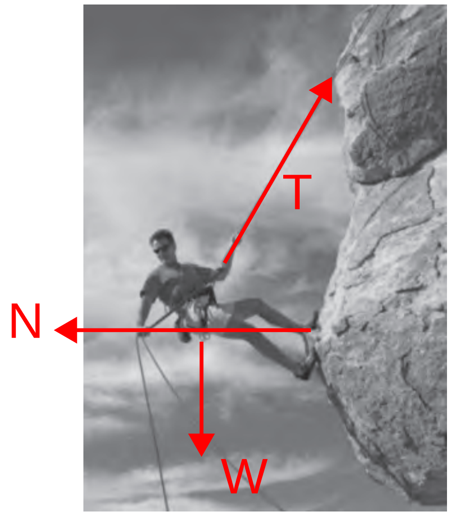
SECTION A

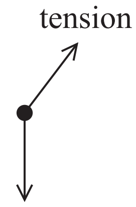
Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒.
If you change your mind, put a line through the box ~~☒~~ and then
mark your new answer with a cross ☒.

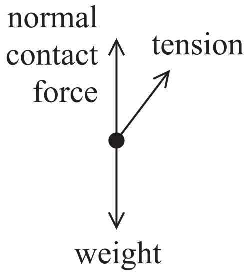
1 A climber slides down a rope attached to a rock face, as shown in the photograph.



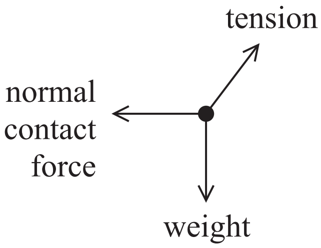
Select a possible free-body force diagram for the climber.



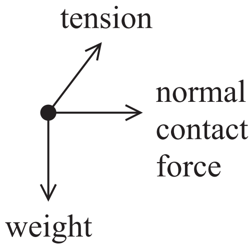
A



B



C



D

☐ **A**

☐ **B**

☒ **C**

☐ **D**

(Total for Question 1 = 1 mark)

2 The correct definition of the term centre of gravity is the point at which

☐ **A** all of the force acts on a body.

☐ **B** gravity acts on a body.

☒ **C** the weight of a body may be considered to act.

☐ **D** the weight is concentrated.

(Total for Question 2 = 1 mark)

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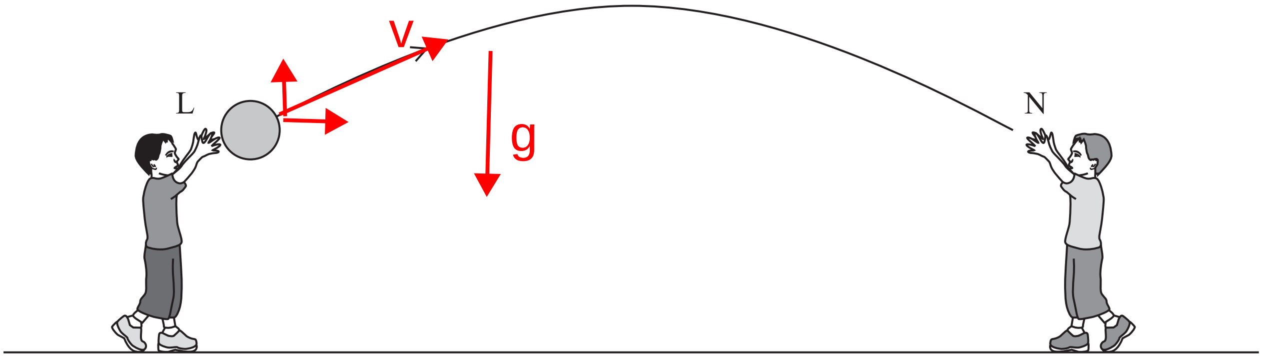
3 A ball is thrown from position L and caught at position N.

L and N are the same height above the ground. The trajectory of the ball is shown.



If vectors directed upwards are taken as positive, and air resistance is neglected then the acceleration of the ball at L is $-g$ and its speed is v.

Select the row of the table that correctly gives the acceleration and speed of the ball as it reaches N.

	Acceleration	Speed
☒ **A**	$-g$	v
☐ **B**	$-g$	$-v$
☐ **C**	g	v
☐ **D**	g	$-v$

(Total for Question 3 = 1 mark)

Questions 4 and 5 refer to the experiment described below.

A student carries out an experiment to calculate a value for *g*, the acceleration of free fall. A marble is dropped from a height of 2.0 m and the time taken for the marble to fall to the floor is recorded.

The following readings were obtained:

0.55 s 0.57 s ~~0.49 s~~ 0.56 s

4 Which of the following times should the student use to determine their value for *g*?

☐ **A** 0.54 s

☐ **B** 0.55 s

☒ **C** 0.56 s

☐ **D** 0.57 s

ignore 0.49s and take
mean of other 3 to
give 0.56

(Total for Question 4 = 1 mark)

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5 Select the equation that would, by itself, enable the student to calculate a value for *g*.

☐ **A** $mgh = \frac{1}{2}mv^2$

☒ **B** $s = ut + \frac{1}{2}at^2$

☐ **C** $v = u + at$

☐ **D** $v^2 = u^2 + 2as$

s 2
u 0
v
a g
t 0.56

(Total for Question 5 = 1 mark)

6 In the manufacture of cars, mild steel sheets are formed into panels of an appropriate shape.

Mild steel can be shaped in this way because it is

☐ **A** brittle.

☐ **B** hard.

☒ **C** malleable.

☐ **D** strong.

(Total for Question 6 = 1 mark)

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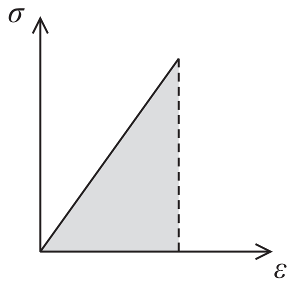
7 A force was applied across the ends of an iron bar. The following stress-strain graph was obtained.



The shaded area represents

☐ **A** $\frac{\text{work done}}{2 \times \text{volume}}$

☒ **B** $\frac{\text{work done}}{\text{volume}}$

☐ **C** $\frac{2 \times \text{work done}}{\text{volume}}$

☐ **D** work done

Area under the graph = 1/2 x stress x strain

1/2 x F/A x ΔL/L

Work done = 1/2 FΔL

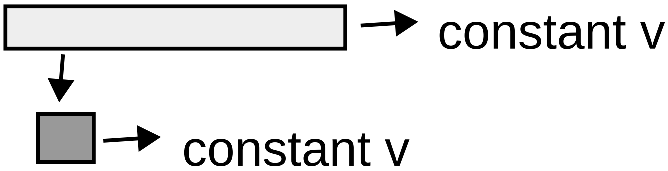
Volume = AL

therefore work done/volume

(Total for Question 7 = 1 mark)

8 A box is dropped from a plane flying at a constant velocity and height.

Assuming that air resistance is negligible, as the box falls to the ground its horizontal position will



☒ **A** remain unchanged.

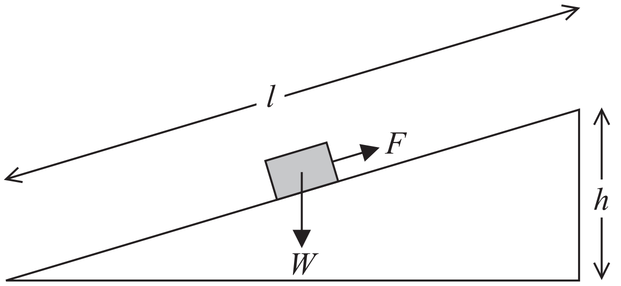
☒ **B** lag behind the plane.

☒ **C** move ahead of the plane.

☑ **D** remain directly under the plane.

(Total for Question 8 = 1 mark)

9 A student uses a force *F* to push a block of weight *W* all the way up a frictionless ramp, at a constant speed.



The work done by the student can be calculated using

☒ **A** Fh

☒ **B** $(F–W)\ l$

☑ **C** Wh

☒ **D** Wl

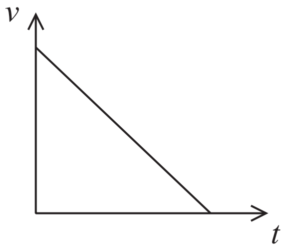
work done = change in energy
potential energy = mgh
where W=mg
so change in energy= Wh

(Total for Question 9 = 1 mark)

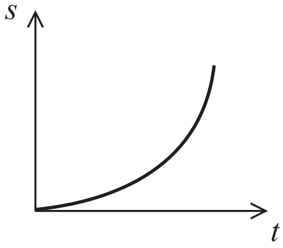
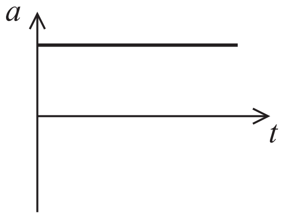
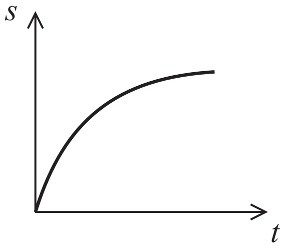
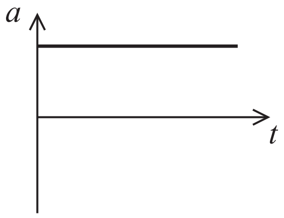
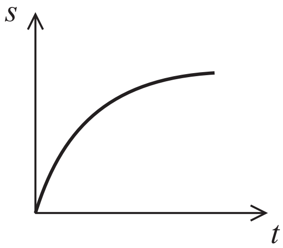
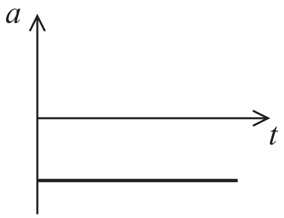
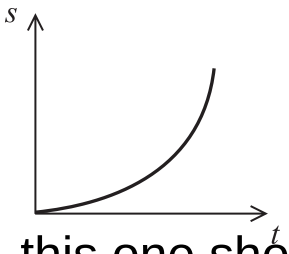
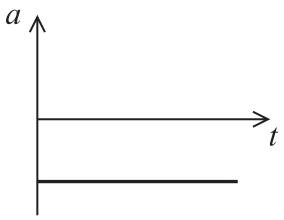
10 A ball is rolled along a horizontal surface. Frictional forces slow the ball to rest.

The velocity-time graph for the ball is shown.

the ball is decelerating



Select the row of the table that correctly gives the corresponding displacement-time and acceleration-time graphs for the ball.

	Displacement-time graph	**Acceleration-time graph**
☐ **A**		
☐ **B**		
☑ **C**		
☐ **D**		

so acceleration is negative

this one shows acceleration

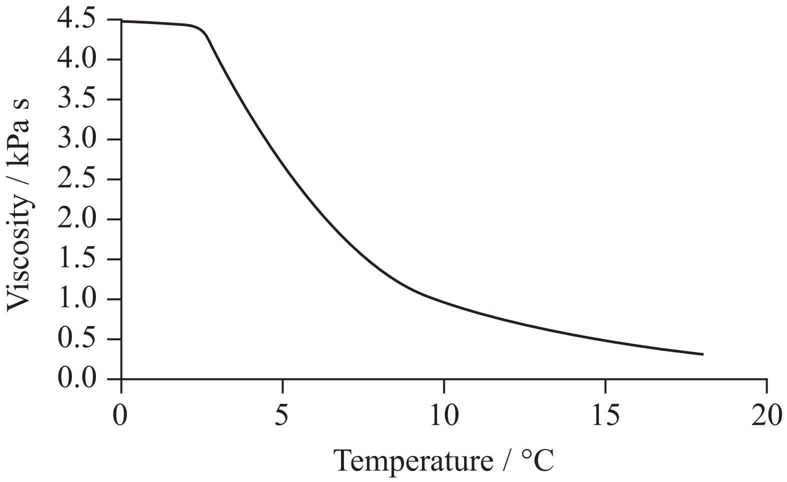
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The graph shows the effect of temperature on viscosity for butter.



A student wants to spread butter on some bread.

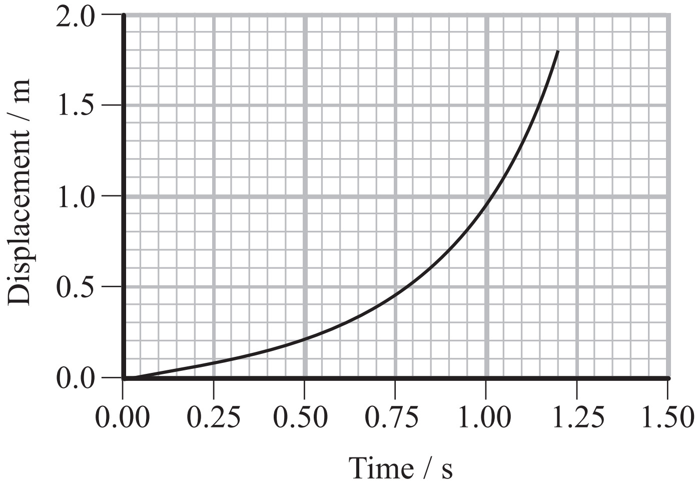
Explain why it is easier to use butter at room temperature than straight from the fridge.

(2)

Viscosity is lower at a higher temperature (Room temperature is higher than the fridge temperature). This means that less work has to be done in spreading the butter on the bread as there is less friction acting against it.

(Total for Question 11 = 2 marks)

12 A small, gas-filled balloon was dropped from a height. The displacement-time graph for the balloon is shown.



As the displacement of the balloon from its point of release increased, gravitational potential energy was transferred to kinetic energy and thermal energy.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

The balloon has the maximum velocity at 1.20s, (the greatest distance is covered in the shortest time). Where v=d/t

(b) By calculating the change in gravitational potential energy of the balloon between 1.05 s and 1.20 s, show that the average rate at which the gravitational potential energy was transferred during this time interval was about 0.2 W.

mass of balloon and air = 0.004 kg

(3)

g.p.e = mgΔh

at 1.05s Displacement = 1.1m so Δh 0.7m
at 1.20s Displacement = 1.8m in time 0.15s

0.004kg x 9.81 N/kg x 0.7m = 0.027J
Av rate of energy transfer = 0.027/ 0.15s
= 0.18W

(Total for Question 12 = 4 marks)

13 (a) State what is meant by work done.

(1)

force x distance in the direction of the force

(b) A car of mass 1.5×10^3 kg is travelling on a country road towards a village at 55 miles per hour. The speed limit in the village is 30 miles per hour.

When the brakes are applied, there is a constant braking force of 3750 N.

Calculate the minimum distance before reaching the village that the driver should apply the brakes to avoid exceeding the speed limit.

55 miles per hour = 24.6 m s^{-1}

30 miles per hour = 13.4 m s^{-1}

(3)

KE= $1/2mv^2$

Initial Kinetic Energy = $1/2 \times 1.5 \times 10^3 \times 24.6 = 4.54 \times 10^5$

Final Kinetic Energy = $1/2 \times 1.5 \times 10^3 \times 13.4 = 1.35 \times 10^5$

change in KE = $(4.54-1.35) \times 10^5 = 3.19 \times 10^5$ J

Work done = Force x Distance

where change in KE is equal to the Work done against resistance.

$3.19 \times 10^5 = 3750 \times D$

D=85.1m

Minimum distance = 85.1m

(Total for Question 13 = 4 marks)

14 Physical quantities can be vectors or scalars.

(a) Describe what is wrong with each of the following statements.

(3)

A car has a mass of 10 000 N acting vertically downwards.

Newton is not the unit for mass, this should be kg, or it should have used "Weight" instead of mass.

The velocity of light from the Sun is 3×10^8 m s^{-1}.

Velocity is a vector so needs a direction.

The car slowed down with an acceleration of 2.5 m s^{-2}.

The value 2.5ms^{-2} should have a negative sign in front of it as it is decelerating.

(b) A car travels 45 km due north and then 30 km due east.

(i) Calculate the total distance travelled by the car.

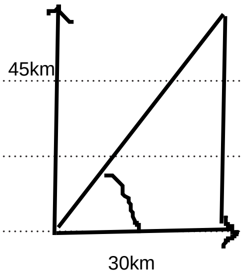
(1)

45 + 30 = 75m

Total distance travelled = ...

(ii) Calculate the displacement of the car.

(3)



use Pythagoras.

$45^2 + 30^2 = \text{displacment}^2$ $\sqrt{2925}$ = 54.1km

arctan 45/30 = 56 degrees North of East

Magnitude of displacement = ...

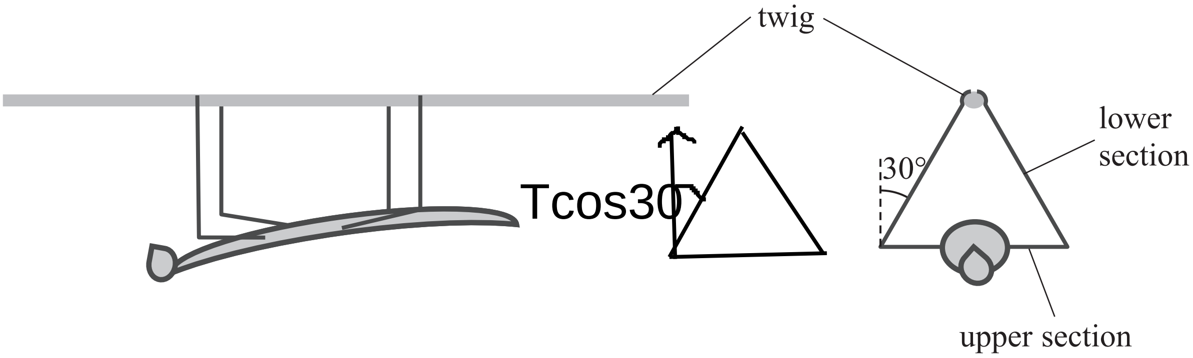
Direction = ...

(Total for Question 14 = 7 marks)

15 The photograph shows a praying mantis hanging from a thin twig. Four of the praying mantis's six legs are in contact with the twig. The tension in the legs balances the weight to keep the praying mantis stationary.

© Robert Clamp

(a) The diagrams show a simplified model of the situation. For each leg in contact with the twig, the upper section is horizontal and the lower section is at an angle of 30° to the vertical.



Side view

End view

(i) Calculate the tension in the lower section of each leg in contact with the twig assuming that these tensions are all equal.

mass of praying mantis = 5.4×10^{-4} kg

(4)

Weight = mg = 5.4×10^{-4} kg x 9.81 Nkg^{-1} = 5.30×10^{-3} N

4Tcos30=mg as 4 Legs

rearrange to find T

T= 5.30x10 / 4cos30

= 1.53×10^{-3} N

Tension = ...

(ii) A student suggests that the tension in each leg in contact with the twig is 25% of the weight of the praying mantis. State why this is **not** correct.

(1)

Tension is split into both horizontal and vertical components. Only the vertical component supports the weight.

(b) The praying mantis moves around the twig so that it is now standing upright and on top of the twig.

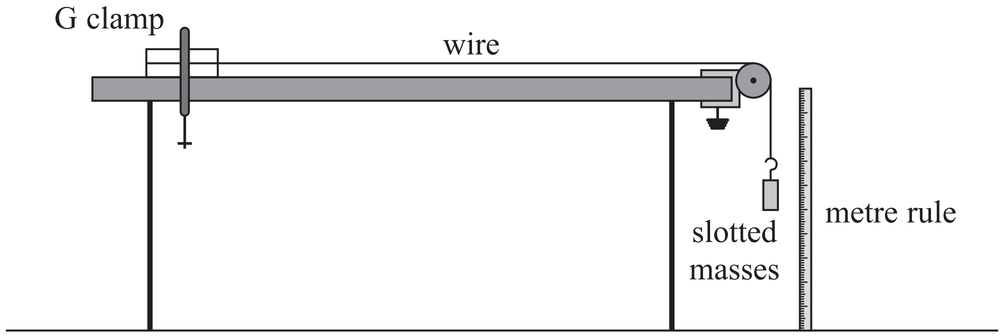
State the difference between the stress in the legs when the praying mantis is beneath the twig and when it is on top of the twig.

(1)

When the mantis is underneath the stress is tensile. When the mantis is on top the stress is compressive

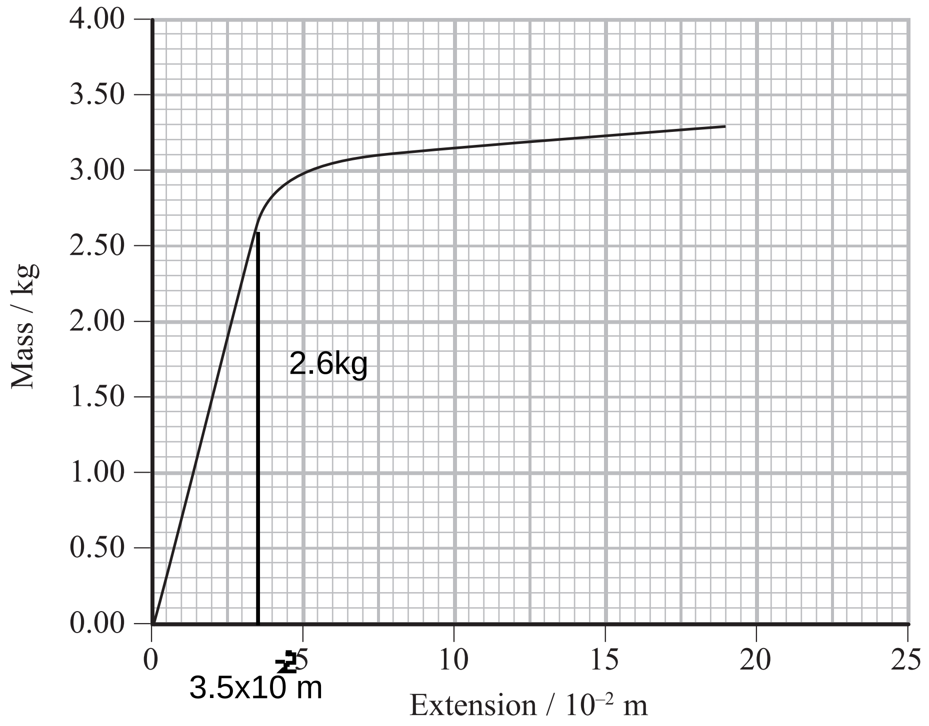
(Total for Question 15 = 6 marks)

16 The diagram shows the equipment a student used to investigate the behaviour of a material in the form of a wire under an increasing tension.



Masses were added up to a maximum of 3.30 kg. Each time a mass was added the extension of the wire was calculated.

(a) The following mass-extension graph was obtained.



(i) Initially the extension increased linearly.

State what is meant by 'increased linearly' in relation to this graph and what can be concluded about the wire from this observation.

(2)

increased linearly means that the increase in extension is constant for a fixed increase in mass.

the graph shows that the wire obeys Hookes Law

(ii) Use the graph to calculate the maximum energy that the wire could store while behaving linearly.

(3)

Area under the graph = Energy stored by the wire.

1/2 x 3.5x10^{-1} x 2.6 = 0.046kg m

0.046kg m x 9.81N kg^{-1} = 0.45J

Maximum energy = ...

(iii) Describe the behaviour of the wire when the added mass was greater than 2.9 kg.

(2)

The wire will experience a large extension for a small increase in mass. The wire has passed its elastic limit and not return to its original length.

(b) The student modifies the investigation.

(i) Suggest **one** modification that would produce a greater extension for a given mass.

(1)

A thinner wire.

(ii) Suggest **two** measuring techniques that could be used to ensure the accuracy of the measured extensions.

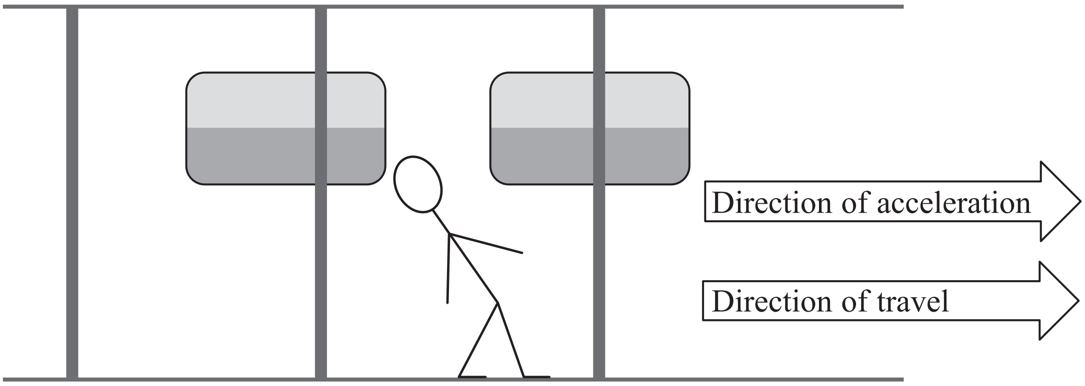
(2)

Use a pointer on the wire.
Use a set square to ensure rule is vertical.
Add masses gently.
Wait for extension to finish before adding more mass.

(Total for Question 16 = 10 marks)

17 A passenger is standing in a train.

(a) The train accelerates and he falls backwards.



Use Newton's first law of motion to explain why he falls backwards.

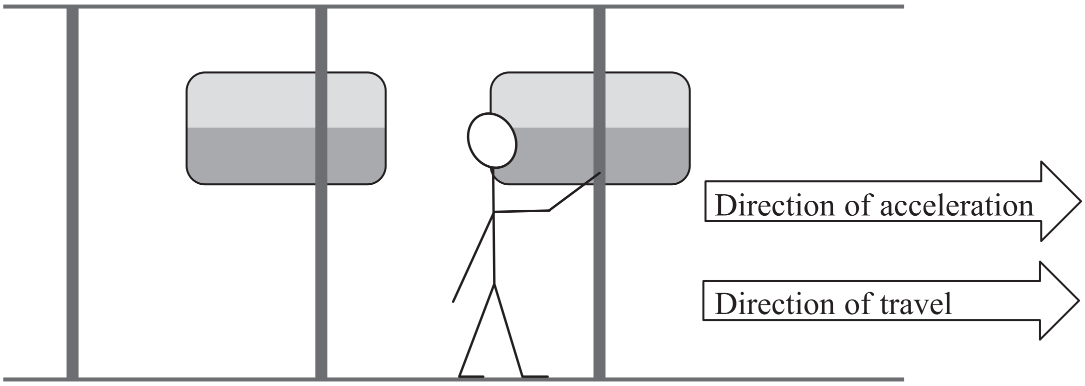
(3)

Newtons First Law of Motion states that an object at rest stays at rest and an object in motion stays in motion with the constant velocity and in the same direction unless acted upon by an unbalanced force.

The friction between the floor and the feet creates an unbalanced force on the feet.

Then the train accelerates but the man continues travelling at the original constant velocity.

*(b) As the train leaves the next station the passenger holds on to a vertical support as the train accelerates. This prevents the passenger falling backwards.



With reference to Newton's laws of motion, explain why holding on to a vertical support prevents the passenger falling backwards.

(5)

The man pulls on the vertical support. Newtons 3rd Law states that for every force there is an opposite and equal force. So there is an opposite force exerted on the man. This force is an unbalanced force on the man. Due to Newtons 2nd Law (Force = mass x acceleration), and Newtons 1st Law means that the man will accelerate with the same acceleration as the train.

(Total for Question 17 = 8 marks)

18 A student investigated the physics of football.

(a) She used the equations of motion to model the behaviour of a ball when kicked at different angles to the horizontal. She predicted the height of the ball when it reached the goal, presuming it was kicked from the same place, with the same initial speed, each time. The results are shown in the table below.

Angle to the horizontal / °	**Height of the ball when it reached the goal / m**
10	–0.78
20	1.0
30	2.8
40	4.7

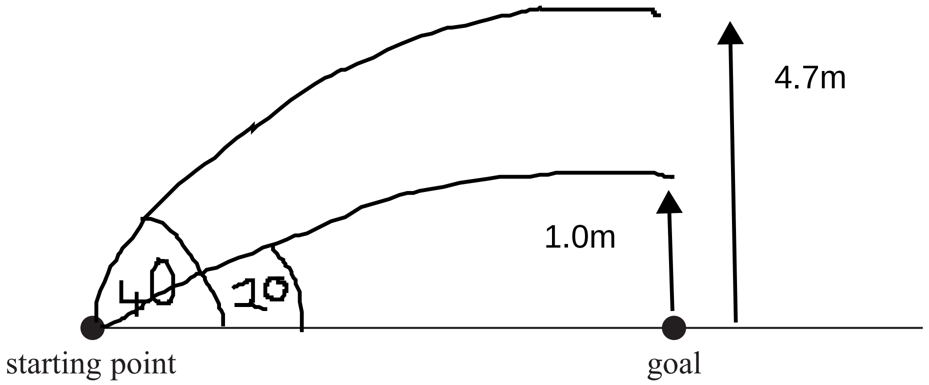
(i) State the significance of the negative value of height for an angle of 10°.

(1)

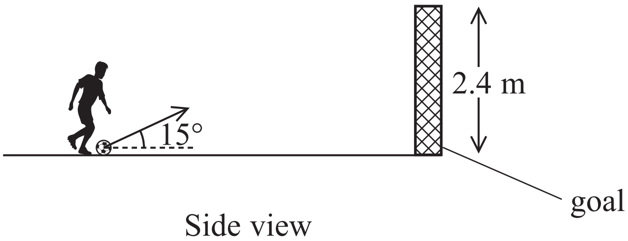
The ball has bounced below the initial height.

(ii) On the diagram below, sketch and label the predicted path of the ball for angles of 20° and 40°.

(2)



(b) (i) During a football match the ball is kicked towards the goal, at an angle of 15° to the horizontal, from a distance of 11 m as shown.



Side view

The ball has a diameter of 0.22 m and an initial speed of 26 m s^{-1}.

By means of a calculation, determine whether or not the ball will pass into the goal. You may ignore the effects of air resistance.

(6)

horizontal velocity = 26cos15= 25.1ms^{-1}

s=ut 11=25.1x t t= 0.44s

vertical velocity = 26sin15 = 6.7ms^{-1}

s=ut + 1/2at^{2}

6.7(0.44) +1/2(9.81)(0.44)^{2}

2.01m

2.01+0.22 (diameter) = 2.23m so it will pass into the goal.

(ii) Air resistance would cause an additional force on the ball.

Explain the effect this would have on the ball's motion.

(2)

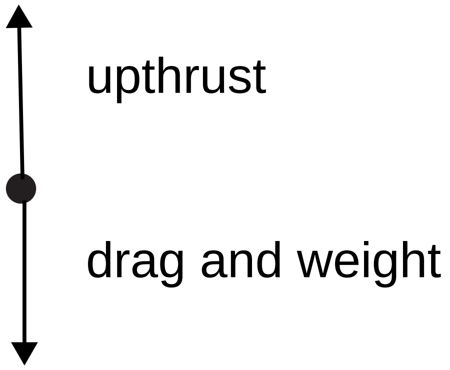
Air resistance acts in the opposite direction to the motion of the ball. This means that the ball will decelerate and take longer to reach the goal.

(Total for Question 18 = 11 marks)

19 An exhibit in a science museum requires the observer to use a pump to create air bubbles in a column of liquid. The bubbles then rise through the liquid.

(a) (i) Complete the free-body force diagram for a bubble as it rises through the liquid.

(3)



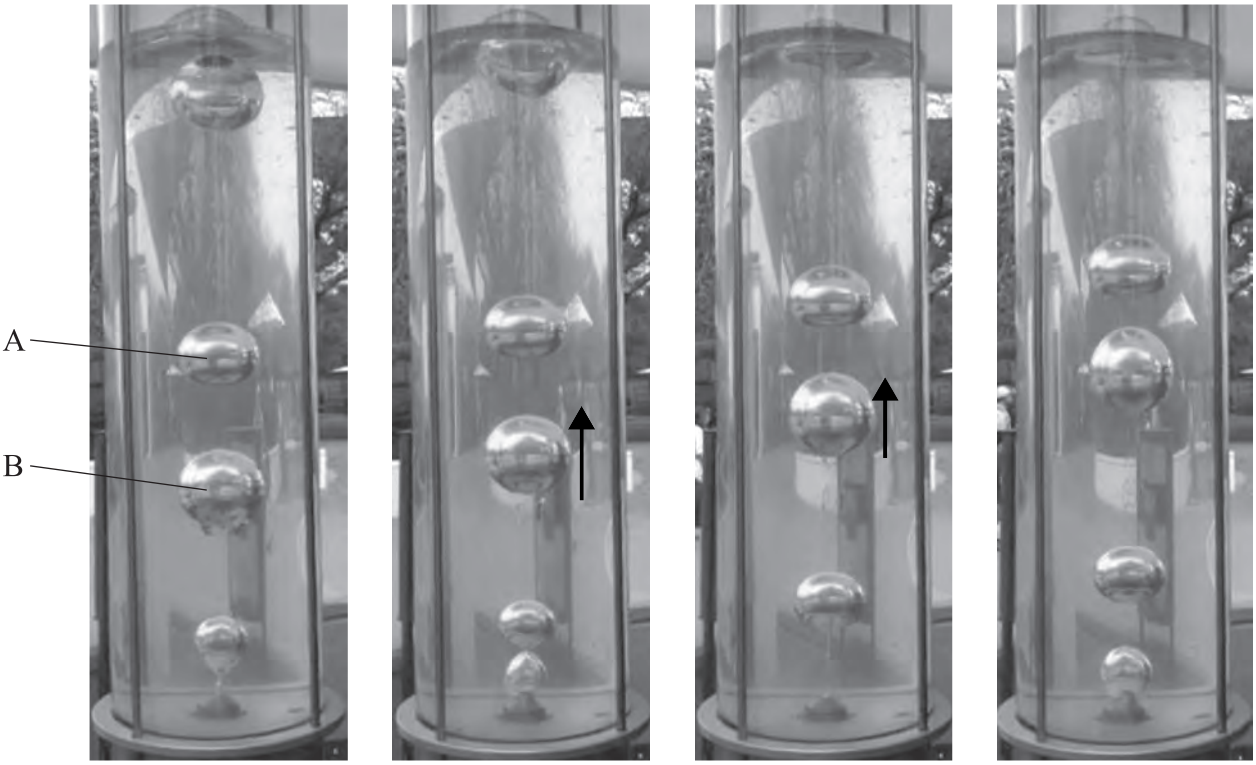
*(ii) It is observed that larger bubbles reach the top of the column of liquid in less time than smaller bubbles.

By considering the forces acting on a bubble as it rises, explain this observation.

(3)

Upthrust is greater for larger bubbles. The drag increases too. The upthrust increases more than drag so a higher terminal velocity and the larger bubble reaches the top of the column quicker than smaller bubbles.

(b) The following photographs were taken at 0.33 s intervals.



Photograph 1
time = 0

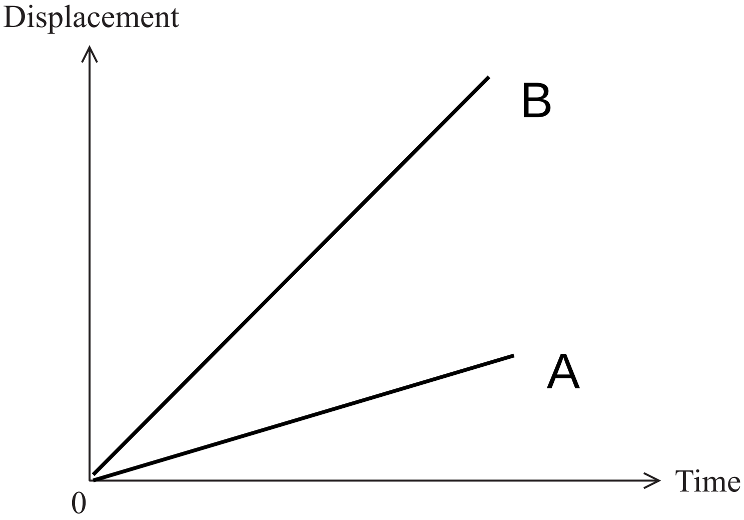
Photograph 2

Photograph 3

Photograph 4

(i) Sketch on the axes below two labelled lines to show how the displacements of the smaller bubble A and the larger bubble B vary with time over the four images.

(2)



(ii) The photographs are at a scale of 1 to 12. By using measurements from the photographs, calculate the speed of bubble B between photographs 2 and 3.

(4)

Measurement = 0.55cm

distance = measurement x scale factor 12

0.0055m x 12 = 0.066m

Photos taken at 0.33s interval

speed = distance/time 0.066/0.33 = 0.20ms^{-1}

Speed of bubble B = ...

(c) A student wishes to determine the total drag force acting on a bubble.

(i) Explain why it might not be possible to use Stokes' law to calculate the drag force acting on a bubble.

(2)

Stokes law is for small solid spheres so cant be applied to bubbles. Also the container sides are too close to the bubbles.

*(ii) Describe an additional measurement that would need to be taken from the photograph and how it could be used to determine the drag force, assuming that the bubble has reached its terminal velocity.

(4)

Using the photograph measure the diameter of the bubble.
Then use 4/3πr to find the volume of the sphere.
Use Vpg to find the upthrust of the bubble.
Drag= upthrust - weight.

(Total for Question 19 = 18 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS