3 Forces and ener

3.1 Forces and motion

Exercise 3.1A Balanced forces

Focus

In this exercise, you will describe balanced forces.

1 What is needed for two forces to be balanced?

Tick (✓) two statements in the table.

Statement	Needed for forces to be balanced?
Two forces must be the same size.	✓
Two forces must be different sizes.	
Two forces must be in the same direction.	
Two forces must be in opposite directions.	✓

2 A box sits on the ground. The box is not moving.

Write 'true' or 'false' after each statement.

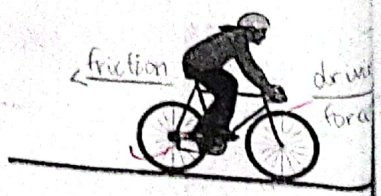
a There are no forces acting on the box. False

b There are balanced forces acting on the box. True

c There is an unbalanced force acting on the box. False

3 Sofia is riding her bicycle. The driving force on the bicycle is balanced with the force of friction on the bicycle.

Draw arrows on the diagram to show these forces. Write the names of the forces on the arrows.



Exercise 3.1B Unbalanced forces

Practice skills

In this exercise, you will be thinking about the effects of unbalanced forces.

1 Which of these can happen because of unbalanced forces?

Tick (✓) all correct statements.

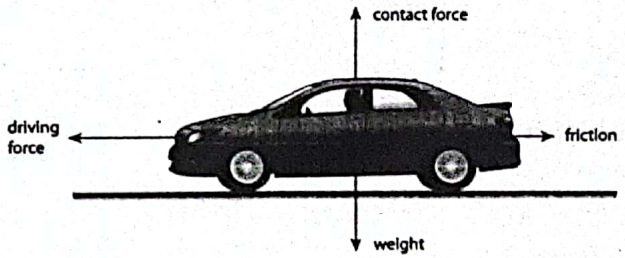
A car will move at a constant speed. ☐

A boat will slow down. ☑

A football will change direction. ☑

A book will not move on a desk. ☐

2 The diagram shows the forces on a car.



State:

a which forces are balanced

contact force and weight

b which forces are unbalanced

friction and driving force

c what will happen to the car.

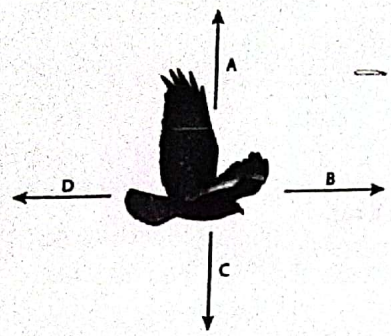
it will go faster.

Exercise 3.1C Changing direction

Challenge

In this exercise, you will describe how unbalanced forces can cause a change in direction of movement.

1 The diagram shows the forces, A–D, acting on a bird when it is flying.



a Describe the effects of these forces on the movement of the bird.

All these forces acting on the bird are balanced therefore the bird will move at a constant speed & will neither move upwards nor downwards

b Describe one change needed to the forces for the bird to go higher.

If force A increases & C decreases, the bird will go higher.

c Describe two changes to the forces that would make the bird go slower.

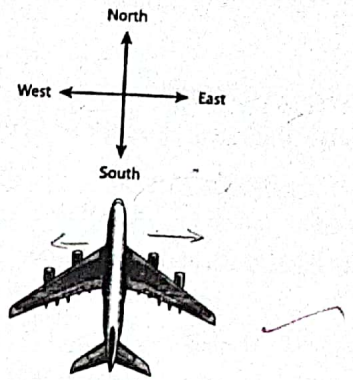
1 D should increase

2 B should decrease

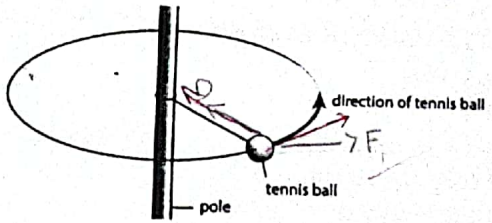
2 An aeroplane is flying north, in a straight line, at a constant speed.

The aeroplane needs to turn towards east.

Draw an arrow on the diagram to show the direction of the unbalanced force needed to make the aeroplane turn east.



3 Tetherball is a game. A tennis ball is attached to a string. The string can rotate around a vertical pole. The tennis ball moves in a circle around the pole.



The tennis ball in the diagram is moving in the direction shown.

a Draw an arrow on the diagram to show the direction of the unbalanced force on the tennis ball. Label this arrow F.

b The string breaks when the tennis ball is at the position shown.

Draw another arrow on the diagram to show the direction that the tennis ball will move when the string breaks. Label this arrow D.

3.2 Speed

Exercise 3.2A Units of speed

Focus

In this exercise, you will consider the units of speed.

1 a Which of these is the standard unit of distance in science?
Circle one unit.

metre foot mile kilometre

b Which of these is the standard unit of time in science?
Circle one unit.

day hour minute second

c Which of these is the standard unit for speed in science?
Circle one unit.

m s m/s m/s^2 m^2s

2 Speed can be measured in kilometres per hour, km/h.
A motorcycle travels at 60 km/h.
What does 60 km/h mean?
Tick (✓) one box.

It travels a distance of 60 m every second. ☐
It travels a distance of 60 m every hour. ☑
It travels a distance of 60 km every second. ☐
It travels a distance of 60 km every hour. ☐

3 In the year 2016, a spacecraft reached a speed of 260 000 km/h.
Calculate the distance this spacecraft would travel in 2 hours.
Show your working.

$D = S \times T$
$D = 260{,}000 \times 2$
$D = 520{,}000$ km

520,000 km

Exercise 3.2B Calculating speed

Practice

In this exercise, you will calculate the speeds of some objects.

1 a Write the equation that links speed, distance and time.

$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$

b Give the unit of speed when distance is in metres and time is in seconds.

m/s

In each of these calculations, show your working and give the unit with your answer.

2 A car travels a distance of 70 m in a time of 2 s.

a Calculate the average speed of the car.

$\text{Avg speed} = \frac{\text{Total distance}}{\text{Total time}}$

$= \frac{70\text{ m}}{2\text{ s}}$

35 m/s

The car changes speed to travel a distance of 30 m in a time of 2 s.

b Calculate the new speed of the car.

speed = distance / time

speed = 30 m / 2 s

= 15 m/s

3 Arun walks from home to school. School is a distance of 450 m from Arun's home.

Arun walks this distance in a time of 300 s.

a Calculate Arun's average walking speed.

speed = distance / time

= 450 m / 300 s

= 1.5 m/s

b Explain why your answer to part **a** is an average speed.

While walking from home to school, Arun did not walk in a constant speed

4 An aeroplane travels a distance of 5400 km in a time of 6 hours.

Calculate the average speed of the aeroplane, in km/h.

~~distance~~ speed = distance / time

= 5400 km / 6 h

= 900 km/h

Exercise 3.2C Calculating distance and time

Challenge

In this exercise, you will use speed to calculate either the distance or the time of travel.

a Complete the equation for calculating distance from speed and time.

distance = speed × time

b Complete the equation for calculating time of travel from speed and distance.

time = distance / speed

In each of these calculations, show your working and give the unit with your answer.

1 A train travels at a constant speed of 45 m/s.

a Calculate the distance travelled by the train in:

i 30 s

D = S × T

= 45 m/s × 30 s

= 1350 m

ii 2 minutes.

D = S × T

= 45 m/s × 120 s

= 5400 m

3 Zara runs at a constant speed of 4 m/s.
Sofia rides her bicycle at a constant speed of 6 m/s.

a Calculate the time taken for Zara to run a distance of 120 m.

T = D/S
= 120m / 4m/s
= 30s

b Calculate how much further Sofia travels in one minute than Zara does.

Distance travelled by Sofia = D = S × T
= 6 × 60
= 360m

Distance travelled by Zara = D = S × T
= 4 × 60
= 240m

difference = 360 - 240
= 120m

4 Marcus's father plans to travel by car. He needs to travel a distance of 50 km in a time of 2 hours.

a Calculate the average speed at which the car must travel.

S = D/T
= 50km / 2h
= 25km/h

b Explain why the car must go faster than your answer to part a for some parts of the journey.

It may travel slower than 25 km/h at some parts, so to make the average speed work out, it must go faster for some parts.

3.3 Describing movement

Exercise 3.3A Distance/time graphs 1

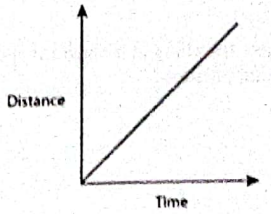
Focus

In this exercise, you will decide what you can work out from a distance/time graph.

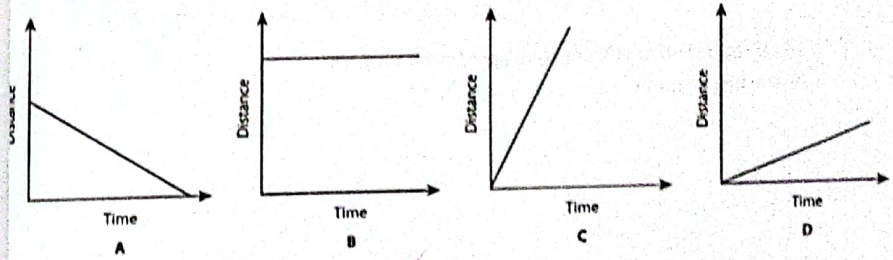
Which of these can be worked out from a distance/time graph?
Tick (✓) one box.

- The force on an object. ☐
- The speed of an object. ☑
- The mass of an object. ☐
- The weight of an object. ☐

Look at the distance/time graph for a train.



a Which of these distance/time graphs shows the train going faster?



Write the letter. C

b Which distance/time graph in part a shows no change in distance with time?

Write the letter. B

Exercise 3.3B Distance/time graphs 2

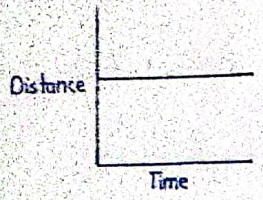
Practice

In this exercise, you will sketch some distance/time graphs.

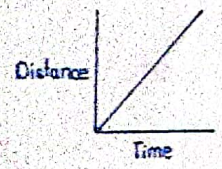
When sketching a graph, you only label the axes with quantities.
You do not need to scale the axes or put numbers on the axes.

1 Sketch a distance/time graph for:

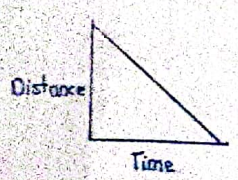
a a stationary object



b an object travelling at a constant speed away from a starting position



c an object travelling at a constant speed back towards its starting position.



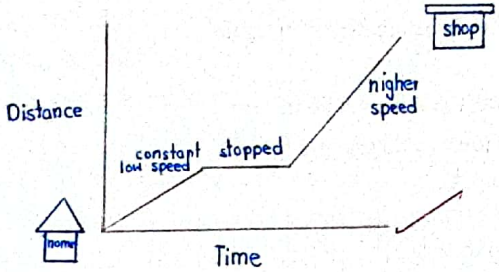
2 Sofia walks from home to a shop.

She walks at a constant low speed.

She stops to talk to a friend.

She continues walking to the shop at a higher speed than before.

Sketch a distance/time graph of Sofia's journey from home to the shop.

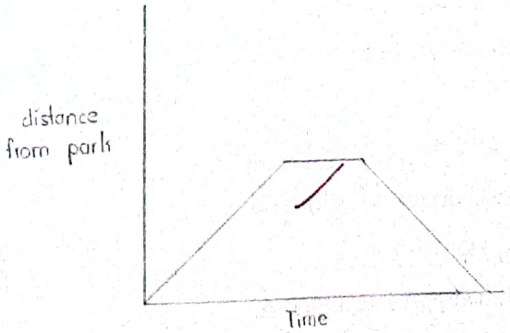


3 Marcus rides a bicycle at a constant speed from the park to a friend's house.

Marcus stays at his friend's house for a short time.

Marcus rides his bicycle at the same constant speed back again from his friend's house to the park.

Sketch a distance/time graph of Marcus's journey from the park and back to the park. Label the vertical axis 'distance from park'.



Exercise 3.3C Distance/time graphs 3

Challenge

In this exercise, you will draw a distance/time graph and work out values from the graph.

1 An aeroplane departs from airport A at time 0 hours.

The aeroplane takes 4.5 hours to travel to airport B.

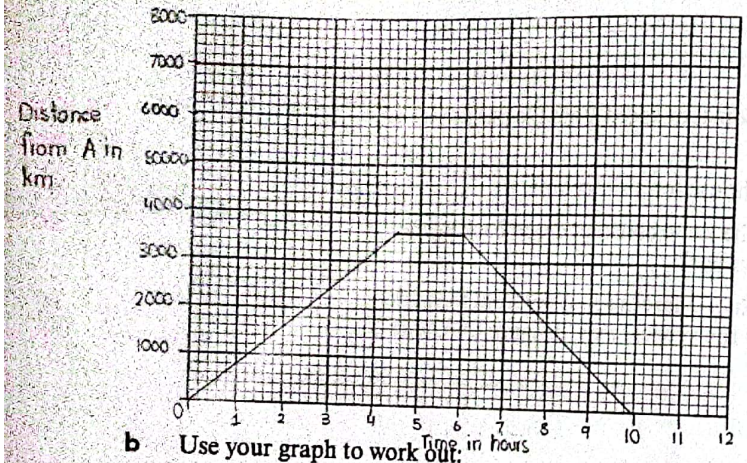
Airport B is a distance of 3600 km away from airport A.

The aeroplane spends 1.5 hours at airport B, before departing again for airport A.

The journey back from airport B to airport A takes 4.0 hours.

a Draw a distance/time graph of the journey on the grid below.

Label the vertical axis 'distance from A'.



b Use your graph to work out:

i the total time of the journey

10 hours

ii the speed of the aeroplane going from airport A to airport B

$S = \frac{D}{T} = \frac{3600\text{ km}}{4.5\text{ h}} = 800\text{ km/h}$

iii the speed of the aeroplane going from airport B to airport A.

$S = \frac{D}{T} = \frac{3600\text{ km}}{4\text{ h}} = 900\text{ km/h}$

> 3.4 Turning forces

Exercise 3.4A Identifying turning forces

Focus

In this exercise, you will decide where turning forces are used.

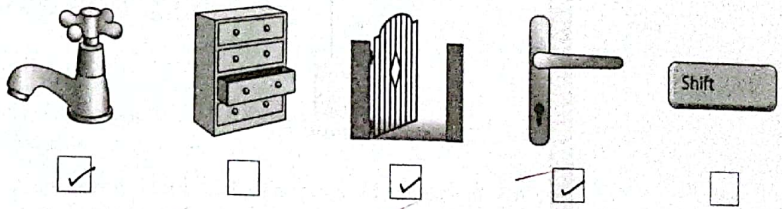
1 Which of these actions needs a turning force to happen?

Tick (✓) **all** that apply.

pushing a door open	☑
pulling a chair across the floor	☐
twisting the top off a bottle	☑
pushing the hands of a clock around	☑
pushing a trolley up a ramp	☐
stretching an elastic band	☐

2 Which of these objects needs a turning force to work?

Tick (✓) **all** that apply.



☑ ☐ ☑ ☑ ☐

3 What name is given to the turning effect of a force?

Circle **one** word.

minute **moment** **rotate** **revolve**

Exercise 3.4B Calculating moments

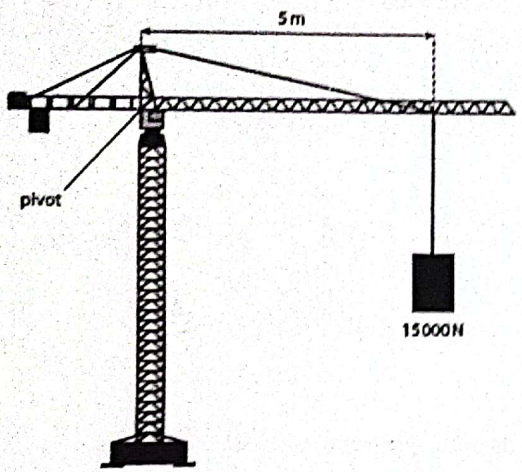
Practice

In this exercise, you will calculate moments and make predictions about moments.

1 Write the equation that links moment, force and distance.

Moment = Force × Distance ✓

2 The picture shows a crane supporting a 15 000 N weight.
The weight is supported 5 m from the pivot of the crane.



a Calculate the moment caused by the weight on the crane.
Show your working.

M = F × D
= 15000 × 5
= 75000 Nm

15000 × 5 = 75000

75,000 Nm ✓

b Explain the effect on this moment of:

i moving the weight further from the pivot

The moment will increase. ✓

ii moving the weight closer to the pivot.

The moment will decrease. ✓

3 Some people use units that are not international standard units.
One of these units of force is pounds.
One of these units of distance is the foot.
Write the unit of moment in these units.

moment = pounds × foot ✓

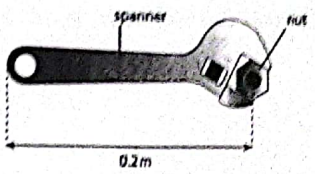
Exercise 3.4C Moments, force and distance

Challenge

In this exercise, you will calculate forces and distances or moments.

A spanner will turn a nut. The nut needs a moment of 40 N m to turn. The spanner is 0.2 m long.

a Calculate the minimum force that must be exerted on the spanner.
Show your working and give the unit.



M = F × D
F = M / D = 40 / 0.2 × 10 = 200 N ✓

200 N

b Explain why using a longer spanner will make the nut easier to turn.

As the distance between the pivot and the force increases the moment increases and the nut is easy to turn.

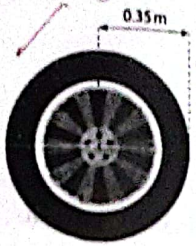
2 An engine exerts a moment of 350 N m when measured at a wheel.

The engine drives a wheel that has a radius of 0.35 m.

The pivot of the wheel is at the centre.

Calculate the force at the outside of the wheel.

Show your working and give the unit.



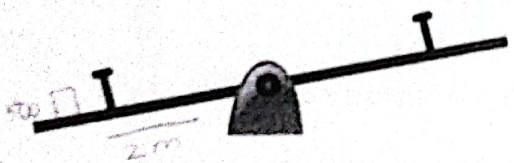
$M = F \times D$

$F = \frac{M}{D}$

$= \frac{350}{0.35} = 1000\,N$

1000 N

3 Sofia weighs 500 N. She sits on a seesaw at a distance of 2 m from the pivot.



a Calculate the moment that Sofia exerts on the seesaw.

Show your working and give the unit.

Moment = F × D

= 500 × 2

= 1000 N m

1000 N m

b The seesaw will balance when the moments on both sides are equal.

Zara weighs 400 N.

Calculate the distance from the pivot to where Zara should sit to balance the seesaw.

Show your working and give the unit.

$M = F \times D$

$D = \frac{M}{F}$

$= \frac{\text{slope}}{2400} = \frac{5}{2}$

D: 2.5m

2.5 m

3.5 Pressure between solids

Exercise 3.5A Describing pressure

Focus

In this exercise, you will describe what affects pressure in solids.

Which of these is used to work out pressure?

Tick (✓) one box.

- pressure = $\frac{\text{force}}{\text{area}}$ ☑
- pressure = mass × area ☐
- pressure = $\frac{\text{mass}}{\text{area}}$ ☐
- pressure = force × area ☐

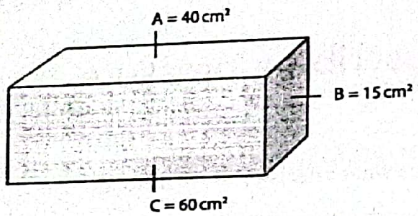
2 Zara has four different styles of shoes.

Which shoes will exert the greatest pressure on the floor when Zara wears them?

Tick (✓) one box.

☐ ☐ ☑ ☐

3 The picture shows a box. The areas of three faces of the box, A, B and C, are shown.



a Which face of the box will exert the **smallest** pressure on the floor?

Write the letter. C

b Explain your answer to part a.

As the surface area increases, the pressure decreases.

Exercise 3.5B Calculating pressure

Practice

In this exercise, you will calculate pressure in solids and think about the units of pressure.

1 A rock exerts a pressure of 20 N/cm² on the ground.

What does 20 N/cm² mean?

Complete the sentence.

A force of 20 N acts on each 1 cm² of area.

2 A large book has a weight of 15 N. The area of one end of the book is 60 cm².

Calculate the pressure the book exerts when standing on this end.

Show your working.

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

$= \frac{15}{60}$

$= 0.25$

0.25
4) 1.00
-8
20

0.25 N/cm²

3 A nail will go into wood if the pressure on the end of the nail is 60 N/mm².

The area of the end of the nail in contact with the wood is 0.5 mm².

Calculate the force needed on the nail to make it go into the wood.

Show your working and give the unit with your answer.

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

$F = P \times A$

$= 60 \times 0.5$

$= 30$

60
0.5
30.0

30 N

4 Not all of the units used by people are standard scientific units. Some people use other units.

One of these other units of force is pounds.

One of these other units of area is square inch.

State the unit of pressure in these other units.

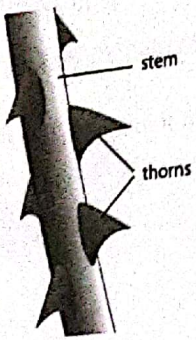
Pressure = $\frac{\text{Pounds}}{\text{Square inch}}$ = Pounds / inch²

Exercise 3.5C Variables affecting pressure

Challenge

In this exercise, you will consider the variables that affect pressure in solids.

1 The picture shows part of the stem of a plant called a rose.
The stem has parts called thorns.



Explain, in terms of pressure, why touching the thorns is more likely to cause injury than touching other parts of the stem.

The ends of the thorns have a smaller area compared to other parts of the stem. Thus, there will be a greater pressure on the skin, causing injury.

2 Cars can get stuck in sand when a wheel sinks down into the sand.

Explain why putting a large piece of wood under the wheel can stop the wheel from sinking.

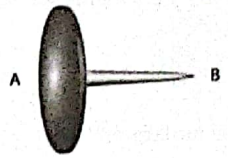
The large piece of wood would have a greater area, so it would have less pressure on the sand, stopping the wheel from sinking.

Arun is cutting bread.

Explain why a sharp knife is better for cutting bread than a knife that is **not** sharp.

Since a sharp knife has a small area, it has more pressure, which allows the bread to be cut properly.

The picture shows a drawing pin. The two ends of the drawing pin are labelled A and B.



Part A is pushed by your thumb.

Part B goes into a wall or drawing board.

Explain the shape of each end of the drawing pin.

Part A has a wide and flat shape with more area, causing less pressure on our thumb and avoiding injury. Whereas, part B has a sharp end and less area, causing more pressure on a surface and making it more likely to go into the surface.

3.6 Pressure in liquids and gases

Exercise 3.6A Trends in pressure 1

Focus

In this exercise, you will describe what affects pressure in liquids and gases.

1 **Extension material:** State what happens to the pressure in a liquid as depth increases.

The pressure increases

2 **Extension material:** Where is pressure in the air largest?

Tick (✓) **one** box.

- at sea level ☑
- at the top of a mountain ☐
- at the top of clouds ☐
- at the top of the atmosphere ☐

3 A car tyre is filled with air.

When the car is moving, the temperature of the tyre increases.

State what happens to the pressure of the air in the tyre when temperature increases.

The pressure increases

4 A plastic bottle is filled with air. The top is on the bottle so the air **cannot** escape.

The bottle is squeezed so the volume decreases.

State what happens to the pressure of the air in the bottle when the volume decreases.

It increases

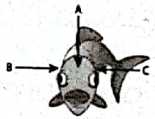
Exercise 3.6B Trends in pressure 2

Practice

In this exercise, you will think in more detail about what affects pressure in liquids and gases.

1 The picture shows a small fish in deep water. The fish is **not** moving. The water is **not** moving.

The arrows A, B and C show three directions from which pressure from the water acts on the fish.

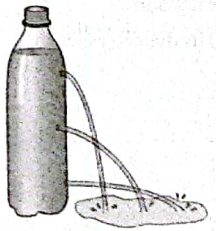


Which statement is correct?

Tick (✓) **one** box.

- The pressure in direction A is the largest. ☐
- The pressure in direction B is the largest. ☐
- The pressure in direction C is the largest. ☐
- The pressure is equal in all directions. ☑

2 The picture shows water coming out of three holes in a bottle.



Describe the conclusion that can be made from this observation.

As the depth of a liquid increases, so does the pressure

3 A balloon is filled with air. The balloon is then sealed so that air cannot escape.

a State what will happen to the pressure inside the balloon if the temperature decreases.

The balloon will shrink as the pressure will decrease with temp and particles will lose energy.

b Explain your answer to part a.

The pressure will decrease with temp because there will be less collusion and bouncing off between particles.

Exercise 3.6C Trends in pressure 3 (extension material)

Challenge

In this exercise, you will demonstrate understanding of changes in pressure in gases.

1 A balloon is filled with air. The balloon is then sealed so that air cannot escape.

The diameter of the balloon is 20 cm.

Very cold liquid is poured over the balloon.

The balloon becomes smaller until its diameter is 5 cm.

Explain this observation.

The balloon will shrink as the pressure has decreased with temp. the particles have lost energy and there will be less collusion with the walls.

2 The tyres on an aeroplane are filled with nitrogen gas.

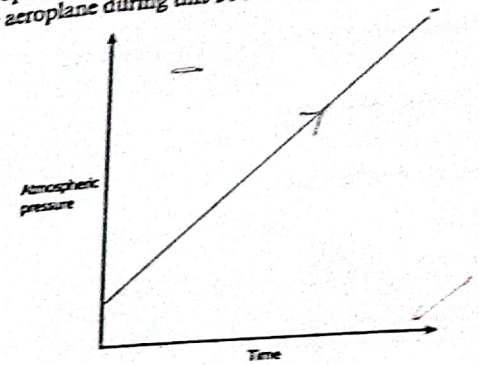
The aeroplane is at an altitude of 11 000 m. The temperature of the tyres is −50°C.

The aeroplane lands on the ground 30 minutes later.

The temperature of the tyres is now 25°C.

Nitrogen has cooling effect.

a Sketch a graph to show the change in atmospheric pressure outside the aeroplane during this 30 minute period.



b Sketch a graph to show the change in gas pressure inside the tyres during this 30-minute period.