Technology, Engineering and Design
Unit 3: Systems
Class Notes – Mr. Dion

Big Idea: Systems are the building blocks of technology and users must properly maintain, troubleshoot, and analyze systems to ensure safe and proper function.

Key concepts:

1. How to identify the core technologies, subsystems, and systems that make up technological devices,
2. Introduction to simple machines (lever, pulley, wheel and axle, inclined plane and screw), how to calculate mechanical advantage for all examples and how to determine their impact on force through word problems.
3. Introduction to simple electrical circuits and ohms law.
4. Understand how all systems can be broken down into the Universal Systems Model.
5. Why and how companies and countries reverse engineer products.
6. Discover how to diagnose problems when they occur through troubleshooting techniques.

Unit Vocabulary:

Core Technology - The core technologies are the “building blocks” of all technology systems. Every system and product is made up of one or more of the nine Core technologies: biotechnology, electrical, electronic, fluid, material, mechanical, optical, structural, and thermal technology.

Biotechnology - Technology of using, adapting, and altering organisms and biological processes for a desired outcome. Examples include: cloning, genetically altered food, food preservatives.

Electrical Technology - Technology of producing, storing, controlling, transmitting, and getting work from electrical energy. Examples include: power to a washing machine, power transformer, generator.

Electronic Technology – Technology of using small amounts of electricity for controlling; detecting; and information collecting, storing, retrieving, processing, and communicating. Examples include: remote control, mobile phone, circuit board.

Fluid Technology - Technology of using fluid, either gas (pneumatics), or liquid (hydraulic) to apply force or to transport. Examples include: pneumatic tools, hydraulic lift, brake systems.

Materials Technology - Technology of producing, altering, and combining materials. Examples include: welding, metal alloys, textiles.

Mechanical Technology - Technology of putting together mechanical parts to produce, control, and transmit motion. Examples include: gears on a bicycle, windshield wipers, engine, sewing machine arm.

Optical Technology - Technology of producing light, using light for information collection, storage, retrieval, processing, and communication; and using light to do work. Examples include: lasers, telescopes, fiber optics.
Structural Technology - Technology of putting mechanical parts and materials together to create supports, containers, shelters, connectors, and functional shapes. Examples include: trusses on bridge, steel frame of skyscraper, legs of a chair.
Thermal Technology - Technology of producing, storing, controlling, transmitting, and getting work from heat energy. Examples include: Thermos, insulated clothing solar panels
Simple Machines - Simple machines (Lever, pulley, wedge, screw, inclined plane (ramp), wheel and axle) apply "Mechanical Advantage (MA)" which changes the required effort to lift a load. Simple machines are often combined to **create complex mechanical machines**.
Mechanical Advantage - Simple machines apply "Mechanical Advantage (MA)" which changes the required effort to lift a load.

- Mechanical Advantage (MA) = Load/Effort
- Load = Effort x MA
- Effort = Load/MA

Conductors – Keep loose grip of electrons and allow them to move freely (ex. metals usually good conductors).
Insulators – Keep close hold of their electrons and do not allow free movement of electrons (ex, glass, wood, plastic, mica, fiberglass and air).
Current - The flow of electrons (measure in amperes).
Resistance – The ability to oppose electrical current, measured in ohms.
Ohm's Law – Electrical and electronic technologies utilize Ohm's law to explain the relationship between voltage, current, and resistance. Ohms law states that voltage (V) = amps(I) x resistance (R) or V-IR:
Circuits – Designers and engineers using Ohm's Law to determine the specific electrical and electronic components needed in a circuit, depending on the desired purpose. Basic circuits contain four parts: Power source, Conductor, Load, Control (switch).
Series Circuit – In a series circuit electricity has only 1 path to follow. All parts are connected one after another. Electrons flow from the negative side of the battery around in a loop to the positive side, so the current has only 1 path to take.
Parallel Circuit – In a parallel circuit, electricity has more than one path on which to travel. The current in a parallel circuit breaks up, with some flowing along each parallel branch and re-combining when the branches meet again.
The voltage across each resistor in parallel is the same.
Total Resistance – The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors: R = R1 + R2 + R3 + ...
System – A system is a group of interrelated components designed collectively to achieve a desired goal. Systems are used in a number of ways in technology and appear in many aspects of daily life, such as solar systems, political systems, and technological systems.
Universal System Model– Every system that exists can be broken down using the universal systems model. The Universal System Model includes Input, Process, Output and Feedback.
Open System – An open-loop system has no feedback path and requires human intervention.

Closed System – A system that uses feedback from the output to control the input.
Input – Inputs consist of the resources that flow into a technological system. Inputs include: People, Materials, Tools and/or Machines, Energy, Information, Capital, Time.
Process – The process is the systematic sequence of actions that combines resources to produce an output. Processes can be categorized into:

- Problem Solving: process that works through problem identification to select a final solution.
- Production: process that involves the creation of the product or structure.
- Management: controlling and managing the inputs and other processes involved in the system.

Output – The output is the end result, which can have either a positive or negative impact. Outputs can take the following forms:

- Unexpected Desired
- Expected Desired
- Unexpected Undesired
- Expected Undesired

Feedback - Feedback is information used to monitor or control a system. The feedback loop allows the system to make necessary adjustments during operation.
Reverse Engineering - The process of taking something apart and analyzing its workings in detail, usually with the intention to construct a new device or program that does the same thing without actually copying anything from the original.
Forward Engineering – The process of moving from high-level abstractions and logical designs to the physical implementation of a system.
Troubleshooting - Troubleshooting is a specific form of problem solving aimed at identifying the cause of a malfunctioning system.
Maintenance - An established schedule to maintain proper operation of product/device.
Diagnostic – A test used to find out what is going wrong with a piece of equipment.
Constraint – A limitation in a product or device, requirements or specifications that could not be implemented due to cost or some other trade-off.
Criteria – Specifications and requirements that must be included in a product.

Lesson 1: Core Technologies

Big Idea: Every system and product is made up of one or more of the nine core technologies: bio-technology, electrical, electronic, fluid, material, mechanical, optical, structural, and Thermal technology..

Key Concepts:

1. Core technologies, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.
2. Identify the various systems embedded within the larger system (technological, social, or environmental), using the language of the core technologies.

3. Simple machines effect how much force is required to lift a load. The amount of the effect is called, “Mechanical Advantage”.
4. Each simple machine has a different formula for Mechanical Advantage (MA). Algebraic equations can be solved to determine how mechanical advantage effects the load/effort of a simple machine.
5. Ohm’s law is used represent the relationship between Voltage, Current and Resistance. V=IR

Mechanical Advantage Formulas:

The General equation for Mechanical Advantage is Load/Effort; MA=Load/Effort. Each simple machine has its own equation to calculate Mechanical Advantage.

- The Mechanical Advantage of a Lever = Length to Effort/Length to Load.
- The Mechanical Advantage of an Inclined Plane(ramp) = Length of Plane/Height of Plane
- The Mechanical Advantage of a Pulley = Number of ropes that support the pulley
- The Mechanical Advantage of a Wheel and Axle = Wheel Radius/Axle Radius
- The Mechanical Advantage of a Wedge = Length of slope/thickness of wedge
- The Mechanical Advantage of a Screw = Circumference/pitch

Example problem:

If we build a ramp in Tech Ed class that is 2 feet high, and the length of the ramp is 30 feet, what is the mechanical advantage?

> *The simple machine described in the problem is an incline plane. The formula for calculating the Mechanical Advantage of an incline plane is length of the plane/height of the plane. In this case, the length is 30 ft. and the height is 2 ft. Therefore, the Mechanical Advantage is 30/2=15.*

How much effort force would someone need to push a 60-pound box up the ramp?

> *The general equation for Mechanical Advantage is; MA= Load/Effort. Since we are looking for Effort we can rearrange the equation to be; Effort = Load/MA. In this case we have calculated the MA to be 15 and we are given the load to be 60lbs. Therefore, the effort required to lift the load would be 60lbs/15 = 4lbs.*

Basic electricity formulas:

Ohm’s law is used represent the relationship between Voltage, Current and Resistance. V=IR.

Example Problem:

A 110-volt wall outlet supplies power to a black light with a resistance of 4400 ohms. How much current is flowing through the black light?

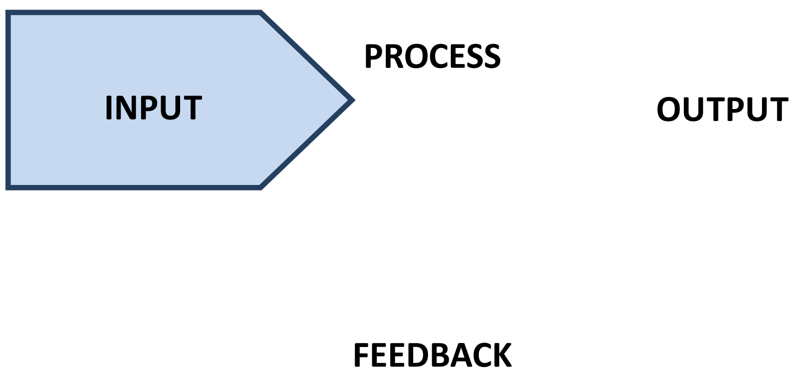
Ohm's law is Voltage = Current x Resistance. In this case, Voltage is given to be 110 volts and Resistance is given to be 4400 ohms. Since we are looking for current we can rearrange the equation to be I (current) = Voltage/Resistance. Therefore, current = 110/4400 or 1/40.

Lesson 2: Systems Model

Big Idea: The universal systems model—input, process, output, and feedback—helps users isolate system components so that they may be properly used and maintained.

Key Concepts:

The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.



- Inputs consist of the resources that flow into a technological system. Inputs include; People, materials, tools and machines, energy, information, capital, and time.
- The process is the systematic sequence of actions that combines resources to produce an output. Processes can be categorized into:
  - Problem Solving: process that works through problem identification to select a final solution
  - Production: process that involves the creation of the product or structure
  - Management: controlling and managing the inputs and other processes involved in the system
- The output is the end result, which can have either a positive or negative impact. Outputs can take the following forms:
  - Unexpected Desired

- Expected Desired
- Unexpected Undesired
- Expected Undesired

- Feedback is information used to monitor or control a system. The feedback loop allows the system to make necessary adjustments during operation.

Lesson 3: Reverse Engineering

Big Idea: Companies use reverse engineering to analyze the functioning and manufacturing of a current product for product improvement and/or optimization.

Key Concepts:

Reverse engineering includes:

- Identifying the system's components and their interrelationships
- Creating representations of the system in another form or a higher level of abstraction
- Creating the physical representation of that system

Why do Reverse Engineering?

- The original manufacturer of a product no longer produces a product.
- The original design documentation has been lost or never existed.
- Some bad features of a product need to be designed out.
- To explore new avenues to improve product performance and features.
- To gain competitive benchmarking methods to understand competitors' products and develop better products.
- To update obsolete materials or antiquated manufacturing processes with more current, less-expensive technologies.

The steps of Reverse Engineering:

1. **Prediction** - What is the purpose of this product? What market was it designed to appeal to? List some of the design objectives for the product. List some of the constraints that may have influenced the design.
2. **Observation** - How do you think it works? How does it meet design objectives (overall)? Why is it designed the way it is?
3. **Disassemble** - How does it work? How is it made? How many parts? How many moving parts? Any surprises?
4. **Analyze** - Carefully examine and analyze subsystems (i.e. structural, mechanical, and electrical). Develop annotated sketches that include measurements and notes on components, system design, safety, and controls.

5. **Test** - Carefully reassemble the product. Operate the device and record observations about its performance in terms of functionality (operational and ergonomic) and projected durability.
6. **Documentation** - Inferred design goals, inferred constraints, design (functionality, form [geometry], and materials), schematic diagrams, lists (materials, components, critical components, flaws, successes, etc.).

Lesson 4: Troubleshooting

Big Idea: Troubleshooting allows users to continue to use and maintain the proper operation of a system or product.

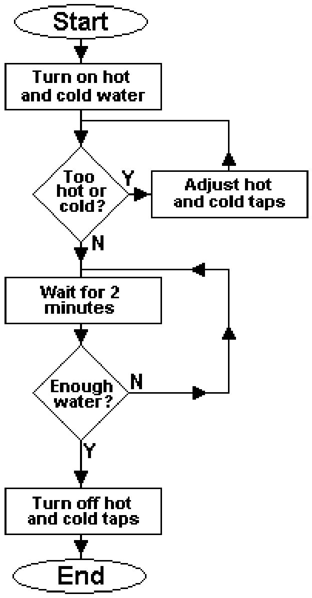
Key Concepts:

Troubleshooting:

Often technological products do not always function as they are designed—to the frustration of the consumer. Systems and products fail because they have faulty or poorly matched parts, are used in ways that exceed what was intended by the design, or were poorly designed to begin with.

- Troubleshooting is a specific form of problem solving aimed at identifying the cause of a malfunctioning system.
- Troubleshooting a malfunctioning system demands considering the various parts and how those parts affect the entire system.
- Troubleshooting involves a logical and orderly process of discovering the problem in a part or system.

Troubleshooting Diagrams -



Maintenance - Established schedule to maintain proper operation of a product/device.

- Users must maintain the safe and proper operation of the system or product.
- Companies develop materials to ensure that users are able to use systems for the designed purpose, such as manuals.
- The most common ways companies can prevent failure are pretesting of parts and procedures, overdesign, and redundancy.