LECTURE 1

Reverse Engineering design project stuff, USELESS

LECTURE 2

Engineering

- Engineers design the "stuff" that society uses (including scientists and other engineers)!
  - Problem solving & critical thinking (applied analysis)
  - Design (synthesis)
  - Professionalism (formal organization, ethics).
- First used to describe those who had ability to invent/operate weapons of war - military engineer
- **Officially** : A person who uses science, mathematics, experience, and judgement to create, operate, manage control, or maintain devices, mechanisms, processes, structures, or complex systems. Does this in a rational and economic way with human, societal, and natural resources and environmental constraints.
- **Engineering Disciplines**

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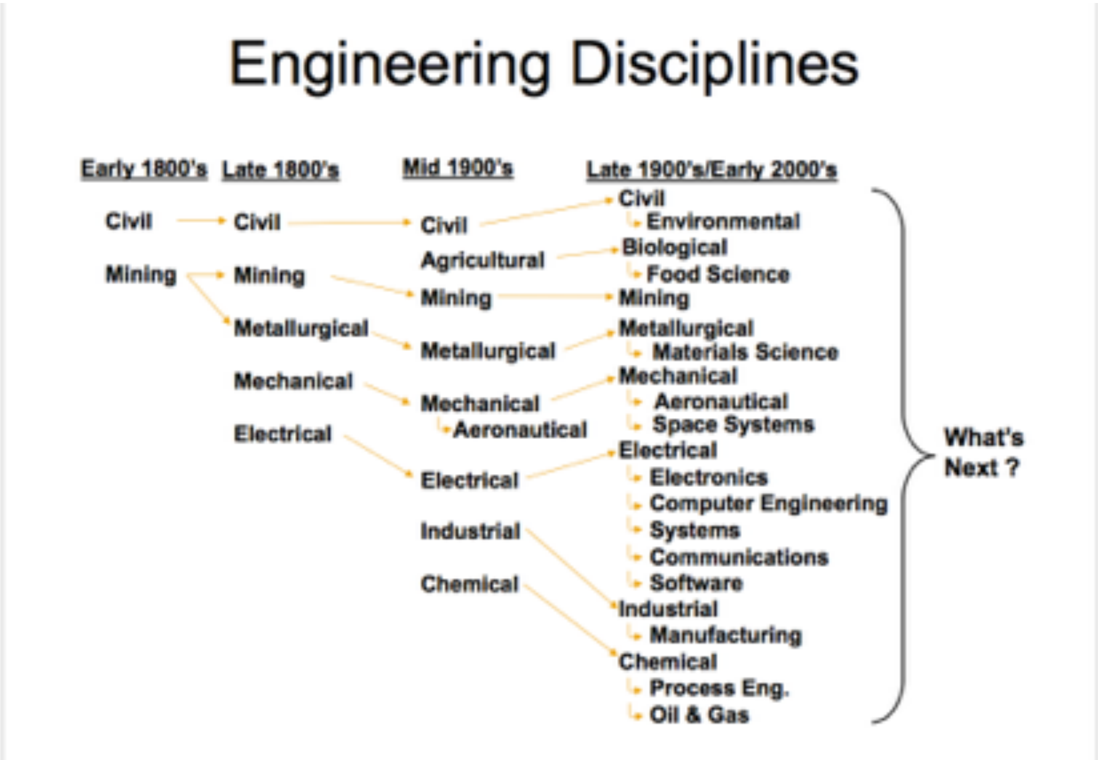


typical technical team might consist of:
- engineers
- scientists
- technologists
- technicians
- social scientists
- skilled workers
- **The Engineer**
  - Provides the key link between theory and practical applications.
- **Professional Engineer**
  - In Canada, the title "professional engineer" is restricted by law.

- Only persons who have :
  - Demonstrated competence
  - Been licensed by provincial professional engineerig licensing association.
- **Canadian Engineering Accreditation Board (CEAB)**
  - CEAB conducts regular & rigorous reviews of engineering programs.
  - Publishes list of accredited programs in Canada.
- **CEAB Academic Requirements**
  - Maths
  - Basic sciences
  - Eng Sciences
  - Eng Design
  - Complimentary studies (TSE, etc)
  - Graduate Attributes
- **Technologist**
  - Applies eng principles and methods to complex problems, completion of three year technology program from community college. Technology diploma usually more hands on then eng diploma.
- **Technician**
  - Works under the supervision of an engineer or technologist in the practical aspects of engineering (.g., tests, maintenance). Not Cert necessary.
- **Skilled Worker**
  - Skilled in a trade such as electrician, welder, etc. Typically carries out the designs and plans of others.
- **All Engineering Is Interdisciplinary**
  - Many engineering disasters are rooted in inadequate interdisciplinary knowledge.

LECTURE 3

- **Identify different types of reports and their structures**
  - **Comprehensive Engineering Report**
    - Title Page
    - Executive Summary, Abstract
    - Table of Contents, List of Figures, List of Tables
    - Intro
      - Any necessary background info, reasons for the report, objective
    - Method
      - Method uses to fulfill the objective. Steps that were taken, tools used, etc.
    - Results and Discussion
      - Findings, tables, graphs, etc must support this section. Difficulties/anomalies, significance of results.
    - Conclusions
      - Objective achieved?
  - Appendices

  - **Resumé**
    - Who/Where are you?
    - Your Education
    - Your Work Experience
    - Technical Interests & Achievements
    - Volunteer & Community Activities - Leadership
    - Academic Marks & Standing
    - References
    - Customize for different jobs

  - **Covering Letter**
    - Concise, Formal, Respectful But Confident
    - Confined to Specific Job
      - Indicate knowledge of Job/Company
      - Why Hire Me
    - Contact details On letter

  - **Internal Memos**
    - Rapid Transfer of info
    - Formal
    - Concise but not necessarily short
    - technical info, meeting report, production summaries, quarterly progress, etc.

  - **Project Proposals**
    - Development of Future Work (capabilities, proposals, new design, development)
    - Compete for internal funds, compete for external work, can be costly to produce.
    - Rationale fro expenditure, what is to be done, schedule, risks, capability of project group, how will it be done, budget, major potential problems.
    - YOU MAY HAVE TO DO WHAT YOU PROPOSE

  - **Technical Research Papers**
    - Summary of significant technical advance
    - Structure format: Abstract, intro, procedural details, results, discussion conclusions, acknowledgements, references.
    - Info is public, cannot directly criticize competitors product or process

  - Patents
    - Legal docs, significant initial and ongoing costs
    - Protection of intellectual property
    - Must divulge technical details
    - Structured format : field of invention, background of invention, summary of invention, description of invention, example of use, claims.
    - lengthy process.

- **Define measurements, dimensions, and units**
  - Physical quantity that has been observed : Measurement compared to a standard quantity (called a unit). Consists of two parts : a numerical magnitude and a name/symbol.
- **Define base and derived units**
  - Base Unit: Fundamental units from which all other units are derived
  - Derived Unit: Derived in terms of base units (1 newton = 1kgm/s^2)
- **Describe SI, and absolute and gravitational systems**

  - **Système International d'Unités (SI)**
    - Adopted by almost all countries except them dumb amoricans
    - Metric system introduced as measurement system "for all people, for all time".
    - Metre is the length of the path travelled by light in a vacuum during a time interval of 1/299 792 458 of a second.
    - m, kg, s, A, K, cd, mol

TABLE 10.1 Base and derived SI units

Symbol	Unit Name	Quantity	Definition
~~M~~ →m	metre, meter	length	base unit
kg	kilogram	mass	base unit
s	second	time	base unit
K	kelvin	temperature	base unit
°C	degree Celsius	temperature	(kelvin temperature) − 273.15
N	Newton	force	$m \cdot kg \cdot s^{-2}$
J	joule	energy	$N \cdot m = m^2 \cdot kg \cdot s^{-2}$
W	watt	power	$J/s = m^2 \cdot kg \cdot s^{-3}$
Pa	pascal	pressure	$N/m^2 = m^{-1} \cdot kg \cdot s^{-2}$
Hz	hertz	frequency	s^{-1}

AND MANY MORE

- **Absolute (SI)**
  - Mass is a fundamental unit
  - Newton's second law (force = mass x acceleration) is invoked to derive force due to gravity.
- **FPS (gravitational system)**
  - Force is a fundamental unit, mass is derived from newtons second law
  - ft, lbs, s.

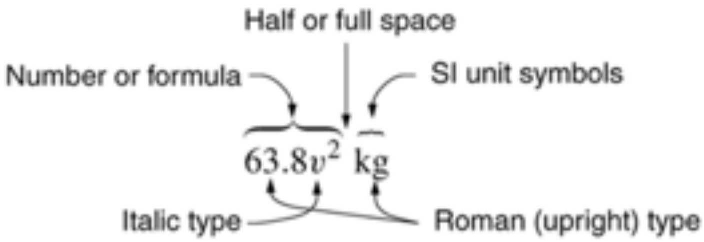
- **Convert units using "factor label" method**
  - Convert by factoring out the units (you know how to do this).

LECTURE 4

- **Recognize "main" SI prefixes**

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}			

- **Write quantities with units**
  - unit is half or full space away from the number, variables in italic type



- **Use fixed, scientific, and**

engineering notation

- Fixed Notation
  - Normal : 300.6
- Scientific Notation
  - Foofoo 3.006×10^2
- Eng Notation
  - 0.3006×10^3

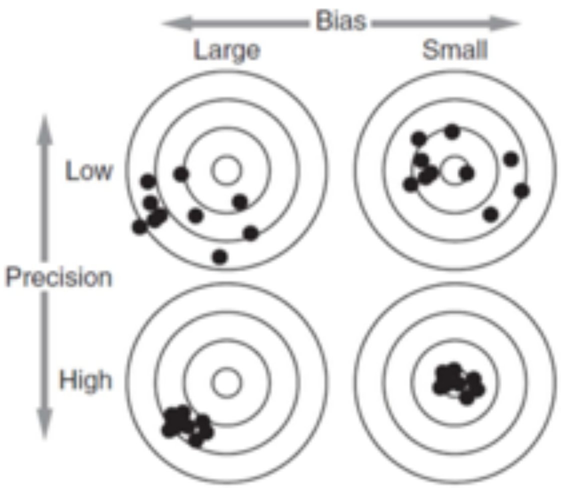
- **Calculate unit algebra**
  - Simple, it is the determination of the units of a variable by canceling out the units of the formula. Ex : F = ma = kgm/s^2

- **Define measurement and uncertainty**
  - **Measurement** : Property of a physical object that can be represented using a real number. (not exact, unlike counting). Usually measured with an instrument.

  - **Uncertainty** : Measuring instruments are not perfect, it is an estimate of true value and an interval around estimate in which true value lies. This is called the uncertainty interval.
  - True value - Measured Value = measurement error.

- **Classify systemic and random errors**

  - **Three types of systematic errors:**
    - **Natural Error**
      - From environmental effects (ex temperature changes affect electronic components and measuring instruments). Can be compensated for.
    - **Instrument Error**
      - Also called offset, caused by imperfections in adjustment or construction of instrument.
    - **Personal Error**
      - Result from habits of the observer, can be reduced by proper training.
  - **Random Errors**
    - Results of small variations in measurements (connect things differently), produce both + and - errors with 0 mean value. Best to do many many measurements.
    -
- **Explain accuracy, precision, and bias**
  - **Precision** : repeatability, measurements have a small random error, discrepancies between repeated measurements taken under the same conditions are small.
  - **Accuracy** : Are close to true value, very little bias.



- **Write inexact quantities**
  - Measurement is complete only when a statement about its uncertainty is included.
  - Uncertainty is normally expressed as an estimated range; can be stated explicitly or implicitly.

- **Correctly use significant digits**
  - Determine the precision of the number : Should not use more sig figs than justified by the measurement.

- **Perform calculations with inexact quantities**
  - + and - —> +/- uncertainty1 + uncertainty2
  - x and / —> +/- uncertainty1/value1 + uncertainty2/value2.

LECTURE 5 - 7

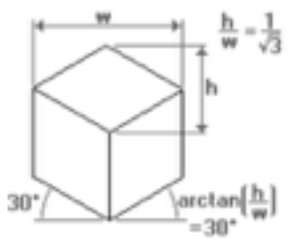
- **Describe the importance of graphical communication**
  - Most eng info is transmitted by graphical means
  - But unambiguous written and verbal communication is also central to successful engineering communication.
  - It is clear concise efficient and with reduced ambiguity. Universal language.
  - Image must be precise and exact.

- **Recognize and explain perspective, oblique, isometric and orthographic projection**

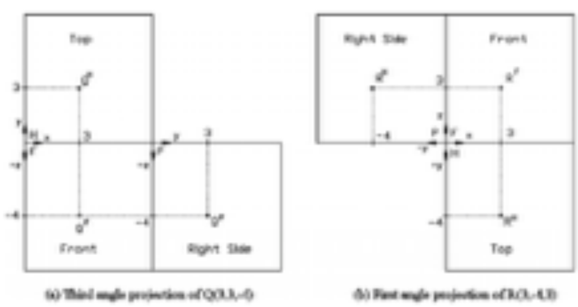
  - **Perspective projection**: Intersects at finite points (vanishing points), seen from by a single eye in a single point in space. Primarily used by architects and commercial artists. One, or two point perspective projection.

  - **Oblique Projection**: Front face of the object is parallel to the viewer, that face is true size, no projection lines that converge at a vanishing point. Mainly used to give an indication of depth. Easier to compare sizes thanks to lack of perspective. Parallel projectors are at an oblique angle (not 90 degrees) to the paper plane).

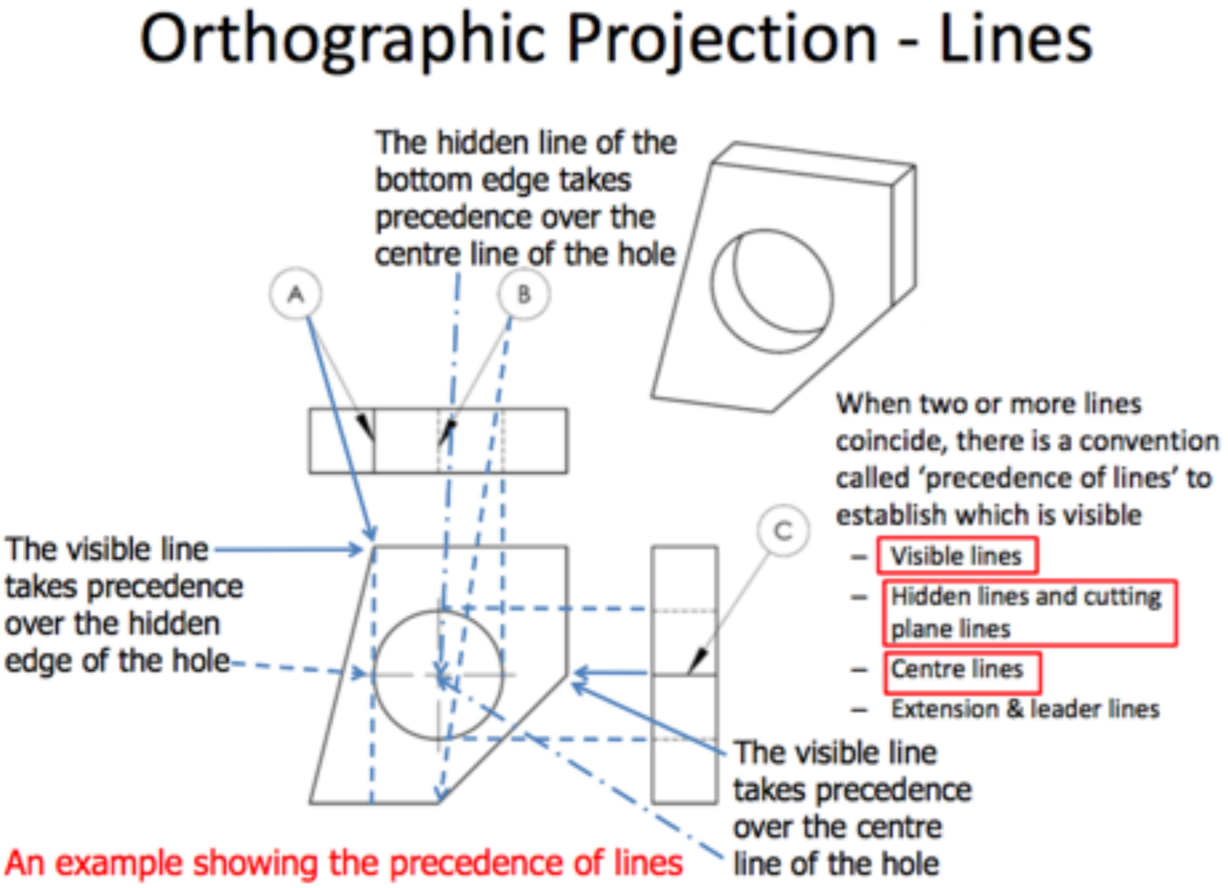
  - **Isometric Projection** : Parallel lines remain parallel instead of converging to a vanishing point. Axis are each 120 degrees apart.



  - **Orthographic Projection**: Most important method. 2D representations of a 3D object, extensively used in engineering. Useful technical information is needed, often isometric view is included with the standard views.



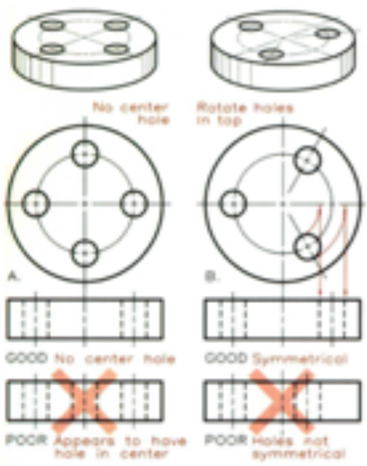
- **Create a 3-view engineering drawing using orthographic projection, correct line types and line precedence**



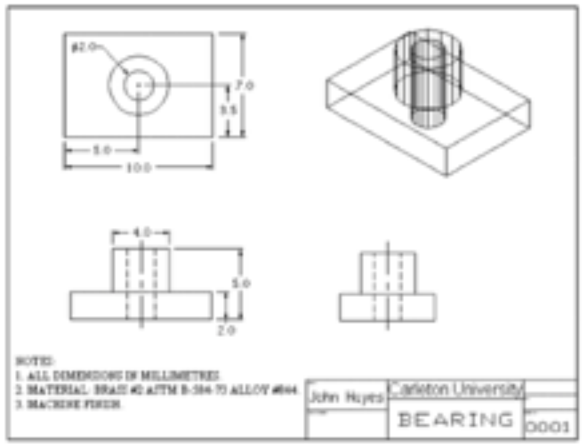
- **Properly dimension an engineering drawing**
  - Dimensions must describe the complete geometry of the part
  - Redundant dimensions should be avoided
  - Dimension from visible lines, not hidden features
  - Repeated regular identical features may be dimensioned once along with a small note indicating quantity, etc…
  - The designer should locate dimensions in a way to indicate how tolerance accumulate.
  - Never dimension holes or cylinders with radii … use diameter and dimension holes where they look like holes (circles).
  - Dimension lines for angles are drawn as arcs

- **Utilize standard conventions in preparing engineering drawings**
  - For autographic drawings, sometimes only tow views are necessary, the views however must be aligned. The best layout to convey the info in the most effective way possible.Section views.
  - Sometimes, the rules of projection must be violated to improve clarity.
  - Title block

Drawing Layout Conventior



Orthographic – Example - 1



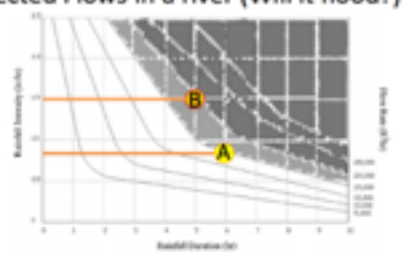
-Recognize and explain other types of engineering graphics (6)

- **Descriptive Geometry (Engineering Drawing already seen above)**

- **Graphical Mathematics**
  - For ex: The intersection of all the possible positions of a robot arm can have and a space in which it will operate.
  - Solving algebraic equations using graphical techniques without projection.
- **Nomography**
  - A nomograph, 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

Nomograph example:

Expected Flows in a river (Will it flood?):



- It rains 5 inches in 6 hours, the average intensity is 0.83 in/h; the point on the chart falls closest to the curve for 22,000 cu ft/s: yellow "Flood Caution" zone
- It rains for 4 hours at an intensity of 1.5 in/h (for a total of 6.0 in). It is expected the rain will continue for another hour at the same rate, a flow level of ~23,500 ft³/s can be expected: flooding is highly likely!

- **Empirical Equations**
  - Modeling relations between empirical data with math equations
  - Ex: equation to describe how a robot heats up while performing a continuous task.
  - Any equation that reproduces data in an acceptable way can be used if the goal is for an interpolating equation. A theoretical-based equation that is derived from some physical insight. Or a combination.
- **Technical Illustration**
  - Like in manuals, used to communicate an idea, not necessarily exact.
- **Engineering Computer Graphics : CAD**

        - CAD software, effective and time saving way of communicating ideas. Better for manufacturing, allows systems to become more complex.
        - Allows better accuracy, speed, easy revision, better design analysis, better presentation, libraries of drawing aids, improved filing. Mostly used for machine parts, or when someone else is doing the manufacturing.
- **Describe the importance of sketching and visualization**
    - Sketching allows quick sketch on paper or napkins, intended to quickly jot down an idea. Is used when on site problems are encountered. Used on the job to explain ideas, delegate work, or get help, best way to communicate eng ideas.
    - Visualization is crucial, allows the creation of graphical representations of real objects.

LECTURE 8

- **Define engineering design**
    - Design is a creative process that incorporates all areas of an engineering education, it is basically what engineers do.
    - It is the identification of problems, solving them, as well as the implementation of solutions.
    - Textbook Definition : Process of developing workable plans for the construction or manufacture of devices, equipment, machinery or structure, to satisfy some observed need.
    - A good design requires organization, teamwork, communication, as well as creativity and criticism.
    - The needs should be categorized and defined in a Statement of Requirements (SoR)

- **Describe systems and product design**
    - **Systems design**
        - Deals with the arrangement of available products into a unique combination that yields the desired result.
        - Residential building is a system: Heating, Plumbing, Electricity, Windows, etc.
        - Requires additional professionals; Lawyers, Historians, Social Scientists, Psychologists, etc.
        - A good example is a car, which is a combination of many systems.

    - **Product design**
        - Deals with design, testing, manufacture and sale of (generally) mass-produced goods.
        - Product Designers must deal with current market needs, production costs, function, sales, etc.
        - Some products are complex designs, such as robotic devices, ships, cars, etc.
        - But some aren't, like a nail clipper or a comb.

- **Explain the engineering design process/method**

    - **Recognition of need**
        - Often the need is written in a Statement of Requirements (SoR)
    - **Definition of the design problem**
        - Requires the gathering of information (Research)
        - Must define the problem correctly in order to provide a solution
    - **Definition of the design criteria**
        - Performance standards to be met by the design as well as limitations (constraints)
        - Criteria and constraints must be quantitative values.

    - **Then, the design loop is used**

- **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**
  - Using design criteria identified in step 3, we decide if the design is optimum (best design at a reasonable cost)
  - If it is not optimal, then the design loop may need to be reiterated
- **Evaluation**
  - Review of the design, senior engineers and others must approve the design
  - If flaws are detected, the design must be iterated, beginning at step 2 if necessary.
- **Communication**
  - Once the design is approved, it can be built or manufactured, must be communicated effectively.

- **Define codes and standards**
  - **Codes**
    - A set of specifications for the analysis, design, manufacture, and construction of things.
    - Purpose is to achieve a specified degree of safety, efficiency, performance, or quality.
  - **Standards**
    - A set of specifications for parts, materials or processes intended to achieve uniformity
    - Places limits so as to provide reasonable inventory of tooling, sizes, shapes, varieties, etc.

- **Explain the role of creativity and innovation in engineering design**
  - Very important in the design process as a whole
  - allows for the generation of ideas during the design loop process
  - Stimulated through brainstorming, sticky-note brainstorming, brainwriting, etc.
- **Explain different types of design reports**
  - **Written Reports**
    - Organize logically, attention to detail (especially in spelling and grammar), PROOF READ
    - Usually for;
      - **Proposals**
        - Made to convince people with money they should pay for the project
        - Should reflect the interests and language of the reader (know your audience).
        - Problem statement, work plan, personnel needed, schedules, budget and summary.
      - **Progress Reports**
        - Periodic reports on the status of a project
        - Usually tried letters or memos, lets your customer know how things are going
      - **Final Reports**
        - Final step in the project
        - Cover, Table of contents, Abstract, Intro, Methods used, Body (results, findings), Discussion, Conclusion, Recommendations, Appendix, References.
  - **Oral Reports**
  - **Graphical Reports**

LECTURE 9

- **Describe the features of Creo**
  - Important changes can be easily incorporated at any point during the design process
  - The changes propagate through the model automatically
  - It enables the user to create fully detailed standard engineering working drawings almost automatically after model generation
  - Solid modeling was easy!
    - In Creo, solid parts are constructed with a series of geometric operations, much like sculpting process
    - Each separate operation (or shape) is called a "feature"
    - Each feature has it’s own defining characteristics
- **Define 3D printing and rapid prototyping**
  - Allows rapid prototyping
  - Create a CAD model of the design
  - COnvert CAD model to STL format
  - Slice the STL file into thin cross-sectional layers
  - Build the model one layer atop another
  - Clean and finish the model
- **Describe the stl file format**
  - Stereolithography (STL) files were introduced in software by 3D Systems of Valencia, CA, as a method for storing info about 3D objects
  - Industry standard data transmission format, used in Rapide Prototyping to produce physical 3D models or replicas
- **Describe additive and subtractive rapid prototyping**
  - **Subtractive (SRP)**
    - Removes material from a set "block"
  - **Additive Rapid Prototyping (ARP)**
    - Machine lays down layer after layer of liquid plastic, or some other material, and builds up the model

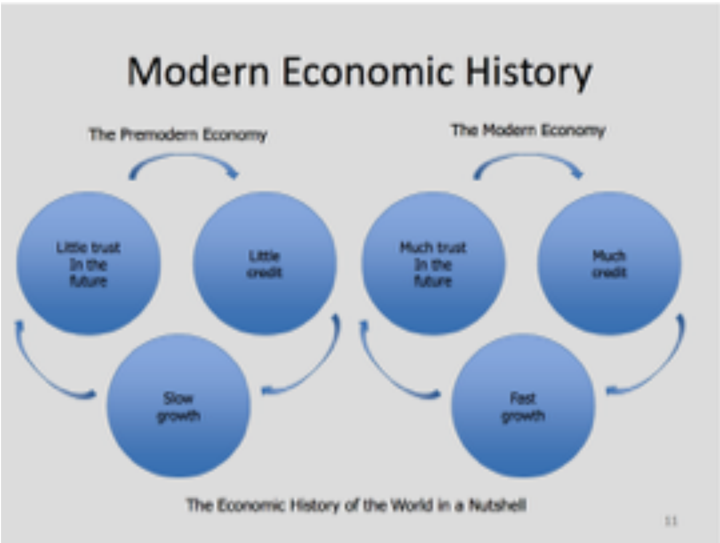
- **Describe various rapid prototyping technique**

  - **1 Stereolithography**
    - Builds 3D models from liquid photosensitive polymers that solidify when exposed to ultraviolet light
    - Excellent for making complex prototyped with fine details (favorite in the aerospace industry)
  - **2 Laminated Object Manufacturing**
    - Layers of adhesive coated sheet material are bonded together to form a prototype
    - Low cost as raw material is readily available
    - No chemical reaction involved, parts can be made quite large.
  - **3 Selective Laser Sintering**
    - Uses a laser beam to selectively fuse powdered materials, such as nylon, elastomer, and metal, into solid object
  - **4 Fused Deposition Modeling**
    - Surface finish and accuracy are not good
    - Specializes in building small, durable, handheld components
  - **5 Solid Ground Curing**
    - Uses ultraviolet light to selectively harden photosensitive polymers, cures an entire layer at a time
  - **6 3-D Ink-Jet Printing**
    - Parts are built upon a platform in a bin of powder material selectively hardened with binder deposited with the print head.

TSE 3

- **Explain modern economic history**

- **Explain the main events and reasons for the industrial revolution**



TSE 4

- **Describe the lasting effects of the Industrial Revolution**
  - Cheap Abundant energy and raw materials
  - Explosion in human productivity
  - Agricultural Revolution
  - Less people working the land, as more and more variety of jobs were created.
  - CONSUMERISM produced more then we needed

- **Describe the engineering accomplishments of the 10th century**
- **Appreciate the engineering challenges of the 21st century**
  - Many many things