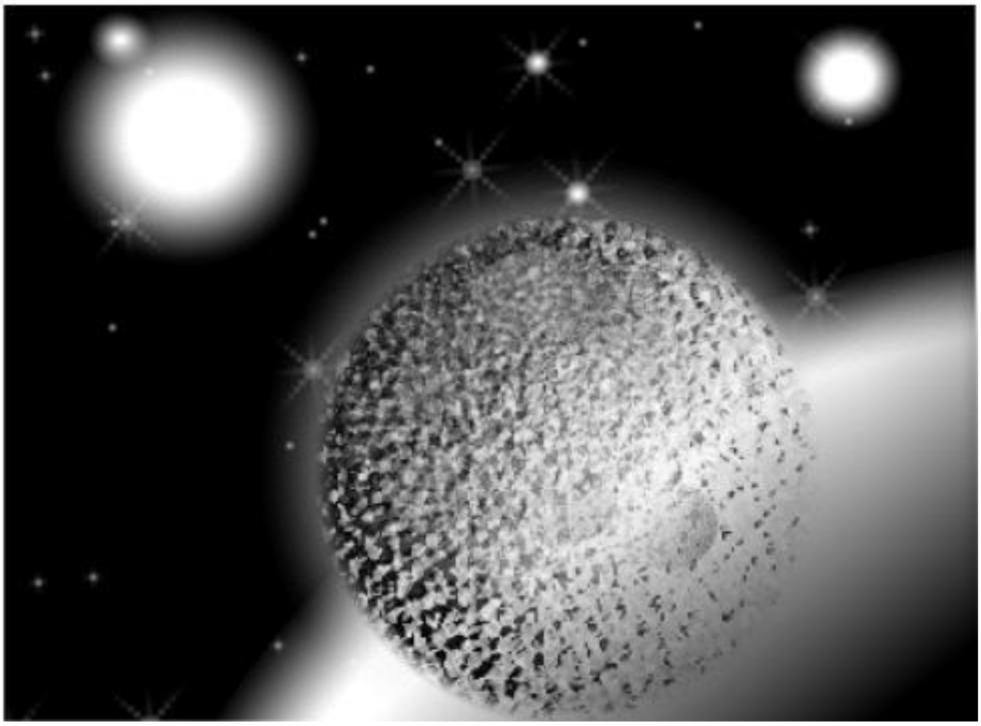
Grove Academy

National 4 Physics

Dynamics and Space

Problems



Key Area – Speed and Acceleration

Exercise 1 – Average Speed

1. A car travels a distance of 2 000 metres in a time of 160 seconds. Calculate the average speed of the car in metres per second.

2. Jane jogs to work every day at an average speed of 4 ms^{-1}. Most days it takes her 600 seconds to reach work. Calculate how far she jogs.

3. A model train travels round 10 m of track at an average speed of 1·5 ms^{-1}. How long does this take?

4. Christopher takes 26 seconds to swim one length of a swimming pool. If the pool is 50 metres long, calculate his average speed.

5. How far will a cyclist travel in 60 seconds if he is travelling at an average speed of 13 metres per second?

6. Calculate a hurdler's time if she completes the 400 m hurdle race at an average speed of 7 ms^{-1}.

7. How far will a jet aircraft travel in 5 minutes (300 seconds) if it flies at 400 metres per second?

8. The Channel Tunnel is approximately 50 km (50 000 m) long. How long will it take a train travelling at 90 ms^{-1} to travel from one end of the tunnel to the other?

9. A hill walker walks at an average speed of 1·5 ms^{-1}. How long will it take her to cover a distance of 27 km (27000 m)?

10. Richard Noble captured the world land speed record in 1983 in his vehicle Thrust 2. The car travelled one kilometre (1000m) in 3·5 seconds. Calculate the average speed of the car.

11. Andy Green broke the world land speed record in 1997 in his vehicle Thrust SSC. He travelled at an average speed of 340 ms^{-1} over a distance of 1000 m. Calculate what time he took to travel this distance.

12. On a motorway a car has a speed of 130 kmh^{-1}. If it travels for 2 hours, calculate the distance it travels in km.

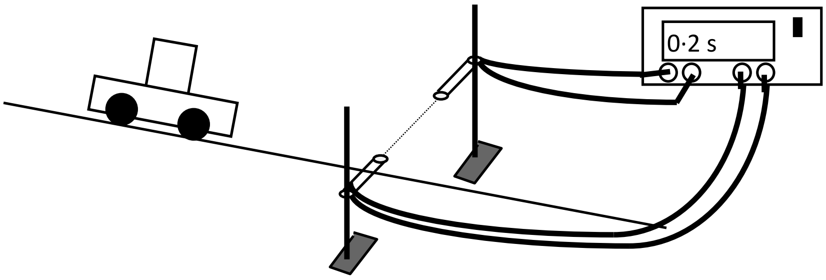
13. A lorry takes 4 hours to travel 160 km. Calculate the average speed of the lorry in kmh^{-1}.

14. In 1889 the first Daimler car reached a speed of 20 kmh^{-1}. How far would the car travel in 3.5 hours if it travelled at a constant speed of 20 kmh^{-1}?

Exercise 2 – Instantaneous Speed

1. A car has a length of 4 m and passes a point in 0.5 s. Calculate the car's instantaneous speed.

2. A card of length 0.05m is attached to a trolley. The card takes 0.2 s to pass a light gate. Calculate the instantaneous speed of the trolley at this point.



3. The same equipment is used again for measuring the instantaneous speed of a trolley as it travels down a runway.

   Use the equation:

$$instantaneous\ speed = \frac{length\ of\ mask}{time\ to\ cut\ beam}$$

   to find the missing values in the following table:

	instantaneous speed (ms^{-1})	*mask length* (m)	*time* (s)
(*a*)		0·02	0·1
(*b*)		0·015	0·1
(*c*)	4·1	0·03	
(*d*)	3·5		0·05
(*e*)	2·0		0·2
(*f*)	1·86	0·01	

4. An observer wants to find the instantaneous speed of a car as it passes a pedestrian crossing. He measures the length of the car and finds it to be 3·5 m. He then stands with a stop watch at the crossing, starts timing as the front of the car passes him and stops when the back of the car has passed. The time recorded is 2·4 s. Calculate the instantaneous speed of the car.

5. A runner decides to analyse his track performance in order to improve his overall running time during the 400 m event. He sets up light gates at six points round the track so that he can work out his instantaneous speeds at each point.
As the runner cuts the beam of light from the light gate the timer operates. The results he recorded are shown below.

Position	***Width of runner* (m)**	***Time to cut through light gate* (s)**	***Instantaneous speed* (ms^{-1})**
A	0·2	0·025	
B	0·2	0·026	
C	0·2	0·030	
D	0·2	0·029	
E	0·2	0·025	
F	0·2	0·024	

$$Instantaneous\ speed = \frac{Width\ of\ runner}{Time\ to\ cut\ through\ light\ gate}$$

Use the results to calculate his instantaneous speed at each position and hence say at which point he is running:

(a) Fastest
(b) Slowest

6. Civil engineers need to know the speeds of a train as it enters a tunnel which they are planning to build. They set up their equipment to measure the length of a section of the train and time how long that section takes to pass the planned point of entry to the tunnel. The length of train is 150 m and the time to pass the point of entry is recorded as 1·42 s. Calculate the instantaneous speed of the train.

7. A coin is dropped from a height so that it passes through a light gate connected to a computer. The coin has a width of 0·02 m and it takes 0·005 seconds to pass through the light gate. Find its instantaneous speed.

Exercise 3 – Acceleration

1. State the definition of acceleration.

2. Copy and complete the following table:

	Change in speed (ms^{-1})	*Time (s)*	*Acceleration (ms^{-2})*
(a)	30	10	
(b)	90	3	
(c)	-25	5	
(d)		2	10
(e)		14	-1.5
(f)		8	-4
(g)	24		3
(h)	-120		-20

3. A Ford KA increases its speed by 14ms^{-1} in 10s.
A Peugeot 106 takes 8s to accelerate to 11 ms^{-1} from rest.
Show by calculation which car has the greater acceleration.

4. A car slows down by 40 mph in 5 s when taking the exit from a motorway.

   (a) Calculate the deceleration in $mphs^{-1}$.

   (b) If 1 mile = 1.6 km, what is the deceleration in $kmh^{-1}s^{-1}$?

   (c) Calculate the deceleration in ms^{-2}.

5. During a game of ten-pin bowling, a player gives bowling ball an acceleration of 3 ms^{-2} for 1.2 s. Calculate the change in speed of the bowling ball.

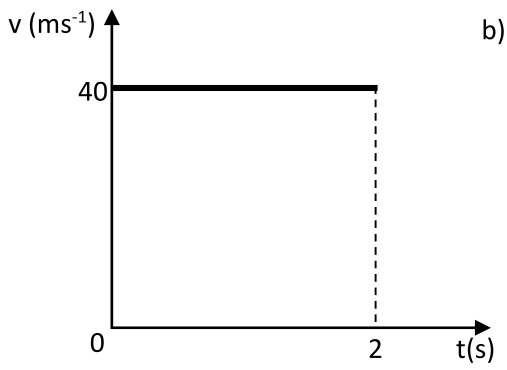
6. A super tanker travelling at 13 ms^{-1} decelerates at a rate of 0.03 ms^{-2}. How long does it take to come to a complete stop?

7. A rocket accelerates at 5.2 ms^{-2} for 10 minutes. Calculate the change in speed of the rocket.

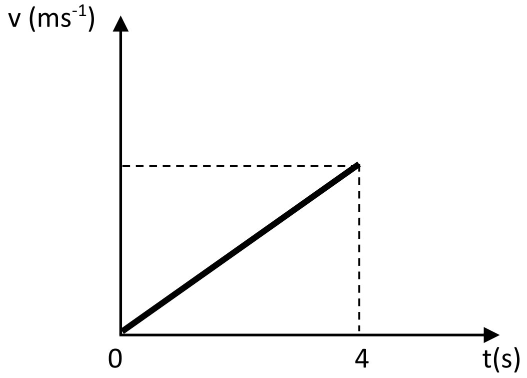
Exercise 4 – Speed-time Graphs

1. Describe the motion represented by each of the following speed – time graphs.

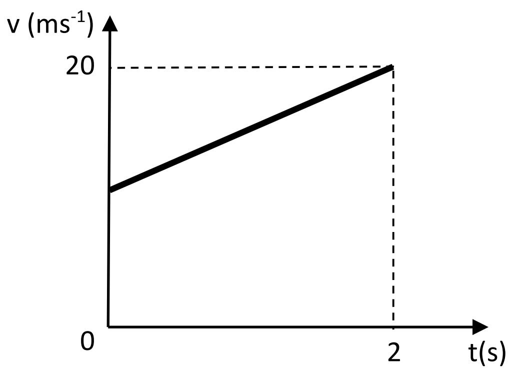
a)



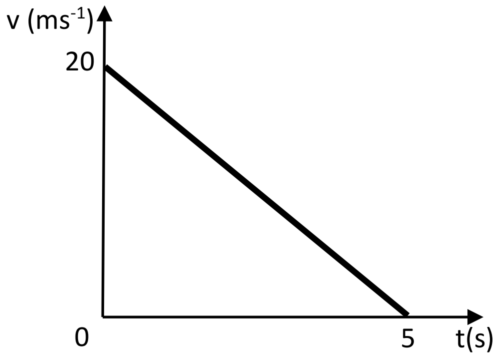
b)



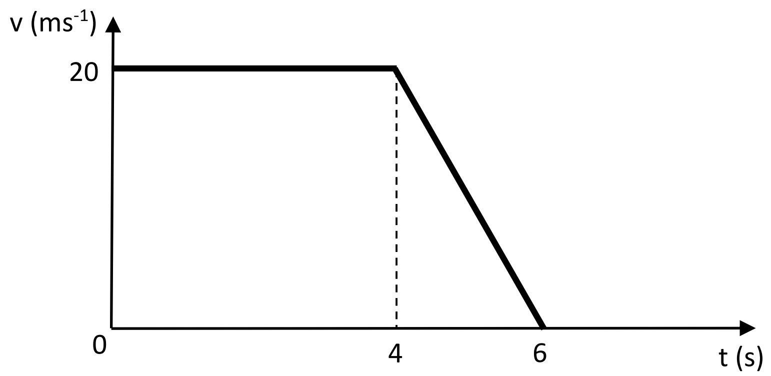
c)



d)



2. The speed-time graph below describes the motion of a van over a period of 6 s..

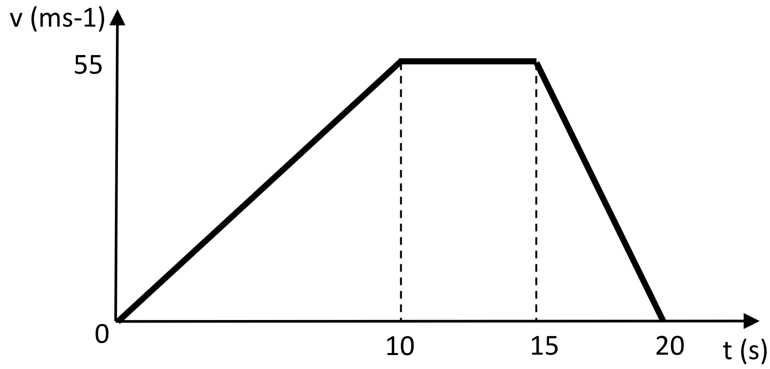


State if the speed is increasing, decreasing or constant at the following parts of the graph.

(a) Between 0 and 4 s

(b) Between 4 and 6 s

3. The speed-time graph shown below shows the motion of a train over a period of 20 s.



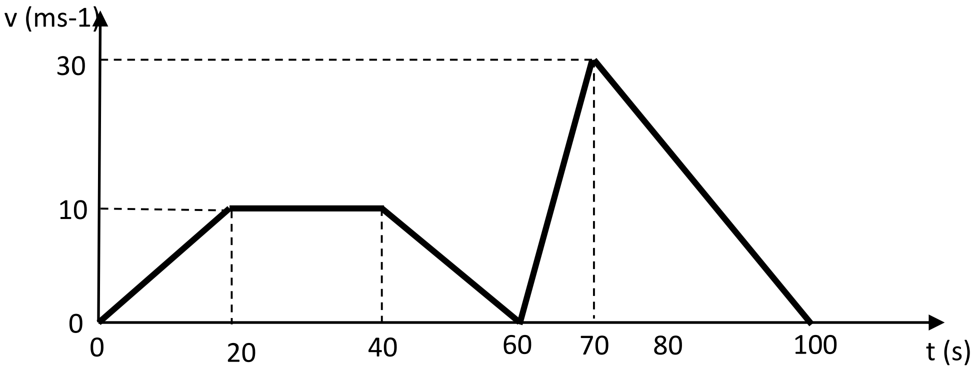
State the train's speed at:

(a) 0 s
(b) 10 s
(c) 15 s
(d) 20 s

State if the speed is increasing, decreasing or constant at the following parts of the graph.

(e) Between 0 and 10 s
(f) Between 10 and 15 s
(g) Between 15 and 20 s

4. The motion of a lorry is shown in the graph below.



(a) During what time interval was the lorry's acceleration greatest?
(b) At what times was the lorry stopped?
(c) Describe the motion of the lorry after 70s.

Key Area – Relationship between Forces, Motion and Energy

Exercise 1 – Newton's First Law

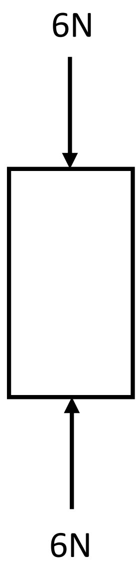
1. Which of the following diagrams show balanced forces?

(a)

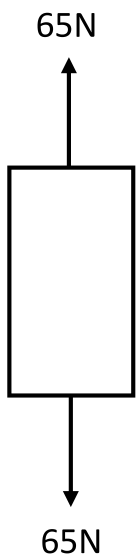
(b)

(c)

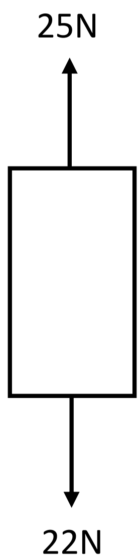
(d)



(e)



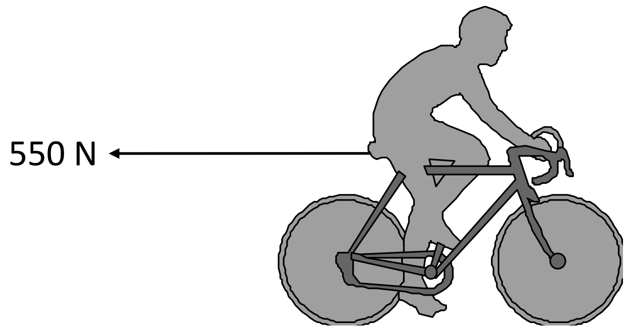
(f)



2. A fully loaded oil super-tanker moves at a constant speed of 12 ms^{-1}. Its engines produce a constant forward force of 16 000 N. What is the size of the friction force acting on the tanker?

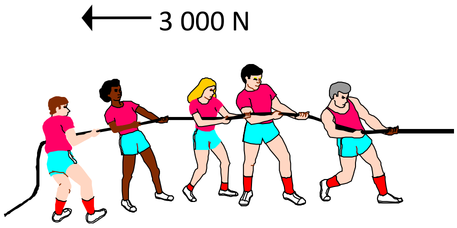
3. A clock hangs from a peg on a wall. If the weight of the clock is 2 N what is the size of the upward force provided by the peg?

4. David cycles along the road at a constant speed of 8 ms^{-1}. The total friction force acting on David and the bike is 550 N.



What size is the forward force provided by David pedalling?

5. In a tug of war the blue team pull the red team with a force of 3000 N to the left. The two teams remain stationary.



(a) What is the size and direction of the force exerted by the red team on the blue team?
(b) Each member of the red team can pull with an average force of 250 N. Calculate how many people there are in the red team.
(c) One of the members of the red team sprains her ankle and has to leave the competition. What would be the force exerted by the red team now?
(d) What would happen now?

Exercise 2 – Friction

1. Describe two methods of:
   (a) Increasing friction
   (b) Decreasing friction

2. Where, in a bicycle, is friction deliberately:
   (a) Increased?
   (b) Decreased?

Exercise 3 - Newton's Second Law

1. Find the missing values in the following table.

	Force (N)	Mass (kg)	Acceleration (ms^{-2})
(a)		2	4
(b)		6	3
(c)	20	0.2	
(d)	900		10
(e)	28.8		3.5
(f)	450	20	

2. Calculate the force required to accelerate a mass of 12 kg at 2 ms^{-2}.

3. Calculate the force required to accelerate a car of mass 1000 kg at 5 ms^{-2}.

4. If a force of 500 N is applied to a mass of 20 kg, calculate its acceleration.

5. A man pushes a stacked trolley of mass 25 kg with a force of 25 N. Calculate the acceleration of the trolley.

6. Find the mass of a boy and his bike if they accelerate at 1·5 ms^{-2} when pushed with a force of 65 N.

7. A car in an automatic wash and valet machine is acted on by an unbalanced force of 500 N and accelerates at 0·25 ms^{-2}. What is the mass of the car?

8. A forklift truck applies a force of 2 kN to move a crate of mass 1700 kg. Calculate the acceleration of the crate.

9. A bus applies a braking force of 2·4 kN in order to avoid a road accident ahead. The mass of the bus and the people on board is 4000 kg. Calculate the deceleration of the bus.

10. A table tennis ball of mass 30 g is found to accelerate at 150 ms^{-2} when hit with a bat. Calculate the unbalanced force causing the ball to accelerate.

11. Calculate the acceleration of a steel ball bearing of mass 100 g when fired with a force of 1·5 N in a pin ball machine.

12. A ship of mass 1 x 10^7 kg is accelerated by a force of 3·2 x10^6 N. Calculate the size of the acceleration.

13. An oil tanker of mass 1·5 x10^8 kg accelerates at 2 ms^{-2}. Calculate the unbalanced force required to cause this acceleration.

Exercise 4 – Weight, Mass and Gravitational Field Strength

Planet	g (Nkg^{-1})
Mercury	3.7
Venus	8.8
Earth	9.8
Mars	3.8
Jupiter	26.4
Saturn	11.5
Uranus	11.7
Neptune	11.8
Pluto	4.2
The Moon	1.6

1. Calculate the weight of each of the following on Earth :
   a) a girl whose mass is 50 kg
   b) a dog of mass 20 kg
   c) a 9 kg box
   d) a ball of mass 0.5 kg

2. Calculate the mass of each of the following weighed on Earth:
   a) a man who weighs 750 N
   b) a tin of peas which weighs 4.5 N
   c) a chair which weighs 350 N
   d) a rabbit which weighs 40 N

3. What does a 500 g packet of cornflakes weigh:
   a) on Earth b) on the Moon c) in Space?

4. An astronaut has a weight of 800 N on Earth. What is his mass:
   a) on Earth?
   b) on the Moon?

5. A question in a Physics examination asked, 'What is meant by the weight of an object?'
   Two pupils, Steven and Nicola, answered as follows:

   Steven - 'The weight of an object is the gravitational field strength.'
   Nicola - 'The weight of an object is the force of gravity acting on the object.'

   a) Who was correct?
   b) What does the term 'gravitational field strength' mean?

6. A rocket of mass 2 000 000 kg travels from Saturn to Earth.
   a) What is the weight of the rocket on Saturn?
   b) What is the weight of the rocket on Earth?

Exercise 5 – Re-entry into a Planet's Atmosphere

1. A Space Shuttle orbits the earth at 10 000 ms^{-1}. It then re-enters the Earth's atmosphere and comes in to land.
   (a) During re-entry it does not fire any engines to slow itself down. What causes its speed to be reduced?
   (b) What happens to the energy of the space shuttle when it re-enters the Earth's atmosphere?
   (c) The Space shuttle is covered with heat resistant tiles. Why are the tiles on the underside thicker than those on the upper surface of the shuttle?

2. A meteor of mass 75 kg enters the Earth's atmosphere at 30 000 ms^{-1}. Explain what is likely to happen to the meteor before it reaches the surface of the Earth?

<u>Key Area – Satellites</u>

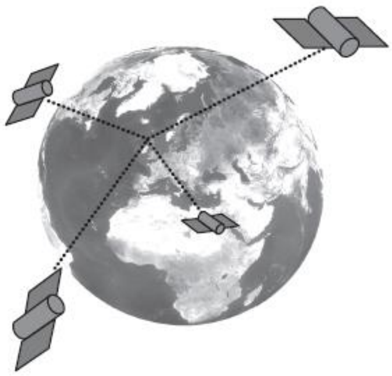
<u>Exercise 1 – Uses of Satellites</u>

1. What determines the period of a satellite?

2. One of the most useful types of satellites is a **geostationary** satellite.
   (a) What is meant by a geostationary satellite?
   (b) How long does it take to orbit the Earth?
   (c) Where is the orbit of the satellite relative to the Earth?
   (d) How many satellites are needed to give communication between all points on the Earth?

3. The first satellite – Sputnik 1 was launched on 4/10/1957. There are now a very large number of satellites orbiting the Earth using cutting edge technologies to collect signals from tracking devices, to take photographs and temperature readings as well as many other functions.
   (a) What effect does changing the height above the Earth's surface have on the period of the satellite?
   (b) How are satellites used in weather forecasting?
   (c) How are they used in environmental monitoring?
   (d) What is GPS and what is it used for?
   (e) Find out about satellite tracking:-
      i) Why would you want to track vehicles?
      ii) Why would you want to track animals?

4. A satellite navigation system receives radio signals transmitted by satellites in orbits around the Earth.



   (a) In addition to the speed of the signals, what other quantity must be known to calculate distance.
   (b) Copy and complete the passage below using words from the list in **bold.**

greater ***sound*** ***light*** ***energy*** ***height*** ***mass*** ***less***

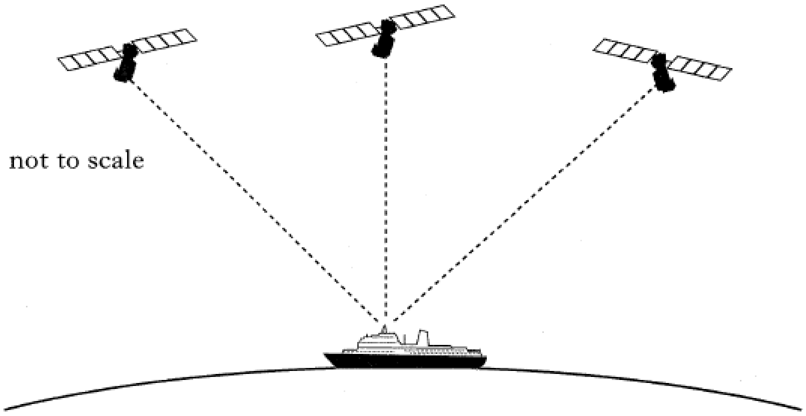
Radio signals are waves which transfer ________________. The radio signals travel at the speed of light, which is ____________ than the speed of sound. The period of a satellite orbit depends on its ____________ above the Earth.

5. A mountain climber carries a device which receives radio signals to determine the climber's position. The device can also be used to send the emergency services in the event of an accident.

(a) One satellite sends a radio signal that is received by the device 0.068 s after transmission. State the speed of the radio signal.

(b) Calculate the distance between the satellite and the climber.

6. A ship has a satellite navigation system. A receiver on the ship picks up signals from three global positioning satellites which are orbiting at a height of 20,200 km.



These satellites transmit radio signals to the boat.

(a) State the speed of these radio signals.

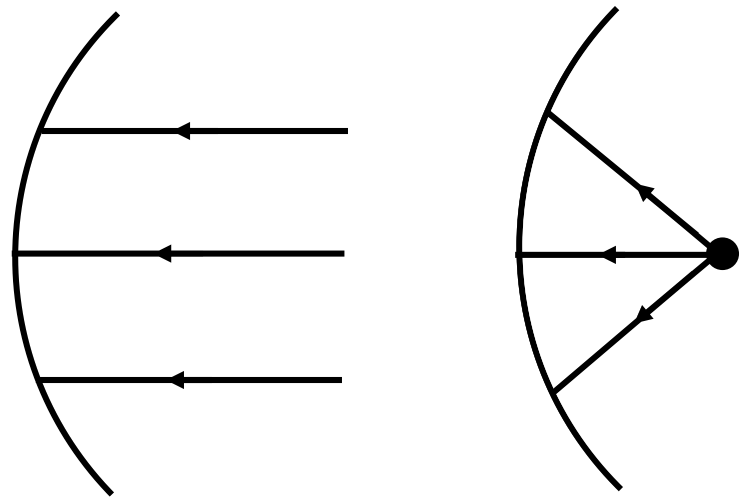
(b) One of these satellites is directly above the ship at a height of 20,200 km.
Calculate the time it takes for the radio signal to travel from the satellite to the ship.

(c) A geostationary satellite orbits at a height of 36,000 km and has a period of one day.
A satellite which is a few hundred kilometres above the Earth has a period of one hour.
Suggest a period for the global positioning satellites which are in communication with the ship.

<u>**Exercise 2 – Curved Reflectors**</u>

1. Explain why a curved reflector is needed:
   (c) at the aerial transmitting signals to a satellite,
   (d) at the aerial receiving signals from a satellite.

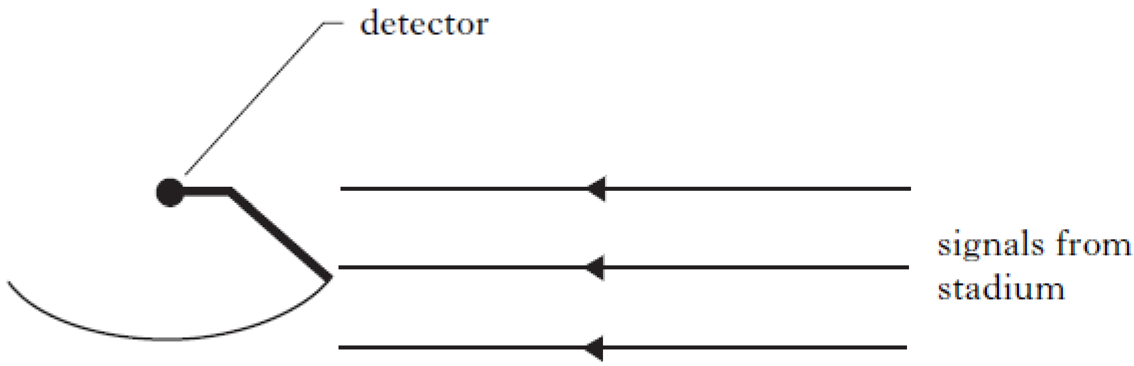
2. Copy and complete the following diagrams for waves striking a curved reflector:



Label the curved reflectors:

TRANSMITTING or **RECEIVING**

3. During a storm, a curved reflector is blown into a new position as shown below.



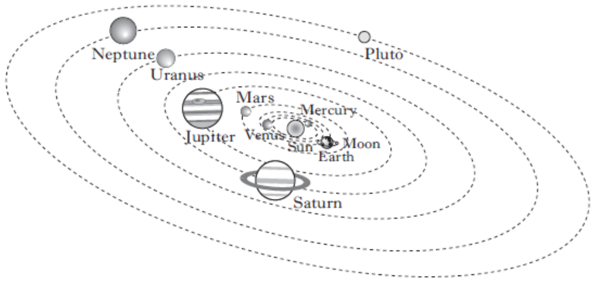
State the effect that this has on the signal received at the detector.

Key Area – Cosmology

Exercise 1 – What Do You Know About Space?

1. What is a solar system?
2. The moon orbits the Earth, it is an example of a natural _______.
3. List the eight planets in our solar system, in order, from closest to the sun to furthest away from the sun.
4. Which of the planets is the largest?
5. Which planets have no moons?
6. What is the difference between the four planets nearest the sun compared to the four furthest away from the sun?
7. What is the description now given to describe Pluto?
8. What is a star mostly made of?
9. What is a galaxy?
10. What is the name of our galaxy?
11. What is the name given to the unit of distance typically used in space?
12. What is the name of the nearest star to the sun – and how far away is it?
13. What is the name given to the start of the Universe?
14. What is meant by 'the Universe'?
15. Give one piece of evidence that supports the theory behind the start of the Universe?
16. What estimate do cosmologists put on the age of the Universe?
17. List three conditions which must exist for life, as found on Earth, to exist on another planet.
18. What is the name given to a planet which orbits around another star (but not our Sun)?
19. What is the name given to the area where planets which might be habitable are found?
20. List three ways we can explore space.

21. Astronomers study space.



Copy and complete:

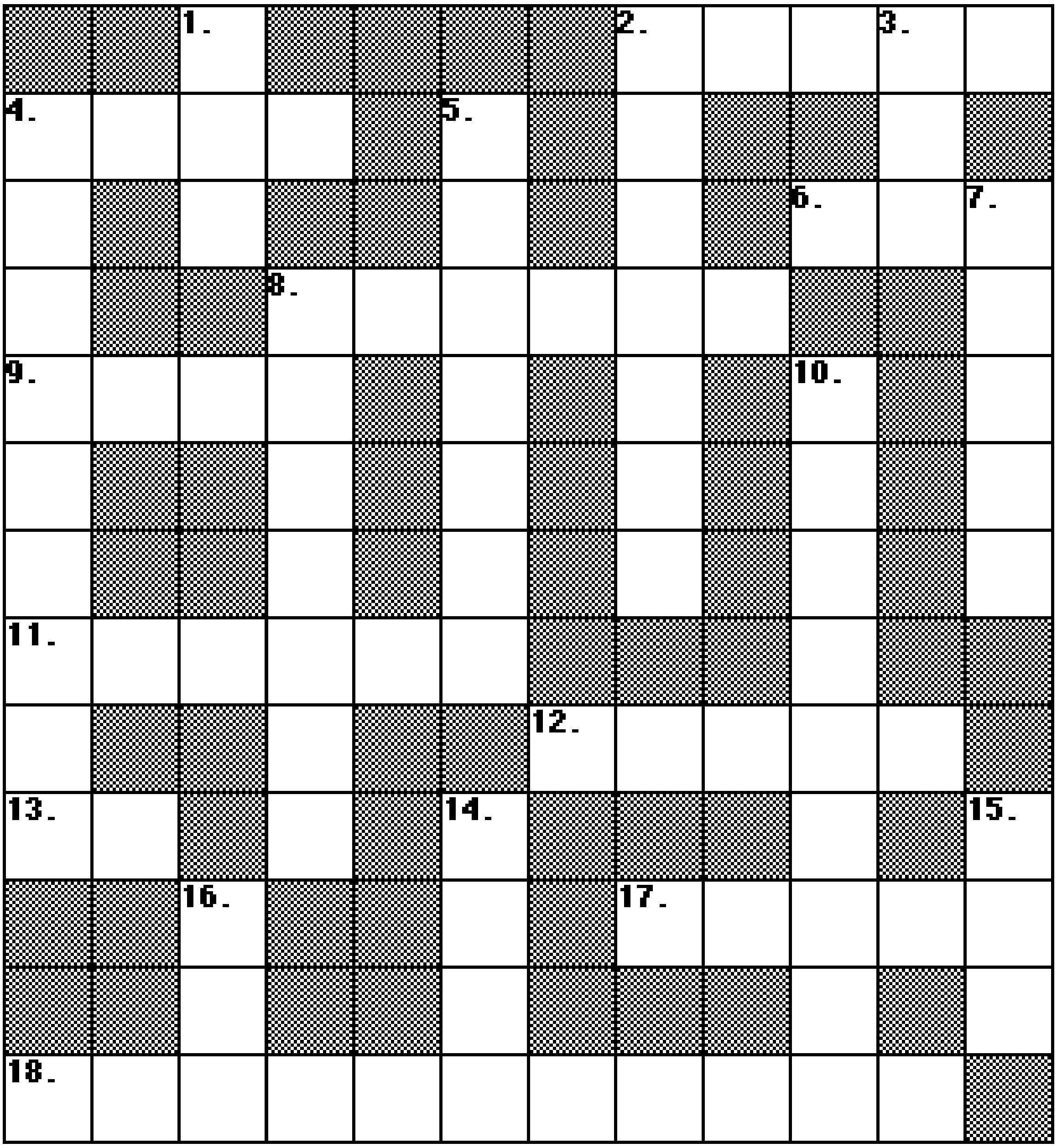
The Earth is a _____________ which orbits the Sun. The Earth has one natural satellite called the _____________.

The Sun is at the centre of our ____________ ____________. Light from the Sun takes about ____ ____________ to travel to the Earth.

The nearest star to Earth is __ ______.

All of space is known as the ______________.

Exercise 2 – Cosmology Crossword



Clues down

1. Jupiter --- Mars are planets.

2. ------- Centauri is the nearest star out with our Solar System.

3. The closest 'star' to Earth.

4. A useful object for star gazing.

5. We see these because of the different frequencies in white light.

7. The moon is a natural satellite of this planet.

8. This keeps our feet on the ground!

10. This large lens in a telescope creates the image of a star.

14. This quantity is measured in kilograms and does not change from planet to planet.

15. 700 nm is the wavelength of this light.

16. The Universe is the name given to --- matter and space.

Clues across

2. This object can separate white light into its various colours.

4. We could describe ourselves as this compared to the Universe.

6. The number of stars in our Solar System.

8. A cluster of stars.

9. The sun will not keep burning for ----.

11. Paths for planets around the Sun.

12. Here the gravitational field strength is virtually zero.

13. This fictional character was not from Earth!

17. Obtained by mixing red, green and blue.

18. The Sun and its nine planets.

Exercise 3 – Distances in Space

1. How far is a light year?
2. The star Vega is 27 light years from earth. How far away is Vega in metres?
3. The star Pollux is $3{\cdot}78 \times 10^{17}$ m from earth. How far is this in light years?
4. The star Beta Centauri is 300 light years from earth. How long does it take light to travel from this star to the earth?
5. An astronomer on Earth views the planet Pluto through a telescope. Pluto is $5{,}763 \times 10^{6}$ km from earth. How long did it take for the light from Pluto to reach the telescope?
6. Our galaxy, the Milky Way, is approximately 100,000 light years in diameter. How wide is our galaxy in kilometres?
7. The nearest star to our solar system is Proxima Centuri which is $3{\cdot}99 \times 10^{16}$ m away. How far is this in light years?
8. Andromeda (M31) is the nearest galaxy to the Milky Way and can just be seen with the naked eye. Andromeda is $2{\cdot}1 \times 10^{22}$ m away from the Milky Way. How long does it take for light from Andromeda to reach our galaxy?
9. The Sun is the nearest star to the planet Earth. It takes light 8·3 minutes to reach us from the Sun. Use this information to find out the distance from the Earth to the Sun in kilometres?
10. Sir William Herschel, an amateur astronomer, discovered the planet Uranus in March 1781. Uranus is $2\,871 \times 10^{6}$ km away from the sun. How long does it take for sunlight to reach Uranus?