St Ninian's HS



National 5 Physics

Dynamics

and

Space

Pupil Notes

Unit 2: Dynamics and Space

Topics:

- [ ] 2.1 Vectors and Scalars
- [ ] 2.2 Velocity – Time Graphs and Acceleration
- [ ] 2.3 Newton's Laws
- [ ] 2.4 Projectile Motion
- [ ] 2.5 Space Exploration and Cosmology

SQA Course Specifications N5

Vectors and Scalars

- ☐ Definition of vector and scalar quantities.
- ☐ Identification of force, speed, velocity, distance, displacement, acceleration, mass, time and energy as vector or scalar quantities.
- ☐ Calculation of the resultant of two vector quantities in one dimension or at right angles.
- ☐ Determination of displacement and/or distance using scale diagram or calculation.
- ☐ Determination of velocity and/or speed using scale diagram or calculation.
- ☐ Use of appropriate relationships to solve problems involving velocity, speed, displacement, distance and time.
- ☐ Description of experiments to measure average and instantaneous speed.

2.1 Vectors and Scalars

In Physics all quantities can be divided into two groups, Scalars and Vectors.

A **scalar quantity** has **magnitude** (size) **only**.

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

Some examples of scalars and vectors are given in the table below:

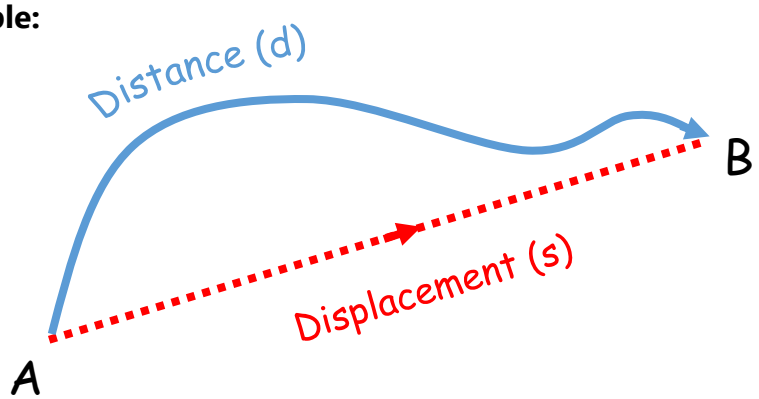
Scalar	Vector
Distance	Displacement
Speed	Velocity
Mass	Force (Weight)
Energy	Acceleration
Time	

Distance and Displacement:

Distance is a **scalar** quantity. It measures the <u>total</u> distance travelled.

Displacement is a **vector** quantity. Displacement is the length measured from the starting point to finishing point in a straight line.

Example:

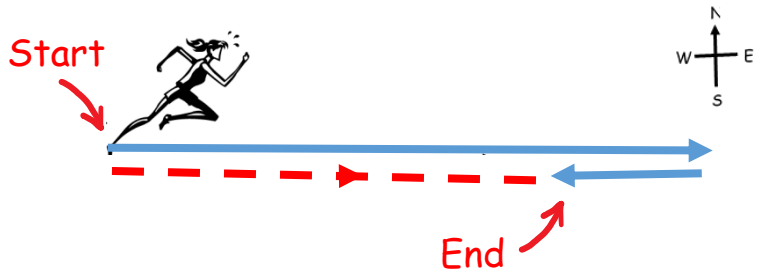


Note: As displacement is a vector, the direction must be stated. The direction of the displacement is usually given as a **bearing**.

Combining vectors:

Vectors are represented by a line with an arrow. The length of the line represents the size of the vector. The arrow head shows the direction of the vector.

The sum of the vectors is called the resultant.

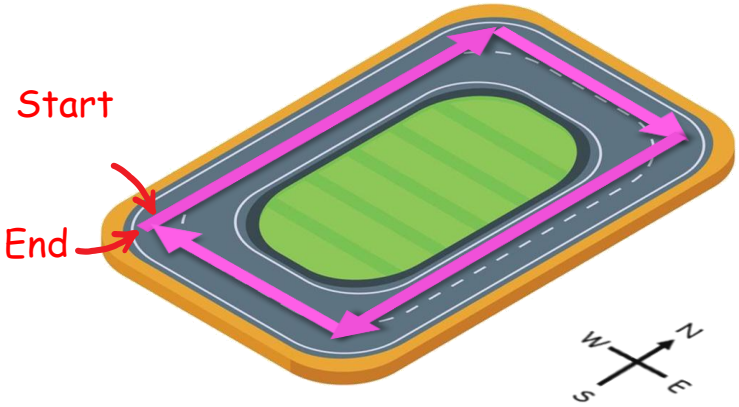


The runner runs 8m East (090) and then runs 2m West (270)

In the above example the resultant displacement of the runner from start to end is **6m East**.

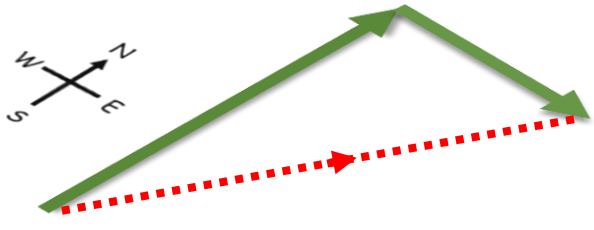
A car drives 30m north, 10m east, 30m south and then 10m west.

In this example the resultant displacement of the car, from start to end, is **0m**.



Vectors at right angles

A boat sails 500m north and then 100m east:



In this example our vectors make a right angle.

This right angle gives us a triangle.

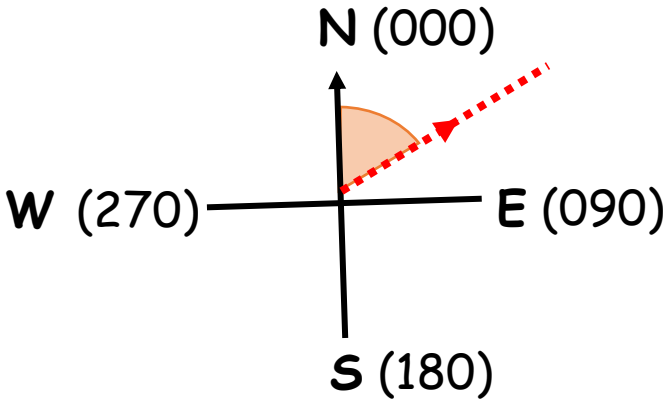
We can work out the magnitude of (how big) the displacement (s) is by using Pythagoras:

$$s^2 = b^2 + c^2$$

To work out the direction of the displacement we use bearings:

Bearings:

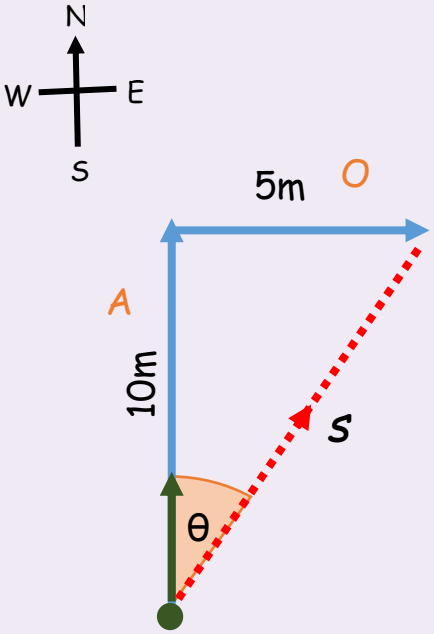
Bearings are angles measured clockwise relative to North. Bearings are always stated as three-figure numbers.



In the example above the bearing is **(050).** Bearings are always 3 figures and have no units. When doing this for yourself you will either use a protractor (only for scale drawings) or trigonometry to determine these angles.

Worked Example:

A person walks 10m north then 5m east.



a) State the total distance.

$$d = 10 + 5 = 15m$$

b) Determine the **magnitude** of the displacement.

$$s^2 = b^2 + c^2$$

$$s^2 = 10^2 + 5^2$$

$$s = \sqrt{10^2 + 5^2} = 11\ m$$

c) Determine the **direction** of the displacement.

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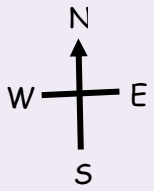
$$\tan\theta = O/A$$

$$\tan\theta = 5/10$$

$$\theta = \tan^{-1}(5/10) = 26.6$$

$$= 027$$

Worked Example:



Someone walks 7km east, 4km south and then 2km west.

a) **Determine** the magnitude of the displacement.

b) **Determine** the direction of the displacement.

Step 1: Draw a vector diagram if one was not given in the question.



Step 2: Simplify your diagram into a triangle.

In this example we take (7km East – 2km West = 5km East).

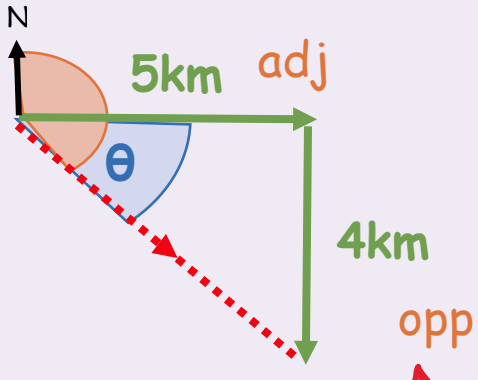
Step 3: Use Pythagoras and trigonometry to solve:

(a) $s^2 = b^2 + c^2$

$s^2 = 4^2 + 5^2$

$s = \sqrt{4^2 + 5^2} = 6\ m$

(b) To work out the bearing (our angle from north) we must first work out the angle inside our triangle (θ).



Always label opposite and adjacent

$\tan\theta = O/A$

$\tan\theta = \frac{4}{5}$

$\theta = \tan^{-1}\frac{4}{5}$

$\theta = 38.7$

To get our bearing in this example we add 90

$38.7 + 90 = 129$

Speed and Velocity:

Average Speed

Average speed is the **total** distance travelled per unit time.

Average speed can be calculated using:

$$d = \bar{v}t$$

distance (m) → d

time (s) ← t

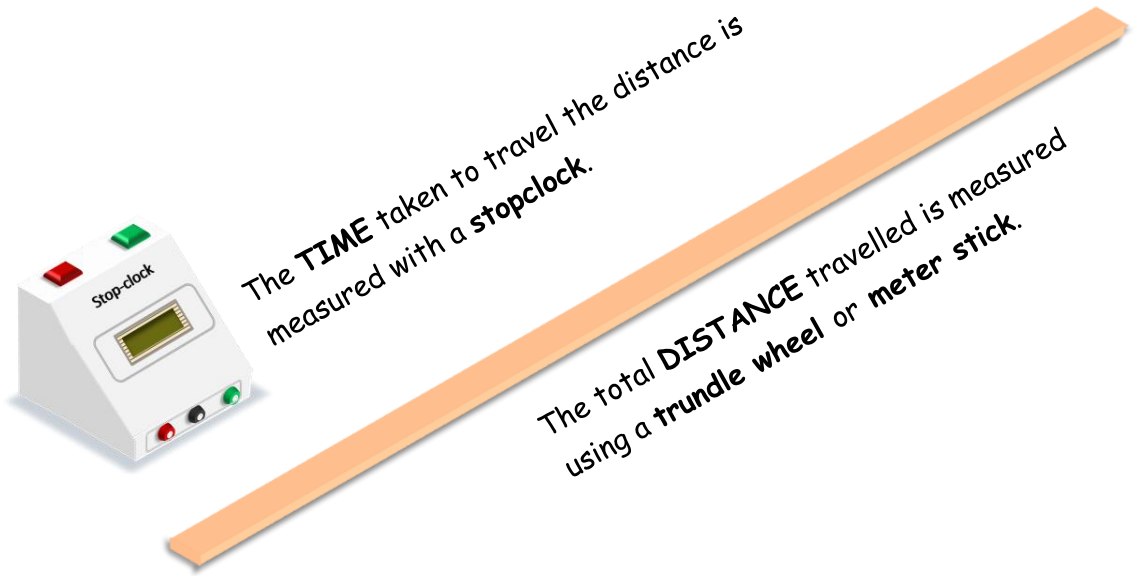
average speed (ms^{-1}) ↑ $\bar{v}$

The standard unit for speed can be written as m/s or ms^{-1}. Sometime alternatives such as kilometres per hour (km/h) can be used.

Measuring Average Speed

To determine average speed between two points you must measure:

- the total **DISTANCE** travelled
- the **TIME** taken to travel that distance



The speed is then calculated using: $\text{speed} = \frac{\text{distance}}{\text{time}}$

Instantaneous Speed

The **instantaneous speed** of an object is the speed of an object as it passes one particular point.

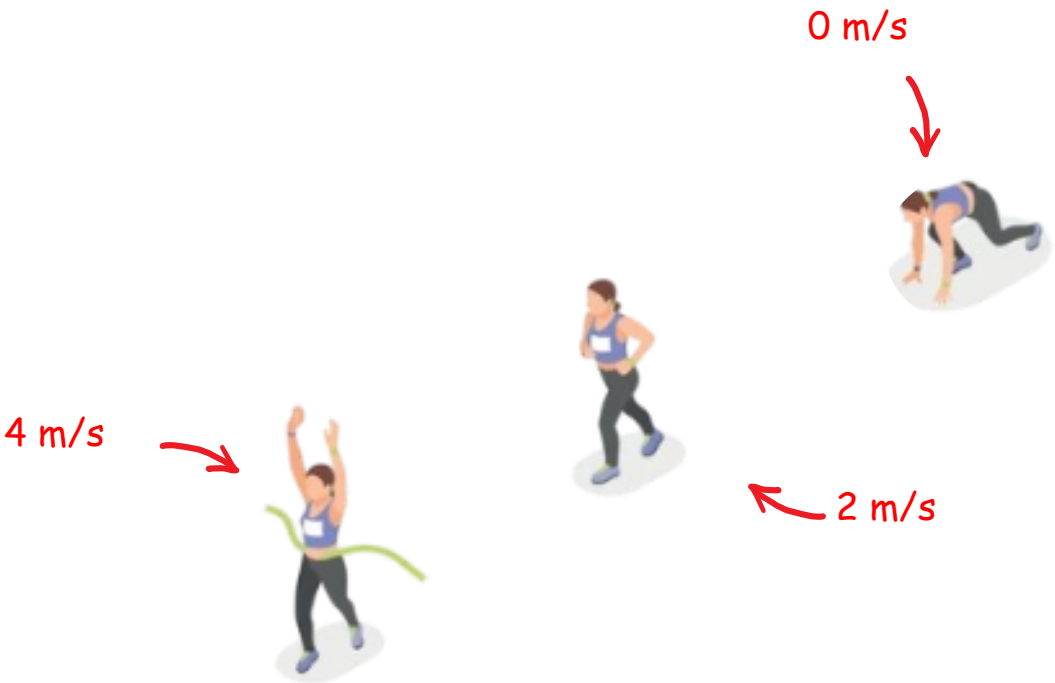
Instantaneous speed can be calculated using:

$$d = vt$$

- d: width of object (m)
- t: Time for object to pass a point (s)
- v: instantaneous speed (ms^{-1})

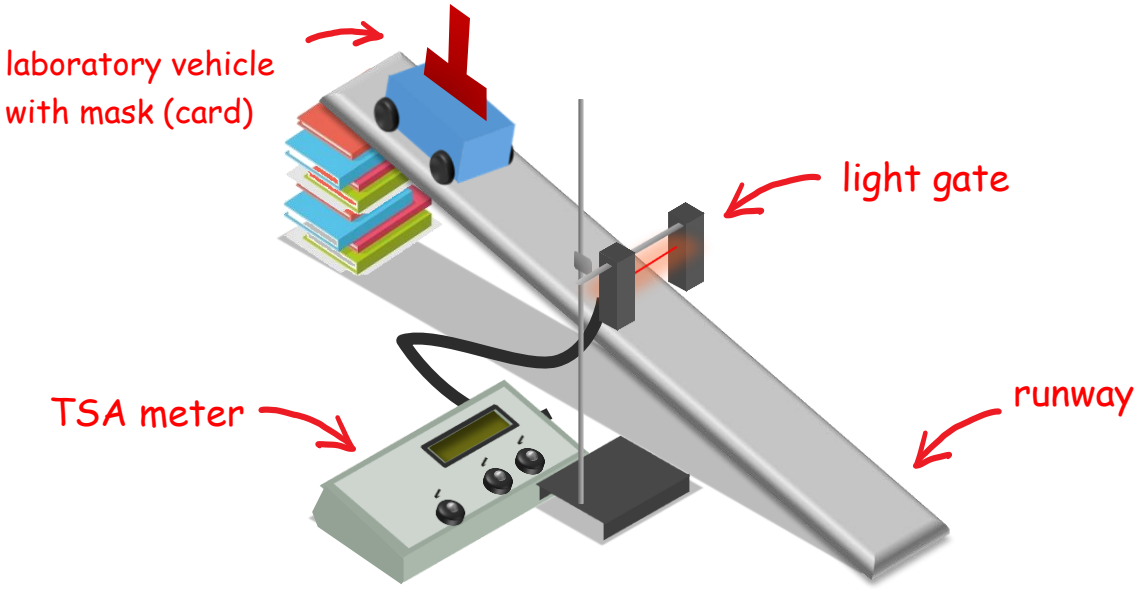
The difference between average and instantaneous speed:

Average Speed	Instantaneous Speed
Total distance of journey divided by total time of journey. Used for "full journeys" Example: Speed over a full 100m race.	Width of object divided by time to pass a point. Used for specific points with a journey. Example: The speed as a runner crosses the finish line.



Measuring Instantaneous Speed:

The measurement of instantaneous speed requires the following apparatus:



Procedure for measuring instantaneous speed:

· The **distance** which is the length of the mask (card) is measured with a ruler.

The trolley is released from the top of the runway.

· The trolley passes through the light gate at the bottom of the runway, the TSA meter will measure the **time** taken by the mask (card) to cut the light gate.

· Calculate instantaneous speed using; $$\textbf{instantaneous speed} = \frac{\textbf{length of card}}{\textbf{time to cut beam}}$$

Worked Example:

A laboratory trolley runs down a 1.1 m ramp in 3 seconds. The trolley has a 5 cm mask attached to it. The trolley takes 0.1s to pass through the light gate. **Calculate** the instantaneous speed of the trolley as it passes the light gate.

$v = ?$

$d = 5\ cm = 0.05\ m$

$t = 0.1\ s$

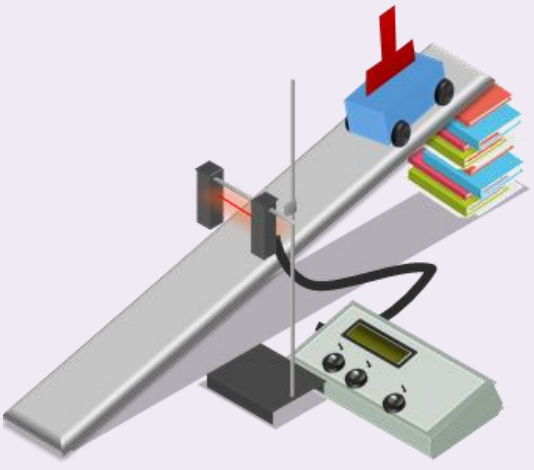
Note: both the time and distance used are different than if you were calculating the average speed

$$d = v \times t$$

$$0.05 = v \times 0.1$$

$$v = \frac{0.05}{0.1}$$

$$v = 0.5\ ms^{-7}$$



Velocity

Speed is a scalar quantity, it is the distance covered by an object per unit time. Velocity is a vector quantity.

Velocity can be calculated using:

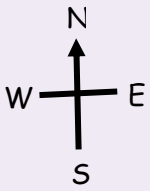
displacement (m) → $s = vt$ ← time (s)

velocity (ms^{-1}) ↑

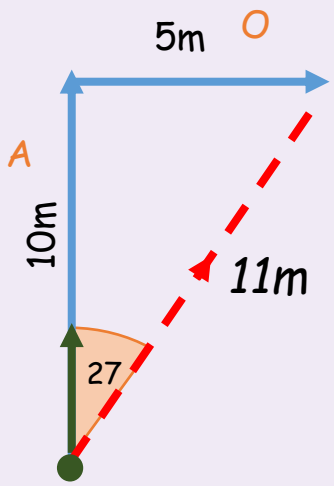
As velocity is a vector it therefore **requires a direction**, this will be the same as the direction of the displacement.

Worked Example: (continued from page 2)

A person walks 10m north then 5m east in a time of 30 seconds.



c) **Calculate** the average speed of the person.



$d = vt$

$15 = v \times 30$ | x 30

$v = \frac{15}{30}$

$v = 0.5\ ms^{-1}$

d) **Calculate** the average velocity of the person.

$s = vt$

$11 = v \times 30$ | x 30

$v = \frac{11}{30}$

$v = 0.37\ ms^{-1}$ (027)

Note: velocity is a vector and needs a direction (this was worked out on pg 2)

SQA Course Specifications N5

Velocity – Time Graphs and Acceleration

- ☐ Drawing or sketching of velocity–time or speed–time graphs from data.
- ☐ Interpretation of a velocity–time graph to describe the motion of an object.
- ☐ Determination of displacement from a velocity–time graph.
- ☐ Definition of acceleration in terms of initial velocity, final velocity and time.
- ☐ Use of an appropriate relationship to solve problems involving acceleration, initial velocity (or speed), final velocity (or speed) and time.
- ☐ Determination of acceleration from a velocity–time graph.
- ☐ Description of an experiment to measure acceleration.

2.2 Velocity-Time Graphs and Acceleration

Acceleration

The velocity of an object is how fast it is travelling and is the distance travelled in a second.

> The **acceleration** of an object is the **change** in velocity per unit time.

Acceleration can be calculated using:

final velocity (ms^{-1}) — initial velocity (ms^{-1})

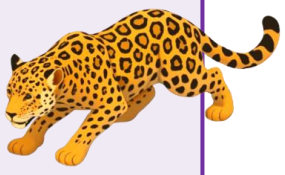
$$a = \frac{v - u}{t}$$

acceleration (ms^{-2}) — time (s)

Acceleration is a vector quantity.

If the object is decelerating, then the final speed is less than the initial speed, then acceleration is in the opposite direction to motion of the object and acceleration will be negative.

Worked Example:



A jaguar can reach 27ms^{-1} from rest in 9.0 s.

Calculate its acceleration.

Solution:

$a = ?$

$v = 27 \ ms^{-1}$

$u = 0 \ ms^{-1}$ (starts from rest)

$t = 9 \ s$

$$a = \frac{v - u}{t}$$

$$a = \frac{27 - 0}{9}$$

$$a = 3 \ ms^{-2}$$



Rearranging the acceleration formula:

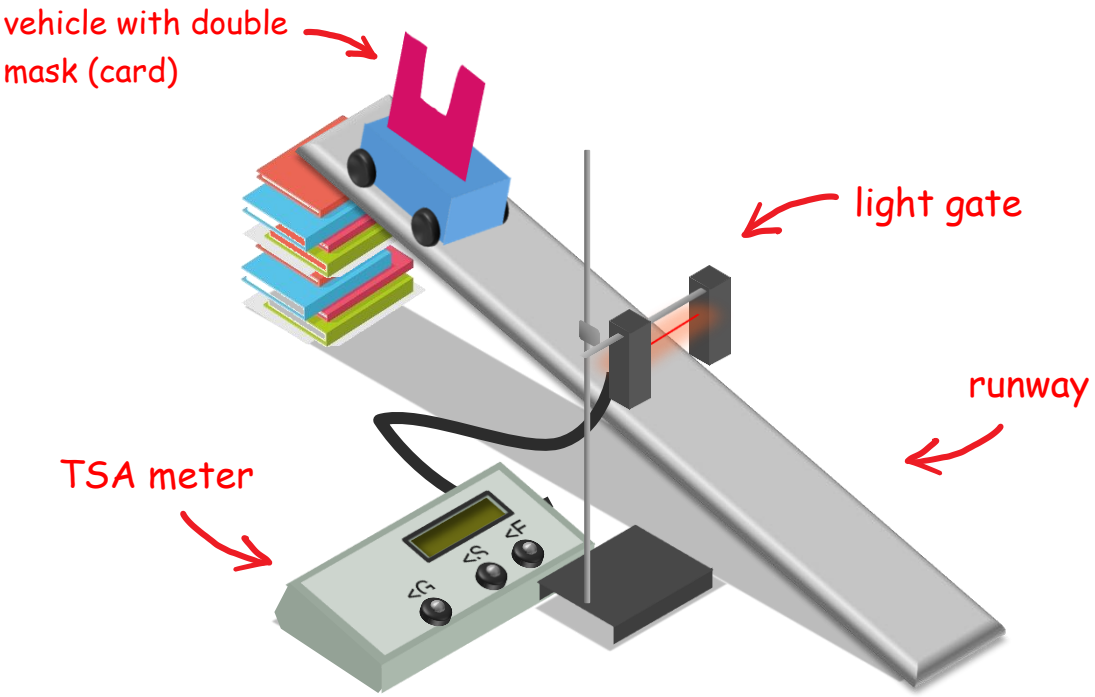
The acceleration equation can be rearranged in terms of the final velocity, $\boldsymbol{v}$:

$$\boldsymbol{v = u + at}$$

This version of the formula is **not** provided on the relationship sheet but is useful when solving for final or initial velocity.

Measuring Acceleration:

The measurement of acceleration requires the following apparatus:

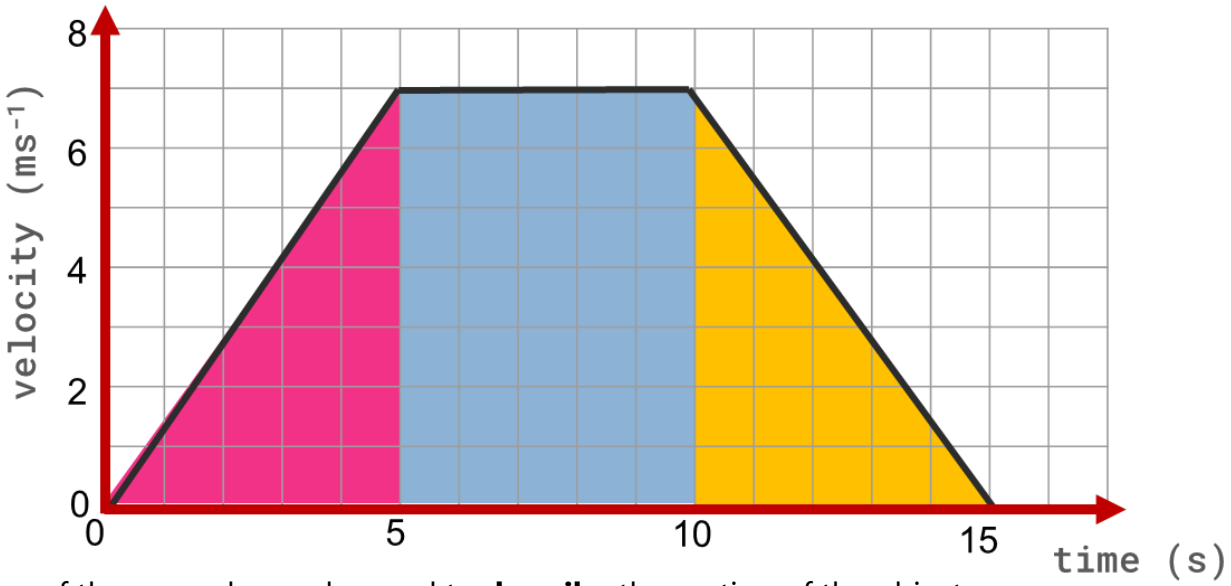


Procedure for measuring acceleration:

- Measure the length of one of the masks of card on the mask and input into the TSA.
- Allow the trolley to run down the runway.
- The first part of the mask will allow the initial instantaneous speed, $\boldsymbol{u}$ to be measured as it passes through the light gate.
- The second part of the mask will allow the final instantaneous speed, $\boldsymbol{v}$ to be measured as it passes through the light gate.
- Measure time taken for the change in speed using a light gate connected to a TSA.
- Calculate acceleration using; $$a = \frac{v - u}{t}$$

Velocity-Time Graphs

Information about the motion of an object can be obtained from both velocity-time and speed-time graphs.



The shape of these graphs can be used to **describe** the motion of the object:

For the graph above:

- The object has a **constant acceleration** between 0 and 5 seconds.
- It travels at a **constant velocity** between 5 and 10 seconds.
- And has a **constant deceleration** between 10 and 15 seconds.

These graphs can also be used to determine the displacement of the object (or the distance for speed-time graphs) by working out the area under the graph.

Worked Example:

For the graph above determine the displacement of the object during the 15 seconds.

Displacement = Area under graph

Area 1

$= \frac{1}{2} \times 1 \times b$
$= \frac{1}{2} \times 5 \times 7$
$= 17.5$ m

Area 2:

$= 1 \times b$
$= 5 \times 7$
$= 35$ m

Area 3:

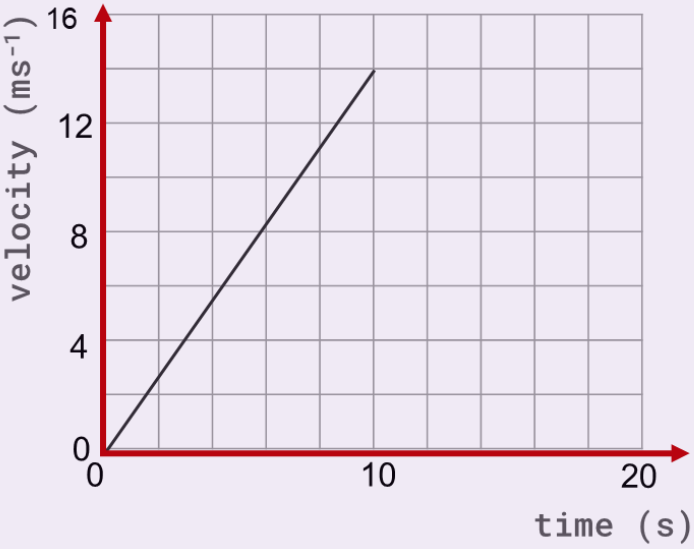
$= \frac{1}{2} \times 1 \times b$
$= \frac{1}{2} \times 5 \times 7$
$= 17.5$ m

Total displacement = 70 m

Worked Example 2:

The velocity of a cyclist is seen on the graph below.

a) Use the graph to **calculate** the acceleration of the cyclist for the first 8 seconds of their journey.



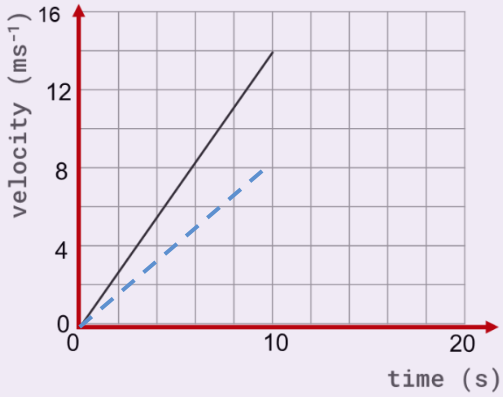
$$a = \frac{v - u}{t}$$

$$a = \frac{14 - 0}{10}$$

$$a = 1{\cdot}4 \text{ ms}^{-2}$$

b) A second cyclist has a lower acceleration.

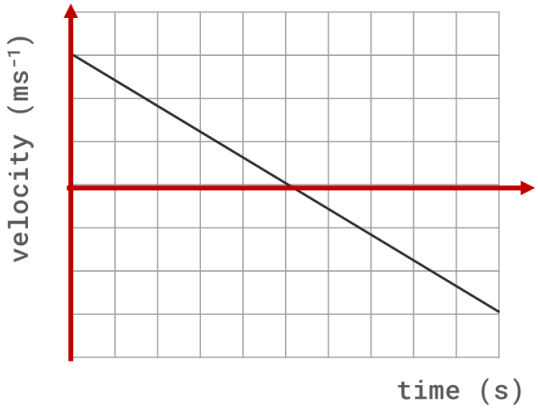
Add a line to the graph to show the motion of the second cyclist for the first 10 seconds of their journey.



The lower gradient of the dotted line shows lower acceleration.

Objects changing direction

The initial velocity is positive (its above the time axis)



The final velocity is negative (its below the time axis)

That means this graph shows an object slowing down in one direction and then accelerating in the other direction.

SQA Course Specifications N5

Newton's Laws

- ☐ Application of Newton's laws and balanced forces to explain constant velocity (or speed), making reference to 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.

- ☐ Use of an appropriate relationship to solve problems involving unbalanced force, mass and acceleration for situations where one or more forces are acting in one dimension or at right angles.

- ☐ Use of an appropriate relationship to solve problems involving weight, mass and gravitational field strength.

- ☐ Explanation of motion resulting from a 'reaction' force in terms of Newton's third law.

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

2.3 Newton's Laws

Forces

Forces are measured in Newtons (N) and are normally considered to be a **push** or a **pull** from one object to another.

Forces can change the:

- Shape of an object
- Speed of an object
- Direction of an object

Friction:

When two surfaces rub against one another, microscopic bumps on both surfaces catch onto each other – this causes **friction**.

Friction is a resistive force that opposes motion.

Friction always acts in the opposite direction to the movement of an object. Friction occurs as **kinetic energy** changes into **heat energy**.

Air resistance:

Air resistance is a type of friction. It is caused when an object moves through the air and collides with air particles. Objects that move faster experience more air resistance.

Examples of factors affecting friction (and air resistance):

aerodynamic shape reduces air resistance





large surface area on tyres means more contact with the ground, therefore greater friction

Thinner tires less contact with the ground, therefore less friction

Weight and Mass

In every day speech mass and weight are often used interchangeably but in Physics there is an important difference:

Mass is a measure of the amount of matter in an object.

Mass **does not** change on different planets. It is a scalar quantity, it is measured in kilograms (kg).

Weight is a force which is caused by the pull of gravity on an object.

Weight **does** change on different planets. It is a vector quantity. Since weight is a force it is measured in Newtons, (N).

Weight and mass are related with the following relationship:

$$W = mg$$

weight (N) — gravitational field strength (N/kg) — mass (kg)

The gravitational field strength is the force that gravity exerts on every kilogram of mass. The value is different on different planets and can be found on the data sheet.

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Worked example:

At age 27, Helen Sharman was the first Briton in space when she visited the Mir space station on an eight day journey in May 1991. Her mass was 60 kg.

a) Calculate her weight on Earth.

b) Calculate her weight if she landed on the moon.

(a) $W = ?$ $\quad W = mg$

$m = 60kg$ $\quad W = 60 \times 9{\cdot}8$

$g = 9{\cdot}8\ Nkg^{-1}$ $\quad W = 588\ N$

(b) $W = ?$ $\quad W = mg$

$m = 60kg$ $\quad W = 60 \times 1{\cdot}6$

$g = 1{\cdot}6\ Nkg^{-1}$ $\quad W = 96\ N$

Newton's 1st Law

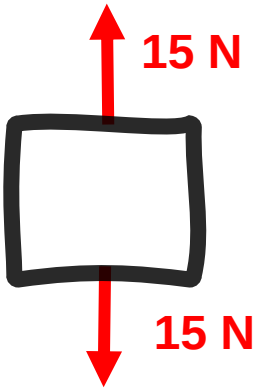
Newton's first law states:

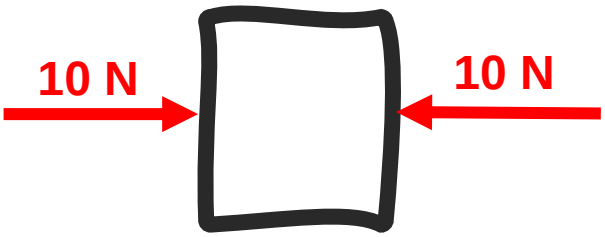


> *"An object will remain at rest or move at a constant velocity in a straight line unless acted on by an unbalanced force."*

This means that if two forces of the same magnitude are acting on an object in opposite directions, that object will remain stationary or move at a constant velocity. We describe these forces as **balanced.**

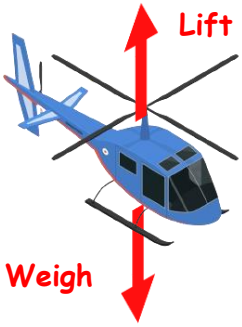
We often use free body diagrams to visualise this:





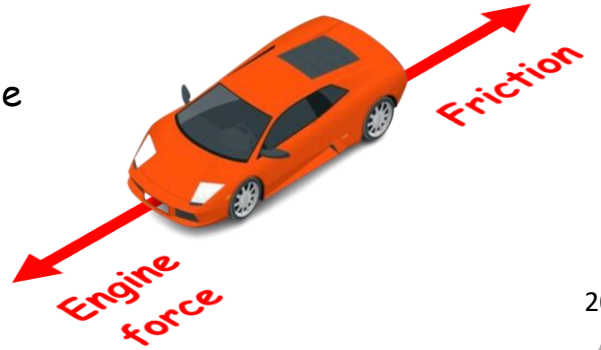
In each case the overall (resultant) force is 0 N. This means the object will **remain stationary** or will travel at a **constant velocity**.

Examples of Balanced Forces:



A helicopter is hovering at a constant height. The weight of the helicopter is balanced by the lift provided by the blades.

A car travelling at its maximum speed. The engine force is equal and opposite to the forces of friction acting upon the car.



Newton's 2nd Law

Newton's second law states:

> *"When an object is acted on by a constant unbalanced force the body moves with constant acceleration in the direction of the unbalanced force."*

This means when unbalanced forces act upon an object, the object will **accelerate** (or **decelerate**) in the direction of the unbalanced force.

Newton's second law is often given as the following formula:

$$F = ma$$

F: unbalanced force (N)

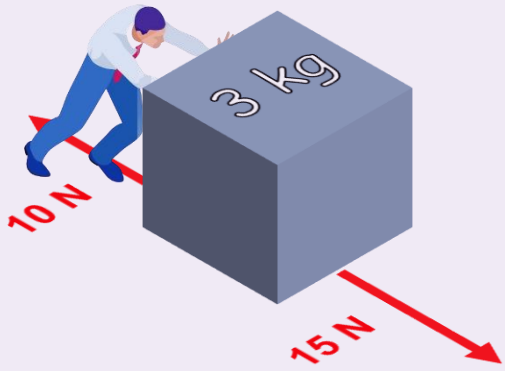
m: mass (kg)

a: acceleration (ms^{-2})

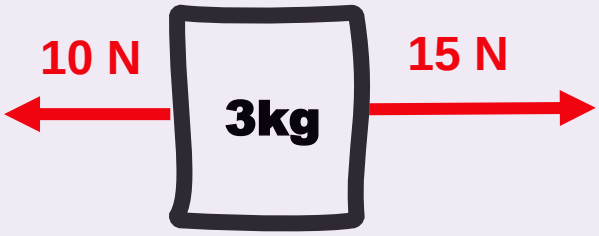
This means the acceleration of an objects is increased in the unbalanced force is increase and/or the mass is decreased. (and vice versa)

Worked Example:

A 3 kg block is pushed forward with an applied force of 15 N, while also experiencing 10 N of friction as seen in the image:



Calculate the acceleration of the block.



$F_{un} = 15 - 10 = 5\ N$

$m = 3kg$

$a = ?$

$F_{un} = m\ a$

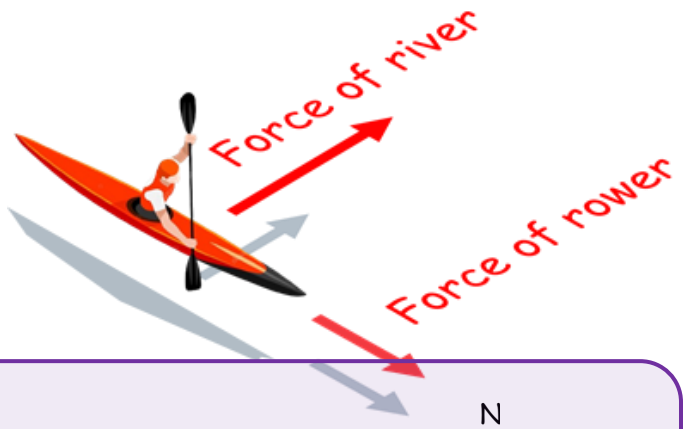
$5 = 3 \times a$

$a = 1{\cdot}7ms^{-2}$

F is written as F_{un} to remind you that it must be the unbalanced force that you use!"

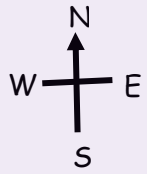
Forces at right angles

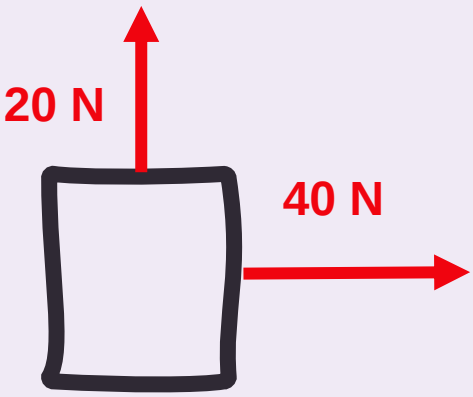
When forces act at a right angle to each other the resultant force can be determined in much the same way as in displacement questions:



Worked Example:

Two forces are acting on the block as seen in the diagram below:

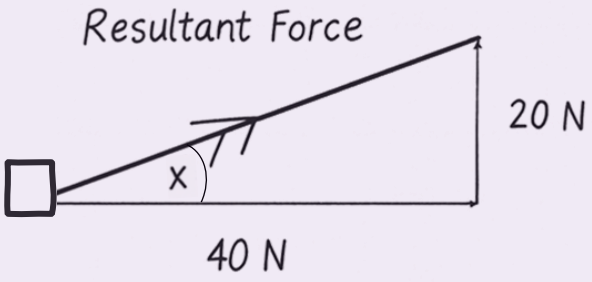




a) **Determine** the magnitude of the resultant force acting on the block

b) **Determine** the direction of the resultant force acting on the block

First redraw the forces to be "nose to tail"



(a)

Determine magnitude using pythagoras

$$\text{Magnitude of force} = \sqrt{40^2 + 20^2}$$
$$= 44.7 \text{ N}$$

Determine direction using trigonometry

(b) $\tan x = O/A$ SOH CAH TOA

$$\tan x = \frac{20}{40}$$
$$x = 26.6^\circ$$

$\therefore$ the bearing is given by 90 – 26.6 = 63.4

Resultant force = 44.7 N (063)

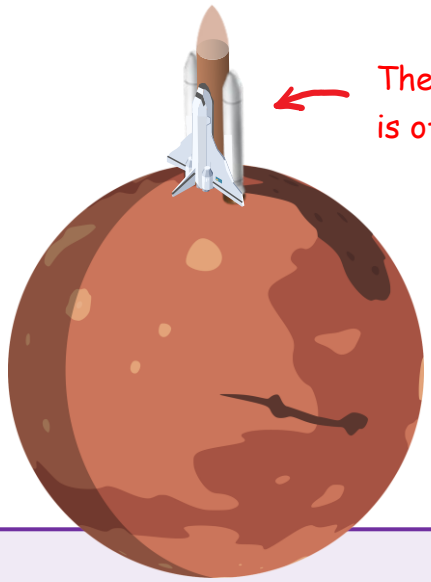
Rockets

Newton's Laws help up explain how rockets launch.

Rockets have a very large mass so must produce a large unbalanced force to allow them to accelerate upwards, and away from the surface of a planet.



Like all objects, a rocket will have a different weight on different planets.



The engine force of a rocket is often called thrust.

Worked Example:

A rocket of mass 2.5 x 10^6 kg lifts off from the Earth with a thrust of 3.5 x 10^7 N.

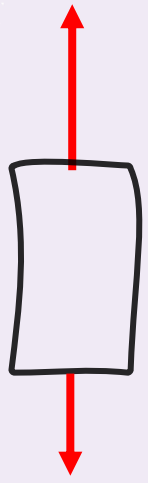
a) **Draw** a free body diagram showing the vertical forces acting on the rocket at lift off.

b) **Calculate** the resultant force acting on the rocket.

c) **Calculate** the initial acceleration of the rocket.

part b) is asking us to determine the "overall force" acting on our force diagram from part a)

(a)



b) $W = m\ g$

One of our forces is Weight which we can calculate using:

$W = 2{\cdot}5x10^{6} \times 9{\cdot}8$

$W = 2{\cdot}45x10^{7}$

We then take this away from the thrust as they are acting in **opposite** directions:

$F_{un} = thrust - weight$

$F_{un} = 3{\cdot}5x10^{7} - 2{\cdot}45x10^{7}$

$F_{un} = 1{\cdot}1x10^{7}\ N$

c) $F_{un} = ma$

Remember: resultant or "unbalanced force" must be used when calculating acceleration

$1{\cdot}1x10^{7} = 2{\cdot}5x10^{6} \times a$

$a = 4{\cdot}4\ ms^{-2}$

Newton's 3rd Law

Newton's third law states:

> *"For every action, there is an equal and opposite reaction".*

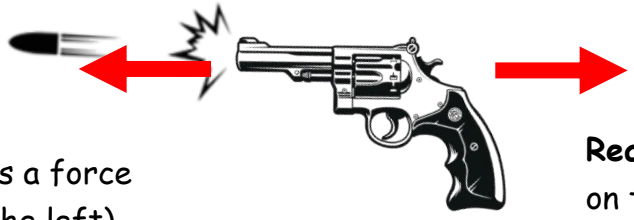
Forces come in pairs called the action and reaction. These two forces are always equal in size, but opposite in direction. They do not both act on the same object.

If object A exerts a force (the action) on object B, then object B will exert an equal, but opposite force (the reaction) on object A. These action and reaction forces are also known as **Newton Pairs.**

Action: exerts a backwards force on the ground.

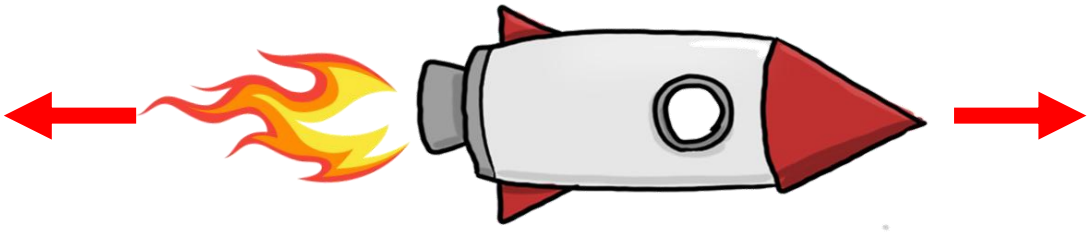


Reaction: Ground exerts a forwards force on the foot.



Action: Gun exerts a force on the bullet (to the left).

Reaction: Bullet exerts a force on the gun (to the right).



Action: Rocket engines exert a backwards force on the exhaust gases.

Reaction: Exhaust gases exert a forwards force on the rocket engines.



Freefall & Terminal Velocity

An object falling from a height will accelerate due to its weight. If the unbalanced force is equivalent to the object's weight, the object is in **free-fall**.



At the beginning of the journey weight is larger than air resistance.

This unbalanced force causes the skydiver to accelerate downwards.



As their speed increases the magnitude of air resistance increases.

At a certain point it will be the same magnitude as the weight (and opposite in direction).

Balanced forces result in the skydiver travelling at a constant speed (**terminal velocity**).



Parachutes increase the magnitude of air resistance (by increasing surface area).

The forces are once again **un**balanced.

The direction of the unbalanced force (upwards) causes the skydiver to decelerate.

SQA Course Specifications N5

Projectile Motion

- [ ] Explanation of projectile motion in terms of constant vertical acceleration and constant horizontal velocity.

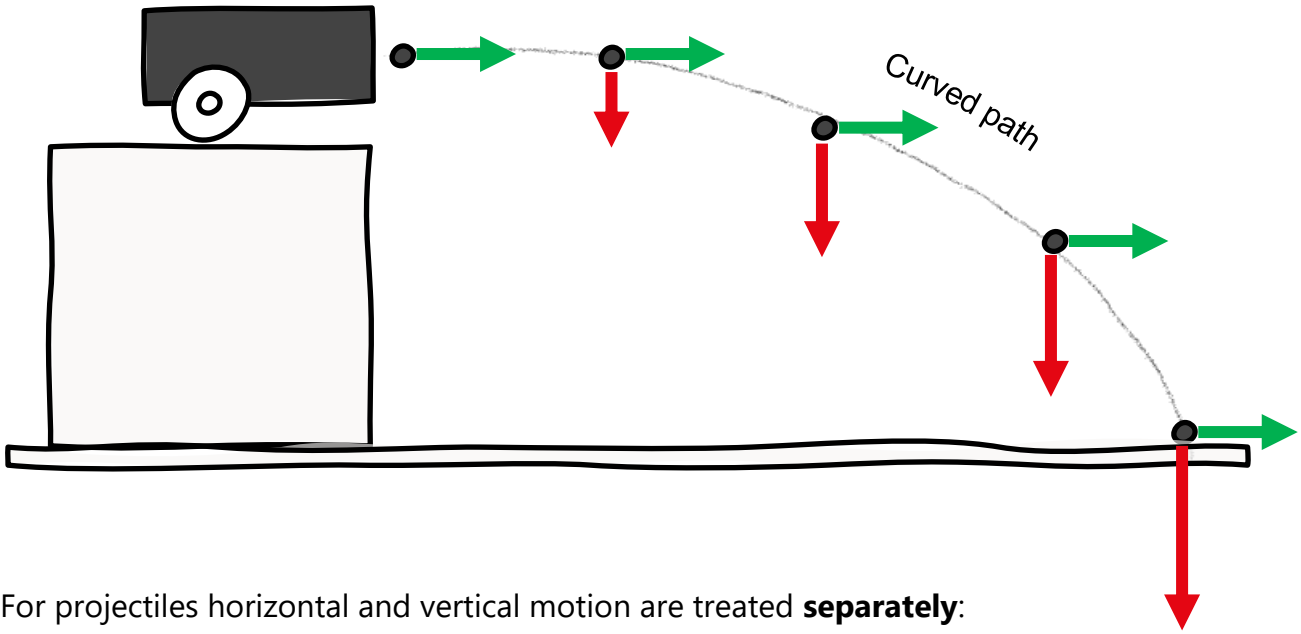
- [ ] Use of appropriate relationships to solve problems involving projectile motion from a horizontal launch, including the use of motion graphs.

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

2.4 Projectile Motion

Projectiles

A **projectile** is an object that moves freely through space/air under the influence of gravity (we consider the only force a projectile experiences to be **weight** – air resistance is negligible). Projectiles often follow a curved path as shown below:



For projectiles horizontal and vertical motion are treated **separately**:

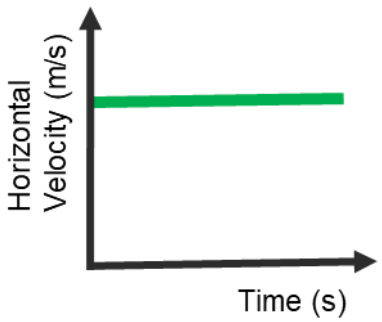
Horizontal Motion:

Since there are no horizontal forces acting on the object the horizontal velocity is constant.

This means we can use the formula:

$$d = vt$$

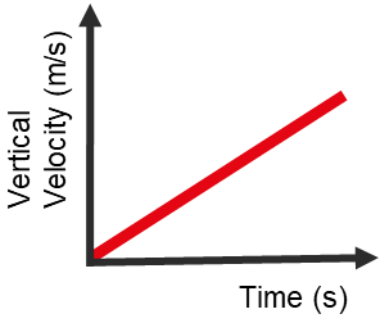
The Horizontal motion can be represented:



Vertical Motion:

A projectile has a constant (downwards) acceleration due to gravity (unbalanced force = weight), therefore the equation below should be used.

$$v = u + at$$



Worked Example:

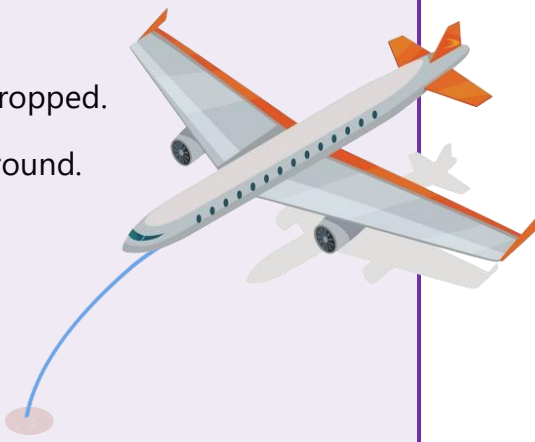
A plane is travelling horizontally at 150 ms^{-1} a food parcel falls from the plane and hits the ground 10 seconds later.

Calculate:

(a) the horizontal distance travelled by the food parcel after being dropped.

(b) the vertical velocity of the food parcel just before it strikes the ground.

(c) the height that the food parcel was dropped from.



(a) horizontally

$d = ?$
$v = 150\ ms^{-1}$
$t = 10\ s$

parcel maintains the horizontal speed of the plane

$$v = \frac{d}{t}$$

$$150 = \frac{d}{10}$$

$$d = 1500\ m$$

(b) Vertically

$u = 0\ ms^{-1}$
$a = 9.8\ ms^{-2}$
$t = 10\ s$
$v = ?$

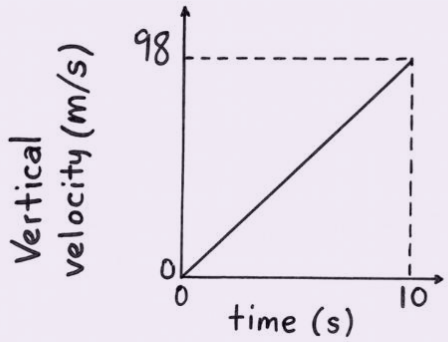
acceleration due to gravity

$$v = u + at$$

$$v = 0 + (9.8 \times 10)$$

$$v = 98\ ms^{-1}$$

(c)



Height (or vertical distance) does not appear in our vertical motion formula. As such, the only way to determine height is to sketch a velocity time graph.

Vertical height = area under the grap

= ½ x 10 x 98

= 490 m

SQA Course Specifications N5

Space Exploration and Cosmology

- ☐ Basic awareness of our current understanding of the universe.
- ☐ Use of the space terms correctly and in context
- ☐ Awareness of the benefits of satellites:
- ☐ Knowledge that geostationary satellites have a period of 24 hours and orbit at an altitude of 36 000 km.
- ☐ Knowledge that the period of a satellite in a high altitude orbit is greater than the period of a satellite in a lower altitude orbit.
- ☐ Awareness of the challenges of space travel.
- ☐ Awareness of the risks associated with manned space exploration
- ☐ Knowledge of Newton's second and third laws and their application to space travel, rocket launch and landing.
- ☐ Use of an appropriate relationship to solve problems involving weight, mass and gravitational field strength, in different locations in the universe.
- ☐ Use of the term 'light-year' and conversion between light-years and metres.
- ☐ Basic description of the 'Big Bang' theory of the origin of the universe.
- ☐ Knowledge of the approximate estimated age of the universe.
- ☐ Awareness of the use of the whole electromagnetic spectrum in obtaining information about astronomical objects.
- ☐ Identification of continuous and line spectra.
- ☐ Use of spectral data for known elements, to identify the elements present in stars.

2.5 Space Exploration and Cosmology

Space Terms:

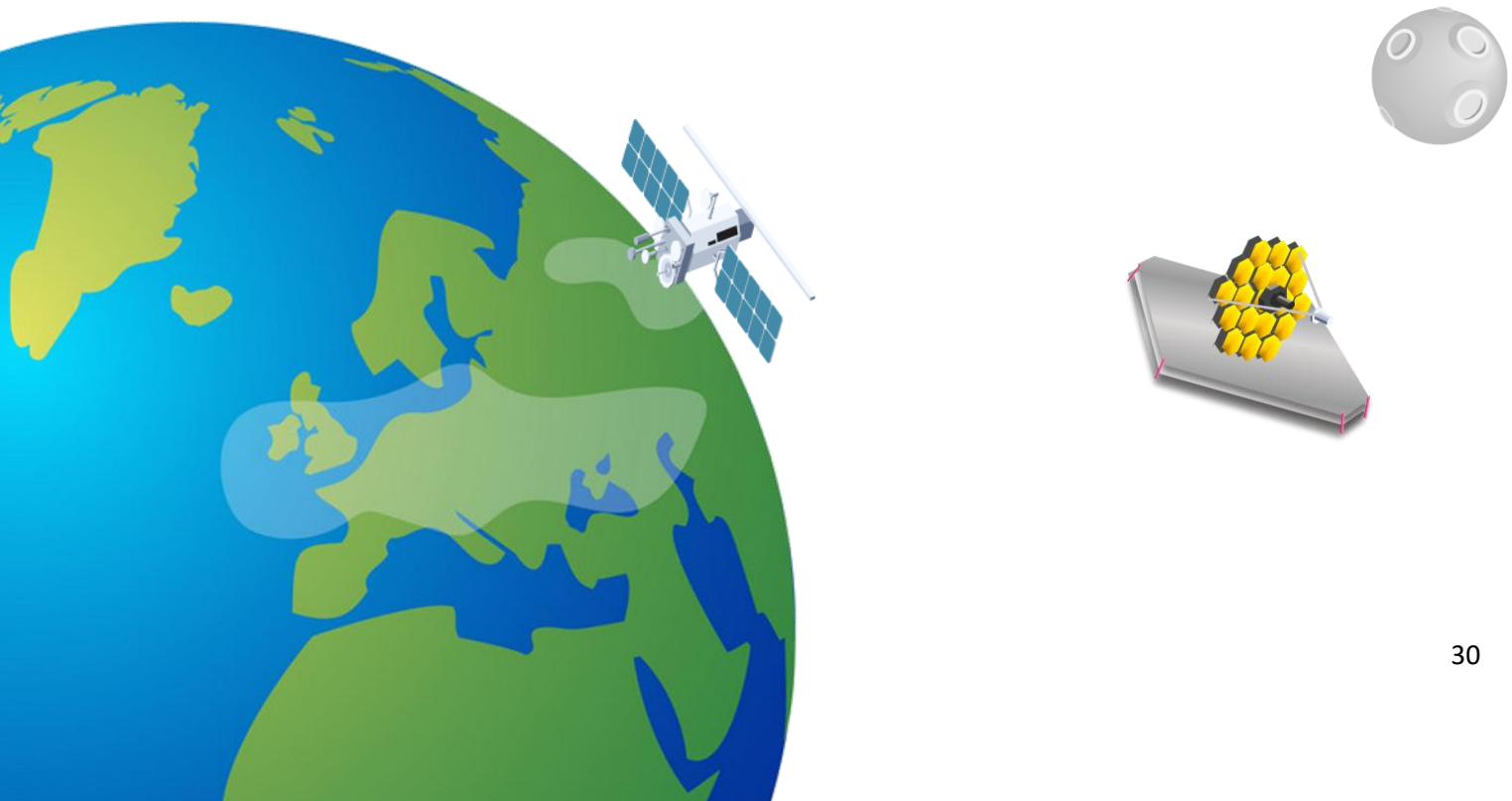
The following terms are used to describe various things in Space:

Term	Definition
Planet	An object that orbits a star.
Dwarf Planet	An object that orbits a star but is not large enough or roughly spherical enough to be classed as a small planet.
Moon	A natural satellite (see below)
Sun	A star
Asteroid	An orbiting object which is even smaller than a dwarf planet. They are formed of rock and metals. When an asteroid enters a planet's atmosphere, we call it a meteor.
Solar-system	Consists of a central star orbited by planets.
Star	A large ball of matter that is undergoing nuclear fusion and emitting light
Exoplanet	A planet outside of our solar system.
Galaxy	A collection of solar-systems eg. the Milky-Way
Universe	All of space

Satellites:

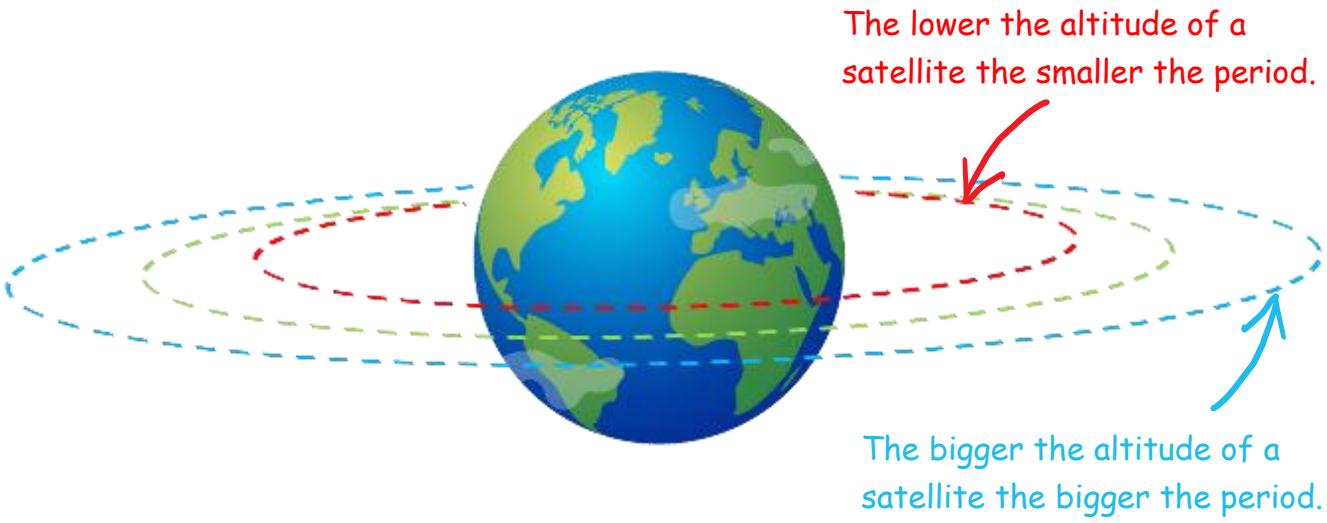
A **satellite** is an object that orbits a planet.

Satellites have many benefits: GPS, weather forecasting, communications, scientific discovery and space exploration (for example Hubble telescope, ISS).



Period of Satellites:

The time taken for a satellite to obit the planet is known as the period.



Geostationary satellites are satellites that have a period of 24 hours and orbit at a height of 36 000 km .

This means that they rotate around the Earth at the same rate as the Earth spins and stay above the same point during their orbit.

Light Years

One challenge of space travel is that the distances involved in space are huge: the distance is so large that we measure it in light years.

A **light year** is the <u>distance</u> that light travels in a year.

Worked Example:

Calculate how many meters are in **one** light year you do the following:

$d = v \times t$

$d = 3 \times 10^{8} \times 1 \times 365 \times 24 \times 60 \times 60$

speed of light; years; days; hours; minutes; seconds

$d = 9{\cdot}5 \times 10^{15}\ m$

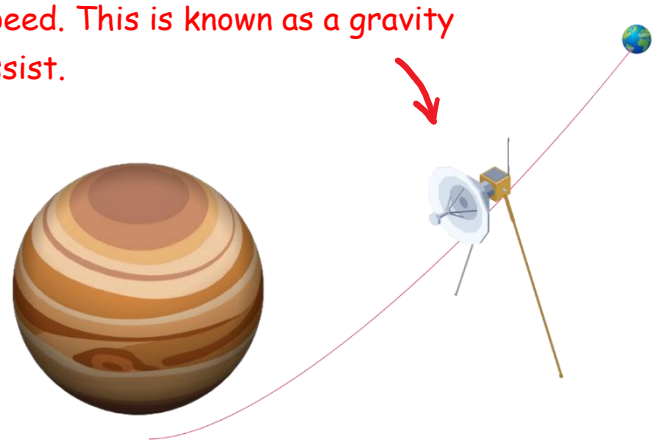
Space Travel:

Travelling in space is a difficult process with many obstacles and danger that Physicists must overcome:

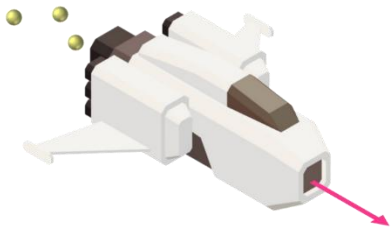
Challenge 1 - Travelling large distances:

Many things in Space are incredibly far apart. As such, traveling at normal speeds would result in journey times becoming enormous. Scientists have two possible solutions:

Using the gravitational pull of a planet/moon to 'catapult' and gain speed. This is known as a gravity assist.

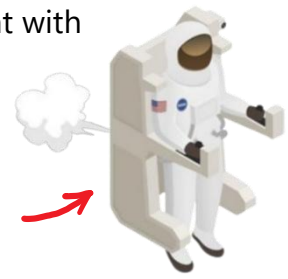


Attaining high velocity by using ion drive (producing a small unbalanced force over an extended period of time)



Challenge 2 - Manoeuvring in a zero friction environment:

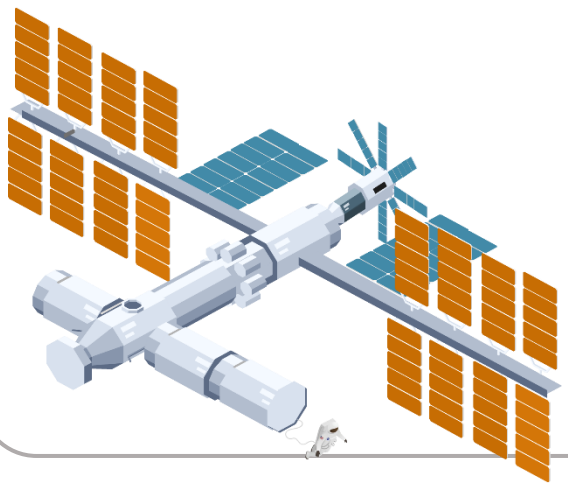
Without the force of friction to oppose their motion and being in an environment with no atmosphere to "swim" through, astronauts are unable to move without propulsion systems.



Propulsion systems use Newton's third law!

Challenge 3 - Maintaining sufficient energy:

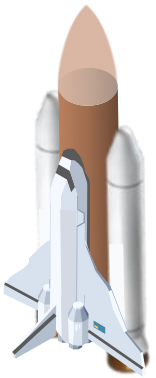
Operating life support systems in a spacecraft requires an energy source. Batteries and fuel are often avoided as these are finite and will add extra mass to your space craft.



Solar panels are a possible solution to this in situation where the space craft is relatively close to a star.

Risks of Space Travel:

Risk 1 - fuel load on take-off:



Due to the large mass of rockets a massive amount of combustible fuel is required to produce enough thrust for the space craft to reach escape velocity.

Risk 2 - potential exposure to radiation:



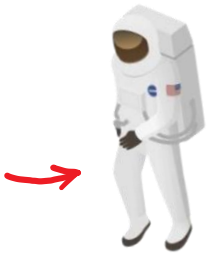
The Sun releases many cosmic rays

Without the protection of the Earth's atmosphere, astronauts may receive a far larger equivalent dose from this source.



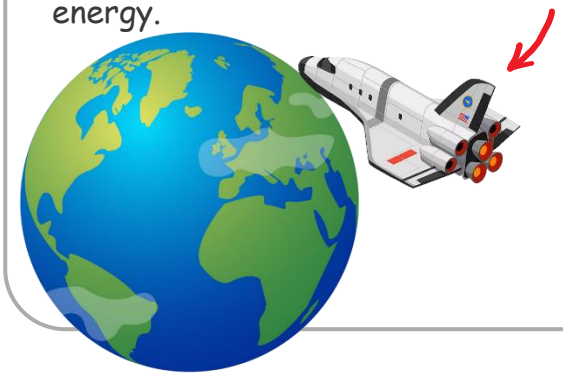
Risk 3- pressure differential:

Spacecraft and spacesuits must manage a significant differences in pressure between the internal pressure and the near-vacuum of space.



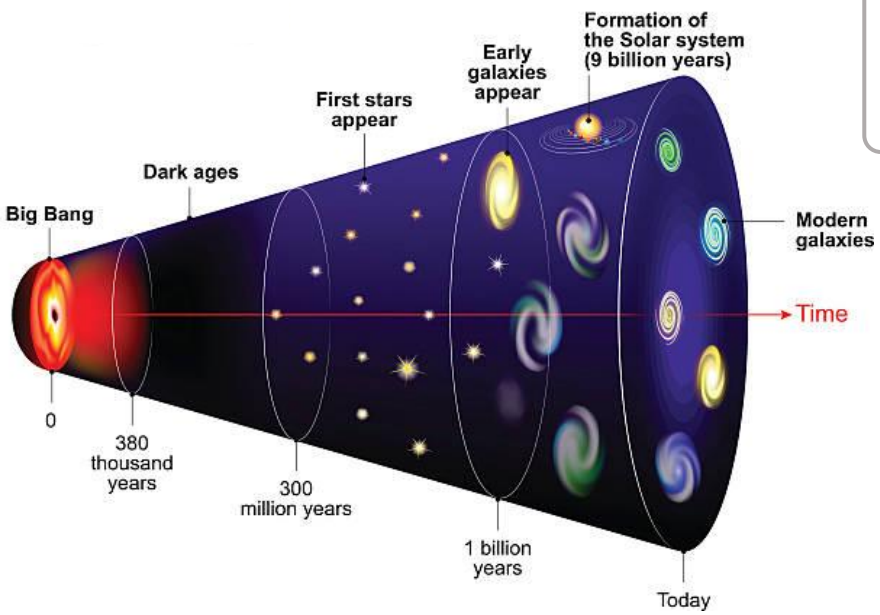
Risk 4 - re-entry through an atmosphere:

When returning to Earth, spacecraft typically travel at very large speeds. A large amount of friction is created as the craft reaches the atmosphere. This converts the kinetic energy of the craft into heat energy.



The Big Bang Theory

The Big Bang Theory is the currently accepted theory based on the available evidence to explain what happened at the very beginning of our Universe.

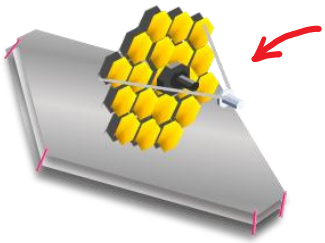


The Universe began as a singularity around **13.8 billion** years ago.

All of the material from the big bang was dispersed in all directions, and has been continuing to expand outwards ever since. As the Universe expanded it cooled going from something very small and hot to our present Universe.

Telescopes

Telescopes are devices that allow scientists to gather information from Space.

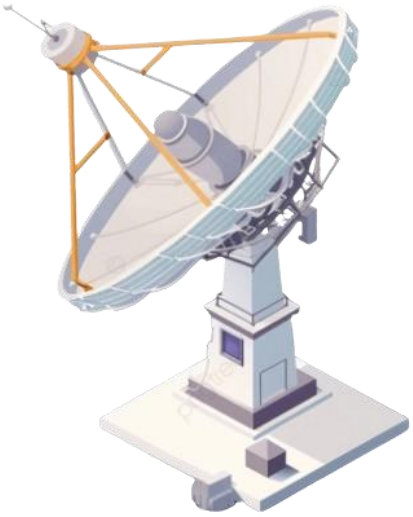


Some telescopes such as the James Webb Telescope are launched as satellites.

This allows them to avoid the distorting effects of the atmosphere and the weather.



Refracting telescopes look at visible light and use the process of refraction to enhance the image seen.



Many celestial objects emit waves beyond the visible spectrum.

These electromagnetic waves can also be detected with different types of telescopes such as this radio telescope.

Spectra

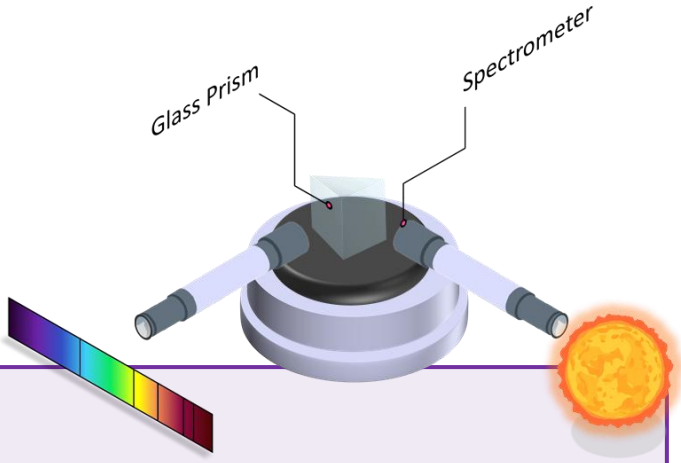
White light is made up of a range of colours. These colours can be separated by splitting white light with a prism to obtain a continuous spectrum:



Each element in the periodic table emits a unique set of wavelengths of visible light. This is called a line spectrum:

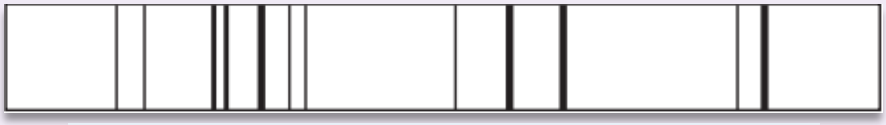


Astronomers can identify elements present in distant stars. Using known element spectra elements present in unknown sources can be identified.



Worked Example:

Using the spectral lines from gases in a nebula, **identify** the elements present in the nebula.



Spectral lines from gases in a nebula



nitrogen

Lines from nitrogen do not match



helium

All lines from helium do match



hydrogen

All lines from hydrogen do match



krypton

Only some lines from krypton match (all lines must match)

*Therefore, **hydrogen** and **helium** are present in the nebula.*