Forces and Energy

Motoharu Torii

General Units:

Mass	Kg
Energy	J (joule)
Length/Distance	M
Velocity	m/s
Acceleration	m/s^2
Force	N
Time	s
Power	W (watt)

Equations:

- Efficiency = $\frac{useful\ energy\ output}{total\ energy\ input}$ x 100
-

Law of Conservation of Energy:

Energy can neither be created or destroyed, it is either stored or transferred.

Energy Types:

Energy Stores	**Energy Transfers**
Chemical	Mechanical (force moves through distance)
Kinetic	Electrical (charge moves through potential)
Sound	Heating (temperature difference)
Elastic Potential	Radiation (light, microwaves, sound, etc)
Gravitational Potential	
Magnetic	
Electrostatic	
Nuclear	
Thermal	

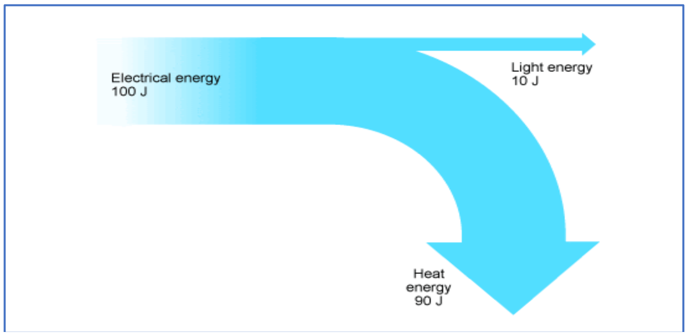
Forces and Energy

Motoharu Torii

Efficiency:

$$\text{Efficiency} = \frac{\text{Useful Energy Output}}{\text{Energy Input}} \times 100\%$$

Sankey Diagrams:



Heat Transfers:

- Moves from Hot to Cold (temp. difference from warmer area to cooler area)

Conduction
- Particles close together transfer heat (in SOLID and LIQUID)
- Energy transfer by vibration
- As metals are heated, particles vibrate, and particles can transfer the energy to neighbors
- Delocalized electrons also move faster (kinetic energy) which makes heat energy transfer more efficiently in Metals.
- (Insulators do not have free electrons, therefore are bad conductors)

Convection (convection current)
- Occur in LIQUID and GAS (fluids)
- The cooler the denser (sinks)
- The hotter the less dense (rises)
- Hot fluids are more spread out, and therefore are less dense

Radiation (thermal radiation)
- Travels by infrared waves (electromagnetic waves) – ex. Sun heats Earth surface.
- Infrared waves can travel through a vacuum
- They can be reflected and absorbed (object will warm up if absorbed)
- Shiny material emits the least.

Matt Black	→	White	→	Silver
(best emitter)				*(worst emitter)*
(best absorber)				*(worst absorber)*

Motoharu Torii

Thermal Insulators:
- Poor Conductors
- Ex. Plastics, Wood, Ceramics, Polystyrene, Air (when trapped and not moving).

Vacuum Flasks:
- Lid prevents Convection currents from escaping (gas, liquid)
- Vacuum between outer and inner layer prevents heat movement by Conduction
- Silver inner surface prevent heat leaving or enter by Radiation

Heat Loss from Houses:
- Thermogram shows distribution of heat over surface of an object.

- **Windows**: Double glazing has air trapped between two glass panes reducing heat loss by Conduction. Removing air and making a vacuum makes it more effective. However, it is expensive, and difficult to break in emergencies.

- **Walls:** A cavity (empty space btw/ two layers) traps air reducing and heat loss by Conduction. Plastic foam insulation pumped in the cavity prevents Convection.

- **Roof**: Warm air continues to rise, and therefore roof needs to be insulated to prevent heat loss by Convection. Loft insulation contains trapped air reducing heat loss through roof.

- **Radiators:** Radiator produces infrared radiation, which can be absorbed by walls which can escape. Placing a Shiny foil between the wall and radiator reflects the heat.

- **Doors:** A draught (movement of air due to Convection current) can occur by gaps under doors and around windows. Draught excluders can be used to close the gaps.

- **Curtains**: Curtains can prevent heat from leaving through small gaps by convection. They also prevent heat loss by radiation as curtains are opaque.

Payback Time:

- Time it takes for cost to be equaled by savings made from reduced energy costs.

$$\text{payback time (in years)} = \frac{\text{cost of insulation}}{\text{saving each year}}$$

Cost-effectiveness:

- Comparison of annual savings and cost of insulation.

$$\text{Cost-effectiveness} = \frac{\text{saving each year}}{\text{cost of insulation}}$$

Forces and Energy

Motoharu Torii

<u>KE and GPE:</u>
- GPE lost = KE gain (if friction and air resistance not applied)
- Total amount of Energy stays the same.

<u>Gravitational Potential Energy:</u>
- Greatest at the highest point.

$$\textit{gravitational potential energy} = \textit{mass} \times \textit{gravitational field strength} \times \textit{height}$$
$$\text{GPE} = m \times g \times h$$

<u>Kinetic Energy:</u>
- Greatest at the lowest point.

$$\textit{Kinetic energy} = \frac{1}{2} \times \textit{mass} \times \textit{speed}^2$$
$$\text{KE} = \frac{1}{2} \times m \times v^2$$

Work:
- Transfer of Energy (j)
- Depends on the size of the force and distance.
- Work done = the energy transferred.

$$\textit{work done} = \textit{force} \times \textit{distance moved}$$
$$\text{W} = \text{F} \times d$$

Power:
- The rate at which energy is transferred.
- The rate at which work is done.

$$\textit{power} = \frac{\textit{work done}}{\textit{time taken}}$$

$\frac{1}{1000,000,000}$	$\frac{1}{100,1000}$	$\frac{1}{1000}$	1	1,000	1,000,000	1000,000,000
10^{-9}	10^{-6}	10^{-2}	10^{0}	10^{2}	10^{6}	10^{9}
n	Mg	mg	g	Kg	Mg	Gg
0.000.000.001	0.000.001g	0.001g	1g	1000	1,000,000	1,000,000,000
nano	micro	milli		Kilo	Mega	Giga