Raedwald Trust KS4 Science Programme of Study   - Physics

The three pathways below increase in difficulty and content from left to right. Baseline assessments are given to each student within the first science lessons at a site and the appropriate pathway is selected. This Programme of Study lists the Physics element of Entry Level Science and the foundation and higher AQA GCSE Physics content for comparison. Please see the Raedwald Trust KS4 Chemistry and Biology Programmes of Study for those parts of the full content. The full AQA Physics GCSE content taught at The Raedwald Trust, is listed below.

Working Scientifically

All of the below skills are taught throughout this Programme of Study, within the separate units. The lists below are for reference only and should only be taught explicitly if a significant difficulty with certain aspects are identified, to help a student to close any gaps in learning.

AQA Entry Level Certificate Science	Foundation AQA Physics GCSE	Higher AQA Physics GCSE – Extra content on top of Foundation content
AO1: Show knowledge and understanding of science, and how it works, and apply it where appropriate. Students should be able to: • recall scientific facts • apply scientific ideas. AO2: Demonstrate the ability to design an investigation, take measurements, present data and identify patterns and relationships. Students should be able to: • plan a simple investigation, identifying the techniques or equipment needed and the method to be followed • make a simple prediction about the outcome of the investigation • use equipment and materials safely to take simple measurements or observations that are meaningful and valid • record the results in an appropriate way • display the data using an appropriate method	**1 Development of Scientific Thinking** WS 1.3 Appreciate the power and limitations of science and consider any ethical issues which may arise. WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. WS 1.5 Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences. WS 1.6 Recognise the importance of peer review of results and of communicating results to a range of audiences. **2 Experimental Skills and Strategies** WS 2.1 Use scientific theories and explanations to develop hypotheses. WS 2.2 Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena. WS 2.3 Apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment. WS 2.4 Carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations. WS 2.5 Recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative. WS 2.6 Make and record observations and measurements using a range of apparatus and methods. WS 2.7 Evaluate methods and suggest possible improvements and further investigations.	All aspects of working scientifically are in both the Foundation and Higher Assessments.

• state what has been found out during the investigation (drawing a conclusion) and describe simple relationships in the data • simply evaluate the investigation for its success in justifying the initial prediction.	**3 Analysis and Evaluation** WS 3.1 Presenting observations and other data using appropriate methods. WS 3.2 Translating data from one form to another. WS 3.3 Carrying out and represent mathematical and statistical analysis. WS 3.4 Representing distributions of results and make estimations of uncertainty. WS 3.5 Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions. WS 3.6 Presenting reasoned explanations including relating data to hypotheses. WS 3.7 Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error. WS 3.8 Communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms. **4 Scientific Vocabulary, quantities, units, symbols and nomenclature.** WS 4.1 Use scientific vocabulary, terminology and definitions. WS 4.2 Recognise the importance of scientific quantities and understand how they are determined. WS 4.3 Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate. WS 4.4 Use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano). WS 4.5 Interconvert units. WS 4.6 Use an appropriate number of significant figures in calculation.	

Energy (NC Energy)

AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Physics GCSE - Extra content on top of Foundation content
3.5 Component 5: *Energy, Forces and the Structure of Matter* 3.5.1 Energy, Energy Transfers and Energy Resources Outcome 1 * Describe, for common situations, the changes involved in the way energy is stored when a system changes. For example: • an object projected upwards • a moving object hitting an obstacle • a vehicle slowing down • bringing water to a boil in an electric kettle. * Students may be required to describe the intended energy changes and the main energy wastages that occur in a range of devices. Outcome 2 * Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed. * The idea of efficiency. Whenever there are energy transfers in a system only part of the energy is usefully transferred. The rest of the energy is dissipated so that it is stored in less useful ways. This energy is often described as being 'wasted'. * Unwanted energy transfers can be reduced in a number of ways, eg through lubrication and the use of thermal insulation.	**4.1 Energy** **4.1.1 Energy changes in a system, and the ways energy is stored before and after such changes** 4.1.1.1 Energy stores and systems • A system is an object or group of objects. • There are changes in the way energy is stored when a system changes. • Students should be able to describe all the changes involved in the way energy is stored when a system changes, for common situations. • Throughout this section on Energy students should be able to calculate the changes in energy involved when a system is changed by: • heating • work done by forces • work done when a current flows • Use calculations to show on a common scale how the overall energy in a system is redistributed when the system is changed. 4.1.1.2 Changes in energy • Students should be able to calculate the amount of energy associated with a moving object, a stretched spring and an object raised above ground level. • The kinetic energy of a moving object can be calculated using the equation: *kinetic energy = 0.5 × mass × (speed)^2* $[E_k = 1/2\ m\ v^2]$ • The amount of elastic potential energy stored in a stretched spring can be calculated using the equation: *elastic potential energy = 0.5 × spring constant × (extension)^2* $[E_e = 1/2\ k\ e^2]$ • The amount of gravitational potential energy gained by an	

* How the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls.
* The higher the thermal conductivity of a materia,l the higher the rate of energy transfer, by conduction across the material.
*Suggested TDA Activity, eg,
    Rate of Cooling/ Thermal
    Conductivity

object raised above ground level can be calculated using the equation:
gpe . = mass × gravitational field strength × height [Ep = mgh]

4.1.1.3 Energy changes in systems
* The amount of energy stored in or released from a system as its temperature changes can be calculated using the equation:
change in thermal energy = mass $\times$ specific heat capacity $\times$ temperature change
$\Delta E = m c \Delta \theta$
change in thermal energy, ΔE, in joules, J, mass, *m*, in kilograms, kg, specific heat capacity, *c*, in joules per kilogram per degree Celsius,
J/kg°C, temperature change, $\Delta \vartheta$, in degrees Celsius, °C
* The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.
Required practical activity 1: investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.

4.1.1.4 Power
  • Power is defined as the rate at which energy is transferred or the rate at which work is done.
    power = energy trans f erred / time
    [P = E/t]
    power = work done / time
    [P = W/t]
    power, P, in watts, W
    energy transferred, E, in joules, J
    time, t, in seconds, s
    work done, W, in joules, J
* An energy transfer of 1 joule per second is equal to a power of 1 watt.
* Students should be able to give examples that illustrate the definition of power eg comparing two electric motors that both lift the same weight through the same height but one does it

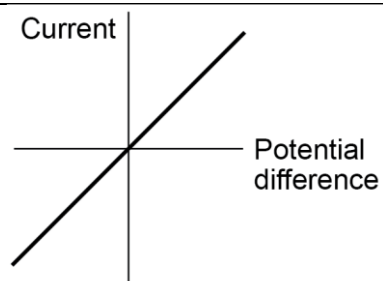|		
Outcome 2: • Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed. • The idea of efficiency. Whenever there are energy transfers in a system only part of the energy is usefully transferred. The rest of the energy is dissipated so that it is stored in less useful ways. This energy is often described as being 'wasted'. • Unwanted energy transfers can be reduced in a number of ways, eg through lubrication and the use of thermal insulation. • How the rate of cooling of a building is affected by the thickness and thermal	faster than the other. **4.1.2 Conservation and dissipation of Energy** 4.1.2.1 Energy transfers in a system *Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed. *Students should be able to describe with examples where there are energy transfers in a closed system, that there is no net change to the total energy. *Students should be able to describe, with examples, how in all system changes energy is dissipated, so that it is stored in less useful ways. This energy is often described as being 'wasted'. *Students should be able to explain ways of reducing unwanted energy transfers, for example through lubrication and the use of thermal insulation. *Students should be able to explain ways of reducing unwanted energy transfers, for example through lubrication and the use of thermal insulation. *The higher the thermal conductivity of a material, the higher the rate, of energy transfer by conduction across the material. *Students should be able to describe how the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls. *Students do not need to know the definition of thermal conductivity. *Required practical activity 2 (physics only): investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material. 4.1.2.2 Efficiency *The energy efficiency for any energy transfer can be calculated using the equation: *efficiency = useful output energy transfer/* *total input energy transfer* Efficiency may also be calculated using the equation: *efficiency = useful power output/* *total power input*	*Students should be able to describe ways to increase the efficiency of an intended energy transfer.

conductivity of its walls. The higher the thermal conductivity of a material the higher the rate of energy transfer by conduction across the material.

Outcome 3:
- Describe the main energy resources available for use on Earth. These include fossil fuels (coal, oil and gas), nuclear fuel, bio-fuel, wind, hydro-electricity, geothermal, the tides, the Sun, water waves.
- Distinguish between energy resources that are renewable and energy resources that are non-renewable.

4.1.3 National and Global Energy Resources

*The main energy resources available for use on Earth include: fossil fuels (coal, oil and gas), nuclear fuel, bio-fuel, wind, hydroelectricity, geothermal, the tides, Sun and water waves.

*A renewable energy resource is one that is being (or can be) replenished as it is used.

*The uses of energy resources include: transport, electricity generation and heating.

*Students should be able to:
  • describe the main energy sources available
  • distinguish between energy resources that are renewable
    And energy resources that are non-renewable
  • compare ways that different energy resources are used, the
    uses to include transport, electricity generation and heating
  • understand why some energy resources are more reliable
    than others
  *describe the environmental impact arising from the use of
    different energy resources
  *explain patterns and trends in the use of energy resources

*Descriptions of how energy resources are used to generate electricity are **not** required.

*Students should be able to:
  *consider the environmental issues that may arise from the
    Use of different energy resources
  *show that science has the ability to identify environmental
    issues arising from the use of energy resources but not
    always the power to deal with the issues because of political,
    social, ethical or economic considerations.

Electricity (NC Electricity)

| AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Biology GCSE

3.6 Component 6; Electricity, Magnetism and Waves

3.6.1 Electrical Current

Outcome 1

* Electric current is a flow of electrical charge. The size of the electric current is the rate of flow of electrical charge.
* The current through a component depends on both the resistance of the component and the voltage across the component. The greater the resistance of the component the smaller the current for a given voltage across the component.
* The resistance of a component is a measure of how difficult it is for an electric current to pass through it.

Suggested TDA Activity: Investigate which materials are the best Electrical conductors.

Outcome 2

* A complete circuit is necessary for a current to flow.
* Cells and batteries supply current that always passes in the same direction. This is called direct current (d.c.).
* An alternating current (a.c.) is one that changes direction.
Mains electricity is an a.c. supply. In the UK it has a frequency of 50 Hz and is 230 V.

4.2 Electricity

4.2.1 Current, Potential Difference and Resistance

4.2.1.1 Standard circuit diagram symbols

*Circuit diagrams use standard symbols
*Students should be able to draw and interpret circuit diagrams

4.2.1.2 Electrical charge and current

*For electrical charge to flow through a closed circuit the circuit must include a source of potential difference.
*Electric current is a flow of electrical charge. The size of the electric current is the rate of flow of electrical charge. Charge flow, current and time are linked by the equation:

charge f low = current × time

$[Q = I\,t]$

charge flow, Q, in coulombs, C
current, I, in amperes, A (amp is acceptable for ampere)
time, t, in seconds, s
A current has the same value at any point in a single closed loop.

4.2.1.3 Current, Resistance and Potential Difference

*The current (I) through a component depends on both the resistance (R) of the component and the potential difference (V) across the component. The greater the resistance of the component the smaller the current for a given potential difference (pd) across the component.
*Questions will be set using the term potential difference. Students will gain credit for the correct use of either potential difference or voltage.
*Current, potential difference or resistance can be calculated using the equation:

potential difference = current $\times$ resistance

$[V = I\,R]$

potential difference, *V*, in volts, V
current, *I*, in amperes, A (amp is acceptable for ampere)
resistance, *R*, in ohms, Ω

4.2.1.4 Resistors

*Students should be able to explain that, for some resistors, the value of R remains constant but that in others it can change as the current changes.
*The current through an ohmic conductor (at a constant temperature) is directly proportional to the potential difference across the resistor. This means that the resistance remains constant as the current changes.
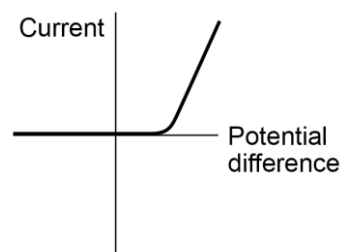
*The resistance of components such as lamps, diodes, thermistors and LDRs is not constant; it changes with the current through the component.
*The resistance of a filament lamp increases as the temperature of the filament increases.
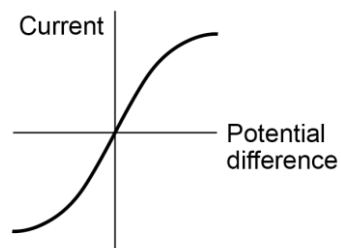
*The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction.

*The resistance of a thermistor decreases as the temperature increases.
*The applications of thermistors in circuits eg a thermostat is required.
*The resistance of an LDR decreases as light intensity increases.

*The application of LDRs in circuits eg switching lights on when it gets dark is required.
*Students should be able to:
  *explain the design and use of a circuit to measure the
   Resistance of a component by measuring the current
   through and potential difference across, the component.
  *draw an appropriate circuit diagram using correct circuit
   Symbols.
*Students should be able to use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties.

4.2.2 Series and Parallel Circuits
*There are two ways of joining electrical components, in series and in parallel. Some circuits include both series and parallel parts.
*For components connected in series:
  *there is the same current through each component
  *the total potential difference of the power supply is shared
   between the components
  * the total resistance of two components is the sum of the
   resistance of each component
Rtotal = R1 + R2
resistance, *R*, in ohms, Ω

*For components connected in parallel:
  *the potential difference across each component is the same
  *the total current through the whole circuit is the sum of the
   Currents through the separate components
  *the total resistance of two resistors is less than the
   Resistance of the smallest individual resistor.
*Students should be able to:
  *use circuit diagrams to construct and check series and
   parallel circuits that include a variety of common circuit
   components
  *describe the difference between series and parallel circuits
  * explain qualitatively why adding resistors in series increases
   the total resistance whilst adding resistors in parallel
   decreases the total resistance
  *explain the design and use of dc series circuits for
   measurement and testing purposes
   calculate the currents, potential differences and resistances

in dc series circuits
*solve problems for circuits which include resistors in series
Using the concept of equivalent resistance.
*Students are **not** required to calculate the total resistance of
two resistors joined in parallel.

4.2.3 Domestic uses and safety
4.2.3.1 Direct and Alternating Potential Difference
*Mains electricity is an ac supply. In the United Kingdom the
domestic electricity supply has a frequency of 50 Hz and is about
230 V.
*Students should be able to explain the difference between direct and alternating
potential difference.

4.2.3.2 Mains Electricity
*Most electrical appliances are connected to the mains using three-core cable.
*The insulation covering each wire is colour coded for easy
identification:
live wire – brown
neutral wire – blue
earth wire – green and yellow stripes.

3.6.2 Domestic Electricity
Outcome 3
* Most electrical appliances are
connected to the mains using a three-core
flex.
* The insulation covering each wire in the
flex is colour-coded for easy
identification:
• live wire – brown
• neutral wire – blue
• earth wire –green and yellow stripes.
* The earth wire is a safety wire to stop
the appliance becoming live and the fuse
contains a thin piece of wire, which melts
if the current becomes too large, thereby
cutting off the supply.
* Students should be able to select the
correct fuse from a list when given the
current rating of an appliance.
* Students should be able to select the
correct fuse from a list when given the
current rating of an appliance.

Outcome 4

*The live wire carries the alternating potential difference from the supply. The
neutral wire completes the circuit. The earth wire is a safety wire to stop the
appliance becoming live.
*The potential difference between the live wire and earth (0 V) is about 230 V. The
neutral wire is at, or close to, earth potential (0 V).
The earth wire is at 0 V, it only carries a current if there is a fault.
*Students should be able to explain:
*That a live wire may be dangerous even when a switch in
The mains circuit is open
*The dangers of providing any connection between the live
wire and earth.

4.2.4 Energy Transfers
4.2.4.1 Power
*Students should be able to explain how the power transfer in any circuit device is
related to the potential difference across it and the current through it, and to the
energy changes over time:

* Everyday electrical appliances are designed to bring about energy transfers.
* The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power of the appliance.
	power = potential difference × current
	$[P = V\,I]$
	power = (current)^2 × resistance
	$[P = I^2\,R]$
	power, P, in watts, W
	potential difference, V, in volts, V
	current, I, in amperes, A (amp is acceptable for ampere)
	resistance, R, in ohms, Ω
	
	4.2.4.2 Energy Transfers in Everyday Appliances
	*Everyday electrical appliances are designed to bring about energy transfers.
	*The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power of the appliance.
	*The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power of the appliance.
	*Work is done when charge flows in a circuit.
	*The amount of energy transferred by electrical work can be calculated using the equation:
	
	energy transferred = power × time
	$[E = P\,t]$
	energy transferred = charge flow × potential difference
	$[E = Q\,V]$
	energy transferred, E, in joules, J
	power, P, in watts, W
	time, t, in seconds, s
	charge flow, Q, in coulombs, C
	potential difference, V, in volts, V
	*Students should be able to explain how the power of a circuit device is related to:
	    *the potential difference across it and the current flow
	     Through it
	     The energy transferred over a given time
	*Students should be able to describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use.
	
	4.2.4.3 The National Grid
	*The National Grid is a system of cables and transformers linking power stations to consumers.	

*Electrical power is transferred from power stations to consumers using the National Grid.

*Step-up transformers are used to increase the potential difference from the power station to the transmission cables then step-down transformers are used to decrease, to a much lower value, the potential difference for domestic use.

*Students should be able to explain why the National Grid system is an efficient way to transfer energy.

4.2.5 Static Electricity

4.2.5.1 Static Charge

*When certain insulating materials are rubbed against each other they become electrically charged. Negatively charged electrons are rubbed off one material and on to the other. The material that gains electrons becomes negatively charged. The material that loses electrons is left with an equal positive charge.

*When two electrically charged objects are brought close together they exert a force on each other. Two objects that carry the same type of charge repel. Two objects that carry different types of charge attract. Attraction and repulsion between two charged objects are examples of non-contact force.

*Students should be able to:

   *describe the production of static electricity, and sparking, by
    rubbing surfaces
   *describe evidence that charged objects exert forces of
    Attraction or repulsion on one another when not in contact
   *explain how the transfer of electrons between objects can
    explain the phenomena of static electricity.

4.2.5.2 Electric Fields

*A charged object creates an electric field around itself. The electric field is strongest close to the charged object. The further away from the charged object, the weaker the field.

*A second charged object placed in the field experiences a force. The force gets stronger as the distance between the objects decreases.

*Students should be able to:

   *draw the electric field pattern for an isolated charged
    Sphere
  *explain the concept of an electric field
  *explain how the concept of an electric field helps to explain
   The non-contact force between charged objects as well as
   Other electrostatic phenomena such as sparking

Particle Model of Matter (NC Particle Model of Matter)

AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Biology GCSE

3.5.4 Atoms and nuclear radiation
 	
Outcome 10
• Some atomic nuclei are unstable. The nucleus gives out ionising radiation. This is a random process called radioactive decay.The nuclear radiation emitted may be:
- alpha particles
- beta particles
- gamma rays.
• Properties of alpha particles, beta particles and gamma rays limited to their penetration through materials and their range in air.
• Students will be expected to know some of the uses and dangers of the three types of radiation.
	4.3 Particle Model of Matter
	4.3.1 Changes of State and the Particle Model
	4.3.1.1 Density of Materials
	*The density of a material is defined by the equation:
	Density mass/volume
	[p=m/v]
	density, ρ, in kilograms per metre cubed, kg/m3
	mass, m, in kilograms, kg
	volume, V, in metres cubed, m3
	*The particle model can be used to explain
	  *the different states of matter
	  *differences in density
	*Students should be able to recognise/draw simple diagrams to model the difference between solids, liquids and gases.
	*Students should be able to explain the differences in density between the different states of matter in terms of the arrangement of atoms or molecules.
	
	4.3.1.2 Changes of State
	*Students should be able to describe how, when substances change state (melt, freeze, boil, evaporate, condense or sublimate), mass is conserved.
	*Changes of state are physical changes which differ from chemical changes because the material recovers its original properties if the change is reversed.
	
	4.3.2 Internal Energy and Energy Transfers	

4.3.2.1 Internal Energy
*Energy is stored inside a system by the particles (atoms and
molecules) that make up the system. This is called internal energy.
*Internal energy is the total kinetic energy and potential energy of all the particles
(atoms and molecules) that make up a system.
*Heating changes the energy stored within the system by increasing the energy of the
particles that make up the system. This either raises the temperature of the system or
produces a change of state.

4.3.2.2 Temperature Changes in a System and Specific Heat
Capacity
*If the temperature of the system increases, the increase in
temperature depends on the mass of the substance heated, the
type of material and the energy input to the system.
*The following equation applies:
*change in thermal energy = mass × specific heat capacity
× temperature change*
$\Delta E = m c \Delta \theta$
change in thermal energy, ΔE, in joules, J
mass, m, in kilograms, kg
specific heat capacity, c, in joules per kilogram per degree Celsius,
J/kg °C
temperature change, $\Delta\theta$, in degrees Celsius, °C.
The specific heat capacity of a substance is the amount of energy required to raise the
temperature of one kilogram of the substance by one degree Celsius.

4.3.2.3 Changes of State and Specific Latent Heat
*If a change of state happens:
*The energy needed for a substance to change state is called latent heat. When a
change of state occurs, the energy supplied changes the energy stored (internal
energy) but not the temperature.
*The specific latent heat of a substance is the amount of energy
required to change the state of one kilogram of the substance with no change in
temperature.
energy f or a change of state = mass × specific latent heat
[E = m L]
energy, E, in joules, J
mass, m, in kilograms, kg
specific latent heat, L, in joules per kilogram, J/kg
Specific latent heat of fusion – change of state from solid to liquid
Specific latent heat of vaporisation – change of state from liquid to vapour

*Students should be able to interpret heating and cooling graphs that include changes of state.
*Students should be able to distinguish between specific heat capacity and specific latent heat.

4.3.3 Particle Model and Pressure
4.3.3.1 Particle Motion in Gases
*The molecules of a gas are in constant random motion. The temperature of the gas is related to the average kinetic energy of the molecules.
*Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas.
*Students should be able to:
   *explain how the motion of the molecules in a gas is related
   To both its temperature and its pressure
   *explain qualitatively the relation between the temperature
   Of a gas and its pressure at constant volume

4.3.3.2 Pressure in Gases
*A gas can be compressed or expanded by pressure changes. The pressure produces a net force at right angles to the wall of the gas container (or any surface).

*Students should be able to use the particle model to explain how increasing the volume, in which a gas is contained, at constant temperature, can lead to a decrease in pressure.
*For a fixed mass of gas held at a constant temperature:
pressure × volume = constant
[p V = constant]
pressure, p, in pascals, Pa
volume, V, in metres cubed, m3
*Students should be able to calculate the change in the pressure of a gas or the volume of a gas (a fixed mass held at constant temperature) when either the pressure or volume is increased or decreased.

4.3.3.3 Increasing the Pressure of a Gas
*Work is the transfer of energy by a force.
*Doing work on a gas increases the internal energy of the gas and can cause an increase in the temperature of the gas.
*Students should be able to explain how, in a given situation eg a bicycle pump, doing work on an enclosed gas leads to an increase in the temperature of the gas.

Atomic Structure (NC Atomic Structure)

AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Biology GCSE
	4.4 Atomic Structure **4.4.1 Atoms and Isotopes** **4.4.1.1 The Structure of and Atom** *Atoms are very small, having a radius of about 1×10^{-10} metres. *The basic structure of an atom is a positively charged nucleus composed of both protons and neutrons surrounded by negatively charged electrons. *The radius of a nucleus is less than 1/10 000 of the radius of an atom. Most of the mass of an atom is concentrated in the nucleus. *The electrons are arranged at different distances from the nucleus (different energy levels). The electron arrangements may change with the absorption of electromagnetic radiation (move further from the nucleus; a higher energy level) or by the emission of electromagnetic radiation (move closer to the nucleus; a lower energy level). 4.4.1.2 Mass number, Atomic number and Isotopes *In an atom the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge. *All atoms of a particular element have the same number of protons. The number of protons in an atom of an element is called its atomic number. *The total number of protons and neutrons in an atom is called its mass number. *Atoms can be represented as shown in this example: $$^{23}_{11}\text{Na}$$ (Mass number) 23 (Atomic number) 11 *Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.	

*Atoms turn into positive ions if they lose one or more outer electron(s).
*Students should be able to relate differences between isotopes to differences in conventional representations of their identities, charges and masses.

4.4.1.3 The development of the model of the Atom
*Students should be able to describe:
   *Why the new evidence from the scattering experiment led
    A change in the atomic model
   *The difference between the plum pudding model of the
    Atom and the nuclear model of the atom

4.4.2Atoms and Nuclear Radiation
4.4.2.1 Radioactive decay and Nuclear Radiation
*Some atomic nuclei are unstable. The nucleus gives out radiation as it changes to become more stable. This is a random process called radioactive decay.
* Activity is the rate at which a source of unstable nuclei decays.
*Activity is measured in becquerel (Bq)
* Count-rate is the number of decays recorded each second by a detector (eg Geiger-Muller tube).
*The nuclear radiation emitted may be:
   *An alpha particle (α) – this consists of two neutrons and two
    Protons, it is the same as a helium nucleus
   *a beta particle (β)– a high speed electron ejected from the
    Nucleus as a neutron turns into a proton
   *a gamma ray (γ)– electromagnetic radiation from the nucleus
   *A neutron (n)
*Required knowledge of the properties of alpha particles, beta particles and gamma rays is limited to their penetration through materials, their range in air and ionising power.
*Students should be able to apply their knowledge to the uses of radiation and evaluate the best sources of radiation to use in a given situation.

4.4.2.2 Nuclear Equations
*Nuclear equations are used to represent radioactive decay.
*In a nuclear equation an alpha particle may be represented by the symbol:

$$^{4}_{2}\text{He}$$

And a beta particle by the symbol:

$$_{-1}^{0}\text{e}$$

*The emission of the different types of nuclear radiation may cause a change in the mass and /or the charge of the nucleus. For example:

$$_{86}^{219}\text{radon} \longrightarrow _{84}^{215}\text{polonium} + _{2}^{4}\text{He}$$

So alpha decay causes both the mass and charge of the nucleus to decrease.

$$_{6}^{14}\text{carbon} \longrightarrow _{7}^{14}\text{nitrogen} + _{-1}^{0}\text{e}$$

So beta decay does not cause the mass of the nucleus to change but does cause the charge of the nucleus to increase.

*Students are not required to recall these two examples.

*Students should be able to use the names and symbols of common nuclei and particles to write balanced equations that show single alpha (α) and beta (β) decay. This is limited to balancing the atomic numbers and mass numbers. The identification of daughter elements from such decay is not required.

*The emission of a gamma ray does not cause the mass or the charge of the nucleus to change.

4.4.2.3 Half-lives and the Random Nature of Radioactive Decay
*Students should be able to explain the concept of half-life and how it is related to the random nature of radioactive decay.
*Students should be able to determine the half-life of a radioactive isotope from given information.

4.4.2.4 Radioactive Contamination
*Students should be able to compare the hazards associated with contamination and irradiation.
*Suitable precautions must be taken to protect against any hazard that the radioactive source used in the process of irradiation may present.
*Students should understand that it is important for the findings of studies into the effects of radiation on humans to be published and shared with other scientists so that the findings can be checked by peer review.

4.4.3 Hazards and Uses of Radioactive Emissions and of background Radiation
4.4.3.1 Background Radiation
*Background radiation is around us all of the time. It comes from:

C5, Component 5
3.5.4 Atoms and Nuclear Radiation
Outcome 10
* Some atomic nuclei are unstable. The nucleus gives out ionising radiation. This is a random process called radioactive decay.
* The nuclear radiation emitted may be:
• alpha particles
• beta particles
• gamma rays.
* Properties of alpha particles, beta particles and gamma rays limited to their penetration through materials and their range in air.
* Students will be expected to know

*Students should be able to calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives

| some of the uses and dangers of the three types of radiation. | *Natural sources such as rocks and cosmic rays from space
*Man-made sources such as the fallout from nuclear weapons testing and nuclear
  Accidents
*The level of background radiation and radiation dose may be
affected by occupation and/or location.
*Radiation dose is measured in sieverts (Sv)
*1000 millisieverts (mSv) = 1 sievert (Sv)
*Students will not need to recall the unit of radiation dose.

4.4.3.2 Different half-lives of Radioactive Isotopes
*Radioactive isotopes have a very wide range of half-life values.
*Students should be able to explain why the hazards associated with
radioactive materials differ according to the half-life involved.
4.4.3.3 Uses of Nuclear Radiation
*Nuclear radiations are used in medicine for the:
  *Exploration of internal organs
  *Control or destruction of unwanted tissue
*Student should be able to:
  *describe and evaluate the uses of nuclear radiations for exploration of internal organs,
   And for control or destruction of unwanted tissue
  *Evaluate the perceived risks of using nuclear radiations in relation to given data and
   Consequences.

4.4.4 Nuclear Fission and Fusion
4.4.4.1 Nuclear Fission
*Nuclear fission is the splitting of a large and unstable nucleus (eg. uranium or plutonium).
*Spontaneous fission is rare. Usually, for fission to occur the unstable nucleus must first absorb a neutron.
*The nucleus undergoing fission splits into two smaller nuclei, roughly equal in size, and emits two or three neutrons plus gamma rays. Energy is released by the fission reaction.
*All of the fission products have kinetic energy.
*The neutrons may go on to start a chain reaction.
*The chain reaction is controlled in a nuclear reactor to control the energy released. The explosion caused by a nuclear weapon is caused by an uncontrolled chain reaction.
*Students should be able to draw/interpret diagrams representing nuclear fission and how a chain reaction may occur.
4.4.4.2 Nuclear fusion
*Nuclear fusion is the joining of two light nuclei to form a heavier nucleus. In this process some of the mass may be converted into the energy of radiation. | |

Forces (NC Forces)

AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Biology GCSE

3.5.2 Forces and Work
Outcome 4
* A force is a push or pull that acts on an object due to the interaction with another object.
All forces between objects are either:
   • contact forces – the objects are physically touching
   • non-contact forces – the objects are physically separated.
	4.5 Forces
	4.5.1 Forces and their interactions
	4.5.1.1 Scalar and vector quantities
	*Scalar quantities have magnitude only.
	*Vector quantities have magnitude and an associated direction.
	*A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the vector quantity.
	
	4.5.1.2 Contact and Non-Contact Forces
	*A force is a push or pull that acts on an object due to the interaction with another object. All forces between objects are either:
	   *Contact forces – the objects are physically touching
	   *Non-contact forces – the objects are physically separated
	*Examples of contact forces include friction, air resistance, tension and normal contact force.
	*Examples of non-contact forces are gravitational force, electrostatic force and magnetic force.
	*Force is a vector quantity.
	*Students should be able to describe the interaction between pairs of objects which produce a force on each object. The forces to be represented as vectors.
	
	4.5.1.3 Gravity	

*Weight is the force acting on an object due to gravity. The force of gravity close to the Earth is due to the gravitational field around the Earth.
*The weight of an object depends on the gravitational field strength at the point where the object is.
*The weight of an object can be calculated using the equation:
weight = mass × gravitational field strength
[W = m g]
weight, W, in newtons, N
mass, m, in kilograms, kg
gravitational field strength, g, in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength (g) will be given.)
*The weight of an object may be considered to act at a single point referred to as the object's 'centre of mass'.
*The weight of an object and the mass of an object are directly proportional.
*Weight is measured using a calibrated spring-balance (a newtonmeter).

4.5.1.4 Resultant Forces
*A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force.
*Students should be able to calculate the resultant of two forces that act in a straight line.

4.5.2 Work done and Energy Transfer
*When a force causes an object to move through a distance work is done on the object. So a force does work on an object when the force causes a displacement of the object.
*The work done by a force on an object can be calculated using the equation:
work done = force × distance
(moved along the line of action of the force)
[W = F s]
work done, W, in joules, J
force, F, in newtons, N
distance, s, in metres
*One joule of work is done when a force of one newton causes a displacement of one metre.
*1 joule = 1 newton-metre
*Students should be able to describe the energy transfer involved when work is done.
*Students should be able to convert between newton-metres and joules.

Outcome 5
* When a force causes an object to move through a distance, work is done on the

object.
* Work done against the frictional forces acting on an object causes a rise in the temperature of the object.
***Suggested TDA Activity**:
 Investigate how different surfaces affect the amount of friction on a moving block.

*Work done against the frictional forces acting on an object causes a rise in the temperature of the object.

4.5.3 Forces and Elasticity
*Students should be able to:
  *Give examples of the forces involved in stretching, bending or compressing an object
  *Explain why, to change the shape of an object (by stretching, bending or compressing)
    More than one force has to be applied – this is limited to stationary objects only
  *Describe the difference between elastic deformation and inelastic deformation
    Caused by stretching forces.
*The extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.
force = spring constant × extension
[F = k e]
force, F, in newtons, N
spring constant, k, in newtons per metre, N/m
extension, e, in metres, m
*This relationship also applies to the compression of an elastic object, where 'e' would be the compression of the object.
*A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. Provided the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal.
*Students should be able to:
  *Describe the difference between a linear and non-linear relationship between force
    And extension
  *Calculate a spring constant in linear cases
  *Interpret data from an investigation of the relationship between force and extension
  *Calculate work done in stretching (or compressing) a spring (up to the limit of Proportionality) using the equation:
   elastic potential energy = 0.5 × spring constant × extension ^{2}
   [$E_e = 1/2k\ e^{2}$]
*Students should be able to calculate relevant values of stored energy and energy transfers.
Required practical activity 6: investigate the relationship between force and extension for a spring.

4.5.4 Moments, Levers and Gears

*A force or a system of forces may cause an object to rotate.

*Students should be able to describe examples in which forces cause rotation.

*The turning effect of a force is called the moment of the force. The size of the moment is defined by the equation:

moment o f a force = force × distance

[M = Fd]

moment of a force, M, in newton-metres, Nm

force, F, in newtons, N

distance, d, is the perpendicular distance from the pivot to the line of action of the force, in metres, m.

If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot.

Students should be able to calculate the size of a force, or its distance from a pivot, acting on an object that is balanced.

A simple lever and a simple gear system can both be used to transmit the rotational effects of forces.

Students should be able to explain how levers and gears transmit the rotational effects of forces.

4.5.5 Pressure and Pressure Differences in Fluids

4.5.5.1 Pressure in a Fluid

4.5.5.1.1 Pressure in a Fluid 1

*A fluid can be either a liquid or a gas.

*The pressure in fluids causes a force normal (at right angles) to any surface.

*The pressure at the surface of a fluid can be calculated using the equation:

pressure = force normal to a surface/area of that surface

[p = F/A]

pressure, p, in pascals, Pa

force, F, in newtons, N

area, A, in metres squared, m2

4.5.5.2 Atmospheric Pressure

*The atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude.

*Air molecules colliding with a surface create atmospheric pressure.

The number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases. So as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure

4.5.5.1.2 Pressure in a Fluid 2

*The pressure due to a column of liquid can be

	decreases with an increase in height.
	*Students should be able to:
	  *Describe a simple model of the Earth's atmosphere and of atmospheric pressure
	  *Explain why atmospheric pressure varies with height above a surface
	
	4.5.6 Forces and Motion
	4.5.6.1 Describing Motion along a Line
	4.5.6.1.1 Distance and Displacement
	*Distance is how far an object moves. Distance does not involve direction. Distance is a scalar quantity.
	*Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line. Displacement is a vector quantity.
	*Students should be able to express a displacement in terms of both the magnitude and direction.
	
	4.5.6.1.2 Speed
	*Speed does not involve direction. Speed is a scalar quantity.
	*The speed of a moving object is rarely constant. When people walk, run or travel in a car their speed is constantly changing.
	*The speed at which a person can walk, run or cycle depends on many factors including: age, terrain, fitness and distance travelled.
	*Typical values may be taken as:
	walking- 1.5 m/s
	running- 3 m/s
	cycling- 6 m/s.
	*Students should be able to recall typical values of speed for a person walking, running and cycling as well as the typical values of speed for different types of transportation systems.
	*It is not only moving objects that have varying speed. The speed of sound and the speed of the wind also vary.
	*A typical value for the speed of sound in air is 330 m/s.
	*Students should be able to make measurements of distance and time and then calculate speeds of objects.
	*For an object moving at constant speed the distance travelled in a specific time can be calculated using the equation:
	*distance travelled = speed x time
	[s = vt]
	Distance, s, in metres, m
		calculated using the equation:
		pressure = height of the column × density of the liquid
		× gravitational field strength
		[p = h ρ g]
		pressure, p, in pascals, Pa
		height of the column, h, in metres, m
		density, ρ, in kilograms per metre cubed, kg/m3
		gravitational field strength, g, in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength (g) will be given.)
		*Students should be able to explain why, in a liquid, pressure at a point increases with the height of the column of liquid above that point and with the density of the liquid.
		*Students should be able to calculate the differences in pressure at different depths in a liquid.
		*A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards. This force is called the upthrust.
		*Students should be able to describe the factors which influence floating and sinking.

3.5.3 Speed and Stopping Distances	Speed v, in metres per second, m/s	

Outcome 6 * Speed is measured by the distance travelled in a certain time. * Units of speed include metres per second and kilometres per hour. * Simple calculations of average speed using the equation: speed= distance/time will be required.	Time, t, in seconds, s *Students should be able to calculate average speed for non-uniform motion. **4.5.6.1.3 Velocity** *The velocity of an object is its speed in a given direction. Velocity is a vector quantity. *Students should be able to explain the vector–scalar distinction as it applies to displacement, distance, velocity and speed. **4.5.6.1.4 The Distance – Time Relationship** *If an object moves along a straight line, the distance travelled can be represented by a distance–time graph. *The speed of an object can be calculated from the gradient of its distance–time graph. *Students should be able to draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form. *Students should be able to determine speed from a distance–time graph. **4.5.6.1.5 Acceleration** *The average acceleration of an object can be calculated using the equation: *Acceleration = change in velocity / time taken* $[a = \Delta v/t]$ acceleration, a, in metres per second squared, m/s^2 change in velocity, Δv, in metres per second, m/s time, t, in seconds, s *An object that slows down is decelerating. *Students should be able to estimate the magnitude of everyday accelerations. The acceleration of an object can be calculated from the gradient of a velocity–time graph. *Students should be able to: *Draw velocity – time graphs from measurements and interpret lines and slopes to Determine acceleration *The following equation applies to uniform acceleration: *(final velocity)² –(initial velocity)² = 2 x acceleration x distance* $[v^2 – u^2 = 2\,a\,s\,]$ final velocity, v, in metres per second, m/s initial velocity, u, in metres per second, m/s acceleration, a, in metres per second squared, m/s^2 distance, s, in metres, m	
Outcome 7 * The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance).		*Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity.

* For a given braking force the greater the speed of the vehicle, the greater the stopping distance.
 	
Outcome 8
* Reaction times vary from person to person. Typical values range from 0.2 s to 0.9 s.
* Knowledge and understanding of methods used to measure human reaction times.
* Knowledge of how a driver's reaction time can be affected by tiredness, drugs and alcohol. Distractions may also affect a driver's ability to react.
*Suggested TDA Activity
Investigate factors that affect human reaction time, eg tiredness, distraction, practise.
Outcome 9
* The braking distance of a vehicle can be affected by adverse road and weather conditions, and poor condition of the vehicle.
* Students should be able to analyse a given situation to identify how braking could be affected.
	*Near the Earth's surface any object falling freely under gravity has an acceleration of about 9.8 m/s².
	*An object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity.
	*Students should be able to:
	  *Draw and interpret velocity-time graphs for objects that reach terminal velocity
	  *Interpret the changing motion in terms of the forces acting
	
	 4.5.6.2 Forces, accelerations and Newton's Laws of motion
	4.5.6.2.1 Newton's First Law
	*If the resultant force actin on an object is zero and:
	  *The object is stationary, the object remains stationary
	  *The object is moving, the object continues to move at the same speed and in the same
	   Direction. So the object continues to move at the same velocity.
	*So, when a vehicle travels at a steady speed the resistive forces balance the driving force.
	*So, the velocity (speed and/or direction) of an object will only change if a resultant force is acting on the object.
	*Students should be able to apply Newton's First Law to explain the motion of objects moving with a uniform velocity and objects where the speed and/or direction changes.
	
	4.5.6.2.2 Newton's Second Law
	*The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.
	*As an equation:
	Resultant force = mass x acceleration
	F = m x a
	force, F, in newtons, N
	mass, m, in kilograms, kg
	acceleration, a, in metres per second squared, m/s2
	*Students should be able to estimate the speed, accelerations and forces involved in large accelerations for everyday road transport.
	*Students should recognise and be able to use the symbol that indicates an approximate value or approximate answer;·
	
	***Required practical activity 7**: investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an
		*If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.
		
		*The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph.
		*Students should be able to measure, when appropriate, the area under a velocity–time graph by counting squares.

	object on the acceleration produced by a constant force.
	
	4.5.6.2.3 Newton's Third Law
	*Whenever two objects interact, the forces they exert on each other are equal and opposite.
	*Students should be able to apply Newton's Third Law to examples of equilibrium situations.
	
	4.5.6.3 Forces and Braking
	4.5.6.3.1 Stopping distance
	*The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance). For a given braking force the greater the speed of the vehicle, the greater the stopping distance.
	*Students should be able to estimate how the distance for a vehicle to make an emergency stop varies over a range of speeds typical for that vehicle.
	*Students will be required to interpret graphs relating speed to stopping distance for a range of vehicles.
	
	4.5.6.3.2 Reaction Time
	*Reaction times vary from person to person. Typical values range from 0.2 s to 0.9 s.
	*A driver's reaction time can be affected by tiredness, drugs and alcohol. Distractions may also affect a driver's ability to react.
	*Students should be able to:
	  *Explain methods used to measure human reaction times and recall typical results
	  *Interpret and evaluate measurements from simple methods to measure the different
	  Reaction times of students
	  *Evaluate the effect of various factors on thinking distance based on given data.
	
	4.5.6.3.3 Factors affecting braking distance 1
	*The braking distance of a vehicle can be affected by adverse road and weather conditions and poor condition of the vehicle.
	*Adverse road conditions include wet or icy conditions. Poor condition of the vehicle is limited to the vehicle's brakes or tyres.
	*Students should be able to:
	  *Explain the factors which affect the distance required for road transport vehicles
		*The tendency of objects to continue in their state of
		Rest or of uniform motion is called inertia.
		
		*Students should be able to explain that:
		  *inertial mass is a measure of how difficult it is to
		  Change the velocity of an object
		  *inertial mass is defined as the ration of force over
		  Acceleration.
		  *Estimate the forces involved in the deceleration of
		  Road vehicles in typical situations on a public road

	to
	  Come to rest in emergencies, and the implications for safety.
	  * Estimate how the distance required for road vehicles to stop in an emergency varies
	  Over a range of typical speeds
	
	4.5.6.3.4 Factors affecting braking distance 2
	*When a force is applied to the brakes of a vehicle, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.
	
	*The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.
	*The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.
	*Students should be able to:
	 *Explain the dangers caused by large decelerations
		.
		4.5.7 Momentum
		4.5.7.1 Momentum is a property of moving objects
		*Momentum is defined by the equation:
		momentum = mass × velocity
		$p = m\,v$
		momentum, p, in kilograms metre per second, kg m/s
		mass, m, in kilograms, kg
		velocity, v, in metres per second, m/s

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4.5.7.2 Conservation of momentum
*In a closed system, the total momentum before an event is equal to the total momentum after the event.
*This is called conservation of momentum.
*Students should be able to use the concept of momentum as a model to:
  • describe and explain examples of momentum in   an event, such as a collision
  • (physics only) complete calculations involving an   event, such as the collision of two objects.

4.5.7.3 Changes in Momentum
*When a force acts on an object that is moving, or able to move, a change in momentum occurs.
The equations $F = m \times a$ and $a = v - u/t$
combine to give the equation $F = m \, \Delta v/\Delta t$
where $m\Delta v$ = change in momentum
ie force equals the rate of change of momentum.
*Students should be able to explain safety features such as: air bags, seat belts, gymnasium crash mats, cycle helmets and cushioned surfaces for playgrounds with reference to the concept of rate of change of momentum.
*Students should be able to apply equations relating force, mass, velocity and acceleration to explain how the changes involved are inter-related.

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Waves (Waves in Matter/Light and Electromagnetic Waves NC)

AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Biology GCSE
C6, Component 6	*4.6 Waves* **4.6.1 Waves in air, fluids and solids** **4.6.1.1 Transverse and longitudinal waves**	

3.6.4 Different types of Waves
Outcome 7
* Waves may be either transverse or longitudinal.
* In a transverse wave the oscillations are perpendicular to the direction of energy transfer. The ripples on a water surface are an example of a transverse wave.
* In a longitudinal wave the oscillations are parallel to the direction of energy transfer. Longitudinal waves show areas of compression and rarefaction. Sound waves travelling through air are longitudinal.
Outcome 8
* Waves are described by their amplitude, wavelength and frequency.
* The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.
* The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.
* Students may be required to use the equation:
wave speed (m/s) = frequency (Hz) x wavelength (m)
The frequency of a wave is the number of waves passing a point each second.
	*Waves may be either transverse or longitudinal.
	*The ripples on a water surface are an example of a transverse wave.
	*Longitudinal waves show areas of compression and rarefaction. Sound waves travelling through air are longitudinal.
	*Students should be able to describe the difference between longitudinal and transverse waves.
	*Students should be able to describe evidence that, for both ripples on a water surface and sound waves in air, it is the wave and not the water or air itself that travels.
	
	4.6.1.2 Properties of Waves
	*Students should be able to describe wave motion in terms of their amplitude, wavelength, frequency and period.
	*The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.
	*The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.
	*The frequency of a wave is the number of waves passing a point each second.
	Period = 1/frequency
	[T=1/f]
	Period, T, in seconds, s
	Frequency, *f*, in hertz, Hz
	The wave speed is the speed at which the energy is transferred (or the wave moves) through the medium.
	*All waves obey the wave equation:
	Wave speed = frequency x wavelength
	[v = f λ]
	Wave speed, v, in metres per seconds, m/s
	Frequency, f, in hertz Hz
	Wavelength, λ, in metres, m
	*Students should be able to:
	  *Describe a method to measure the speed of sound waves in air
	  *Describe a method to measure the speed of ripples on a water surface
	*Students should be able to show how changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related.
	***Required practical activity 8**: make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.
		4.6.1.4 Sound Waves
		*Students should be able to:
		  • describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids. Examples may include the effect of sound waves on the ear drum.
		  • explain why such processes only work over a limited frequency range and the relevance of this to human hearing.
		*Students should know that the range of normal human hearing is from 20 Hz to 20 kHz.
		4.6.1.5 Waves for Detection and Exploration
		*Students should be able to explain in qualitative terms, how the differences in velocity, absorption and reflection between different types of wave in solids and liquids can be used both for detection and exploration of structures which are hidden from direct observation.
		*Ultrasound waves have a frequency higher than the upper limit of hearing for humans. Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for the reflections to reach a detector can be used to determine how far away such a boundary is. This allows ultrasound waves to be used for both medical and industrial imaging.
		*Seismic waves are produced by earthquakes. P-waves are longitudinal, seismic waves. P-waves travel at

4.6.1.3 Reflection of Waves
*Waves can be reflected at the boundary between two different materials.
*Waves can be absorbed or transmitted at the boundary between two different materials.
*Students should be able to construct ray diagrams to illustrate the reflection of a wave at a surface.
*Students should be able to describe the effects of reflection, transmission and absorption of waves at material interfaces.
*Required practical activity 9 (physics only): investigate the reflection of light by different types of surface and the refraction of light by different substances.

4.6.2 Electromagnetic Waves
4.6.2.1 Types of Electromagnetic Waves
*Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.
*Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.
*The waves that form the electromagnetic spectrum are grouped in terms of their wavelength and their frequency. Going from long to short wavelength (or from low to high frequency) the groups are: radio, microwave, infrared, visible light (red to violet), ultraviolet, Xrays and gamma rays.

Long wavelength ⟶ Short wavelength

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

Low frequency ⟶ High frequency

*Our eyes only detect visible light and so detect a limited range of electromagnetic waves.
*Students should be able to give examples that illustrate the transfer of energy by electromagnetic waves.

4.6.2.2 Properties of Electromagnetic Waves 1
*Students should be able to construct ray diagrams to illustrate the refraction of a wave at the boundary between two different media.
***Required practical activity 10**: investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.

4.6.2.3 Properties of Electromagnetic Waves 2

different speeds through solids and liquids. S-waves are transverse, seismic waves.
S-waves cannot travel through a liquid. P-waves and S-waves provide evidence for the structure and size of the Earth's core.
*Echo sounding, using high frequency sound waves is used to detect objects in deep water and measure water depth.
*Students should be aware that the study of seismic waves provided new evidence that led to discoveries about parts of the Earth which are not directly observable.

*Different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength.
*Some effects, for example refraction, are due to the difference in velocity of the waves in different substances.
*Students should be able to use wave front diagrams to explain refraction in terms of the change of speed that happen

*Radio waves can be produced by oscillations in electrical circuits.
*When radio waves are absorbed they may create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit.

3.6.5 Electromagnetic Waves
Outcome 9
* Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.
* Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.
* The waves that form the electromagnetic spectrum are grouped in terms of their wavelength and their frequency.
* Going from long to short wavelength (or from low to high frequency) the groups are:
• radio
• microwave
• infrared
• visible light (red to violet)
• ultraviolet
• X-rays
• gamma rays.
* Ultraviolet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose.

*Suggested TDA Activity:
Testing visual acuity in different colours of light.

Outcome 10
* Electromagnetic waves have many

*Changes in atoms and the nuclei of atoms can result in electromagnetic waves being generated or absorbed over a wide frequency range. Gamma rays originate from changes in the nucleus of an atom.
*Ultraviolet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose. Radiation dose (in sieverts) is a measure of the risk of harm resulting from an exposure of the body
to the radiation.
*1000 millisieverts (mSv) = 1 sievert (Sv)
*Students will not be required to recall the unit of radiation dose.
*Students should be able to draw conclusions from given data about the risks and consequences of exposure to radiation.
*Ultraviolet waves can cause skin to age prematurely and increase the risk of skin cancer. X-rays and gamma rays are ionising radiation that can cause the mutation of genes and cancer.

4.6.2.4 Uses and Applications of Electromagnetic Waves
*Electromagnetic waves have many practical applications. For example:
• radio waves – television and radio
• microwaves – satellite communications, cooking food
• infrared – electrical heaters, cooking food, infrared cameras
• visible light – fibre optic communications
• ultraviolet – energy efficient lamps, sun tanning
• X-rays and gamma rays – medical imaging and treatments.

4.6.2.5 Lenses
*A lens forms an image by refracting light. In a convex lens, parallel rays of light are brought to a focus at the principal focus. The distance from the lens to the principal focus is called the focal length. Ray diagrams are used to show the formation of images by convex and concave lenses.
*The image produced by a convex lens can be either real or virtual.
*The image produced by a concave lens is always virtual.
*Students should be able to construct ray diagrams to illustrate the similarities and differences between convex and concave lenses.
*The magnification produced by a lens can be calculated using the equation:
magnification = image height / object height
*Magnification is a ratio and so has no units.
*Image height and object height should both be measured in either mm or cm.
*In ray diagrams a convex lens will be represented by:

*Students should be able to give brief explanations why each type of electromagnetic wave is suitable for the practical application.

practical applications, eg
• radio waves – television and radio (including Bluetooth)
• microwaves – satellite communications, cooking food
• infrared – electrical heaters, cooking food, infrared cameras
• visible light – fibre optic communications
• ultraviolet – energy efficient lamps, sun tanning
• X-rays – medical imaging and treatments
• gamma rays – for sterilising.
* Students should be able to give brief explanations of why each type of electromagnetic wave is suitable for the practical application.

*Suggested TDA Activity
Investigate the range over which a Bluetooth device is effective

A concave lens will be represented by:

4.6.2.6 Visible light
*Students should be able to explain:
• how the colour of an object is related to the differential absorption, transmission and reflection of different wavelengths of light by the object
• the effect of viewing objects through filters or the effect on light of passing through filters
• Why an opaque object has a particular colour.

4.6.3 Black Body Radiation
4.6.3.1 Emission and Absorption of Infrared Radiation
*All bodies (objects), no matter what temperature, emit and absorb infrared radiation. The hotter the body, the more infrared radiation it radiates in a given time.
*A perfect black body is an object that absorbs all of the radiation incident on it. A black body does not reflect or transmit any radiation. Since a good absorber is also a good emitter, a perfect black body would be the best possible emitter.
4.6.3.2 Perfect Black Bodies and Radiation
*Students should be able to explain:
• that all bodies (objects) emit radiation
• that the intensity and wavelength distribution of any emission depends on the temperature of the body.

*A body at constant temperature is absorbing radiation at the same rate as it is emitting radiation. The temperature of a body increases when the body absorbs radiation faster than it emits radiation
*The temperature of the Earth depends on many factors including: the rates of absorption and emission of radiation, reflection of radiation into space.
*Students should be able to explain how the temperature of a body is related to the balance between incoming radiation absorbed and radiation emitted, using everyday examples to illustrate this balance, and the example of the factors which determine the temperature of the Earth.
*Students should be able to use information, or draw/interpret diagrams to show how radiation affects the temperature of the Earth's surface and atmosphere.

Magnetism and Electromagnetism (NC Magnetism and Electromagnetism)

AQA Entry Level Certificate	Foundation AQA Biology GCSE	Higher AQA Biology GCSE

Science		
3.6.3 Magnetism and Electromagnetism Outcome 5 * The poles of a magnet are the places where the magnetic forces are strongest. When two magnets are brought close together they exert a force on each other. Two like poles repel each other. Two unlike poles attract each other. Attraction and repulsion between two magnetic poles are examples of non- contact force. * The patterns of magnetic fields between bar magnets will be required. Outcome 6 * When a current flows through a conducting wire a magnetic field is produced around the wire. * The strength of the magnetic field depends on the current through the wire and the distance from the wire. * Shaping a wire to form a solenoid increases the strength of the magnetic field created by a current through the wire. Adding an iron core increases the magnetic field strength of a solenoid. An electromagnet is a solenoid with an iron core. * Students should be familiar with common uses of electromagnets, eg in scrapyard cranes and relays.	***4.7 Magnetism and electromagnetism*** **4.7.1 Permanent and induced magnetism, magnetic forces and fields** **4.7.1.1 Poles of a magnet** *Students should be able to describe: 　• the attraction and repulsion between unlike and like poles for permanent magnets 　• the difference between permanent and induced magnets. 4.7.1.2 Magnetic Fields *Students should be able to: 　• describe how to plot the magnetic field pattern of a magnet using a compass 　• draw the magnetic field pattern of a bar magnet showing how strength and direction change from one point to another 　• explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic. ***4.7.2 The Motor Effect*** **4.7.2.1 Electromagnetism** *Students should be able to: 　• describe how the magnetic effect of a current can be demonstrated 　• draw the magnetic field pattern for a straight wire carrying a current and for a solenoid (showing the direction of the field) 　• explain how a solenoid arrangement can increase the magnetic effect of the current.	4.7.2.2 Fleming's left-hand rule *Students should be able to show that Fleming's left-hand rule represents the relative orientation of the force, the current in the conductor and the magnetic field. *Students should be able to recall the factors that affect the size of the force on the conductor. *For a conductor at right angles to a magnetic field and carrying a current: *force = magnetic f lux density × current × length* [F = B I l] force, F, in newtons, N magnetic flux density, B, in tesla, T current, I, in amperes, A (amp is acceptable for ampere) length, l, in metres, m 4.7.2.3 Electric Motors *A coil of wire carrying a current in a magnetic field tends to rotate. This is the basis of an electric motor. *Students should be able to explain how the force on a conductor in a magnetic field causes the rotation of the coil in an electric motor. 4.7.2.4 Loudspeakers *Loudspeakers and headphones use the motor effect to convert variations in current in electrical circuits to the pressure variations in sound waves. *Students should be able to explain how a moving-coil loudspeaker and headphones work. **4.7.3 Induced Potential, Transformers and the National Grid** 4.7.3.1 Induced Potential *If an electrical conductor moves relative to a magnetic field or if there is a change in the magnetic field around a conductor, a potential difference is induced across the ends of the conductor. If the conductor is part of a complete circuit, a current is induced in the conductor. This is called the generator effect.

*An induced current generates a magnetic field that opposes the original change, either the movement of the conductor or the change in magnetic field.
*Students should be able to recall the factors that affect the size of the induced potential difference/induced current.
*Students should be able to recall the factors that affect the direction of the induced potential difference/induced current.
*Students should be able to apply the principles of the generator effect in a given context.

4.7.3.2 Uses of the Generator

*The generator effect is used in an alternator to generate ac and in a dynamo to generate dc.
*Students should be able to:
  • explain how the generator effect is used in an alternator to generate ac and in a dynamo to generate dc
• draw/interpret graphs of potential difference generated in the coil against time.

4.7.3.3 Microphones

*Microphones use the generator effect to convert the pressure variations in sound waves into variations in current in electrical circuits.
*Students should be able to explain how a moving-coil microphone works.

4.7.3.4 Transformers

*A basic transformer consists of a primary coil and a secondary coil wound on an iron core.
*Iron is used as it is easily magnetised.
*Knowledge of laminations and eddy currents in the core is not required.
*The ratio of the potential differences across the primary and secondary coils of a transformer Vp and Vs depends on the ratio of the number of turns on each coil, np and ns.

<table>
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[vp/vs= np/ns]
potential difference, Vp and Vs in volts, V
In a step-up transformer Vs > Vp
In a step-down transformer Vs < Vp
If transformers were 100% efficient, the electrical power output would equal the electrical power input.
$Vs \times Is = Vp \times Ip$
Where Vs × Is is the power output (secondary coil) and Vp × Ip is the power input (primary coil).
power input and output, in watts, W
*Students should be able to:
  • explain how the effect of an alternating current in one coil in inducing a current in another is used in transformers
• explain how the ratio of the potential differences across the two coils depends on the ratio of the number of turns on each
• calculate the current drawn from the input supply to provide a particular power output.
  • apply the equation linking the p.d.s and number of turns in the two coils of a transformer to the currents and the power transfer involved, and relate these to the advantages of power transmission at high potential differences.

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Space Physics (NC Space Physics)

| AQA Entry Level Certificate Science	Foundation AQA Biology GCSE	Higher AQA Biology GCSE

	4.8 Space Physics (Physics Only)
	4.8.1 Solar system; stability of orbital motions; satellites (physics only)
	4.8.1.1 Our solar system
	*Students should be able to explain:
	  • how, at the start of a star's life cycle, the dust and gas drawn together by gravity causes fusion reactions
	  • that fusion reactions lead to an equilibrium between the	

gravitational collapse of a star and the expansion of a star due to fusion energy.

4.8.1.2 The Life Cycle of a Star
*A star goes through a life cycle. The life cycle is determined by the size of the star.
*Students should be able to describe the life cycle of a star:
  • the size of the Sun
  • much more massive than the Sun.
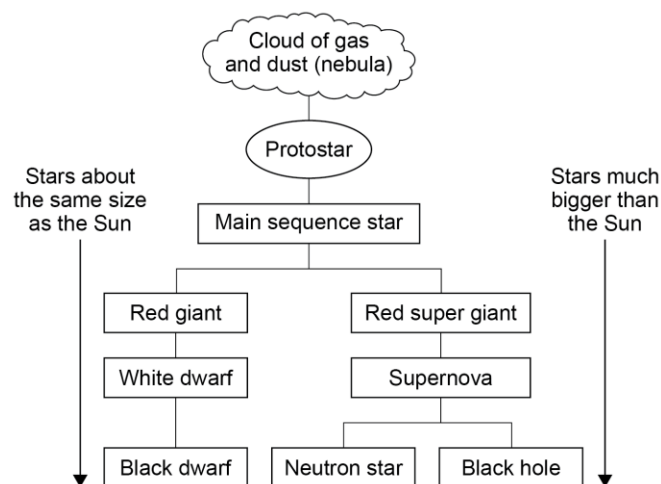
*Fusion processes in stars produce all of the naturally occurring elements. Elements heavier than iron are produced in a supernova.
*The explosion of a massive star (supernova) distributes the elements throughout the universe.
*Students should be able to explain how fusion processes lead to the formation of new elements.

4.8.2 Red – Shift
*Students should be able to explain:
  • qualitatively the red-shift of light from galaxies that are receding
  • that the change of each galaxy's speed with distance is evidence of an expanding universe
  • how red-shift provides evidence for the Big Bang model

• how scientists are able to use observations to arrive at theories such as the Big Bang theory
   • that there is still much about the universe that is not
      understood, for example dark mass and dark energy.

4.9 Key Ideas

*The complex and diverse phenomena of the natural and man-made world can be described in terms of a small number of key ideas in physics.
*These key ideas are of universal application, and we have embedded them throughout the subject content. They underpin many aspects of the science assessment and will therefore be assessed across all papers.
*Key ideas in physics include:
   • the use of models, as in the particle model of matter or the wave models of light and   of sound
• the concept of cause and effect in explaining such links as those between force and
   acceleration, or between changes in atomic nuclei and radioactive emissions
• the phenomena of 'action at a distance' and the related concept of the field as the key   to analysing electrical, magnetic and gravitational effects
• that differences, for example between pressures or temperatures or electrical potentials, are the drivers of change
• that proportionality, for example between weight and mass of an object or between force and extension in a spring, is an important aspect of many models in science
• that physical laws and models are expressed in mathematical form.