Physics Knowledge Organiser

Energy (Triple Science)

Energy can be stored and transferred between objects as different types.

Kinetic	**K**ids
Thermal	**T**oday
Light	**L**earn
Gravitational Potential	**G**
Chemical	**C**
Sound	**S**
Elastic Potential	**E**
Electrical	**E**nergy
Nuclear	**N**ames

Type of Energy	Description
Elastic Potential	Anything that can stretched stores this energy. Examples are elastic bands or springs.
Chemical	Anything with energy released by a chemical reaction. Examples are food, fuels and batteries.
Kinetic	Anything that moves
Gravitational Potential	Anything that is moved up and down in a gravitational field.
Thermal	The higher its temperature, the more of this energy it has.
Nuclear	Energy released from nuclear fission or fusion.
Sound	Anything noisy such as vocal cords, speakers and musical instruments
Light	Anything luminous such as the sun, light bulbs and candles.
Electrical	If it is an electrical device, this type of energy will be transferred within it.

Conservation of energy

1) Energy cannot be destroyed

2) Energy cannot be created

3) Energy can be transferred usefully, stored or dissipated.

Examples of changes in energy stores

1) Ball falling to the ground
- **The gravitational potential energy store of the ball decreases.**
- **The kinetic energy store of the ball increases.**

2) An electric car starting to move
- **The chemical energy store in the battery decreases.**
- **The kinetic energy store of the car increases.**
- **The thermal energy store of the surroundings increase**

3) A rocket taking off
- **The chemical energy store in the fuel decreases.**
- **The kinetic energy store of the rocket increases.**
- **The gravitational potential energy store of the rocket increases.**
- **The thermal energy store of the surroundings increases.**

Effects of burning fossil fuels

We are trying to reduce our use of fossil fuels in our society.

This causes the emission of carbon dioxide (a greenhouse gas) into the atmosphere which contributes to global warming/climate change.

Sulphur dioxide emissions can lead to acid rain.

Nitrous oxide (Nox) emissions can lead to harm of living organisms

Particulates can lead to global dimming.

Comparing Energy Resources

Renewable: Can be replenished as it is used.

Non-renewable: There is a finite (limited) quantity. Not capable of being replenished as it is used.

Reliable: It can constantly generate electricity most of the time and does not rely on other factors. i.e. the weather.

Energy Resource	Renewable (R) or Non-renewable (NR)	Reliable (R) or unreliable (UR)
Wind	Renewable	Unreliable
Coal (fossil fuel)	Non-renewable	Reliable
Oil (fossil fuel)	Non-renewable	Reliable
Wave	Renewable	Unreliable
Natural gas (fossil fuel)	Non-renewable	Reliable
Nuclear	Non-renewable	Reliable
Tidal	Renewable	Reliable
Bio fuel	Renewable	Reliable
Solar	Renewable	Unreliable
Geothermal	Renewable	Reliable
Hydroelectric	Renewable	Reliable

Power Equations

Work done = energy supplied or transferred

Power is the rate at which energy is transferred.

It is the amount of energy being transferred per second.

Objects or devices which have a higher power rating (are more powerful) will transfer more energy every second.

You will need to learn the following two equations:

Equation 1: $P = \frac{E}{t}$ *Equation 2:* $P = \frac{W}{t}$

E = Energy transferred in joules (J)
P = Power in Watts (W)
t = time in seconds (s)
W = work done in joules (J)

Examples of using the equations:

Example 1: Applying the equation.

Calculate the power consumption of a toaster that transfers 20,000 J of energy in 20 seconds.

$$P = \frac{E}{t}$$

$$P = \frac{20{,}000}{20}$$

$$P = 1{,}000W$$

Example 2: Rearranging the equation

Calculate the energy transferred by a 4,000W heater transfer in 10 seconds.

$$P = \frac{E}{t}$$

$$4{,}000 = \frac{E}{10}$$

$$4{,}000 \times 10 = E$$
$$40{,}000J = E$$
$$E = 40{,}000J$$

Energy Dissipation

To reduce unwanted energy transfers taking place between materials, two main steps can be taken:

1) Insulating objects or insulation between materials.
2) Lubrication to reduce friction.

Friction Braking

When an object brakes work is done by friction, kinetic energy is transferred into thermal energy in the brakes.

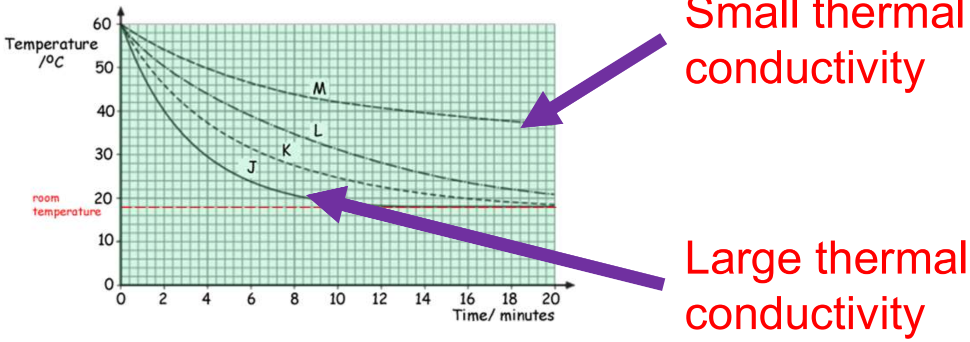
Thermal Energy Transfers

Different materials have different thermal conductivities.

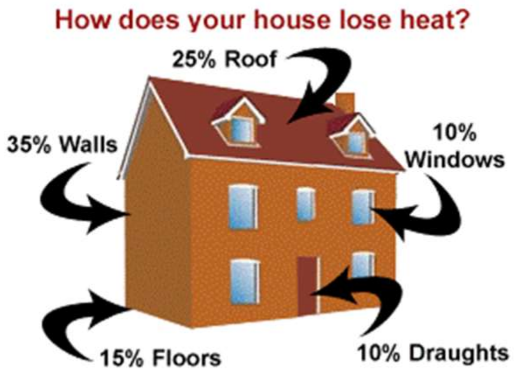
These affect the rate at which energy transfer takes place.

Large thermal conductivity have a high rate of energy transfer.

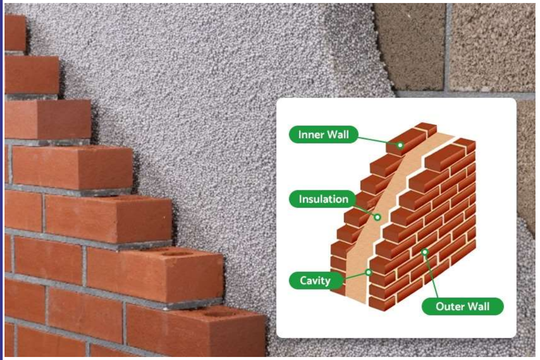
Small thermal conductivity have a low rate of energy transfer.



Uses of insulation



Insulation is added to homes to reduce the rate at which energy is transferred from them.



Wall cavity insulation with a small thermal conductivity is used. This reduces the rate at which energy is transferred from the home to the surroundings.

Efficiency

- A measure of how well something transfers energy.
- Efficient objects transfer a large proportion of their energy input into useful energy output.
- Energy that is not usefully transferred is wasted energy.

You will need to learn these two equations

$$\text{Efficiency} = \frac{\text{Useful energy output}}{\text{Total energy input}}$$

$$\text{Efficiency} = \frac{\text{Useful Power output}}{\text{Total Power input}}$$

Efficiency = decimal or a percentage if multiplied by 100

$Useful\ energy\ output$ = Joule, J

$Total\ energy\ input$ = Joule, J

$Useful\ Power\ output$ = Watts, W

$Total\ Power\ input$ = Watts, W

Example 1: Applying the equation

A light bulb has 100J of total energy input. The useful output energy is 25J. Calculate the light bulb's efficiency.

$$Efficiency = \frac{Useful\ energy\ output}{Total\ energy\ input}$$

$$Efficiency = \frac{25}{100}$$

$$Efficiency = 0.25$$

Examples of rearranging the equations

Example 2: Rearranging the equation

A lightbulb has an efficiency of 0.4 and the input energy is 2000J. Determine is the light bulb's useful energy output?

$$Efficiency = \frac{Useful\ energy\ output}{Total\ energy\ input}$$

$$0.4 = \frac{\text{Useful energy output}}{2000}$$

$$0.4 \times 2000 = \text{Useful energy output}$$

$$800J = \text{Useful energy output}$$

$$\text{Useful energy output} = 800J$$

Example 3: Harder rearrangement

2600J of input energy is transferred to a Range Rover and has an efficiency of 40%. Calculate the total output energy.

$$Efficiency = \frac{Useful\ energy\ output}{Total\ energy\ input}$$

$$Efficiency = 40 \div 100 = 0.4$$

$$0.4 = \frac{2600}{Total\ energy\ input}$$

$$0.4 \times Total\ energy\ input = 2600$$

$$Total\ energy\ input = \frac{2600}{0.4} = 6500J$$

Gravitational potential energy and equation

Any object in a gravitational field will have gravitational potential energy.

This energy can be changed in three different ways:

1) Changing its height
2) Changing its mass
3) Changing the gravitational field strength.

You will need to learn the following equation

$E_p = m \times g \times h$

E_p = Gravitational potential Energy in Joules (J).

m = Mass in kilograms (kg).

g = Gravitational Field Strength (N/kg)

h = Height in metres (m).

Example 1: Applying the equation

Calculate the gravitational potential energy of a ball that with a mass of 3kg at a height of 5m (g = 10N/kg).

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$E_p = m \times g \times h$

$E_p = 3 \times 10 \times 5$

$E_p = 150J$

Examples of rearranging the equation

Example 2: Rearranging the equation

A rocket of 200kg mass launches with 100,000J of gravitational potential energy, calculate the maximum height it will reach.

E_P=m x g x h

100,000 = 200 x 10 x h

100,000 = 2000 x h

h = $\frac{100,000}{2,000}$

h = 50m

Kinetic energy and equation

Any moving object has kinetic energy.

This energy can be changed in two different ways:

1) Changing its speed
2) Changing its mass

You will need to learn the following equation

$E_k = 0.5 \times m \times v^2$

E_k = Kinetic Energy in Joules (J).

m = Mass in kilograms (kg).

v = Speed in metres per second (m/s).

Example 1: Applying the equation

Calculate the kinetic energy of a 10kg snow sleigh moving at a speed of 8 m/s.

$$E_k = \frac{1}{2} \times m \times v^2$$

$$E_k = \frac{1}{2} \times 10 \times 8^2$$

$$E_k = 320\text{J}$$

Examples of rearranging the equation

Example 2: Rearranging the equation for mass, m

Serena Williams serves a tennis ball at a speed of 60 m/s. It has a kinetic energy of 90 J. Calculate the mass of the ball.

E_k = ½ x m x v^2

90 = ½ x m x 60^2

90 = ½ x m x 3600

90 = 1800 x m

$m = \frac{90}{1800}$

m = **0.05 kg**

Example 3: Rearranging the equation for speed, v

A small spacecraft with a mass of 100kg launches with 5000J of kinetic energy. Calculate the speed of the spacecraft.

E_k = ½ x m x v^2

5000 = ½ x 100 x v^2

5000 = 50 x v^2

$v^2 = \frac{5,000}{50}$

v^2 = 100

$v = \sqrt{100}$

v = 10 m/s

Elastic potential energy and equation

Any stretched or compressed object stores elastic potential energy.

This energy can be changed in two different ways:

1) Changing its extension
2) Changing its stiffness (spring constant).

This equation is given on the equation sheet.

$$E_e = \frac{1}{2} \times k \times e^2$$

E_e = Elastic Potential Energy in Joules (J).

k = Spring Constant in Newtons per metre (N/m).

e = extension in metres (m).

Example 1: Applying the equation

A bow with a spring constant of 500N/m extends by 0.1m. Calculate the elastic potential energy stored in the bow.

$$E_e = \frac{1}{2} \times k \times e^2$$

E_e = 0.5 x 500 x 0.1^2

E_e = 2.5J

Examples of rearranging the equation

Example 2: Rearranging the equation for spring constant, k

A spring stores 5J of elastic potential energy. It extends in length by 0.6m. **Calculate the spring constant of the spring.**

$$E_e = \frac{1}{2} \times k \times e^2$$

5 = 0.5 x k x 0.6^2

5 = 0.18 x k

$$\frac{5}{0.18} = k$$

k = 27.7 N/m

Example 3: Rearranging the equation for extension, e

A spring with spring constant of 100N/m has a force of 600N applied to it. Calculate the extension of the spring.

E_p = ½ x k x e^2

600 = ½ x 100 x e^2

600 = 50 x e^2

$e^2 = \frac{600}{50}$

e^2 = 12

e = $\sqrt{12}$

e = **3.46 m**

Combining energy equations

The *total* energy before = The *total* energy after

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

$E_k = E_p$

$\frac{1}{2}mv^2 = mgh$

Combining energy equations example (HT)

A child of mass 40 kg climbs up a wall of height 2.0 m

and then steps off. Assuming no significant air resistance

calculate the maximum:

(a) gpe of the child

(b) speed of the child

Gravitational field strength = 10 N/kg

(a) Max gpe occurs when the child is on the wall

E_p ***= m x g x h***

E_p = 40 x 10 x 2.0

max gpe = 800 J

(b) Max speed occurs when the child reaches the ground

½ x m x v² = m x g x h
½ x m x v² = 800 J
v² = (2 x 800) / 40
v² = 40

v = √40

max speed = 6.32 m/s

Combining energy equations example (HT)

A ball is dropped from a height of 5m. Assuming no significant air resistance

calculate the maximum speed of the child

Gravitational field strength = 10 N/kg

We are assuming no air resistance. Therefore, the ball's gravitational potential energy will be transferred into kinetic energy.

$E_k = E_p$

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}v^2 = gh$ — Simplify each side of the equation by dividing by mass on both sides.

$\frac{1}{2}v^2 = 10 \times 5$ — Substitute in the values

$\frac{1}{2}v^2 = 50$ — Do the easy maths

$v^2 = 2 \times 50$

Rearrange for v

$v = \sqrt{2 \times 50}$

$v = 10\ m/s$ — Solve