

Midterm is on Lectures 1 -9 and TSE 1-4

LECTURE 2

What is engineering?

- Problem solving & critical thinking (applied analysis)
- Design (Synthesis)
- Professionalism (formal organization)

Definition of an Engineer

A person who uses science, mathematics, experience, and judgement to create, operate, manage...Does this in a rational and economic way with human, societal, and natural resources and environmental constraints.

Role of engineers

- Engineering is a team activity
 - Engineering teams involve individuals with widely different abilities, interests and education who cooperate to advance the project.
 - A typical technical team might consist of
 - Engineers
 - Scientists
 - Technologists
 - Technicians
 - Social workers
 - Skilled workers

Engineer

- Provides the key link between theory and practical applications
 - Has theoretical knowledge
 - Thinks creatively
 - Leads a team towards a common goal (motivation)
 - Knack for obtaining practical skills
- Education
 - Basic requirement is a bachelor's degree
 - Master's or PhD is useful and sometimes preferred

Professional Engineer

In Canada, the title "professional engineer" is restricted by law.

- Only people that can be called "professional engineer" if they have:
 - Demonstrated competence
 - Been licensed by a provincial professional engineering association (PEO in Ontario)

Canadian Engineering Accreditation Board (CEAB)

- Provincial/territorial associations rely on CEAB to evaluate and accredit engineering programs in Canada

- CEAB conducts rigorous and regular reviews of engineering programs across Canada
- They publish a list of accredited programs in Canada

Why Conform to CEAB?

If you want to be a professional engineer, one of the principal requirements is to graduate from a CEAB accredited program.

CEAB requirements?

Practical Experience (4 Years)

Professional Practice Examination

Character attested to by references

No longer required to be a Canadian Citizen or Permanent Resident

Technologist

- Works under the direction of an engineers
 - They apply engineering principles and methods to complex technical problems
- Required Education:
 - 3 Year technology program from community college
- Often supervises work of others and is encouraged to have qualifications recognized by technical society.
- Engineer Vs Technologist
 - Engineering education typically provides greater theoretical depth
 - The technology diploma is more hands-on experience

Skilled Worker

- Skilled in a trade like electrician, welder, plumber, carpenter, machinist, etc
 - Typically carries out the designs and plans of others
- Has great expertise acquired thru apprenticeship or years of experience in the trade
- Most trades have a trade organization and certification procedure

Technician

- Works under the supervision of an engineer or technologist in the practical aspects of engineering
 - Ex. Of Work: Making tests and maintaining equipment.
- Education
 - Completion of two year technician program in a community college
- Association may confer to the title of Certified Engineer Technician
 - Although, Certification is not necessary to work as a technician

Open-Ended Problems

Most Engineering Problems are open-ended

- Meaning they don't have a single solution

Also just because there isn't just one answer, doesn't mean the problem is easier to solve

- What skills are needed to solve open-ended problems?
 - Broad base of engineering knowledge
 - Critical thinking
 - Innovation
 - Perseverance

Engineering Skills

- How to represent a design problem
- How to make assumptions
- How to generate ideas for designs
- How to conduct effective research to solve a problem
- How to plan and schedule activities
- How to make efficient use of resources
- How to organize components and activities of a team design project (Teamwork)

Ingenuity

- Engineers can find clever ways to solve problems
- Innovation
- Critical thinking
- Problem solving

Canadian Engineering Accomplishments

- Transcontinental Railway - links coast to coast
- De Havilland Beaver 1947 - Water landing plane
- Very High Voltage Transmission - Transmission lines at very long distances with very high voltage
- St Lawrence Seaway - Connects Ocean and great lakes
- Nuclear Power - CANDU Reactor
- Athabasca Oil Sands - Recovering Oil from the Oilsands
- Winnipeg Floodway - Diverts flood water around city
- Alouette Satellite - 3rd Satellite in space
- CanadaARM
- Trans Canada phone Network
- Pacemaker
- Confederation Bridge
- CN Tower
- IMAX

LECTURE 3

Measurements

- Physical quantity that can be observed

- Measurement compared to a standard quantity
- A measurement consists of two parts
 - A numerical magnitude
 - A name, symbol, or combination of symbols that define the reference standard

Base and Derived Units

- Derived in terms of base units
 - Ex. 1 Newton = 1 Kilogram x 1 Metre / Second squared
- Base Units
 - Are fundamental units from which all other units are derived from

Systeme International d'Unites (SI Units)

- Adopted by almost all countries
 - Notably the United States is an exception
- Metric system introduced as measurement system "for all people, for all time"

7 Base Units in SI

- Metre for length
- Kilogram for mass
- Second for time
- Ampere for electric current
- Kelvin for temperature
- Candela for liminous intensity
- Mol for the amount of a substance

Absolute and Gravitational Unit Systems

SI Unit system

- Absolute System
 - Mass is a fundamental unit
 - Newton's second law (force=mass x acceleration) is invoked to derive force due to gravity

FPS unit system

- Gravitational system
 - Force is a fundamental unit
 - Mass is derived from Newton's second law.
 - Distance, force and time are all fundamental dimensions, measured in units of feet, seconds and pounds.

Forces and Gravity

- The application of gravity in Newton's Second Law ($F=ma$) presents several problems.

- It's treated differently in each system of units
- SI: $1\text{N} = 1\text{kg} \times 1\text{m/s}^2$
- American: 1lbf doesn't not equal $1\text{lbm} \times 1\text{ft/sec}^2$
- For American system you have to re-write Newton's 2nd law:
 $F = ma / \text{gravitational constant } g_c = 32.17$

Read Chapter 10 for Lecture 3

Lecture 4 - Measurements, Units and Errors

SI Magnitude Prefixes

A Unit may be preceded by a magnitude prefix:

Y	yotta	10^{24}	M	mega	10^6	f	femto	10^{-15}
Z	zetta	10^{21}	k	kilo	10^3	a	atto	10^{-18}
E	exa	10^{18}	m	milli	10^{-3}	z	zepto	10^{-21}
P	peta	10^{15}	μ	micro	10^{-6}	y	yocto	10^{-24}
T	tera	10^{12}	n	nano	10^{-9}			
G	giga	10^9	p	pico	10^{-12}			

Writing Quantities With Units

- Standardized rules for correctly representing quantities with units:
 Number or Formula (italic typed) preceded by a half or full space then SI unit symbols (Roman typed)

Rules for writing with Units

- Always put a space between numeric value and unit
- Unit symbols are treated like algebraic factors that can be multiplied or divided with numbers or other unit symbols:
 - Multiplication between units is indicated by a centred dot or a half space
 - Division between units is indicated by a slash or a negative superscript
- Unit symbols are not modified with subscripts:
 - $-V_{\text{max}} = 200\text{V}$ NOT $V = 200 V_{\text{max}}$
- Relation between numerical quantity and unit symbols must be clear:
 - $3.7\text{ km} \times 2.8\text{ km}$ for an area, NOT $3.7\text{ km} \times 2.8$
- Unit symbols not mixed with unit names in sentences:
 - Use kg/m^2 or kilogram per metre squared NOT kilogram/m^2
- Long numbers, written in groups of 3, the groups should be separated by a non-breaking half space rather than a comma or period:
 - 930 000 000 miles NOT 930,000,000 miles
 - 21 298.046 83 miles NOT 21298.04683 miles

Fixed, Scientific and Engineering Notation

- Fixed Notation
 - Ordinary decimal notation
 - Ex. 30 140.0
- Scientific Notation
 - Ex. 3.014×10^4
- Engineering Notation
 - Exponent of 10 is a multiple of 3 to correspond to SI prefixes
 - Ex. 30.14×10^3

Dimensions

- Dimensions differ slightly from units
 - Ex. Speed
 - Dimensions = distance/time
 - Units are known as km/hr, or mm/s, etc.
- Fundamental dimensions
 - Distance, time, mass, etc.

Measurement

Property of a physical object that can be represented using a real number

- Not like counting, measurement is not exact

Quantities are usually measured with an instrument

- Calipers, scale, measuring cup, etc.

Uncertainty

- Measuring instruments are not perfect

True Value - Measured Value = Measurement Error

Systematic Errors

- Constant deviation from the true value, is called a bias or offset.
- Error has the same measurement and sign when repeated measurements are made under the same conditions
- Systematic Errors can be detected by
 - Calibration
 - Comparison with results obtained with an independent method

Lecture 5

How do engineers Communicate?

- The 3 ways Engineers convey information:
 - Written Documents
 - Oral Presentations
 - Graphically
- Sometimes a combination of ways is used

Engineering Graphics

- The majority of engineering information is transmitted by graphical means
- But written and verbal communication is also important to engineering communication

Advantages of Graphical Communication

- Clear
- Concise
- Efficient
- Reduced Ambiguity

Engineering Graphics

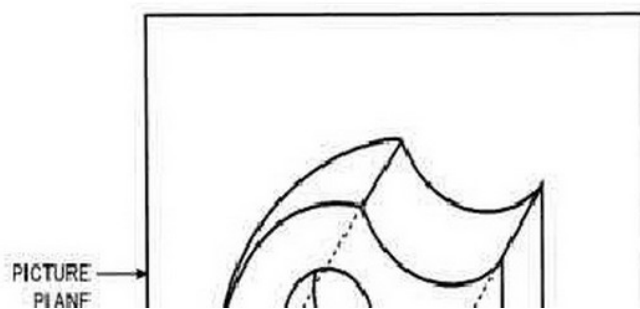
- Graphics is a universal language
- Engineering graphics are directed towards graphical problem solving
- A good engineering Graphic is worth a thousand words

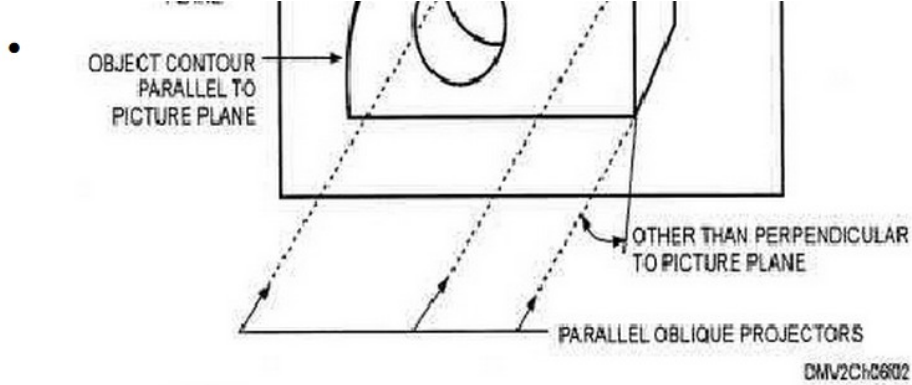
Technical Illustration

- Technical Illustrations are used to describe products in catalogues, user and maintenance manuals.
- Pictorial sketching is an important engineering communication tool
- Helpful to describe difficult to visualize components or assemblies
- How to put components together, NOT how to make them
- There common types of Technical Illustration:
 - Perspective
 - Oblique
 - Isometric

Oblique Projection

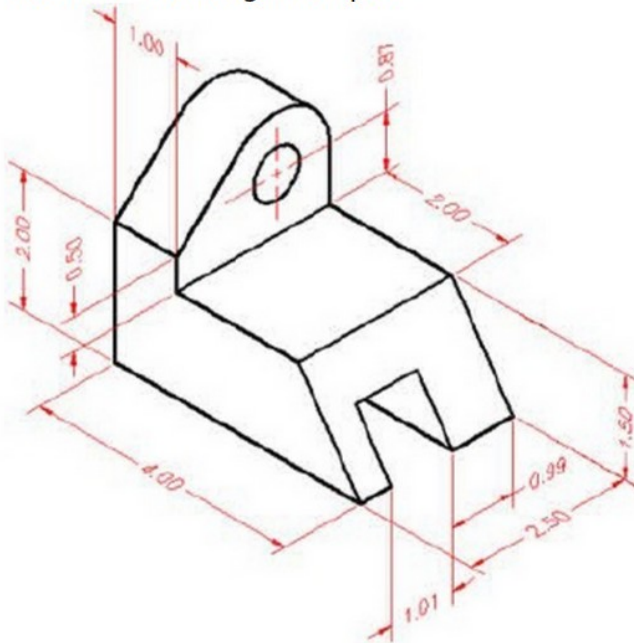
- Front face of the object is parallel to the viewer, therefore the face is true size
- The projection lines do not converge into a vanishing point





Isometric Projection

- Parallel lines remain parallel instead of converging to a vanishing point
- Axes are 120 degrees apart



Orthographic Projection

- Most important graphical drawing method
- 2D representations of a 3D figure
- Extensively used in engineering
- Useful when technical information is needed

- Enable parts to be made
- Sometimes the isometric view is included into the Orthographic Projection
- Geometric backbone of a technical drawing

Third Angle Projection

- The object is placed in the third quadrant and then view from the first quadrant

- Projection planes are between the observer and the object
- Used in Canada, US and Britain
- Top view over the front view, then to the right of that is the right view

First Angle Projection

- The object is placed in the first quadrant and then viewed from the third quadrant
- The object is between the observer and projection planes
- Used in most of the world
- Right view, to the right of that is the Front view then below is Top view

Selection of views

- The most descriptive view is usually selected to be the front view
- The remaining views are selected to be the ones with the least hidden lines
- If a tie occurs, we use the conventional view (right and top)

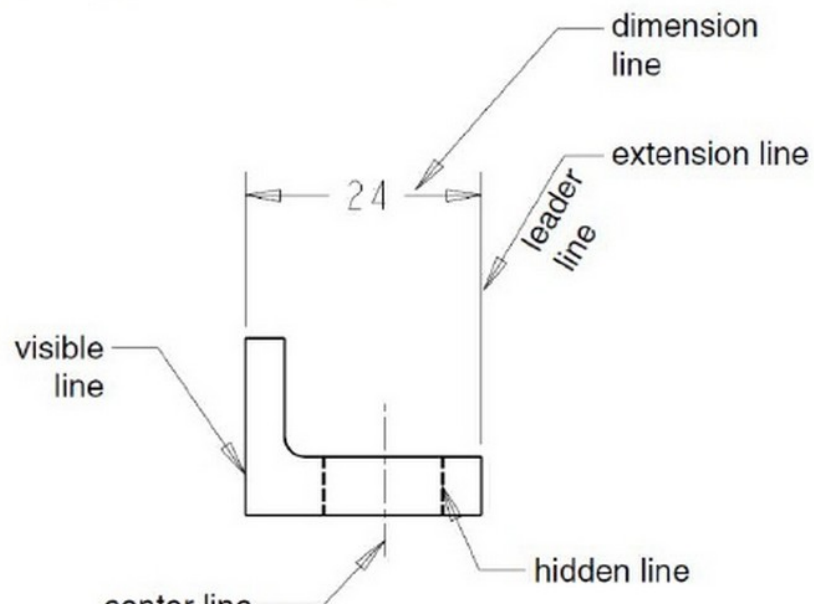
Read Chapters 12-14

Lecture 6 - Engineering Graphics

Standard Drawing Layout

- Three-view orthographic projection
 - Top view located above the front view
 - Right view located to the right of the front view
 - The views must be aligned

Orthographic Projection - Lines



- When two or more lines coincide, there is a convention called 'precedence of lines' to establish which is visible:
 1. Visible Object Lines
 2. Hidden Object Lines & Cutting plane lines
 3. Centre Lines
 4. Extension & Leader Lines
- Line Types:
 - Object Lines: indicate all visible edges of an object; must stand out and be apparent to the eye
 - Hidden Lines: shows object lines that are hidden from the view
 - Cutting Plane Lines: indicated edge view of an imaginary cutting plane (Section views)
 - Centre Lines: indicates centres of holes and symmetrical features of an object



Dimensions

- Two fundamental rules for dimensioning:
 - Dimensions must describe the complete geometry of the part
 - Redundant dimensions should be avoided
- More specific rules apply to the geometry, the placement and style of the dimension
 - Dimensions must be from visible lines, not hidden features
 - Repeated regular identical features may be dimensioned only once, along with a small note indicating quantity, etc.
 - The designer should be able to locate dimensions in a way to indicate how tolerances accumulate
- Dimensioning Circles
 - Radii are dimensioned using a leader line with an arrow at the end of the line
 - Capital "R" indicates radius
 - Dimension rounds and fillets with their radii

- Similarly, a diameter has a leader line with an arrow
 - The diameter symbol indicates diameter
 - Never dimension holes or cylinders with radius, use diameter
- Angles
 - Fractional degree measurements can be represented with decimals or minutes and seconds
 - Dimensional lines are drawn as arcs
- Rule Zero
 - When dimensioning a drawing, set the dimensions size to a readable size for when it's printed in its final size
- Rule One
 - The first dimension height should be three times the letter height, from the object.
 - Successive dimensions should be two times the letter height apart
- Rule 2
 - Place dimensions between the views sharing the same dimensions
- Rule 3
 - Dimension the most descriptive view
- Rule 4
 - Dimension from visible (object) features, and not hidden features
- Rule 5
 - Give an overall dimension, omitting the last in a chain of

- dimensions
- Rule 6
 - Organize the dimensions to reduce the clutter in the drawings
- Rule 7
 - To avoid errors and confusion, do not duplicate dimensions
- Rule 8
 - Dimension lines never cross any other lines, unless absolutely necessary
- Rule 9
 - Extension lines may cross other extension lines, or object lines, if necessary
- Rule 10
 - Do not leave gaps where extension lines cross object lines or other object lines
- Rule 11
 - Where possible, place object lines outside the objects
- Rule 12
 - Dimension Cylinders in the RECTANGULAR view, not CIRCULAR
 - Only Diameter, NOT Radii
 - BUT dimension inside of circular holes in view where they look like holes, in the circular view

- Dimension circular holes in the view where they look like holes ie If model is not a cylinder

Orthographic Projections

- Advantages
 - Able to contain a high degree of detail
 - Angle and length measurements can be made on all views (exceptions do exist)
- Disadvantages
 - Effort is needed to interpret the object
 - Many conventions must be followed - not as easy as the other three

Read Chapter 13

LECTURE 6 - Engineering Graphics

Nomographs

- Also called an alignment chart, is a calculating chart with scales that contain values of three or more mathematical variables
 - Widely used in engineering, industry, and the natural and physical sciences

Why do we need CAD?

- CAD is an effective way to communicate your ideas and designs
 - Used to produce working drawings
- Manufacturing is becoming more integrated, more global
- Systems are becoming more complex
- Working drawings are needed in all disciplines

- Electrical, Civil, Mechanical, Aerospace, Manufacturing & Architecture

CAD Advantages

- Increased accuracy
- Increased Speed
- Easy Revision
- Better Design analysis
- Better presentation
- Libraries of drawing aids
- Improved filing

Solid Modeling

- The software creates 3D virtual objects
- The virtual objects appear as axonometric projections
- The models can be virtually manipulated, just like a physical object
- Ex. Products:
 - Pro/ENGINEER
 - Solid Edge

LECTURE 8 - Introduction to Design

What is design?

- Design is a creative process
- Incorporates all areas of engineering education
- Design is basically what engineers do
- Almost always involves a team effort
- An iterative process
- Open-ended problems, often with many possible solutions
- Usually, only a handful of good solutions

Engineering Design

- Identifying problems, solving them, and implementing the solutions.

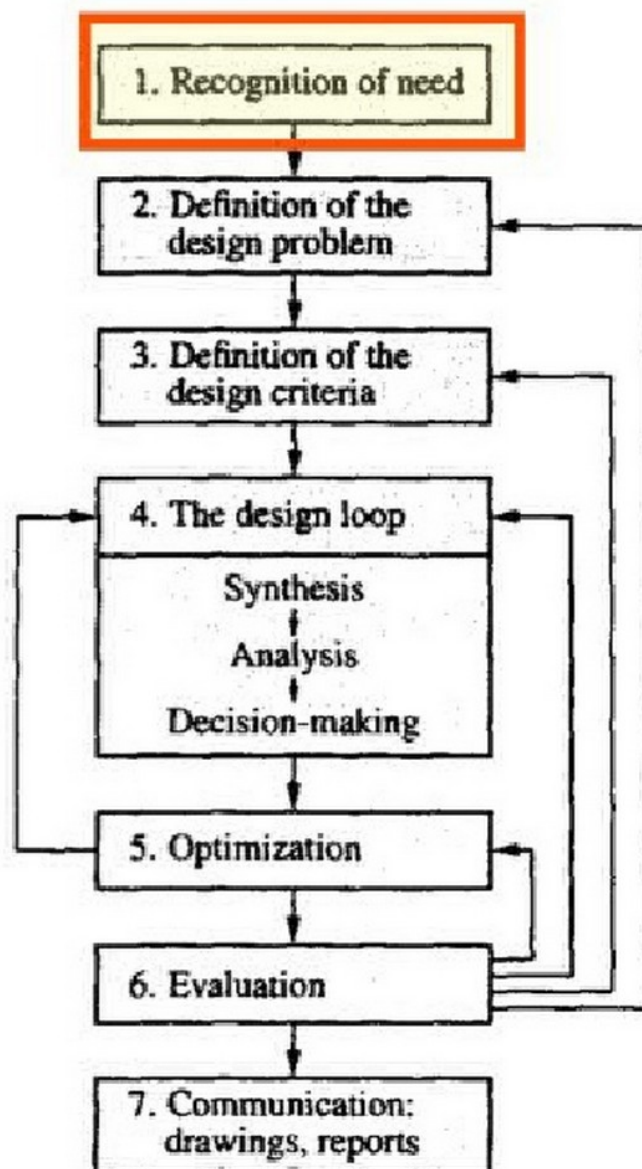
Good Design Requires:

- Organization
- Teamwork
- Communication

In addition, it requires, creativity and criticism is essential

The key is knowing when to criticize and when to be creative

- Before a problem can be solved, it has to be identified
- Needs should be categorized and defined in a Statement of Requirements
- Most design problems can be categorized as:
 - Systems Problem



Method of Design

- Recognition of Need
 - A need can be either very obvious or hidden
 - Usually very vague
 - The vagueness of the need can cause the design process to

- The vagueness of the need can cause the design process to become open-ended
- Often the need is written in a Statement of Requirements
- Definition of the design problem
 - Critical for a good design
- May require the gathering of information of the topic (research)
- Must define the problem correctly in order to provide a solution
- Definition of the design criteria
 - Design criteria are performance standards to be met by the design
 - Design constraints are limitations placed on the designer
 - The design criteria and constraints must be quantitative values
- The design loop
 - Synthesis
 - Suggesting ideas or methods to solve the problem
 - Analysis
 - Calculating the expected result of each idea or method
 - Decision-making
 - Deciding which alternative is best
- Optimization
 - Optimum implies a compromise between cost and benefits - the best design at a reasonable cost
 - If the design is not optimum, the design loop may be needed to be reiterated
- Evaluation
 - Once the design is completed, it must be reviewed
 - The senior engineer and "others" have to approve of the design before they finalize it
 - If the design is flawed, it must be iterated and send back to step 2
- Communication
 - Once the design is approved, it can be built or manufactured
 - The final design must be communicated effectively
 - Reports
 - Technical Drawings

Creativity and Innovation

- Are required for the design process
 - Brainstorming

Read Chapter 16-17

LECTURE 9 - Rapid Prototyping with 3D Printing

- Ideal to complement to CAD
- Process to build concept and working models from 3D CAD Data
 - Several different techniques available

- Used for
 - Communication/collaboration
 - Time reduction
 - Cost reduction

Additive and Subtractive RP

- There are two main methods of Rapid prototyping, which are derived from similar approaches in sculpture
 - Additive Rapid Prototyping (ARP)
 - Subtractive Rapid Prototyping (SRP)

3D Printing

- 3D printing is a variation of rapid prototyping
- A 3D printer is less expensive, easier to use and usually faster than a RP System
- 3D printer is small and can fit in an office environment

Read Chapters 12-17