Energy & Energy resources

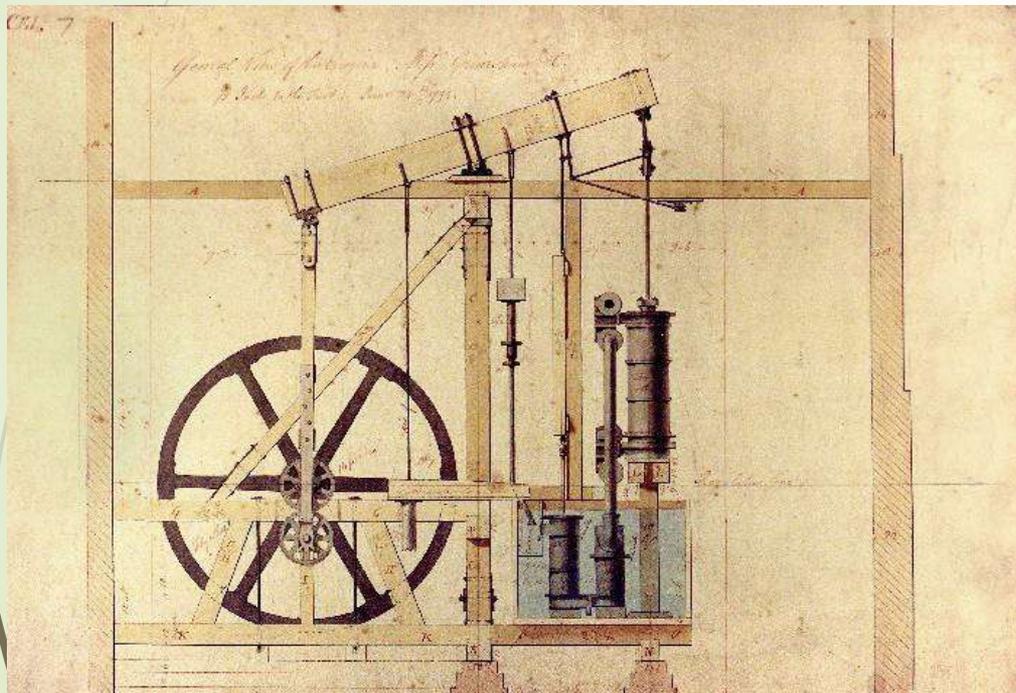By
Mrs.T.Pandimeena
Guest Lecturer
C.P.A College
Bodinayakanur

Energy historically

Steam engines:

- 1712 Newcomen, efficiency ~1%,

- 1775 Boulton & Watt, efficiency ~7%

Energy and power

	by analogy
$energy = power \times time$ measured in joules, MJ or kWh	$water\ volume = flow \times time$ measured in litres
$power = \dfrac{energy}{time}$ measured in joules per second, W, MW, GW, TW, kWh per day	$water\ flow = \dfrac{volume}{time}$ measured in litres per minute

Learning outcomes

- describe physical processes in terms of energy stores and transfers

- distinguish between temperature and internal energy

- explain thermal transfers (conduction, convection, radiation)

- calculate the specific thermal capacity of metal objects

- discuss energy changes associated with change of state (latent heat)

- explain the law of conservation of energy, calculate efficiency in energy transfers and recognise dissipation

- relate work done by a force to $E_p = mgh$ and $E_k = \dfrac{mv^2}{2}$

- describe rate of mechanical working as power

- apply energy concepts to decision-making about energy policy

- use a variety of experiments to convey key ideas about energy

Teaching challenges

- 'Energy', an everyday word, in science is an abstract quantity.

- Energy conservation defies common sense, as everyday things 'run out of energy'.

- Simply naming different types of energy, or energy chains, provides no explanation for physical processes.

- Students find work done (force exerted over a distance) more difficult than impulse (force exerted over an interval of time).

- Although temperature is a very familiar and tangible property, it needs to be associated with the random thermal motion of particles inside a body (internal energy).
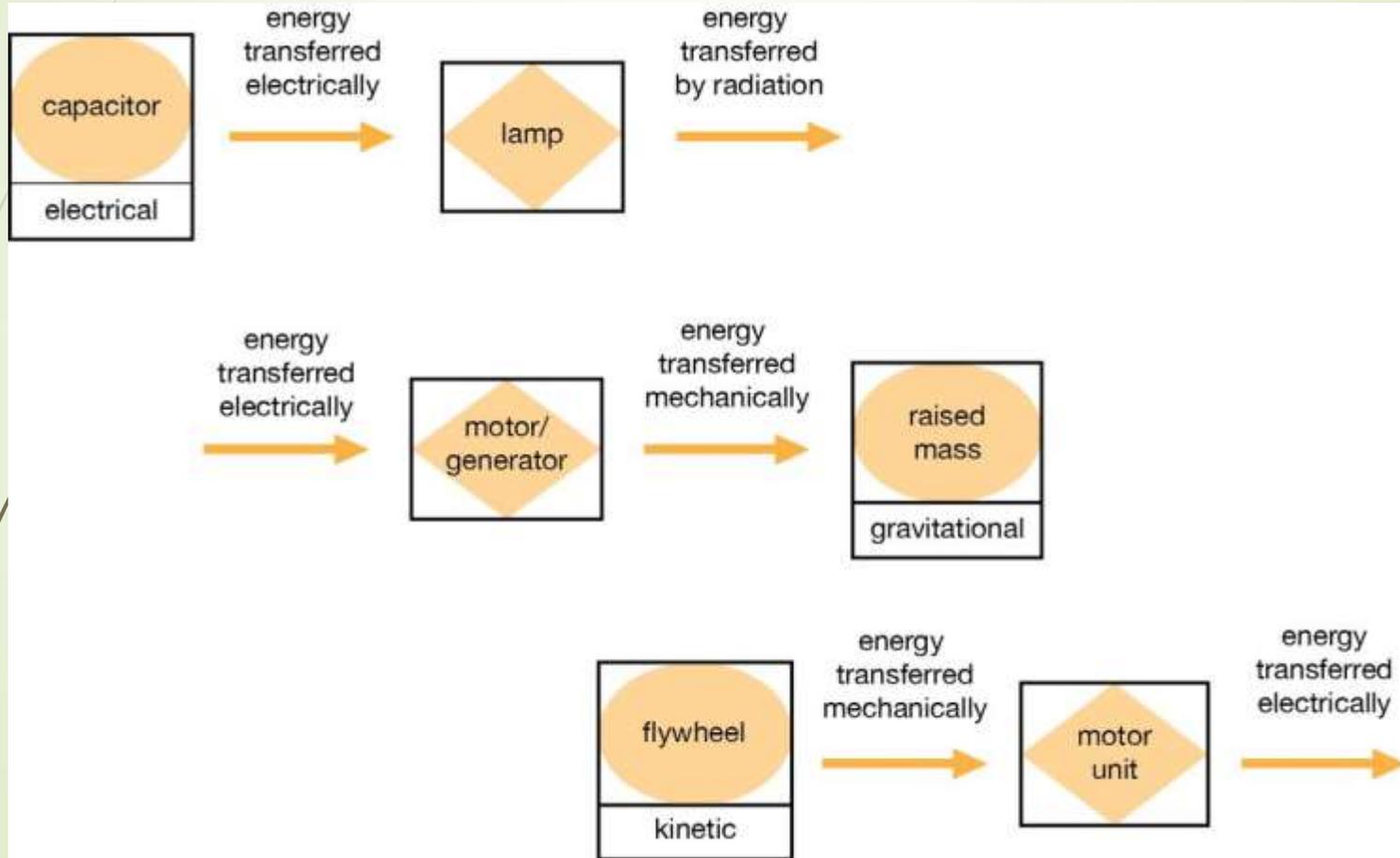
What is 'energy'?

'A certain quantity that does not change'

'It is not a description of a mechanism, or anything concrete; it is just a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same.'

Richard Feynman

The law of conservation of energy

SEP energy diagrams

Mechanical energy

For an object starting from rest,

$$\text{impulse} = \text{force} \times \text{time} = mv$$

Work done

$$W = F \times \text{displacement} = F \times (\text{average velocity} \times \text{time})$$

$$W = Ft \times \frac{v}{2} = mv(\frac{v}{2}) = \frac{mv^2}{2}$$

Therefore no surprise that, in some mechanical systems,

$$mgh + \frac{mv^2}{2} = \text{constant}$$

e.g. roller coaster, or pendulum

'Mechanical equivalent of heat'

Early in 19th C, 'heat' was thought to be a fluid, called 'caloric'.

Many experiments, mainly 1840 – 1900, showed conversions of
heat to/from mechanical or electrical sources, leading to the
concepts of **energy** & **energy conservation**.

$$\text{specific heat capacity of water, } c = 4200 \frac{J}{kg\,^{o}C}$$

James Prescott **Joule**, Manchester brewer & amateur scientist.
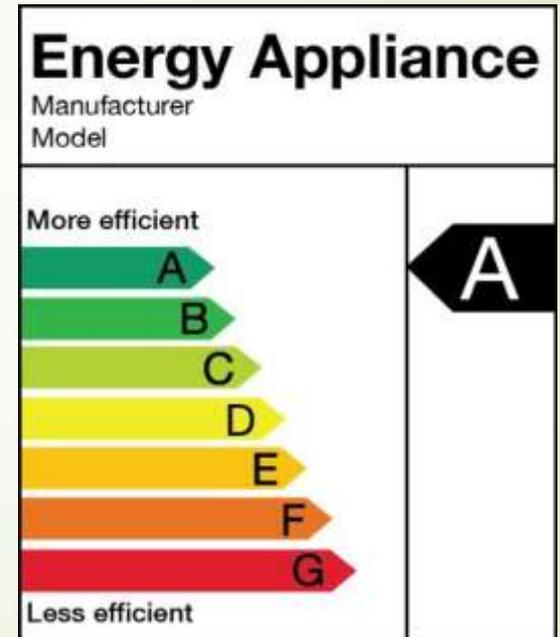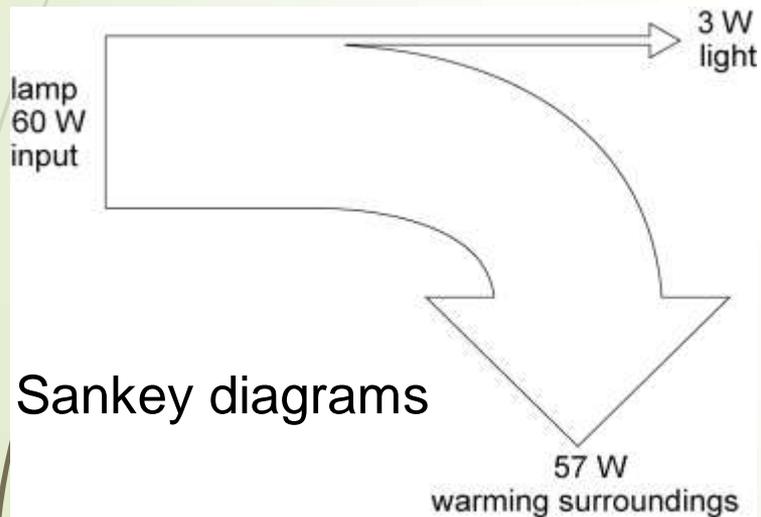40 expts! e.g. Swiss honeymoon: thermometer to measure temperature
of water at top & bottom of a waterfall. $\frac{m}{t} g \Delta h = \frac{m}{t} c \Delta T$

1850 article, *Philosophical Transactions* (Royal Society)

Clausius, Thomson (Lord Kelvin), Helmholtz, Rankine

Energy efficiency

$$efficiency = \frac{useful\ energy\ transferred}{total\ energy\ supplied} \times 100\%$$

Sankey diagrams

lamp
60 W
input

3 W
light

57 W
warming surroundings

Energy Appliance

Manufacturer
Model

More efficient

A

A
B
C
D
E
F
G

Less efficient

product labelling

Thermal transfers

Energy transfer from one store to another because of a temperature difference.

conduction: E_k transferred from atom to atom

convection: bulk movement of a fluid caused by localised thermal expansion and hence differences of density in the fluid.

radiation: warm body emits a continuous spectrum of electromagnetic radiation, with peak frequency related to absolute temperature.

Heat capacity

thermal store associated with a **temperature change but no change of state.**

Start simple: Why is a bite of hot potato more likely to burn the tongue than a bite of cabbage at the same temperature? Which foods stay hot longer on your plate?

Thermal (heat) capacity of an object: energy stored or released **by an object** per degree of temperature change, in J $^oC^{-1}$

'Specific' thermal capacity: energy stored or released **by a kg of material** per degree of temperature change, in J kg^{-1} $^oC^{-1}$

Materials used as coolants have a high specific thermal capacity.

Table

$$Q = mc\Delta T$$

Experiments to determine *c*

- Electrical method

  $$\text{electrical energy supplied} = \text{energy gained by object}$$

  $$IVt = mc\Delta T$$

- Method of mixtures e.g. solid placed in water

  energy lost by hotter object = energy gained by cooler object

  $$m_1 c_1 (T_3 - T_1) = m_2 c_2 (T_3 - T_2), \text{ where } T_3 \text{ is the equilibrium temp}$$

NOTE: Both the equations above assume no heat loss. Insulate calorimeter & include it in calculations.

- Using a cooling curve

  ref: Nelkon & Parker *Advanced level Physics*

  Practical Physics *Energy* collection *'Thermal physics'*

Latent heat

thermal store associated with a **change of state but no temperature change.**

Term 'latent' introduced ~1750 by Joseph Black [derived from the Latin $latere$, to lie hidden].

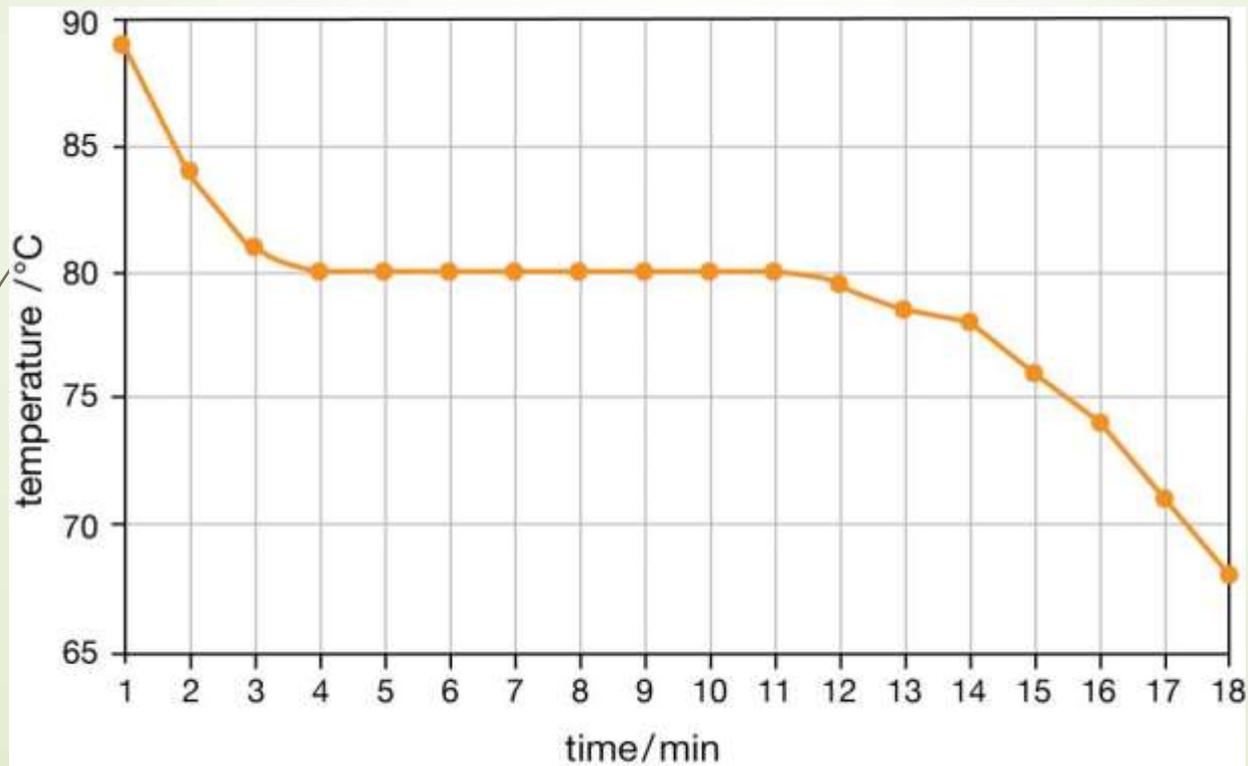$$Q = \text{mass} \times \text{specific latent heat}$$

Fusion: reversible change solid to liquid
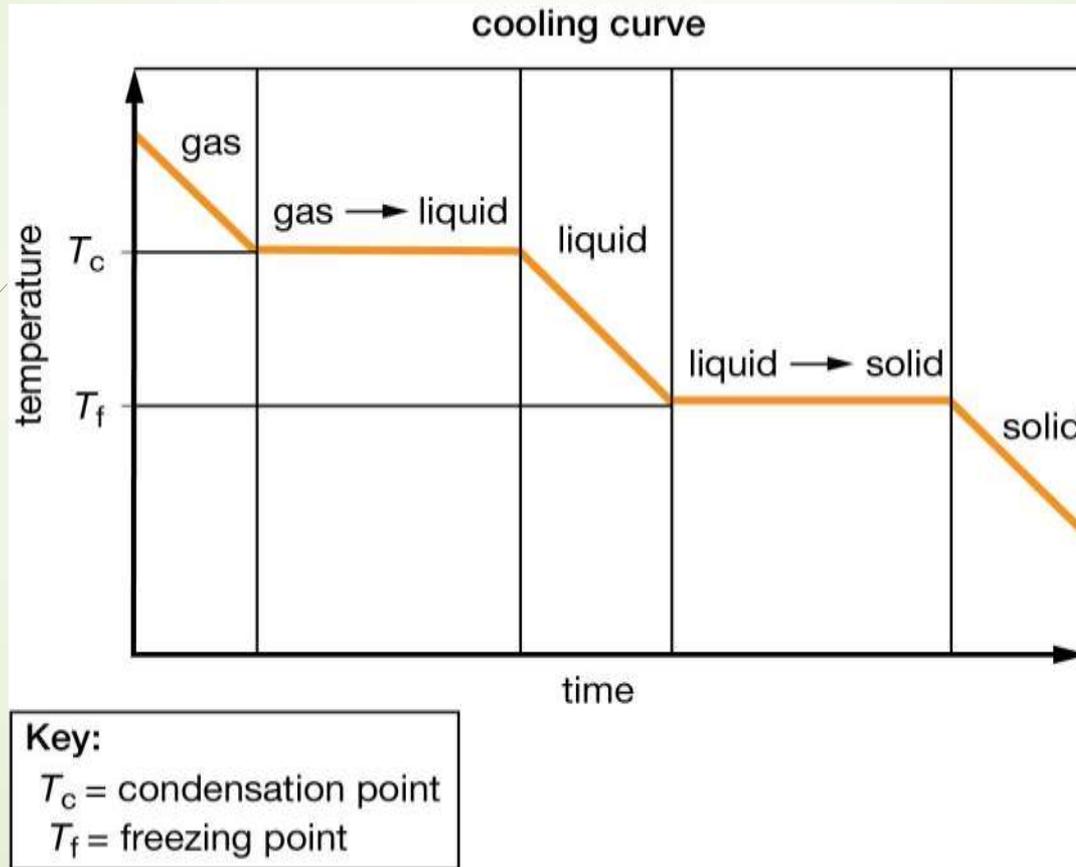
Vaporisation: reversible change liquid to vapour

Table

Cooling or heating curves

previously schools used naphthalene (now hexadecanol)

Cooling or heating curves

Latent heat

Experiments

- Fusion: Melting ice in a calorimeter

- Vapourisation: passing steam through a calorimeter; electrical method.

References: Nelkon & Parker *Advanced level Physics,*

Practical Physics *Energy* collection *'Thermal physics'*

Applications releasing energy as liquid changes to solid

- hot pad hand-warmer

- thermal energy storage in buildings

THANK YOU