JABstem

National 5

Physics

Self-Evaluation Summary

National 5 Physics Unit 1a
Dynamics: Vectors and Scalars

No.		Traffic Light: Red	Amber	Green

1
2

A **vector** quantity has both size/magnitude and direction.

force	*velocity*	*displacement*	*weight*	*acceleration*

A **scalar** quantity has only size/magnitude but no direction.

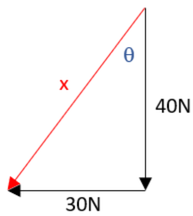
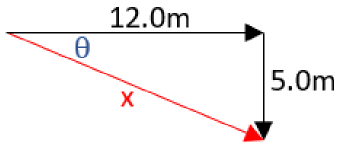
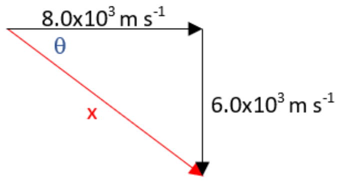
time	*speed*	*distance*	*mass*	*energy*

- Energy could be kinetic energy, potential energy, other forms of energy or work done.

☹ 😐 ☺

3
4
5

The resultant of two vector quantities in one dimension or at right angles can be worked out from scale diagrams or calculation for forces, displacements and velocities.

Forces	Displacement	Velocity
Resultant:  	Resultant:  	Resultant: 
Magnitude: $x = \sqrt{(40)^2 + (30)^2}$ $x = \sqrt{1600 + 900}$ $x = \sqrt{2500}$ $x = 50$ N	Magnitude: $x = \sqrt{(12.0)^2 + (5.0)^2}$ $x = \sqrt{144 + 25}$ $x = \sqrt{169}$ $x = 13$ m	Magnitude: $x = \sqrt{(6000)^2 + (8000)^2}$ $x = \sqrt{36000000 + 64000000}$ $x = \sqrt{100000000}$ $x = 10000\ m\ s^{-1}$
Direction: $\tan\theta = \frac{opp}{adj} = \frac{30}{40} = 0.75 \therefore \theta = 37^\circ$ Bearing = 180° + 37° = 217°	Direction: $\tan\theta = \frac{opp}{adj} = \frac{5.0}{12.0} = 0.417 \therefore \theta = 23^\circ$ Bearing = 90° + 23° = 127°	Direction: $\tan\theta = \frac{opp}{adj} = \frac{6.0x10^3}{8.0x10^3} = 0.75 \therefore \theta = 37^\circ$ Bearing = 90° + 37° = 127°

☹ 😐 ☺

6

Problems involving velocity, speed, displacement, distance and time can be solved using:

a) **$s = v\ t$**

Symbol	Quantity	Unit
s	displacement	m
v	instantaneous velocity	$m\ s^{-1}$
t	time	s

b) **$s = \bar{v}\ t$**

Symbol	Quantity	Unit
s	displacement	m
$\bar{v}$	average velocity	$m\ s^{-1}$
t	time	s

c) **$d = \bar{v}\ t$**

Symbol	Quantity	Unit
d	distance	m
$\bar{v}$	average speed	$m\ s^{-1}$
t	time	s

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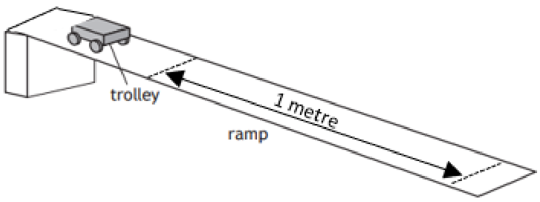
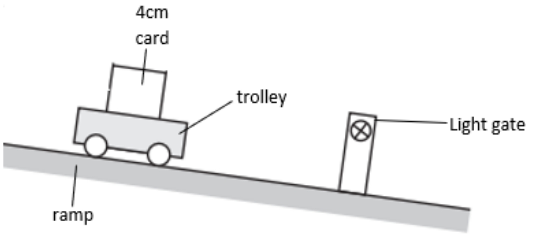
7

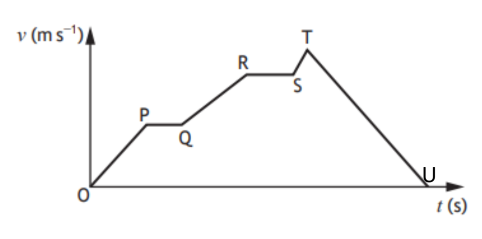
Experiments to measure average and instantaneous speed can be performed.

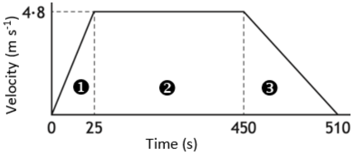
Average Speed Experiment	Instantaneous Speed Experiment
 	
Measure the time taken for the trolley to travel the 1 metre on the ramp with a stopwatch or light gates. The average speed over the 1 metre length can be worked out by:	The light gate will measure the time taken for the 4cm card on the trolley to pass though the light gate. The instantaneous velocity can be worked out by:
$\bar{v} = \frac{d}{t} = \frac{1\ m}{2.12\ s} = 0.47\ m\ s^{-1}$	$v = \frac{s}{t} = \frac{0.04\ m}{0.16} = 0.25\ m\ s^{-1}$

☹ 😐 ☺

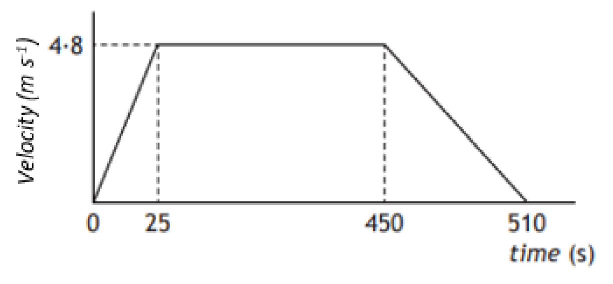
<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 1b
Dynamics: Velocity–Time Graphs</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>8
9</td><td>Velocity–time or speed–time graphs can be drawn and/or interpreted.

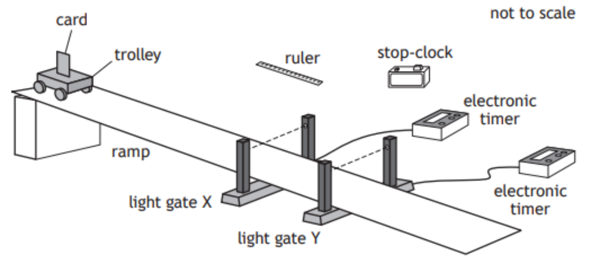
Straight horizontal line indicates constant velocity
Straight uphill line (i.e. positive gradient) indicates constant acceleration
Straight downhill line (i.e. negative gradient) indicates constant deceleration



<table>
<tr><td>O → P</td><td>Constant acceleration (higher than Q→R)</td></tr>
<tr><td>P → Q</td><td>Constant velocity</td></tr>
<tr><td>Q → R</td><td>Constant acceleration (lower than O→P)</td></tr>
<tr><td>R → S</td><td>Constant velocity</td></tr>
<tr><td>S → T</td><td>Constant acceleration (highest as steepest)</td></tr>
<tr><td>T → U</td><td>Negative acceleration (deceleration)</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>10</td><td>Displacement can be determined from the area under a velocity–time graph.


<table>
<tr><th>Area ❶</th><th>Area ❷</th><th>Area ❸</th></tr>
<tr><td>Distance = area under graph
$= \frac{1}{2} \times 25 \times 4.8$
= 60 m</td><td>Distance = area under graph
= 4.8 x 425
= 2040 m</td><td>Distance = area under graph
$= \frac{1}{2} \times 60 \times 4.8$
= 144 m</td></tr>
<tr><td colspan="3">Total distance = 60 + 2040 + 144 = 2244m</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 1c
Dynamics: Acceleration</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>11
12</td><td>Acceleration is the change on velocity per unit time.
The equation for calculating acceleration is: $a = \frac{v - u}{t}$
e.g. Calculate the acceleration of a car which has an initial speed of 5 m s^{-1} and accelerated over a period of 20 s to a final speed of 45 m s^{-1}
a = ? $v = 45$ m s^{-1} $u = 5$ m s^{-1} t = 20 s
$a = \frac{v - u}{t} = \frac{45 - 5}{20} = \mathbf{2.0\ m\ s^{-2}}$</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>13</td><td>Determination of acceleration from a velocity–time graph.
acceleration a = gradient of the line on a v - t graph.


Calculate the acceleration in the first 25 seconds:
$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$
$\text{gradient} = \frac{4.8 - 0.0}{25 - 0}$
$\text{gradient} = \frac{4.8}{25}$
gradient = 0.19 m s^{-2}</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>14</td><td>Acceleration can be calculated using the following experiment:


Acceleration can be measured by:

Measuring the initial velocity (u) of the tolley as it passes through light gate X
Measuring the final velocity (v) of the trolley as it passes through light gate Y
The time taken (t) is measured with a stopwatch

Acceleration is calculated using the equation
$a = \frac{v - u}{t}$</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

No.

National 5 Physics Unit 1d
Dynamics: Newton's Laws

Traffic Light: Red | Amber | Green

15 16

Newton's laws can explain constant velocity using balanced forces. frictional forces. Application of Newton's laws and unbalanced forces to explain and/or determine acceleration for situations where more than one force is acting.

<u>Newton's First Law</u>:
An object will remain at rest or continue to travel with constant speed, and in the same direction, unless acted upon by an unbalanced force.

<u>Newton's Second Law</u>:
The acceleration of a body is proportional to the unbalanced force acting upon it and inversely proportion to the objects mass.

☹ 😐 ☺

17

Problems involving unbalanced force, mass and acceleration for forces acting in one dimension or at right angles can be solved using the following equation:

$$F = m\ a$$

Symbol	**Quantity**	**Unit**
F	Unbalanced Force	N
m	mass	kg
a	acceleration	m

e.g. Calculate the acceleration of the 5.0kg block shown in the diagram.

F_{un} = 25N – 15N = 10 N (WEST)

m = 0.5 kg a = ?

$a = \frac{F}{m} = \frac{10}{5.0} = \underline{\mathbf{2.0\ m\ s^{-2}}}$ **(WEST)**

☹ 😐 ☺

18

Problems involving weight, mass and gravitational field strength use the following equation:

$$W = m\ g$$

Symbol	**Quantity**	**Unit**
W	weight	N
m	mass	kg
g	gravitational field strength	$N\ kg^{-1}$

e.g. Calculate the weight of a spaceship, including fuel & crew, of 1.3×10^6 kg on planet Mars.

W = ?
$m = 1.3x10^6$ kg
$g = 3.7\ N\ kg^{-1}$

W = m g
$W = 1.3x10^6 \quad x \quad 3.7$
W = $\mathbf{4.8x10^6\ N}$

☹ 😐 ☺

19

<u>Newton's Third Law</u>:
If object A exerts a force on object B, then object B exerts an equal and opposite force on object A

A person is sitting on a chair:
A person exerts a force on a chair and the chair exerts an equal but opposite force on person.

The chair that a person is sitting on:
The chair exerts a force on Earth and the Earth exerts an equal but opposite force on the chair

☹ 😐 ☺

20

Explanation of free-fall and terminal velocity in terms of Newton's laws.

When an object falls out of an aeroplane	The object accelerates as due to gravity	Eventually the object in free fall will hit terminal velocity	At terminal velocity weight is equal and opposite to the air resistance	Forces are balances and object falls at constant velocity

☹ 😐 ☺

No.	Traffic Light: Red	Amber	Green

National 5 Physics Unit 1e
Dynamics: Energy

21 Energy cannot be created or destroyed. Energy can only be converted from one form of energy to another and energy can then be transferred.

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22 Work done is a measure of the energy required to move an object through a distance.

- Work done can have the symbol E_w or W.

$$E_W = F\ d$$

Symbol	Quantity	Unit
E_w	Work Done	J
F	Unbalanced Force	N
d	distance/displacement	m

e.g. A car of mass 1200 kg is travelling along a straight level road at a constant speed. The driving force on the car is 2500 N as it drives over a 50m stretch of road. Calculate the work done moving the car over this stretch of road?

E_w = ?
F = 2500 N
d = 50m

E_w = F d
E_w = 2500 x 50
E_w = **125000 J**

☹ 😐 ☺

23
24
Gravitational potential energy is the energy an object has by virtue of its position above the surface of the Earth. Gravitational potential energy problems can be solved using the equation:

$$E_p = mgh$$

Symbol	Quantity	Unit
E_p	Gravitational Potential Energy	J
m	Mass of object	kg
g	Gravitational field strength	$N\ kg^{-1}$
h	Height of object	m

e.g. An inflatable raft is dropped from an aircraft into the sea from a height of 250m as part of a rescue. Calculate the gravitational potential energy the raft has just as it is dropped from the aircraft if its mass is 60 kg.

E_p = ? m = 60 kg
g = 9.8 $N\ kg^{-1}$ h = 250m

E_p = m g h
E_p = 60 x 9.8 x 250
E_p = **1.47×10^5 J**

☹ 😐 ☺

25
26
Kinetic energy is the energy an object possesses by virtue of its movement.

- The greater the mass and the speed of the object the greater its kinetic energy.
- Kinetic energy problems are solved using the following equation:

$$E_k = \frac{1}{2}mv^2$$

Symbol	Quantity	Unit
E_k	Kinetic Energy	J
m	Mass	kg
v	Velocity	$m\ s^{-1}$

e.g. after passing Jupiter, New Horizons was travelling at a speed of 23·0 $km\ s^{-1}$. The mass of New Horizons space probe is 454 kg. Calculate the kinetic energy of New Horizons space probe.

E_k = ?
m = 454 kg
v = 23.0 $km\ s^{-1}$ = 23000 $m\ s^{-1}$

$E_k = \frac{1}{2}$ m v^2
$E_k = \frac{1}{2}$ x 454 x $(23000)^2$
E_k = **1.20×10^{11} J**

☹ 😐 ☺

27 Use the following relationships to solve problems involving conservation of energy.

E_w = Fd or W = Fd E_p = mgh $E_k = \frac{1}{2}mv^2$

e.g. A ball is dropped from a height of 5.0 m to the ground. If the ball has a mass of 0.5 kg, calculate the velocity the ball hits the ground at assuming no air resistance.

E_p = ? m = 0.5 kg g = 9.8 $N\ kg^{-1}$ h = 5.0 m
E_p = m g h
= 0.5 x 9.8 x 5.0
= 24.5 J

Due to conservation of energy
E_p at start = E_k at end

E_k = 24.5 J m = 0.5 kg v = ?
$E_k = \frac{1}{2}mv^2$
$24.5 = \frac{1}{2} \times 0.5 \times v^2$
v^2 = 98
v = 9.9 $m\ s^{-1}$

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No.

National 5 Physics Unit 1f
Dynamics: Projectile Motion

Traffic Light

Red

Amber

Green

28

The motion of an object moving freely through the air can be analysed by considering the horizontal component of the motion separately from the vertical component. The trajectory of the object has

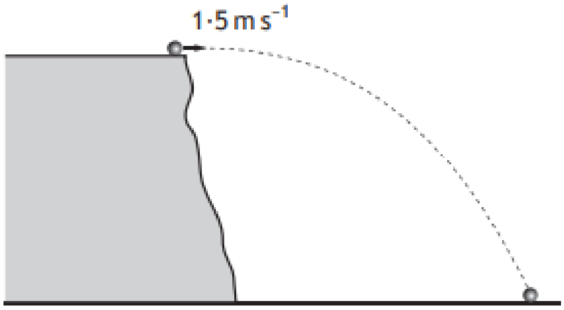
- a horizontal component has constant velocity in the original horizontal direction of the object
- a vertical component has a constant vertical acceleration due to gravity

29

Use of appropriate relationships to solve problems involving projectile motion from a horizontal launch, including the use of motion graphs.

Horizontal	Vertical
The area under a v_h – t graph can be used to calculate the horizontal distance travelled	The area under a v_v – t graph can be used to calculate the vertical distance fallen.
Constant Horizontal Velocity $v_h = \frac{s}{t}$ Can be used to calculate the displacement or time using the horizontal velocity at the start. The horizontal velocity remains constant unless acted upon by friction/air resistance.	**Constant Vertical Acceleration** $v_v = u_v + at$ Used to calculate the vertical velocity of an object hitting the ground if the time to hit the ground is known

e.g. A ball is projected horizontally with a velocity of 1.5 m s^{-1} and it hits the ground 1.2s later.
Calculate a) the distance the ball has travelled from the top edge of the cliff horizontally
b) the vertical velocity the ball hits the ground with
c) the vertical distance from the top of the cliff to the ground level



$v_h = 1.5$ m s^{-1} s = ? t = 1.2 s

$v_h = \frac{s}{t} \quad \therefore \quad 1.5 = \frac{s}{1.2} \quad \therefore$ **s** $= 1.5 \times 1.2 =$ **1.8 m**

$$\mathbf{v_v} = u_v + at$$
$$v_v = 0 + (9.8x1.2)$$
$$v_v = 0 + 11.8 \text{ m s}^{-1}$$
$$v_v = \mathbf{11.8 \text{ m s}^{-1}}$$

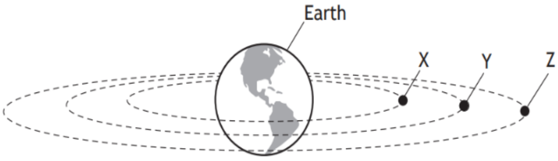
$\bar{v}_v$ = ? $u_v = 0$ m s^{-1} $v_v = 11.8$ m s^{-1}

$$\bar{v}_v = \frac{u_v + v_v}{2} = \frac{0 + 11.8}{2} = \frac{11.8}{2} = 5.9 \text{ m s}^{-1}$$

$\bar{v}_h = \frac{d}{t} \quad \therefore \quad 5.9 = \frac{s}{1.2} \quad \therefore$ **s** $= 5.9 \times 1.2 =$ **7.1 m**

30

Explanation of satellite orbits in terms of projectile motion, horizontal velocity and weight.

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 2a
Space: Space Exploration</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>31</td><td>Basic awareness of our *current* understanding of the universe.
The universe is a term that is used to describe everything that exists in the entirety of space.
The universe is of a collection of galaxies. Some astronomers' estimates mention a figure of 2 trillion galaxies (2×10^{12} galaxies).
As more information becomes available, scientists refine their theories about the origins and structure of the universe. Current theories regarding the origin of the universe favour the 'Big Bang' model, happening nearly 14 billion years ago leading to the continuing formation of stars and galaxies.</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>32</td><td>Understand the use of the following terms:
<table>
<tr><td>Planet</td><td>An object that orbits a star/sun but does not undergo nuclear fusion</td></tr>
<tr><td>Dwarf Planet</td><td>Orbits a star similar to a planet but too small to clear its orbital path of debris</td></tr>
<tr><td>Moon</td><td>A natural satellite that orbits a planet</td></tr>
<tr><td>Sun</td><td>A star at the centre of a solar system</td></tr>
<tr><td>Asteroid</td><td>An object that orbits sun but does not meet all the requirements to be a planet</td></tr>
<tr><td>Solar System</td><td>A central star orbited by planets</td></tr>
<tr><td>Star</td><td>Large ball of hot gases undergoing nuclear fusion and emitting EM radiation.</td></tr>
<tr><td>Exoplanet</td><td>A planet that orbits a star outside our solar system</td></tr>
<tr><td>Galaxy</td><td>A cluster of gravitationally bound stars, gas and dust clouds.</td></tr>
<tr><td>Universe</td><td>A universe consists of many galaxies separated by empty space.</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>33</td><td>Satellites have many benefits:
<table>
<tr><td colspan="2">**Weather Forecasting**
Geostationary weather satellites are used to photograph cloud cover, images are animated and used in weather forecasts on TV.
Polar orbiting satellites collect data measurements twice a day at the same point on the Earth's surface at the same time each day. Three polar-orbiting satellites working together can observe the entire planet every six hours.</td><td>**Space Telescopes**
Some forms of EM Radiation are blocked by the Earth's atmosphere, but can be detected by telescopes placed in orbit round the Earth.
The Hubble Space Telescope in space can observe the whole sky, both night and day. While it is difficult and expensive to launch & maintain a space telescope, they give images far more detailed than those that can be taken on Earth. The James Webb space telescope was launched in 2021 and produces excellent high definition images.</td></tr>
<tr><td>**Communications**
Signals are received by a satellite, amplified and then retransmitted on a different frequency back to earth.</td><td>**International Space Station**
The ISS was initially launched in 1998. It was originally intended to be a laboratory, observatory & factory and provide transportation, maintenance and a low Earth orbit staging base for possible future missions to the Moon, Mars, and asteroids</td><td>**GPS**
A GPS receiver finds its position by measuring the distance between itself and at least three GPS satellites in a process called trilateration.
The GPS receiver measures how long it took for the signal to reach it. Each signal gives a likely location and the more satellite signals the more accurate the location and height indicated.</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>34</td><td>Geostationary satellites remain in orbit over the same place on Earth
have a period of 24 hours
orbit at an altitude of 36000 km.</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>35</td><td>Period of a satellite in high altitude orbit is greater than period of a satellite in lower altitude orbit.
Compared to Satellite Y:
X is closer to Earth
X has a shorter Period of Orbit
X is moving faster

</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>36</td><td>***Awareness of the challenges of space travel***:
travelling huge distances in space can be aided by attaining a higher velocity using an ion drive which produces a small, unbalanced force over an extended period of time.
travelling large distances using a 'catapult' from a fast moving asteroid, moon or planet.
Spacecraft accelerates towards planet/moon/large asteroid but misses it
When travelling close to planet/asteroid, object will accelerate due to force of gravity and increase its velocity and can change the direction of travel.
manoeuvring a spacecraft in a zero friction environment, possibly to dock with the ISS
maintaining sufficient energy to operate life support systems in a spacecraft, with the possible solution of using solar cells with area that varies with distance from the Sun.
The journey getting to and landing on another planet is complicated by having a return journey.</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

<table>
<tr><td>37</td><td>Awareness of the risks associated with manned space exploration:
• huge amounts of energy required to get into orbit and the heavier the spacecraft the more fuel needed on take-off and increases the risks.
• potential exposure to high levels of radiation and cosmic rays unprotected away from Earth.
• pressure differential between the vacuum of space and inside spacecraft can lead to accidents.
• re-entry through an atmosphere will lead to very high temperatures on spacecraft surface.
• very small objects moving a high speed can damage spacecraft.
• extremes of temperature (hot in sun, cold in shade) must be worked into the design of spacecraft</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>38</td><td>Knowledge of Newton’s Laws and their application to space travel, rocket launch and landing.
<table>
<tr><td>Newton’s First Law
“An object will remain at rest or continue to travel with constant speed, and in the same direction, unless acted upon by an unbalanced force”</td><td>Once a spacecraft is moving in the vacuum of space it will continue to move and will not slow down.
• Fuel will accelerate the spacecraft to the required velocity and once the engines are switched off the velocity will remain constant.
• Thrust must be provided to slow or halt the motion of a spacecraft as there is no frictional force to assist with this process.</td></tr>
<tr><td>Newton’s Second Law
“The acceleration of a body is proportional to the unbalanced force acting upon it and inversely proportion to the objects mass”</td><td>On take off, the acceleration of the rocket is determined
• using F = ma, where F is the unbalanced force
• where Unbalanced Force = Thrust – Weight
Large quantities of fuel are required to launch a spacecraft and the mass of the spacecraft will decrease as the fuel is used up. This will increase the acceleration of the spacecraft.</td></tr>
<tr><td>Newton’s Third Law
“If object A exerts a force on object B, then object B exerts an equal and opposite force on object A”</td><td>Releasing or ejecting any part of a spacecraft will result in this equal and opposite force on the remaining spacecraft.
The forces will be balanced and the force of the jettisoned section will be balanced by an equal force on the spacecraft in the opposite direction.
This will cause an acceleration in the spacecraft which will alter the velocity of the spacecraft.</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>39</td><td>Weight, mass and gravitational field strength can be worked out using the relationship W = m g
• Mass, in kg, is the same regardless of the gravitational field strength
<table>
<tr><td>W</td><td>=</td><td>m</td><td>x</td><td>g</td></tr>
<tr><td>Weight</td><td></td><td>Mass</td><td></td><td>Gravitational Field Strength</td></tr>
<tr><td>(N)</td><td></td><td>(kg)</td><td></td><td>(N kg^{-1})</td></tr>
</table>
As gravitational Field Strength is different in different locations across the universe, care must be taken to use the correct value of Gravitational Field Strength.
Calculate the weight of an individual with mass 71kg on a) Earth, b) Moon and c) Mars.
<table>
<tr><td>a) Earth (g= 9.81 N kg^{-1})
W = mg
= 71 x 9.81
= 697 N</td><td>b) Moon (where g=1.6 N kg^{-1})
W = mg
= 71 x 1.6
= 114 N</td><td>c) Mars (where g = 3.7 N kg^{-1})
W = mg
= 71 x 3.7
= 263 N</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

No.	National 5 Physics Unit 2b Space: Cosmology	Red	Amber	Green

Traffic Light

40

Use of the term ‘light year’ and conversion between light years and metres.

A light year is the distance that light/EM Radiation travels in one year.

A light year can be calculated in metres:

$d = v \times t$

$d = 3.0\times10^{8} \times 1 \times 365.25 \times 24 \times 60 \times 60$

$d = 9.47\times10^{15}$ m

$d = ?$

$v = 3\times10^{8}$ m s^{-1}

$t = 1$ year $= 1\times365.25\times24\times60\times60$ s

NB: We use the conversion 1 year = 365.25 days so that leap years are taken into account.

☹ 😐 ☺

41

The ‘Big Bang’ theory is the theory for the origin of the universe.

- the universe having originated from an extremely hot common dense origin
- Big Bang was the start of the universe as a rapid expansion
- almost all galaxies are moving away from us showing the universe is expanding
- If the universe ever stops expanding then it may collapse (Big Crunch)

☹ 😐 ☺

42

The approximate estimated age of the universe is 13.8 billion years (13,800,000,000 years)

☹ 😐 ☺

43

The whole electromagnetic spectrum is used to obtain information about astronomical objects.

Gamma-ray Astronomy Gamma rays are emitted by pulsars, black holes, active galaxies and unidentified objects responsible for high energy gamma ray bursts.	**X-ray Astronomy** X-rays are emitted by incredibly hot gases and objects with temperatures of over one million kelvin (K).	**Ultraviolet Astronomy** Ultraviolet radiation is mostly emitted by very hot young stars, including the sun
Visible Spectrum Astronomy Visible light is able to pass through the atmosphere, provided the sky is clear of clouds. Visible light is distorted by the atmosphere. Galaxies, star clusters, planets, moons and nebulae (clouds of gas in space) can be observed.	**Infrared Astronomy** Infrared observatories are placed in dry climates and at high altitude locations. The wavelength emitted can be used to determine the temperature of the source.	**Microwave Astronomy** Most microwave frequencies are blocked by the Earth’s atmosphere so space-based telescopes are used. Astronomer have detected microwaves from all directions in space known as the Cosmic Microwave Background. **Radio Astronomy** Observations can be made during the day and on cloudy days. Radio waves are emitted by stars and galaxies and newly identified classes of objects, such as radio galaxies, quasars, pulsars, & masers.

☹ 😐 ☺

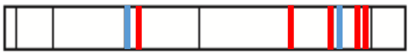
44

Identification of continuous and line spectra.

Continuous Spectrum		No lines on a spectrum of colours
Line Emission Spectrum		Colour lines on Black Background
Line Adsorption Spectrum		Black lines on a coloured background

☹ 😐 ☺

45

Spectral data of known elements can identify elements present in stars.	Star X		Contains Hydrogen and Helium
	Star Y		Contains Helium but not Hydrogen
	Star Z		Contains Hydrogen and Helium
	Helium		
	Hydrogen		

☹ 😐 ☺

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 3a
Electricity: Electric Charge Carriers</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>46</td><td>Electrical current is defined as the electric charge transferred per unit time.</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>47</td><td>Calculations involving charge, current and time use the following equation:

$$Q = I\,t$$

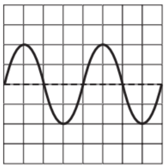
<table>
<tr><th>Quantity</th><th>Symbol</th><th>Unit</th></tr>
<tr><td>Charge</td><td>Q</td><td>Coulomb (C)</td></tr>
<tr><td>Current</td><td>I</td><td>Amp (A)</td></tr>
<tr><td>Time</td><td>t</td><td>second (s)</td></tr>
</table>

e.g. During one lightning strike 24 C of charge is transferred to the ground in 0·0012 s. Calculate the average current during the lightning strike.

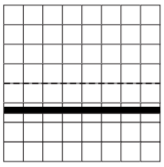
Q = 24 C I = ? t = 0.0012 s

$$Q = I \times t \quad \therefore \quad 24 = I \times 0.0012 \quad \therefore \quad I = \frac{24}{0.0012} = 20000\text{ A}$$</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>48
49</td><td>Alternating Current and Direct Current are different in nature and can be identified on an oscilloscope or datalogging computer.
<table>
<tr><th>a.c. Alternating Current</th><th>d.c. Direct Current</th></tr>
<tr><td>In alternating current

the direction of electrons in current changes back and forth at regular intervals
the size of the current varies with time and is not constant
gives an oscilloscope trace as below

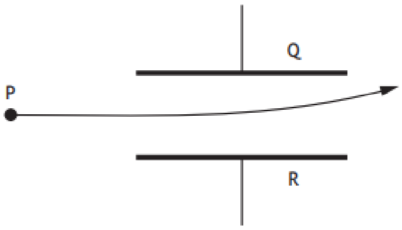
</td><td>In direct current

negative charges (electrons) flow in one direction only.
gives a constant trace on oscilloscope as shown below

</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 3b
Electricity: Potential Difference (Voltage)</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>50</td><td>A charged particle experiences a force in an electric field.</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>51</td><td>Path of a charged particle is worked out using <i>opposite charges attract and like charges repel</i>:

a) between two oppositely charged parallel plates



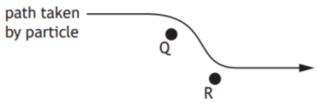
If particle P is <i>positive</i>

Plate Q must be negative if particle P is attracted to it
Plate R must be positive if particle P is deflected away

If particle P is <i>negative</i>

Plate Q must be positive if particle P is attracted to it
Plate R must be negative if particle P is deflected away

b) near a single point charge, between two oppositely charged points or between two like charged points.

<table>
<tr><td>
</td><td>If particle is Positive:

Single point charge Q must be <i>negative</i> for particle to be attracted to it
Single point charge R must be <i>positive</i> for particle to be repelled by it
</td><td>If particle is Negative:

Single point charge Q must be <i>positive</i> for particle to be attracted to it
Single point charge R must be <i>negative</i> for particle to be repelled by it
</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>52</td><td>Voltage and potential difference is a measure of the energy given to the charge in a circuit.

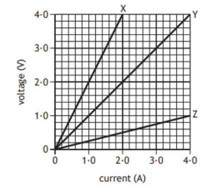
the voltage of a battery is the number of joules of energy it gives to each coulomb of charge.
A cell or battery has a voltage when not connected in a complete circuit
Electrons are free to move through a circuit made of conductor material
</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

No.	National 5 Physics Unit 3c Electricity: Ohm's Law	Traffic Light: Red	Amber	Green

National 5 Physics Unit 3c
Electricity: Ohm's Law

53

Resistance can be calculated from a V-I graph by working out gradient of a line of best fit:

V-I Graph	Resistance of Line X	Resistance of Line Y	Resistance of Line Z
	R_X = gradient of line X $\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$ $\text{gradient} = \frac{4.0 - 0.0}{2.0 - 0.0}$ $\text{gradient} = \frac{4.0}{2.0}$ gradient = 2 Ω	R_Y = gradient of line Y $\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$ $\text{gradient} = \frac{4.0 - 0.0}{4.0 - 0.0}$ $\text{gradient} = \frac{4.0}{4.0}$ gradient = 1 Ω	R_Z = gradient of line Z $\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$ $\text{gradient} = \frac{1.0 - 0.0}{4.0 - 0.0}$ $\text{gradient} = \frac{1.0}{4.0}$ gradient = 0.25 Ω

☹ 😐 ☺

54

Equations involving potential difference (voltage), current and resistance are listed below:

$$V = I\,R$$

Quantity	Symbol	Units
Voltage	V	V
Current	I	A
Resistance	R	Ω

P = ? V = 230 V I = 2.5 A

$P = V \quad I$

$P = 230 \times 2.5$

$P = 575$ W

$$V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$$

Quantity	Symbol	Units
Supply Voltage	V_s	V
Voltage in Resistor 2	V_2	V
Resistance in Resistor 1	R_1	Ω
Resistance in Resistor 2	R_2	Ω

V_s =5.0 V V_2 = ? R_1 = 16 Ω R_2 = 4Ω

$V_2 = \frac{R_2}{R_1 + R_2} \times V_s$

$V_2 = \frac{4}{16 + 4} \times 20.0$

V_2 = 4 V

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

Quantity	Symbol	Units
Voltage over Resistor 1	V_1	V
Voltage over Resistor 2	V_2	V
Resistance in Resistor 1	R_1	Ω
Resistance in Resistor 2	R_2	Ω

V_1 = ? V_2 = 12.0V R_1 = 20 Ω R_2 = 60Ω

$\frac{V_1}{V_2} = \frac{R_1}{R_2}$

$\frac{V_1}{12.0} = \frac{20}{60}$

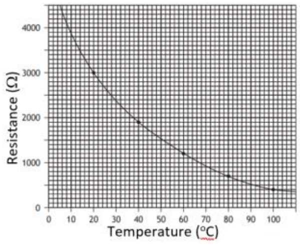
$V = \frac{20 \times 12.0}{60}$

V = 4.0 V

☹ 😐 ☺

55

In a conductor, temperature and resistance are linked to each other as shown in the graph:

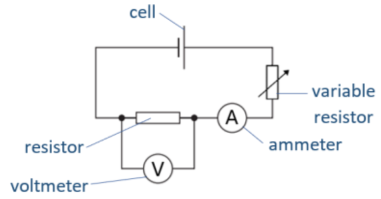


- Higher the temperature the lower the resistance

☹ 😐 ☺

56

Description of an experiment to verify Ohm's law can be verified using the following experiment



- The variable resistor is altered to achieve a range of currents on the ammeter and the current recorded.
- The voltage achieved on the voltmeter should recorded for each setting of the variable resistor.

The ratio $\frac{V}{I}$ should be constant and equal to R

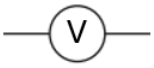
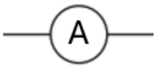
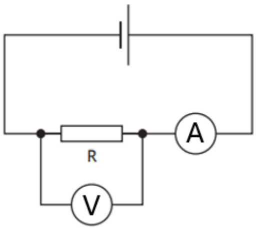
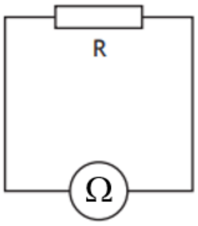
☹ 😐 ☺

No.	National 5 Physics Unit 3d Electricity: Practical Electrical and Electronic Circuits	Traffic Light: Red	Amber	Green

National 5 Physics Unit 3d
Electricity: Practical Electrical and Electronic Circuits

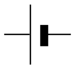
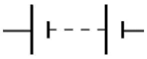
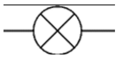
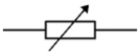
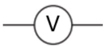
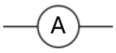
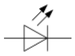
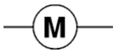
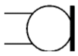
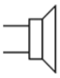
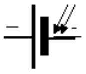
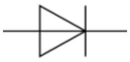
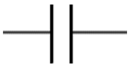
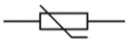
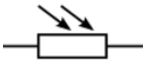
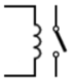
57

The correct use of meters to measure current (ammeter), voltage (voltmeter) and resistance (ohmmeter) are:

Voltmeter	Ammeter	Ohmmeter
 V	 A	 Ω
Voltmeters are placed in parallel around the component that is having its voltage measured.	Ammeters are placed in series in the circuit where the current is being measured.	Ohmmeters are placed in series circuit with the component where the resistance is being measured
 A R V		 R Ω

☹ 😐 ☺

58

Name	Symbol	Function	Application
cell		Supplies electrical energy to a circuit, the longer line shows the positive side of cell.	Portable devices
battery		A battery has 2 or more cells joined together (+ to –)	Portable devices
lamp		A lamp lights when current flows through it, converting electrical energy to light energy.	Room lighting
switch		A switch allows you to complete or break a circuit. (Closed switch means current flows)	Light switch
resistor		A resistor restricts the flow of current to protect components from too much current	Circuit protection from overload
variable resistor		A resistor, the resistance of which can be varied in the circuit.	Used as a dimmer switch to raise or lower the brightness of a lamp.
voltmeter		Measures potential difference. Must be placed in **parallel** to measure the difference in electrical potential between two points.	Electrician’s multimeter
ammeter		Measures current. Must be placed in **series** to measure the current flowing in a circuit.	Electrician’s multimeter
Ohmmeter		Ohmmeters measures the resistance in a component in a circuit. No cell required.	Electrician’s multimeter
LED		Emits light when a current flows but only allows current to flow in one direction. Requires less energy than a lamp	Car lights
motor		Converts electrical energy into kinetic energy by turning.	Electric car
microphone		Converts sound energy into an electrical signal.	Microphone at a concert
loudspeaker		Converts electrical energy into sound energy.	Loudspeaker at a concert
photovoltaic cell		Converts light energy to electrical energy, can be used as the power source in a circuit. More light will mean a greater p.d. across the cell.	Calculator
fuse		A fuse is a safety device – the metal core will melt when too much current is flowing in the circuit.	Plugs on devices
diode		Only allows current to flow in one direction.	
Capacitor		Used to store electrical charge, can be used to create a simple timing circuit, or in the flash in a camera.	
thermistor		The resistance of a thermistor will increase as the temperature increases.	Temperature sensor in greenhouse
LDR		Can be used to control a circuit. The resistance goes down as the light increases.	Outdoor lighting sensor for light/dark
relay		An electronically operated switch. Used to protect operators from high currents, by using a low current supply to switch on a high current/voltage supply	Safe switching mechanism for high current device
transistor		Acts as a switch when a voltage of 0.7 V is applied across the base and emitter	

☹ 😐 ☺

59	For transistors, knowledge of the symbols for an npn transistor and an n-channel enhancement mode MOSFET. Explanation of their function as a switch in transistor switching circuits.	☹	😐	☺
60	The rules for calculating current and potential difference (voltage) in series and parallel circuits:	☹	😐	☺

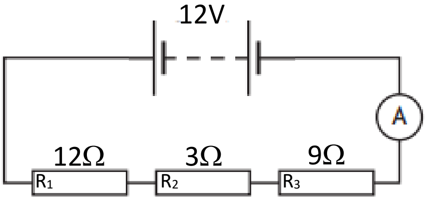
Type	Current	Voltage

Series Circuit

Current

$$I_s = I_1 = I_2 = ...$$

The current in a series circuit is the same at every point in the circuit



Total resistance in series $R_T = R_1 + R_2 + R_3$

$= 12\Omega + 3\Omega + 9\Omega$

$= 24\Omega$

V = 12V I = ? R = 24Ω

$V = I \quad R$

$12 = I \text{ x } 24$

$I = {}^{12}/_{24} = 0.5 \text{ A}$

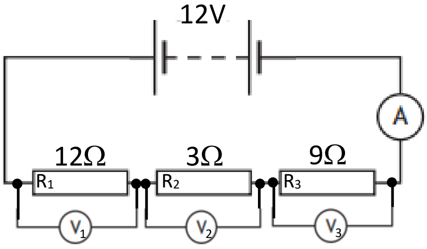
On ammeter	In resistor R_1	In resistor R_2	In resistor R_3
$I_s = 0.5$ A	$I_1 = 0.5$ A	$I_2 = 0.5$ A	$I_3 = 0.5$ A

$$\therefore I_s = I_1 = I_2 = I_3 = 0.5\text{A}$$

Voltage

$$V_s = V_1 + V_2 + ...$$

In a series circuit, the sum of the voltages of the components connected in series is equal to the supply voltage



$V_s = 12$V

In resistor R_1 $R_1 = 12\Omega$	In resistor R_2 $R_2 = 3\Omega$	In resistor R_3 $R_3 = 9\Omega$
In resistor R_1 $I_1 = 0.5$ A	In resistor R_2 $I_2 = 0.5$ A	In resistor R_3 $I_3 = 0.5$ A
Over resistor R_1 V = I R V = 0.5 x 12 V = 6V	Over resistor R_2 V = I R V = 0.5 x 3 V = 1.5V	Over resistor R_3 V = I R V = 0.5 x 9 V = 4.5V

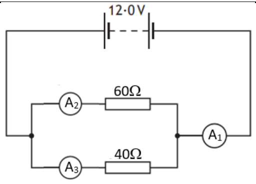
$$\therefore V_s = V_1 + V_2 + V_3 = 12\text{V}$$

Parallel Circuit

Current

$$I_p = I_1 + I_2 + ...$$

The total current outside the branches in a parallel circuit is equal to the sum of the currents in those branches



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{60} + \frac{1}{40} = \frac{5}{120}$$

$$R_T = \frac{120}{5} = 24\Omega$$

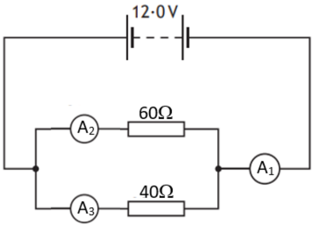
Outside Parallel Branches $R_T = 24\Omega$	Over 60Ω resistor $R_2 = 60\Omega$	Over 40Ω resistor $R_3 = 40\Omega$
Outside Parallel Branches $V_p = 12.0$ V	Over 60Ω resistor $V_1 = 12.0$ V	Over 40Ω resistor $V_2 = 12.0$ V
Outside Parallel Branches $I_1 = {}^{V}/_{R}$ $I_1 = {}^{12.0}/_{24}$ $I_1 = 0.5$A	Current 60Ω resistor $I_2 = {}^{V}/_{R}$ $I_2 = {}^{12.0}/_{60}$ $I_2 = 0.2$A	Current 40Ω resistor $I_3 = {}^{V}/_{R}$ $I_3 = {}^{12.0}/_{24}$ $I_3 = 0.3$A

$$\therefore I_1 = I_2 + I_3 = 0.5\text{A}$$

Voltage

$$V_p = V_1 = V_2 = ...$$

The voltage is the same in each branch of a parallel circuit and equal to the voltage outside the branches



$V_{supply} = 12.0$ V

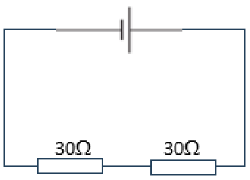
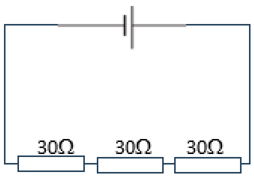
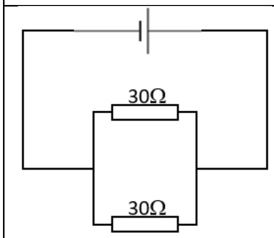
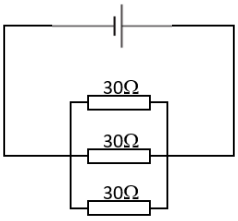
A voltage is the same
in each branch of parallel circuit

Over battery	Over 60Ω resistor	Over 60Ω resistor
$V_p = 12.0$ V	$V_1 = 12.0$ V	$V_2 = 12.0$ V

$$\therefore V_p = V_1 = V_2 = 12.0\text{ V}$$

61

Adding further resistors to circuits in series and parallel has the following effect:

Series		Parallel	
2 Resistors in Series	3 Resistors in Series	2 Resistors in Series	3 Resistors in Series
			
$R_T = R_1 + R_2$ $= 30 + 30$ $= 60\Omega$	$R_T = R_1 + R_2 + R_3$ $= 30 + 30 + 30$ $= 90\Omega$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_T} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4}$ $R_T = \frac{4}{2} = 2\Omega$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $\frac{1}{R_T} = \frac{1}{30} + \frac{1}{30} + \frac{1}{30}$ $R_T = \frac{30}{3} = 10\Omega$

Adding an additional resistor to a series circuit

- Increase in total resistance of circuit
- Decrease in current flowing in circuit
- Total voltage is same but more resistance means less voltage over each additional resistor.

Adding an additional resistor in a parallel circuit

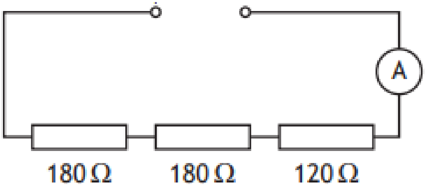
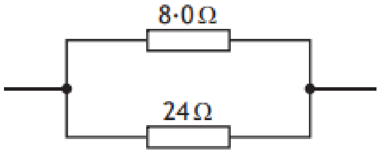
- Decrease in total resistance of circuit
- Increase in current flowing outside parallel branches
- Voltage is still the same in each branch and same as supply voltage

☹ 😐 ☺

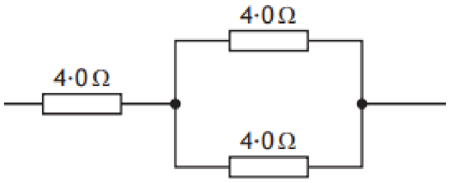
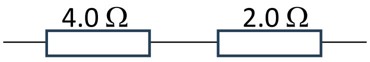
62

The total resistance of resistors in series and in parallel circuits can be calculated

- Both can be used for problems with a combination of series and parallel resistors.

Series	Parallel
$R_t = R_1 + R_2 + ...$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + ...$
e.g. Calculate the total resistance in the following series circuit  $R_T = R_1 + R_2 + R_3$ $R_T = 180 + 180 + 120$ $R_T = 480\Omega$	e.g. Calculate the total resistance in the following parallel circuit  $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_T} = \frac{1}{8} + \frac{1}{24} = \frac{4}{24}$ $R_T = \frac{24}{4} = 6\Omega$

e.g. Calculate the total resistance in the following circuit

	
Combine resistors in parallel section: $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_T} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4}$ $R_T = \frac{4}{2} = 2\Omega$	Combine series resistors: $R_T = R_1 + R_2$ $R_T = 4 + 4$ $R_T = 6\Omega$

☹ 😐 ☺

No.	National 5 Physics Unit 3e Electricity: Electrical Power		Traffic Light		
			Red	Amber	Green

National 5 Physics Unit 3e
Electricity: Electrical Power

63 Power is defined as electrical energy per unit time. ☹ 😐 ☺

64 Use of an appropriate relationship to solve problems involving energy, power and time. ☹ 😐 ☺

$$P = \frac{E}{t}$$

Quantity	Symbol	Unit
Power	P	W
Energy	E	J
time	t	s

e.g. The hot water dispenser takes 26 s to heat enough water for one cup. If the power dispenser has a power rating of 3.5kW, calculate the energy supplied to the hot water dispenser.

P = 3.5kW = 3500W E = ? t = 26s

$$P = \frac{E}{t} \therefore \quad 3500 = \frac{E}{26} \therefore \quad E = \quad 3500 \text{ x } 26 \quad = 91000 \text{ J}$$

65 Knowledge of the effect of potential difference (voltage) and resistance on the current in and power developed across components in a circuit.

66 Calculations involving power, potential difference (voltage), current and resistance in electrical circuits can be solved using the following three equations. ☹ 😐 ☺

$P = I V$	$P = I^2 R$	$P = \frac{V^2}{R}$
Where P = Power (W)	I = current (A) V = Voltage (V)	R = resistance (Ω)
An electric iron operates at 230 V a.c. The power rating of the iron is 1750W. Calculate the current in the iron when it is operating. P = 1750W I = ? V = 230V $P = I \quad V$ $1750 = I \times 230$ $I = {}^{1750}/_{230}$ $I = 7.61\text{A}$	In a series circuit, a 0.2A current is flowing through a resistor with a resistance of 15Ω. Calculate the power in this circuit. P = ? I = 0.2 R = 15Ω $P = I^2 \quad R$ $P = (0.2)^2 \text{ x } 15$ $P = 0.04 \text{ X } 15$ $P = 0.6\text{W}$	A kettle uses 230V a.c. and is rated at 920 W. The resistance of this appliance is? P = 920 W R = ? V = 230 V $P = \frac{V^2}{R} \therefore 920 = \frac{(230)^2}{R}$ $\therefore R = \frac{52900}{920}$ $R = 57.5\ \Omega$

67
68 The appropriate fuse must be used depending on the power rating of an electrical appliance. ☹ 😐 ☺
- 3 A fuse should be selected for most appliances rated up to 720 W
- 13 A fuse for appliances rated over 720 W.

No.

National 5 Physics Unit 4a
Properties of Matter: Specific Heat Capacity

Traffic Light: Red Amber Green

69 Different materials require different quantities of heat to raise the temperature of unit mass by one degree Celsius e.g. metals require less heat to raise their temperature than stone ☹ 😐 ☺

- The measure of this different quantities of heat required is called the *specific heat capacity*

70 Calculations involving mass, heat energy, temperature change & specific heat capacity use the equation: ☹ 😐 ☺

$$E_h = c \quad m \quad \Delta T$$

Heat Energy (J)
Specific Heat Capacity ($J\ kg^{-1}\ {}^oC^{-1}$)
Mass (kg)
Temperature change (°C)

e.g. The hot water dispenser heats 0·250 kg of water for each cup of tea made. Calculate the minimum energy required to heat 0·250 kg of water from an initial temperature of 20·0 °C to its boiling point

E_h = ? c= 4180 $J\ kg^{-1}\ {}^oC^{-1}$ m = 0.250kg T= 100.0-20.0 = 80.0°C

$$E_h = c \quad m \quad \Delta T$$
$$E_h = 4180 \times 0.250 \times 80.0$$
$$E_h = 83600\ J$$

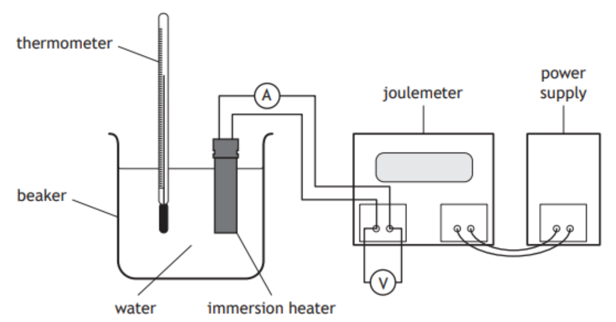
71 The temperature is a measure of the mean kinetic energy of the particles in a substance. ☹ 😐 ☺

- The higher the temperature the greater the kinetic energy of the average particle in a substance

72 The principle of conservation of energy to can be used to determine heat transfer. ☹ 😐 ☺

- Energy can be released from an electric heater and the principle of conservation of energy allows that quantity to be used in $E_h = cm\Delta T$ calculations.

The student switches on the power supply and the immersion heater heats the water and a joulemeter measures the energy supplied.
The student records the following measurements:
energy supplied to immersion heater = 21600 J
mass of water = 0·50 kg
initial temperature of the water = 16 °C
final temperature of the water = 24 °C
Determine the value of the specific heat capacity of water obtained from these measurements.



$$E_h = c \quad m \quad \Delta T$$
$$21600 = c \times 0.50 \times 8$$
$$c = 5400\ J\ kg^{-1}\ {}^oC^{-1}$$

No.

National 5 Physics Unit 4b
Properties of Matter: Specific Latent Heat

Traffic Light: Red Amber Green

73
74
Different materials require different quantities of heat to change physical state per unit mass. ☹ 😐 ☺
Different quantities of heat are required to change the state

- from solid to liquid (fusion) e.g. specific latent heat of fusion of water = $3.34\text{x}10^5\ J\ kg^{-1}$
- from liquid to gas (vaporisation) e.g. specific latent heat of vaporisation of water = $22.6\text{x}10^5\ J\ kg^{-1}$

75 Calculations involving mass, heat energy and specific latent heat use the equation: ☹ 😐 ☺

$$E_h = m \quad l$$

Heat Energy (J)
Mass (kg)
Specific latent heat ($J\ kg^{-1}$)

e.g. What is the minimum amount of energy required to change 0·5 kg of water at its boiling point into steam at the same temperature?

$$E_h = m \quad l$$
$$E_h = 0.5 \times 22.6$$
$$E_h = 11.3\ J$$

No.	National 5 Physics Unit 4c Properties of Matter: Gas Laws and the Kinetic Model	Traffic Light Red	 Amber	 Green
76	Pressure is defined as Force per unit area.	☹	😐	☺

77 Pressure, force and area are linked by the following equation: ☹ 😐 ☺

$$P = \frac{F}{A}$$

Symbol	Quantity	Unit
P	Pressure	Pa
F	Force	N
A	Area	m^2

e.g. Calculate the pressure for an object on a table with a base of area of $0.05m^2$ and weight of 700N.

$$P = \frac{F}{A} = \frac{700}{0.05} = 14000N$$

78 The pressure of a gas can be explained by the Kinetic Model: ☹ 😐 ☺

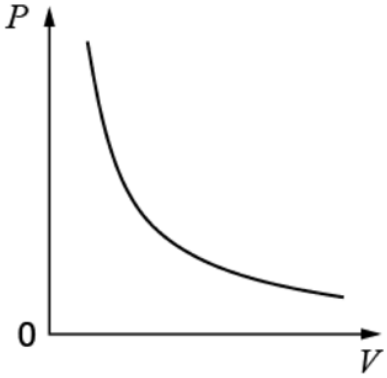
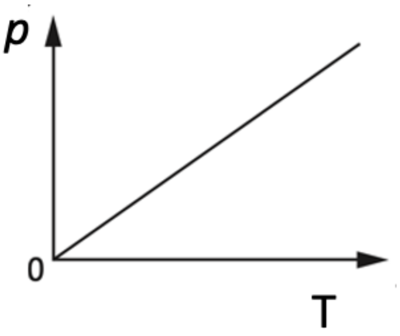
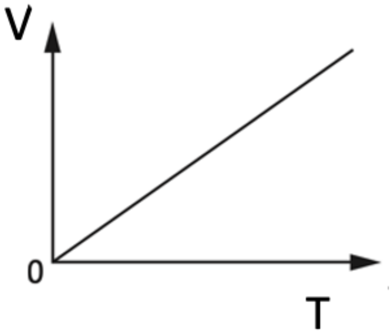
- the increase in temperature increases kinetic energy of gas particles
- the particles move faster
- the particles hit the walls of the container/walls
  - more frequently
  - with greater force
- Pressure increases as the walls of the container are hit more often by gas particles

79 The Kelvin and degrees Celsius temperature scales can be interchanged as 1 K is 1°C difference in temp. ☹ 😐 ☺

e.g. Calculate the temperature in Kelvin of 200°C	e.g. Calculate the temperature in °C of the temperature of 150K
$T = 200 + 273 = 473K$	$T = 150 - 273 = -123^{o}C$
For °C → K add 273 to temperature in °C	For K → °C subtract 273 from temperature in K

The absolute zero of temperature in. the Kelvin scale (0 K) is -273°C

80 The Kinetic Model can explain the Pressure–volume, pressure–temperature and volume–temperature laws: ☹ 😐 ☺

a) Pressure-Volume Law (Boyle's Law)	b) Pressure-Temperature Law (Gay-Lussac's Law)	c) Volume-Temperature Law (Charles' Law)
		
***p**ressure is inversely proportional to **V**olume	***p**ressure is directly proportional to **T**emperature	**V**olume is directly proportional to **T**emperature
an increase in **V**olume gives a decrease in ***p**ressure	an increase in ***p**ressure gives a increase in **T**emperature	an increase in **V**olume gives an increase in **T**emperature
The pressure of a gas is caused by the molecules hitting the walls of the container. Reducing the volume results in a shorter distance between the walls and so the number of molecules hitting the walls increases, resulting in increased pressure.	If the absolute temperature of a gas increases, the speed of the molecules increases. The force and frequency of the impacts on the walls of the container increases, as this is the cause of pressure, then pressure increases	The pressure of a gas is caused by the molecules hitting the walls of the container. If the absolute temperature of the gas increases the speed of the molecules increase with more forceful and more frequent collisions on the walls. If the walls are flexible, the Volume will increase and the pressure will remain the same.

81a The Boyle's Law relationship of pressure and volume at a constant temperature is represented by:

$$p_1V_1 = p_2V_2$$

$p_1 = 1.0\times10^5$ Pa	$V_1 = 4.0\times10^{-4}$ m^3	same temperature
p_2 = ?	$V_2 = 1.6\times10^{-4}$ m^3	

$$p_1V_1 = p_2V_2 \therefore 1.0\times10^5 \times 4.0\times10^{-4} = p_2 \times 1.6\times10^{-4} \therefore p_2 = \frac{1.0\times10^5 \times 4.0\times10^{-4}}{1.6\times10^{-4}} = 2.5\times10^5 \text{ Pa}$$

☹ 😐 ☺

81b The Gay-Lussac's Law relationship of pressure and temperature at a constant volume is represented by:

$$\frac{\boldsymbol{p_1}}{\mathbf{T_1}} = \frac{\boldsymbol{p_2}}{\mathbf{T_2}}$$

p_1 = 150kPa	$T_1 = 27^oC$ = 300K	same volume
p_2 = ?	$T_2 = 47^oC$ = 330K	

$$\frac{p_1}{T_1} = \frac{p_2}{T_2} \therefore \frac{150}{300} = \frac{p_2}{330} \therefore p_2 = \frac{150 \times 330}{300} = 165 \text{ kPa}$$

☹ 😐 ☺

81c The Charles' Law relationship of volume and temperature at a constant temperature is represented by:

$$\frac{\mathbf{V_1}}{\mathbf{T_1}} = \frac{\mathbf{V_2}}{\mathbf{T_2}}$$

V_1 = 0.3 m^3	$T_1 = 20^oC$ = 293K	same pressure
V_2 = ?	$T_2 = 50^oC$ = 323K	

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \therefore \frac{0.3}{293} = \frac{V_2}{323} \therefore V_2 = \frac{0.3 \times 323}{293} = 0.33 \text{ m}^3$$

☹ 😐 ☺

81d Pressure, volume and temperature are linked by the following relationship:

$$\frac{\boldsymbol{p}\mathbf{V}}{\mathbf{T}} = \textit{constant}$$

$p_1 = 6.0\times10^5$ Pa	V_1 = 2.5 m^3	$T_1 = 27^oC$ = 300K
p_2 = ?	V_2 = 5.0 m^3	$T_2 = 54^oC$ = 327K

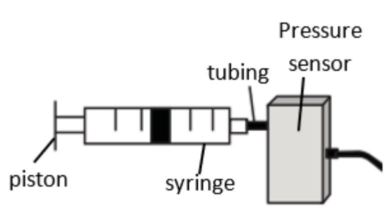
$$\frac{p_1V_1}{T_1} = \text{constant} \therefore \frac{6.0\times10^5 \times 2.5}{300} = 5000 = \text{constant}$$

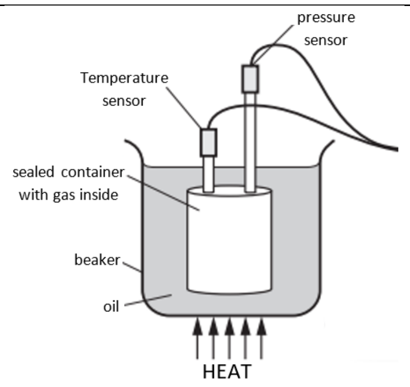
$$\frac{p_2V_2}{T_2} = \text{constant} \therefore \frac{p_2 \times 5.0}{327} = 5000 \therefore p_2 = \frac{5000 \times 327}{5.0} = 3.3\times10^5 \text{ Pa}$$

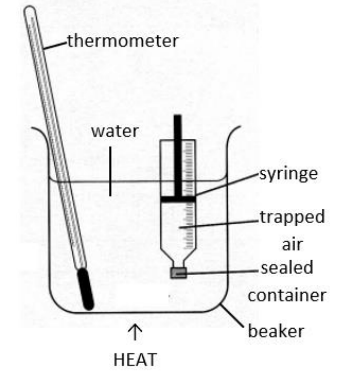
☹ 😐 ☺

82 Description of experiments to verify the pressure–volume law (Boyle's law), the pressure–temperature law (Gay-Lussac's law) and the volume–temperature law (Charles' law).

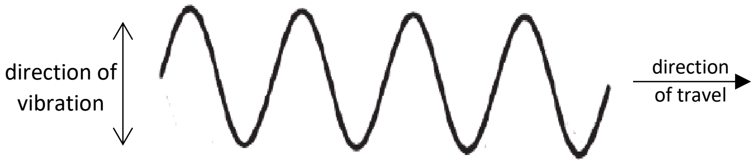
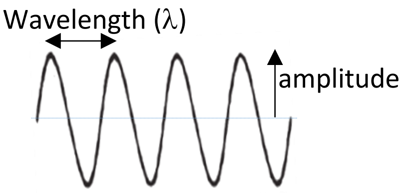
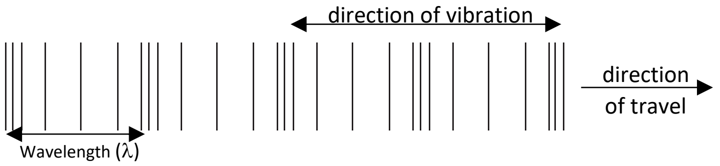
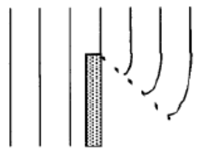
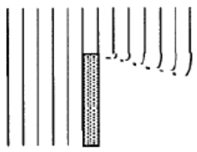
a) Pressure-Volume Law (Boyle's Law)	b) Pressure-Temperature Law (Gay-Lussac's Law)	c) Volume-Temperature Law (Charles' Law)
Watch this BBC Bitesize video	Watch this BBC Bitesize video	Watch this BBC Bitesize video
The piston on the syringe can be used to change the volume of the gas in the syringe. The pressure inside the syringe is measured by the pressure sensor. The volume of the gas in the syringe could be halved and the pressure sensor would measure the resulting doubling of the pressure in the syringe.	The oil in the beaker is slowly heated and the pressure is measured on the pressure sensor at a series of increasing temperatures (measured in Kelvin). As the volume is fixed in the sealed container, the ratio of $^{\text{pressure}}/_{\text{temperature}}$ should be constant.	The beaker is heated and the volume in the sealed container should start to expand. The piston moves up the container to equalised pressure inside and outside the container. The volumes in the sealed container and measured against the temperatures in Kelvin and the ratio of $^{\text{volume}}/_{\text{temperature}}$ should be constant.







☹ 😐 ☺

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 5a
Waves: Parameters & Behaviours</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>83</td><td>Waves transfer energy. The higher the amplitude of the wave, the more energy is transferred</td><td></td><td></td><td></td><td></td></tr>
<tr><td>84a
85a</td><td>Definition of transverse waves.
Transverse Waves

Transverse waves have the direction of vibration at right angles to the direction of wave travel e.g. water waves and electromagnetic waves.
<table>
<tr><td>**frequency (f)**
number of waves that pass a point in one second.</td><td rowspan="3"> </td></tr>
<tr><td>**wavelength (λ)**
horizontal distance between any two corresponding points on adjacent waves.</td></tr>
<tr><td>**amplitude**
vertical distance measured from the middle of the wave to the top or to the bottom. Independent of wavelength</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>84b
85b</td><td>**Longitudinal Waves**

Longitudinal waves have the direction of the vibration in the same direction as the direction of the wave e.g. sound waves.
- The wavelength can be calculated from the number of complete waves over a distance.</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>86a</td><td>Speed, distance and time problems can be solved using the following equation:
$$v = \frac{d}{t}$$
<table>
<tr><th>Symbol</th><th>Quantity</th><th>Unit</th></tr>
<tr><td>v</td><td>speed</td><td>$m\ s^{-1}$</td></tr>
<tr><td>d</td><td>distance</td><td>m</td></tr>
<tr><td>t</td><td>time</td><td>s</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>86b</td><td>Frequency, number of waves and time problems can be solved using the following equation:
$$f = \frac{N}{t}$$
<table>
<tr><th>Symbol</th><th>Quantity</th><th>Unit</th></tr>
<tr><td>f</td><td>frequency</td><td>Hz</td></tr>
<tr><td>N</td><td>number of waves</td><td></td></tr>
<tr><td>T</td><td>time</td><td>s</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>87c</td><td>Speed, frequency and wavelength problems can be solved using the following equation:
$$v = f \lambda$$
<table>
<tr><th>Symbol</th><th>Quantity</th><th>Unit</th></tr>
<tr><td>v</td><td>speed</td><td>$m\ s^{-1}$</td></tr>
<tr><td>f</td><td>frequency</td><td>Hz</td></tr>
<tr><td>λ</td><td>wavelength</td><td>m</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>87d</td><td>Time and frequency problems can be solved using the following equation:
$$t = \frac{1}{f}$$
<table>
<tr><th>Symbol</th><th>Quantity</th><th>Unit</th></tr>
<tr><td>t</td><td>Period</td><td>s</td></tr>
<tr><td>f</td><td>frequency</td><td>Hz</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>87
88
89</td><td>Diffraction occurs when waves pass through a gap or around an object.
- Waves which have a longer wavelength produce more diffraction than waves with a shorter wavelength.
<table>
<tr><td></td><td></td><td rowspan="2">Wavelength must be same before *and* after barrier.

Wave curl at the corners after barrier</td></tr>
<tr><td>Long Wave diffraction</td><td>Short Wave diffraction</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

No.

National 5 Physics Unit 5b
Waves: Electromagnetic Spectrum

Traffic Light: Red, Amber, Green

90

Knowledge of the relative frequency and wavelength of bands of the electromagnetic spectrum.

EM Type	Gamma	X-Ray	Ultra-violet	Visible	Infra-Red	Microwave	Radio & TV
Energy	High	↔					Low
Frequency	High	↔					Low
Wavelength	Low	↔					High

☹ 😐 ☺

91

Knowledge of typical sources, detectors and applications for each band in the electromagnetic spectrum.

EM Type	Gamma	X-Ray	Ultra-violet	Visible	Infra-Red	Microwave	Radio & TV
Sources	Nuclear decay, Cosmic rays, Some stars.	Fast electrons hitting metal, Some stars.	Ultra-hot objects, Sparks, Stars	Very hot objects, Starlight	All hot objects Starlight	Electrical Circuits Some stars	Electrical Circuits, Some stars
Detectors	Photographic film, GM Film	Photographic film	Causes Fluorescence, film	Photographic film LDR	Black-bulb thermometer, Heat-Sensitive paper	aerial	aerial
Applications	Killing Cancer Cells, Sterilising equipment	Medical imaging of bones	Sunbeds, Killing bacteria	Seeing, Photography, Lasers	“Night” vision, Remote Controls	Cooking, Mobile Phone signals	Communications, Television Signals

☹ 😐 ☺

92

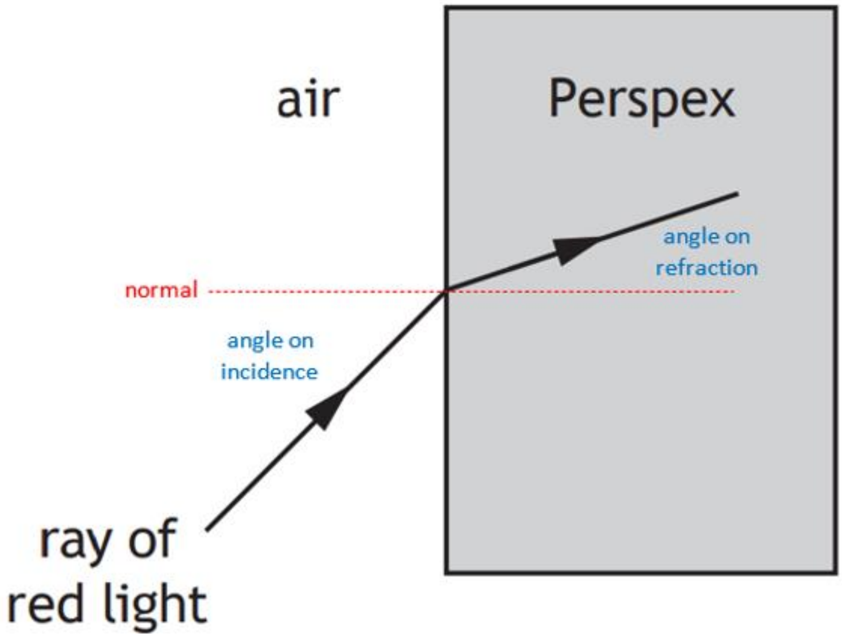
Knowledge that all radiations in the electromagnetic spectrum are transverse and travel at the speed of light.

All forms of Electromagnetic Radiation are transverse waves.

Gamma	X-Ray	Ultra-violet	Visible	Infra-Red	Microwave	Radio & TV

All travel at the speed of light (3.0x10^{8}m s^{-1})

☹ 😐 ☺

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">National 5 Physics Unit 5
Waves: Refraction of Light</th><th rowspan="2"></th><th colspan="3">Traffic Light</th></tr>
<tr><th>Red</th><th>Amber</th><th>Green</th></tr>
<tr><td>93</td><td>Refraction occurs when waves pass from one medium to another.
e.g. glass into air, air into water, air into perspex plastic</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>94</td><td>Description of refraction in terms of change of wave speed, change in wavelength and change of direction (where the angle of incidence is greater than 0°), for waves passing into both a more dense and a less dense medium.
<table>
<tr><th>Property</th><th>Less Dense medium
↓
More Dense Medium
e.g. air → glass</th><th>More Dense medium
↓
Less Dense Medium
e.g. glass → air</th></tr>
<tr><td>Wave Speed</td><td>deceases</td><td>increases</td></tr>
<tr><td>Change in Wavelength</td><td>deceases</td><td>increases</td></tr>
<tr><td>Change of Direction</td><td>bends towards the normal</td><td>bends away the normal</td></tr>
<tr><td>Frequency</td><td>same</td><td>same</td></tr>
<tr><td>Colour of Light</td><td>same</td><td>same</td></tr>
</table></td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
<tr><td>95</td><td>Identification of the normal, angle of incidence and angle of refraction in ray diagrams showing refraction.

</td><td></td><td>☹</td><td>😐</td><td>☺</td></tr>
</table>

No.	National 5 Physics Unit 6a Radiation: Nuclear Radiation	Traffic Light Red	 Amber	 Green

96
98

Type of Radiation	Alpha α	Beta β	Gamma γ
Nature	Helium Nucleus	(Fast) Electron from the Nucleus	Electromagnetic Radiation
Mass	Heavier than Beta	Lighter than Alpha	No Mass
Charge	Positively Charged	Negatively Charged	No charge
Deflection in Electric Field	Attracted to Negative Plate Repelled from Positive Plate	Attracted to Positive Plate Repelled from Negative Plate	No deflection
Stopped By	Piece of paper/few cm air	layer of Aluminium	layer of Lead

☹ 😐 ☺

97
102

Ionisation is the process where **atoms** become charged particles by losing or gaining electrons.

Neutral atoms form **Positive Ions** by *losing* one or more electrons	Neutral atoms form **Negative Ions** by *gaining* one or more electrons

Ionising radiation can have a significant effect on biological tissue.

- Exposing cells to the energy transferred by the radiation can lead to cells being altered by ionising radiation and change their function.
- Cells can be destroyed by ionising radiations.
- A person’s exposure to radiation must be measured to ensure their safety

☹ 😐 ☺

99
100

Activity is the number of nuclear disintegrations per second (or other unit of time)

Activity, number of nuclear disintegrations and time problems can be solved using the equation:

$$A = \frac{N}{t}$$

Symbol	Quantity	Unit
A	Activity	Bq
N	Number of nuclear disintegrations	
t	time	s

e.g. Calculate the activity of a radioactive source where 2400 atoms decay in 5 minute.

$$A = \frac{N}{t} = \frac{2400}{5\text{x}60} = 8 \text{ Bq}$$

☹ 😐 ☺

101

There are many sources of background radiation, some are natural sources.

radon gas	rocks and buildings (e.g. granite)	food and drink
cosmic rays	nuclear power and weapons	medical uses

☹ 😐 ☺

103a

Absorbed dose can be calculated from energy and mass.

$$D = \frac{E}{m}$$

Symbol	Quantity	Unit
D	Absorbed Dose	Gy
E	Energy	J
m	Mass of absorbing tissue	kg

e.g. Calculate the absorbed dose received by a 75kg worker from an X-ray machine from which 2.5mJ of energy is absorbed.

$$D = \frac{E}{m} = \frac{2.5\text{x}10^{-3}}{75} = 3.3\text{x}10^{-5} \text{ Gy}$$

☹ 😐 ☺

103b

Equivalent dose can be calculated from absorbed dose and weighting factor.

- The weighting factor is different for each radiation type (see data sheet)

$$H = D w_r$$

Symbol	Quantity	Unit
H	Equivalent Dose	Sv
D	Absorbed Dose	Gy
w_r	Weighting factor	-

e.g. Calculate the equivalent dose for the person which received an absorbed dose of 0.016 Gy of alpha particles?

$$H = D w_r = 0.016 \text{ x } 20 = 0.32 \text{ Sv}$$

☹ 😐 ☺

104

Use of an appropriate relationship to solve problems involving equivalent dose rate, equivalent dose and time.

$$\dot{H} = \frac{H}{t}$$

Symbol	Quantity	Unit
$\dot{H}$	Equivalent Dose Rate	Sv h^{-1}
H	Dose Equivalent	Sv
t	time	h

e.g. Calculate the equivalent dose received by a passenger on a flight to New York if the flight takes 8 hours and the cosmic radiation received had a equivalent dose rate of 7 μSv h^{-1}

$$\dot{H} = \frac{H}{t} \quad \therefore \quad 7\mu Sv\, h^{-1} = \frac{H}{8h} \quad \therefore \quad H = 7\mu Sv\, h^{-1} \times 8h \quad = 56\ \mu Sv$$

☹ 😐 ☺

105

Comparison of equivalent dose due to a variety of natural and artificial sources.

- Artificial sources account for about 15 per cent of the average background radiation dose.

Natural Sources	**Artificial Sources**
cosmic rays	medical and dental X-rays
radon gas	radiation used in medical diagnosis or treatment
rocks and building materials	radioactive fallout from nuclear weapons testing
food and drink	radioactive waste from nuclear power stations
water & air	industrial measurement equipment

☹ 😐 ☺

106

Equivalent dose rate and exposure safety limits for the public and for workers in the radiation industries can be described by annual effective equivalent dose.

Average annual background radiation in UK	Annual effective dose limit for member of the public	Annual effective dose limit for radiation worker
2·2 mSv	1 mSv	20 mSv

☹ 😐 ☺

107

Applications of nuclear radiation include:

Electricity Generation by Nuclear Power	**Cancer Treatment**
Nuclear Fission Power Station Nuclear Fusion to create energy	Radiotherapy cancer treatment (gamma)
Medical Uses	**Industrial Uses**
Sterilisation e.g. gamma rays kill bacteria Tracers	Smoke Detectors (smoke stops alpha particles) Measuring thickness of paper Tracers to map movement and/or leaks

☹ 😐 ☺

108

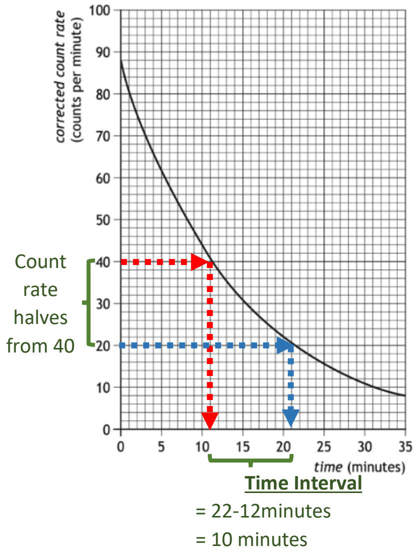
Half-life is defined as:

The time taken for the $\left[\begin{array}{l}\text{activity}\\ \text{corrected count rate}\end{array}\right]$ of a radioactive source to half.

☹ 😐 ☺

109a

Use of graphical data to determine the half-life of a radioactive material.



Take any halving of the corrected count rate on the y-axis.

Work out the time interval on the x-axis for this halving.

From the graph:

Half Life = 10 minutes

☹ 😐 ☺

109b

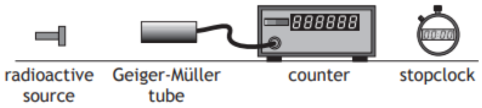
Use numerical data to determine the half-life of a radioactive material.

A radioactive source has an initial activity of 400 kBq. After 15 days the activity of the source is 50 kBq. The half-life of the source is	The source has a half-life of 24 hours. The initial activity of the source is 88 kBq. Determine the activity of the source 96 hours later.	Determine the half-life of a sample for the activity to decrease to one eighth of its original value over a period of 39 hours
400 → 200 → 100 → 50 No. of half-lives = 3 If 1 half-life = 15 days 3 half-lives = 3x15 days = **45days**	No. of half-lives = $\frac{96}{24}$ = 4 Initial Activity = 88kBq 88 → 44 → 22 → 11 → 5.5 Activity after 4 half-lives = **5.5kBq**	1 → $^{1}/_{2}$ → $^{1}/_{4}$ → $^{1}/_{8}$ No. of half-lives = 3 If 3 half-lives = 39 hours 1 half-life = $^{39}/_{3}$ hours = **13 hours**

☹ 😐 ☺

110

The half-life of a radioactive material can be measured using the following equipment



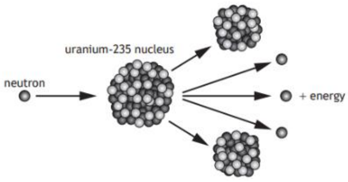
Measure the count in a set time interval
Repeat at (regular) intervals
Measure background (count) and subtract

☹ 😐 ☺

111

Nuclear fission is when a large nucleus of an atom splits into two or more smaller nuclei.

- Induced nuclear fission happens when neutrons are used to bombard a uranium nucleus
- a neutron is absorbed but the nucleus becomes unstable
- this unstable nucleus splits into two (or more) smaller nuclei
- neutrons are also released in the fission reaction and those neutrons can go on and split more nuclei.
- this process is called a chain reaction & heat is given off.
    - If the number of neutrons released is controlled the fission reaction continues at a steady rate and this is the process in nuclear reactors in power generation
    - If the number of neutrons released is left to increase, the fission reaction increases in rate until it explodes. This is the process in a nuclear bomb.



☹ 😐 ☺

112

During a nuclear fusion reaction two nuclei of smaller mass number combine to produce a nucleus of larger mass number.

- Nuclear fusion reactions take place at very high temperatures
- fusion reactions are important because they can release energy
    - plasma containment is required to sustain nuclear fusion reactions in a reactor
    - requires strong magnetic fields

☹ 😐 ☺

No.

National 5 Physics Unit 6b
Radiation: Units, Prefixes and Scientific Notation

Traffic Light
Red Amber Green

113

SI Units are often used with the following prefixes:

Prefix	nano-	micro	milli	kilo	mega	giga
Symbol	n	μ	M	k	M	G
Meaning	x10^{-9}	x10^{-6}	x10^{-3}	x10^{3}	x10^{6}	x10^{9}

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114

The appropriate number of significant figures must be used in the final answer.

- the final answer can have no more significant figures than the value with the least number of significant figures used in the calculation.

☹ 😐 ☺

115

Scientific notation is often used in calculations e.g.

0.0004686 in scientific notation is 4.69x10^{-4} (3 SIG FIG)

468400000 in scientific notation is 4.68x10^{8} (3 SIG FIG)

Scientific notation has a number greater than or equal to one but less than 10 multiplied by 10^{x} where X is an integer.

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