# Physics

## P1

### Y11 P1.1.1: Infrared absorption/emission

- Radiation is emitted by all materials and the hotter the material the more strongly it gives out infrared radiation
- Dark surfaces are good absorbers of radiation as it does not reflect many wavelengths of light
- Light surfaces are bad absorbers of radiation as they reflect lots of radiation
- Matte surfaces are good absorbers of radiation as they have a larger surface area to absorb maximum radiation
- Reflective surfaces are bad absorbers of radiation due to their small surface area

### Y11 P1.1.2: Kinetic Theory, states of matter

- Evaporation is when the highest kinetic energy particles of a liquid escape from the surface reducing the average kinetic energy of particles remaining and therefore the temperature
- The higher the liquid temperature the faster the rate of reaction
- The greater the surface area, the faster the evaporation
- The greater the airflow over the surface the faster the evaporation rate



### Y11 P1.1.3: Energy Transfer by heating

- Conduction of heat energy is the process where vibrating particles pass on their extra kinetic energy to neighbouring particles
- The more dense the solid the better the conductor
- Metals are good conductors because of free moving electrons can move much quicker than fixed atoms and pass on their heat (KE) by colliding with other electrons

- Convection occurs when the more energetic particles move from the hotter region to the cooler region and take their heat energy with them
- This occurs as the hotter particles move faster and are less dense so rise and the more dense particles above them sink to then be heated

### Y11 P1.1.4: Building Design

- U-value of a material gives a numeric value of how efficient heat transfer is through the material
- Calculated as the power per unit area per degree temperature difference
- The lower the U-value the better its insulating properties

- Specific heat capacity is the amount of energy required to change the temperature of one kilogram of the substance by one degree Celsius
- The higher the heat capacity the more energy it can hold for a given mass

- Loft insulation – Cheap and effective – a thick layer of fibreglass wool laid all over the loft floor and reduces conduction and convection of heat lost through the roof – payback time a few years
- Cavity wall insulation – insulating foam injected between brick walls – reduces convection, conduction and radiation across the walls – quite costly payback time a few years
- Hot water tank jacket - cheap and effective - a jacket of lagging of a foam filled plastic cover reduces conduction and radiation heat losses - quick payback time
- Double glazing - expensive, longer payback time - insulating air is trapped between the glass panes reducing heat losses by conduction and convection
- Draught-proofing - cheap, effective, a few years payback time - strips of foam or plastic around door frames, thick curtains across the windows - all of these measures reduce heat loss from the house by convection

## Y10 P1.2.1: Energy Transfer

- Heat transfer occurs from a hot body to a cooler body
- The bigger the temperature difference the bigger the rate of heat transfer
- Efficiency is the percentage of useful energy out



## Y11 P1.3.1: Transferring electrical energy

- Calculating electricity

## Y11 P1.4.1: Electricity generation

- Knowledge of various methods of generating electricity
- The national grid consists of a network of pylons and cables
- Step up transformers are used so that the voltage increases and the current decreases so less energy is disputed through heat caused by high current

## Y9 P1.5.1: Electromagnetic Waves

- waves transfer energy
- Waves can either be transverse (oscillations perpendicular to transfer of energy) or longitudinal (oscillations in same direction as transfer of energy)
- All types of electromagnetic waves travel at the same speed through a vacuum
    - 300,000,000 m/s
- Electromagnetic waves form a spectrum from gamma to radio
- Longitudinal waves show areas of compression and rarefaction
- Waves only show significant diffraction if the gap or obstacle is on the same magnitude as the wavelength
- Waves are not refracted if travelling along the normal
- When a ray enters a more dense medium the ray bends towards the normal
- Amplitude is the distance from zero to the crest

- If the radio wave has a long wavelength then direct line of sight is not needed as it can diffract around hills
- For good reception higher frequency is needed like FM radio or TV which need line of sight
    - Can also be received over large distances because they bounce of the Earth's surface and ionosphere
- Know properties of other electromagnetic waves

## Y11 P1.5.2: Reflection

- The normal is a construction line perpendicular to the smooth reflecting surface at the point of incident
- The angle of incidence is equal to the angle of reflection
- An image produced in a plane mirror is virtual, upright and laterally inverted

## Y11 P1.5.3: Sound

- Sound waves are longitudinal waves that cause vibrations in a medium
    - They have areas of compression and rarefaction
    - The denser the medium the quicker the sound waves
- Pitch of sound is determined by its frequency and loudness by its amplitude
- Echoes are reflections of sounds
    - Sound waves are reflected by hard flat surfaces but are absorbed by rough soft surfaces
    - The further away the surface the longer the time interval between sound and echo



## Y9 P1.5.4: Red Shift and the Big Bang

### Doppler Effect

- If an object moving towards you emits waves they are compressed closer together because the object has moved closer between each one
- If an object moving away from you emits waves they are spread apart because the object has moved further away between each one.
    - This is what causes red shift in galaxies that are moving away from us
    - The light we receive from them is slightly shifted to the red
- This means the wavelength of the waves change depending on the speed and direction of travel of the object
    - This is what causes blue shift in galaxies that are moving away from us
    - The light we receive from them is slightly shifted to the blue
- Hubble noticed that almost all galaxies were red-shifted and so moving away from us
- He also noticed that the further away they were the more red-shifted they were
- This led him to the conclusion that the universe is expanding
- He traced back this expansion and decided that the universe must have come from a single point
- The expansion from this point was called the Big Bang
- This explains the uniformity of the CMBR

# P2

## Y9 P2.1: Forces

### Weight, Mass and Gravity

- Gravity gives everything weight
- On the surface of the Earth everything accelerates towards the ground at 10 $m/s^2$

### Y9 P2.1.1: Resultant Forces

- Resultant force is the overall force on a point or an object
- If a resultant force acts on an object it will change its velocity

### Y9 P2.1.2: Forces and Motion

#### Newton's Laws of Motion

1. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.
    a. If the resultant force on a stationary object is zero the object will remain stationary
    b. Is there is no resultant force on the moving object it will just carry on moving at the same velocity
    c. If there is a non-zero resultant force then the object will accelerate in the direction of the force
2. The relationship between an object's mass m, its acceleration a, and the applied force F is F = ma.
3. For every action there is an equal and opposite reaction.



### Y9 P2.1.3: Terminal Velocity

- Friction always acts in the opposite direction to movement
- Friction increases with speed
- This means that at a certain speed (terminal velocity) the friction force will be equal to the driving force
- The terminal velocity can be increased by an increased driving force or decreased by an increased surface area for friction.

### Y10 P2.1.3: Forces and Braking

### Y10 P2.1.5: Forces and Elasticity

### Y10 P2.2.1: Forces and Energy

### Y10 P2.2.2: Momentum

### Y10 P2.3.1: Static Electricity

### Y10 & Y11 P2.3.2: Electric Circuits

- A coulomb is a measure of charge or electrons.
- An amp is the number of coulombs per second
- Voltage is the amount of energy per coulomb
- So coulombs are the electrons.
- Current is the speed or number of electrons.
- Voltage is the amount of energy each electron has.

- In a series circuit all the components are connected in a line, end to end
- If you remove or disconnect one component the whole circuit is broken
- They are not used much in practice
- The total voltage is shared between the different components because the electrons lose different amounts of energy at each component
- The current is the same everywhere because all the electrons travelling have to flow through them all

- In a parallel circuit each component is separately connected to the supply
- If you remove one it does not affect the  others
- The voltage is the same across all components because all of the electrons have the same energy
- The current is shared with the overall current increasing if a new component is added so the power at each component is satisfactory

## Y11 P2.4.1: Household electricity

## Y11 P2.4.2: Current, charge and power

## Y10 P2.5.1&2: Atomic Structure and Radiation

### Plum Pudding Model



- Originally it was believed that an atom was made up of a sphere of positive material with tiny negative charges stuck in them like plums in a plum pudding
- This was proved false when Rutherford and Marsden fired a beam of alpha particles at thin gold foil and observed that:
    - The alpha particles  mainly went straight through apart from a few that came back the opposite direction
    - This is not what they expected they thought that the alpha particles would be slightly affected but not turned around

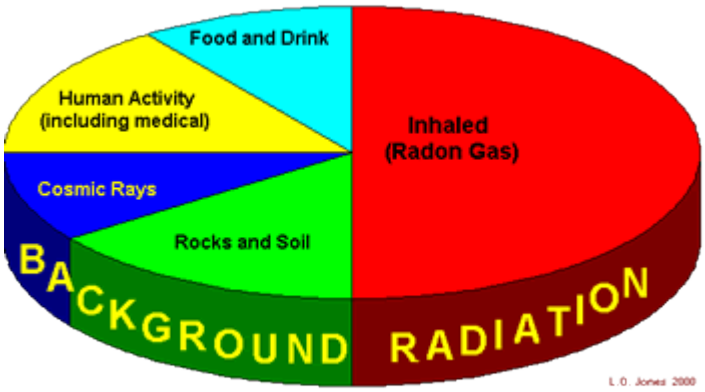
### Atomic Model

- This led them to believe that all the positive mass of the atom must be concentrated in a small nucleus
    - This was because the majority of the alpha particles missed the nucleus and the ones that did not were repelled straight back
- They also concluded that the atom must be mainly empty space as the alpha particles went through them

### Radioactive decay

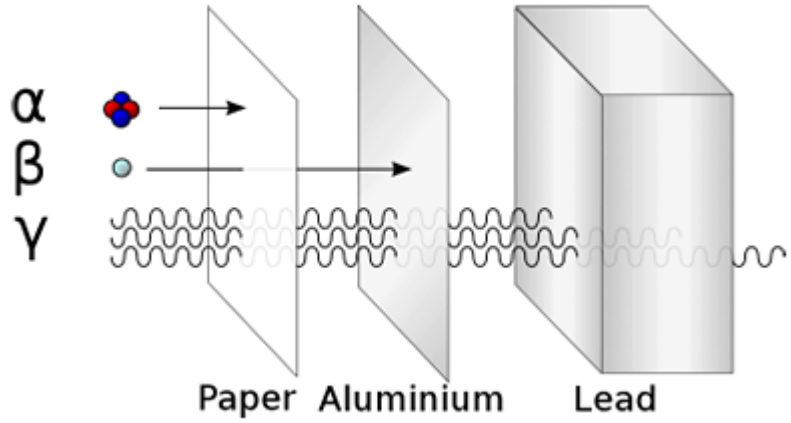
- Radioactive decay is random process in which an unstable isotope emits radition and changes
    - A neutron turns into a proton and a beta particle

    - A nucleus emits a alpha particle and produces a nucleus with two fewer protons and neutrons as before
- We are bombarded with radiation from different background sources every day




- There are three main types of ionising radiation:
    - Alpha Particles
        - These are the nucleus of helium atoms
        - They have a large mass and positive charge
        - They are highly ionising but not very penetrative
    - Beta Particles
        - These are highly charged electrons
        - They have a small mass and negative charge
        - They are quite ionising and reasonably penetrate
    - Gamma Rays
        - These are very short wavelength electromagnetic waves
        - They have no mass or charge
        - They are weakly ionising and highly penetrative






## Nuclear equations

## Uses of radiation

- Smoke detectors use alpha radiation
- The source causes ionisation and a current flows between two electrodes
- If there is a fire the smoke will absorb the radiation

    - So the current will stop and the alarm will sound

- Beta and gamma emitters with a short half-life are used as medical tracers
- These can show the circulatory or respiratory system and where the reading is strongest
    - Iodine-131 is absorbed by the thyroid gland like iodine-127 and gives out radiation
        - This can be used to check if the thyroid gland is working correctly

- Radiotherapy uses high doses of gamma rays to kill cancer cells
- The gamma rays are directed from multiple directions so they are only strong enough to kill cells at the area they are directed at
- However, still causes damage to healthy cells making patient feel ill

- Sterilisation of food or medical equipment using a high dose of gamma rays to kill the microbes

## Half-Life

- The average time it takes for the number of nuclei in a radioactive isotope to halve
- In the calculations repeatedly divide by 2



## Radiation Safety

- Collisions between radiation and molecules causes ionisation
- If this occurs inside the body it can damage DNA and kill cells
- Cells with damaged DNA can become cancerous

- Alpha radiation is not very dangerous outside the body as it cannot penetrate our skin
- However, inside the body it is very dangerous as it is highly ionising

- Aircraft pilots get more radiation as they have a higher exposure to cosmic rays
- Granite rocks release radiation and radon gas which can get trapped in peoples houses
- Radiographers have a higher risk of exposure so were lead aprons and stand behind lead screens
- Nuclear industry workers typically get 10 times more radiation than most people

### *Safety Precautions*

- Keep exposure time as short as possible
- Do not allow skin contact with source
- Hold source at arm's length
- Point source away from body and do not look at it
- Store in lead box when not in use

## Y11 P2.6.1 & 2: Nuclear fission and fusion

- Nuclear power stations generate energy from fission
- They utilise a controlled chain reaction of usually uranium-235 to heat water into steam to power a turbine

### Fission

- For nuclear fission a slow neutron is absorbed into a uranium nucleus
- This makes the nucleus unstable so it splits into two daughter nucleus and releases high energy neutrons
- The two daughter nuclei are usually radioactive as they have a strange isotope
- The neutrons released by fission have to be slowed down in order to be absorbed into a nucleus
- This is what the coolant is for it absorbs the energy of the neutrons heating it up to provide power and slowing them down so they are slow enough to cause fission
- This causes a chain reaction which is controlled by lowering in control rods which absorb the neutrons and stop the reaction



### Fusion

- Two light nuclei joining together into a larger nucleus and releasing energy
- This is what powers the stars
- It requires huge heat and pressure

## Y9 P2.6.2: Life Cycle of Stars

- Stars initially form from nebulas
- Gravity causes the dust and gas to spiral together to form a protostar
- When the temperature and pressure gets high enough it starts fusing hydrogen and becomes a main sequence star
- It enters a stable period where the nuclear pressure balances the force of gravity
- When it runs out of hydrogen it starts creating heavier elements such as iron from the fusion of helium
- This causes the star to swell into a Red Giant as it tries to find more fuel
    - It turns red as the surface is cooling
- If it is a small star like the sun then it will shrink again into a white dwarf ejecting its outer layer to form a plantar nebula
- If it is a big star them it will become a Red Super Giant  and continuously expand and contract fusing elements right up to iron
- Eventually, it will explode in a supernova which can fuse elements heavier than iron

- What is left behind after the supernova either shrinks to become a neutron star or collapses in on its self, forming a black hole

# P3

## Y10 P3.1.1: X-Rays

- X-rays are **transmitted** by healthy tissue but **absorbed** by dense materials like bone or metal
- They affect photographic film in the same way as light
- They create a negative image as the plate starts off white and the bits exposed to x-rays turn black
- They can also be formed electronically by CCD sensors the same as they use in cameras

- CT scans use x-rays to produce images of both hard and soft tissue
- The patient is put in a cylindrical scanner and the x-ray source and detector rotate around their body
- They can use these scans to produce a 3D-image of the inside of the body
- It can detect changes in tissue as it does absorb small amounts of radiation



- X-rays can also be used to treat cancer by pointing a weak beam at the tumour and then rotating the x-ray around the body still pointing at the tumor

## Y10 P3.1.2: Ultrasound

- Ultrasound is sound with a high frequency than we can hear (20, 000 Hz)
- When it passes from one medium to another some of the sound is reflected back and some is refracted
- You can tell how far away something is from the time between the pulse and the reflection
- This can be used for pre-natal scanning of a fetus where ultrasound is is passed into the fetus and reflected back at boundaries
- This is good because it has no danger to the patient and produces a video

- Ultrasound can also be concentrated and used for breaking up kidney stones by vibrating them until they turn into sand
- This means the patient does not require surgery

## Y10 P3.1.3&4: Lenses and the Eye

- Refraction occurs when waves change speed usually at a change in medium
- As waves slow down they bend towards the normal
    - When light enters plastic or glass it slows down
    - So it will bend towards the normal

- If a wave enters a medium and then exits again it will be parallel to the original wave
- The angle of incidence is the angle at wave approaches the change in media at
- The angle of refraction is the angle of the wave after refraction

- Every transparent material has a refractive index
- This is equal to the sin of the angle of incidence(i) over the sine of the angle of refraction (r)
    - Refractive index = sin i/sin r
- Convex lenses bring the light to focus and are used for magnifying glasses
- Knowledge of the eye – ciliary muscles change the shape of the lens allowing focus at varying distances
- Long sightedness is caused by eyeball being too short and vice versa
- Near point of focus is approximately 25cm
- The film in a camera or CCDs is the equivalent of the retina in the eye
- Power of lens given in **dioptres** and is 1/focal point
    - Power of a converging lens is positive and diverging negative
- Focal length is determined by the refractive index and the curvature of the lens
    - For any given focal length the greater the refractive index the flatter the lens
        - Allows thin lens to be manufactured
- When the angle of incidence is bigger than the critical angle the light total internal reflection will occur
- Can be used by endoscopes to image the inside of the body allowing keyhole surgery



## Y11 P3.2.1 & 3: Centre of Mass and Hydraulics

- The centre of mass is the point at which the mass of the object may thought to be concentrated
- If freely suspended an object will come to rest with its centre of mass directly below the point of suspension
- All liquids are virtually incompressible and the pressure in a liquid is transmitted equally in all directions so a force exerted on one point on liquid is transmitted to all other points
- Hydraulic systems act as force multipliers by using different cross-sectional areas on the effort and load side

## Y10 P3.2.2: Moments

- A moment is the turning force around a pivot
- They are the distance multiplied by force
- If a object is stationary is has a net moment of 0
- Measured in Nm

## Y9 P3.2.4: Circular Motion

- When an object is moving circularly it is constantly accelerating as its velocity is constantly changing
- Objects are held in circular motion by centripetal forces
- These are forces that keep the object moving circularly and not firing off
- Centripetal force can be many things including gravity and tension
- It depends on mass, speed and radius
- The faster an object moves the bigger the centripetal force has to be
- The larger mass of an object the bigger the centripetal force has to be
- The smaller the radius the larger the centripetal force there has to be

## Y10 P3.3.1: The Motor Effect

- A current in a magnetic field experiences a force
- The direction of the force, current and field can be determined using Flemings left hand rule

- This can be used to create a simple electrical motor
- If you pass a current through a coil in a magnetic field it rotates
- You use a commutator to swap the contacts every half turn to keep the motor rotating the same direction



An electric motor is a coil of wire suspended in between two permanent magnets of opposite polarisation. A turning force is produced when a current is passed through the coil of wire perpendicular to the magnetic field which produces an upwards force on one side and a downwards force on the other. This causes the coil of wire to turn but after half a turn the forces will stay in the same direction so the coil will eventually come to a stop vertically between the magnets after fluctuating either side. In order to counteract this a commutator is used which consists of a split contact of +/- on the end of the power supply and brushing contacts that rest on this from the coil of wire. After half a turn the direction of current also switches due to the commutator meaning that the forces switch direction leading to a continual rotational force being applied to the coil in the same direction. In order to increase this force you to increase the current/voltage in the coil, increase the number of turns on the coil, increase the area of the coil or increase the strength of the permanent magnetic field. Include a diagram to further explain the layout of the electric motor and how the commutator works.

## Y11 P3.3.2: AC generators & Transformers

- You can generate current in a wire by moving it through a magnetic field
- This is called electromagnetic induction
    - The creation of voltage across a conductor which is experiencing a change in the magnetic field
- In a generator they rotate a magnetic in a wire coil so that it generates electricity as the direction of voltage reverses every half turn it generates AC current

- Transformers change the voltage
- A step-down transformer generates a lower voltage in the secondary coil
- A step-up transformer generates a higher voltage in the secondary coil
- The primary and secondary coils are wrapped around a iron core
- The AC current applied to the primary coil generates a quickly changing magnetic field
- The iron core traps the magnetic field and forces it through the secondary coil
- This changing magnetic field induces a current in the secondary coil
- If there are less turns in the secondary coil the voltage is less because there is less charge in the wire
- If there are more turns in the secondary coil the voltage is greater as there is more charge in the wire
- The ratio between turns and voltage change is the same