IGCSE Double Award Extended Coordinated Science
Physics 3.1 & 3.3 & 3.4 - Energy, Work, and Power

Energy, Work, and Power

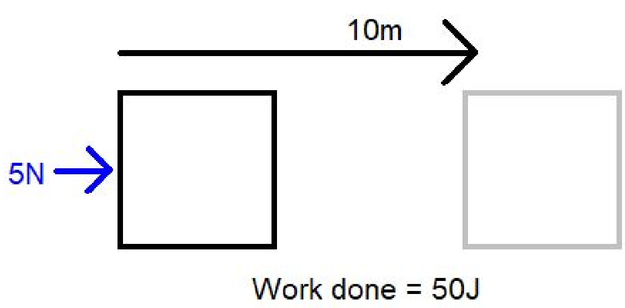
You need to know what energy, work, and power is, and the units for energy and power.

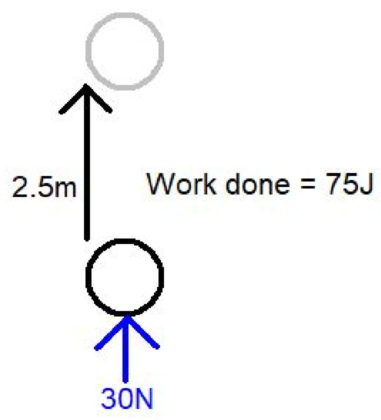
Energy, E is **the capacity to perform work.**
- Energy is measured in units of **joules (J)**
- There are many different types of energy
    - They can either be **stored** energies or **"moving" active** energies.
- Energy can **neither** be created **nor** destroyed; rather, it can be **transformed** from one form to another.
    - This is the **Law of Conservation of Energy**

Type of Energy	State	Description	Found in / Uses
Kinetic (KE)	Moving	Energy in moving objects, a.k.a movement energy	All moving objects have KE
Gravitational Potential (GPE)	Stored	Energy stored in objects raised from the ground	All objects above ground have KE
Sound	Moving	Energy released by vibrating objects	Microphone, voice, etc
Thermal (Heat)	Moving	Energy of vibrating particles in an object	All objects at temperature above 0K
Electrical	Moving	Energy in moving or static electric charges	Electronic device, nervous system
Light	Moving	Only visible form of energy, part of the ER spectrum.	Vision, laser beams
Elastic Potential	Stored	Energy stored in stretched or squashed objects	Springs, rubber bands
Chemical	Stored	Energy stored in molecular bonds	Stored in food, fuels, and batteries
Nuclear	Stored	Energy stored in the nuclei of atoms	Nuclear reactor

Work is done when a **force is applied to an object to move it through a distance**
- When work is done, energy is transferred
- So the unit of work is also joules, J.

To calculate work done, use the formula:
- The force and the distance moved must be in the **same direction**
    - **Work done = force x distance**
    - **W = F x d**
    - J = N x m
- **1 joule is the energy transferred by a force of 1 newton when it moves through a distance of 1 metre**





Power is the rate of doing work (Work done per unit time or energy transferred per unit time)

- **Power = work done ÷ time taken**
- **P = W ÷ t**
- W = J ÷ s

The unit of power is the **watt (W),** and it is equivalent to **J/s**

- **A power of 1 watt means that 1 joule of energy is being transferred every second**

Energy Transformations

You need to know energy transformations in simple systems.

According to the Law of Conservation of Energy:

- Energy can **neither** be created **nor** destroyed; rather, it can be **transformed** from one form to another.

When there is an energy transformation, there is an **input energy** and an **output energy.**

- Input energy ---transformation--> output energy

For the output energy, there is **useful energy**, which is what we want to use, and **waste energy.**

- For example, in a light bulb,
    - The goal is to convert **electrical energy** into **light energy**
    - **Electrical energy is the input energy, and light energy is the useful output energy**
    - However, a light bulb will also produce **heat energy which is the waste energy.**
- Not all 100% of the input energy is transformed into output energy.

You need to know what efficiency is, and how to calculate efficiency.

Efficiency is the **percentage ratio of useful output energy to total input energy**

- **(Useful Energy ÷ Input Energy) x 100% = Efficiency**

No device has an energy transformation of 100% efficiency

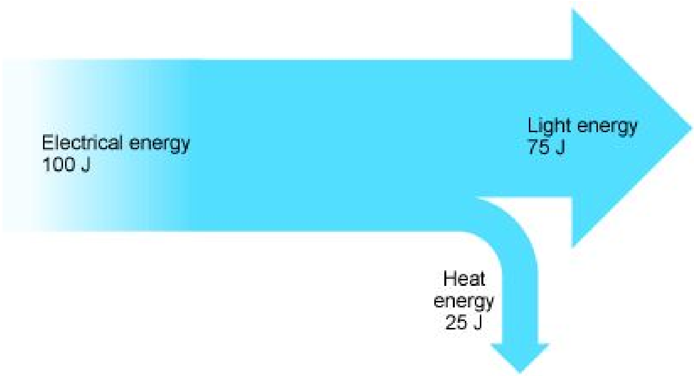
e.g. 5000J of electrical energy is put through a light bulb and 3500J of light energy is emitted,

- what is the bulbs efficiency?
- (Useful Energy ÷ Input Energy) x 100% = Efficiency
- (3500/5000) x 100% = **70% efficiency.**

You need to know how to draw and interpret **Sankey diagrams**

Sankey diagrams are a way to show energy transformations, along with efficiency.

- They look like arrows, with input energy coming from the **left**
- Useful energy continues straight on to the **right**, whereas the waste energy curves off **downwards.**
- The thicknesses of the arrows show the percentages.



You should be able to write some iconic energy transformations like:

Filament Lamp :
- Electrical -> **Light**, Heat

Television :
- Electrical -> **Light, Sound**, Heat

Microphone to amplifier:
- Sound -> **Electrical** -> **Sound**, Heat

Car:
- Chemical -> **Kinetic**, Heat, Sound

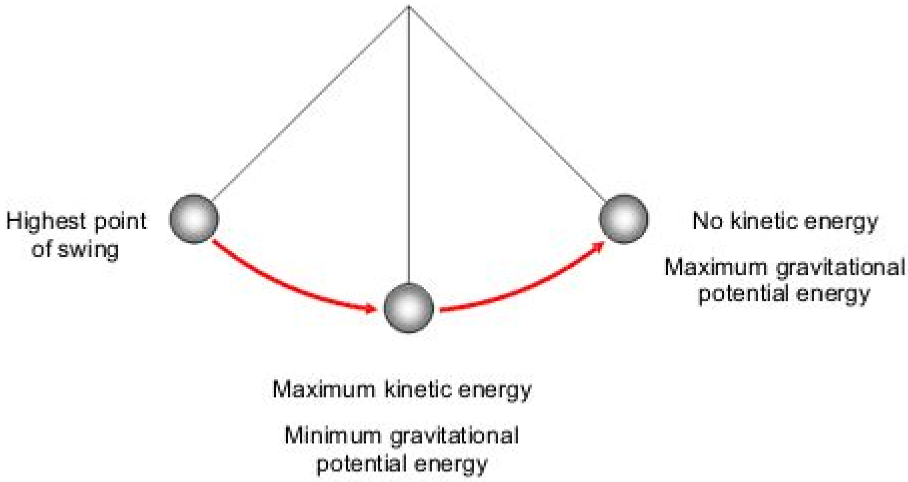
A man jumping off a cliff:
- Gravitational Potential -> **Kinetic** -> Sound, Heat

MP3 Player with screen:
- Chemical -> **Electrical** -> **Sound, Light**, Heat

Coal Power Station:
- Chemical -> **Heat** -> **Kinetic** -> **Electrical,** Heat

Nuclear Power Station:
- Nuclear -> **Heat** -> **Kinetic** -> **Electrical,** Heat

Pendulum:
- **Gravitational Potential** -> **Kinetic,** Heat -> **Gravitational Potential** -> **Kinetic,** Heat -> etc..



- In a pendulum, the kinetic energy and gravitational potential energy is continuously transformed between one another with small amounts of energy lost as heat due to air resistance.

Kinetic Energy (K.E.)

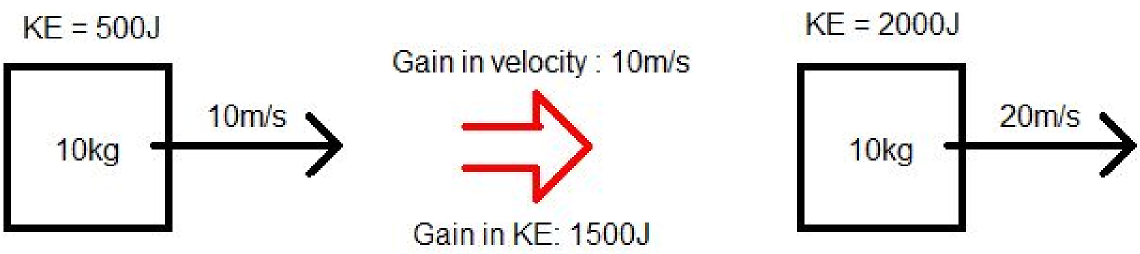
You should be able to calculate kinetic energies of moving objects.

An object possesses a certain amount of kinetic energy at a certain speed.

- **KE = ½mv²**
- **Kinetic Energy = ½ x mass x (velocity)²**

From this we can see that the **kinetic energy is dependant on both the mass and velocity** of the object.

- Doubling the mass doubles the kinetic energy
- Doubling the velocity **quadruples** the kinetic energy.

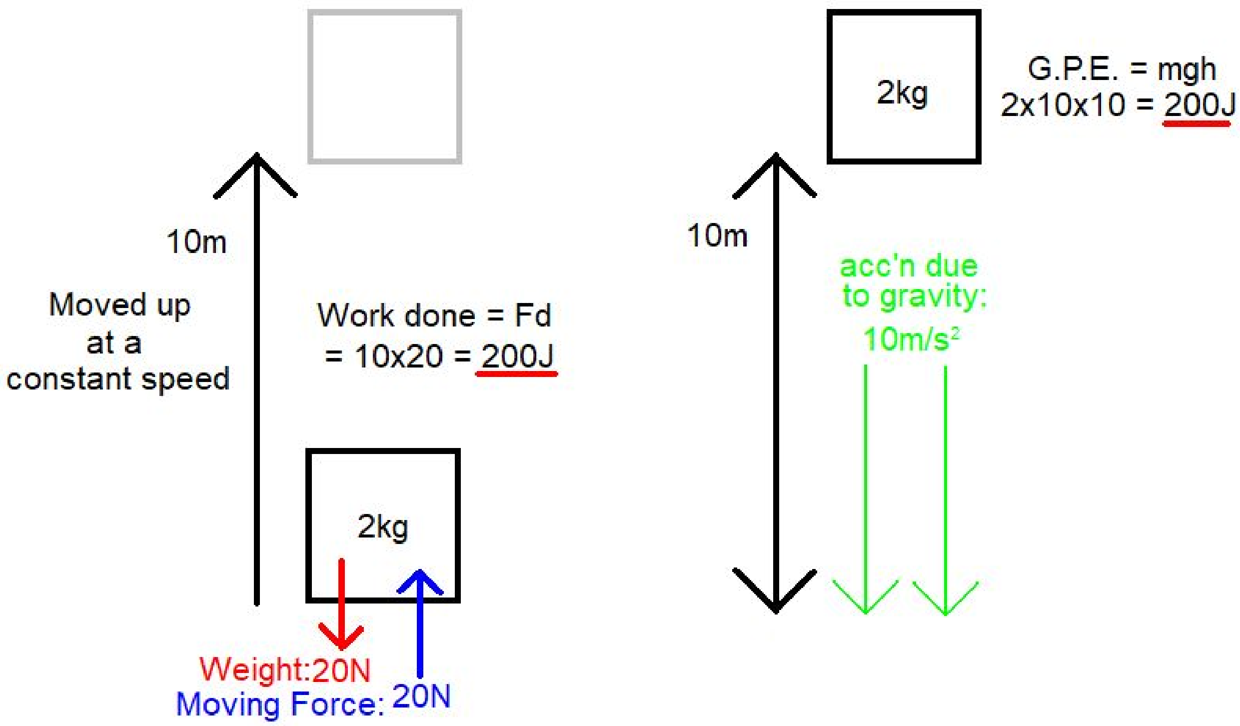


Gravitational Potential Energy (G.P.E.)

You should be able to calculate gravitational potential energies of objects.

Gravitational potential energy is the stored energy possessed by an object by its position in a gravitational field.

- It is calculated by:
    - **GPE = mgh**
    - **Gravitational Potential Energy = mass x gravity**(acc'n due to gravity) **x height**
        - For acceleration due to gravity, we take the rounded value $10 m/s^2$ (rather than 9.81)
- It is also equal to the energy that is required to move the object against gravity to that position.



The syllabus says you should be able to, (SO check if you can):

- Know that energy and work are measured in joules (J), and power in watts (W).
- Give and identify examples of energy in different forms, including kinetic, gravitational, chemical, strain, nuclear, thermal (heat), electrical, light and sound.
- Give and identify examples of the conversion of energy from one form to another, and of its transfer from one place to another.
- Apply the principle of energy conservation to simple examples.
- Demonstrate a qualitative understanding of efficiency.
- Recall and use the equation: efficiency = useful energy output / energy input × 100%

- Demonstrate understanding that an object may have energy due to its motion (kinetic energy, K.E.) or its position (potential energy, P.E.), and that energy may be transferred and stored.
- Recall and use the expressions
    - K.E. = $\frac{1}{2}mv^2$
    - P.E. = mgh

- Relate (without calculation) work done to the magnitude of a force and the distance moved.
- Describe energy changes in terms of work done.
- Recall and use $W = F \times d$

- Relate (without calculation) power to work done and time taken, using appropriate examples.
- Recall and use the equation $P = E/t$ in simple systems.