000,000. Because of the understated price, the contractor was the lowest bidder and the contract was awarded to the contractor.

The owner insisted that the contractor perform its obligations on award of the contract, even though the contractor attempted to persuade the owner that its low price was due to a software defect. The contractor performed the work under the contract as best it could, and upon completion of the contract determined that its loss on the project amounted to $1,400,000.

The contractor claimed that its loss of $1,400,000 was entirely due to the software defect. The contractor retained an independent expert who confirmed that the contractor had performed as well as it could have on the project and that the losses were in fact due to the pricing error that had resulted from the software defect.

The contractor sued the software developer to recover its loss.

Explain and discuss whether the contractor could succeed in a breach of contract claim agains the software developer. In answering, please include a brief summary and description of the development of relevant case precedents relating to the enforceability of contractual provisions that limit liability.

5.7.84 HOW SOLVE TO LAW/ETHICS PROBLEMS

1. Identify major events and issues.
2. State the applicable laws and precedents.
3. Apply legal principles and precedents to analyze the situation.
4. Consider possible outcomes.
5. Recommend an action.

5.7.85 A NOTE TO YOU

If you have benefited by using these problems, help others and give me more recent copies of the exams. I would prefer electronic copies (jackh@gvsu.edu), but faxed copies would also work (616) 336-7215. Thanks. If you want to see if anybody else offered the exam to me first, send me an email (jackh@gvsu.edu)

6. LEARNING AND TEACHING

6.1 LEARNING IN GENERAL

• Some learning strategies are,
- collaboration
- demonstrations
- didactic presentation
- discovery
- drill
- games
- interpersonal discussion
- problem-solving
- simulation
- tutorial

6.1.1 Learning Theories

• Kolb's Learning Styles Inventory (LSI) includes four areas, [Ellsworth, pg. 386]

Concrete Experience (CE) - experience based, peer oriented, emphasizes feedback.

Abstract Conceptualization (AC) - analytical, oriented towards things and symbols, authority directed impersonal learning situations.

Abstract Experimentation (AE) - Active orientation, focussed on "doing", project oriented.

Reflective Observation (RO) - Reflective, Observational approach, prefer lecture situations.

• Four levels of learning are suggested [Ellsworth, pg. 388],

Level 1 - "Why are we doing this?"
Level 2 - Learning the technology
Level 3 - Mastering the tools
Level 4 - Application of knowledge to problem solving

• Bloom developed a set of six learning objectives. In order these are,

1. Knowledge - list, name, state, define, identify, match, recall
2. Comprehension - discuss, paraphrase, compute, extrapolate, describe, explain, distinguish
3. Application - choose, classify, use, interpret, calculate, relate, demonstrate
4. Analysis - separate, recognize, test, differentiate, solve

5. Synthesis - design, order, develop, create, summarise, combine, propose
6. Evaluation - evaluate, justify, critique, appraise

6.1.2 References/Bibliography

Ellsworth, J.H., Education on the Internet, Sams Publishing, 1994.

6.2 ON-LINE LEARNING

• Basic characteristics of on-line education,
fast - immediate connections/delivery in some cases
not scheduled - material can be reviewed and questions answered at any time
location independant - connection from any location, even home
high connectivity - a very large number of people, and information are readily available
individualized - sequence of material, depth of material, additional review, etc. can be adjusted by the student as needed

• Some important concepts when planning on-line courses are,
- bring the students into a learning neighborhood.
- create appropriate challenges for the content and format.
- context for all material must be clearly defined.
- set out a clear start and end to the work.

• When creating on-line courses,
- identify course goals.
- analyse material for suitability, some is not suited to distance, and solutions should be found.
- set objectives for modules (if this mode is used).
- try to make best use of tools available.
- don’t forget support, technical, library, etc.
- set up and maintain records of interactions in the class. (comments, discussions, etc.)
- set up an ongoing evaluation system, including feedback.

• From the faculty standpoint, factors for success are,
- faculty control of the course (ownership)
- don’t let technology replace the value of learning
- good technical support all round.

•

6.2.1 Relevant WWW Sites

Internet oriented training tools
http://www.clark.net/pub/journalism/awesome.html

Internet Resource Directory for Educators (IRD)
ftp://tcet.unt.edu/pub/telecomputing-info/IRD

Open University
http://hcrl.open.ac.uk/ou/ouhome.html

Distance Education Resources
http://ollc.mta.ca/disted.html

University of Minnesota Adult Education Resources
gopher://aded.coled.umn.edu:70

University of Utah Adult Education Resources
gopher://gopher.cc.utah.edu:70

State University of New York
gopher://adam.cc.sunysb.edu:70

University of Georgia
gopher://gopher.PeachNet.EDU:70

6.2.2 References/Bibliography

Ellsworth, J.H., Education on the Internet, Sams Publishing, 1994.

7. THE ENVIRONMENT

• In previous centuries environmental issues typically affected local areas and went untreated until they reached crisis proportions.

• The industrial revolution has provided us the new ability to overload the environment at a much faster rate and with greater damage. And, the results of the pollution are no longer contained in a local area.

• Most of the environmental problems arise because the products that are delivered back into nature are not in the forms they were in when originally extracted.

• The main sources of problems are,
1. extracting raw materials often results in damage to the environment.
2. purifying raw materials produces by-products, requires energy and other materials.
3. shaping materials into useful form also produces by-products, requires energy and other materials.
4. during the life of a product there is upkeep, maintenance and consumption.
5. at the end of a products life it must be discarded.

• There are three good strategies when dealing with the environment,
- use less (eliminates 1, 2, 3, 4 and 5)
- reuse when possible (eliminates 1, 2, 5)
- recycle (eliminates 1, 5)

• The most common sources of problems are emissions. Common types are,
- Air based exhaust
- Runoff to waterways
- Stored toxic dump
- Stored solids

• many countries and are starting or have already enacted laws aimed at reducing environmental problems.
Germany - requires manufacturers to accept back used products such as automobiles
California - a zero emissions law requires no emissions on new vehicle in future

• These issues are already being addressed as voluntary standards such as ISO 14000.

• There are a wide variety of agencies and organizations that influence environmental policies and practices.
OSHA (Occupational Safety and Health Administration)
EPA (Environment Protection Agency)
NIOSH (National Institute for Occupational Safety & Health)
UL (Underwriters Laboratory)
CSA (Canadian Safety Association)

7.1 ENVIRONMENTAL PROTECTION AGENCY (EPA)

• This agency was created when Nixon combined various health and regulatory agencies into the EPA.

• The EPA primarily verifies environmental practices and takes corrective actions.

• Corrective actions might include,
- warnings
- conditions
- fines
- jail

• The EPA also sets some policies that are intended to be guides for industry.

• Recently the role of the EPA has been changing to be less adversarial and more supportive for industry.

• Some of the chemicals that the EPA targets in toxic releases are,

Benzene
Cadmium and compounds
Carbon Tetrachloride
Chloroform
Chromium and compounds
Cyanides
Dichloromethane (Methylene Chloride)
Lead and compounds
Mercury and compounds
Methyl Ethyl Ketone
Methyl Isobutyl Ketone
Nickel and compounds
Tetracholoethylene
Toluene
Trichloroethylene
Toluene
Trichloroethane
Trichloroethylene
Xylene(s)

7.2 LEGISLATION

• Legislation has been the most effective tool in causing environmental change.

• Much of the environmental legislation is criminal law.

• Keep in mind that while some legislation can be deal with in civil court, it does not prevent individuals from pursuing lawsuits that fall outside legislation.

• Well know legislation includes,

CAA (Clean Air Act) 1970 - Allows EPA to police airborne pollution sources, lists pollution types. Amended over the years.

CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) 1980 - amended RCRA, set up fund for site remediation and establishes liability responsibilities.

CWA (Clean Water Act) 1972 - Empowered EPA to police discharges of wastes into waterways.

EPCRA (Emergency Planning and Community Right to Know Act) 1986 - makes toxic releases public record with fines.

HSWA (Hazardous and Solid Waste Amendments) 1984 - national hazardous waste management.

PPA (Pollution Prevention Act) 1990 - deals with sources of pollution and requires reporting of improvements.

RCRA (Resource Conservation and Recovery Act) 1976 - deals with waste disposal issues and hazardous waste controls.

TSCA (Toxic Substances Control Act) 1976 - deals with toxic chemicals entering the marketplace.

• One significant impact is that when purchasing property the new owner assumes all liability for environmental problems. This means than now an environmental survey will be conducted before purchasing a property.

7.2.1 Clean Air Act (CAA) 1970

• Some chemicals on the National Ambient Air Quality Standards (NAAQS) chemical list are given below. These are found in section 109 under section 40 of the CAA.

- carbon dioxide
- hydrocarbons
- nitrogen oxides
- suspended particulates
- photochemical oxidants
- sulfur oxides
- lead

• Some chemicals on the National Emission Standard for Hazardous Air Pollutants (NESHAPS) chemical list are given below. These are found in section 112 under section 40 of the CAA.
    - asbestos
    - benzene
    - beryllium
    - coke oven emissions
    - mercury
    - vinyl chloride
    - inorganic arsenic
    - Rn-222
    - radionuclides
    - copper
    - nickel
    - phenol
    - zinc and zinc oxides

7.3 OCCUPATION SAFETY AND HEALTH ADMINISTRATION (OSHA)

• Workers are often exposed to environments that are hazardous.

• To deal with this it was created by congress in 1970.

• It deals with,
    - noise
    - indoor air quality
    - guards and safety equipment on machines
    - worker training and instruction

• The agency helps set policy and police problems.

• One example is the MSDS sheets that must be posted on all chemicals and be on file in public places. This was created under the Worker Right to Know Act.

7.4 PRACTICE PROBLEMS

1. Suggest 10 ways to redesign a car to lessen the life cycle impact it has on the environment.

ans. lower weight to reduce fuel consumption
add emission controls
use more of the same materials to ease sorting
use removable materials
use materials that are easy to recycle
use materials that have been recycled
make the engine more fuel efficient
reduce fluids used
make the vehicle more durable
etc.

2. Which environmental factors will affect workers.
ans. Most environmental considerations affect the performance of workers. There are different levels of influence. Some are barely noticeable, and have no tangible effects. Others are mild irritants. over long periods of time these can cause mental and physical stress. There are more severe irritants that will lead to discomfort or worse. These will reduce the effectiveness of the employee, to the point where the employee will be unable to work without aids and other support.

3. What factors would need to be considered when measuring noise in a manufacturing plant?
ans. Noise levels in a plant are typically measured while the machine is in operation in the intended environment to obtain the worst case noise level. The noise levels near the machine will be slightly higher because of the direct sound transmission. Noise levels throughout the room will have a basic level based on the reverberant component and the sound absorption in the room.

4. Discuss the two main organizations that deal with environmental issues. Who do they serve? What are their main environmental concerns?

8. SYSTEM DESIGN

• This field is largely overlooked, not because it is unimportant, but because most engineers are educated in selected disciplines, and this is an interdisciplinary topic.

• Most of the successful uses of this topic have been by computer system designers, electrical engineers, and aerospace designers.

• The basic set of problems in any system design are,
- what functions are needed
- how do the modules interact
- what do we do when a module fails
- how reliable is a system
- etc.

8.1 SYSTEM FAILURE

8.1.1 Introduction

• Basic concept, anticipate things going wrong, and determine what to do ahead of time.

• Key terms,

backup - a secondary system that can be used to replace the primary system if it fails.

fail operational - even when components fail, the system continues to operate within specifications.

fail safe - when the system fails, it does not cause damage, and possibly allows continued operation outside of specification.

failure tolerant - in the event that one system component fails, the entire system does not fail.

prime - a main system that is responsible for a task.

redundant - secondary systems that run in parallel with the prime, and will be able to hot swap if the prime fails.

time critical - the system has a certain response time before a failure will occur.

• essential components in these systems are,

monitoring systems - check for sanity or failure of systems. The purpose of these system is detection and reporting of failures.

emergency control functions - these functions will switch control when faults are detected. In some cases this might include human intervention, and be triggered automatically. These systems are intended to eliminate or reduce the effects of a failure.

• safety criticality might be categorized as below,
    Criticality I - Catastrophic
        - causes human disability/death
        - causes loss of equipment
    Criticality II - Critical
        - causes major human injury
        - lose use of emergency system
        - major damage to essential equipment
    Criticality III - Marginal
        - minor human injury
        - major damage to emergency system
        - minor damage to essential equipment

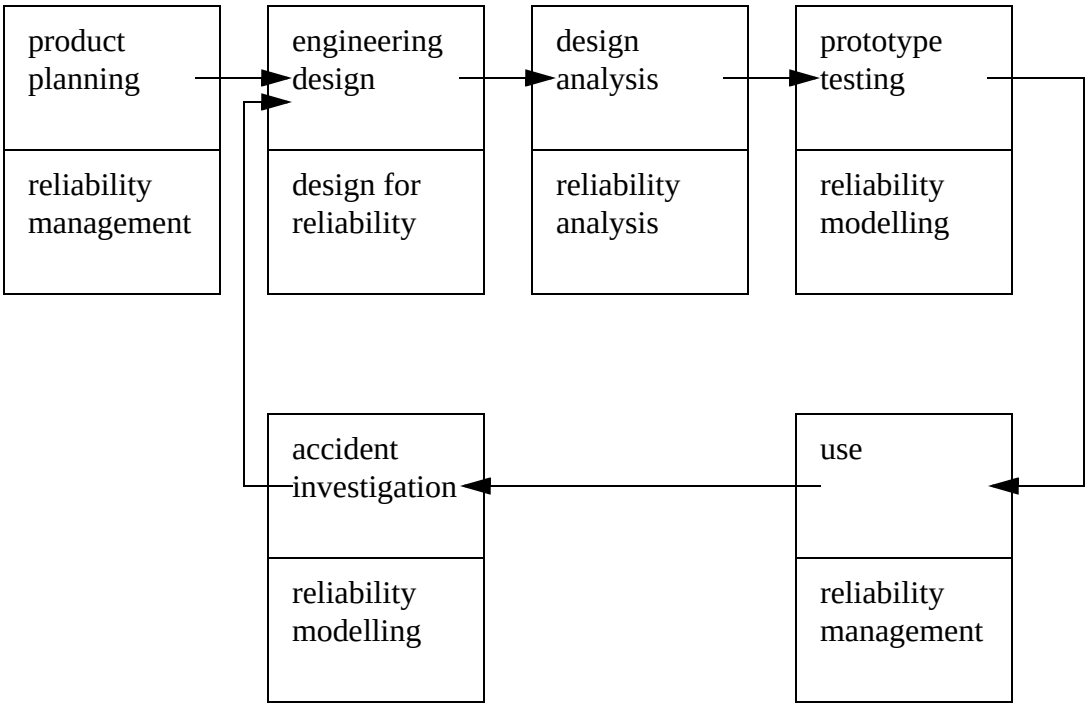
• safing is a process whereby a system that has failed is shut down appropriately (i.e., actuators shut down, brakes applied, or whatever is appropriate to the situation).

• safing paths often include,
    - braking equipment
    - removal of power to actuators
    - consideration of complete power failure
    - operator control should be available, even when automated systems are in place
    - multiple safing paths should be available

• the operator will be a good decision maker. Possible options include,
    - safing procedures
    - attempt to manually repair
    - ignore

• techniques used are,
    - checksums
    - parity bits
    - software interlocks
    - watch dog timers
    - sample calculations

• The role of various reliability programs can be related to a product life cycle.



8.1.2 The Theory of Module Reliability and Dependability

• Dependability is a combination of,
  - reliability - the probability that a system operates through a given operation specification.
  - availability - the probability that the system will be available at any instant required.

• Failure rate is the expected number of failures per unit time, and is shown with the constant (lambda), with the units of failures per hour.

• Basically,

$$z(t) = -\frac{\frac{d}{dt}R(t)}{R(t)} = \frac{\frac{d}{dt}Q(t)}{1 - Q(t)}$$

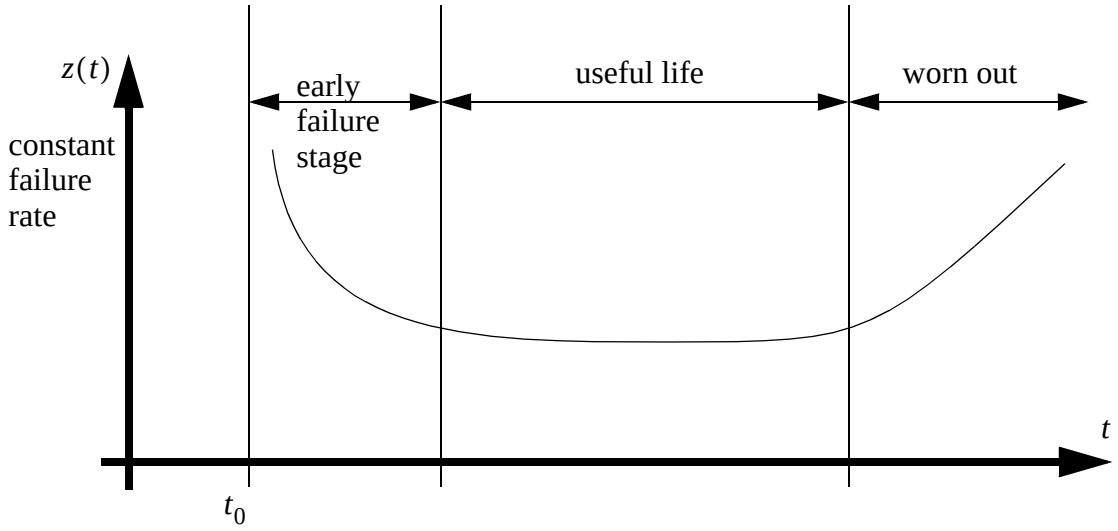
where,

$R(t)$ = the reliability, the chance that the system will fail betwee n$[t_0, t]$

$z(t)$ = the failure rate

$Q(t)$ = unreliability = $1 - R(t)$

• The bathtub curve shows typical values for the failure rate.



• The basic reliability equation can be rearranged, eventually leading to a compact expression,

$$z(t) = -\frac{\frac{d}{dt}R(t)}{R(t)}$$

$$\therefore \frac{d}{dt}R(t) = -z(t)R(t)$$

$$\therefore R(t) = e^{-\int z(t)dt}$$

During the useful life of the product, we can approximate the failure rate as linear, as reflected by the relation below,

$$\int z(t)dt \approx \lambda t$$

$$\therefore R(t) = e^{-\lambda t} = \text{The Exponential Distribution}$$

• MTTF (Mean Time To Failure) - this is the expected time before a failure.

$$E[X] = \int_{-\infty}^{\infty} xf(x)dx$$

where,

X = a random variable

$E[X]$ = expected value

$f(x)$ = a probability density function

$$MTTF = \int_0^{\infty} tf(t)dt$$

Given the probability density function, and using integration by parts we can find the relationship between the MTTF, and reliability.

$$f(t) = \frac{d}{dt}Q(t)$$

$$\therefore MTTF = \int_0^{\infty} t\frac{d}{dt}Q(t)dt = -\int_0^{\infty} t\frac{d}{dt}R(t)dt = [-tR(t) + \int R(t)dt]\Big|_0^{\infty} = \int_0^{\infty} R(t)dt$$

• The MTTR (Mean Time To Repair) for a system is the average time to repair a system. This is not simple to determine and often is based on experimental estimates.

$$MTTR = \frac{1}{\mu}$$

where,

$$\mu = \text{the repair rate} = \frac{\text{number of repairs}}{\text{time period for all repairs}}$$

• The MTTF and MTTR both measure the time that the system is running between repairs, and the time the system is down for repairs. But, they must be combined for the more useful measure MTBF (Mean Time Before Failure),

$$MTBF = MTTF + MTTR$$

• The difference between MTBF and MTTR is often small, but when critical the difference must be observed.

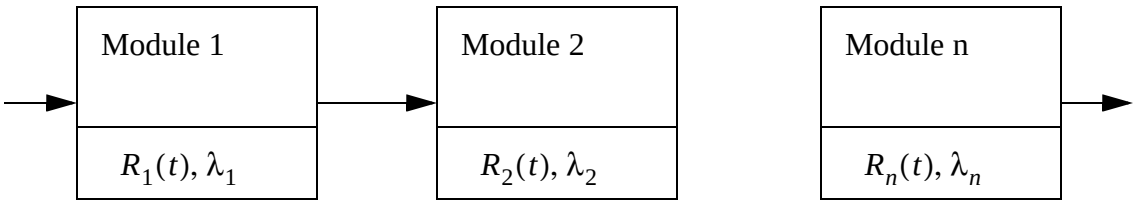
8.1.3 The Theory of System Reliability

• Fault Coverage is the probability that a system will recover from a failure. This can be derived approximately by examining the design, and making reliable estimates. This number will be difficult to determine exactly because it is based on real, and often unpredictable phenomenon.

• Reliability can be determined with individual system components as a function of probabilities. The two main categories of systems are series, and parallel (redundant). In the best case a high reliability system would have many parallel systems in series.

• In terms of design, a system designer must have an intuitive understanding of the concept of series/parallel functions.

• We can consider a series system where if any of the units fails, then the system becomes inoperative. Here the reliabilities of each of the system components is chained (ANDed) together.



$$R_s(t) = (R_1(t))(R_2(t))\ldots(R_n(t)) = \prod_{i=1}^{n} R_i(t)$$

where,

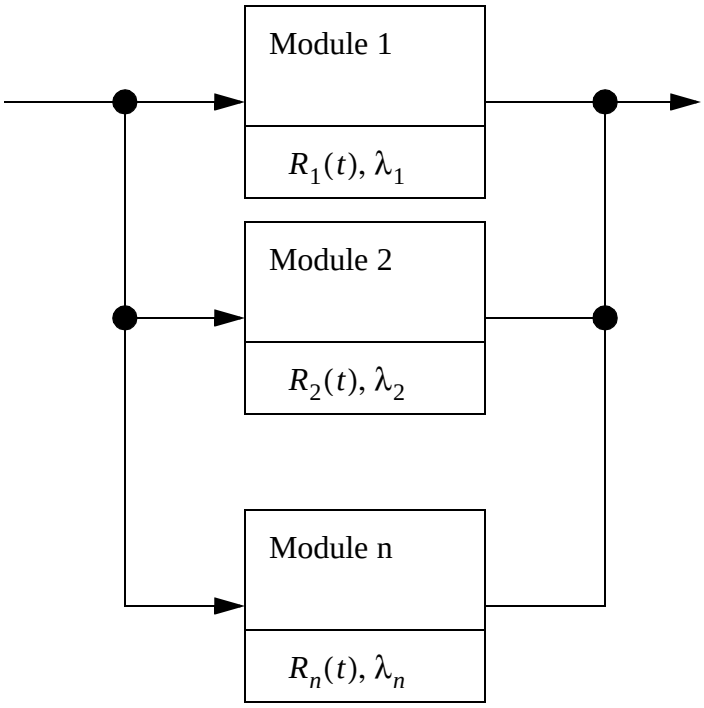
$R_s(t)$ = the reliability of a series system at time t

$R_i(t)$ = the reliability of a unit at timet

Now, consider the exponential failure law presented before. If each element in a system observes this law, then we can get an exact value of reliability.

$$R_s(t) = (e^{-\lambda_1 t})(e^{-\lambda_2 t})\ldots(e^{-\lambda_n t}) = \prod_{i=1}^{n} e^{-\lambda_i t} = e^{-\sum_{i=1}^{n} \lambda_i t}$$

• We can also consider a parallel system. If any of the units fails the system will continue to operate. Failure will only come when all of the modules fail. Here we are concerned with complements of the chained unreliabilities.



$$Q_p(t) = (Q_1(t))(Q_2(t))\ldots(Q_n(t)) = \prod_{i=1}^{n} Q_i(t)$$

$$R_p(t) = 1 - Q_p(t) = 1 - \prod_{i=1}^{n} (1 - R_i(t))$$

where,

$Q_s(t)$ = the unreliability of a parallel system at time t

$Q_i(t)$ = the unreliability of a module at time t

$R_p(t)$ = the reliability of a parallel system at time t

$R_i(t)$ = the unreliability of a module at time t

• also consider the case of a parallel system that requires ‘m’ of ‘n’ identical modules to be functional, such as a hybrid system, or a voting system that needs two out of three functional units. The student will consider the binomial form of the probabilities.

$$R_{m;n}(t) = \sum_{i=0}^{n-m} \binom{n}{i} (R(t))^{(n-i)} (1 - R(t))^{i}$$

where,

$R_{m;n}(t)$ = reliability of a system that contains m of n parallel modules

$R(t)$ = the reliability of the modules at time t

$\binom{n}{i} = \frac{n!}{(n-i)!\,i!}$ = the binomial operator (we can also use Pascal's triangle)

- keep in mind that many systems are a combination of series and parallel units, to find the total reliability, calculate the reliability of the parallel units first, and then calculate the series reliability, replacing the parallel units with their grouped reliability.

- availability is the chance that at any time a system will be operational. This can be determined experimentally, or estimated. For a system that is into it's useful lifetime, this can be a good measure. Note that at the beginning, and end of its life, this value will be changing, and will not be reliable.

$$A(t) = \frac{t_o}{t_o + t_r} = \frac{MTTF}{MTTF + MTTR} = \frac{MTTF}{MTBF} = \frac{1}{1 + \frac{\lambda}{\mu}}$$

where,

$A(t)$ = probability that a system will be available at any time

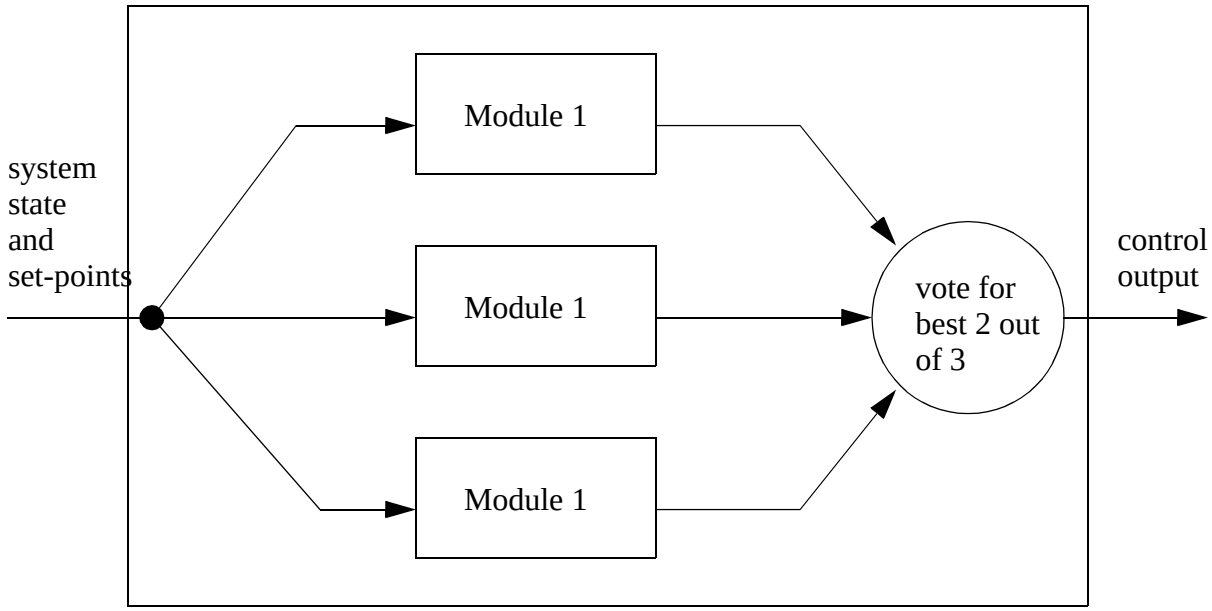
t_o = hours [illegible]

t_r = hours [illegible]

8.1.4 Design For Reliability (DFR)

8.1.4.1 - Passive Redundant

• three identical, yet independent systems are used to produce three outputs. The three outputs are compared and a voting procedure is used to select one. This method is called Triple Modular Redundancy (TMR)



• In this event, if there is a random failure in any of the modules, it will be outvoted by the others, and the system will continue to operate as normal.

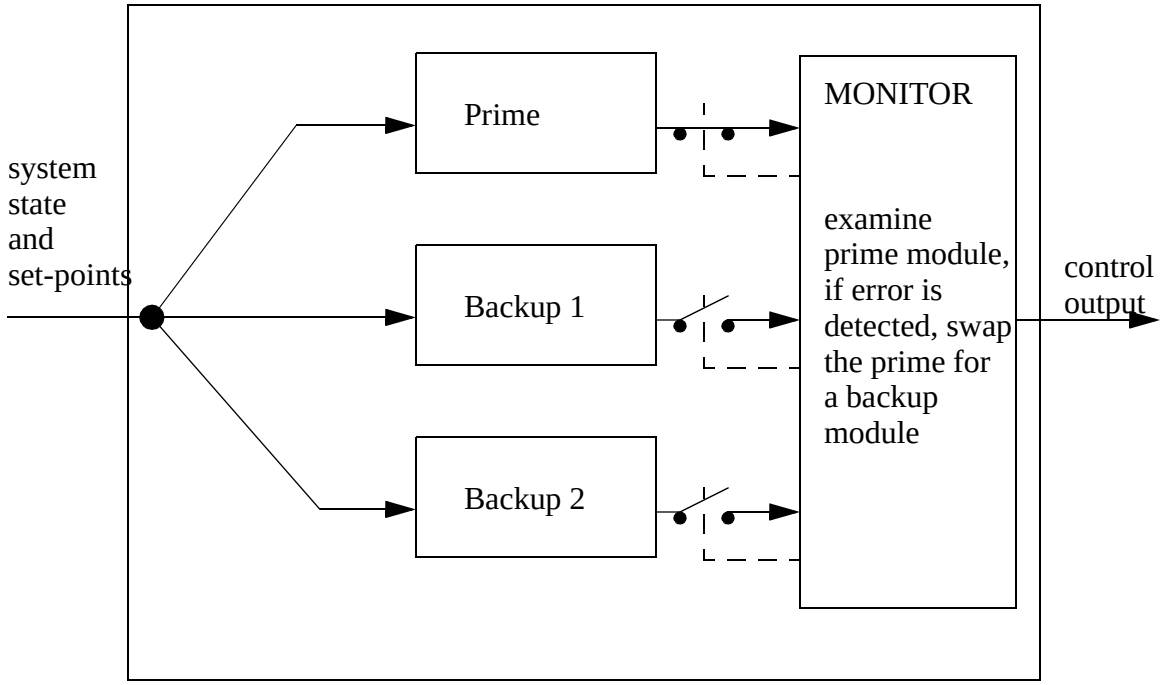
• This type of module does not protect against design failures, where all three modules are making the same error. For example if all three had Intel Pentium chips with the same math mistake, they would all be in error, and the wrong control output would result.

• This module design is best used when it is expected that one of the modules will fail randomly with an unrecoverable state.

• This type of system can be used easily with computer algorithms and digital electronics.

8.1.4.2 - Active Redundant

• A separate monitoring system tracks the progress of separate modules. In the event one of the modules is believed to have failed, it is taken off line, and replaced with a new module.



• This method depends upon a good design of the monitor module.

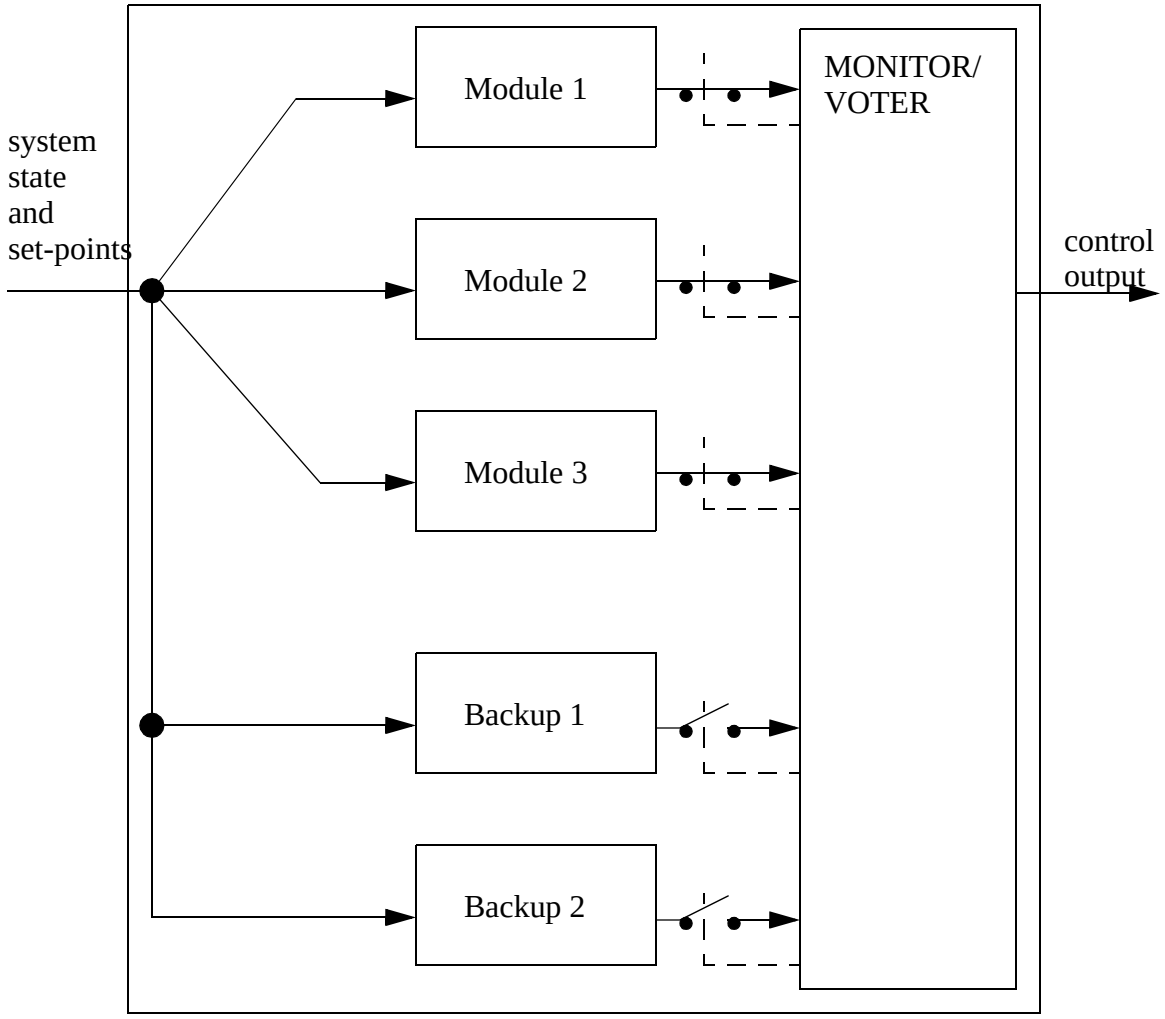
• As with the passive redundant module, this module is also best used to compensate for complete module failure.

• This type of system can be used easily with analog electronics and mechanics, as well as with switched modules.

8.1.4.3 - Hybrid Active

• A combination of the voting system and the reconfiguration system

• the voting modules continue to make decisions, but voting members can be replaced with backup units.



8.1.4.4 - Other Design Points

• Parity and check bits can be used to detects errors in calculations. Checksums can be used for blocks of data, and grey code can be used for detecting errors in sequential numbers.

• The amount of redundant hardware can be reduced by doing the same calculation twice, at different points in time on the same processor. If the results are compared, and found to be different. This would indicate a transient fault. This can be important in irradiated environments where bits can be flipped randomly.

• Software redundancy involves writing multiple versions of the same algorithm/program. All of the algorithm versions are executed simultaneously. If a separate acceptance algorithm estimates that the primary version is in err, it is disabled, and the secondary version is enabled.

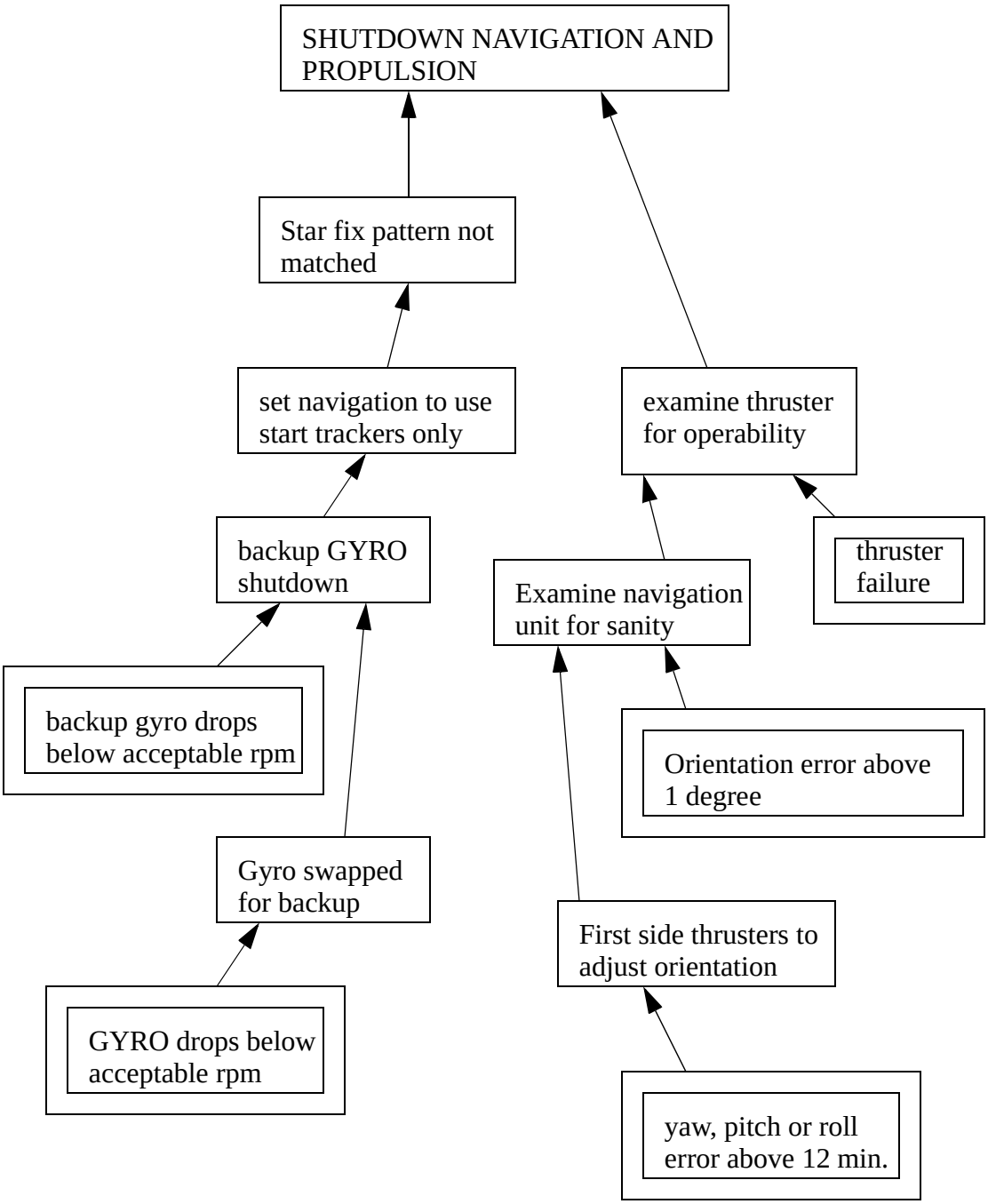
This continues as long as remaining modules are left.

8.1.5 Formal Methods For Failure Modelling

• There are a number of steps required to properly evaluate a system for fault probabilities.

8.1.5.1 - Event Trees

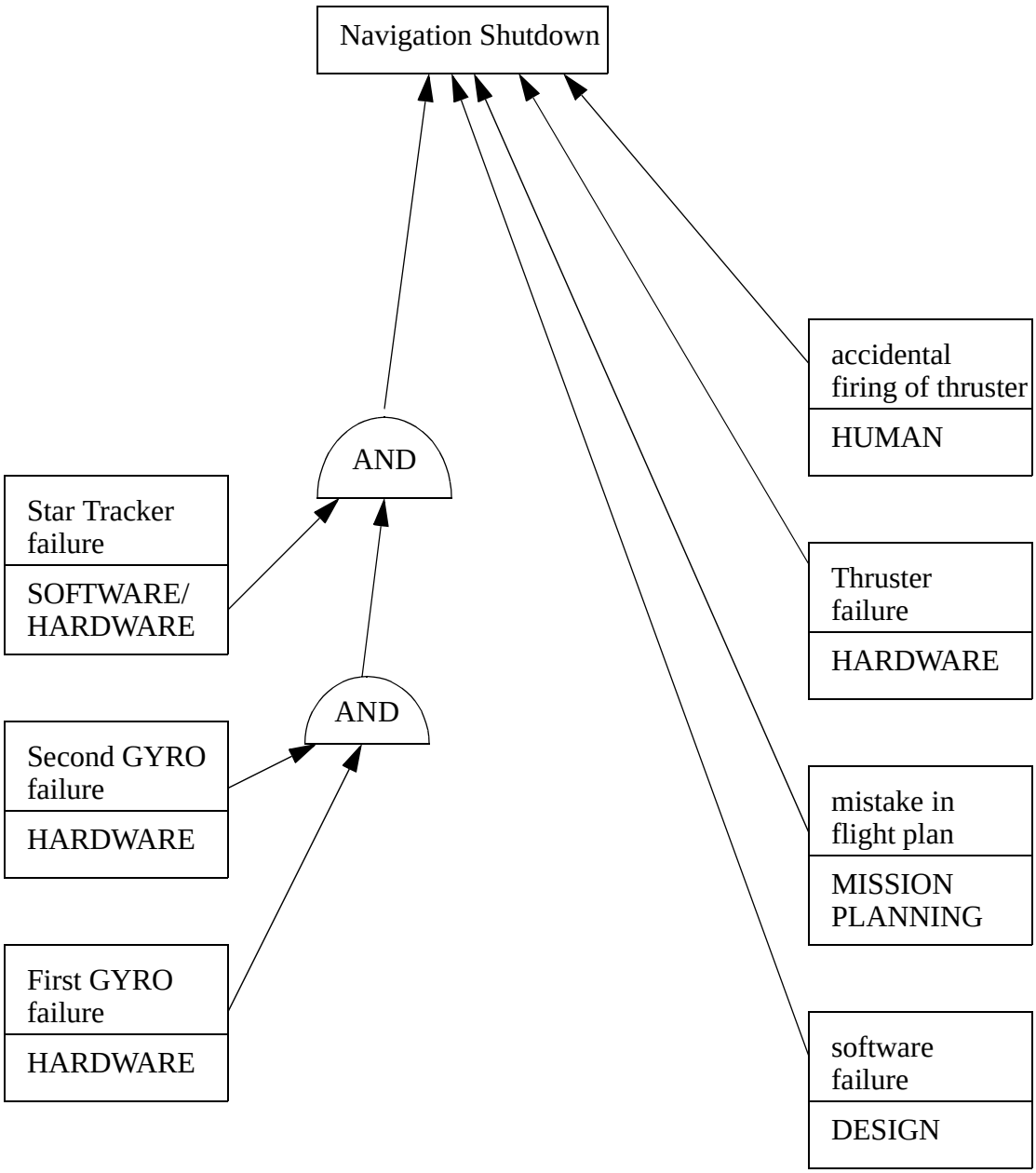
• These trees match outside events in the system to actions of the system. When applied to safety systems we can related failures to actions of the safety systems.


SHUTDOWN NAVIGATION AND PROPULSION
Star fix pattern not matched
set navigation to use start trackers only
backup GYRO shutdown
backup gyro drops below acceptable rpm
Gyro swapped for backup
GYRO drops below acceptable rpm
examine thruster for operability
thruster failure
Examine navigation unit for sanity
Orientation error above 1 degree
First side thrusters to adjust orientation
yaw, pitch or roll error above 12 min.

8.1.5.2 - Fault Trees

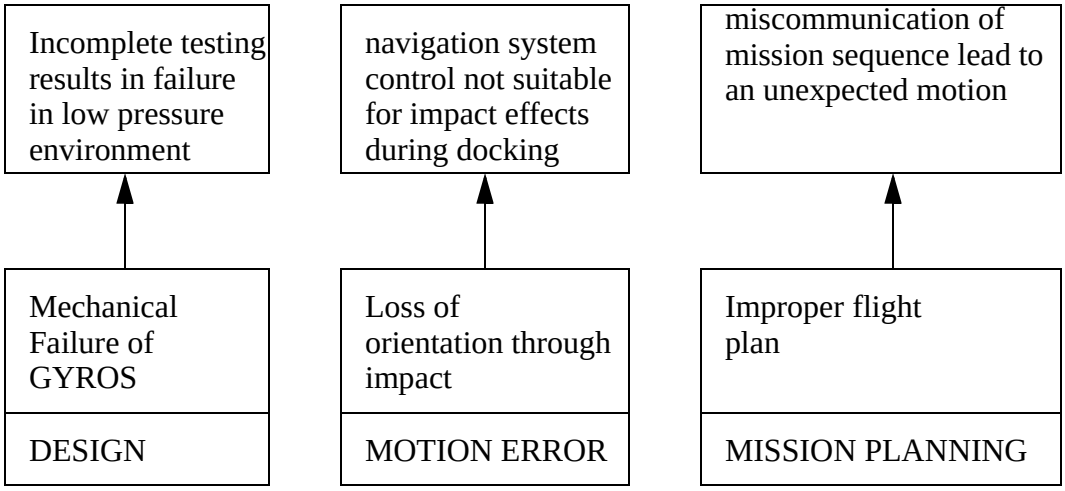
• Fault trees try to relate events in the system to causes of failure that will cascade to the point of a safing, or failure.

• A simple example is given below



8.1.5.3 - Causes Trees

• Causes trees can be used to focus on controlling error situations.



• Note Ishikawa/fishbone diagrams used in quality control are useful here, as well as Pareto diagrams for selecting problems for elimination.

8.1.6 Error Sources

• Humans are very flexible, and are capable of adapting to many diverse situations. On the other hand this creates the ability to make mistakes.

• An estimate of human error rates, for trained operators was made available for nuclear power plant operation [Rasmussen et. al., 1987, pg. 136],

DESCRIPTION	RATE
Operator selects a safeguard switch (with an additional step such as a key) when a non-safeguard switch should be selected.	0.0001
Wrong switch selection through label misreading	0.003
Fatigue induced mistakes	0.01

• Another table of human error estimates is given below. [Leveson, 1995, pg.353]

ACTIVITY	RATE
omission of control action when no status display present. For example, the pilot tests landing gear, but there is no landing gear down indicator, and the pilot neglects to retract it.	0.01
items are neglected because they occur midway through a long procedure list, as opposed to the end. For example, On a list of 100 prelaunch steps, the step to retract a gantry is missed.	0.003
operational mistake. For example, an operator that is fully familiar with a system misreads a label and actuates the wrong switch.	0.03
simple mathematical mistakes. For example, a simple addition or flow values.	0.03
inspection or monitoring error. For example, the first operator has made a mistake, and it is not observed during checking.	0.1
change of personnel without information exchange. For example, as control crews change, abnormal settings in the controls are not noticed.	0.1

• A list of generic hazards for the space shuttle was found in [Leveson, 1995, pg. 297],

Hazard Categories	Hazard Types
contamination/corrosion	chemical disassociation, chemical replacement/combination, moisture, oxidation, organic (fungus/bacterial, etc.), particulate
electrical discharge/shock	external shock, internal shock, static discharge, corona, short
environment/weather	fog, fungus/bacterial, lightning, precipitation (fog, rain, snow, sleet, hail), vacuum, wind, temperature extremes
fire/explosion	chemical change (exothermic/endothermic), fuel and oxidizer in presence of fuel and ignition source, pressure release/ implosion, high heat source
impact/collision	acceleration (including gravity), detached equipment, mechanical shock/vibration, acoustical, meteoroids/meteorites, moving/rotating equipment
loss of habitable environment	contamination, high pressure, low oxygen pressure, low pressure, toxicity, low temperature, high temperature
pathological/psychological/ physiological	acceleration/shock/impact/vibration, atmospheric pressure (high/low, rapid change), humidity, illness, noise, sharp edges, lack of sleep, visibility (glare, window/helmet fogging), temperature, excessive workload
radiation	electromagnetic, ionizing, thermal/infrared, ultraviolet
temperature extremes	high, low, variations

8.1.7 Risk Control During Design

8.1.7.1 - Failure Modes and Effects Analysis (FMEA)

• Estimates overall reliability of a detailed or existing product design in terms of probability of failure

• basically, each component is examined for failure modes, and the effects of each failure is con-

sidered. In turn, the effects of these failures on other parts of the system is considered.

• the following is a reasonable FMEA chart.

Critical Components	Failure Probability	Failure Mode	Number of Failures by Mode	EFFECTS	
				Critical	Non critical
car brakes (car in motion)	10-4	disengage engage weaken	10 5 85	1x10-5 5x10-6	 X
car brakes (car parked)	10-6	disengage engage weaken	40 30 30	4x10-7	 X X

• the basic steps to filling one out is,

1. consider all critical components in a system. These are listed in the critical items column.
2. If a component has more than one operation mode, each of these should be considered individually.
3. estimate failure probability based on sources such as those listed below. Error bounds may also be included in the FMEA figures when numbers are unsure. These figures are entered in the “Failure Probability” column.
   - historical data for similar components in similar conditions
   - published values
   - experienced estimates
   - testing
   - etc.
4. The failures in a particular operation mode can take a number of forms. Therefore, each mode of failure for a system is considered and its % of total failures is broken down.
5. In this case the table shows failures divided into critical/non-critical (others are possible). The effects are considered, and in the event of critical failures the probabilities are listed and combined to get the overall system reliability.

• Suitable applications include,

- analyze single units or failures to target reliability problems.
- identify,
    - redundant and fail-safe design requirements
    - single item failure modes
    - inspection and maintenance requirements
    - components for redesign

• This technique is very complete, but also time consuming.

• not suited to complex systems where cascaded errors may occur.

8.1.7.2 - Critical Items List (CIL)

• This list can be generated from an FMEA study

• This might look like the table below,

Item	Failure mode(s)	Probability	Effect on mission	Criticality

8.1.7.3 - Failure Modes, Effects, and Criticality Analysis (FMECA)

• This is basically FMEA with greater analysis of criticality

• this involves additional steps including,
    - determining the means of control

- the results of the FMEA are reconsidered with the control factors

8.1.7.4 - Hazard Causal Analysis (HCA)

• A process where hazards are considered for their causes and their effects. The results of this analysis is used for control of hazards.

• The causes and effects can be extensive, and must be determined by a person/team with a good knowledge of a system.

• the analysis may focus on whole systems, or subsystems.

• it can be helpful to trace causes and effects both forwards and backwards in a system.

• Sensitivity analysis can be used to determine the more significant causes/effects.

• Some categories of this analysis are,

System Hazard Analysis - the entire system is considered at once, including interactions of components, interfaces to operators, modes of operations, etc. This is meant for global system failures creating hazards.

SubSystem Hazard Analysis - individual subsystems are examined individually. The effect of a failure of one subsystem on the entire system is considered. This evaluates individual system failures creating hazards.

Operational Hazard Analysis - an analysis of the detailed procedures of operation, and how a deviation from these procedures could lead to a hazard. Variations in the procedure could be unexpected events, operator errors, etc.

8.1.7.5 - Interface Analysis

• relationships between modules can be categorized as,
- physical
- functional
- or flow

• typical problems that arise are,
- a unit or connection fails, resulting in a loss of data across the interface
- a partial failure of a unit or connection results in a reduced flow across the interface
- there is an intermittent or unstable flow across the interface
- there is an excessive flow across the interface
- unexpected flow could result in unexpected operation, or functional failure
- undesired effect - the interface is operating as specified, but additional undesired effects

are present. For example heat flow across a conductor.

• This analysis is best done by a team of experts familiar with the modules being interfaced.

8.1.8 Management of Reliability

8.1.8.1 - Preliminary Hazard Analysis (PHA)

• As the name suggests this procedure is carried out early in projects.

• typically this involves,
- determining hazards that might exist and possible effects
- determine a clear set of guidelines and objectives to be used during a design
- create plans to deal with critical hazards
- assigning responsibility for hazard control (management and technical)
- allocate time and resources to deal with hazards

• The results of this analysis are used for preparing specification, testing, implementation, maintenance and management.

• The modules within the system must be clearly identified, with consistent boundaries.

• Specific hazards may be obvious, or they may be mandated by government regulations.

• Some hazards can be identified by,
- examining similar existing systems
- review existing checklists and standards
- consider energy flow through the system
- consider inherently hazardous materials
- consider interactions between system components (e.g., materials corrode or power drain)
- review previous hazard analysis for similar systems
- review operation specifications, and consider all environmental factors
- use brainstorming in teams
- consider human/machine interface
- consider usage mode changes
- try small scale testing, and theoretical analysis
- think through a worst case what-if analysis

• Hazard forms are not completed all at once, but as project steps develop.

• Hazard level (either likelihood and/or effects) should be indicated on a PHA, these levels are specific to the application. For example, NASA uses 1, 1R, 2, 2R, etc. Other methods may have several divisions between ‘impossible’ to ‘always’.

• Design criteria are used to specify constraints on a design to minimize or prevent a hazard. For example the hazard of an engine still running even after controller power has failed suggests that the motor must not operate when controller power is off.

• The operational phase which a hazard might occur in must also be considered. Some hazards will become more/less severe over the operational life.

Preliminary Hazard Analysis Form PHA Ref. #/Title _____

Operation Mode _____

Subsystem/Operation _____

Effective _____

Engineer _____ Date _____

Hazardous Condition	Hazard Cause	Hazard Effect	Hazard Level	Safety Requirements	Hazard Control

Sheet____ of ____

8.1.9 Implemented Risk Management Programs

8.1.9.1 - NASA Safety Methods

- A large part of NASA's policies deal with identifying potential problems, and eliminating or reducing them. This system has been recognized as successful and sufficient when properly implemented [Leveson, 1995, pg. 274]. These are not described in detail here, as they are somewhat distant from the design process, although they do provide a valuable source of feedback and control.

- NASA bases most of it's analysis of systems on FMEA and CILs. (The CIL below is from [Leveson, 1995, pg. 283])

Shuttle Critical Items List - Orbiter

Subsystem: Assembly: P/N RI: P/N Vendor: Quantity:	FMEA No.: Abort.: Vehicle: Effectivity: Phase: Redundancy Screen:	Revision: Crit. Func.: Crit. Hdw.:

Prepared by: Approved by: Approved by (NASA):

Item:

Function:

Failure Mode:

Cause(s):

Effect(s) on (A)Subsystem (B)Interfaces (C)Mission (D)Crew/Vehicle

Disposition and Rationale:

- The FMEA is done by contractors and, based on the results a criticality is assigned to each item.
  - 1 - failure could cause loss of life or vehicle
  - 1R - failure could cause loss of life or vehicle, but redundant hardware is present
  - 1S - a ground support element that could cause loss of life or equipment
  - 2 - failure could cause loss of mission

2R - failure could cause loss of mission, but redundant hardware is present
2S - a ground support system that could cause loss of vehicle systems
3 - other failure types that may cause less severe damage without catastrophic effects on the mission

• Items rated 1, 1R, 2, 2R must be on the CIL.

• Items on the CIL must be redesigned or improved to fail safe, or else they will require that a special waiver be granted.

• EIFA (Element Interface Functional Analysis) is used to evaluate the effects of failure modes in either component on other components.

• These procedures don't typically extend to software, although efforts were made to consider its effects. And, future efforts are expected to address some aspects.

• Other types of hazards are considered by,
- PHA (Process Hazard Analysis)
- SHA (Subsystem Hazard Analysis)
- OHA (Operations Hazard Analysis)

8.1.10 References and Bibliography

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8.2 PRACTICE PROBLEMS

1. How are series and parallel reliability different?
ans. Series reliability means that a failure of any unit will cause the entire group to fail. Parallel reliability means that there is some redundancy.

8.2.1 Design Applications of Risk Management

8.2.1.1 - The Space Shuttle Orbiter Control Computers

• The space shuttle uses 5 computers for flight control. The first 4 run a primary flight control system. The fifth computer runs a separate flight control program, and is only used in the most dire emergencies. The 4 redundant systems will operate separately, then compare outputs. These should be identical, but in the event of disagreement, they can vote a conflicting system out.

8.2.1.2 - A Mobile Service Robot for the Space Station

• We can see a figure depicting the SPDM for the planned space station.
********** Include Robot Arm figure

• All discussions in this section are based on the space station manipulator as described in SSP30000.

• The basic functions (at PMC) are classified as,
  Category 1 - requires tolerance for two consecutive failures in each system - fail safe/fail operational - basically required 1 prime + 1 redundant + 1 backup
  Category 2 - requires tolerance for one failure in each system - failure tolerant - typically requires 1 prime + 1 backup
  Category 2S - requires tolerance for one failure in the system - fail operational

• Examples of equipment in the different categories are,
  • Category 1 - The orbiter is a time critical system
  • Category 2 - MBS
  • Category 2S - Safety monitoring and emergency control systems

• Recall the following hazard levels, also consider the control requirements,

Hazard Criticality	Description	Requirement
1	Catastrophic - disables/kills personnel. Loss of vehicle or extensive damage to major ground facilities.	No combination of any two failures, either operator error or equipment faults, will result in a hazard.
2	Critical - severe injuries to personnel, loss/use of emergency system, extensive damage to essential vehicle systems, extensive damage to ground facilities.	No single operator or equipment failure can result in a hazard.
3	Marginal - minor injury to personnel, minor damage to vehicle or ground facilities.	Systems and equipment that can result in hazards should have two inhibiting controls.

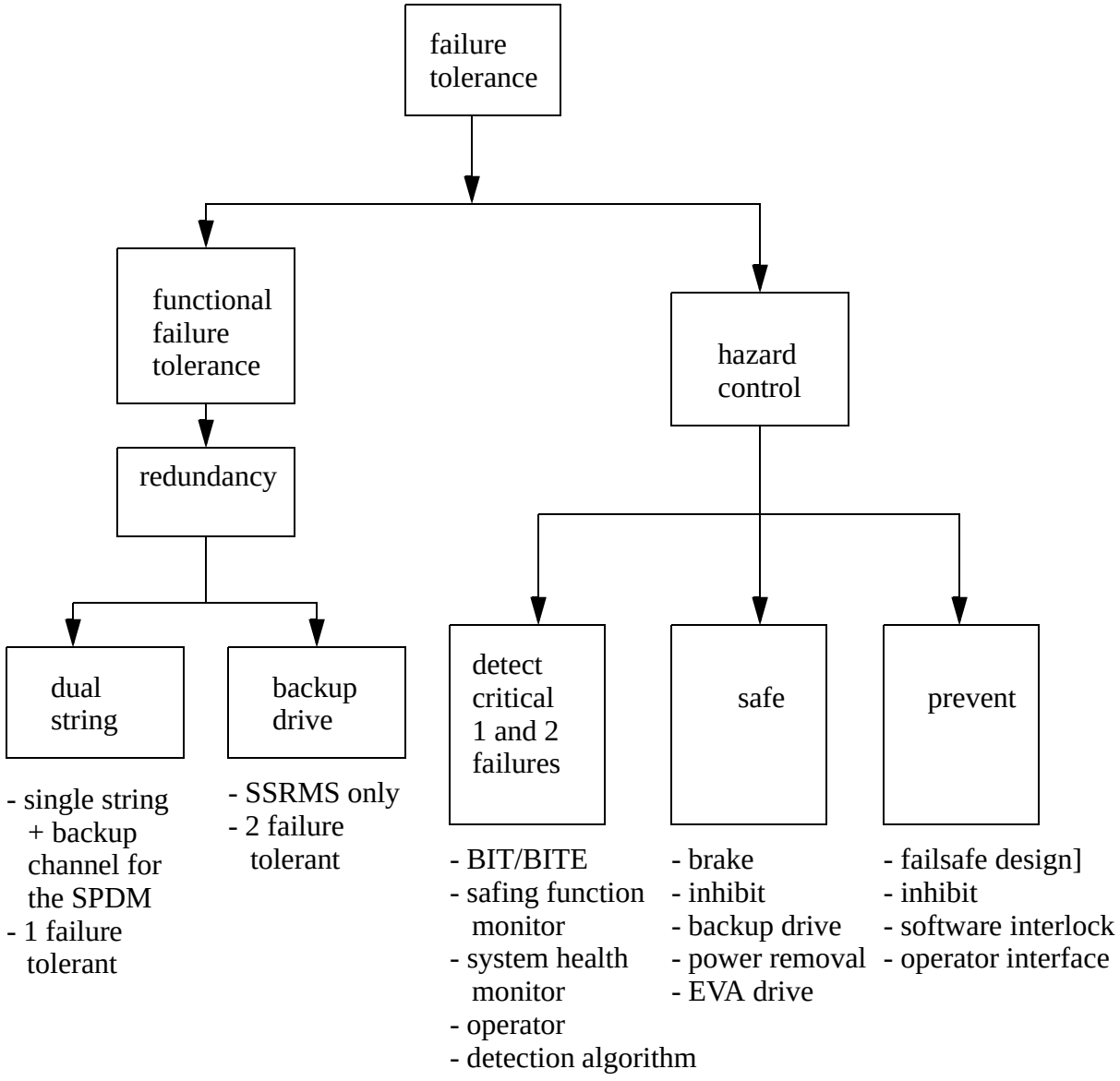
• For the manipulator (SSRMS) hazards include,
    • Criticality 1
        - payload released without command
            - possible collision
        - payload cannot be released
            - orbiter stuck to space station via SSRMS
            - orbiter collides with space station because of failed capture (docking with SSRMS).
        - motion of arm without command
            - possible collisions
        - no motion in arm in response to command
            - orbiter stuck to space station via SSRMS.

• Dealing with failures,
    - Criticality 1
        - all functions must be safed within 250 ms of occurrence of fault
    - Criticality 2
        - report as occurs
        - side effects are
            - can’t report critical failure
            - can’t safe a system
            - can’t implement alternate operation

• isolation - we want to estimate the % failures that are prevented from reaching a specific module. Typically these values are,
    95% isolated through ORU

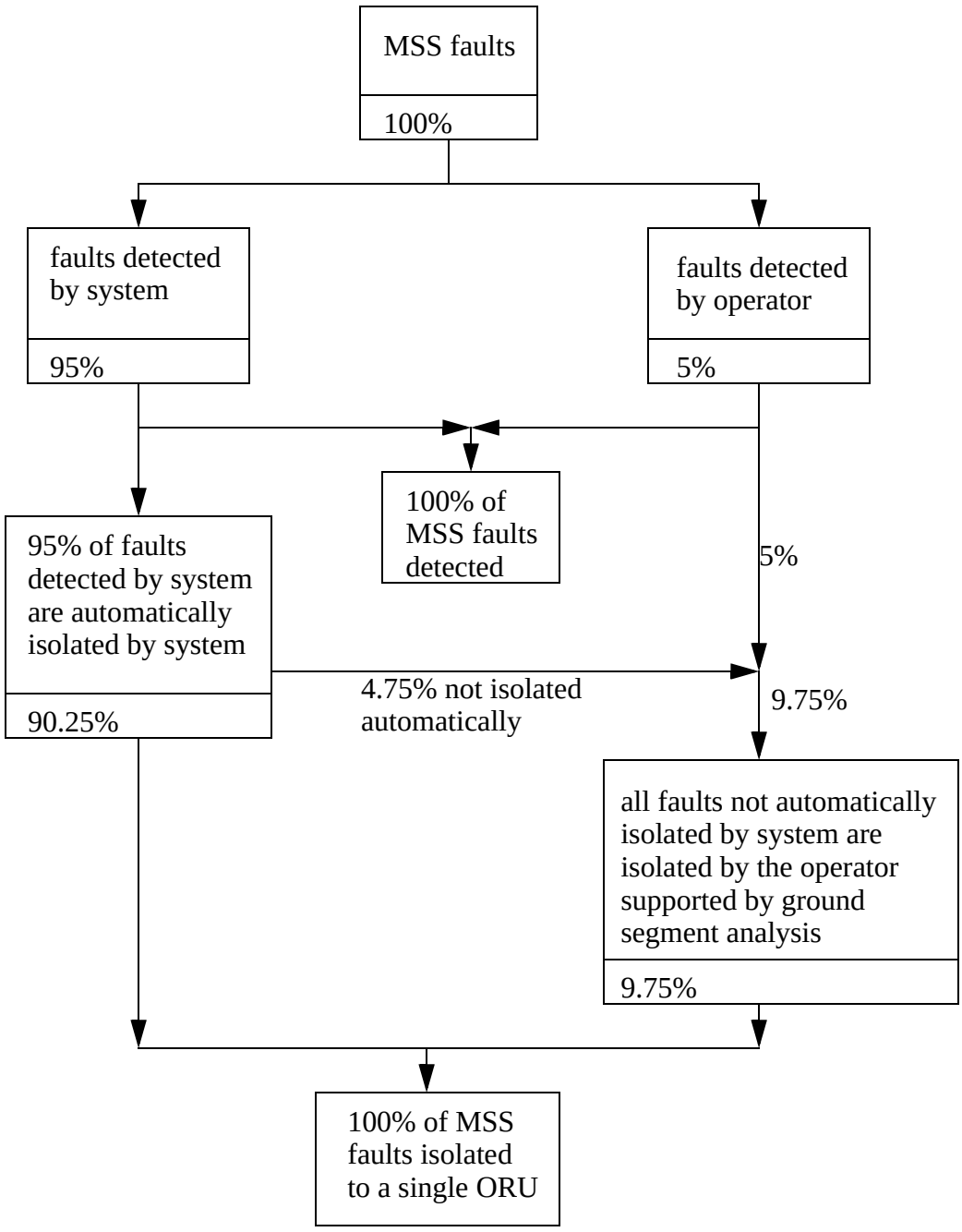
90% isolated by online bits
5% maximum false error indication rate

• MSS Failure Tolerance Concept [Brimley]

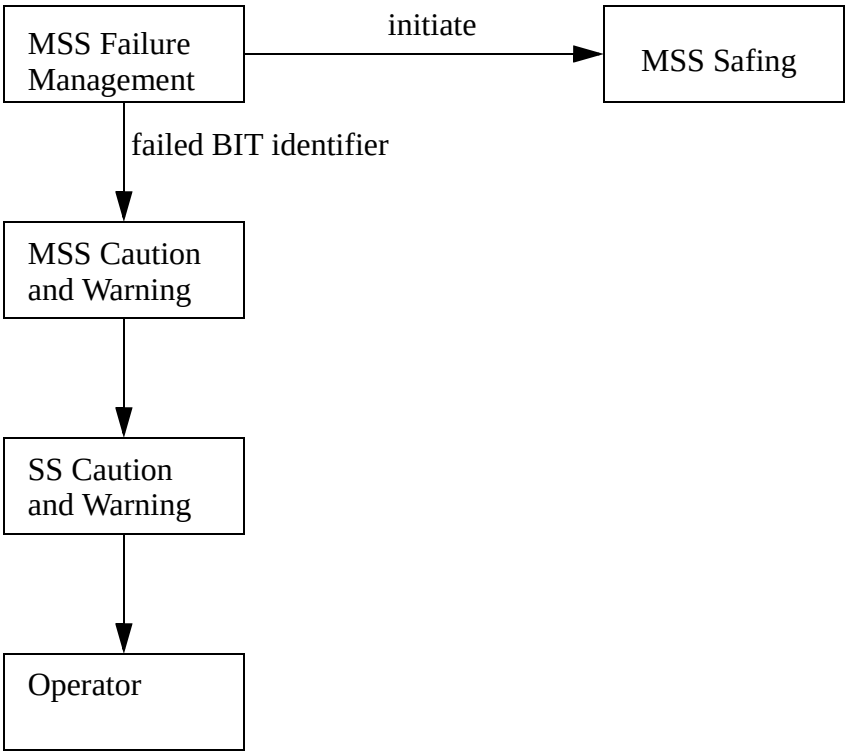


where,
BIT - Built In Test
BITE - BIT Equipment
CRIT - failure CRITicality
FT - Failure Tolerance

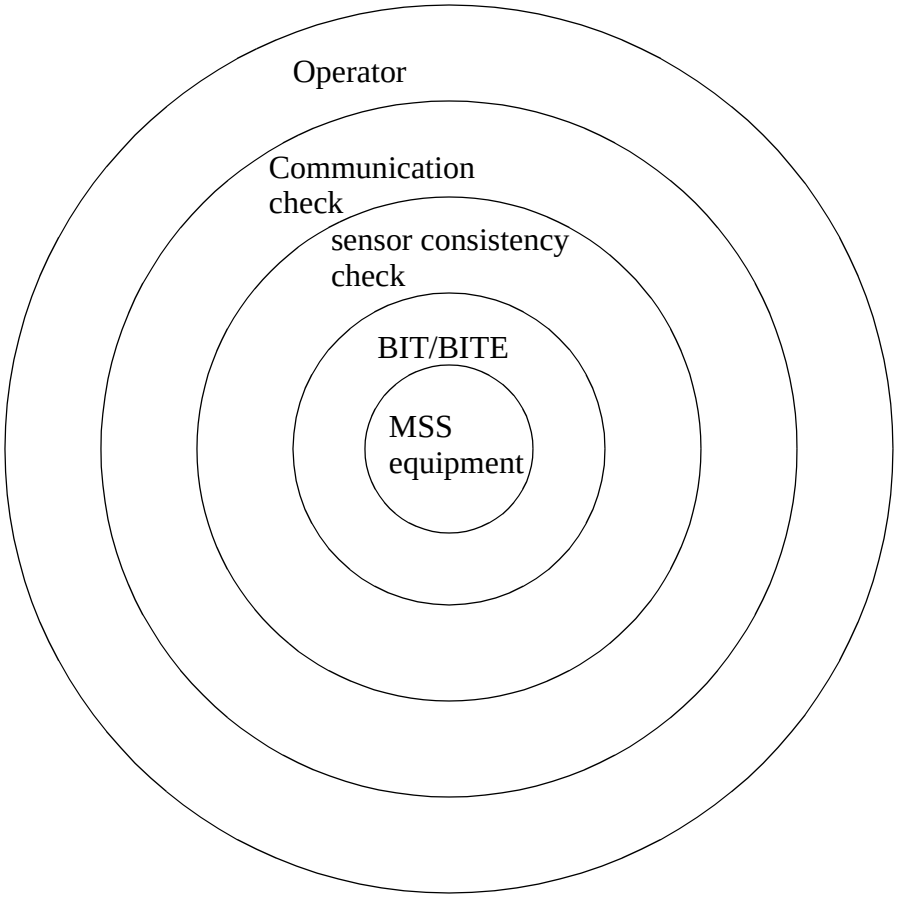
• Failure Detection and Isolation Coverage Scheme [Brimley]



• MSS Failure Management Functional Interfaces [Brimley]



• Layered defense approach for Detection of Sensor Data Failures [Brimley]



• Failure tolerance
    - fault tolerance
        - single failure tolerant
        - two failure tolerant for orbiter
        - provide drive (EVA) for joint and LEE latch mechanisms

• Reconfigurations
    - alternate data path/transmission
    - reconfiguration time less than 271 seconds

• The purpose for these measures
    - when the failure occurs, the software, and hardware engineers must know what their systems are to do. This is the best way to get all to agree.

• operation failure of computational units may include,

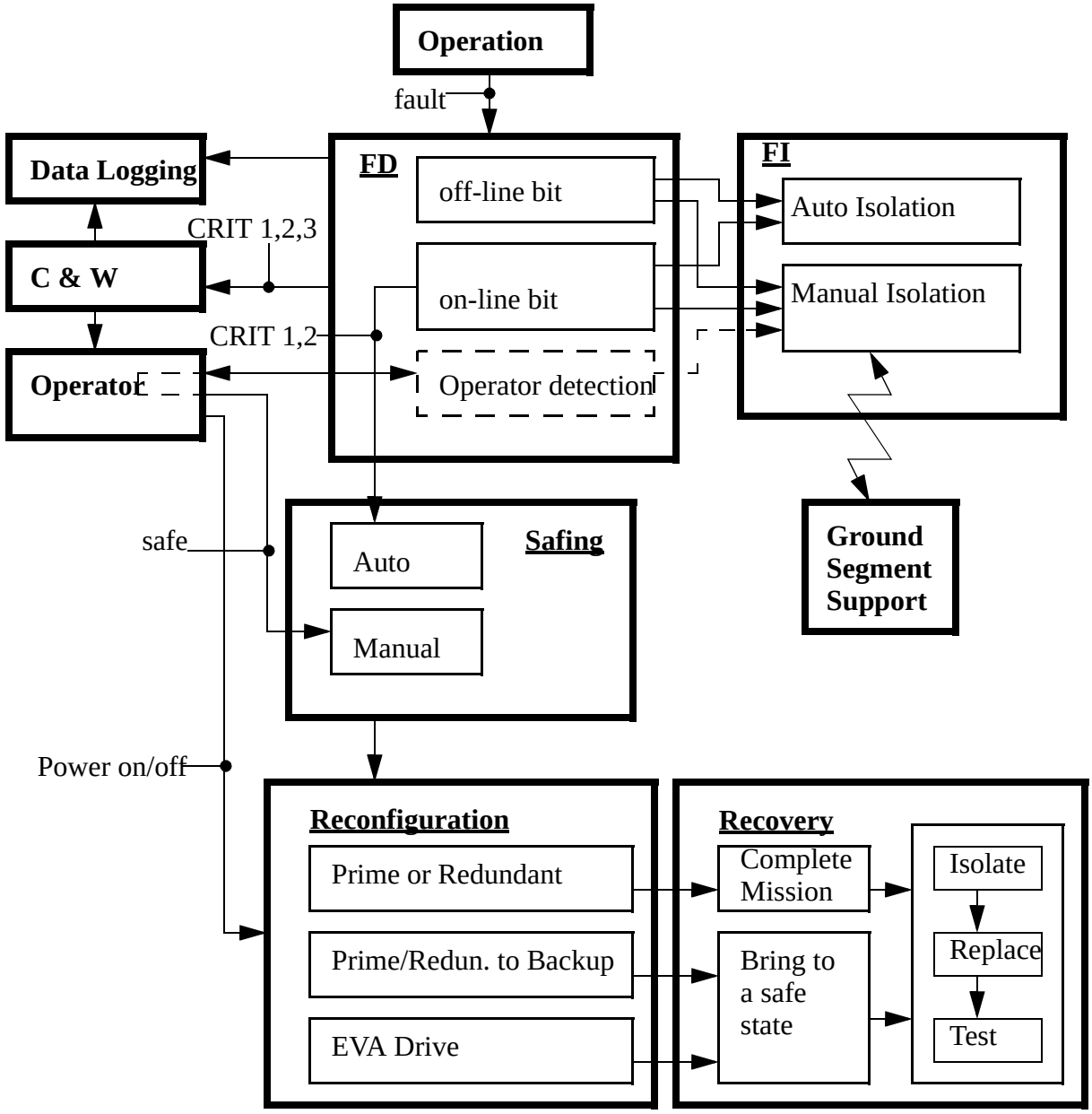
- invoking off-line bit checks with error checking algorithms
- operator visual inspections via cameras, etc.
- analysis of units memory through data dumps, etc.
- ground support failure isolation analysis
- exercising equipment with known algorithms

• Note: in the case of SSRMS the operator may use EVA units to move the arm away from contact.

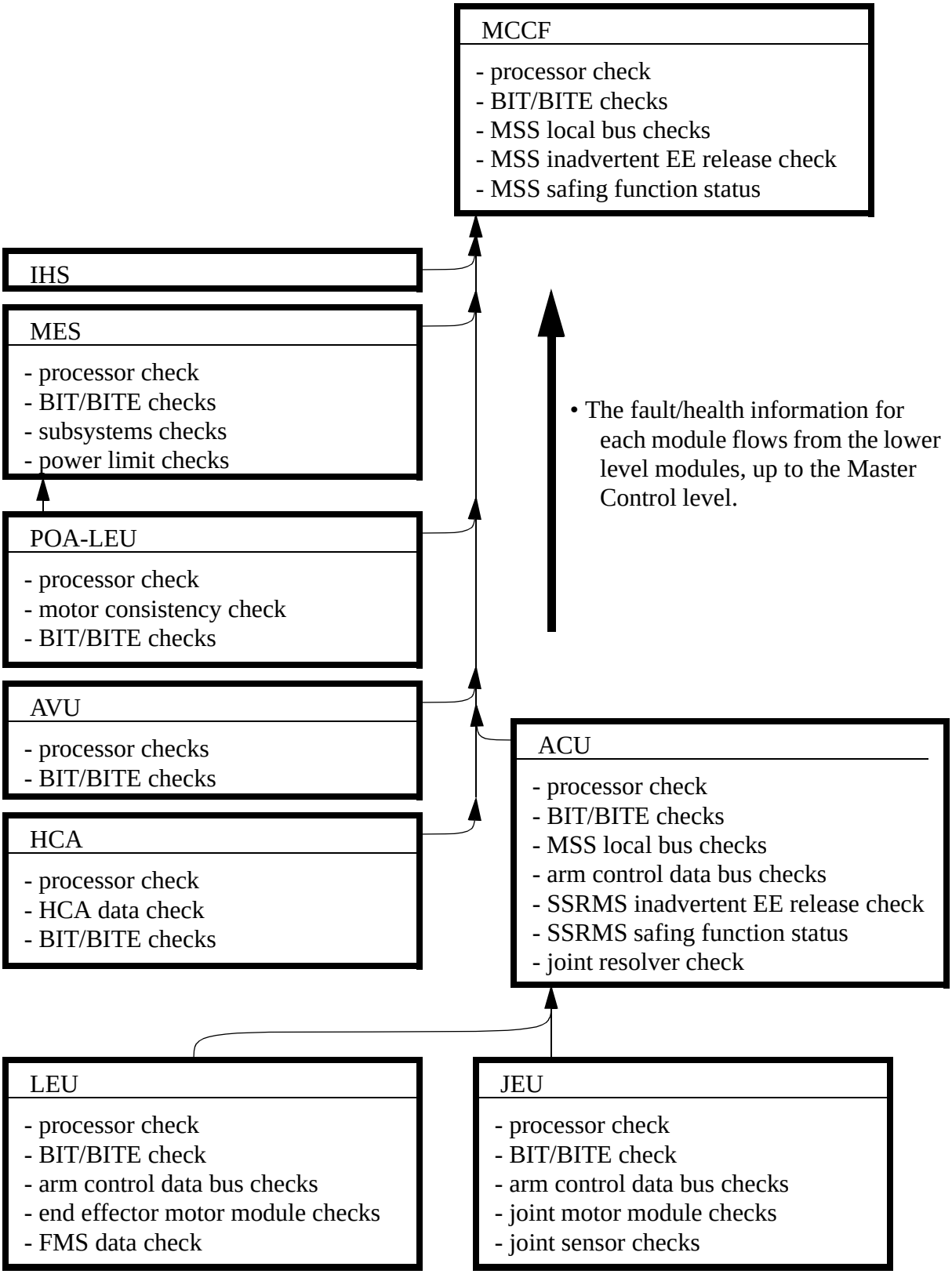
• Operators may always elect to replace failed units, if extras available.

• A diagram of the MSS Failure Management Concept is shown below, [Brimley]. This depicts a scheme for dealing with faults once they are detected. Some of the acronyms used are,

FD - Failure Detection
FI - Failure Isolation
C&W - Caution & Warning
CRIT - Failure Criticality
EVA - Extra Vehicular Activity
BIT - Built-In-Test



• There is also a scheme for estimating when a system has erred. This is based on a bottom up approach where the checks for errors are made in the specific modules, and then error reports are propagated up to the high level software/hardware. The diagram below depicts the system used in the SSRM.


MCCF
- processor check
- BIT/BITE checks
- MSS local bus checks
- MSS inadvertent EE release check
- MSS safing function status
IHS
MES
- processor check
- BIT/BITE checks
- subsystems checks
- power limit checks
POA-LEU
- processor check
- motor consistency check
- BIT/BITE checks
AVU
- processor checks
- BIT/BITE checks
HCA
- processor check
- HCA data check
- BIT/BITE checks
• The fault/health information for each module flows from the lower level modules, up to the Master Control level.
ACU
- processor check
- BIT/BITE checks
- MSS local bus checks
- arm control data bus checks
- SSRMS inadvertent EE release check
- SSRMS safing function status
- joint resolver check
LEU
- processor check
- BIT/BITE check
- arm control data bus checks
- end effector motor module checks
- FMS data check
JEU
- processor check
- BIT/BITE check
- arm control data bus checks
- joint motor module checks
- joint sensor checks

8.2.2 Case Studies In Failure

8.2.2.1 - Apollo 204

• Three astronauts were burned to death on the launch pad (1967)

• General Electric (GE) and other companies were commissioned to develop safety programs.

• These were developed based on combinations of existing programs for risk managements, such as those used by the Air Force, and Department of Defense.

8.2.2.2 - Apollo 13

• a definitive example of failure management

• the mission objective was to land on the surface of the moon, and return.

• the mission had four major components,

1. The booster (a saturn V rocket) was used for the initial launch, and was discarded after use.
2. The lunar module (dubbed Aquarius) was to be used for descent and ascent from the lunar surface, and to be discarded after use.
3. The service module was to be used for the trip to and from the moon.
4. The command module was equipped with a heat shield, and would be the only module to return to earth.

• In basic terms the mission had to be aborted as a result of an oxygen tank rupture. The fact that the astronauts managed to return back safely is a tribute to the quality of design in the space program.

• The events are chronicled below,

PRELAUNCH

- during a test the booster oxygen tank drains (causing fires in nearby automobiles, sparked by ignition systems)
- a helium tank on the lunar module is found to have excessive pressure a number of times
- oxygen tanks that supplied breathing air and fuel cells were not draining properly. This

was overcome by turning on heat, and redraining the tanks. No action was taken because the performance was adequate. It is believed that a problem arose at this point where insulation on wires inside the tank was worn down because of overheating, and the slower drain of oxygen from the tank.

T-5 DAYS
- one of the backup crew (Charles Duke) got german measles, and had exposed one of the crew (Thomas Mattingly). He was replaced by Jack Swigert as the command module pilot. This crew had not had any experience together in critical situations.

LAUNCH
- The Saturn V rocket burn is cut off 2 minutes early, requiring additional fuel to be burned to reach earth orbit. Fuel level were now lower, but not critical.

T+0 TO 55 HOURS
- one of the oxygen tank pressure gauges had gone off the scale and ground control had requested several times that the oxygen be stirred by a small fan in the tank.
- there were also pressure problems in a lunar module helium tank, and a hydrogen tank.

56 HOURS
- a warning light indicates low pressure in a hydrogen tank in the service module. Fans in the tanks were turned on to stir up the hydrogen.

56 HOURS + 16 SECONDS
- an arc between two wires starts a fire in an oxygen tank fueled by the insulators. The pressure in the oxygen tank builds, and warnings are not sounded because they are overridden by the hydrogen tank warning. The fire spreads through the service module bay.

56 HOURS + 5 MINUTES
- a bang is heard, crew assumes it is a noisy valve actuation, and that it might have been done as a practical joke.
- the pressure has built enough to blow out an outer panel on the service module bay.
- the master power alarm sounds as power on a master bus is lost. This was caused by damaged oxygen lines to the fuel cells. It turns out that 2 of the 3 were off line.
- hatch to lunar module is closed.
- Huston is informed of the problem.
- readings are scrambled, pressures and temperatures appeared erratic. Oxygen pressure in one tank was zero, and dropping in another.
- a cloud is observed outside the service module
- the venting of gases causes the craft to drift off course, the guidance system fails, and the craft begins to wobble, interrupting communications with the ground.
- Huston is still taken by surprise, assuming that four failures indicated could not be related, and almost impossible independently, and they began looking for instrumentation problems.
- a battery for reentry was connected to the power bus, but disconnected to reduce power

drain.
- Huston suggests disconnecting the 3rd fuel cell to check to see if oxygen loss was caused by the fuel cell. This operation could not be reversed.
- the goal of landing on the moon is no longer assumed possible, but the lunar module is kept intact for its supply of water and oxygen.
- the reentry battery is recharged and the command module is shut down, as the astronauts move to the lunar module. This is done acknowledging that the effects of the cold on the electronics is not known, and may affect earth reentry.
- it was decided to continue the flight path, and use the moons gravity to get back (with no lunar landing) for a total flight time of 100 hours.

THE NEXT 3 AND A HALF DAYS
- the remainder of the trip was punctuated by,
    - cold (minimal power for heating left temperatures about 10°C)
    - stress
    - fatigue (standing room only, or sleeping in the cold service module)
    - hunger (the food was meant to be mixed with hot water)
    - thirst (water was generated by the fuel cells)
- the CO_2 was normally absorbed by filters. With the extra use the filters in the lunar module were exhausted. The filters from the service module were not the correct shape to fit, requiring a jury rigged arrangement using duct tape.
- a new reentry procedure was devised and had to be relayed verbally to the crew and written on paper (not plentiful). This checklist took 2 hours to transmit verbally.

DESCENT
- The astronauts moved back to the command module, powered up the equipment (luckily the effects of the cold did not cause any malfunctions). There was a new concern that the heat shield was still intact. No instruments allowed this to be checked. The other modules were jettisoned.
- the spacecraft landing began, and finished safely, with one of the fastest recoveries.

• In retrospect the accident was reviewed, and the causes for this accident were believed to be,
- budget pressures, morale problems, and schedule pressures encouraged the use of the damaged oxygen tank.
- the estimates of failure effects had been incomplete because of assumptions of adequacy.
- emergency plans were available but not practiced.

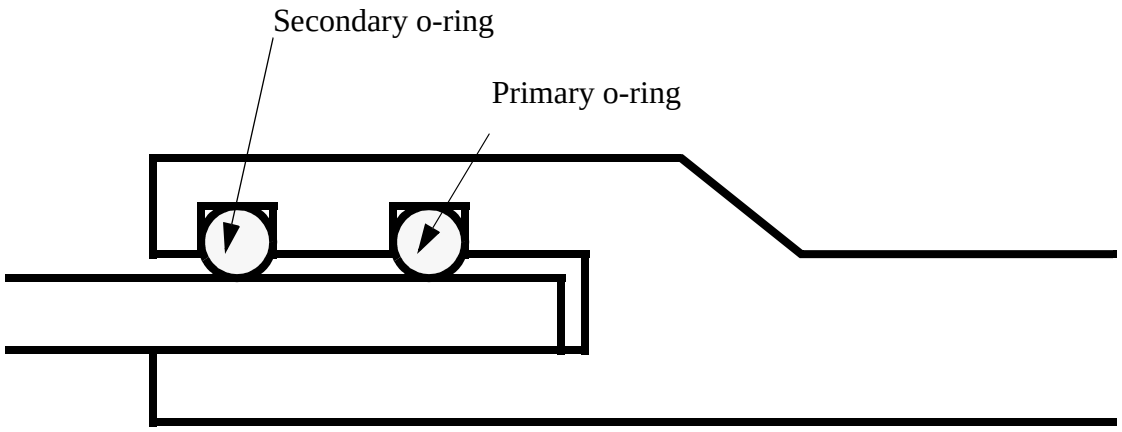
8.2.2.3 - The Challenger

• The Challenger accident would have been prevented with the existing NASA procedures. The explosion of the Challenger is more the result of management failure in NASA and Morton Thiokol than the result of technical failures.

• In general the important notes are,

1972 - contract awarded to Morton Thiokol to design the Solid Rocket Boosters (SRBs)

- the design is based on a modified Titan III rocket, with significant design changes
- one of the changes was an o-ring seal along the rocket body. The joint was made longer, and a second ring added to provide a redundant seal.



1977-78 - An engineer discovers during tests that under pressure the joints rotated significantly causing the secondary o-ring to become ineffective. This is a result of the elongated joint to hold the secondary o-ring. Morton Thiokol management did not recognize the problem.

1980 - The joint is classified on the CIL (Critical Item List) as 1R, indicating that failure would be catastrophic, but there is a redundant o-ring to act as a backup in the event of failure. This was only one of 700 items listed as criticality 1.

1981 - the shuttle begins orbital testing

1982 - the space shuttle is declared operational

- After a few flights, problems with the o-rings were noted, as were other items. The normal procedure was to assign a problem tracking number, and examine the causes. This was not done for the o-ring problem. Eventually the problem was recognized and the rating was changed to 1 on the CIL. It was shown that despite NASA's reclassification, the system was still listed as 1R in the Morton Thiokol paperwork, as well as a number of other documents. Also, Morton Thiokol disagreed with the criticality change, and went to a referee procedure.

1984 - the erosion of the o-rings has become a significant concern, and review procedures are requested for the packing of the o-ring joint with the asbestos filled putty that prevents heating of the rings. Morton Thiokol responds with a letter suggesting that higher pressures used in testing the joints was resulting in channels in the putty, and increased erosion of the o-rings. statistics from before and after the change in testing pressure seemed to confirm this. Morton Thiokol recommends continuing the tests to ensure sealing despite the problems, and begins investigat-

ing the effects of the testing on the putty.

Jan 1985 - A launch of a space shuttle at the coldest temperatures to date leads to the greatest failure of the o-rings to date. The o-rings will deform under pressure to seal the gap, but this is hindered when they are colder, and the material stiffer.

Jan-April 1985 - Continued flights and investigations show continued problems with the o-rings, and a relationship to launch temperature. Morton Thiokol acknowledges the problem, and the effects of temperature, but concludes that the second o-ring will ensure safety.

April 1985 - the primary o-ring does not seal, and the secondary ring carries the pressure, with some blowby (i.e., the backup was starting to fail). As a result a committee concludes that the shuttle must only be operated in an acceptable flight envelope for the o-ring seal. This report is received by Morton Thiokol, but does not seem to be properly distributed. The problem was also not properly reported within NASA to upper management.

July 1985 - A Morton Thiokol engineer recommends that a team be set up to study the o-ring seal problem, citing a potential disaster.

August 1985 - Morton Thiokol and NASA managers brief NASA headquarters on the o-ring problems, with a recommendation to continue flights, but step up investigations. A Morton Thiokol task force is set up.

October 1985 - The head of the Thiokol task force complains to management about lack of cooperation and support.

December 1985 - One Thiokol engineer suggests stopping shipments of SRBs until the problem is fixed. Thiokol writes a memo to NASA suggesting that the problem tracking of the o-rings be discontinued. This lead to an erroneous listing of the problem as closed, meaning that it would not be considered as critical during launch.

Jan 1986 - The space shuttle Challenger is prepared to launch Jan., 22, originally it was scheduled for July 1985, and postponed 3 times, and scrubbed once. It was rescheduled again to the 23rd, then 25th, then 27th, then 28th. This was a result of weather, equipment, scheduling, and other problems.

Jan., 27th, 1986 - The shuttle begins preparation for launch the next day, despite predicted temperatures below freezing (26°F) at launch time. Thiokol engineers express concerns over low temperatures, and suggests NASA managers be notified (this was not done). A minimum launch temperature of 53°F had been suggested to NASA. There was no technical opinion supporting the launch at this point. The NASA representative discussing the launch objected to Thiokol’s engineers opinions, and accused them of changing their opinions. Upper management became involved with the process, and “convinced” the technical staff to withdraw objections to the launch. Management at Thiokol gave the go ahead to launch under pressure from NASA officials (this was the critical decision).

- the shuttle is wheeled out to the launch pad. Rain has frozen on the launch pad, and may have gotten into the SRB joints and frozen there also.

Jan., 28th, 1986 - The shuttle director gives the OK to launch, without having been informed of the Thiokol concerns. The temperature is 36°F.

11:39 am - The engines are ignited, and a puff of black smoke can be seen blowing from the right SRB. As the shuttle rises the gas can be seen blowing by the

o-rings. The vibrations experienced in the first 30 seconds of flight are the worst encountered to date.

11:40 am - A flame jet from the SRB starts to cut into the liquid fuel engine tank, and a support strut.

11:40:15 am - the strut gives way, and the SRB pointed nose cone pierces the liquid fuel tank. The resulting explosion totally destroys the shuttle and crew.

11:40:50 am - the SRB's are destroyed by the range safety officer.

8.2.3 Assignment Problems

8.2.4 Glossary

AFSCN Air Force Satellite Control Network
A/L Approach and Landing
ALT Approach and Landing Test
AMU Astronaut Maneuvering Unit
AOA Abort Once Around
APS Alternate Payload Specialist
APU Auxiliary Power Unit
ASE Airborne Support Equipment
ATE Automatic Test Equipment
ATO Abort to Orbit
BFC Backup Flight Control
BOC Base Operations Contract
CAPCOM Capsule Communicator
CCAFS Cape Canaveral Air Force Station
CCMS Checkout, Control and Monitor Subsystem
CCTV Closed Circuit Television
CDMS Command & Data Management Systems Officer
CDR Commander
CDS Central Data System
CFES Continuous Flow Electrophoresis System
CIC Crew Interface Coordinator
CIE Communications Interface Equipment
CITE Cargo Integration Test Equipment
CTS Call to Stations
DCC Data Computation Complex
DCS Display Control System

DFI Development Flight Instrumentation
DFRF Hugh L. Dryden Flight Research Facility
DIG Digital Image Generation
DMC Data Management Coordinator
DMOS Diffusive Mixing of Organic Solutions
DOD Department of Defense
DOP Diver Operated Plug
DPS Data Processing System
EAFB Edwards Air Force Base
ECLSS Environmental Control & Life Support System
EECOMP Electrical, Environmental & Consumables Systems Engineer
EI Entry Interface
EMU Extravehicular Mobility Unit
ESA European Space Agency
ESMC Eastern Space and Missile Center
ET External Tank
EVA Extravehicular Activity
FAO Flight Activities Officer
FAWG Flight Assignment Working Group
FBSC Fixed Base Crew Stations
F/C Flight Controller
FCT Flight Crew Trainer
FCTS Flight Crew Trainer Simulator
FD Flight Director
FDF Flight Data File
FDO Flight Dynamics Officer
FOD Flight Operations Directorate
FOE Flight Operations Engineer
FOPG Flight Operations Planning Group
FOSO Flight Operations Scheduling Officer
FR Firing Room
FRC Flight Control Room
FRCS Forward Reaction Control System
FRF Flight Readiness Firing
FRR Flight Readiness Review
FSE Flight Simulation Engineer
FSS Fixed Service Structure
GAS Getaway Special
GC Ground Control
GDO Guidance Officer
GLS Ground Launch Sequencer
GN Ground Network
GNC Guidance, Navigation & Control Systems Engineer
GPC General Purpose Computer
GSE Ground Support Equipment
GSFC Goddard Space Flight Center

HAC Heading Alignment Circle
HB High Bay
HMF Hypergolic Maintenance Facility
HPPF Horizontal Payloads Processing Facility
HUS Hypergolic Umbilical System
IECM Induced Environment Contamination Monitor
IG Inertial Guidance
ILS Instrument Landing System
IMF In Flight Maintenance
IMU Inertial Measurement Unit
INCO Instrumentation & Communications Officer
IRIG Interrange Instrumentation Group
ISP Integrated Support Plan
IUS Inertial Upper Stage
IVA Intravehicular Activity
JPL Jet Propulsion Laboratory
JSC Lyndon B. Johnson Space Center
KSC John F. Kennedy Space Center
LC Launch Complex
LCC Launch Control Center
LCS Launch Control System
LDEF Long Duration Exposure Facility
LETF Launch Equipment Test Facility
LOX Liquid Oxygen
LPS Launch Processing System
LSA Launch Services Agreement
LWG Logistics Working Group
MBCS Motion Base Crew Station
MCC Mission Control Center
MD Mission Director
MDD Mate/Demate Device
ME Main Engine
MECO Main Engine Cutoff
MET Mission Elapsed Time
MLP Mobile Launch Platform
MLR Monodisperse Latex Reactor
MLS Microwave Landing System
MMACS Maintenance, Mechanical Arm & Crew Systems Engineer
MMPSE Multiuse Mission Payload Support Equipment
MMSE Multiuse Mission Support Equipment
MMU Manned Maneuvering Unit
MOD Mission Operations Directorate
MOP Mission Operations Plan
MPGHM Mobile Payload Ground Handling Mechanism
MPPSE Multipurpose Payload Support Equipment
MPS Main Propulsion System

MS Mission Specialist
MSBLS Microwave Scanning Beam Landing System
MSC Mobile Servicing Centre
MSCI Mission Scientist
MSFC George C. Marshall Space Flight Center
MSS Mobile Service Structure
MST Mobile Service Tower
MTE Mobile Transporter Element
MUM Mass Memory Unit Manager
NASCOM NASA Communications Network
NBT Neutral Buoyancy Facility
NIP Network Interface Processor
NOCC Network Operations Control Center
NSRS NASA Safety Reporting System
NSTL National Space Technology Laboratories
NSTS National Space Transportation System
OAA Orbiter Access Arm
OAST Office of Aeronautics & Space Technology
OC Operations Coordinator
O&C Operations and Checkout (Building)
OFI Operational Flight Instrumentation
OFT Orbiter Flight Test
OMBUU Orbiter Midbody Umbilical Unit
OMRF Orbiter Maintenance & Refurbishment Facility
OMS Orbital Maneuvering System
OPF Orbiter Processing Facility
OSF Office of Space Flight
OSS Office of Space Science
OSSA Office of Space Science and Applications
OSTA Office of Space and Terrestrial Applications
OV Orbiter Vehicle
PACE Prelaunch Automatic Checkout Equipment
PAM Payload Assist Module
PAYCOM Payload Command Coordinator
PCR Payload Changeout Room
PDRS Payload Deployment & Retrieval System
PGHM Payload Ground Handling Mechanism
PHF Payload Handling Fixture
PIP Payload Integration Plan
PLSS Portable Life Support Subsystem
PLT Pilot
POCC Payload Operations Control Center
POD Payload Operations Director
PRC Payload Changeout Room
PRF Parachute Refurbishment Facility
PRSD Power Reactant Storage & Distribution

PS Payload Specialist
R&D Research Development
RCS Reaction Control System
RMS Remote Manipulator System
RPS Record Playback Subsystem
RSS Rotating Service Structure
RTLS Return to Launch Site
SAEF Spacecraft Assembly & Encapsulation Facility
SAIL Shuttle Avionics Integration Laboratory
SCA Shuttle Carrier Aircraft
SCAMMA Station Conferencing & Monitoring Arrangement
SCAPE Self-Contained Atmospheric Protection Ensemble
SID Simulation Interface Device
SIP Standard Interface Panel
SIT Shuttle Interface Test
SL Spacelab
SLF Shuttle Landing Facility
SMAB Solid Motor Assembly Building
SMCH Standard Mixed Cargo Harness
SMS Shuttle Mission Simulator
SN Space Network
SPDM Special Purpose Dextrous Manipulator
SPIF Shuttle Payload Integration Facility
SPOC Shuttle Portable On-Board Computer
SRB Solid Rocket Booster
SRBDF Solid Rocket Booster Disassembly Facility
SRM&QA Safety, Reliability, Maintainability and Quality Assurance
SSC John C. Stennis Space Center
SSCP Small Self-Contained Payload
SSIP Shuttle Student Involvement Project
SSME Space Shuttle Main Engines
SSP Standard Switch Panel
SSRMS Space Station Remote Manipulator System
SST Single System Trainer
STA Shuttle Training Aircraft
STS Space Transportation System
T Time
TACAN Tactical Air Navigation
TAEM Terminal Area Energy Management
TAL Trans-Atlantic Abort Landing
TDRS Tracking and Data Relay Satellite
TPAD Trunnion Pin Acquisition Device
TPS Thermal Protection System
TSM Tail Service Mast
UHF Ultra high Frequency
UV Ultraviolet

VAB Vehicle Assembly Building
VLF Very Low Frequency
VPF Vertical Processing Facility
WCS Waste Collection System
WSMC Western Space & Missile Center
WSSH White Sands Space Harbor

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9. FORMULAS

9.1 ELECTRICAL RELATIONSHIPS

• Ohm's Law

$$I = \frac{E}{R}$$

I = Current (Amperes)
E (or V) = Voltage (Volts)
R = Resistace (Ohms)

• DC Power

$$P = IE$$

P = Power (Watts)
I = Current (Amperes)
E = Voltage (Volts)

$$P = IEt$$

P = Power (Watt-hours)
I = Current (Amperes)
E = Voltage (Volts)
t = time (hours)

• AC Power

$VA = IE$ one phase

$VA = IE\sqrt{2}$ two phase

$VA = IE\sqrt{3}$ three phase

VA = total power (volt-amps)
I = current (RMS amperes)
E = voltage (RMS volts)

• AC Power Factor

$$PF = \frac{W}{VA}$$

PF = power factor (unitless)
W = real power (watts)
VA = total power (volt-amps)

• 3 phase AC motor current

$$I = \frac{HP(746)}{E(efficiency)(PF)\sqrt{3}}$$

I = current (peak amperes)
HP = rated power (horsepower)
efficiency = rated efficiency
PF = power factor
E = applied voltage (peak volts)

9.2 MECHANICAL FORMULAS