COMBINED SCIENCE

**PHYSICS**

**HIGHER TIER**

CHECK LIST

**FOR SUMMER 2022**

WITH LINKS TO

OAK ACADEMY LESSONS

**Name:**

**1. ENERGY**

1. Energy transfers
2. Potential energy
3. Kinetic energy
4. Work done and energy transfer
5. Power
6. Specific heat capacity
7. ***Practical: Investigating specific heat capacity***
8. Dissipation of energy
9. Energy efficiency and Sankey diagrams
10. *Practical: Investigating ways of reducing the unwanted energy transfers in a system*
11. Energy resources and global energy supplies

**2. ELECTRICITY**

1. **Current, potential difference and resistance**
2. Standard circuit diagram symbols
3. Electrical charge and current
4. Current, resistance and potential difference
5. ***Practical:*** *use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits. This should include: a) the length of a wire at constant temperature b) combinations of resistors in series and parallel.*
6. Resistors
7. ***Practical: use circuit diagrams to construct appropriate circuits to investigate the current vs. voltage (I–V) characteristics of a variety of circuit elements, including a filament lamp, a diode and a resistor at constant temperature.***
8. Series and parallel circuits
9. Domestic uses and safety
10. Direct and alternating potential difference
11. Mains electricity
12. **Energy transfers**
13. Power
14. Energy transfers in everyday appliances
15. The National Grid

**3. PARTICLE MODEL OF MATTER**

1. Density
2. *Practical: Investigate the densities of regular and irregular solid objects and liquids*
3. Changes of state
4. Internal energy
5. *Perform an experiment to measure the latent heat of fusion of water.*
6. Specific heat capacity
7. Latent heat
8. Particle motion in gases
9. Increasing the pressure of a gas
10. Particle model and change of state

**4. ATOMIC STRUCTURE**

1. Atomic structure
2. Radioactive decay
3. Background radiation
4. Nuclear equations
5. Radioactive half-life
6. Hazards and uses of radiation
7. Irradiation
8. Uses of radiation in medicine
9. Using nuclear radiation
10. Nuclear fission
11. Nuclear fusion
12. The history of developing ideas for the structure of the atom
13. Using ratios and half-life in calculations

**5. FORCES**

1. Forces and their interactions
2. Work done and energy transfer
3. Forces and elasticity
4. *Practical activity: investigate the relationship between force and extension for a spring.*
5. Forces and motion
6. *Practical activity: 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 object on the acceleration produced by a constant force.*
7. Momentum (HT only)
8. *Practical activity: 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.*

**6. WAVES**

1. Waves in air, fluids and solids
2. Electromagnetic waves
3. ***Practical activity: investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.***

**7. MAGNETISM and ELECTROMAGNETISM**

1. Permanent and induced magnetism, magnetic forces and fields
2. The motor effect

**Web references are to Oak National academy Key Stage 4, Physics Units:**

<https://classroom.thenational.academy/subjects-by-key-stage/key-stage-4/subjects/physics>

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|  | R | A | G |
| **6.1 Energy**[*https://classroom.thenational.academy/units/energy-c750*](https://classroom.thenational.academy/units/energy-c750) |  |  |  |
| *6.1.1 Energy changes in a system, and the ways energy is stored before and after such changes* |  |  |  |
| **6.1.1.1 Energy stores and systems** [**https://classroom.thenational.academy/lessons/energy-transfers-64upac**](https://classroom.thenational.academy/lessons/energy-transfers-64upac) |  |  |  |
| a) Be able to describe 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
* an object accelerated by a constant force
* a vehicle slowing down
* bringing water to a boil in an electric kettle.

b) 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 how the overall energy in a system is redistributed when the system is changed.
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| **6.1.1.2 Changes in energy**  |  |  |  |
| Be able to calculate the amount of energy associatedwith a moving object, a stretched spring and an object raised aboveground level.1. The kinetic energy of a moving object can be calculated using the equation:
* $kinetic energy=\frac{1}{2} x mass x speed^{2}$
* $E\_{k}=\frac{1}{2} x m x v^{2}$

kinetic energy, Ek, in joules, Jmass, m, in kilograms, kgspeed, v, in metres per second, m/s[**https://classroom.thenational.academy/lessons/the-kinetic-energy-store-6thpad**](https://classroom.thenational.academy/lessons/the-kinetic-energy-store-6thpad)1. The amount of elastic potential energy stored in a stretched spring can be calculated using the equation:
* $elastic potential energy=\frac{1}{2} x spring constant x extension^{2}$
* $E\_{e}=\frac{1}{2} x k x e^{2}$

(assuming the limit of proportionality has not been exceeded)elastic potential energy, Ee, in joules, Jspring constant, k, in newtons per metre, N/mextension, e, in metres, m[**https://classroom.thenational.academy/lessons/the-elastic-potential-store-70u62t**](https://classroom.thenational.academy/lessons/the-elastic-potential-store-70u62t)1. The amount of gravitational potential energy gained by an object raised above ground level can be calculated using the equation:
* $gravitational potential energy=mass x gravitational field strength x height$
* $E\_{p}=m x g x h$

gravitational potential energy, Ep, in joules, Jmass, m, in kilograms, kggravitational field strength, g, in newtons per kilogram, N/kg height, h, in metres, m[**https://classroom.thenational.academy/lessons/the-gravitational-potential-store-crr6ar**](https://classroom.thenational.academy/lessons/the-gravitational-potential-store-crr6ar) |  |  |  |

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| **6.1.1.3 Energy changes in systems**[**https://classroom.thenational.academy/lessons/specific-heat-capacity-chhp6r**](https://classroom.thenational.academy/lessons/specific-heat-capacity-chhp6r) |  |  |  |
| a) The amount of energy stored in or released from a system as its temperature changes can be calculated using the equation:* $change in thermal energy=mass x specific heat capacity x temperature change$
* $∆E=m x c x ∆Ө$

change in thermal energy, ΔE, in joules, Jmass, m, in kilograms, kgspecific heat capacity, c, in joules per kilogram per degree Celsius, J/kg °Ctemperature change, Δθ, in degrees Celsius, °Cb) 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. |  |  |  |
| [**https://classroom.thenational.academy/lessons/specific-heat-capacity-required-practical-69j66r**](https://classroom.thenational.academy/lessons/specific-heat-capacity-required-practical-69j66r)**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. |  |  |  |
| **6.1.1.4 Power**[**https://classroom.thenational.academy/lessons/power-crvk4c**](https://classroom.thenational.academy/lessons/power-crvk4c) |  |  |  |
| 1. Power is defined as the rate at which energy is transferred or the rate at which work is done.
* $power= \frac{energy transferred}{time}$
* $P= \frac{E}{t}$
* $power= \frac{work done}{time}$
* $P= \frac{W}{t}$

power, *P*, in watts, Wenergy transferred, *E*, in joules, Jtime, *t*, in seconds, swork done, *W*, in joules, J1. An energy transfer of 1 joule per second is equal to a power of 1 watt. ( 1J/s = 1W )
2. Be able to give examples that illustrate the definition of power e.g. comparing two electric motors that both lift the same weight through the same height but one does it faster than the other.
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| *6.1.2 Conservation and dissipation of energy*[**https://classroom.thenational.academy/lessons/conservation-of-energy-71gk6c**](https://classroom.thenational.academy/lessons/conservation-of-energy-71gk6c) |  |  |  |
| **6.1.2.1 Energy transfers in a system**[**https://classroom.thenational.academy/lessons/energy-transfers-64upac**](https://classroom.thenational.academy/lessons/energy-transfers-64upac) |  |  |  |
| 1. Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
2. In all system changes energy is dissipated, so that it is stored in less useful ways……this energy is often described as being ‘wasted’.
3. Be able to explain ways of reducing unwanted energy transfers, for example through lubrication and the use of thermal insulation.
4. The higher the thermal conductivity of a material the higher the rate of energy transfer by conduction across the material.
5. The rate of cooling of a building is affected by the thickness and thermal conductivity of its walls.
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| [**https://classroom.thenational.academy/lessons/insulating-material-required-practical-part-1-ccukgr**](https://classroom.thenational.academy/lessons/insulating-material-required-practical-part-1-ccukgr)[**https://classroom.thenational.academy/lessons/insulating-material-required-practical-part-2-71h3gc**](https://classroom.thenational.academy/lessons/insulating-material-required-practical-part-2-71h3gc)**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. |  |  |  |
| **6.1.2.2 Efficiency**[**https://classroom.thenational.academy/lessons/efficiency-and-reducing-unwanted-energy-transfers-61jker**](https://classroom.thenational.academy/lessons/efficiency-and-reducing-unwanted-energy-transfers-61jker) |  |  |  |
| 1. The energy efficiency for any energy transfer can be calculated using the equation:
* $efficiency= \frac{useful output energy transfer}{total input energy transfer}$
1. Efficiency may also be calculated using the equation:
* $efficiency= \frac{useful power output}{total power input}$
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| (HT only) Be able to describe ways to increase the efficiency of an intended energy transfer. |  |  |  |

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| *6.1.3 National and global energy resources*[*https://classroom.thenational.academy/lessons/non-renewable-energy-resources-6rupcd*](https://classroom.thenational.academy/lessons/non-renewable-energy-resources-6rupcd)[*https://classroom.thenational.academy/lessons/renewable-energy-resources-ccu6cr*](https://classroom.thenational.academy/lessons/renewable-energy-resources-ccu6cr) |  |  |  |
| 1. a) The main energy resources available for use on Earth include:
* fossil fuels (coal, oil and gas)
* nuclear fuel
* biofuel
* wind
* hydro-electricity
* geothermal
* the tides
* the Sun
* water waves

b) A renewable energy resource is one that is being (or can be) replenished as it is used.c) The uses of energy resources include: transport, electricity generation and heating.d) 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.

e)* 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.
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***Multio-step calculations for the energy topic*:**

<https://classroom.thenational.academy/lessons/multi-step-calculations-for-the-energy-topic-ctgp4e>

***Energy topic review:***

<https://classroom.thenational.academy/lessons/energy-review-6rtkgt>

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| **6.2 Electricity** [**https://classroom.thenational.academy/units/electricity-f083**](https://classroom.thenational.academy/units/electricity-f083) |  |  |  |
| *6.2.1 Current, potential difference and resistance* |  |  |  |
| **6.2.1.1 Standard circuit diagram symbols**[**https://classroom.thenational.academy/lessons/drawing-electrical-circuits-c9hpcc**](https://classroom.thenational.academy/lessons/drawing-electrical-circuits-c9hpcc) |  |  |  |
| 1. Circuit diagrams using standard symbols. The following standard symbols should be known:
	* switch (open and closed)
	* cell
	* battery
	* lamp
	* fuse
	* voltmeter
	* ammeter
	* resistor
	* variable resistor
	* thermistor
	* diode
	* light dependent resistor (LDR)
	* light emitting diode (LED)
2. Be able to draw and interpret circuit diagrams.
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| **6.2.1.2 Electrical charge and current**[**https://classroom.thenational.academy/lessons/charge-and-current-64r36t**](https://classroom.thenational.academy/lessons/charge-and-current-64r36t) |  |  |  |
| 1. For electrical charge to flow through a closed circuit the circuit must include a source of potential difference.
2. Electric current is a flow of electrical charge.
3. The size of the electric current is the rate of flow of electrical charge.
4. Charge flow, current and time are linked by the equation:
* $charge flow=current x time$
* $Q=I x t$

charge flow, *Q*, in coulombs, Ccurrent, *I*, in amperes, A (amp is acceptable for ampere)time, *t*, in seconds, s1. A current has the same value at any point in a single.
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| **6.2.1.3 Current, resistance and potential difference**[**https://classroom.thenational.academy/lessons/potential-difference-74tk4c**](https://classroom.thenational.academy/lessons/potential-difference-74tk4c)[**https://classroom.thenational.academy/lessons/electrical-resistance-6wvk4t**](https://classroom.thenational.academy/lessons/electrical-resistance-6wvk4t)[**https://classroom.thenational.academy/lessons/series-circuits-6wrpad**](https://classroom.thenational.academy/lessons/series-circuits-6wrpad) |  |  |  |
| 1. The current (*I*) through a component depends on both the resistance (*R*) of the component and the potential difference (*V*) across the component.
2. The greater the resistance of the component the smaller the current for a given potential difference (p.d.) across the component.
3. Questions will be set using the term potential difference. (Students will gain credit for the correct use of either potential difference or voltage.)
4. Current, potential difference or resistance can be calculated using the equation:
* $potential difference=current x resistance$
* $V=I x R$

potential difference, *V*, in volts, Vcurrent, *I*, in amperes, A (amp is acceptable for ampere)resistance, *R*, in ohms, Ω |  |  |  |
| [**https://classroom.thenational.academy/lessons/resistance-of-a-wire-69h64d**](https://classroom.thenational.academy/lessons/resistance-of-a-wire-69h64d)**Required practical activity 3:** use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits. This should include:* the length of a wire at constant temperature
* combinations of resistors in series and parallel.
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| **6.2.1.4 Resistors** |  |  |  |
| 1. 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.
2. 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.

<https://classroom.thenational.academy/lessons/properties-of-resistors-6nhp2c> 1. The resistance of components such as lamps, diodes, thermistors and LDRs is not constant; it changes with the current through the component.
2. The resistance of a filament lamp increases as the temperature of the filament increases. <https://classroom.thenational.academy/lessons/filament-lamps-71j34r>
3. The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction. <https://classroom.thenational.academy/lessons/diodes-6gtpcr>
4. The resistance of a thermistor decreases as the temperature increases. <https://classroom.thenational.academy/lessons/thermistors-cgr68d>
5. The applications of thermistors in circuits e.g. a thermostat.
6. The resistance of an LDR decreases as light intensity increases. <https://classroom.thenational.academy/lessons/light-dependent-resistors-chhk8c>
7. The application of LDRs in circuits e.g. switching lights on when it gets dark is required.
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| 1. 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.
1. 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.
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| **Required practical activity 4:** use circuit diagrams to construct appropriate circuits to investigate the current vs. voltage (I–V) characteristics of a variety of circuit elements, including a filament lamp, a diode and a resistor at constant temperature. |  |  |  |

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| *6.2.2 Series and parallel circuits*[*https://classroom.thenational.academy/lessons/series-and-parallel-circuits-69jk8c*](https://classroom.thenational.academy/lessons/series-and-parallel-circuits-69jk8c) |  |  |  |
| 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:1. there is the same current through each component
2. the total potential difference of the power supply is shared between the components
3. the total resistance of two components is the sum of the resistance of each component.
4. It is calculated like this: $R\_{total}= R\_{1}+ R\_{2}+…$ where resistance, *R*, is in ohms, Ω

For components connected in parallel:<https://classroom.thenational.academy/lessons/parallel-circuits-68w3ct> 1. the potential difference across each component is the same
2. the total current through the whole circuit is the sum of the currents through the separate branches
3. the total resistance of two resistors is less than the resistance of the smallest individual resistor.

Be able to:1. use circuit diagrams to construct and check series and parallel circuits that include a variety of common circuit components
2. describe the difference between series and parallel circuits
3. explain qualitatively why adding resistors in series increases the total resistance whilst adding resistors in parallel decreases the total resistance
4. explain the design and use of D.C. series circuits for measurement and testing purposes
5. calculate the currents, potential differences and resistances in D.C. series circuits
6. 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.) |  |  |  |

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| *6.2.3 Domestic uses and safety*[*https://classroom.thenational.academy/lessons/domestic-electricity-c4rp8t*](https://classroom.thenational.academy/lessons/domestic-electricity-c4rp8t) |  |  |  |
| **6.2.3.1 Direct and alternating potential difference** |  |  |  |
| 1. Mains electricity is an alternating current (A.C.) supply.
2. In the United Kingdom the domestic electricity supply has a frequency of 50 Hz and a voltage of about 230 V.
3. Explain the difference between direct (D.C.) and alternating (A.C.) potential difference.
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| **6.2.3.2 Mains electricity** |  |  |  |
| 1. Most electrical appliances are connected to the mains using three-core cable.
2. The insulation covering each wire is colour coded for easy identification:
* live wire – brown
* neutral wire – blue
* earth wire – green and yellow stripes
1. The live wire carries the alternating potential difference from the supply.
2. The neutral wire completes the circuit.
3. The earth wire is a safety wire to stop the appliance becoming live.
4. 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).
5. The earth wire is at 0 V, it only carries a current if there is a fault.
* 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.
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| *6.2.4 Energy transfers* |  |  |  |
| **6.2.4.1 Power**[**https://classroom.thenational.academy/lessons/electrical-power-part-1-6hjk6r**](https://classroom.thenational.academy/lessons/electrical-power-part-1-6hjk6r) |  |  |  |
| 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:a) Electrical power transferred: * $power=potential difference x current$
* $P=I x V$

b) Power lost by the heating effect of the electrical power transferred:* $power= current^{2} X resistance$
* $P= I^{2} x R$

power, *P*, in watts, Wpotential difference, *V*, in volts, Vcurrent, *I*, in amperes, A (amp is acceptable for ampere)resistance, *R*, in ohms, Ω |  |  |  |

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| **6.2.4.2 Energy transfers in everyday appliances**[**https://classroom.thenational.academy/lessons/electrical-power-part-2-cgvkjc**](https://classroom.thenational.academy/lessons/electrical-power-part-2-cgvkjc) |  |  |  |
| 1. Everyday electrical appliances are designed to bring about energy transfers.
2. The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power of the appliance.
3. Describe how different domestic appliances transfer energy from batteries or A.C. mains to the kinetic energy of electric motors or the energy of heating devices.
4. Work is done when charge flows in a circuit.
5. The amount of energy transferred by electrical work can be calculated using equations:

$$energy transferred=power x time$$$$E=P x t$$$$energy transferred=charge flow x potential difference$$$$E=Q x V$$energy transferred, *E*, in joules, Jpower, *P*, in watts, Wtime, *t*, in seconds, scharge flow, *Q*, in coulombs, Cpotential difference, *V*, in volts, V1. Explain how the power of a circuit device is related to:
* the potential difference across it and the current through it
* the energy transferred over a given time.
1. Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use.
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| **6.2.4.3 The National Grid**[**https://classroom.thenational.academy/lessons/the-national-grid-c4rp6t**](https://classroom.thenational.academy/lessons/the-national-grid-c4rp6t) |  |  |  |
| 1. The National Grid is a system of cables and transformers linking power stations to consumers.
2. Electrical power is transferred from power stations to consumers using the National Grid.
3. 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.
4. Explain why the National Grid system is an efficient way to transfer energy.
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***Series & parallel circuits review*:**

[*https://classroom.thenational.academy/lessons/review-of-electrical-circuits-6gv3gc*](https://classroom.thenational.academy/lessons/review-of-electrical-circuits-6gv3gc)

***Electrical circuits review:***

<https://classroom.thenational.academy/lessons/review-of-electrical-circuits-6gv3gc>

***Multi-step calculations for Electricity topic:***

<https://classroom.thenational.academy/lessons/multi-step-calculations-6cwkgd>

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| **6.3 Particle model of matter**[*https://classroom.thenational.academy/units/particle-model-of-matter-a6d5*](https://classroom.thenational.academy/units/particle-model-of-matter-a6d5) |  |  |  |
| *6.3.1 Changes of state and the particle model* |  |  |  |
| **6.3.1.1 Density of materials**[**https://classroom.thenational.academy/lessons/density-of-solids-60w3at**](https://classroom.thenational.academy/lessons/density-of-solids-60w3at) |  |  |  |
| a) The density of a material is defined by the equation:* $density= \frac{mass}{volume}$
* $ρ= \frac{m}{V}$

density, *ρ*, in kilograms per metre cubed, kg/m**3**mass, *m*, in kilograms, kgvolume, *V*, in metres cubed, m**3**b) The particle model can be used to explain* the different states of matter
* differences in density.

c) Recognise/draw simple diagrams to model the difference between solids, liquids and gases.d) Explain the differences in density between the different states of matter in terms of the arrangement of atoms or molecules. |  |  |  |
| **https://classroom.thenational.academy/lessons/density-required-practical-6hhk2r** **Required practical activity 5:** use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of regularly shaped objects, and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometer or Vernier callipers. |  |  |  |
| **6.3.1.2 Changes of state** |  |  |  |
| 1. Describe how, when substances change state (melt, freeze, boil, evaporate, condense or sublimate), mass is conserved.
2. Changes of state are physical changes which differ from chemical changes because the material recovers its original properties if the change is reversed.
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| *6.3.2 Internal energy and energy transfers* |  |  |  |
| **6.3.2.1 Internal energy**[**https://classroom.thenational.academy/lessons/internal-energy-70t6ad**](https://classroom.thenational.academy/lessons/internal-energy-70t6ad) |  |  |  |
| 1. Energy is stored inside a system by the particles (atoms and molecules) that make up the system. This is called internal energy.
2. Internal energy is the total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system.
3. 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.
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| **6.3.2.2 Temperature changes in a system and specific heat capacity** |  |  |  |
| a) 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.b) The following equation applies:* $change in thermal energy=mass x specific heat capacity$
* $ΔE=m x c Δθ$

change in thermal energy, Δ*E*, in joules, Jmass, *m*, in kilograms, kgspecific heat capacity, *c*, in joules per kilogram per degree Celsius, J/kg °Ctemperature change, Δ*θ*, in degrees Celsius, °C.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. |  |  |  |
| **6.3.2.3 Changes of heat and specific latent heat**[**https://classroom.thenational.academy/lessons/latent-heat-chjk2r**](https://classroom.thenational.academy/lessons/latent-heat-chjk2r) |  |  |  |
| If a change of state happens:1. The energy needed for a substance to change state is called latent heat.
2. When a change of state occurs, the energy supplied changes the energy stored (internal energy) but not the temperature.
3. 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.
* $energy for a chnge of state=mass x specific latent heat$
* $E=m x L$

energy, *E*, in joules, Jmass, *m*, in kilograms, kgspecific latent heat, *L*, in joules per kilogram, J/kgSpecific latent heat of *fusion* is the change of state from solid to liquidSpecific latent heat of *vaporisation* is the change of state from liquid to vapour |  |  |  |
| **Perform an experiment** to measure the latent heat of fusion of water.Be able to interpret heating and cooling graphs that include changes of state.Be able to distinguish between specific heat capacity and specific latent heat. |  |  |  |
| *6.3.3 Particle model and pressure* |  |  |  |
| **6.3.3.1 Particle motion in gases**[**https://classroom.thenational.academy/lessons/particle-models-6tj34r**](https://classroom.thenational.academy/lessons/particle-models-6tj34r) |  |  |  |
| 1. The molecules of a gas are in constant random motion.
2. The temperature of the gas is related to the average kinetic energy of the molecules.
3. Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas
4. 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.
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***Review of this topic:***

[*https://classroom.thenational.academy/lessons/review-part-1-6mupcr*](https://classroom.thenational.academy/lessons/review-part-1-6mupcr)

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| **6.4 Atomic structure**[**https://classroom.thenational.academy/units/atomic-structure-d811**](https://classroom.thenational.academy/units/atomic-structure-d811) |  |  |  |
| *6.4.1 Atoms and isotopes* |  |  |  |
| **6.4.1.1 The structure of an atom**[**https://classroom.thenational.academy/lessons/exploring-inside-an-atom-c9h6ac**](https://classroom.thenational.academy/lessons/exploring-inside-an-atom-c9h6ac) |  |  |  |
| 1. Atoms are very small, having a radius of about 1 × 10**-10** metres.
2. The basic structure of an atom is a positively charged nucleus composed of both protons and neutrons surrounded by negatively charged electrons.
3. The radius of a nucleus is less than 1/10 000 of the radius of an atom.
4. Most of the mass of an atom is concentrated in the nucleus.
5. The electrons are arranged at different distances from the nucleus (different energy levels).
6. The electron arrangements may change with the absorption of electromagnetic radiation (move further from the nucleus, to a higher energy level) or by the emission of electromagnetic radiation (move closer to the nucleus, to a lower energy level).
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| **6.4.1.2 Mass number, atomic number and isotopes**[**https://classroom.thenational.academy/lessons/isotopes-and-ionisation-crrk8c**](https://classroom.thenational.academy/lessons/isotopes-and-ionisation-crrk8c) |  |  |  |
| 1. In an atom the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.
2. 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.
3. The total number of protons and neutrons in an atom is called its mass number.
4. Atoms can be represented as shown in these examples:

$$ usually in Chemistry$$ usually in Physics1. Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.
2. Atoms turn into positive ions if they lose one or more outer electron(s).
3. Relate differences between isotopes to differences in their identities, charges and masses.
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| **6.4.1.3 The development of the model of the atom (common content with chemistry)**[**https://classroom.thenational.academy/lessons/history-of-atomic-models-c8wk2t**](https://classroom.thenational.academy/lessons/history-of-atomic-models-c8wk2t) |  |  |  |
| 1. New experimental evidence may lead to a scientific model being changed or replaced.
2. Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided.
3. The discovery of the electron led to the plum pudding model of the atom. The plum pudding model suggested that the atom is a ball of positive charge with negative electrons embedded in it.
4. The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model.
5. Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observations.
6. Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name proton was given to these particles.
7. The experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus. This was about 20 years after the nucleus became an accepted scientific idea.
8. This historical context provides an opportunity to show an understanding of why and describe how scientific methods and theories develop over time.
* why the new evidence from the scattering experiment led to a change in the atomic model
* the difference between the plum pudding model of the atom and the nuclear model of the atom.

(Details of experimental work supporting the Bohr model are not required. Details of Chadwick’s experimental work are not required.) |  |  |  |

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| *6.4.2 Atoms and nuclear radiation* |  |  |  |
| **6.4.2.1 Radioactive decay and nuclear radiation**[**https://classroom.thenational.academy/lessons/radioactivity-6tgkjc**](https://classroom.thenational.academy/lessons/radioactivity-6tgkjc) |  |  |  |
| 1. 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.
2. Activity is the rate at which a source of unstable nuclei decays.
3. Activity is measured in becquerel (Bq)
4. Count-rate is the number of decays recorded each second by a detector (eg Geiger-Muller tube).
5. 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 when a neutron turns into a proton and an electron
* a gamma ray (*γ*) – electromagnetic radiation from the nucleus
* (a neutron (n) – as a by-product of nuclear fission)
1. Required knowledge of the properties of alpha particles, beta particles and gamma rays
	* penetration through materials
	* range in air
	* ionising power.
2. 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.
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| **6.4.2.2 Nuclear equations**[**https://classroom.thenational.academy/lessons/decay-equations-crup6d**](https://classroom.thenational.academy/lessons/decay-equations-crup6d) |  |  |  |
| 1. Nuclear equations are used to represent radioactive decay.
2. In a nuclear equation an alpha particle may be represented by the symbol: $$
3. and a beta particle by the symbol: $$
4. 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 alpha decay: $$ so alpha decay causes both the mass and charge of the nucleus to decrease.
* For example beta decay: $$ 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 the examples above.1. 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 decays is not required.1. The emission of a gamma ray does not cause the mass or the charge of the nucleus to change.
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| **6.4.2.3 Half-lives and the random nature of radioactive decay**[**https://classroom.thenational.academy/lessons/activity-and-half-life-ht-c9jk6d**](https://classroom.thenational.academy/lessons/activity-and-half-life-ht-c9jk6d) |  |  |  |
| 1. Radioactive decay is random.
2. The half-life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve, or the time it takes for the count rate (or activity) from a sample containing the isotope to fall to half its initial level.
3. Explain the concept of half-life and how it is related to the random nature of radioactive decay.
4. Determine the half-life of a radioactive isotope from given information.
5. (HT only) Calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives.
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| **6.4.2.4 Radioactive contamination**[**https://classroom.thenational.academy/lessons/uses-and-hazards-of-radiation-combined-science-only-74uk6d**](https://classroom.thenational.academy/lessons/uses-and-hazards-of-radiation-combined-science-only-74uk6d) |  |  |  |
| 1. Radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials.
2. The hazard from contamination is due to the decay of the contaminating atoms.
3. The type of radiation emitted affects the level of hazard.
4. Irradiation is the process of exposing an object to nuclear radiation.
5. The irradiated object does not become radioactive.
6. Compare the hazards associated with contamination and irradiation.
7. Suitable precautions must be taken to protect against any hazard that the radioactive source used in the process of irradiation may present.
8. 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.
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***Review of this topic:***

[*https://classroom.thenational.academy/lessons/p4-atomic-structure-review-part-1-6rv38d*](https://classroom.thenational.academy/lessons/p4-atomic-structure-review-part-1-6rv38d)

<https://classroom.thenational.academy/lessons/p4-atomic-structure-review-part-2-64t32r>

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| **6.5 Forces** |  |  |  |
| *6.5.1 Forces and their interactions* |  |  |  |
| **6.5.1.1 Scalar and vector quantities**[**https://classroom.thenational.academy/lessons/forces-an-introduction-cgwk0d**](https://classroom.thenational.academy/lessons/forces-an-introduction-cgwk0d) |  |  |  |
| 1. Scalar quantities have magnitude (size) only.
2. Vector quantities have magnitude and an associated direction.
3. 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.
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| **6.5.1.2 Contact and non-contact forces**[**https://classroom.thenational.academy/lessons/forces-an-introduction-cgwk0d**](https://classroom.thenational.academy/lessons/forces-an-introduction-cgwk0d) |  |  |  |
| 1. 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.
1. Examples of contact forces include
	* friction
	* air resistance
	* tension
	* normal contact force
2. Examples of non-contact forces are
	* gravitational force
	* electrostatic force
	* magnetic force
3. Force is a vector quantity.
4. 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.
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| **6.5.1.3 Gravity**[**https://classroom.thenational.academy/lessons/weight-mass-and-gravity-74t32d**](https://classroom.thenational.academy/lessons/weight-mass-and-gravity-74t32d) |  |  |  |
| 1. Weight is the force acting on an object due to gravity.
2. The force of gravity close to the Earth is due to the gravitational field around the Earth.
3. The weight of an object depends on the gravitational field strength where the object is.
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| a) The weight of an object can be calculated using the equation:* $weight=mass x gravitational field strength$
* $W=m x g$

weight, *W*, in newtons, Nmass, *m*, in kilograms, kggravitational field strength, *g*, in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength (*g*) will be given.)b) The weight of an object may be considered to act at a single point referred to as the object’s ‘centre of mass’.c) The weight of an object and the mass of an object are directly proportional.d) Weight is measured using a calibrated newton meter (spring-balance). |  |  |  |

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| **6.5.1.4 Resultant forces**[**https://classroom.thenational.academy/lessons/resolving-forces-ht-6hgp4r**](https://classroom.thenational.academy/lessons/resolving-forces-ht-6hgp4r) |  |  |  |
| 1. 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.
2. This single force is called the resultant force.
3. Be able to calculate the resultant of two forces that act in a straight line.

(HT only, d to g)1. describe examples of the forces acting on an isolated object or system
2. use free body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object, including balanced forces when the resultant force is zero.
3. know a single force can be resolved into two components acting at right angles to each other. The two component forces together have the same effect as the single force.
4. use vector diagrams to illustrate resolution of forces, equilibrium situations and determine the resultant of two forces, to include both magnitude and direction (scale drawings only).
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| *6.5.2 Work done and energy transfer*[*https://classroom.thenational.academy/lessons/forces-and-work-6ngkec*](https://classroom.thenational.academy/lessons/forces-and-work-6ngkec) |  |  |  |
| a) 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.b) The work done by a force on an object can be calculated using the equation:* $work done=force x distance moved along the line of action of the force$
* $W=F x s$

work done, *W*, in joules, Jforce, *F*, in newtons, Ndistance, *s*, in metres, me) One joule of work is done when a force of one newton causes a displacement of one metre.1 joule = 1 newton-metref) Students should be able to describe the energy transfer involved when work is done.g) Students should be able to convert between newton-metres and joules.h) Work done against the frictional forces acting on an object causes a rise in the temperature of the object. |  |  |  |

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| *6.5.3 Forces and elasticity*[*https://classroom.thenational.academy/lessons/forces-and-elasticity-part-1-6tjp8c*](https://classroom.thenational.academy/lessons/forces-and-elasticity-part-1-6tjp8c)[*https://classroom.thenational.academy/lessons/forces-and-elasticity-part-2-70vk6t*](https://classroom.thenational.academy/lessons/forces-and-elasticity-part-2-70vk6t) |  |  |  |
| a) 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.

b) 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.* $force=spring constant x extension$
* $F=k x e$

force, *F*, in newtons, Nspring constant, *k*, in newton per metre, N/mextension, *e*, in metres, mc) This relationship also applies to the compression of an elastic object, where ‘*e*’ would be the compression of the object.d) A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. Provided the spring is not permanently deformed, the work done on the spring and the elastic potential energy stored are equal.Students should be able to:1. describe the difference between a linear and non-linear relationship between force and extension
2. calculate a spring constant in linear cases
3. interpret data from an investigation of the relationship between force and extension
4. calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation:
* $elastic potential energy=\frac{1}{2} x spring constant x extension^{2}$
* $E\_{e}= \frac{1}{2} x k x e^{2}$

This equation is also given in Changes in energy.i) Students should be able to calculate relevant values of stored energy and energy transfers. |  |  |  |
| [**https://classroom.thenational.academy/lessons/forces-and-elasticity-part-1-6tjp8c**](https://classroom.thenational.academy/lessons/forces-and-elasticity-part-1-6tjp8c)[**https://classroom.thenational.academy/lessons/forces-and-elasticity-part-2-70vk6t**](https://classroom.thenational.academy/lessons/forces-and-elasticity-part-2-70vk6t)**Required practical activity 6**: investigate the relationship between force and extension for a spring. |  |  |  |

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| *6.5.6 Forces and motion* |  |  |  |
| **6.5.6.1 Describing motion along a line** |  |  |  |
| ***6.5.6.1.1 Distance and displacement*** |  |  |  |
| 1. Distance is how far an object moves. Distance does not involve direction. Distance is a scalar quantity.
2. 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.
3. Students should be able to express a displacement in terms of both the magnitude and direction.
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| ***6.5.6.1.2 Speed***[***https://classroom.thenational.academy/lessons/speed-c5jp4t***](https://classroom.thenational.academy/lessons/speed-c5jp4t) |  |  |  |
| 1. Speed does not involve direction. Speed is a scalar quantity.
2. The speed of a moving object is rarely constant. When people walk, run or travel in a car their speed is constantly changing.
3. The speed at which a person can walk, run or cycle depends on many factors including: age, terrain, fitness and distance travelled.
4. 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. Typical values may be taken as:
	* + - walking ≈ 1.5 m/s
			- running ≈ 3 m/s
			- cycling ≈ 6 m/s
5. It is not only moving objects that have varying speed. The speed of sound and the speed of the wind also vary.
6. A typical value for the speed of sound in air is 330 m/s.
7. Students should be able to make measurements of distance and time and then calculate speeds of objects.

h) For an object moving at constant speed the distance travelled in a specific time can be calculated using the equation:* $distance travelled=speed x time$
* $s=v x t$

distance, *s*, in metres, mspeed, *v*, in metres per second, m/stime, *t*, in seconds, si) Students should be able to calculate average speed for non-uniform motion. |  |  |  |
| ***6.5.6.1.3 Velocity*** |  |  |  |
| 1. The velocity of an object is its speed in a given direction. Velocity is a vector quantity.
2. Students should be able to explain the vector–scalar distinction as it applies to displacement, distance, velocity and speed.
3. (HT only) Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity.
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| ***6.5.6.1.4 The distance–time relationship***[***https://classroom.thenational.academy/lessons/distance-time-graphs-68rp8c***](https://classroom.thenational.academy/lessons/distance-time-graphs-68rp8c) |  |  |  |
| 1. If an object moves along a straight line, the distance travelled can be represented by a distance–time graph.
2. The speed of an object can be calculated from the gradient of its distance–time graph.
3. (HT only) 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.

Students should be able to:1. draw distance–time graphs from measurements
2. extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form
3. determine speed from a distance–time graph
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| ***6.5.6.1.5 Acceleration***[***https://classroom.thenational.academy/lessons/acceleration-60r3ar***](https://classroom.thenational.academy/lessons/acceleration-60r3ar)[***https://classroom.thenational.academy/lessons/velocity-time-graphs-6wr3gr***](https://classroom.thenational.academy/lessons/velocity-time-graphs-6wr3gr)[***https://classroom.thenational.academy/lessons/terminal-velocity-75hkec***](https://classroom.thenational.academy/lessons/terminal-velocity-75hkec) |  |  |  |
| a) The average acceleration of an object can be calculated using the equation:* $acceleration= \frac{change in velocity}{time taken}$
* $a= \frac{Δv}{t}$

acceleration, *a*, in metres per second squared, m/s**2**change in velocity, Δ*v*, in metres per second, m/stime, *t*, in seconds, s1. An object that slows down is decelerating.
2. Students should be able to estimate the magnitude of everyday accelerations.
3. The acceleration of an object can be calculated from the gradient of a velocity–time graph.
4. (HT only) 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:1. draw velocity–time graphs from measurements and interpret lines and slopes to determine acceleration
2. (HT only) interpret enclosed areas in velocity–time graphs to determine distance travelled (or displacement)
3. (HT only) measure, when appropriate, the area under a velocity–time graph by counting squares.
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| a) The following equation applies to uniform acceleration (e.g. acceleration due to gravity):* $final velocity^{2}- initial velocity^{2}=2 x acceleration x distance$
* $v^{2}- u^{2}=2 x a x s$

final velocity, *v*, in metres per second, m/sinitial velocity, *u*, in metres per second, m/sacceleration, *a*, in metres per second squared, m/s**2**distance, *s*, in metres, mb) Near the Earth’s surface any object falling freely under gravity has an acceleration of about 9.8 m/s**2**.c) 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:d) draw and interpret velocity–time graphs for objects that reach terminal velocitye) interpret the changing motion in terms of the forces acting. |  |  |  |
| **6.5.6.2 Forces, accelerations and Newton’s Laws of motion**[**https://classroom.thenational.academy/lessons/newtons-laws-c9k3at**](https://classroom.thenational.academy/lessons/newtons-laws-c9k3at) |  |  |  |
| ***6.5.6.2.1 Newton’s First Law*** |  |  |  |
| 1. Newton’s First Law:

If the resultant force acting on an object is zero:* and the object is stationary, the object remains stationary
* and the object is moving, the object continues to move at the same speed and in the same direction and at the same velocity.
1. When a vehicle travels at a steady speed the resistive forces balance the driving force.
2. 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:1. the motion of objects moving with a uniform velocity
2. the motion of objects where the speed and/or direction changes.
3. (HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia.
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| ***6.5.6.2.2 Newton’s Second Law*** |  |  |  |
| 1. 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.1. As an equation:

$$resultant force=mass x acceleration$$$$F=m x a$$force, *F*, in newtons, Nmass, *m*, in kilograms, kgacceleration, *a*, in metres per second squared, m/s**2**1. Students should recognise and be able to use the symbol for proportionality, ∝
2. (HT only) 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 ratio of force over acceleration.
1. Students should be able to estimate the speed, accelerations and forces involved in large accelerations for everyday road transport.
2. Students should recognise and be able to use the symbol that indicates an approximate value or approximate answer, ≈, ~.
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| [**https://classroom.thenational.academy/lessons/acceleration-rpa-part-1-6xhp2c**](https://classroom.thenational.academy/lessons/acceleration-rpa-part-1-6xhp2c)[**https://classroom.thenational.academy/lessons/acceleration-rpa-part-2-c4v3gr**](https://classroom.thenational.academy/lessons/acceleration-rpa-part-2-c4v3gr)**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 object on the acceleration produced by a constant force. |  |  |  |
| ***6.5.6.2.3 Newton’s Third Law*** |  |  |  |
| 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.
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| **6.5.6.3 Forces and braking** |  |  |  |
| ***6.5.6.3.1 Stopping distance***[***https://classroom.thenational.academy/lessons/stopping-distance-6wvk4c***](https://classroom.thenational.academy/lessons/stopping-distance-6wvk4c) |  |  |  |
| 1. 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).
2. For a given braking force the greater the speed of the vehicle, the greater the stopping distance.
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| ***6.5.6.3.2 Reaction time*** |  |  |  |
| 1. Reaction times vary from person to person. Typical values range from 0.2 s to 0.9 s.
2. 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:1. explain methods used to measure human reaction times and recall typical results
2. interpret and evaluate measurements from simple methods to measure the different reaction times of students
3. evaluate the effect of various factors on thinking distance based on given data.
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| ***6.5.6.3.3 Factors affecting braking distance 1*** |  |  |  |
| 1. The braking distance of a vehicle can be affected by adverse road and weather conditions and poor condition of the vehicle.
2. 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:1. explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies, and the implications for safety
2. estimate how the distance required for road vehicles to stop in an emergency varies over a range of typical speeds.
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| ***6.5.6.3.4 Factors affecting braking distance 2*** |  |  |  |
| 1. 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.
2. The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.
3. 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:1. explain the dangers caused by large decelerations
2. (HT only) estimate the forces involved in the deceleration of road vehicles in typical situations on a public road.
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| *6.5.7 Momentum (HT only)*[*https://classroom.thenational.academy/lessons/momentum-64r6ad*](https://classroom.thenational.academy/lessons/momentum-64r6ad) |  |  |  |
| **6.5.7.1 Momentum is a property of moving objects** |  |  |  |
| Momentum is defined by the equation:* $momentum=mass x velocity$
* $p=m x v$

momentum, *p*, in kilograms metre per second, kg m/smass, *m*, in kilograms, kgvelocity, *v*, in metres per second, m/s |  |  |  |
| **6.5.7.2 Conservation of momentum**[**https://classroom.thenational.academy/lessons/collisions-and-car-safety-crwkce**](https://classroom.thenational.academy/lessons/collisions-and-car-safety-crwkce) |  |  |  |
| 1. In a closed system, the total momentum before an event is equal to the total momentum after the event.
2. This is called conservation of momentum.

Students should be able to use the concept of momentum as a model to:1. describe and explain examples of momentum in an event, such as a collision
2. (physics only) complete calculations involving an event, such as the collision of two objects.
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**Review of the FORCES topic:**

<https://classroom.thenational.academy/lessons/combined-science-review-6mw3gc>

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| **6.6 Waves** |  |  |  |
| *6.6.1 Waves in air, fluids and solids*[*https://classroom.thenational.academy/lessons/wave-properties-60vk0d*](https://classroom.thenational.academy/lessons/wave-properties-60vk0d) |  |  |  |
| **6.6.1.1 Transverse and longitudinal waves** |  |  |  |
| 1. Waves may be either transverse or longitudinal.
2. The ripples on a water surface are an example of a transverse wave.
3. Longitudinal waves show areas of compression and rarefaction.
4. Sound waves travelling through air are longitudinal.
5. Students should be able to describe the difference between longitudinal and transverse waves.
6. 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.
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| **6.6.1.2 Properties of waves**[**https://classroom.thenational.academy/lessons/calculations-with-waves-6xh66e**](https://classroom.thenational.academy/lessons/calculations-with-waves-6xh66e) |  |  |  |
| 1. Students should be able to describe wave motion in terms of their amplitude, wavelength, frequency and period.
2. The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.
3. The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.
4. The frequency of a wave is the number of waves passing a point each second.
* $period= \frac{1}{frequency}$
* $T= \frac{1}{f}$

period, *T*, in seconds, sfrequency, *f*, in hertz, Hze) The wave speed is the speed at which the energy is transferred (or the wave moves) through the medium. |  |  |  |
| a) All waves obey the wave equation:* $wave speed=frequency x wavelength$
* $v=f x λ$

wave speed, *v*, in metres per second, m/sfrequency, *f*, in hertz, Hzwavelength, *λ*, in metres, mStudents should be able to:1. identify amplitude and wavelength from given diagrams
2. describe a method to measure the speed of sound waves in air
3. describe a method to measure the speed of ripples on a water surface.
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| [**https://classroom.thenational.academy/lessons/measuring-the-speed-of-waves-in-water-69k3jd**](https://classroom.thenational.academy/lessons/measuring-the-speed-of-waves-in-water-69k3jd)[**https://classroom.thenational.academy/lessons/measuring-the-speed-of-waves-in-solids-c9gk6t**](https://classroom.thenational.academy/lessons/measuring-the-speed-of-waves-in-solids-c9gk6t)**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. |  |  |  |
| *6.6.2 Electromagnetic waves* |  |  |  |
| **6.6.2.1 Types of electromagnetic waves**[**https://classroom.thenational.academy/lessons/electromagnetic-spectrum-part-1-6dk62r**](https://classroom.thenational.academy/lessons/electromagnetic-spectrum-part-1-6dk62r) |  |  |  |
| 1. Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber.
2. Electromagnetic waves form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.
3. 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 and gamma rays.

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| long wavelength short wavelength |
| radio waves | microwaves | infrared | visible light | ultraviolet | X-rays | gamma rays |
| low frequency high frequency |

d) Our eyes only detect visible light and so detect a limited range of electromagnetic waves.e) Our skin can detect temperature so we can detect infra-red waves.f) Students should be able to give examples that illustrate the transfer of energy by electromagnetic waves. |  |  |  |
| **6.6.2.2 Properties of electromagnetic waves 1**[**https://classroom.thenational.academy/lessons/refraction-cmr64c**](https://classroom.thenational.academy/lessons/refraction-cmr64c) |  |  |  |
| 1. (HT only) Different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength.
2. (HT only) Some effects, for example refraction, are due to the difference in velocity of the waves in different substances.
3. Students should be able to construct ray diagrams to illustrate the refraction of a wave at the boundary between two different media.
4. (HT only) Students should be able to use wave front diagrams to explain refraction in terms of the change of speed that happens when a wave travels from one medium to a different medium.
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| **Required practical activity 10**: investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface. |  |  |  |

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| **6.6.2.3 Properties of electromagnetic waves 2**[**https://classroom.thenational.academy/lessons/electromagnetic-spectrum-part-2-c9h3cr**](https://classroom.thenational.academy/lessons/electromagnetic-spectrum-part-2-c9h3cr) |  |  |  |
| 1. (HT only) Radio waves can be produced by oscillations in electrical circuits.
2. (HT only) 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. 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.
4. 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.
5. Radiation dose (in sieverts) is a measure of the risk of harm resulting from an exposure of the body to the radiation.
6. 1000 millisieverts (mSv) = 1 sievert (Sv)

Students will not be required to recall the unit of radiation dose.1. Students should be able to draw conclusions from given data about the risks and consequences of exposure to radiation.
2. Ultraviolet waves can cause skin to age prematurely and increase the risk of skin cancer.
3. X-rays and gamma rays are ionising radiation that can cause the mutation of genes and cancer.
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| **6.6.2.4 Uses and applications of electromagnetic waves**[**https://classroom.thenational.academy/lessons/infrared-60u3cd**](https://classroom.thenational.academy/lessons/infrared-60u3cd) |  |  |  |
| 1. 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.
1. (HT only) Students should be able to give brief explanations why each type of electromagnetic wave is suitable for the practical application.
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**Review of the WAVES topic:**

[**https://classroom.thenational.academy/lessons/combined-science-review-c9j6ad**](https://classroom.thenational.academy/lessons/combined-science-review-c9j6ad)

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| **6.7 Magnetism and electromagnetism** |  |  |  |
| *6.7.1 Permanent and induced magnetism, magnetic forces and fields* |  |  |  |
| **6.7.1.1 Poles of a magnet** |  |  |  |
| 1. The poles of a magnet are the places where the magnetic forces are strongest.
2. When two magnets are brought close together they exert a force on each other.
3. 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.
4. A permanent magnet produces its own magnetic field.
5. An induced magnet is a material that becomes a magnet when it is placed in a magnetic field. Induced magnetism always causes a force of attraction. When removed from the magnetic field an induced magnet loses most/all of its magnetism quickly.
6. 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.
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| **6.7.1.2 Magnetic fields**[**https://classroom.thenational.academy/lessons/magnetism-75jpad**](https://classroom.thenational.academy/lessons/magnetism-75jpad)[**https://classroom.thenational.academy/lessons/magnetic-fields-61jkcc**](https://classroom.thenational.academy/lessons/magnetic-fields-61jkcc) |  |  |  |
| 1. The region around a magnet where a force acts on another magnet or on a magnetic material (iron, steel, cobalt and nickel) is called the magnetic field.
2. The force between a magnet and a magnetic material is always one of attraction.
3. The strength of the magnetic field depends on the distance from the magnet. The field is strongest at the poles of the magnet.
4. The direction of the magnetic field at any point is given by the direction of the force that would act on another north pole placed at that point.
5. The direction of a magnetic field *line* is from the north (seeking) pole of a magnet to the south (seeking) pole of the magnet.
6. A magnetic compass contains a small bar magnet. The Earth has a magnetic field. The compass needle points in the direction of the Earth’s magnetic field.
7. 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.
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| *6.7.2 The motor effect* |  |  |  |
| **6.7.2.1 Electromagnetism**[**https://classroom.thenational.academy/lessons/electromagnetism-cgv64r**](https://classroom.thenational.academy/lessons/electromagnetism-cgv64r) |  |  |  |
| 1. When a current flows through a conducting wire a magnetic field is produced around the wire.
2. The strength of the magnetic field depends on the current through the wire and the distance from the wire.
3. Shaping a wire to form a solenoid increases the strength of the magnetic field created by a current through the wire. The magnetic field inside a solenoid is strong and uniform.
4. The magnetic field around a solenoid has a similar shape to that of a bar magnet. Adding an iron core increases the strength of the magnetic field of a solenoid. An electromagnet is a solenoid with an iron core.

Students should be able to:1. describe how the magnetic effect of a current can be demonstrated
2. draw the magnetic field pattern for a straight wire carrying a current and for a solenoid (showing the direction of the field)
3. explain how a solenoid arrangement can increase the magnetic effect of the current.
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| **6.7.2.2 Fleming’s left-hand rule (HT only)**[**https://classroom.thenational.academy/lessons/the-motor-effect-and-left-hand-rule-cctp8c**](https://classroom.thenational.academy/lessons/the-motor-effect-and-left-hand-rule-cctp8c)[**https://classroom.thenational.academy/lessons/f-b-i-l-74uk4d**](https://classroom.thenational.academy/lessons/f-b-i-l-74uk4d) |  |  |  |
| 1. When a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other. This is called the motor effect.
2. 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.
3. Students should be able to recall the factors that affect the size of the force on the conductor.
4. For a conductor at right angles to a magnetic field and carrying a current:
* $force=magnetic flux density x current x length$
* $F=B x I x l$

force, *F*, in newtons, Nmagnetic flux density, *B*, in tesla, Tcurrent, *I*, in amperes, A (amp is acceptable for ampere)length,$ l$, in metres, m |  |  |  |
| **6.7.2.3 Electric motors (HT only)**[**https://classroom.thenational.academy/lessons/dc-motors-74r32c**](https://classroom.thenational.academy/lessons/dc-motors-74r32c) |  |  |  |
| 1. A coil of wire carrying a current in a magnetic field tends to rotate.
2. This is the basis of an electric motor.
3. 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.
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**Review of the Electromagnetism topic:**

<https://classroom.thenational.academy/lessons/p7-magnetism-revision-part-1-6cv3gc>

**PHYSICS EQUATIONS TO LEARN BY HEART**

| **ENERGY** |
| --- |
|  | **Quantity** | **Unit** | **Equation** |
| ENERGY | *1* | **Ek****m****v** | kinetic energymassvelocity | joulekilogrammetres per second | Jkgm/s | $$E\_{k}=\frac{1}{2} x m x v^{2}$$ |
| *2* | **Ep****m****g****h** | gravitational potential energymassgravitational field strengthheight | joulekilogramnewton per kilogramm | JkgN/kgm | $$E\_{p}=m x g x h$$ |
| *3* | **P****W****t** | powerworktime | wattjoulesecond | WJs | $$P=\frac{W}{t}$$ |
| **ENERGY and ELECTRICITY** |
|  | **Quantity** | **Unit** | **Equation** |
| *ENERGY & ELECTRICITY* | *4* | **P****E****T****-** | powerenergytimeefficiency (no symbol) | wattjoulesecondno unit | WJS- | $$P=\frac{E}{t}$$ |
| *5* | $$E=P x t$$ |
| *6* | $$efficiency=\frac{useful energy out}{total energy in}$$ |
| *7* | $$efficiency=\frac{useful power out}{total power in}$$ |
| **ELECTRICITY** |
|  | **Quantity** | **Unit** | **Equation** |
| *ELECTRICITY* | *8* | **Q****I****V****R****P****E****t** | chargecurrentpotential differenceresistancepowerenergytime | coulombampvoltohmwattjoulesecond | CAV𝛺WJs | $$Q=I x t$$ |
| *9* | $$V=I x R$$ |
| *10* | $$P=V x I$$ |
| *11* | $$P= I^{2} x R$$ |
| *12* | $$E=Q x V$$ |
| **PARTICLE MODEL topic** |
|  | **Quantity** | **Unit** | **Equation** |
| *PART-ICLES* | *13* | **𝞀****m****v** | densitymassvolume | kilogram per metre3kilogrammetre3 | kg/m3kgm3 | $$ρ=\frac{m}{v}$$ |

**PHYSICS EQUATIONS TO LEARN BY HEART (SEPARATE PHYSICS)**

| **FORCES** |
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|  | **Quantity** | **Unit** | **Equation** |
| *FORCES* | *14* | **W****m****g** | weightmassgravitational field strength | newtonkilogramnewton per kilogram | NkgN/kg | $$W=m x g$$ |
| *15* | **W****F****s** | work doneforce distance travelled | joulenewtonmetre | JNm | $$W=F x s$$ |
| *16* | **F****k****e** | forcespring constantextension | newtonnewton per metremetres | NN/mm | $$F=k x e$$ |
| *17\** | **M****F****d** | momentforcedistance (perpendicular to pivot) | newton metrenewtonmetre | NmNm | $$M=F x d$$ |
| *18\** | **p****F****A** | pressureforcearea | pascalnewtonmetre**2** | PaNm**2** | $$p=\frac{F}{A}$$ |
| *19* | **s****v****t** | distancevelocitytime | metremetre per secondsecond | mm/ss | $$s=v x t$$ |
| *20* | **a****v****u****t** | accelerationfinal velocityinitial velocitytime | metre per second**2**metre per secondmetre per secondsecond | m/s**2**m/sm/ss | $a=\frac{Δv}{t}$OR$$a=\frac{(v-u)}{t}$$ |
| *21* | **F****m****a** | forcemassacceleration | newtonkilogrammetre per second**2** | Nkgm/s**2** | $$F=m x a$$ |
| *22HT* | **p****m****v** | momentummassvelocity | kilogram metre per secondkilogrammetre per second | kg m/skgm/s | $$p=m x v$$ |
| **WAVES** |
|  | **Quantity** | **Unit** | **Equation** |
| *WAVES* | *23* | **v****f****λ** | velocityfrequencywavelength | metre per secondhertzmetre | m/sHzm | $$v=f x λ$$ |

 \* For separate sciences only.

 HT Higher tier only.