Unit 1 Review

Simple Machines

Simple machines comprise most mechanisms.

Simple machines redirect energy by manipulating FORCE, DISTANCE and/or SPEED

$$MA = \frac{R}{E}$$

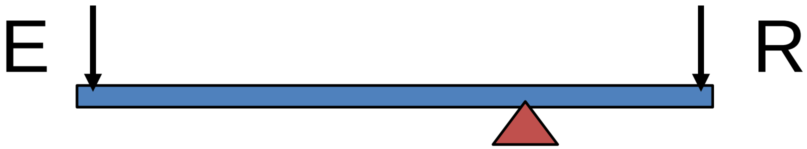
R = Magnitude of resistance force

E = Magnitude of effort force

This is Actual MA

Levers: Lever MA = $\frac{LE}{LR}$

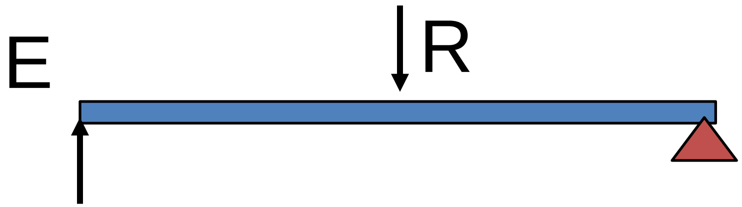
Class 1 Levers: fulcrum is between the load and effort



LE = length to effort

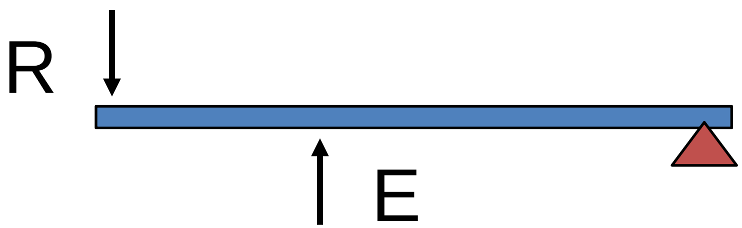
LR = length to resistance

Class 2 Levers: load is between the effort and fulcrum



mechanical advantage **>1**

Class 3 Levers: effort is between the load and fulcrum



mechanical advantage **< 1**

Moment = Force *x* Distance

Moment Equilibrium:

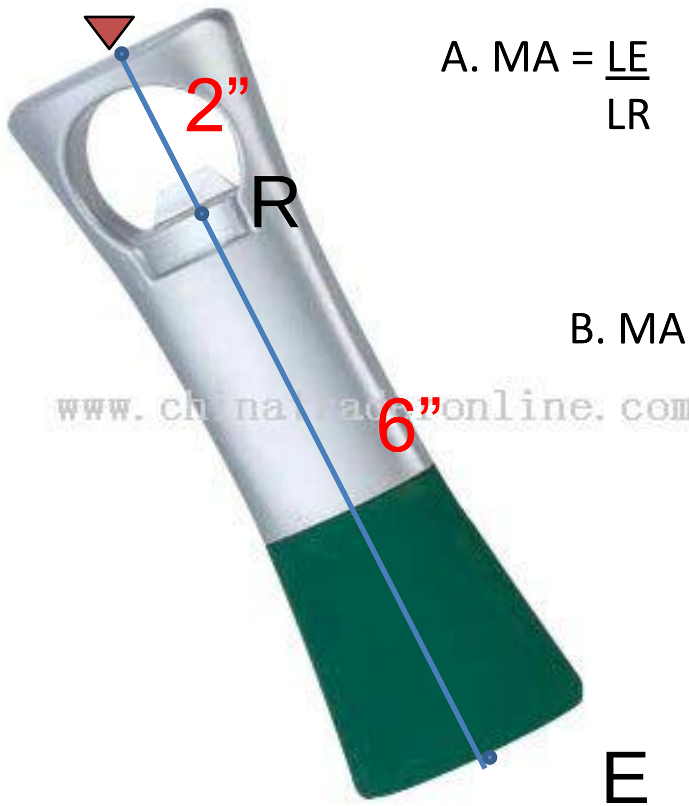
E * Le = R * Lr

Problem

What is my IMA and AMA? If I apply a force of 3 lbs, what is the load?

Problem

A. What is my MA? B. If I apply a force of 3 #, what is the load?



A. $MA = \frac{LE}{LR}$ $MA = \frac{8”}{2”}$ $MA = 4$

B. $MA = \frac{R}{E}$ $4 = \frac{R}{3\#}$

$R = 4 * 3\#$

$R = 12\#$

Wheel & Axle IMA

This formula is different than formula sheet

$$IMA = \frac{D_E}{D_R}$$

$$MA = \frac{R}{E}$$

Wheel and Axle

If the 6” diameter axle on a car turns a 24” diameter wheel, what is the mechanical advantage?

Pulley

used to change the direction and magnitude of a force

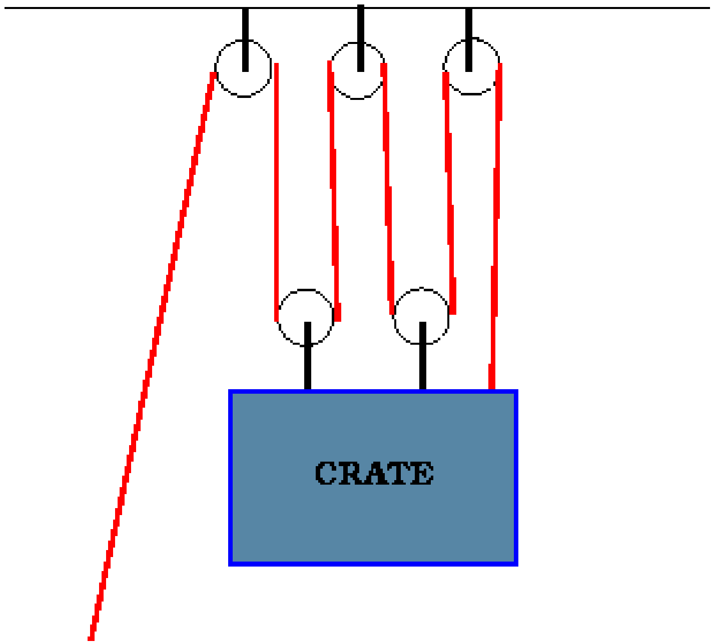
MA= # strands

(only count last strand if it points up)

$$AMA = \frac{F_R}{F_E}$$

Pulley

The pulley system shown below is used to lift a load of 100 lbs. How much effort must be applied? If the rope travels 25’, how high does the load rise?



Pulley

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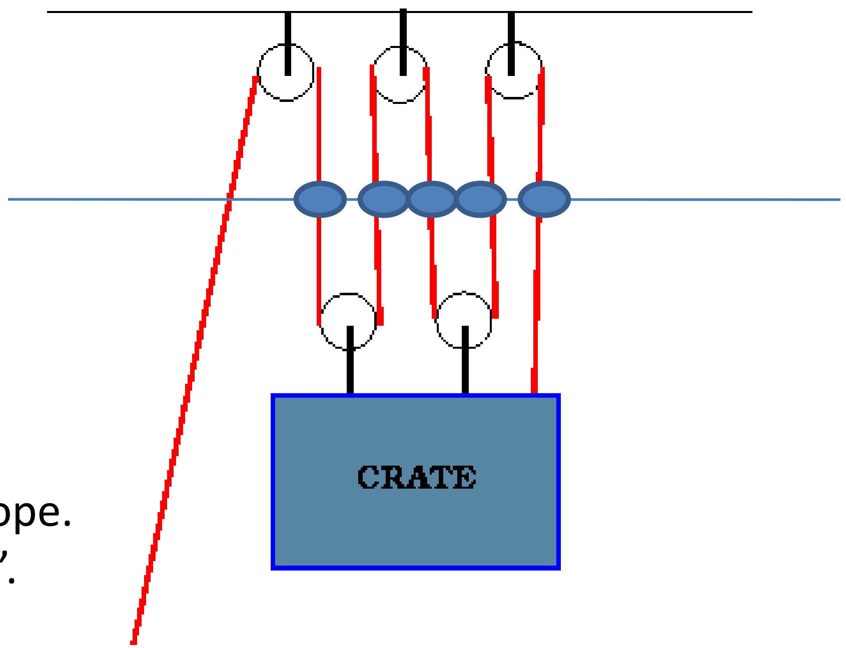


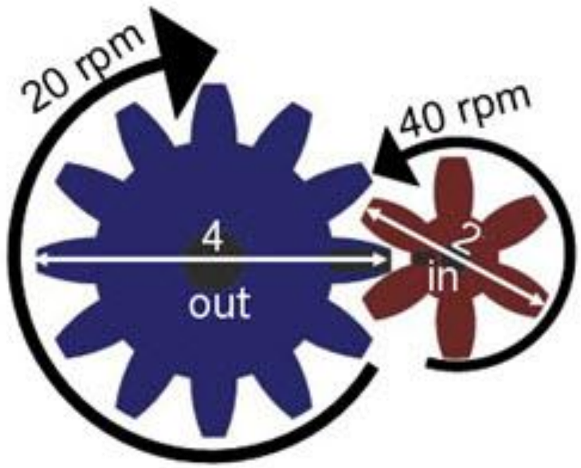
MA = # strands = 5
MA = R/E
5 = 100 lbs/E
E = 20 lbs

MA = De/Dr
5 = 25'/Dr
Dr = 5 feet

Pulling on the rope.
Effort travels 25'.

Gear Ratios

Change the speed of rotation
Change the direction of rotation
Change the amount of torque available to do work



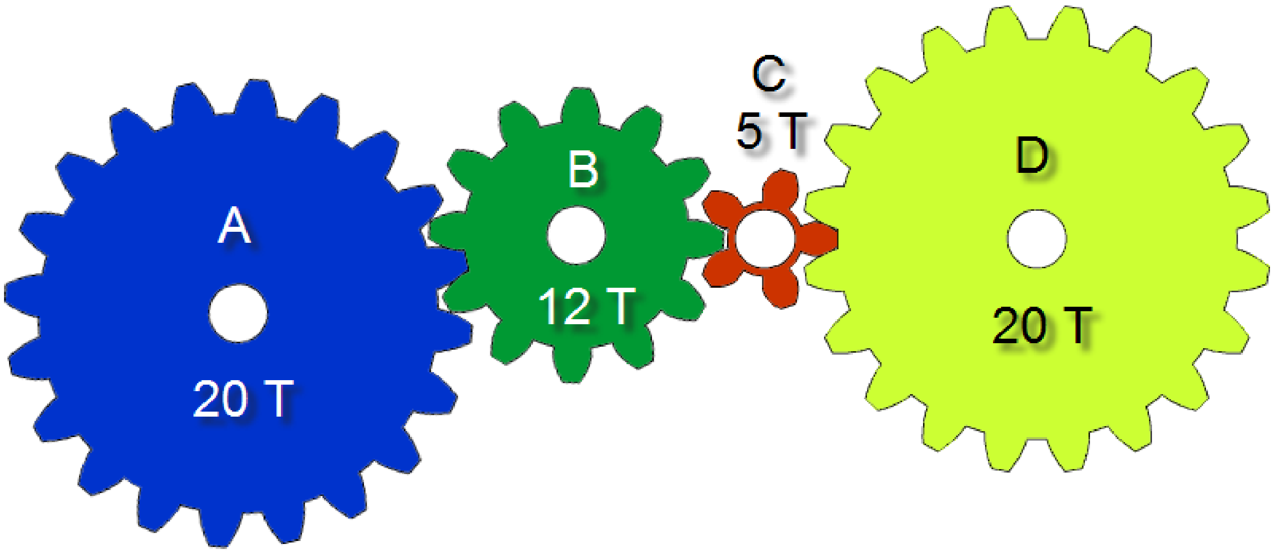
$$\frac{GR}{1} = \frac{n_{out}}{n_{in}} = \frac{d_{out}}{d_{in}} = \frac{\omega_{in}}{\omega_{out}} = \frac{\tau_{out}}{\tau_{in}}$$

This formula is different than formula sheet

GR = gear ratio
n = # of teeth
d = diameter
w = angular velocity (speed)
T = torque

Gears

A input
D output

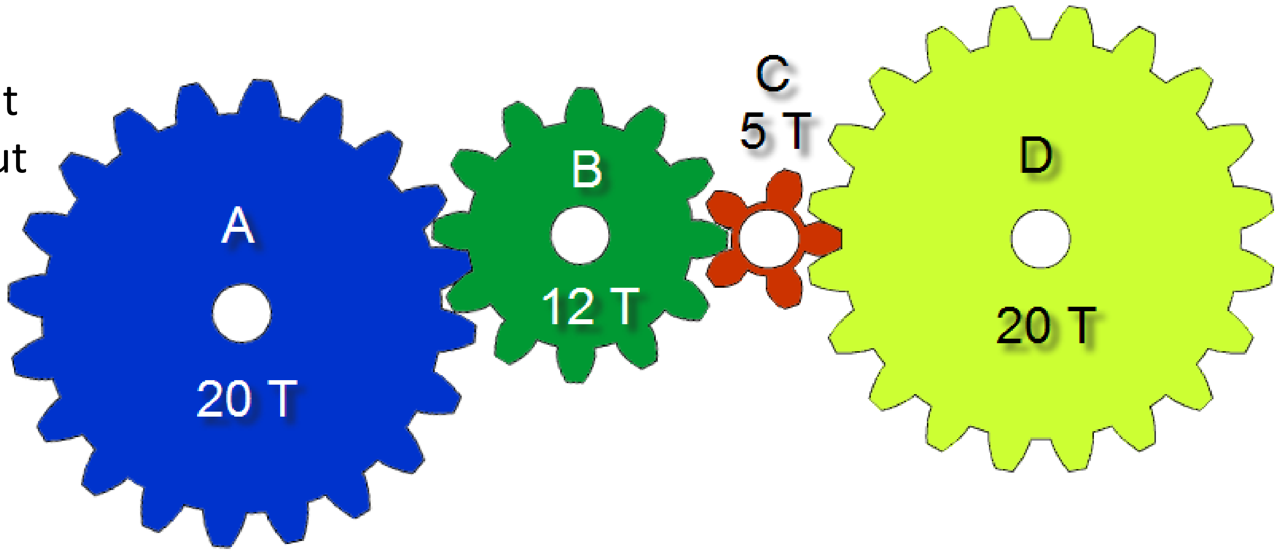


What is the gear ratio between gear A and B?

What is the gear ratio between gear C and D?

Gears

A initial input
D final output



What is the gear ratio between gear A and B?

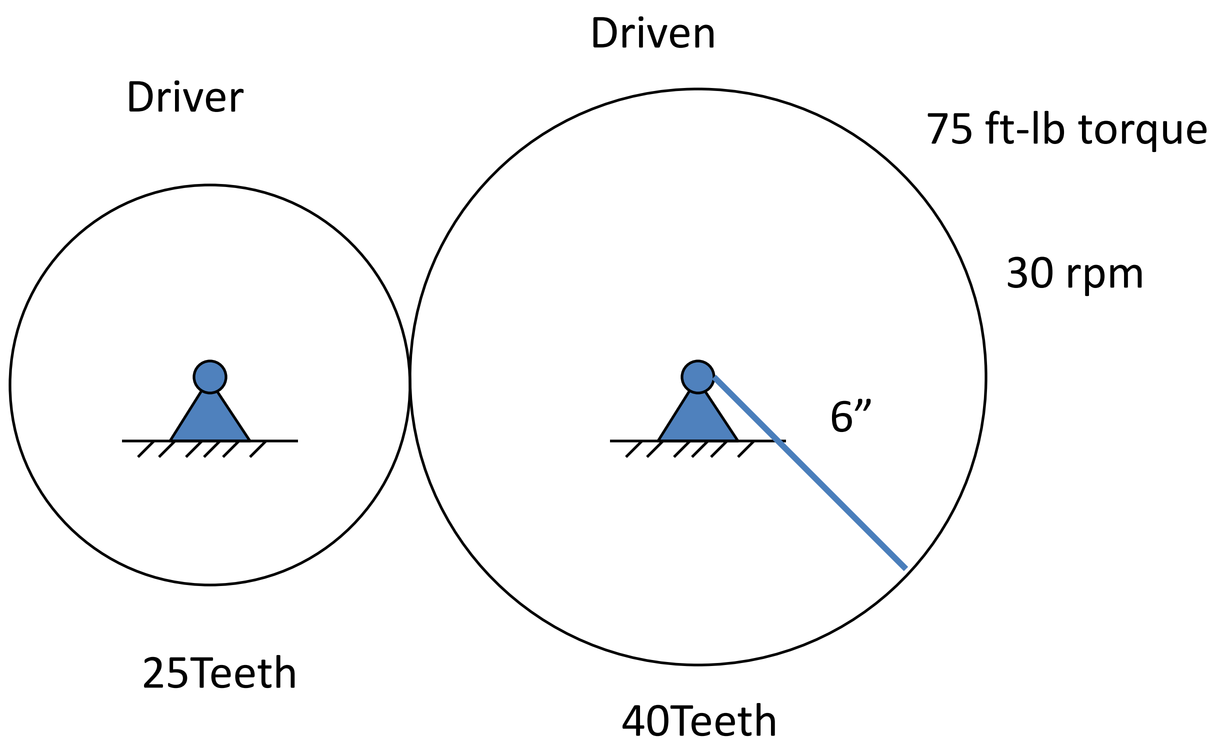
GR = No /Ni
GR = 12 T / 20 T
GR = 0.6

What is the gear ratio between gear C and D?

GR = No/Ni
GR = 20T/5T
GR = 4

Gear Ratios: Example

Find gear ratio and find the input quantities given the following knowns:



GR =

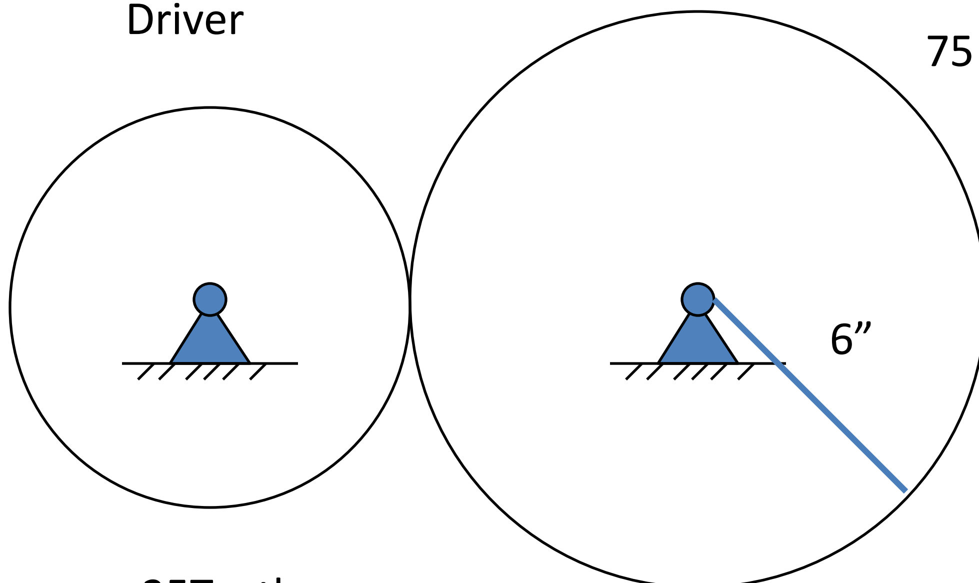
T in =

d in =

w in =

Gear Ratios: Example

Find gear ratio and find the input quantities given the following knowns:



GR = No/Ni = 40 T/25T = 1.6

GR = To/T in   1.6 = 75 ft-lb/Tin
Ti = 46.9 ft-lb

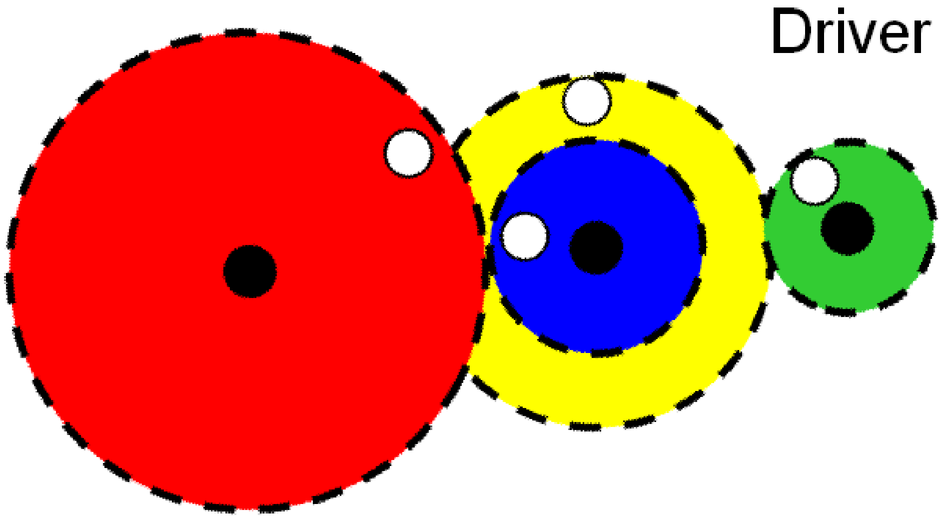
GR = do/d in   1.6 = 12 in / din
D in = 7.5 in

GR = W in/Wo   1.6 = Win/30 rpm   Win = 48 rpm

Compound Gear Train

- Ratio of A to B times C to D

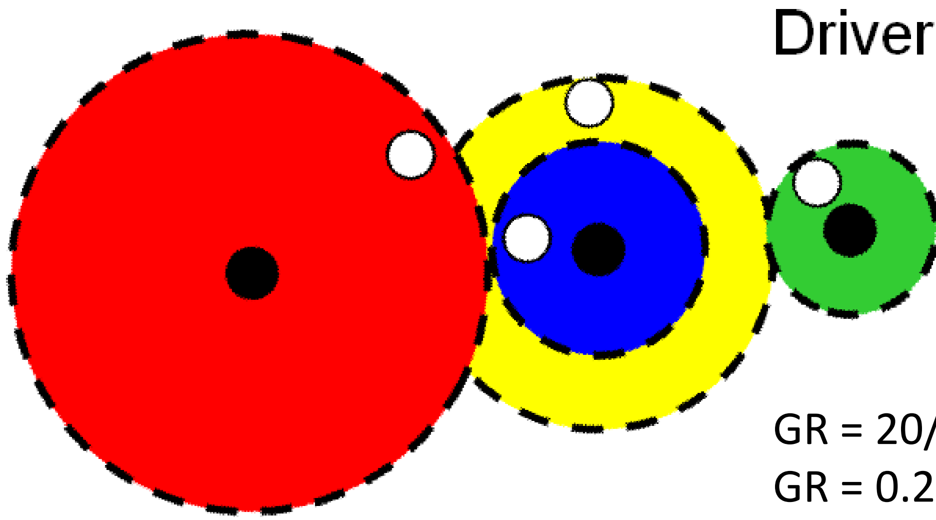
A red 36 teeth
B: blue 20 teeth
C: yellow 28 teeth
D: green 14 teeth



Find MA.
If the output gear D is spinning at 10 revolutions per minute, how fast is the input gear a turning?

Compound Gear Train

A red 36 teeth
B: blue 20 teeth
C: yellow 28 teeth
D: green 14 teeth



GR = 20/36 * 14/28
GR = 0.28

GR = Wi/Wo
0.28 = Wi / 10 rpm
Wi = 2.8 rev per minute

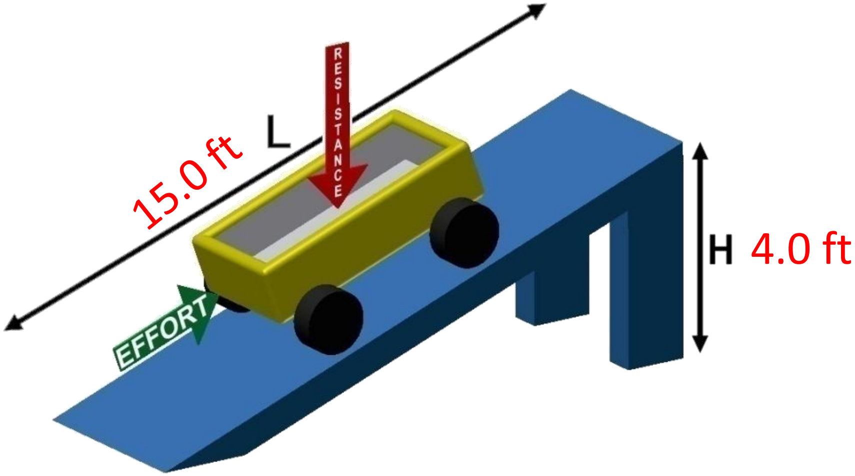
$$MA = GR = \frac{No}{Ni} * \frac{No}{Ni}$$

A to B   C to D

Not on formula sheet

Inclined Plane IMA

$$IMA = \frac{D_E}{D_R}$$



D_E = Distance traveled by the effort = L

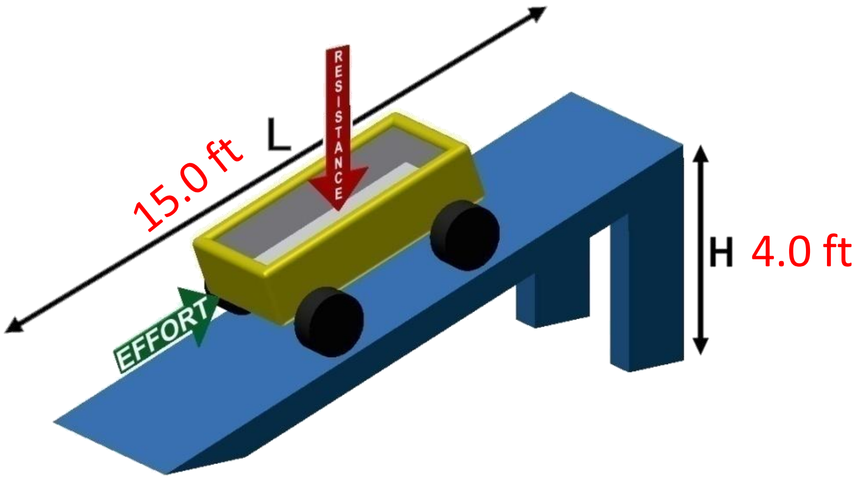
D_R = Distance traveled by the resistance = H

$$IMA = \frac{L}{H}$$

What is the IMA of the inclined plane above?

Inclined Plane IMA

$$IMA = \frac{D_E}{D_R}$$



D_E = Distance traveled by the effort = L

D_R = Distance traveled by the resistance = H

$$IMA = \frac{L}{H}$$

What is the IMA of the inclined plane above?

IMA = 15.0 ft / 4.0 ft = 3.75 = **3.8:1**

Wedge IMA

$$IMA = \frac{D_E}{D_R}$$

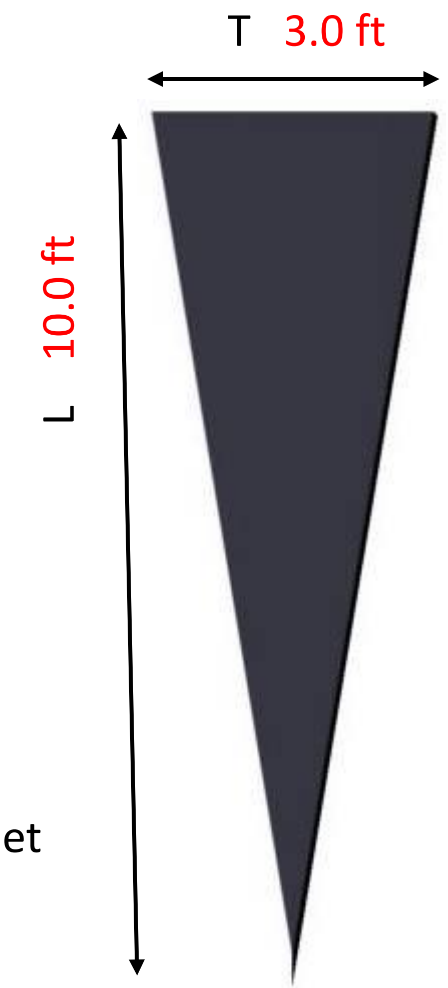
D_E = Distance traveled by the effort = L

D_R = Distance traveled by the resistance = T

$$IMA = \frac{L}{T}$$

This formula is different than formula sheet

What is the IMA of the wedge on the right?



Wedge IMA

$$IMA = \frac{D_E}{D_R}$$

D_E = Distance traveled by the effort = L

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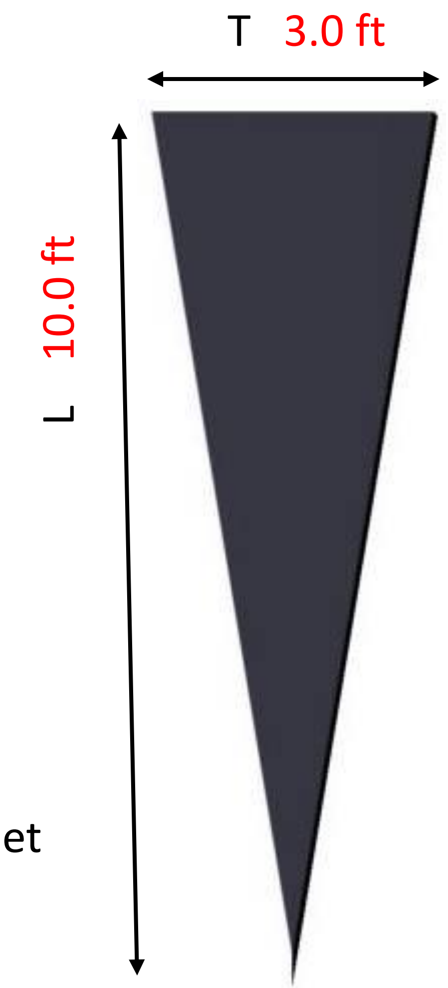
$$IMA = \frac{L}{T}$$

This formula is different than formula sheet



What is the IMA of the wedge on the right?

IMA = 10.0 ft / 3.0 ft = 3.3$\underline{3}$ = **3.3:1**

Screw IMA

Pitch is 1/ threads per inch

1/4 20 NC

$$IMA = \frac{D_E}{D_R}$$

D_E = One rotation of the effort arm = Circumference

D_R = Linear distance traveled during one rotation of the effort arm = Pitch

$$IMA = \frac{\text{Circumference}}{\text{Pitch}} = \frac{2\pi r_E}{P}$$

What is the IMA of the screw above if effort is applied by an 8.0in. long wrench?

Screw IMA

Pitch is 1/ threads per inch

1/4 20 NC

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D_E = One rotation of the effort arm = Circumference

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$$IMA = \frac{\text{Circumference}}{\text{Pitch}} = \frac{2\pi r_E}{P}$$

What is the IMA of the screw above if effort is applied by an 8.0in. long wrench?

$$IMA = \frac{2\pi 8.0in}{\frac{1in}{20}} = 10\underline{05.31} = 1.0 \bullet 10^3$$

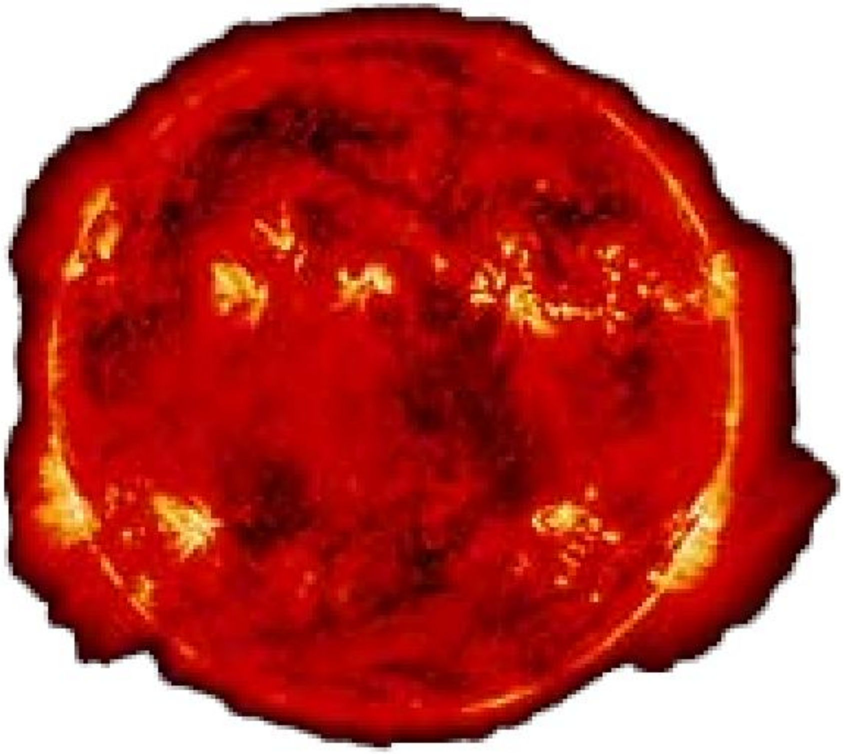
Energy Sources

Energy Sources

Energy: The ability to do work

Energy Sources include

- Nonrenewable
  - Fossil fuels
  - Uranium
- Renewable
  - Animal
  - Food
  - biomass
- Inexhaustible
  - Hydroelectric/tidal
  - Geothermal
  - Wind
  - Solar



Work (W)

The product of the force (F) applied to an object over a distance (d) in which the object travels as a result of the force

(Force and distance must be parallel to each other)

$$W = F \times d$$

Joule (j) is the base unit of work

$$1\,joule = 1\,newton \times 1\,meter$$

$$J = N \times m$$

Power

Rate at which work is performed or energy is expended

$$P = \frac{W}{t} \qquad \begin{matrix} \text{work} \\ \\ \text{time} \end{matrix}$$

Watt is the base unit of Power

One watt is equal to 1 joule of work per second

Mechanical Winch

Power output: Work / time

Not on formula sheet

Power input: Voltage * current

$$\text{Efficiency} = \frac{P\ out}{P\ in} * 100$$

Project Example

A motor lifts a 20 lb weight a distance of 3 feet in 12 seconds. While lifting, voltage was recorded as 12V and current was 1.5 A. What is the motor's efficiency?

Project Example

A motor lifts a 20 lb weight a distance of 3 feet in 12 seconds. While lifting, voltage was recorded as 12V and current was 1.5 A. What is the motor's efficiency?

Power output: Work / time: Work = Force * distance

Power out = (20 lb * 3 feet)/12 sec = 5 ft-lb/s or 5 watts

Power input: Voltage * current

Power in = 12V * 1.5 A = 18 watts

$$\text{Efficiency} = \frac{\text{P out}}{\text{P in}} * 100 = 5\text{ watts}/18\text{ watts} *100 = 27\%$$

Conservation of Energy

Energy cannot be created or destroyed, but it can change from one form to another.

Energy Conversion

Changing one form of energy to another

Energy Efficiency: The ratio of the useful energy delivered by a dynamic system to the energy supplied to it

Entropy: The loss of energy during conversion

$$\text{Efficiency \%} = \left(\frac{\text{output}}{\text{input}}\right) x100$$

Electrical Circuit

A system of conductors and components forming a complete path for current to travel

Properties of an electrical circuit include

Voltage (force *(pressure)* that causes current to flow) measured in **Volts; symbol is V**

Current (*flow* of electric charge) measured in **Amps; symbol is A**

Resistance (opposition of current flow) measured in **Ohms; symbol is Ω**

Ohm's Law

Quantities	Abbreviations	Units	Symbols
Voltage	V	Volts	V
Current	I	Amperes	A
Resistance	R	Ohms	Ω

$$V=IR$$

For any component

$$V_t=I_tR_t$$

For entire circuit

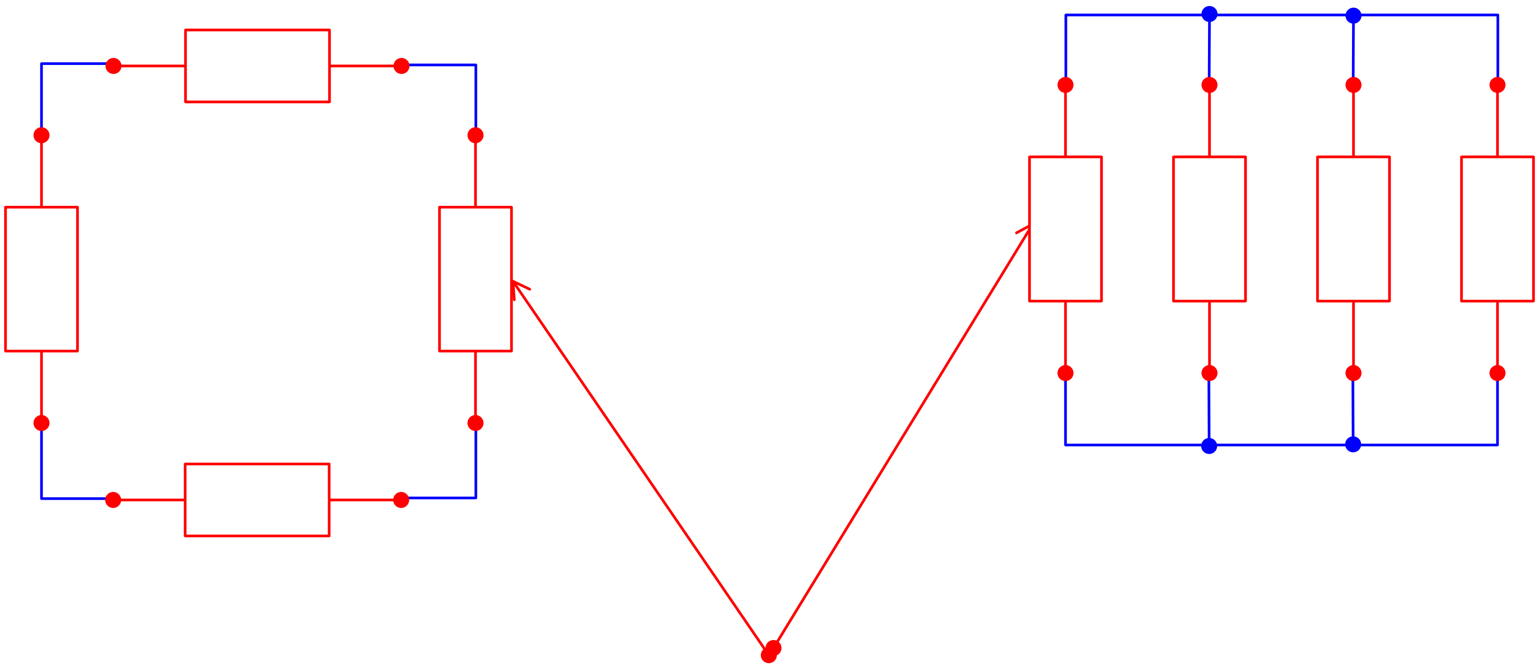
Circuit Configuration

Series Circuits

- Components are connected end-to-end.
- There is only a single path for current to flow.

Parallel Circuits

- Both ends of the components are connected together.
- There are multiple paths for current to flow.



Components

(i.e., resistors, batteries, capacitors, etc.)

Circuits

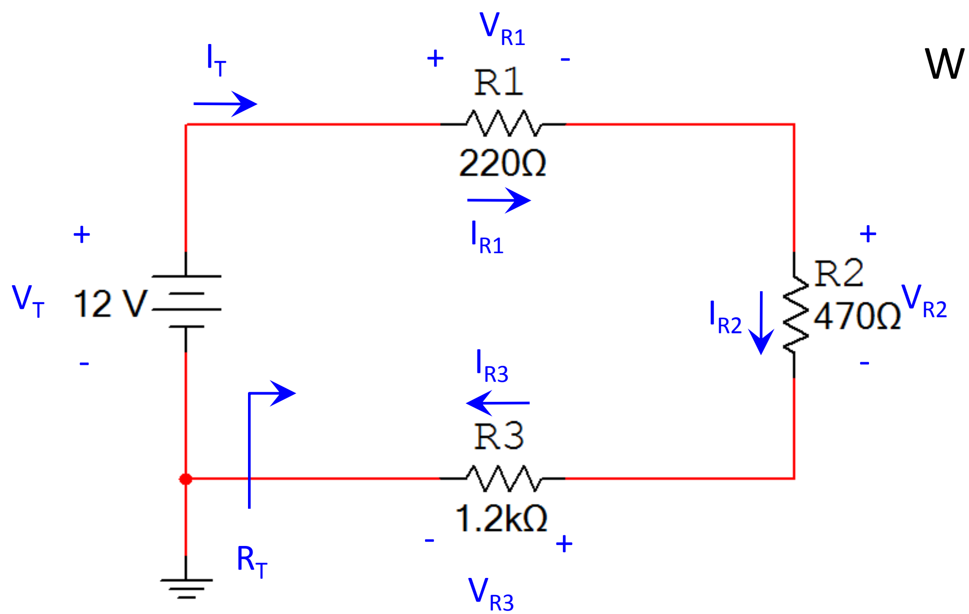
- Series
  - Current same everywhere
  - Resistance adds to total resistance
  - Voltage adds to total voltage
- Parallel
  - Voltage same everywhere
  - Current adds to total current
  - total resistance (R_T) is equal to the reciprocal of the sum of the reciprocal:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Example: Series Circuit

For the series circuit shown, use the laws of circuit theory to calculate the following:

- The total resistance (R_T)
- The current flowing through each component (I_T, I_{R1}, I_{R2}, & I_{R3})
- The voltage across each component (V_T, V_{R1}, V_{R2}, & V_{R3})
- Use the results to verify Kirchhoff's Voltage Law.



What is the current?

Example: Series Circuit

For the series circuit shown, use the laws of circuit theory to calculate the following:

- The total resistance (R_T)
- The current flowing through each component (I_T, I_{R1}, I_{R2}, & I_{R3})
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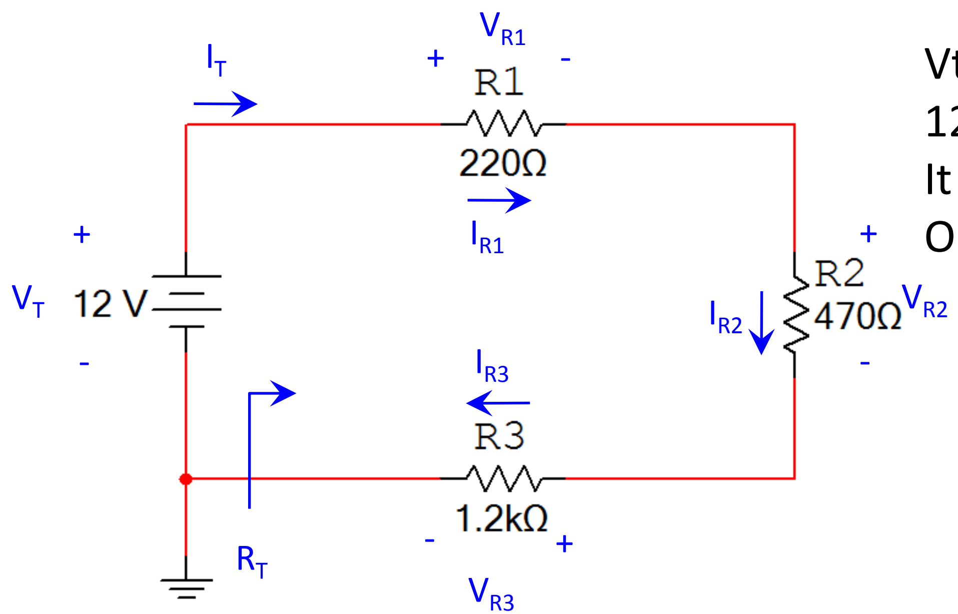
- Use the results to verify Kirchhoff's Voltage Law.

Rt = 220 ohms+ 470 ohms +1200 ohms

Rt = 1890 ohms



Vt = It * Rt

12 V = It * 1890 ohms

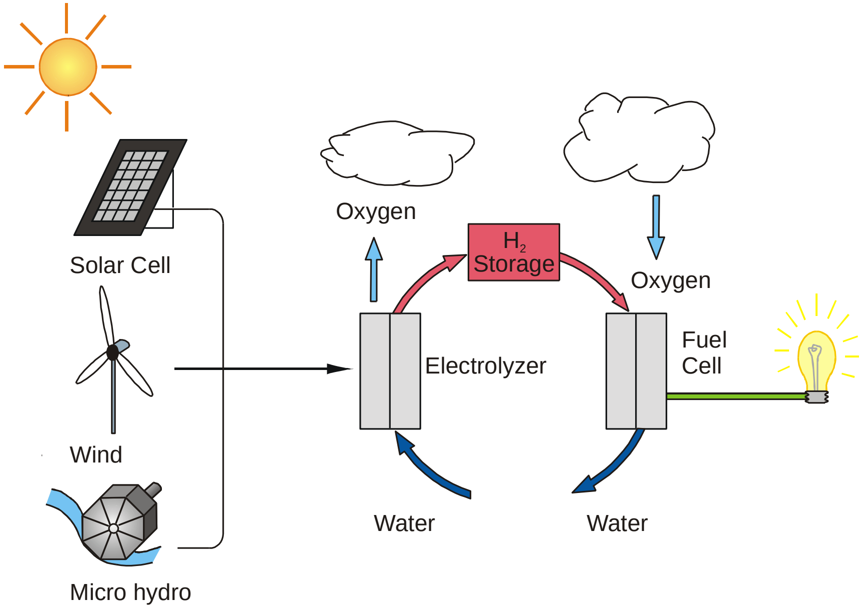
It = 0.006 amps

Or, 6 mA

Energy applications

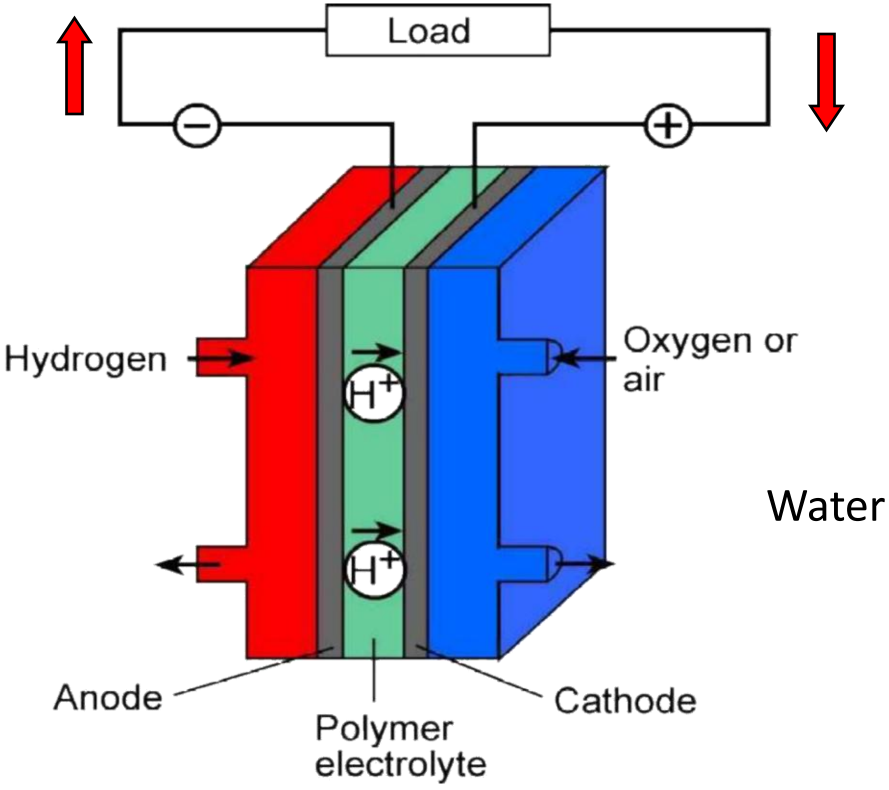
Energy applications

- Look at the system. Understand the system energy requirements to select a proper energy source.



Hydrogen Fuel Cell:

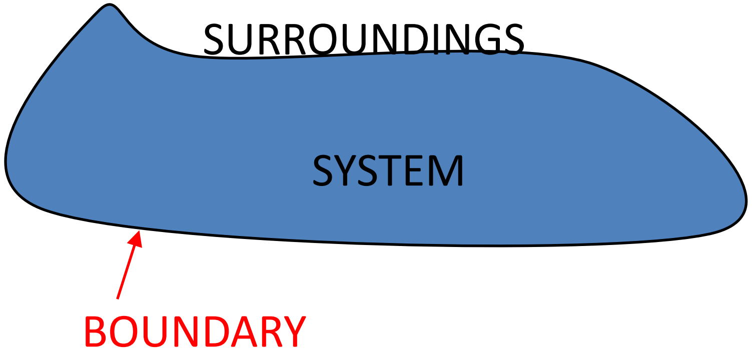
Creates electricity and heat through electrochemical process that converts hydrogen and oxygen to water



Thermodynamics

The study of the effects of work, heat flow, and energy on a system

Movement of thermal energy



Thermal Energy (heat) Transfer

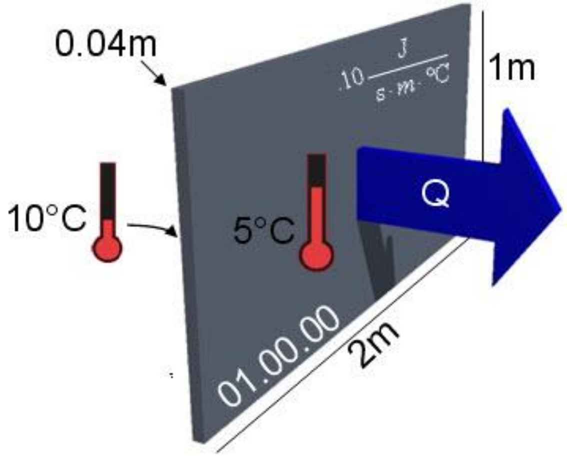
The transfer or movement of thermal energy

Most common types of transfer

- Convection: movement of air
- Conduction: movement thru an object through touching
- Radiation: electromagnetic waves

100% efficiency is unattainable

Calculating Energy Transfer



Q = Energy transfer

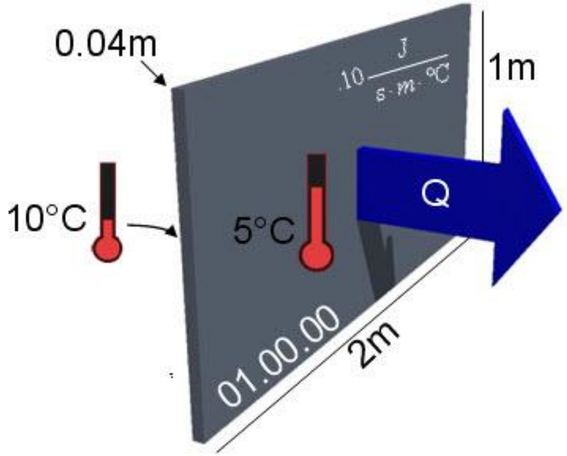
U = U value

Temp = temperature

Q = U * A * change in Temp

Remember   U value = 1/R value

Calculating Energy Transfe



Calculate the energy transfer in a wall section measuring 8ft by 10 ft by 0.25 ft thick with an R value = 4 ft^2 *ºF * hr/BTU if the opposing sides o the wall section have a temperature of 90°F and 75°F after one hour.

Area of thermal conductivity = A = 8 ft * 10 ft = 80 ft^2

U value = 1/ R value

U = 1/ R value = ¼
= 0.25 BTU /ft^2 *ºF * hr

Difference in temperature = ΔT = 90°F -75°F = 15°F

Q = U * A * change in Temp

Q = 0.25 BTU /ft^2 *ºF * hr * 80 ft^2 * 15°F

Q = 300 BTU / hr

Design Problem

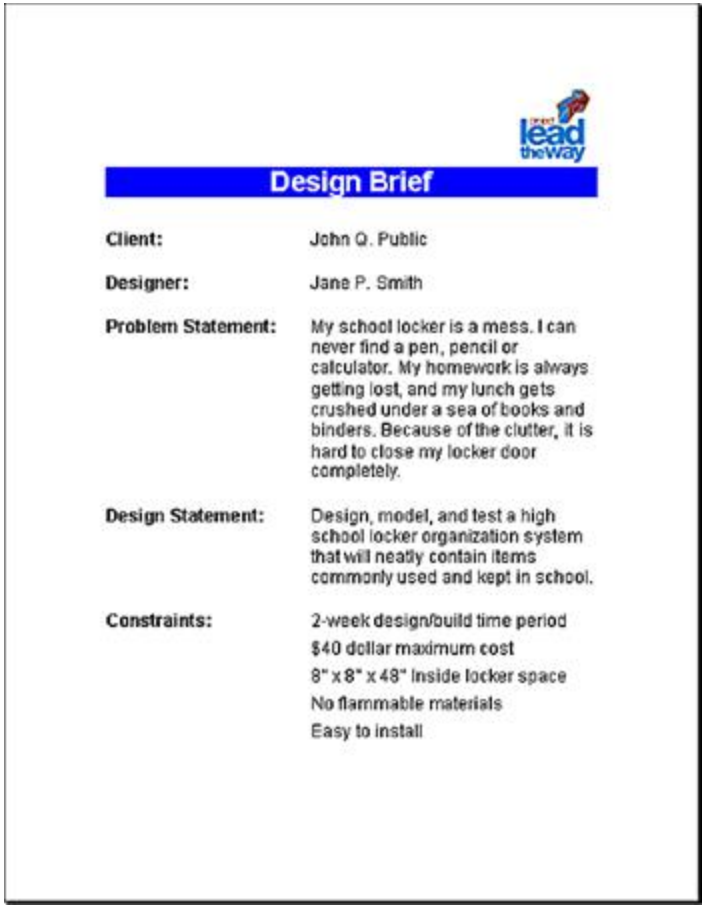
What is a Design Process?

A ***design process*** *is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve or satisfy human needs or wants and to narrow down the possible solutions to one final choice.*

– ITEA *Standards for Technological Literacy*

Design Brief

-defines the problem
-concise document (no more than one page)
-identifies the client
- clearly states client's problem
-Lists specifications
-Lists constraints

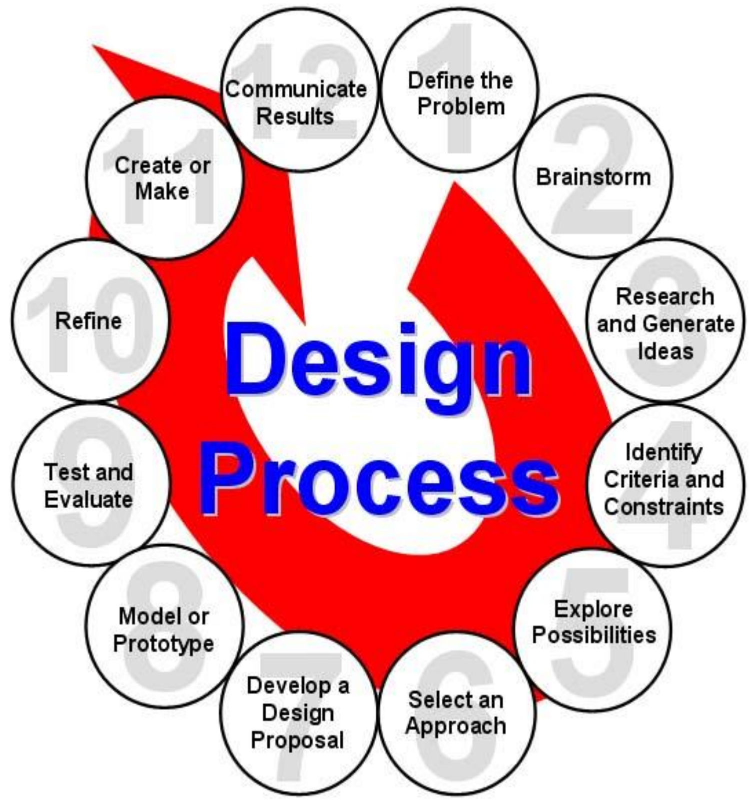


Design Brief

Client:	John Q. Public
Designer:	Jane P. Smith
Problem Statement:	My school locker is a mess. I can never find a pen, pencil or calculator. My homework is always getting lost, and my lunch gets crushed under a sea of books and binders. Because of the clutter, it is hard to close my locker door completely.
Design Statement:	Design, model, and test a high school locker organization system that will neatly contain items commonly used and kept in school.
Constraints:	2-week design/build time period $40 dollar maximum cost 8" x 8" x 48" inside locker space No flammable materials Easy to install

The Adopted Design Process for PLTW® Courses

1. Define a problem
2. Brainstorm
3. Research and generate ideas
4. Identify criteria and specify constraints
5. Explore possibilities
6. Select an approach
7. Develop a design proposal
8. Make a model or prototype
9. Test and evaluate the design using specifications
10. Refine the design
11. Create or make solution
12. Communicate processes and results



– ITEA *Standards for Technological Literacy*

Design Team

A ***team*** is a collection of individuals, each with his or her own expertise, brought together to benefit a common goal.

-Conduct research to develop knowledge base
-Stimulate creative ideas
-Make informed decisions

1. Define a Problem

- Receive a ***problem*** to solve from the client.
- Gather information.
- Be inspired through media exposure of a current ***problem*** and take action.

2. Brainstorm

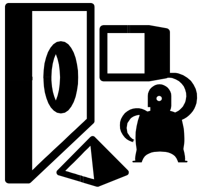
- Generate and record ideas.
- Keep the mind alert through rapidly paced sessions.
- Develop preliminary ideas based on constraints.

3. Generate and Research Ideas

- Conduct interviews with those affected by the problem.
- Research solutions that may already exist; identify shortcomings and reasons why they aren't appropriate to a given situation.
- Compile ideas and report findings to the team.

- Generate and Compile the ideas

4. Identify Criteria and Specific Constraints



- Limitations

- Cost

- Identify what the solution should do and the degree to which the solution will be pursued.
- Identify constraints (i.e., budget, time, etc.).
- Draft the Design Brief.

- Time

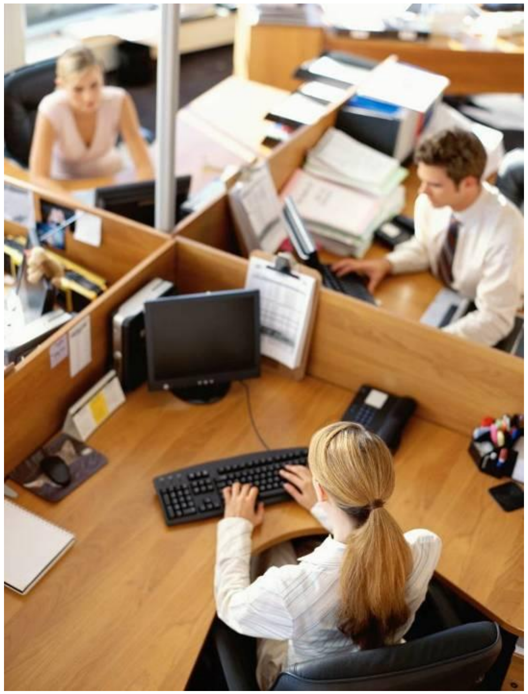
5. Explore Possibilities

- Consider further development of brainstorming ideas with constraints and tradeoffs.
- Explore alternative ideas based on further knowledge and technologies.

6. Select an Approach

- Review brainstormed information and answer any lingering questions.
- Narrow ideas down through a voting process, or by use of a decision matrix.
- Decide on final idea, usually through group consensus.

7. Develop a Design Proposal



•Explore the idea in greater detail with annotated sketches.
•Make critical decisions such as material types and manufacturing methods.
•Generate through computer models detailed sketches to further refine the idea.
•Produce working drawings so the idea can be built.

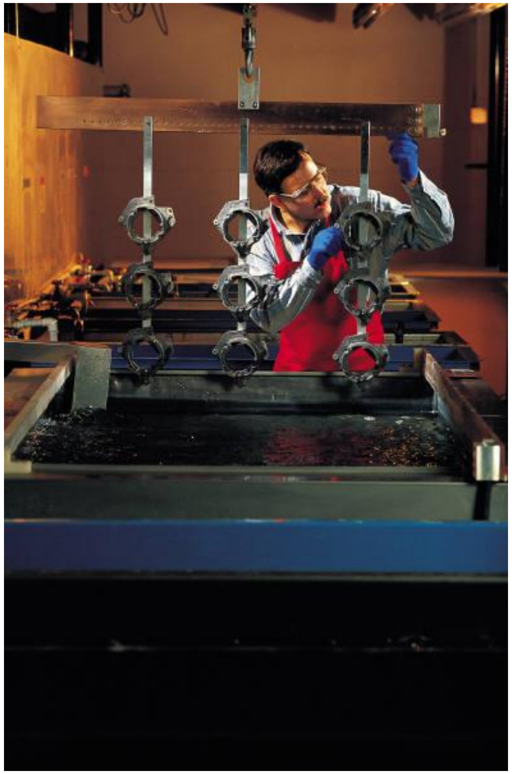
•Generate Design

•Create working drawings

8. Make a Model or Prototype

- Make models to help communicate the idea and to study aspects such as shape, form, fit, or texture.
- Construct a prototype from the working drawings so that the solution can be tested.

BUILD!



Prototype Creation

9. Test and Evaluate the Design Using Specifications

•Design experiments and test the prototype in controlled and working environments.
•Gather performance data; analyze and check results against established criteria.
•Conduct a formal critique to flesh out areas of concerns, identify shortcomings, and establish any need for redesign work.

- Prototype Testing
- Trial Runs

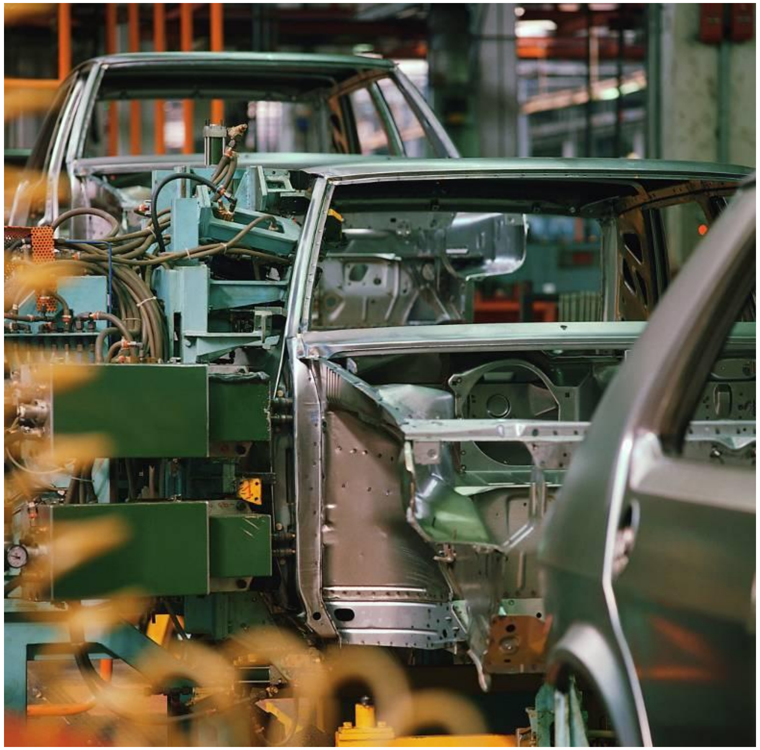
10. Refine the Design

- Make design changes; modify or rebuild the prototype.
- Make refinements until accuracy and repeatability of the prototype's performance results are consistent.
- Update documentation to reflect changes.
- Receive user's critique to provide outside perspective in order to determine whether established criteria have been met.

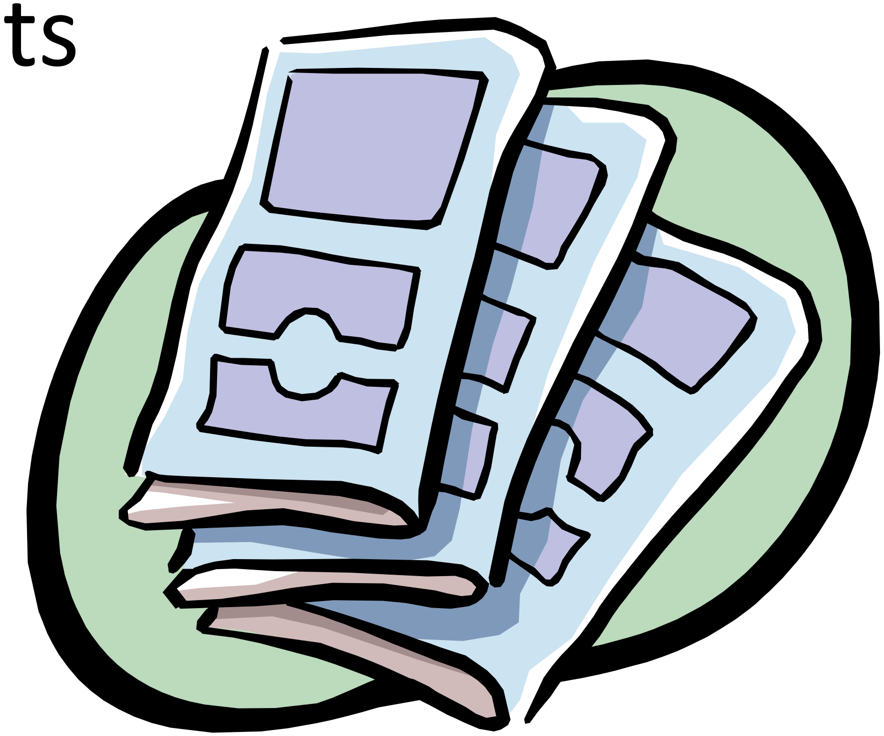
- Modify design

- Rebuild prototype

11. Create Solution



12. Communicate Processes and Results



- Communicate the designer's final solution through media such as PowerPoint, poster session, technical report.
- Market the Product.
- Distribute.