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GCSE (9-1)

***TWENTY FIRST CENTURY SCIENCE PHYSICS B***

**J259**

For first teach in 2016

**Student revision**

**checklist**

Version 1

# Student revision checklist

## Revision checklists

The tables below can be used as a revision checklist.

For more information please see the [OCR GCSE Physics B specification.](https://www.ocr.org.uk/Images/234601-specification-accredited-gcse-twenty-first-century-science-suite-physics-b-j259.pdf)

The table headings are explained below:

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| **Assessable learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| Here is a list of the learning outcomes for this qualification and the content you need to cover and work on.  **Please note the learning outcomes in bold are for Higher tier only.** | You can use the tick boxes to show when you have revised an item and how confident you feel about it.  R = **RED** means you are really unsure and lack confidence; you might want to focus your revision here and possibly talk to your teacher for help.  A = **AMBER** means you are reasonably confident but need some extra practice.  G = **GREEN** means you are very confident.  As your revision progresses, you can concentrate on the **RED** and **AMBER** items in order to turn them into **GREEN** items.  You might find it helpful to highlight each topic in red, orange or green to help you prioritise. | | | You can use the comments column to:   * add more information about the details for each point * add formulae or notes * include a reference to a useful resource * highlight areas of difficulty or things that you need to talk to your teacher about or look up in a textbook. |

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| **P1 Radiation and waves** | | | | |
| **P1.1 What are the risks and benefits of using radiations?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1.1 describe the main groupings of the electromagnetic spectrum – radio, microwave, infrared, visible (red to violet), ultraviolet, X- rays and gamma rays, that these range from long to short wavelengths, from low to high frequencies, and from low to high energies |  |  |  |  |
| P1.1.2 recall that our eyes can only detect a very limited range of frequencies in the electromagnetic spectrum |  |  |  |  |
| P1.1.3 recall that all electromagnetic radiation is transmitted through space with the same very high (but finite) speed |  |  |  |  |
| P1.1.4 explain, with examples, that electromagnetic radiation transfers energy from source to absorber |  |  |  |  |
| P1.1.5 recall that different substances may absorb, transmit, or reflect electromagnetic radiation in ways that depend on wavelength |  |  |  |  |

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| **P1.1 What are the risks and benefits of using radiations?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1.6 recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation, and that atoms can become ions by loss of outer electrons |  |  |  |  |
| P1.1.7 recall that changes in molecules, atoms and nuclei can generate and absorb radiations over a wide frequency range, including:   1. gamma rays are emitted from the nuclei of atoms 2. X-rays, ultraviolet and visible light are generated when electrons in atoms lose energy 3. high energy ultraviolet, gamma rays and X-rays have enough energy to cause ionisation when absorbed by some atoms 4. ultraviolet is absorbed by oxygen to produce ozone, which also absorbs ultraviolet, protecting life on Earth 5. infrared is emitted and absorbed by molecules |  |  |  |  |
| P1.1.8 describe how ultra-violet radiation, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues |  |  |  |  |

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| **P1.1 What are the risks and benefits of using radiations?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1.9 give examples of some practical uses of electromagnetic radiation in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions of the spectrum |  |  |  |  |
| **P1.1.10 recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits** |  |  |  |  |
| **P1.2 What is climate change and what is the evidence for it?** | | | | |
| P1.2.1 explain that all bodies emit radiation, and that the intensity and wavelength distribution of any emission depends on their temperatures |  |  |  |  |
| **P1.2.2 explain how the temperature of a body is related to the balance between incoming radiation, absorbed radiation and radiation emitted; illustrate this balance, using everyday examples including examples of factors which determine the temperature of the Earth** |  |  |  |  |

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| **P1.3 How do waves behave?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.3.1 describe wave motion in terms of amplitude, wavelength, frequency and period |  |  |  |  |
| P1.3.2 describe evidence that for both ripples on water surfaces and sound waves in air, it is the wave and not the water or air itself that travels |  |  |  |  |
| P1.3.3 describe the difference between transverse and longitudinal waves |  |  |  |  |
| P1.3.4 describe how waves on a rope are an example of transverse waves whilst sound waves in air are longitudinal waves |  |  |  |  |
| P1.3.5 define wavelength and frequency |  |  |  |  |
| P1.3.6 recall and apply the relationship between speed, frequency and wavelength to waves, including waves on water, sound waves and across the electromagnetic spectrum:  wave speed (m/s) = frequency (HZ) × wavelength (m) |  |  |  |  |

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| **P1.3 How do waves behave?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.3.7 a) describe how the speed of ripples on water surfaces and the speed of sound waves in air may be measured  b) describe how to use a ripple tank to measure the speed/frequency and wavelength of a wave |  |  |  |  |
| P1.3.8 a) describe the effects of reflection and refraction of waves at material interfaces  b) describe how to measure the refraction of light through a prism  c) describe how to investigate the reflection of light off a plane mirror |  |  |  |  |
| **P1.3.9 recall that waves travel in different substances at different speeds and that these speeds may vary with wavelength** |  |  |  |  |
| **P1.3.10 explain how refraction is related to differences in the speed of the waves in different substances** |  |  |  |  |
| P1.3.11 recall that light is an electromagnetic wave |  |  |  |  |
| P1.3.12 recall that electromagnetic waves are transverse |  |  |  |  |
| **P1.4 What happens when light and sound meet different materials? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.4.1 construct and interpret two-dimensional ray diagrams to illustrate specular reflection by mirrors  *qualitative only* |  |  |  |  |
| P1.4.2 construct and interpret two-dimensional ray diagrams to illustrate refraction at a plane surface and dispersion by a prism  *qualitative only* |  |  |  |  |
| P1.4.3 use ray diagrams to illustrate the similarities and differences between convex and concave lenses  *qualitative only* |  |  |  |  |
| P1.4.4 describe the effects of transmission, and absorption of waves at material interfaces |  |  |  |  |
| P1.4.5 explain how colour is related to differential absorption, transmission, and scattering |  |  |  |  |

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| **P1.4 What happens when light and sound meet different materials? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P1.4.6 describe, with examples, processes in which sound waves are transmitted though solids** |  |  |  |  |
| **P1.4.7 explain that transmission of sound through the bones in the ear works over a limited frequency range, and the relevance of this to human hearing** |  |  |  |  |
| **P1.4.8 explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably:**   1. **in our bodies (ultrasound imaging)** 2. **in the Earth (earthquake waves)** 3. **in deep water (SONAR)** |  |  |  |  |
| P1.4.9 show how changes, in speed, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related |  |  |  |  |

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| **P2 Sustainable energy** | | | | |
| **P2.1 How much energy do we use?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.1.1 describe how energy in chemical stores in batteries, or in fuels at the power station, is transferred by an electric current, doing work on domestic devices, such as motors or heaters |  |  |  |  |
| P2.1.2 explain, with reference to examples, the relationship between the power ratings for domestic electrical appliances, the time for which they are in use and the changes in stored energy when they are in use |  |  |  |  |
| P2.1.3 recall and apply the following equation in the context of energy transfers by electrical appliances:  energy transferred (J, kWh) = power (W, kW) × time (s, h) |  |  |  |  |
| P2.1.4 describe, with examples, where there are energy transfers in a system, that there is no net change to the total energy of a closed system  *qualitative only* |  |  |  |  |

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| **P2.1 How much energy do we use?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.1.5 describe, with examples, system changes, where energy is dissipated, so that it is stored in less useful ways |  |  |  |  |
| P2.1.6 explain ways of reducing unwanted energy transfer e.g. through lubrication, thermal insulation |  |  |  |  |
| P2.1.7 describe the effects, on the rate of cooling of a building, of thickness and thermal conductivity of its walls  *qualitative only* |  |  |  |  |
| P2.1.8 recall and apply the equation:  efficiency = useful energy transferred ÷ total energy transferred  to calculate energy efficiency for any energy transfer and **describe ways to increase efficiency** |  |  |  |  |
| P2.1.9 interpret and construct Sankey diagrams to show understanding that energy is conserved |  |  |  |  |

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| **P2.2 How can electricity be generated?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.2.1 describe the main energy resources available for use on Earth (including fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, the tides and the Sun) |  |  |  |  |
| P2.2.2 explain the differences between renewable and non-renewable energy resources |  |  |  |  |
| P2.2.3 compare the ways in which the main energy resources are used to generate electricity |  |  |  |  |
| P2.2.4 recall that the domestic supply in the UK is a.c., at 50 Hz and about 230 volts and explain the difference between direct and alternating voltage |  |  |  |  |
| P2.2.5 recall that, in the National Grid, transformers are used to transfer electrical power at high voltages from power stations, to the network and then used again to transfer power at lower voltages in each locality for domestic use |  |  |  |  |

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| **P2.2 How can electricity be generated?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.2.6 recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires; hence explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and any earthed object |  |  |  |  |
| P2.2.7 explain patterns and trends in the use of energy resources in domestic contexts, workplace contexts, and national contexts |  |  |  |  |

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| **P3 Electric circuits** | | | | |
| **P3.1 What is electric charge? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.1.1 describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact |  |  |  |  |
| P3.1.2 explain how transfer of electrons between objects can explain the phenomenon of static electricity |  |  |  |  |
| P3.1.3 explain the concept of an electric field and how it helps to explain the phenomenon of static electricity |  |  |  |  |
| **P3.2 What determines the current in an electric circuit?** | | | | |
| P3.2.1 recall that current is a rate of flow of charge, that for a charge to flow, a source of potential difference and a closed circuit are needed and that a current has the same value at any point in a single closed loop |  |  |  |  |

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| **P3.2 What determines the current in an electric circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2.2 recall and use the relationship between quantity of charge, current and time:  charge (C) = current (A) × time (s) |  |  |  |  |
| P3.2.3 recall that current (*I*) depends on both resistance (*R*) and potential difference (*V*) and the units in which these quantities are measured |  |  |  |  |
| P3.2.4 a) recall and apply the relationship between *I*, *R*, and *V*, to calculate the currents, potential differences and resistances in d.c. series circuits:  potential difference (V) = current (A) × resistance (Ω).  b) describe an experiment to investigate the resistance of a wire and be able to draw the circuit diagram of the circuit used |  |  |  |  |
| P3.2.5 recall that for some components the value of *R* remains constant (fixed resistors) but that in others it can change as the current changes (e.g. heating elements, lamp filaments) |  |  |  |  |

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| **P3.2 What determines the current in an electric circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2.6 a) use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties  b) describe experiments to investigate the  *I*-*V* characteristics of circuit elements. To include lamps, diodes, LDRs and thermistors. Be able to draw circuit diagrams for the circuits used |  |  |  |  |
| P3.2.7 represent circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements, filament lamps, diodes, LDRs and thermistors, switches and fixed and variable resistors |  |  |  |  |
| **P3.3 How do series and parallel circuits work?** | | | | |
| P3.3.1 relate the potential difference between two points in the circuit to the work done on, or by, a given amount of charge as it moves between these points:  potential difference (V) = work done (energy transferred) (J) ÷ charge (C) |  |  |  |  |

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| **P3.3 How do series and parallel circuits work?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.3.2 a) describe the difference between series and parallel circuits: to include ideas about how the current through each component and the potential difference across each component is affected by a change in resistance of a component.  b) describe how to practically investigate the brightness of bulbs in series and parallel circuits. Be able to draw circuit diagrams for the circuits used |  |  |  |  |
| P3.3.3 explain, why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased *qualitative only* |  |  |  |  |
| P3.3.4 solve problems for circuits which include resistors in series, using the concept of equivalent resistance |  |  |  |  |
| P3.3.5 explain the design and use of d.c. series circuits for measurement and testing purposes including exploring the effect of:   1. changing current in filament lamps, diodes, thermistors and LDRs 2. changing light intensity on an LDR 3. changing temperature of a thermistor (NTC only) |  |  |  |  |
| **P3.4 What determines the rate of energy transfer in a circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.4.1 describe the energy transfers that take place when a system is changed by work done when a current flows through a component |  |  |  |  |
| P3.4.2 explain, with reference to examples, how the power transfer in any circuit device is related to the energy transferred from the power supply to the device and its surroundings over a given time:  power (W) = energy (J) ÷ time (s) |  |  |  |  |
| P3.4.3 recall and use the relationship between the potential difference across the component and the total charge to calculate the energy transferred in an electric circuit when a current flows through a component:  energy transferred (work done) (J) =  charge (C) × potential difference (V) |  |  |  |  |
| P3.4.4 recall and apply the relationships between power transferred in any circuit device, the potential difference across it, the current through it, and its resistance:  power (W) = potential difference (V)  × current (A)  power (W)= (current (A))2 × resistance (Ω) |  |  |  |  |

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| **P3.4 What determines the rate of energy transfer in a circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.4.5 use the idea of conservation of energy to show that when a transformer steps up the voltage, the output current must decrease and vice versa.   1. select and use the equation:   potential difference across primary coil  × current in primary coil = potential difference across secondary coil  × current in secondary coil |  |  |  |  |
| P3.4.6 explain how transmitting power at higher voltages is more efficient way to transfer energy |  |  |  |  |
| **P3.5 What are magnetic fields?** | | | | |
| P3.5.1 describe the attraction and repulsion between unlike and like poles for permanent magnets |  |  |  |  |
| P3.5.2 describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another |  |  |  |  |
| P3.5.3 explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic |  |  |  |  |
| **P3.5 What are magnetic fields?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.5.4 describe the difference between permanent and induced magnets |  |  |  |  |
| P3.5.5 describe how to show that a current can create a magnetic effect |  |  |  |  |
| P3.5.6 describe the pattern and directions of the magnetic field around a conducting wire |  |  |  |  |
| P3.5.7 recall that the strength of the field depends on the current and the distance from the conductor |  |  |  |  |
| P3.5.8 explain how the magnetic effect of a solenoid can be increased |  |  |  |  |
| **P3.5.9 explain how a solenoid can be used to generate sound in loudspeakers and headphones.**  ***(separate science only)*** |  |  |  |  |

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| **P3.6 How do electric motors work?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P3.6.1 describe the interaction forces between a magnet and a current-carrying conductor to include ideas about magnetic fields** |  |  |  |  |
| **P3.6.2 show that Fleming’s left-hand rule represents the relative orientations of the force, the conductor and the magnetic field** |  |  |  |  |
| **P3.6.3 select and apply the equation that links the force *F* on a conductor to the strength of the field *B*, the size of the current *I* and the length of conductor *l* to calculate the forces involved:**  **force (N) = magnetic flux density (T)**  **× current (A) × length of conductor (m)** |  |  |  |  |
| **P3.6.4 explain how the force on a conductor in a magnetic field is used to cause rotation in the rectangular coil of a simple electric motor**  **Information**  **detailed knowledge of the construction of motors not required** |  |  |  |  |

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| **P3.7 What is the process inside an electric generator? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P3.7.1** **recall that a change in the magnetic field around a conductor can give rise to an induced potential difference across its ends, which could drive a current** |  |  |  |  |
| **P3.7.2 explain the action of a moving coil microphone in converting the pressure variations in sound waves into variations in current in electrical circuits** |  |  |  |  |
| **P3.7.3 recall that the direction of the induced potential difference drives a current which generates a second magnetic field that would oppose the original change in field** |  |  |  |  |
| **P3.7.4 use ideas about electromagnetic induction to explain a potential difference/time graph showing the output from an alternator being used to generate a.c** |  |  |  |  |
| **P3.7.5 explain how an alternator can be adapted to produce a dynamo to generate d.c., including explaining a potential difference/time graph** |  |  |  |  |

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| **P3.7 What is the process inside an electric generator? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P3.7.6 explain how the effect of an alternating current in one circuit in inducing a current in another is used in transformers** |  |  |  |  |
| **P3.7.7 describe how the ratio of the potential differences across the two circuits of a transformer depends on the ratio of the numbers of turns in each** |  |  |  |  |
| **P3.7.8 apply the equations linking the potential differences and numbers 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 voltages:**   1. **potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil** 2. **potential difference across primary coil ÷ potential difference across secondary coil = number of turns in primary coil ÷ number of turns in secondary coil** |  |  |  |  |

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| **P4 Explaining motion** | | | | |
| **P4.1 What are forces?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.1.1 recall and apply Newton’s third law |  |  |  |  |
| P4.1.2 recall examples of ways in which objects interact: by gravity, electrostatics, magnetism and by contact (including normal contact force and friction) |  |  |  |  |
| P4.1.3 describe how examples of gravitational, electrostatic, magnetic and contact forces involve interactions between pairs of objects which produce a force on each object |  |  |  |  |
| P4.1.4 represent interaction forces as vectors |  |  |  |  |
| P4.1.5 define weight |  |  |  |  |
| P4.1.6 describe how weight is measured |  |  |  |  |
| P4.1.7 recall and apply the relationship between the weight of an object, its mass and the gravitational field strength:  weight (N) = mass (kg) × gravitational field strength (N/kg) |  |  |  |  |
| **P4.2 How can we describe motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.2.1 recall and apply the relationship:  average speed (m/s) = distance (m) ÷ time (s) |  |  |  |  |
| P4.2.2 recall typical speeds encountered in everyday experience for wind, and sound, and for walking, running, cycling and other transportation systems |  |  |  |  |
| P4.2.3 a) make measurements of distances and times and calculate speeds.   1. describe how to use appropriate apparatus and techniques to investigate the speed of a trolley down a ramp |  |  |  |  |
| P4.2.4 make calculations using ratios and proportional reasoning to convert units, to include between m/s and km/h |  |  |  |  |
| P4.2.5 explain the vector–scalar distinction as it applies to displacement and distance, velocity and speed |  |  |  |  |

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| **P4.2 How can we describe motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.2.6 a) recall and apply the relationship:  acceleration (m/s2) = change in speed (m/s) ÷ time taken (s)  b) explain how to use appropriate apparatus and techniques to investigate acceleration |  |  |  |  |
| P4.2.7 select and apply the relationship:  (final speed (m/s))2 – (initial speed(m/s))2  = 2 × acceleration (m/s2) × distance (m) |  |  |  |  |
| P4.2.8 draw and use graphs of distances and speeds against time to determine the speeds and accelerations involved |  |  |  |  |
| P4.2.9 interpret distance–time and velocity–time graphs, including relating the lines and slopes in such graphs to the motion represented |  |  |  |  |
| **P4.2.10 interpret enclosed areas in velocity – time graphs** |  |  |  |  |
| P4.2.11 recall the value of acceleration in free fall and calculate the magnitudes of everyday accelerations using suitable estimates of speeds and times |  |  |  |  |
| **P4.3 What is the connection between forces and motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3.1 describe examples of the forces acting on an isolated solid object or system |  |  |  |  |
| P4.3.2 describe, using free body diagrams, examples where several forces lead to a resultant force on an object and the special case of balanced forces (equilibrium) when the resultant force is zero (*qualitative only)* |  |  |  |  |
| **P4.3.3 use scale drawings of vector diagrams to illustrate the addition of two or more forces, in situations when there is a net force, or equilibrium**  **Information**  **Limited to parallel and perpendicular vectors only** |  |  |  |  |
| **P4.3.4 recall and apply the equation for momentum and describe examples of the conservation of momentum in collisions:**  **momentum (kg m/s) = mass (kg) × velocity (m/s)** |  |  |  |  |
| **P4.3.5 select and apply Newton’s second law in calculations relating force, change in momentum and time:**  **change in momentum (kg m/s) = resultant force (N) × time for which it acts (s)** |  |  |  |  |
| **P4.3 What is the connection between forces and motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3.6 apply Newton’s first law to explain the motion of objects moving with uniform velocity and also the motion of objects where the speed and/or direction changes |  |  |  |  |
| **P4.3.7 explain with examples that motion in a circular orbit involves constant speed but changing velocity**  ***(qualitative only)*** |  |  |  |  |
| P4.3.8 describe examples in which forces cause rotation  *(separate science only)* |  |  |  |  |
| P4.3.9 define and calculate the moment of examples of rotational forces using the equation: moment of a force (N m) = force (N) × distance (m) (normal to direction of the force).  *(separate science only)* |  |  |  |  |
| P4.3.10 explain, with examples, how levers and gears transmit the rotational effects of forces  *(separate science only)* |  |  |  |  |

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| **P4.3 What is the connection between forces and motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P4.3.11 explain that inertial mass is a measure of how difficult it is to change the velocity of an object and that it is defined as the ratio of force over acceleration** |  |  |  |  |
| P4.3.12 recall and apply Newton’s second law relating force, mass and acceleration:  force (N) = mass (kg) × acceleration (m/s2) |  |  |  |  |
| P4.3.13 use and apply equations relating force, mass, velocity, acceleration, and **momentum** to explain relationships between the quantities |  |  |  |  |
| P4.3.14 explain methods of measuring human reaction times and recall typical results |  |  |  |  |
| P4.3.15 explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies and the implications for safety |  |  |  |  |
| P4.3.16 explain the dangers caused by large decelerations **and estimate the forces involved in typical situations on a public road** |  |  |  |  |

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| **P4.3 What is the connection between forces and motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3.17 given suitable data, estimate the distance required for road vehicles to stop in an emergency, and describe how the distance varies over a range of typical speeds  *(separate science only)* |  |  |  |  |
| P4.3.18 in the context of everyday road transport, use estimates of speeds, times and masses to calculate the accelerations and forces involved in events where large accelerations occur  *(separate science only)* |  |  |  |  |
| **P4.4 How can we describe motion in terms of energy transfer?** | | | | |
| P4.4.1 describe the energy transfers involved when a system is changed by work done by forces including:   1. to raise an object above ground level 2. to move an object along the line of action of the force |  |  |  |  |
| P4.4.2 recall and apply the relationship to calculate the work done (energy transferred) by a force:  work done (Nm or J) = force (N) × distance (m) (along the line of action of the force) |  |  |  |  |

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| **P4.4 How can we describe motion in terms of energy transfer?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.4.3 recall the equation and calculate the amount of energy associated with a moving object: kinetic energy (J) = 0.5 × mass (kg) × (speed (m/s))2 |  |  |  |  |
| P4.4.4 recall the equation and calculate the amount of energy associated with an object raised above ground level:  gravitational potential energy (J) = mass (kg) × gravitational field strength (N/kg) × height (m) |  |  |  |  |
| P4.4.5 make calculations of the energy transfers associated with changes in a system, recalling relevant equations for mechanical processes |  |  |  |  |
| P4.4.6 calculate relevant values of stored energy and energy transfers; convert between newton- metres and joules |  |  |  |  |

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| **P4.4 How can we describe motion in terms of energy transfer?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.4.7 describe all the changes involved in the way energy is stored when a system changes, for common situations: including an object projected upwards or up a slope, a moving object hitting an obstacle, an object being accelerated by a constant force, a vehicle slowing down |  |  |  |  |
| P4.4.8 explain, with reference to examples, the definition of power as the rate at which energy is transferred (work done) in a system |  |  |  |  |
| P4.4.9 recall and apply the relationship:  power (W) = energy transferred (J) ÷ time (s) |  |  |  |  |

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| **P5 Radioactive materials** | | | | |
| **P5.1 What is radioactivity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.1.1 describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus |  |  |  |  |
| P5.1.2 describe how and why the atomic model has changed over time to include the main ideas of Dalton, Thomson, Rutherford and Bohr |  |  |  |  |
| P5.1.3 recall the typical size (order of magnitude) of atoms and small molecules |  |  |  |  |
| P5.1.4 recall that atomic nuclei are composed of both protons and neutrons, and that the nucleus of each element has a characteristic positive charge |  |  |  |  |
| P5.1.5 recall that nuclei of the same element can differ in nuclear mass by having different numbers of neutrons, these are called isotopes |  |  |  |  |

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| **P5.1 What is radioactivity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.1.6 use the conventional representation to show the differences between isotopes, including their identity, charge and mass |  |  |  |  |
| P5.1.7 recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays |  |  |  |  |
| P5.1.8 relate emissions of alpha particles, beta particles, or neutrons, and gamma rays to possible changes in the mass or the charge of the nucleus, or both |  |  |  |  |
| P5.1.9 use names and symbols of common nuclei and particles to write balanced equations that represent the emission of alpha, beta, gamma, and neutron radiations during radioactive decay |  |  |  |  |
| P5.1.10 explain the concept of half-life and how this is related to the random nature of radioactive decay |  |  |  |  |

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| **P5.1 What is radioactivity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P5.1.11 calculate the net decline, expressed as a ratio, in a radioactive emission after a given (integral) number of half-lives** |  |  |  |  |
| P5.1.12 interpret activity-time graphs to find the half- life of radioactive materials |  |  |  |  |
| **P5.2 How can radioactive materials be used safely?** | | | | |
| P5.2.1 recall the differences in the penetration properties of alpha particles, beta particles and gamma rays |  |  |  |  |
| P5.2.2 recall the differences between contamination and irradiation effects and compare the hazards associated with each of these |  |  |  |  |
| P5.2.3 describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted tissue |  |  |  |  |
| P5.2.4 explain how ionising radiation can have hazardous effects, notably on human bodily tissues |  |  |  |  |
| **P5.2 How can radioactive materials be used safely?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.2.5 explain why the hazards associated with radioactive material differ according to the radiation emitted and the half-life involved |  |  |  |  |
| **P5.3 How can radioactive materials be used to provide energy? *(separate science only)*** | | | | |
| P5.3.1 recall that some nuclei are unstable and may split into two nuclei and that this is called nuclear fission |  |  |  |  |
| P5.3.2 relate the energy released during nuclear fission to the emission of ionising radiation and the kinetic energy of the resulting particles |  |  |  |  |
| P5.3.3 explain how nuclear fission can lead to further fission events in a chain reaction |  |  |  |  |
| P5.3.4 describe the process of nuclear fusion and recall that in this process some of the mass may be converted into the energy of radiation |  |  |  |  |

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| **P6 Matter – models and explanations** | | | | |
| **P6.1 How does energy transform matter?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1.1 a) define density  b) describe how to determine the densities of solid and liquid objects using measurements of length, mass and volume |  |  |  |  |
| P6.1.2 recall and apply the relationship between density, mass and volume to changes where mass is conserved:  density (kg/m3) = mass (kg) ÷ volume (m3) |  |  |  |  |
| P6.1.3 describe the energy transfers involved when a system is changed by heating (in terms of temperature change and specific heat capacity) |  |  |  |  |
| P6.1.4 define the term specific heat capacity and distinguish between it and the term specific latent heat |  |  |  |  |

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| **P6.1 How does energy transform matter?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1.5 a) select and apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature:  change in internal energy (J) = mass (kg) × specific heat capacity (J/kg°C) × change in temperature (°C)    b) explain how to safely use apparatus to determine the specific heat capacity of materials |  |  |  |  |
| P6.1.6 select and apply the relationship between energy needed to cause a change in state, specific latent heat and mass:  energy to cause a change of state (J) = mass (kg) × specific latent heat (J/kg) |  |  |  |  |
| P6.1.7 describe all the changes involved in the way energy is stored when a system changes, and the temperature rises, for example: a moving object hitting an obstacle, an object slowing down, water brought to a boil in an electric kettle |  |  |  |  |

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| **P6.1 How does energy transform matter?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1.8 make calculations of the energy transfers associated with changes in a system when the temperature changes, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes |  |  |  |  |
| **P6.2 How does the particle model explain the effects of heating?** | | | | |
| P6.2.1 explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules |  |  |  |  |
| P6.2.2 use the particle model of matter to describe how mass is conserved, when substances melt, freeze, evaporate, condense or sublimate, but that these physical changes differ from chemical changes and the material recovers its original properties if the change is reversed |  |  |  |  |
| P6.2.3 use the particle model to describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state |  |  |  |  |

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| **P6.2 How does the particle model explain the effects of heating?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.2.4 explain how the motion of the molecules in a gas is related both to its temperature and its pressure: hence explain the relationship between the temperature of a gas and its pressure at constant volume  *qualitative only* |  |  |  |  |
| **P6.3 How does the particle model relate to material under stress?** | | | | |
| P6.3.1 explain, with examples, that to stretch, bend or compress an object, more than one force has to be applied |  |  |  |  |
| P6.3.2 describe **and use the particle model to explain** the difference between elastic and plastic deformation caused by stretching forces |  |  |  |  |
| P6.3.3 a) describe the relationship between force and extension for a spring and other simple systems  b) describe how to measure and observe the effect of forces on the extension of a spring |  |  |  |  |

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| **P6.3 How does the particle model relate to material under stress?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.3.4 describe the difference between the force- extension relationship for linear systems and for non-linear systems |  |  |  |  |
| P6.3.5 recall and apply the relationship between force, extension and spring constant for systems where the force-extension relationship is linear:  force exerted by a spring (N) = extension (m) x spring constant (N/m) |  |  |  |  |
| P6.3.6 a) calculate the work done in stretching a spring or other simple system, by calculating the appropriate area on the force-extension graph  b) describe how to safely use apparatus to determine the work done in stretching a spring |  |  |  |  |
| P6.3.7 select and apply the relationship between energy stored, spring constant and extension for a linear system:  energy stored in a stretched spring (J) = ½ × spring constant (N/m) × (extension (m))2 |  |  |  |  |

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| **P6.4 How does the particle model relate to pressures in fluids? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.4.1 recall that the pressure in fluids cause a force normal to any surface |  |  |  |  |
| P6.4.2 recall and apply the relationship between the force, the pressure, and the area in contact: pressure (Pa) = force normal to a surface (N) ÷ area of that surface (m2) |  |  |  |  |
| P6.4.3 recall that gases can be compressed or expanded by pressure changes and that the pressure produces a net force at right angles to any surface |  |  |  |  |
| P6.4.4 use the particle model of matter to explain how increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure |  |  |  |  |
| P6.4.5 select and apply the equation:  pressure × volume = constant (for a given mass of gas at constant temperature) |  |  |  |  |
| P6.4.6 describe a simple model of the Earth’s atmosphere and of atmospheric pressure and explain why atmospheric pressure varies with height above the surface |  |  |  |  |
| **P6.4 How does the particle model relate to pressures in fluids? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P6.4.7 explain why pressure in a liquid varies with depth and density** |  |  |  |  |
| **P6.4.8 select and apply the equation to calculate the differences in pressure at different depths in a liquid:**  **pressure = density ×**  **gravitational field strength × depth** |  |  |  |  |
| **P6.4.9 explain how the increase in pressure with depth in a fluid leads to an upwards force on a partially submerged object** |  |  |  |  |
| **P6.4.10 describe and explain the factors which influence whether a particular object will float or sink** |  |  |  |  |
| **P6.5 How can scientific models help us understand the Big Bang? *(separate science only)*** | | | | |
| P6.5.1 recall the main features of our solar system, including the similarities and distinctions between the planets, their moons, and artificial satellites |  |  |  |  |

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| **P6.5 How can scientific models help us understand the Big Bang? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P6.5.2 explain, for the circular orbits, how the force of gravity can lead to changing velocity of a planet but unchanged speed** |  |  |  |  |
| **P6.5.3 explain how, for a stable orbit, the radius must change if this speed changes**  ***qualitative only*** |  |  |  |  |
| P6.5.4 recall that the solar system was formed from dust and gas drawn together by gravity |  |  |  |  |
| **P6.5.5 use the particle model of matter to explain how doing work on a gas can increase its temperature (e.g. bicycle pump, in stars)** |  |  |  |  |
| P6.5.6 explain how the Sun was formed when collapsing cloud of dust and gas resulted in fusion reactions, leading to an equilibrium between gravitational collapse and expansion due to the fusion energy |  |  |  |  |
| P6.5.7 explain the red-shift of light from galaxies which are receding.  *qualitative only* |  |  |  |  |

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| **P6.5 How can scientific models help us understand the Big Bang? *(separate science only)*** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.5.8 explain that the relationship between the distance of each galaxy and its speed is evidence of an expanding universe model |  |  |  |  |
| P6.5.9 explain how the evidence of an expanding universe leads to the ‘Big Bang’ model |  |  |  |  |

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| **P7 Ideas about Science** | | | | |
| **P7.1 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.1.1 in given contexts use scientific theories and tentative explanations to develop and justify hypotheses and predictions |  |  |  |  |
| P7.1.2 suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected |  |  |  |  |
| P7.1.3 recognise the importance of scientific quantities and understand how they are determined |  |  |  |  |
| P7.1.4 identify factors that need to be controlled, and the ways in which they could be controlled |  |  |  |  |
| P7.1.5 suggest an appropriate sample size and/or range of values to be measured and justify the suggestion |  |  |  |  |

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| **P7.1 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.1.6 plan experiments or devise procedures by constructing clear and logically sequenced strategies to:   * make observations * produce or characterise a substance * test hypotheses * collect and check data * explore phenomena |  |  |  |  |
| P7.1.7 identify hazards associated with the data collection and suggest ways of minimizing the risk |  |  |  |  |
| P7.1.8 use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms |  |  |  |  |
| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| P7.2.1 present observations and other data using appropriate formats |  |  |  |  |

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| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.2.2 when processing data use SI units where appropriate (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate |  |  |  |  |
| P7.2.3 when processing data use prefixes (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) and powers of ten for orders of magnitude |  |  |  |  |
| P7.2.4 be able to translate data from one form to another |  |  |  |  |
| P7.2.5 when processing data interconvert units |  |  |  |  |
| P7.2.6 when processing data use an appropriate number of significant figures |  |  |  |  |
| P7.2.7 when displaying data graphically select an appropriate graphical form, use appropriate axes and scales, plot data points correctly, draw an appropriate line of best fit, and indicate uncertainty (e.g. range bars) |  |  |  |  |

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| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.2.8 when analysing data identify patterns/trends, use statistics (range and mean) and obtain values from a line on a graph (including gradient, interpolation and extrapolation) |  |  |  |  |
| P7.2.9 in a given context evaluate data in terms of accuracy, precision, repeatability and reproducibility, identify potential sources of random and systematic error, and discuss the decision to discard or retain an outlier |  |  |  |  |
| P7.2.10 evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations |  |  |  |  |
| P7.2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions |  |  |  |  |

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| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.2.12 explain the extent to which data increase or decrease confidence in a prediction or hypothesis |  |  |  |  |
| **P7.3 How are scientific explanations developed?** | | | | |
| P7.3.1 use ideas about correlation and cause to:   * identify a correlation in data presented as text, in a table, or as a graph * distinguish between a correlation and a cause-effect link * suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it * explain why individual cases do not provide convincing evidence for or against a correlation * identify the presence (or absence) of a plausible mechanism as reasonable grounds for accepting (or rejecting) a claim that a factor is a cause of an outcome |  |  |  |  |
| P7.3.2 describe and explain examples of scientific methods and theories that have developed over time and how theories have been modified when new evidence became available |  |  |  |  |
| **P7.3 How are scientific explanations developed?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.3.3 describe in broad outline the ‘peer review’ process, in which new scientific claims are evaluated by other scientists |  |  |  |  |
| P7.3.4 use a variety of models (including representational, spatial, descriptive, computational and mathematical models) to:   * solve problems * make predictions * develop scientific explanations and understanding * identify limitations of models |  |  |  |  |
| **P7.4 How do science and technology impact society?** | | | | |
| P7.4.1 describe and explain everyday examples and technological applications of science that have made significant positive differences to people’s lives |  |  |  |  |
| P7.4.2 identify examples of risks that have arisen from a new scientific or technological advance |  |  |  |  |

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| **P7.4 How do science and technology impact society?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.4.3 for a given situation:   * identify risks and benefits to the different individuals and groups involved * discuss a course of action, taking account of who benefits and who takes the risks * suggest reasons for people’s willingness to accept the risk * **distinguish between perceived and calculated risk** |  |  |  |  |
| P7.4.4 suggest reasons why different decisions on the same issue might be appropriate in view of differences in personal, social, economic or environmental context, and be able to make decisions based on the evaluation of evidence and arguments |  |  |  |  |
| P7.4.5 distinguish questions that could in principle be answered using a scientific approach, from those that could not; where an ethical issue is involved clearly state what the issue is and summarise the different views that may be held |  |  |  |  |
| P7.4.6 explain why scientists should communicate their work to a range of audiences |  |  |  |  |

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| **Equations in Physics** | | | | |
| ***recall and apply the following relationships using standard SI units*** | **R** | **A** | **G** | **Comments** |
| force = mass × acceleration (P4.3.12, P4.3.13) |  |  |  |  |
| kinetic energy = 0.5 × mass × (speed)2 (P4.4.3) |  |  |  |  |
| **momentum = mass × velocity (P4.3.4.) (P4.3.13)** |  |  |  |  |
| work done = force × distance (along the line of action of the force) (P4.4.2) |  |  |  |  |
| power = energy ÷ time (P3.4.2, P4.4.9) |  |  |  |  |
| efficiency = useful energy transferred ÷ total energy transferred (P2.1.8) |  |  |  |  |
| weight = mass × gravitational field strength *g* (P4.1.7) |  |  |  |  |

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| **Equations in Physics** | | | | |
| ***recall and apply the following relationships using standard SI units*** | **R** | **A** | **G** | **Comments** |
| In a gravity field:  gravitational potential energy = mass × gravitational field strength *g* × height (P4.4.4) |  |  |  |  |
| force exerted by a spring = extension × spring constant (P6.3.5) |  |  |  |  |
| moment of a force = force × distance (normal to direction of the force) (P4.3.9)  *(separate science only)* |  |  |  |  |
| average speed = distance ÷ time (P4.2.1) |  |  |  |  |
| acceleration = change in speed ÷ time taken(P4.2.6a) |  |  |  |  |
| wave speed = frequency × wavelength (P1.3.6) |  |  |  |  |
| charge = current × time (P3.2.2) |  |  |  |  |
| potential difference = current × resistance (P3.2.4a) |  |  |  |  |

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| **Equations in Physics** | | | | |
| ***recall and apply the following relationships using standard SI units*** | **R** | **A** | **G** | **Comments** |
| power = potential difference × current = (current)2 × resistance (P3.4.4) |  |  |  |  |
| energy transferred (work done) = power × time = charge flow × potential difference (P2.1.3, P3.4.3) |  |  |  |  |
| density = mass ÷ volume (P6.1.2) |  |  |  |  |
| pressure = force normal to a surface ÷ area of that surface (P6.4.2)  *(separate science only)* |  |  |  |  |
| potential difference = work done (energy transferred) ÷ charge (P3.3.1) |  |  |  |  |

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| **Equations in Physics** | | | | |
| ***In addition, students should be able correctly to select from a list and apply the following relationships:*** | **R** | **A** | **G** | **Comments** |
| (final speed)2 – (initial speed)2 = 2 × acceleration × distance (P4.2.7) |  |  |  |  |
| change in internal energy = mass × specific heat capacity × change in temperature (P6.1.5a) |  |  |  |  |
| energy to cause a change of state = mass × specific latent heat (P6.1.6) |  |  |  |  |
| energy stored in a stretched spring = 1⁄2 × spring constant × (extension)2 (P6.3.7) |  |  |  |  |
| **force = magnetic flux density × current × length of conductor (P3.6.3)** |  |  |  |  |
| potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil (P3.4.5) |  |  |  |  |
| **potential difference across primary coil ÷ potential difference across secondary coil = number of turns in primary coil ÷ number of turns in secondary coil (P3.7.8b)**  ***(separate science only)*** |  |  |  |  |
| for gases: pressure × volume = constant (for a given mass of gas and at a constant temperature) (P6.4.5) *(separate science only)* |  |  |  |  |
| **Equations in Physics** | | | | |
| ***In addition, students should be able correctly to select from a list and apply the following relationships:*** | **R** | **A** | **G** | **Comments** |
| **pressure due to a column of liquid = height of column × density of liquid × *g* (P6.4.8) *(separate science only)*** |  |  |  |  |
| **change in momentum = resultant force × time for which it acts (P4.3.5)** |  |  |  |  |



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