OCR Physics Unit 1

Past Paper Pack

2009-2013

THIS IS A NEW SPECIFICATION

RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A **G481**

Mechanics

Candidates answer on the question paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator
- Protractor
- Ruler (cm/mm)

Tuesday 13 January 2009
Afternoon

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
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- Do **not** write in the bar codes.
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- The total number of marks for this paper is **60**.

Where you see this icon you will be awarded marks for the quality of written communication in your answer.

This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that the meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**9**	
2	**8**	
3	**8**	
4	**10**	
5	**7**	
6	**9**	
7	**9**	
TOTAL	**60**	

Answer **all** the questions.

1 **(a)** Define a *vector quantity*.

....

.... **[1]**

(b) Circle all the vector quantities in the list below.

acceleration speed time displacement weight **[1]**

(c) Fig. 1.1 shows graphs of velocity v against time t for two cars **A** and **B** travelling along a straight level road in the same direction.

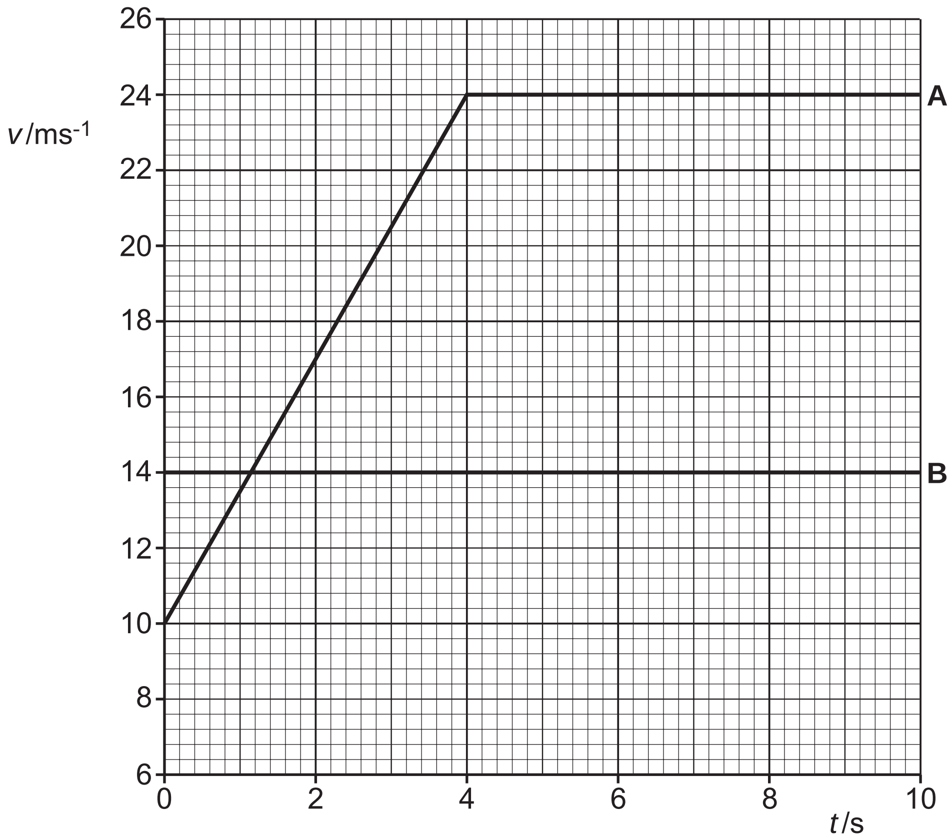

Fig. 1.1

At time t = 0, both cars are side-by-side.

(i) Describe the motion of car **A** from t = 0 to t = 10 s.

....

....

.... **[2]**

(ii) Calculate the distance travelled by car **A** in the first 4.0 s.

distance = ... m **[2]**

(iii) Use Fig. 1.1 to find

1 the time at which both cars have the same velocity

time = ... s **[1]**

2 the time t at which car **A** overtakes car **B**.

t = ... s **[2]**

[Total: 9]

2 Fig. 2.1 shows the path of water from a hose pipe.

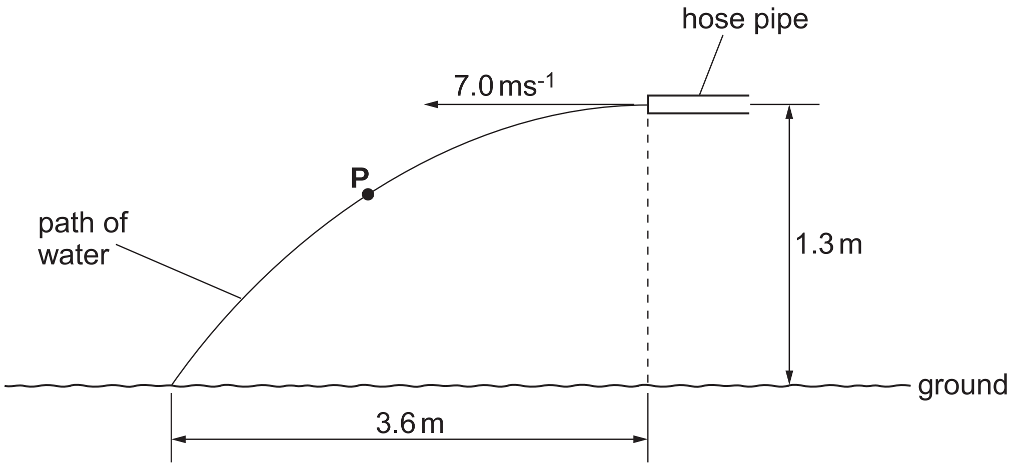

Fig. 2.1

The end of the horizontal hose pipe is at a height of 1.3 m from the ground. The initial horizontal velocity of the water is 7.0 m s^{-1}. The horizontal distance from the end of the hose pipe to the point where the water hits the ground is 3.6 m. You may assume that air resistance has negligible effect on the motion of the water jet.

(a) On Fig. 2.1, draw an arrow to show the direction of the acceleration of the water at point **P**. (Mark this arrow **A**). **[1]**

(b) Describe the energy conversion that takes place as the water travels from the end of the hose pipe to the ground.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

.... **[2]**

(c) Explain why the horizontal component of the velocity remains constant at 7.0 m s^{-1}.

....

.... **[1]**

(d) Show that the water takes about 0.5 s to travel from the end of the pipe to the ground.

[1]

(e) Show that the speed of the water when it hits the ground is $8.6\,m\,s^{-1}$.

[3]

[Total: 8]

3 **(a)** Define the *newton*.

....

.... **[1]**

(b) State why the equation '$F = ma$' cannot be applied to particles travelling at speeds very close to the speed of light.

....

.... **[1]**

(c) Fig. 3.1 shows the horizontal forces acting on a car of mass 900 kg when it is travelling at a particular velocity on a level-road.

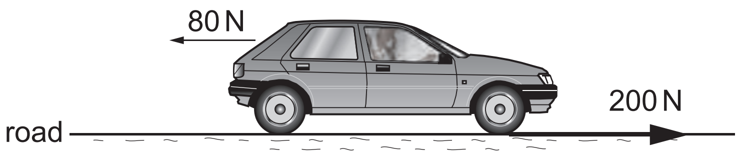

Fig. 3.1

The total forward force between the tyres and the road is 200 N and the air resistance (drag) is 80 N.

(i) Calculate the acceleration of the car.

acceleration = ... $\mathrm{m\,s^{-2}}$ **[2]**

(ii) Explain why we cannot use the equation $v = u + at$ to predict the velocity of the car at a later time even when the forward force is constant.

....

.... **[1]**

(d) Fig. 3.2 shows a person being lifted vertically upwards by a rope.

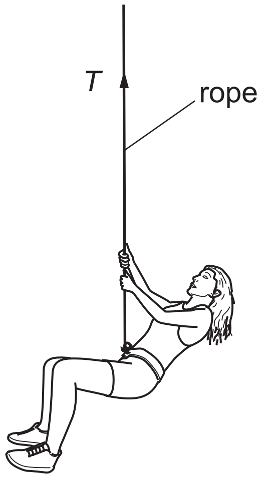

Fig. 3.2

The mass of the person is 72 kg. The upward vertical acceleration of the person is $1.4\,\text{m}\,\text{s}^{-2}$. Calculate the tension T in the rope.

T = ... N **[3]**

[Total: 8]

4 **(a)** Define *torque of a couple*.

....

.... **[1]**

(b) Explain why *moment of a force* and *torque of a couple* have the same unit N m.

....

.... **[1]**

(c) Fig. 4.1 shows an irregular shaped metal plate of constant thickness that can swing freely about point **P**.

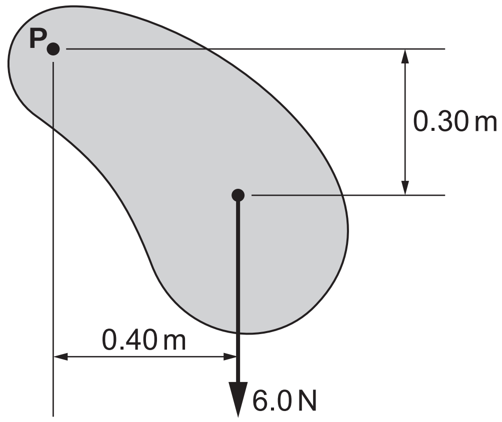

Fig. 4.1

(i) The weight of the plate is 6.0 N. With the plate in the position as shown in Fig. 4.1, calculate the clockwise moment of the weight of the plate about an axis through point **P**.

moment = ... N m **[1]**

(ii) Explain why the moment of the weight reduces to zero when the plate reaches the bottom of the swing.

....

.... **[1]**

(d) Describe an experiment to determine the centre of gravity of the metal plate shown in Fig. 4.1.

....

....

....

....

.... **[3]**

(e) Fig. 4.2 shows a section of the human forearm in equilibrium.

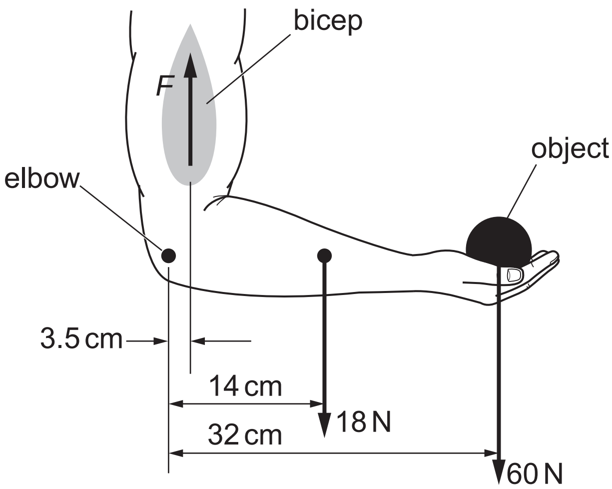

Fig. 4.2

The weight of the object in the hand is 60 N. The centre of gravity of this object is 32 cm from the elbow. The bicep provides an upward force of magnitude *F*. The distance between the line of action of this force and the elbow is 3.5 cm. The weight of the forearm is 18 N. The distance between the centre of gravity of the forearm and the elbow is 14 cm.

By taking moments about the elbow, determine the magnitude of the force *F* provided by the bicep.

F = ... N **[3]**

[Total: 10]

5 (a) Fig. 5.1 shows a 20 N force acting at an angle of 38° to the horizontal.

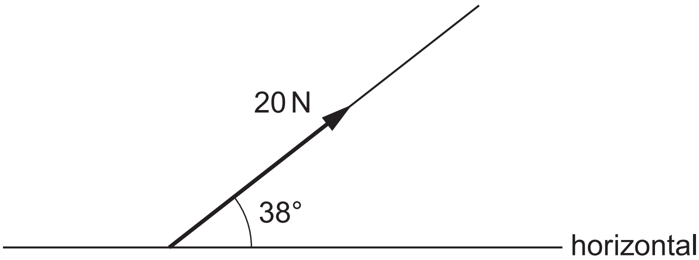

Fig. 5.1

Determine the horizontal and vertical components of this force.

horizontal component = ... N **[1]**

vertical component = ... N **[1]**

(b) Fig. 5.2 shows a metal block held in equilibrium by two wires.

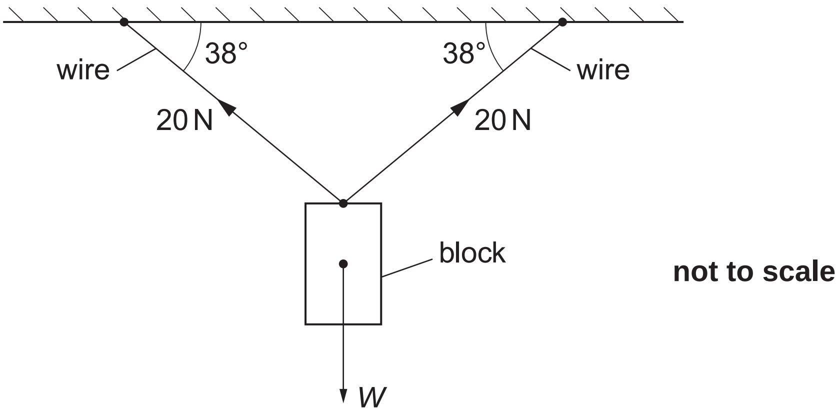

Fig. 5.2

The tension in each wire is 20 N.

(i) Show that the weight W of the metal block is about 25 N.

[2]

(ii) The metal block has a volume of $2.9 \times 10^{-4}\,m^3$. Calculate the density of the metal.

density = ... $kg\,m^{-3}$ **[3]**

[Total: 7]

6 **(a)** Define *stopping distance* of a car.

....

.... **[1]**

(b) State two factors that affect the braking distance of a car. Describe how each factor affects the braking distance.

....

....

....

....

.... **[4]**

(c) Describe how Global Positioning System (GPS) is used to locate the position of a car on the Earth's surface.
In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

.... **[4]**

[Total: 9]

7 **(a)** In what form is energy stored when a metal wire is extended by a force?

.... **[1]**

(b) A metal wire of length 1.2 m is clamped vertically. A weight is hung from the lower end of the wire. The extension of the wire is 0.35 mm. The cross-sectional area of the wire is $1.4 \times 10^{-7}\,m^2$ and the Young modulus of the metal is 1.9×10^{11} Pa.

Calculate

(i) the strain of the wire

strain = ... **[1]**

(ii) the tension in the wire.

tension = ... N **[2]**

Question 7 is continued over the page.

(c) There is great excitement at the moment about structures known as carbon nanotubes (CNTs). CNTs are cylindrical tubes of carbon atoms. These cylindrical tubes have diameter of a few nanometres and can be several millimetres in length. Carbon nanotubes are one of the strongest and stiffest materials known. Recently a carbon nanotube was tested to have an ultimate tensile strength of about 60 GPa. In comparison, high-carbon steel has an ultimate tensile strength of about 1.2 GPa. Under excessive tensile stress, the carbon nanotubes undergo plastic deformation. This deformation begins at a strain of about 5%. Carbon nanotubes have a low density for a solid. Carbon nanotubes have recently been used in high-quality racing bicycles.

(i) **1** The diameter of CNTs is a *few nanometres*. What is one nanometre in metres?

.... **[1]**

2 Explain what is meant by *plastic deformation*.

....

....

.... **[1]**

(ii) How many times stronger are CNTs than high-carbon steel?

....

.... **[1]**

(iii) State two advantages of making a bicycle frame using CNT technology rather than high-carbon steel.

....

....

.... **[2]**

[Total: 9]

END OF QUESTION PAPER

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7	**11**	
TOTAL	**60**	

Turn over

Answer **all** the questions.

1 **(a)** State a similarity and a difference between *distance* and *displacement*.

(i) similarity: ....

.... **[1]**

(ii) difference: ....

.... **[1]**

(b) Fig. 1.1 shows two airports **A** and **C**.

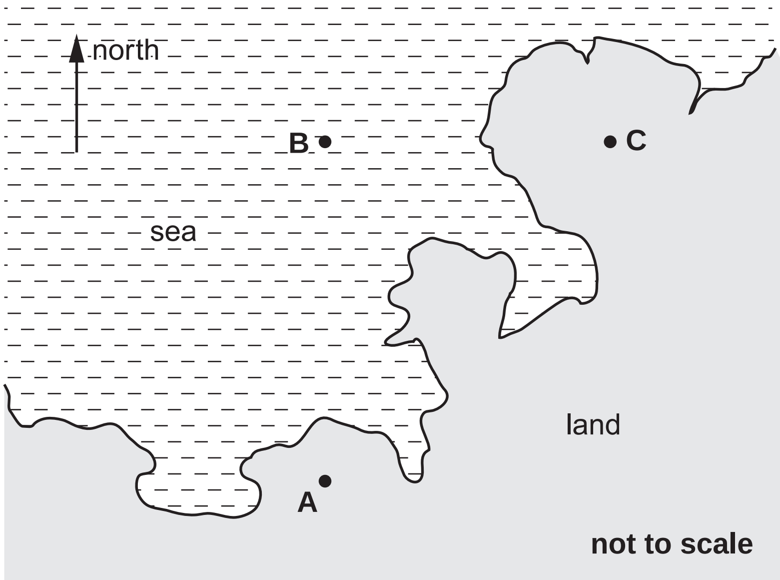

Fig. 1.1

An aircraft flies due north from **A** for a distance of 360 km (3.6×10^5 m) to point **B**. Its average speed between **A** and **B** is 170 m s^{-1}. At **B** the aircraft is forced to change course and flies due east for a distance of 100 km to arrive at **C**.

(i) Calculate the time of the journey from **A** to **B**.

time = ... s **[1]**

(ii) Draw a labelled displacement vector triangle below. Use it to determine the magnitude of the displacement in km of the aircraft at **C** from **A**.

displacement = ... km **[3]**

[Total: 6]

2 Fig. 2.1 shows a graph of velocity against time for an object travelling in a straight line.

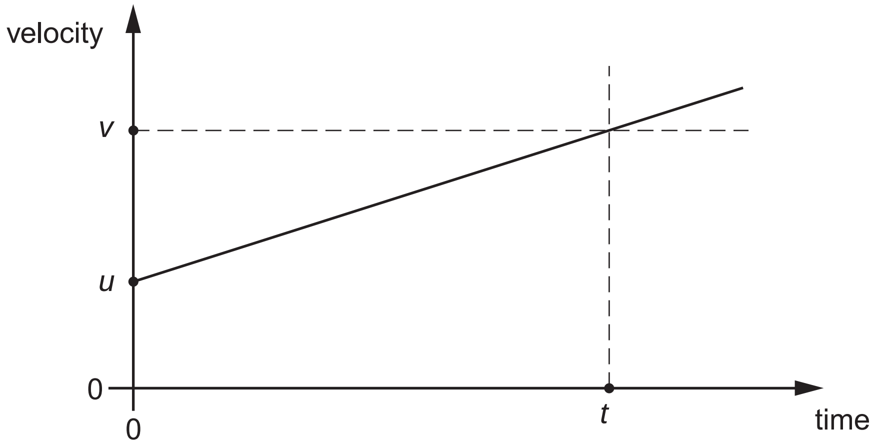

Fig. 2.1

The object has a constant acceleration *a*. In a time *t* its velocity increases from *u* to *v*.

(a) Describe how the graph of Fig. 2.1 can be used to determine

(i) the acceleration *a* of the object

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(ii) the displacement *s* of the object.

....

.... **[1]**

(b) Use the graph of Fig. 2.1 to show that the displacement *s* of the object is given by the equation:

$$s = ut + \frac{1}{2}at^2$$

[2]

(c) In order to estimate the acceleration *g* of free fall, a student drops a large stone from a tall building. The height of the building is known to be 32 m. Using a stopwatch, the time taken for the stone to fall to the ground is 2.8 s.

(i) Use this information to determine the acceleration of free fall.

acceleration = ... $m\,s^{-2}$ **[2]**

(ii) One possible reason why your answer to **(c)(i)** is smaller than the accepted value of $9.81\,m\,s^{-2}$ is the reaction time of the student. State another reason why the answer is smaller than $9.81\,m\,s^{-2}$.

....

.... **[1]**

[Total: 7]

3 A skydiver jumps from a stationary hot-air balloon several kilometres above the ground.

(a) In terms of acceleration and forces, explain the motion of the skydiver

immediately after jumping ....

....

....

....

....

....

at a time **before** terminal velocity is reached ....

....

....

....

....

....

at terminal velocity. ....

....

....

....

....

.... **[6]**

(b) In the final stage of the fall, the skydiver is falling through air at a constant speed. The skydiver's kinetic energy does not change even though there is a decrease in the gravitational potential energy. State what happens to this loss of gravitational potential energy.

....

.... **[1]**

(c) Fig. 3.1 shows a sketch graph of the variation of the velocity *v* of the skydiver with time *t*.

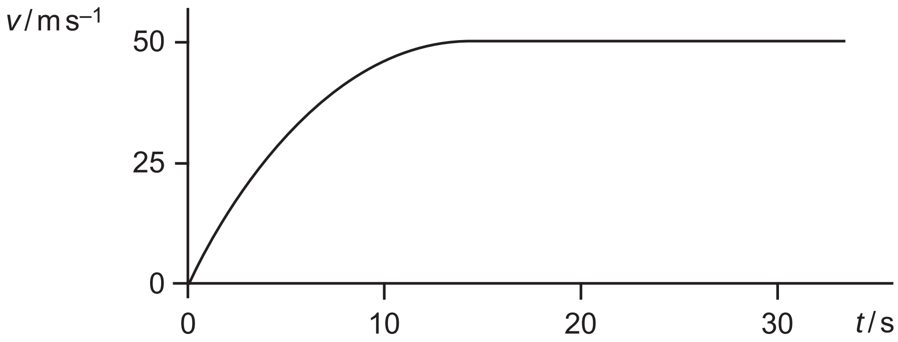

Fig. 3.1

Suggest the changes to the graph of Fig. 3.1, if any, for a more massive (heavier) skydiver of the same shape.

....

....

....

.... **[2]**

[Total: 9]

4 **(a)** Define *work done* by a force.

....

.... **[2]**

(b) Define *power*.

....

.... **[1]**

(c) Explain why the efficiency of a mechanical device can never be 100%.

....

.... **[1]**

(d) A car has a total mass of 810 kg. Its speed changes from zero to 30 $m\,s^{-1}$ in a time of 12 s.

(i) Calculate the change in the kinetic energy of the car.

change in kinetic energy = ... J **[2]**

(ii) Calculate the average power generated by the car engine. Assume that the power generated by the engine of the car is entirely used in increasing the kinetic energy of the car.

power = ...W **[1]**

(iii) The actual efficiency of the car is 25%. The car takes 18 kg of petrol to fill its tank. The energy provided per kilogram of petrol is 46 MJ kg^{-1}. The drag force acting on the car at a constant speed of 30 m s^{-1} is 500 N.

1 Calculate the work done against the drag force per second.

work done per second = ... J s^{-1} **[1]**

2 Calculate the total distance the car can travel on a full tank of petrol when travelling at a constant speed of 30 m s^{-1}.

distance = ... m **[3]**

[Total: 11]

5 **(a)** Fig. 5.1 shows a wooden block motionless on an inclined ramp.

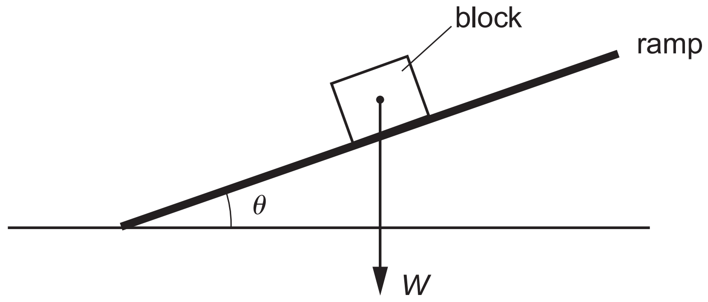

Fig. 5.1

The angle between the ramp and the horizontal is θ.

(i) The weight W of the block is already shown on Fig. 5.1. Complete the diagram by showing the normal contact (reaction) force N and the frictional force F acting on the block. **[2]**

(ii) Write an equation to show how F is related to W and θ.

....

.... **[1]**

(b) Fig. 5.2 shows a kitchen cupboard securely mounted to a vertical wall. The cupboard rests on a support at **A**.

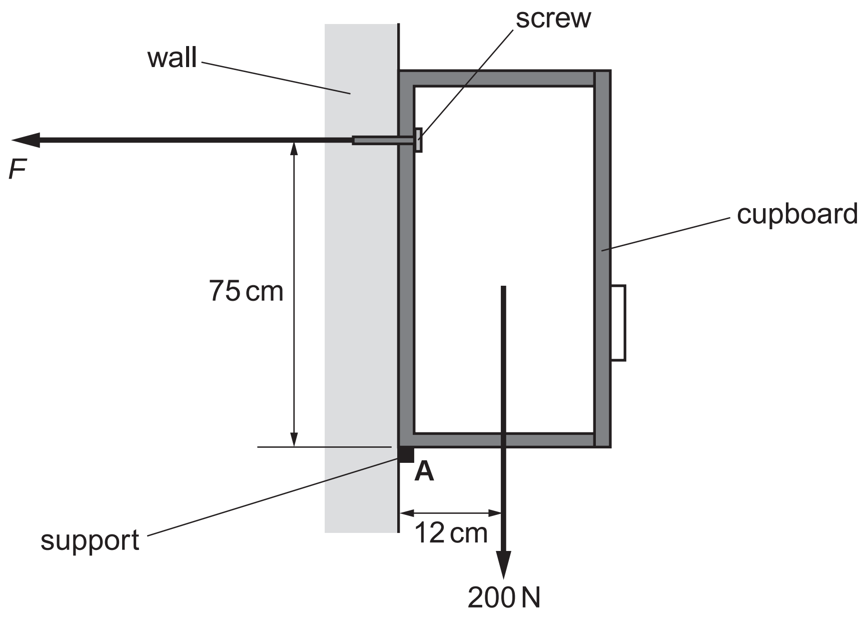

Fig. 5.2

The total weight of the cupboard and its contents is 200 N. The line of action of its weight is at a distance of 12 cm from **A**. The screw securing the cupboard to the wall is at a vertical distance of 75 cm from **A**.

(i) State the principle of moments.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

.... **[2]**

(ii) The direction of the force F provided by the screw on the cupboard is horizontal as shown in Fig. 5.2. Take moments about **A**. Determine the value of F.

F = ...N **[2]**

(iii) The cross-sectional area under the head of the screw in contact with the cupboard is $6.0 \times 10^{-5}\,m^2$. Calculate the pressure on the cupboard under the screw head.

pressure = ...Pa **[2]**

(iv) State and explain how your answer to **(iii)** would change, if at all, if the same screw was secured much closer to **A**.

....

....

.... **[2]**

[Total: 11]

6 In February 1999 NASA launched its Stardust spacecraft on a mission to collect dust particles from the comet Tempel 1. After a journey of 5.0×10^{12} m that took 6.9 years, Stardust returned to Earth with samples of the dust particles embedded in a special low-density gel. When a dust particle hits the gel, it buries itself in the gel creating a cone-shaped track as shown in Fig. 6.1. The length of the track is typically 200 times the diameter of the dust particle.

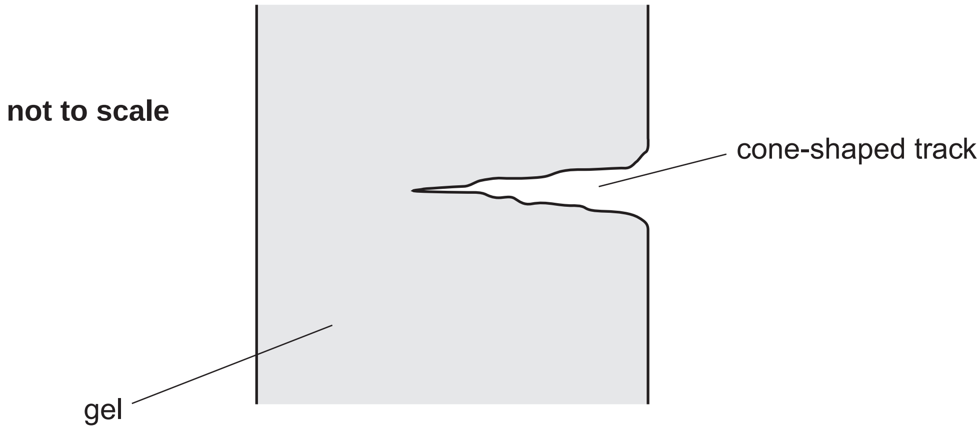

Fig. 6.1

(a) Calculate the average speed in m s^{-1} of Stardust during its voyage.

speed = ... m s^{-1} **[2]**

(b) Calculate the average stopping force produced by the gel for a dust particle of diameter 0.70 mm and mass 4.0×10^{-6} kg travelling at a velocity of 6.1×10^{3} m s^{-1} relative to Stardust.

force = ... N **[3]**

[Total: 5]

7 **(a)** On the axes of Fig. 7.1, sketch a stress against strain graph for a typical ductile material.

Fig. 7.1

[2]

(b) Circle from the list below a material that is ductile.

jelly copper ceramic glass **[1]**

(c) Define *ultimate tensile strength* of a material.

....

.... **[1]**

(d) State *Hooke's law*.

....

.... **[1]**

(e) Fig. 7.2 shows a mechanism for firing a table tennis ball vertically into the air.

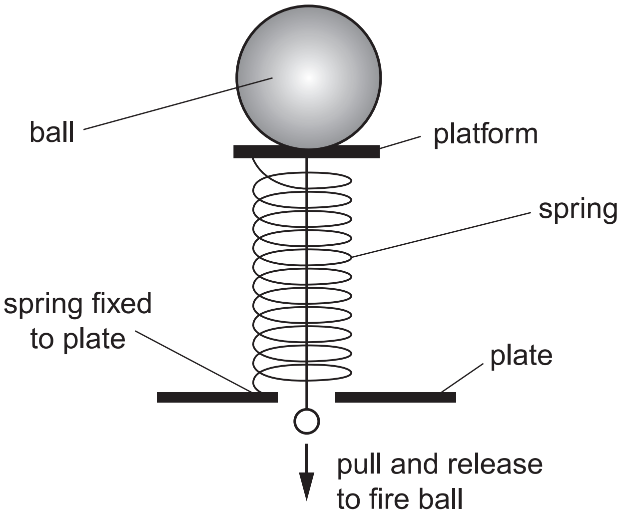

Fig. 7.2

The spring has a force constant of $75\,N\,m^{-1}$. The ball is placed on the platform at the top of the spring.

(i) The spring is compressed by 0.085 m by pulling the platform. Calculate the force exerted by the compressed spring on the ball **immediately** after the spring is released. Assume both the spring and the platform have negligible mass.

force = ... N **[2]**

(ii) The mass of the ball is 2.5×10^{-3} kg. Calculate the initial acceleration of the ball.

acceleration = ... $m\,s^{-2}$ **[1]**

(iii) Calculate the maximum height that could be gained by the ball. Assume all the elastic potential energy of the spring is converted into gravitational potential energy of the ball.

height = ... m **[3]**

[Total: 11]

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Answer **all** the questions.

1 (a) Draw a line from each unit on the left-hand side to the correct equivalent unit on the right-hand side.

joule (J)	kg m s^{-2}
watt (W)	N m
newton (N)	J s^{-1}

[2]

(b) This question is about estimating the pressure exerted by a person wearing shoes standing on a floor, see Fig. 1.1.

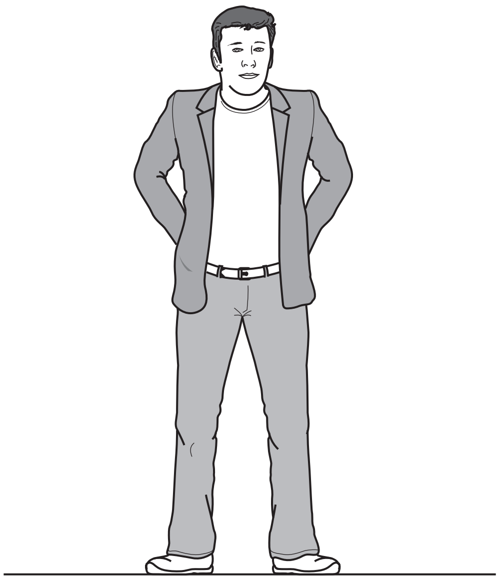

Fig. 1.1

(i) Estimate the weight in newtons of a person.

weight = ... N **[1]**

(ii) Estimate the total area of contact in square metres between the shoes of this person and the floor.

area = ... m^2 **[1]**

(iii) Hence estimate the pressure in pascals exerted by this person standing on the floor.

pressure = ... Pa **[1]**

[Total: 5]

2 Fig. 2.1 shows two masses **A** and **B** tied to the ends of a length of string. The string passes over a pulley. The mass **A** is held at rest on the floor.

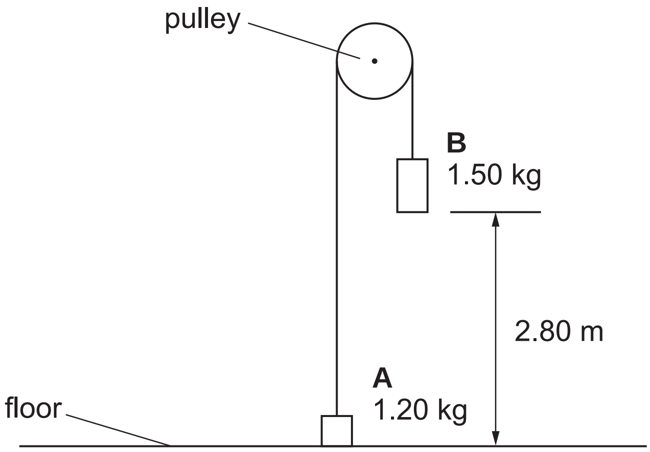

Fig. 2.1

The mass **A** is 1.20 kg and the mass **B** is 1.50 kg.

(a) Calculate the weight of mass **B**.

weight = ... N **[1]**

(b) Mass **B** is initially at rest at a height of 2.80 m above the floor. Mass **A** is then released. Mass **B** has a constant downward acceleration of 1.09 m s^{-2}. Assume that air resistance and the friction between the pulley and the string are negligible.

(i) In terms of forces, explain why the acceleration of the mass **B** is less than the acceleration of free fall *g*.

....

.... **[1]**

(ii) Calculate the time taken for the mass **B** to fall 1.40 m.

time = ... s **[3]**

(iii) Calculate the velocity of mass **B** after falling 1.40 m.

velocity = ... $m\,s^{-1}$ **[2]**

(iv) Mass **B** hits the floor at a speed of 2.47 $m\,s^{-1}$. It **rebounds** with a speed of 1.50 $m\,s^{-1}$. The time of contact with the floor is 3.0×10^{-2} s. Calculate the magnitude of the average acceleration of mass **B** during its impact with the floor.

acceleration = ... $m\,s^{-2}$ **[2]**

[Total: 9]

3 A lift has a mass of 500 kg. It is designed to carry a maximum of 8 people of total mass 560 kg. The lift is supported by a steel cable of cross-sectional area $3.8 \times 10^{-4}\,m^2$. When the lift is at ground floor level the cable is at its maximum length of 140 m, as shown in Fig. 3.1. The mass per unit length of the cable is $3.0\,kg\,m^{-1}$.

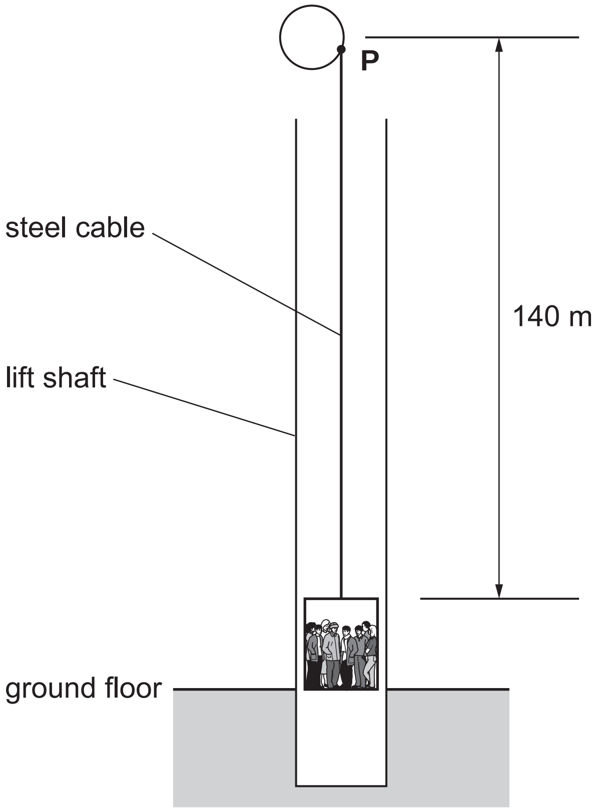

Fig. 3.1

(a) Show that the mass of the 140 m long steel cable is 420 kg.

[1]

(b) (i) The lift with its 8 passengers is stationary at the ground floor level. The initial upward acceleration of the lift and the cable is $1.8\,\mathrm{m\,s^{-2}}$. Show that the **maximum** tension in the cable at point **P** is $1.7 \times 10^4\,\mathrm{N}$.

[4]

(ii) Calculate the maximum stress in the cable.

stress = ... Pa **[2]**

[Total: 7]

4 **(a)** An electron in a particle accelerator experiences a constant force. According to one student, the acceleration of the electron should remain constant because the ratio of force to mass does not change. In reality, experiments show that the acceleration of the electron decreases as its velocity increases. Describe what can be deduced from such experiments about the nature of accelerated electrons.

....

....

....

.... **[2]**

(b) Fig. 4.1 shows the velocity vector for a particle moving at an angle of 31° to the horizontal.

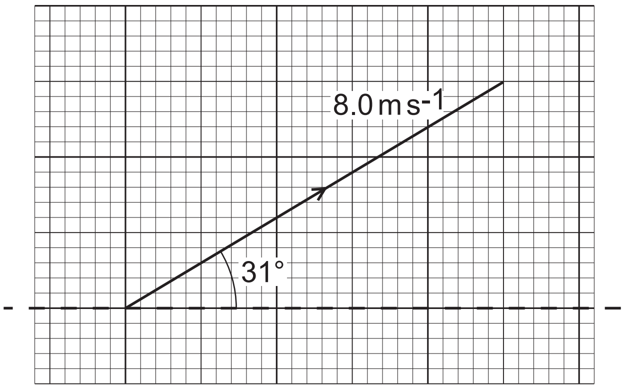

Fig. 4.1

(i) On Fig. 4.1, show the horizontal (*x*-direction) and vertical (*y*-direction) components of the velocity. **[2]**

(ii) Calculate the horizontal (*x*-direction) component of the velocity.

velocity = ... $m\,s^{-1}$ **[1]**

(c) Fig. 4.2 shows a ship **S** being pulled by two tug-boats.

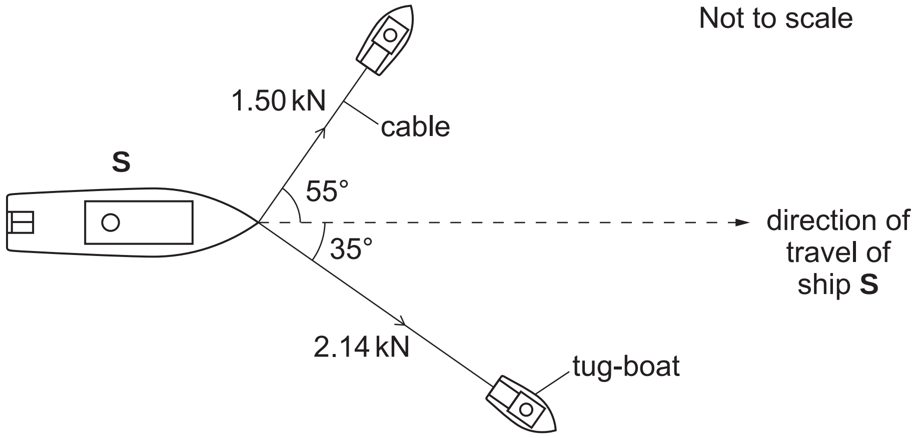

Fig. 4.2

The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in Fig. 4.2.

(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = ... kN **[3]**

(ii) State the value of the drag force acting on the ship **S**. Explain your answer.

....

....

.... **[2]**

[Total: 10]

5 **(a)** State the principle of conservation of energy.

....

.... **[1]**

(b) Describe one example where elastic potential energy is stored.

.... **[1]**

(c) Fig. 5.1 shows a simple pendulum with a metal ball attached to the end of a string.

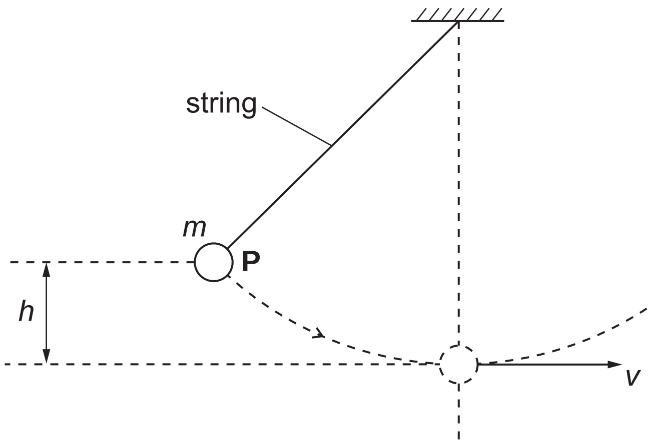

Fig. 5.1

When the ball is released from **P**, it describes a circular path. The ball has a maximum speed v at the bottom of its swing. The vertical distance between **P** and bottom of the swing is h. The mass of the ball is m.

(i) Write the equations for the change in gravitational potential energy, E_p, of the ball as it drops through the height h and for the kinetic energy, E_k, of the ball at the bottom of its swing when travelling at speed v.

E_p =

E_k = **[1]**

(ii) Use the principle of conservation of energy to derive an equation for the speed v. Assume that there are no energy losses due to air resistance.

[2]

(d) Some countries in the world have frequent thunderstorms. A group of scientists plan to use the energy from the falling rain to generate electricity. A typical thunderstorm deposits rain to a depth of 1.2×10^{-2} m over a surface area of 2.0×10^{7} m^2 during a time of 900 s. The rain falls from an average height of 2.5×10^{3} m. The density of rainwater is 1.0×10^{3} kg m^{-3}. About 30% of the gravitational potential energy of the rain can be converted into electrical energy at the ground.

(i) Show that the total mass of water deposited in 900 s is 2.4×10^{8} kg.

[2]

(ii) Hence show that the average electrical power available from this thunderstorm is about 2 GW.

[3]

(iii) Suggest one problem with this scheme of energy production.

....

.... **[1]**

[Total: 11]

6 The force against length graph for a spring is shown in Fig. 6.1.

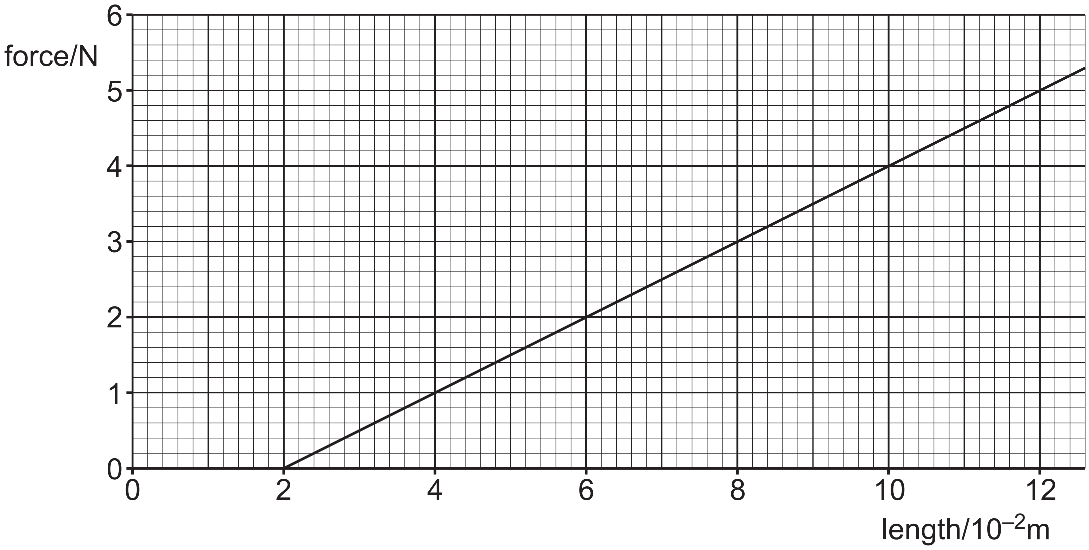

Fig. 6.1

(a) Explain why the graph does not pass through the origin.

....

.... **[1]**

(b) State what feature of the graph shows that the spring obeys Hooke's law.

....

.... **[1]**

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... $N\,m^{-1}$ **[2]**

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2} m to 8.0×10^{-2} m.

work done = ... J **[2]**

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 6.2 shows the displacement *s* against time *t* graph for the mass.

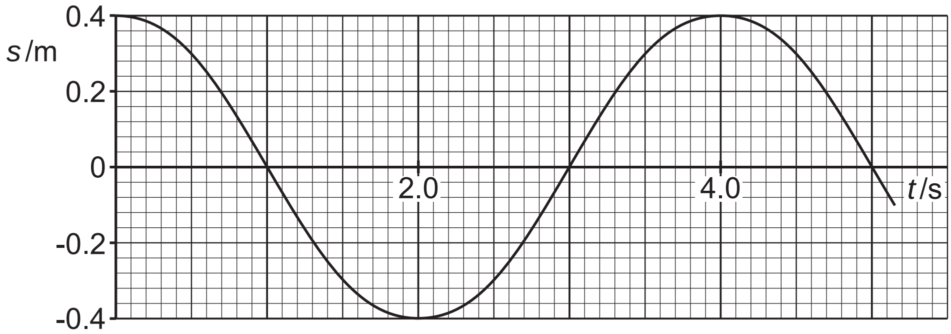

Fig. 6.2

Explain how you can use Fig. 6.2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

....

....

....

.... **[2]**

[Total: 8]

7 **(a)** Fig. 7.1 shows a length of tape under tension.

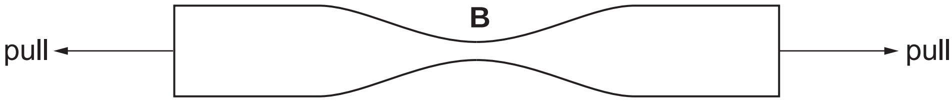

Fig. 7.1

(i) Explain why the tape is most likely to break at point **B**.

....

.... **[1]**

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

....

....

.... **[1]**

(b) Fig. 7.2 shows one possible method for determining the Young modulus of a metal in the form of a wire.

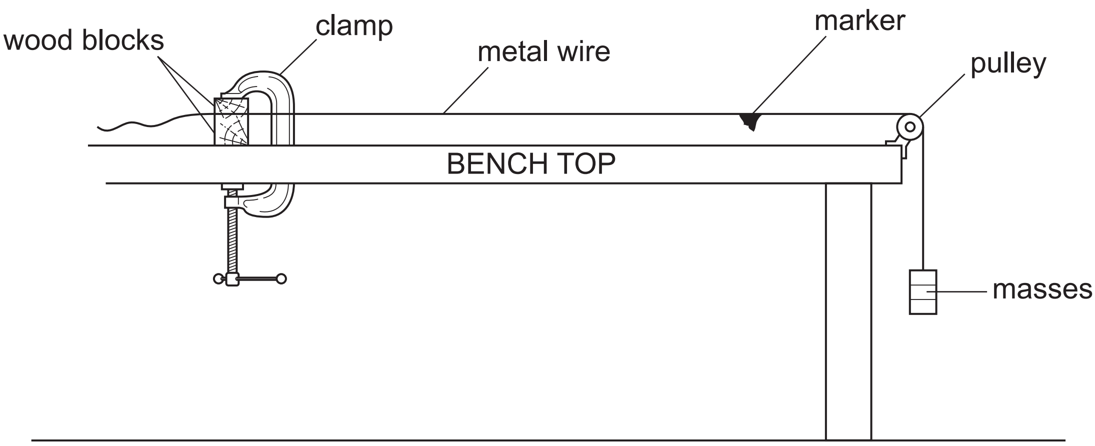

Fig. 7.2

Describe how you can use this apparatus to determine the Young modulus of the metal. The sections below should be helpful when writing your answers.

The **measurements** to be taken:

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

The **equipment** used to take the measurements:

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

How you would **determine** Young modulus from your measurements:

....

....

....

....

....

....

[8]

[Total: 10]

END OF QUESTION PAPER

THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A

G481

Mechanics

Candidates answer on the Question Paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator
- Ruler (cm/mm)
- Protractor

Thursday 27 May 2010
Afternoon

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but must clearly show your Candidate Number, Centre Number and question number(s).

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 **(a)** Complete the table of Fig. 1.1 by stating the value or name of each of the remaining three prefixes.

prefix	value
micro (μ)	10^{-6}
mega (M)	
	10^{-9}
tera (T)	

Fig. 1.1

[3]

(b) Circle all the scalar quantities in the list below.

density **weight** **velocity** **volume** **acceleration**

[1]

(c) The distance between the Sun and the Earth is 1.5×10^{11} m. Calculate the time in minutes for light to travel from the Sun to the Earth. The speed of light is $3.0 \times 10^{8}\,\mathrm{m\,s^{-1}}$.

time = ... min **[2]**

(d) The terminal velocity of a raindrop falling vertically through air is $4.0\,m\,s^{-1}$.

(i) In terms of the forces acting on the raindrop, explain why it is at terminal velocity.

....

....

.... **[2]**

(ii) Fig. 1.2 shows a velocity vector diagram for the falling raindrop in a horizontal crosswind of speed $1.5\,m\,s^{-1}$.

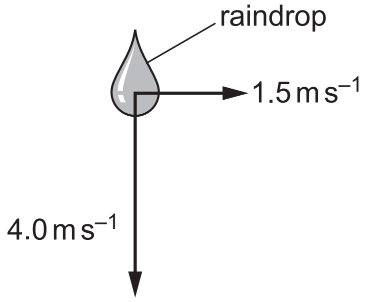

Fig. 1.2

1 On Fig. 1.2, draw an arrow on the raindrop to show the **direction** in which it will travel.

2 Calculate the magnitude of the resultant velocity of the raindrop. Use the space below for your working.

resultant velocity = ... $m\,s^{-1}$ **[3]**

[Total: 11]

2 **(a)** According to Aristotle (384 – 322 B.C.)

'heavier objects fall faster than lighter ones'.

Explain how one experiment carried out by Galileo (1564 – 1642) overturned Aristotle's ideas of motion.

....

....

....

....

....

.... **[3]**

(b) Fig. 2.1 shows an arrangement used in the laboratory to determine the acceleration *g* of free fall.

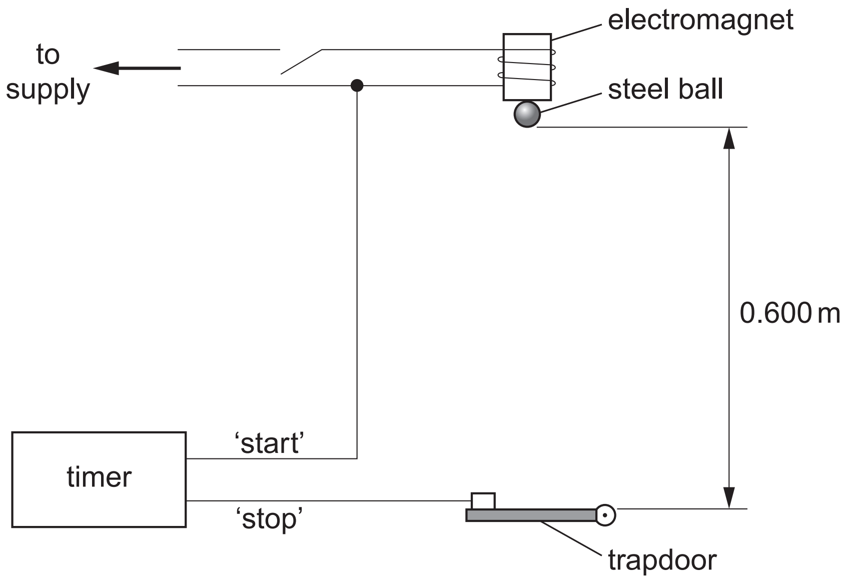

Fig. 2.1

The steel ball is held at rest by an electromagnet. When the electromagnet is switched off, the electronic timer is started and the ball falls. The timer is stopped when the ball opens the trapdoor. The distance between the bottom of the ball and the top of the trapdoor is 0.600 m. The timer records a time of fall of 0.356 s.

(i) Show that the value for the acceleration g of free fall obtained from this experiment is $9.47\,\mathrm{m\,s^{-2}}$.

[2]

(ii) State **one** reason why the experimental value in **(i)** is less than $9.81\,\mathrm{m\,s^{-2}}$.

....

....

.... **[1]**

(iii) On Fig. 2.2 sketch a graph to show the variation of the vertical distance s fallen by the ball with time t.

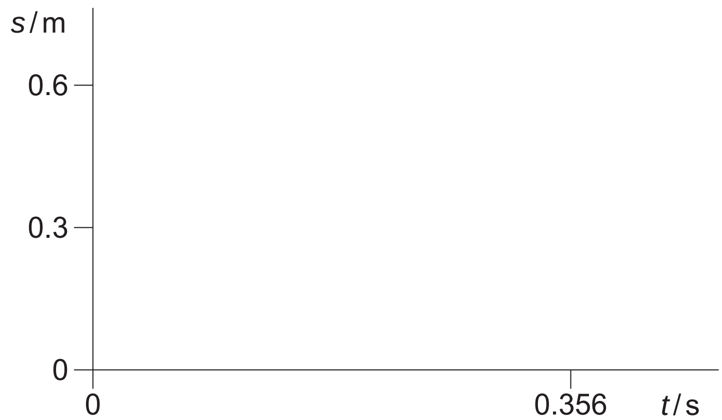

Fig. 2.2

[1]

[Total: 7]

3 **(a)** Define the *newton*.

....

.... **[1]**

(b) Fig. 3.1 shows a spaceship on the surface of the Earth.

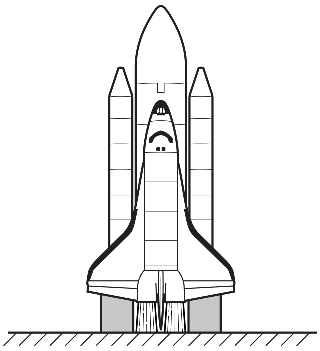

Fig. 3.1

The mass of the spaceship is 1.9×10^6 kg. During lift off, the spaceship rockets produce a vertical upward force of 3.1×10^7 N.

(i) Calculate the weight of the spaceship.

weight = ... N **[1]**

(ii) Calculate the initial vertical acceleration as the spaceship lifts off.

acceleration = ... $m\,s^{-2}$ **[2]**

(iii) The vertical upward force on the spaceship stays constant. Explain why the acceleration of the spaceship increases after lift off.

....

....

....

.... **[1]**

[Total: 5]

4 **(a)** Define *work done* by a force.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) Fig. 4.1 shows a side view of a roller coaster.

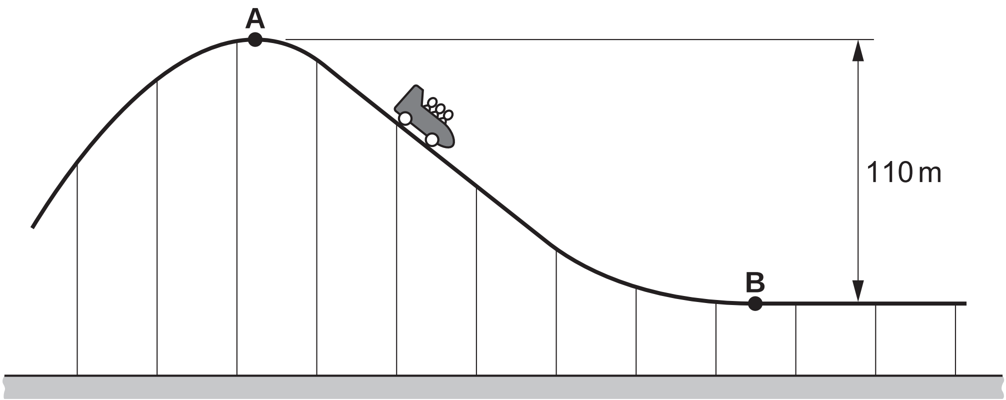

Fig. 4.1

The carriage and its passengers start at rest at **A**. At **B**, the bottom of the ride, the maximum speed of the carriage is 20 m s^{-1}. The vertical distance between **A** and **B** is 110 m. The length of the track between **A** and **B** is 510 m. The mass of the carriage and the passengers is 4000 kg.

(i) Complete the sentence below.

In your answer, you should use appropriate technical terms, spelled correctly.

As the carriage travels from **A** to **B**, ... energy

is transferred to .... energy and heat. **[2]**

(ii) By considering this energy transfer from **A** to **B**, determine the average frictional force acting on the carriage and passengers between **A** and **B**.

force = ... N **[3]**

[Total: 6]

5 **(a)** Define *braking distance* of a car.

....

....

.... **[1]**

(b) Other than the speed of the car, state two factors that affect the braking distance of a car. Describe how the braking distance is affected by each factor.

1. ....

....

....

....

2. ....

....

....

.... **[4]**

(c) Describe and explain how seat belts in cars reduce impact forces on the driver in an accident.

....

....

....

....

....

....

.... **[3]**

(d) Fig. 5.1 shows the variation of braking distance with speed *v* of a car.

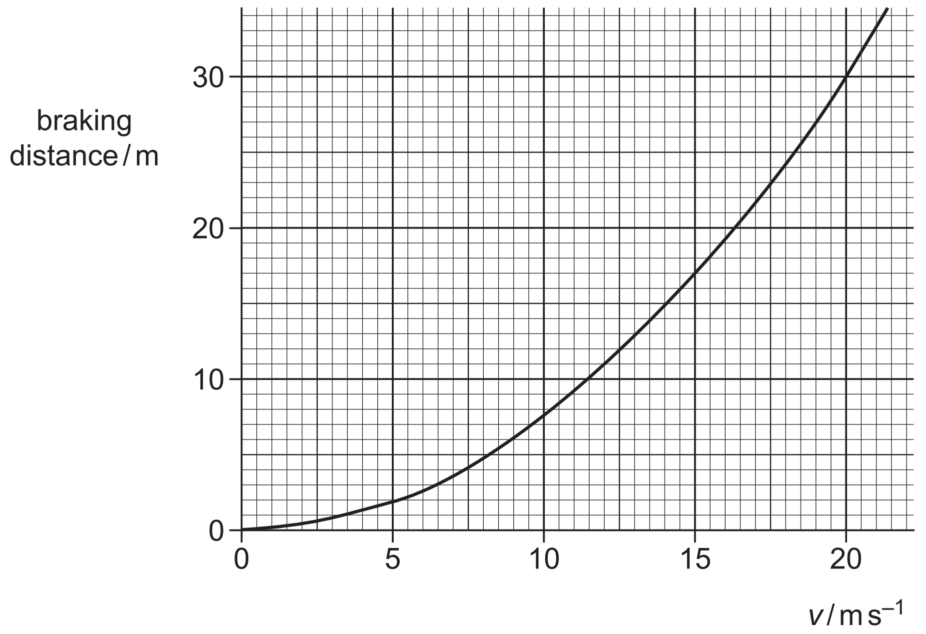

Fig. 5.1

(i) The car is travelling on a level straight road at a speed of 20 m s^{-1}. The reaction time of the driver is 0.50 s.

1 Calculate the thinking distance.

thinking distance = ... m

2 Hence, determine the stopping distance of the car.

stopping distance = ... m
[3]

(ii) In Fig. 5.1, the braking distance is directly proportional to the square of the speed. Determine the braking distance of the car when travelling at a speed of $32\,\mathrm{m\,s^{-1}}$.

braking distance = ... m **[2]**

[Total: 13]

6 (a) Fig. 6.1 shows two equal but opposite forces acting on an object.

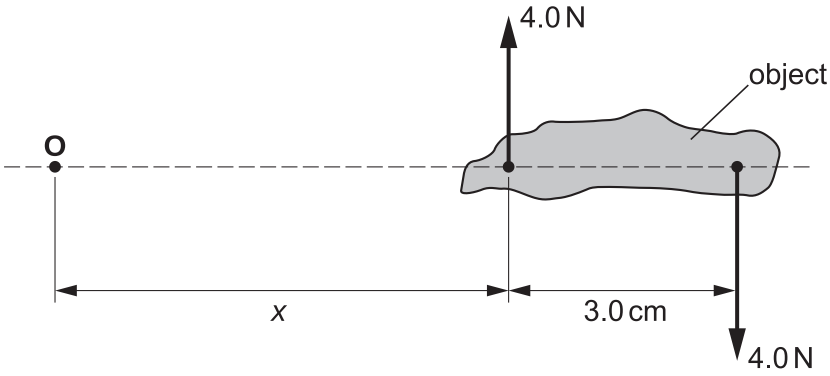

Fig. 6.1

The point **O** is at a distance *x* from the nearer of the two forces.

(i) The separation between the two parallel forces is 3.0 cm. Determine the torque of the couple exerted on the object.

torque = ... N m **[2]**

(ii) Calculate the total moment of the forces about the point **O** and state the significance of this value.

....

.... **[3]**

(b) State two conditions necessary for an object to be in equilibrium.

....

....

.... **[2]**

(c) A concrete paving slab has mass 45 kg and dimensions 0.600 m × 0.600 m × 0.050 m.

(i) Calculate the density of the concrete.

density = ... $kg\,m^{-3}$ **[2]**

(ii) Fig. 6.2 shows the concrete paving slab in equilibrium.

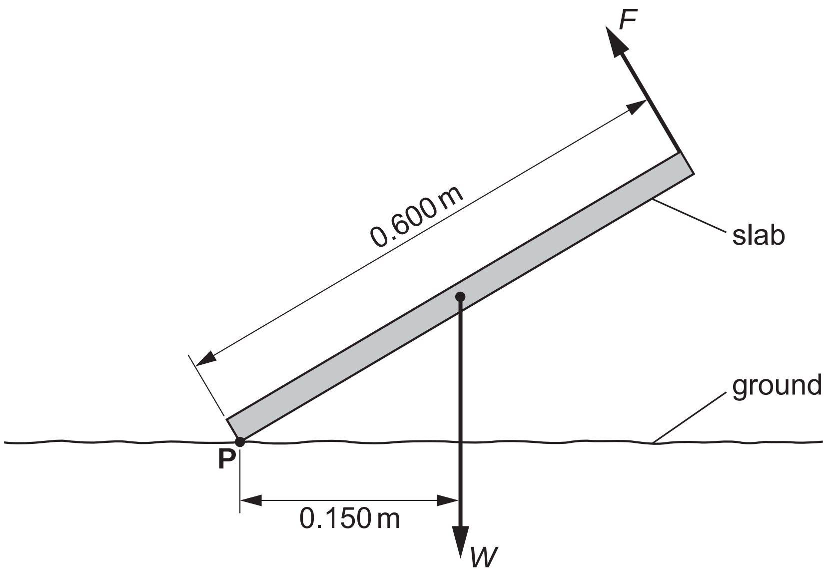

Fig. 6.2

Two forces acting on the slab are shown. The weight of the slab is *W*. The force *F* is applied at right angles to the end of the slab. By taking moments about **P**, determine the size of the force *F*.

F = ... N **[3]**

[Total: 12]

7 **(a)** Fig. 7.1 shows stress against strain graphs for two materials **X** and **Y** up to their breaking points.

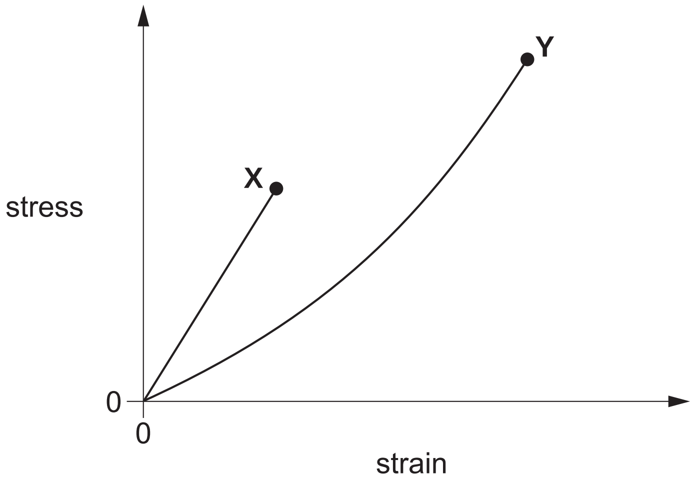

Fig. 7.1

Put a tick (✓) in the appropriate column if the statement applies to the material.

Statement	**X**	**Y**
This material is brittle.		
This material has greater breaking stress.		
This material obeys Hooke's Law.		

[1]

(b) Kevlar is one of the strongest man-made materials. It is used in reinforcing boat hulls, aircraft, tyres and bullet-proof vests. Sudden impacts cause this material to undergo plastic deformation.

(i) Explain what is meant by *plastic deformation*.

....

....

.... **[1]**

(ii) One particular type of Kevlar has breaking stress 3.00×10^9 Pa and Young modulus 1.30×10^{11} Pa. For a Kevlar thread of cross-sectional area 1.02×10^{-7} m^2 and length 0.500 m, calculate

1 the maximum breaking force

force = ... N

2 the extension of the thread when the stress is 1.20×10^9 Pa.

extension = ... m

[4]

[Total: 6]

END OF QUESTION PAPER

ADVANCED SUBSIDIARY GCE

PHYSICS A **G481**

Mechanics

Candidates answer on the question paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet

Other materials required:
- Electronic calculator
- Protractor
- Ruler (cm/mm)

Wednesday 12 January 2011
Morning

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

DC (SHW 00491 5/09) 17466/4

Answer **all** the questions.

1 **(a)** Draw a straight line from each quantity on the left hand side to its correct unit on the right hand side; one has already been done for you.

velocity	$N\,m^{-2}$
work done	$m\,s^{-1}$
stress	$N\,m$
density	$kg\,m^{-3}$

[2]

(b) Fig. 1.1 shows a metal cube which rests on a table.

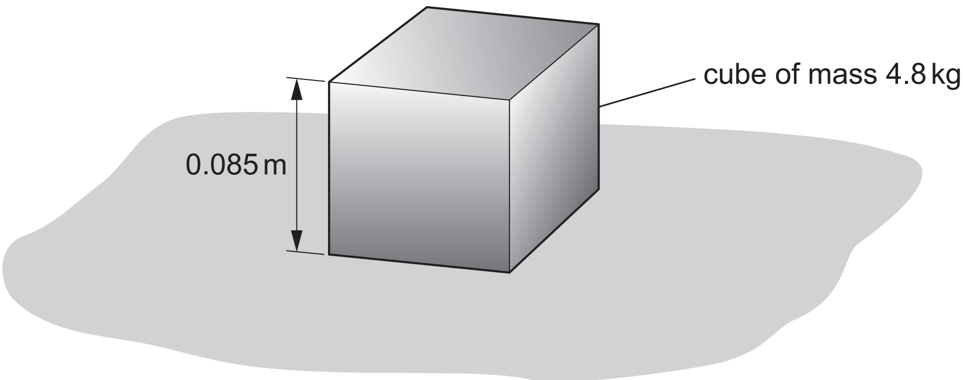

Fig. 1.1

The mass of the metal cube is 4.8 kg. Each side of the cube has length 0.085 m. The cube exerts pressure on the table.

(i) Complete the sentence below:

The force acting on the table is due to the .... of the metal cube. **[1]**

(ii) Calculate the pressure exerted on the table by the metal cube.

pressure = ... Pa **[2]**

(iii) The metal cube shown is replaced by a second cube made of the same material but with each side of double the length of the original cube.

Complete the sentences below for the second cube when compared with the original cube.

The mass of the second cube is …………………… times greater than the original cube.

The cross-sectional area of the base is …………………… times greater than the original cube.

Hence, the pressure exerted by this cube is …………………… times greater than the original cube.

[3]

[Total: 8]

2 A driver travelling in a car on a straight and level road sees an obstacle in the road ahead and applies the brakes until the car stops. The initial speed of the car is $20\,m\,s^{-1}$. The reaction time of the driver is 0.50 s.

Fig. 2.1 shows the velocity against time graph for the car.

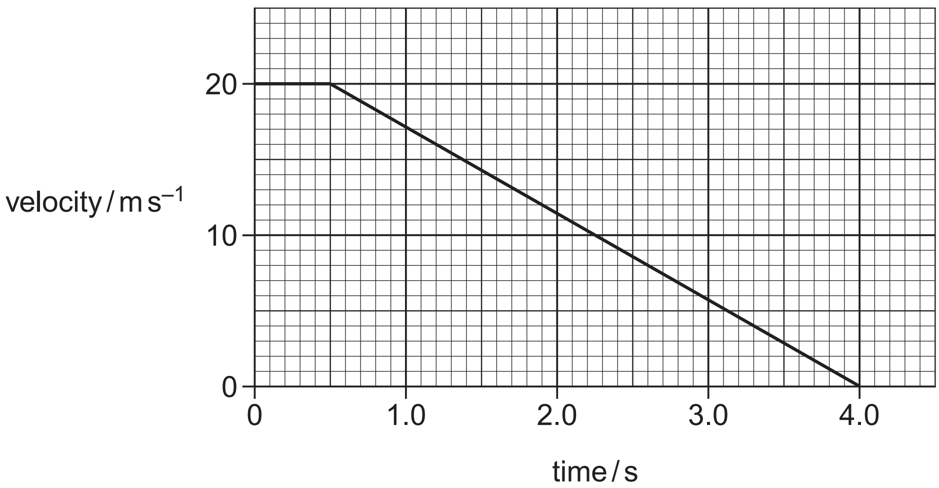

Fig. 2.1

(a) Define *thinking distance*.

....

.... **[1]**

(b) What does the area under a velocity against time graph represent?

.... **[1]**

(c) Use your answer to **(b)** and Fig. 2.1 to determine

(i) the thinking distance

thinking distance = ... m **[1]**

(ii) the braking distance.

braking distance = ... m **[2]**

(d) The total mass of the car is 910 kg. Use Fig. 2.1 to determine

(i) the magnitude of the deceleration of the car

deceleration = ... $m\,s^{-2}$ **[2]**

(ii) the braking force acting on the car as it decelerates.

force = ... N **[2]**

(e) Suppose the initial speed of the car is twice that shown in Fig. 2.1. The braking force remains the same. State and explain by what factor the **braking** distance would increase.

....

....

....

.... **[2]**

(f) One of the safety features in a car is the air bag for the driver. Briefly describe how the air bag is triggered and how it minimises the impact force on the driver.

....

....

....

....

....

....

....

....

....

....

....

.... **[4]**

[Total: 15]

3 **(a)** Define *work done* by a force.

....

.... **[1]**

(b) Fig. 3.1 shows a car travelling up a slope at a constant speed.

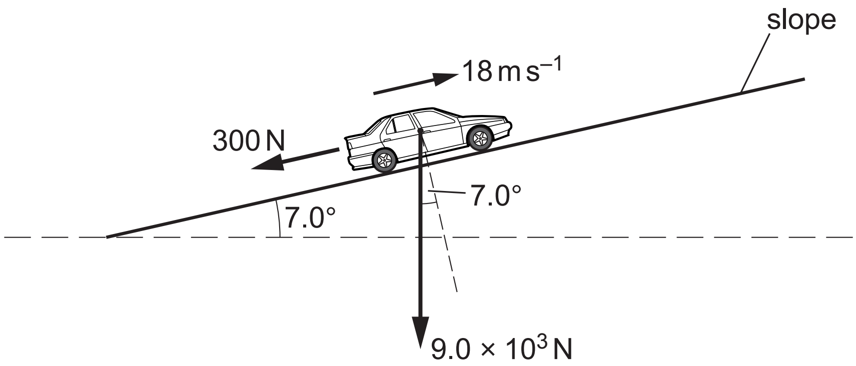

Fig. 3.1

The angle between the slope and the horizontal is 7.0°. The weight of the car is 9.0×10^3 N. The car travels up the slope at a constant speed of 18 m s^{-1}. A resistive force of 300 N acts on the car down the slope.

(i) What is the net force acting on the car? Explain your answer.

....

....

.... **[2]**

(ii) Calculate the component of the weight of the car acting down the slope.

component of weight = ... N **[2]**

(iii) Calculate the work done per second against the resistive force.

work done per second = ... $J\,s^{-1}$ **[1]**

(iv) Calculate the power developed by the car as it travels up the slope.

power = ... W **[3]**

[Total: 9]

4 **(a)** Write a word equation for *kinetic energy*.

kinetic energy =

[1]

(b) A bullet of mass 3.0×10^{-2} kg is fired at a sheet of plastic of thickness 0.015 m. The bullet enters the plastic with a speed of $200\,\mathrm{m\,s^{-1}}$ and emerges from the other side with a speed of $50\,\mathrm{m\,s^{-1}}$.

Calculate

(i) the loss of kinetic energy of the bullet as it passes through the plastic

loss of kinetic energy = ... J **[3]**

(ii) the average frictional force exerted by the plastic on the bullet.

frictional force = ... N **[2]**

[Total: 6]

5 Use your knowledge of physics to state if each statement is correct or incorrect. You then need to explain the reason for your answer. An example has been done for you:

In a vacuum, a 2.0 kg object will fall faster towards the ground than an object of mass 1.0 kg.

This statement is **incorrect**.
Explanation: **All objects falling towards the Earth in a vacuum have the same acceleration**.

(a) The mass of a particle (e.g. electron) remains constant as its speed approaches the speed of light.

This statement is ....

Explanation: ....

....

.... **[2]**

(b) A ball is thrown vertically upwards. Air resistance has negligible effect on its motion. During the flight, the total energy of the ball remains constant.

This statement is ....

Explanation: ....

....

.... **[2]**

(c) An object falling through air has a terminal velocity of $30\,\mathrm{m\,s^{-1}}$. At terminal velocity, the weight of the object is equal to the acceleration of free fall.

This statement is ....

Explanation: ....

....

.... **[2]**

(d) The technique of 'triangle of vectors' is used by a global positioning system (GPS) to locate the position of cars.

In your answer, you should use appropriate technical terms, spelled correctly.

This statement is ....

Explanation: ....

....

.... **[2]**

[Total: 8]

6 **(a)** Explain in terms of forces what is meant by a *couple*.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

.... **[1]**

(b) **(i)** Define *moment of a force*.

....

.... **[1]**

(ii) Fig. 6.1 shows three forces acting on a rod.

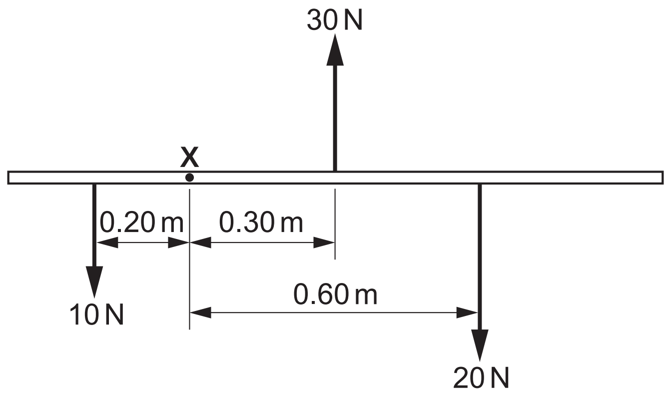

Fig. 6.1

By taking moments about point **X**, show that the rod is not in equilibrium when acted upon by these forces.

....

.... **[2]**

[Total: 4]

7 **(a)** Fig. 7.1 shows stress against strain graphs for materials **X**, **Y** and **Z** up to their breaking points.

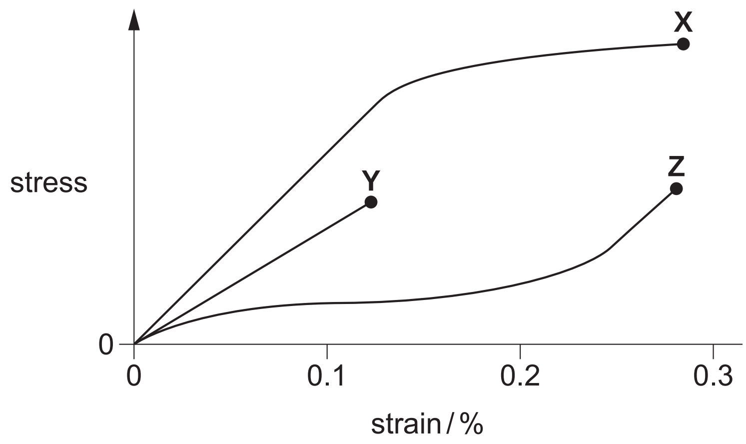

Fig. 7.1

(i) State which of these three materials is brittle.

.... **[1]**

(ii) State one similarity between the properties of materials **X** and **Y** for strains less than 0.05%.

....

.... **[1]**

(iii) State and explain which material has the greatest value for the Young modulus.

....

....

.... **[2]**

(b) Engineers are testing a new material to be used as support cables for a bridge. In a laboratory test, the breaking force for a sample of the material of diameter 0.50 mm is 240 N. Estimate the breaking force for a cable of diameter 15 mm made from the same material.

breaking force = ... N **[2]**

[Total: 6]

Please turnover for Question 8.

8 A small block of wood is held at a horizontal distance of 1.2 m from a metal ball. The metal ball is fired horizontally towards the block at a speed of $8.0\,\mathrm{m\,s^{-1}}$. At the same instant the ball is fired, the block is released and it falls vertically under gravity.

Fig. 8.1 shows the paths of the metal ball and the block. The ball collides with the block. Air resistance is negligible.

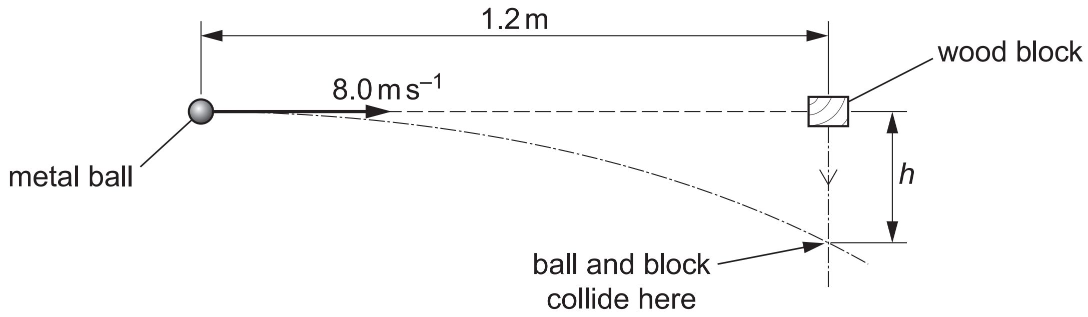

Fig. 8.1

(a) Show that the time between firing the ball and it colliding with the block is 0.15 s.

[1]

(b) Calculate the vertical distance h fallen by the wooden block when it collides with the metal ball.

h = ... m **[2]**

(c) Briefly explain why the metal ball will always collide with the wood block, even if the speed of the ball or the horizontal distance is changed.

....

....

.... **[1]**

[Total: 4]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A

Mechanics

G481

Candidates answer on the question paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet

Other materials required:
- Electronic calculator
- Ruler (cm/mm)
- Protractor

Tuesday 24 May 2011
Morning

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 (a) The areas under the graphs below are physical quantities.

(i) Fig. 1.1 shows a force against extension graph for a rubber band.

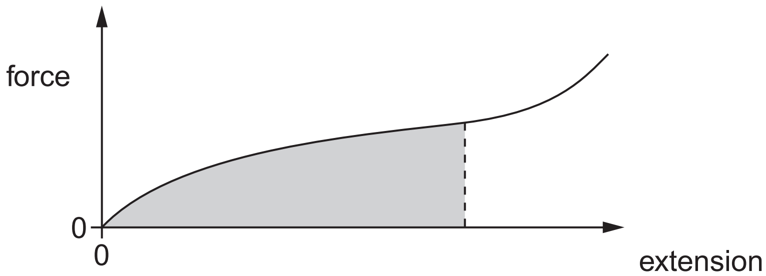

Fig. 1.1

State the quantity represented by the area under the force against extension graph.

.... **[1]**

(ii) Fig. 1.2 shows the velocity against time graph for an accelerating car.

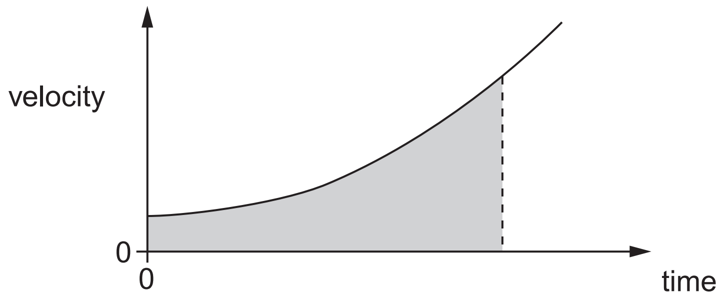

Fig. 1.2

State the quantity represented by the area under the velocity against time graph.

.... **[1]**

(b) State two quantities in physics that have the **same** unit of newton metre (N m).

quantity 1 .... **[1]**

quantity 2 .... **[1]**

[Total: 4]

2 **(a)** Define *density*.

....

.... **[1]**

(b) Fig. 2.1 shows the variation of density of the Earth with **depth** from the surface.

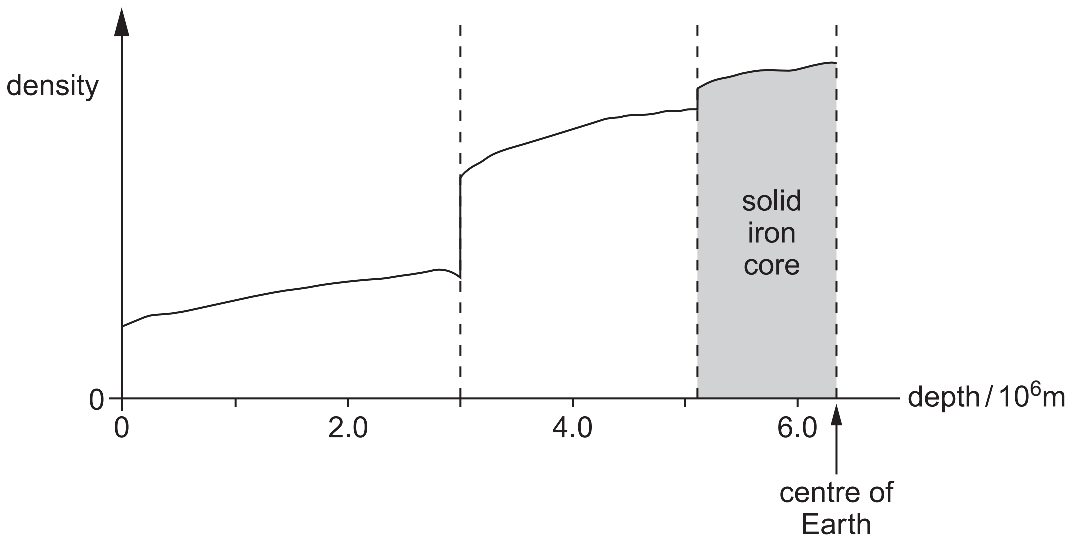

Fig. 2.1

(i) Suggest how Fig. 2.1 shows that the Earth consists of a number of distinct layers.

....

.... **[1]**

(ii) Geophysicists believe that the central core of the Earth is solid iron. This central core is surrounded by a layer of molten metal. The central core starts at a **depth** of 5.1×10^6 m. The solid iron core accounts for 18% of the mass of the Earth. The mass of the Earth is 6.0×10^{24} kg and its radius is 6.4×10^6 m. Calculate the mean density of the central core of the Earth.

volume of a sphere = $\frac{4}{3}\pi r^3$

density = ... kg m^{-3} **[3]**

[Total: 5]

3 **(a)** Define a *vector* quantity and give one example.

....

.... **[2]**

(b) Fig. 3.1 shows a force F at an angle of 30° to the horizontal direction.

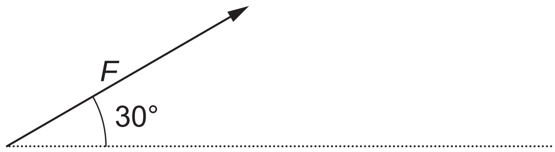

Fig. 3.1

(i) The **horizontal component** of the force F is 7.0 N. Calculate the magnitude of the force F.

F = ... N **[2]**

(ii) The force F moves an object in the horizontal direction. In a time of 4.2 s, the object moves a horizontal distance of 5.0 m. Calculate

1 the work done by the force

work done = ... J **[2]**

2 the rate of work done by the force.

rate of work done = ... W **[1]**

(c) Fig. 3.2 shows the forces acting on a stage light of weight 120 N held stationary by two separate cables.

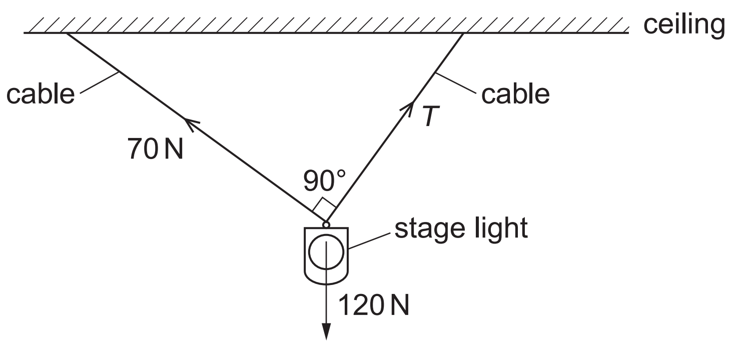

Fig. 3.2

The angle between the two cables is 90°. One cable has tension 70 N and the other has tension *T*.

(i) State the magnitude and the direction of the **resultant** of the tensions in the two cables.

magnitude ....

direction .... **[2]**

(ii) Sketch a labelled vector triangle for the forces acting on the stage light. Hence, determine the magnitude of the tension *T*.

T = ... N **[4]**

[Total: 13]

4 **(a)** State two factors that affect the magnitude of the drag force acting on an object falling through air.

1. ....

2. .... **[2]**

(b) Fig. 4.1 shows a skydiver of total mass 75 kg falling vertically towards the ground.

Fig. 4.1

The air resistance, or drag force, D in newtons (N) acting on the skydiver falling through the air is given by the equation

$$D = 0.3v^2$$

where v is the speed in $\mathrm{m\,s^{-1}}$ of the skydiver.

(i) On Fig. 4.1, draw arrows to represent the weight (labelled W) and drag force (labelled D). **[1]**

(ii) Calculate the weight of the skydiver.

weight = ... N **[1]**

(iii) At a particular instant, the speed of the skydiver is 20 m s^{-1}. Calculate the instantaneous acceleration of the skydiver.

acceleration = ... m s^{-2} **[3]**

(iv) State the relationship between the forces *W* and *D* when the skydiver reaches terminal velocity.

....

.... **[1]**

(v) Determine the terminal velocity of the skydiver.

terminal velocity = ... m s^{-1} **[2]**

[Total: 10]

5 (a) A student conducts an experiment to estimate the acceleration *g* of free fall by dropping a heavy metal ball from a high wall into a sandpit below. Describe how this student can estimate the acceleration *g* of free fall. Your description should include:

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to estimate *g*
- an explanation of why the value for *g* is only an estimate

In your answer, you should use appropriate technical terms, spelled correctly.

.... **[7]**

(b) The global positioning system (GPS) is used to locate accurately the position of cars on the Earth's surface.

(i) Name the electromagnetic waves used by GPS.

.... **[1]**

(ii) Explain how GPS determines the distance between the car and satellite.

....

....

....

.... **[2]**

(iii) Briefly describe how the distances from two or more satellites are used to locate the position of a car.

....

....

....

.... **[2]**

[Total: 12]

6 **(a)** State the principle of *conservation of energy*.

....

....

.... **[1]**

(b) Fig. 6.1 shows a glider on a horizontal frictionless track.

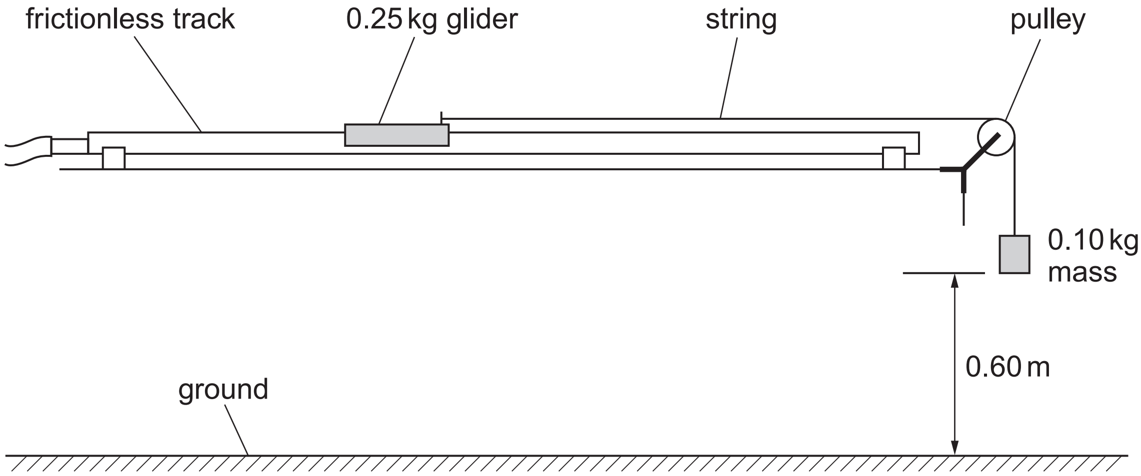

Fig. 6.1

The mass of the glider is 0.25 kg. One end of a string is fixed to the glider and the other end to a 0.10 kg mass. The 0.10 kg mass is held stationary at a height of 0.60 m from the ground. The pulley is more than 0.60 m away from the front of the glider. When the 0.10 kg mass is released, the glider has a constant acceleration of 2.8 $m\,s^{-2}$ towards the pulley. The 0.10 kg mass instantaneously comes to rest when it hits the ground.

(i) Calculate the loss in potential energy of the 0.10 kg mass as it falls through the distance of 0.60 m.

loss in potential energy = ... J **[1]**

(ii) The glider starts from rest. Show that the velocity of the **glider** after travelling a distance of 0.60 m is about 1.8 m s^{-1}.

[2]

(iii) Calculate the kinetic energy of the **glider** at this velocity of 1.8 m s^{-1}.

kinetic energy = ... J **[2]**

(iv) Explain why the answer to **(b)(iii)** is not the same as **(b)(i)**.

....

.... **[1]**

[Total: 7]

7 (a) Atoms in a solid are held in position by electrical forces. These electrical forces can be represented by an imaginary 'interatomic spring' between neighbouring atoms, see Fig. 7.1.

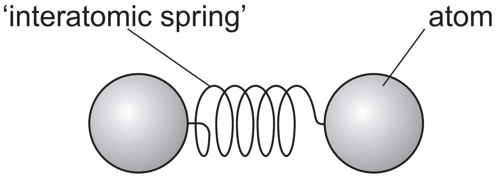

Fig. 7.1

The interatomic spring obeys *Hooke's law* and has a *force constant* just as a normal spring in the laboratory. Researchers in America have recently managed to determine the force experienced by an individual atom of cobalt when the atoms are squeezed together. The researchers found that a force of 210 pN changed the separation between a pair of atoms by a distance of 0.16 nm.

(i) State *Hooke's law*.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

.... **[1]**

(ii) Calculate the force constant of the interatomic spring for a pair of cobalt atoms.

force constant = ... $N\,m^{-1}$ **[3]**

(b) Fig. 7.2 shows a stress against strain graph for a metal wire up to its breaking point.

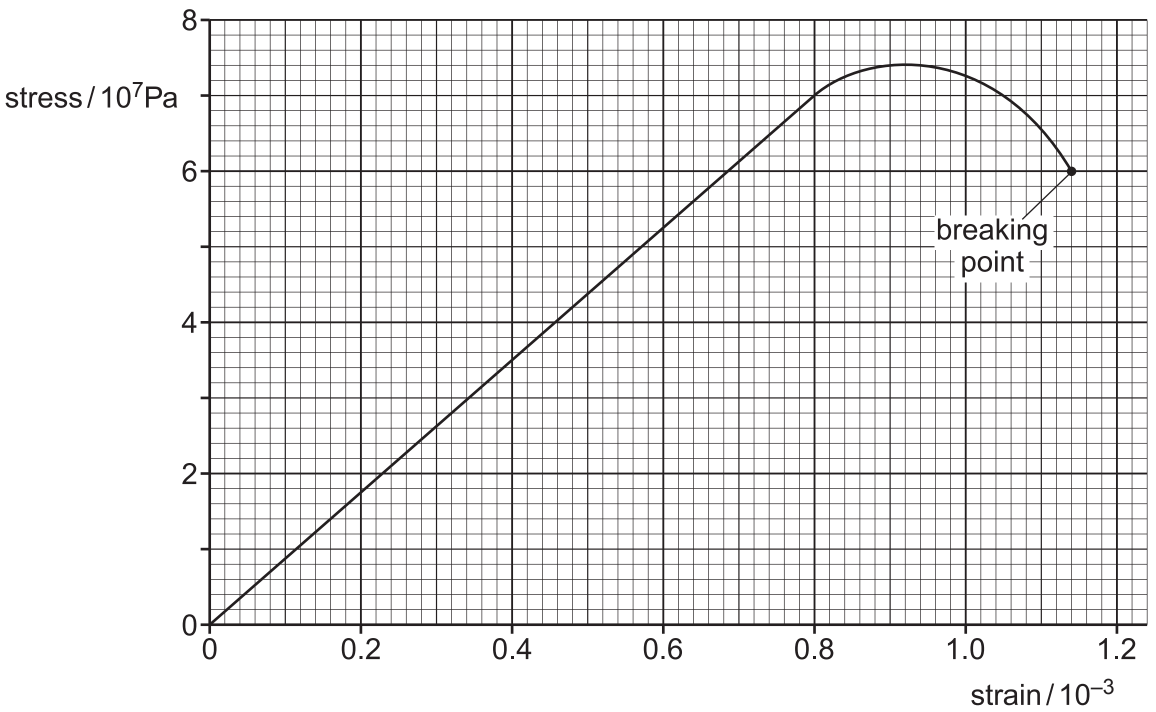

Fig. 7.2

(i) Use the graph to determine the Young modulus of the metal.

Young modulus = ... unit ....**[3]**

(ii) The wire breaks when a force of 19 N is applied. Use the graph to determine the cross-sectional area of the wire at the breaking point.

area = ... m^2 **[2]**

[Total: 9]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

Thursday 12 January 2012 – Afternoon

AS GCE PHYSICS A

G481 Mechanics

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator
- Protractor
- Ruler (cm/mm)

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

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- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

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- The total number of marks for this paper is **60**.
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- You are advised to show all the steps in any calculations.
  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 (a) Define *acceleration*.

....

.... **[1]**

(b) A super-tanker cruising at an initial velocity of 6.0 m s^{-1} takes 40 minutes (2400 s) to come to a stop. The super-tanker has a constant deceleration.

(i) Calculate the magnitude of the deceleration.

deceleration = ... m s^{-2} **[3]**

(ii) Calculate the distance travelled in the 40 minutes it takes the tanker to stop.

distance = ... m **[2]**

(iii) On Fig. 1.1, sketch a graph to show the variation of distance x travelled by the super-tanker with time t as it decelerates to a stop.

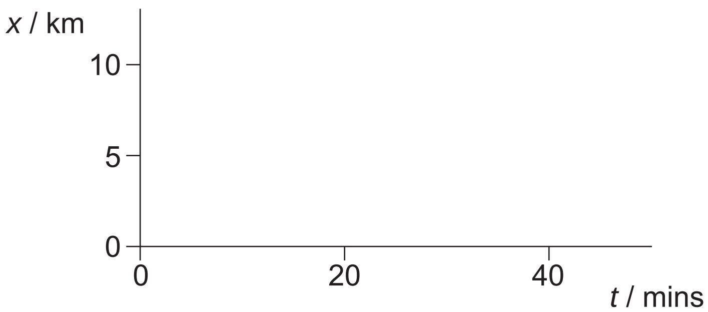

Fig. 1.1 **[2]**

(c) A student repeats one of Galileo's classic experiments from the sixteenth century. Fig. 1.2 shows the arrangement of this experiment.

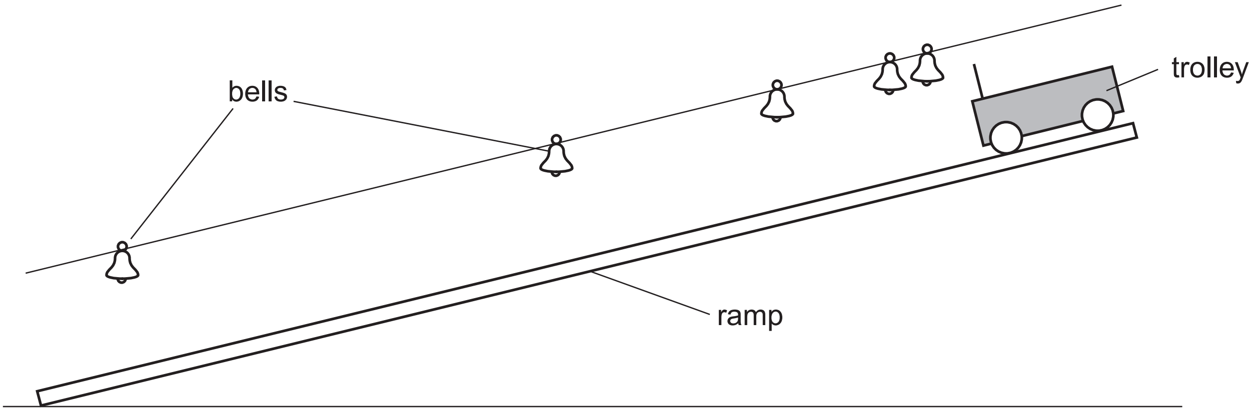

Fig. 1.2

A number of tiny bells are hung above a ramp. A trolley is released from rest from the top of the ramp. It rings each bell on its journey down the ramp. The procedure is repeated several times. The separations between the bells are adjusted until the time taken by the trolley to travel between successive bells is the **same**. This means that the bells ring at regular intervals. The distance between successive bells increases down the ramp.

(i) State what you can deduce about the motion of the trolley as it travels down the ramp.

....

.... **[1]**

(ii) The positions of the bells are unchanged. The mass of the trolley is increased. This heavier trolley is released from rest from the top of the ramp. State and explain the observations made by the student for this trolley.

....

....

....

....

.... **[2]**

[Total: 11]

2 **(a)** State the *principle of conservation of energy*.

....

.... **[1]**

(b) Define *work done* by a force and state its unit.

definition ....

....

....

unit .... **[3]**

(c) Fig. 2.1 shows a crater on the surface of the Earth.

Fig. 2.1

The crater was formed by a meteor impact about 50,000 years ago. The meteor was estimated to have a mass of 3.0×10^8 kg with an initial kinetic energy of 8.4×10^{16} J just before impact.

(i) State one major energy transformation that took place during the impact of the meteor with the Earth.

....

.... **[1]**

(ii) Show that the initial impact speed of the meteor was about $2.0 \times 10^4\,\text{m}\,\text{s}^{-1}$.

[2]

(iii) The crater is about 200 m deep. Estimate the average force acting on the meteor during the impact.

force = ... N **[3]**

[Total: 10]

3 Thinking and braking distances are important quantities when considering road safety.

(a) The driver of a car travelling at constant speed sees a hazard ahead at time $t = 0$. The reaction time of the driver is 0.5 s. On Fig. 3.1, sketch a graph of distance travelled by the car against time t during this interval of 0.5 s.

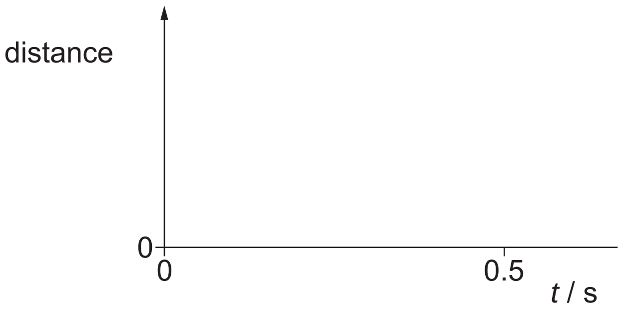

Fig. 3.1 **[1]**

(b) Explain the shape of your graph in Fig. 3.1.

....

.... **[1]**

(c) Define *braking distance*.

....

.... **[1]**

(d) Apart from the conditions of the tyres, brakes, road surface and weather, state two other factors that affect the **braking distance** of a car. For each factor, discuss how it affects the braking distance.

....

....

....

....

....

....

....

....

....

.... **[4]**

(e) Describe and explain how seat belts reduce the forces on a driver during the impact in an accident.

....

....

....

....

....

....

....

....

.... **[3]**

[Total: 10]

4 **(a)** Define *moment of a force*.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) State the two conditions that apply when an object is in equilibrium.

1. ....

2. .... **[2]**

(c) Fig. 4.1 is a diagram of a human arm lifting an object.

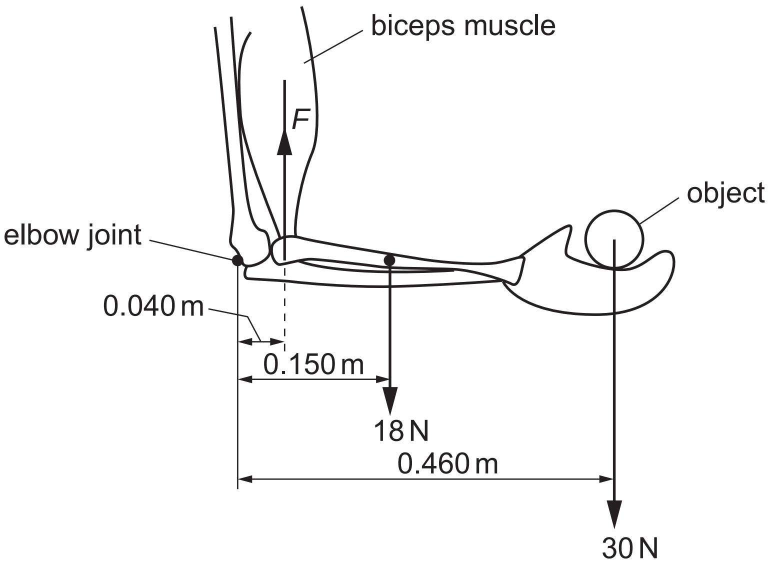

Fig. 4.1

The lower arm is horizontal and its centre of gravity is 0.150 m from the elbow joint. The weight of the lower arm is 18 N. The biceps muscle exerts a vertical force *F* on the arm. The horizontal distance between the elbow joint and the point of attachment of the muscle to the lower arm bone is 0.040 m. The weight of the object held in the hand is 30 N and its centre of gravity is 0.460 m from the elbow joint. The arm is in equilibrium.

(i) Define *centre of gravity.*

....

.... **[1]**

(ii) Calculate the total clockwise moment about the elbow joint.

total clockwise moment = ... N m **[2]**

(iii) As the lower arm is moved away from the body, the force *F* exerted by the biceps muscles acts at an angle θ to the vertical as shown in Fig. 4.2.

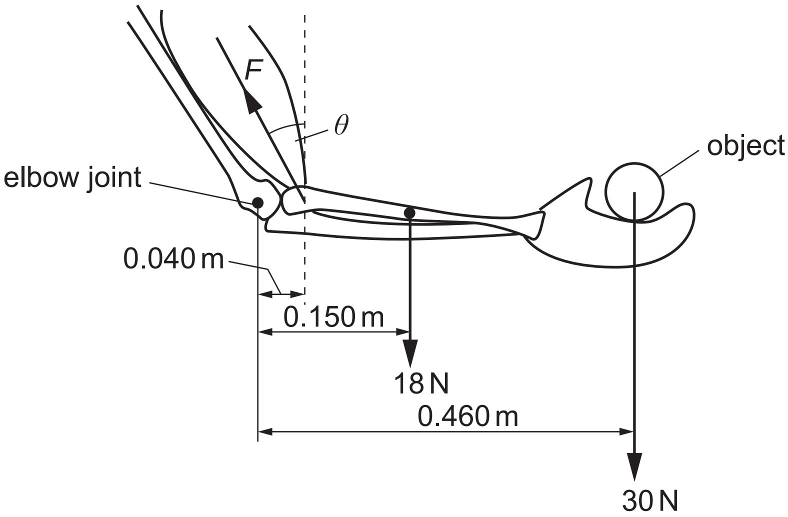

Fig. 4.2

The lower arm remains horizontal and in equilibrium. Describe and explain what happens to each of the following quantities as the angle θ is increased

1 the anticlockwise moment about the elbow joint

....

....

2 the magnitude of the force *F*.

....

....

....

.... **[3]**

[Total: 9]

5 Fig. 5.1 shows a person standing in a stationary lift.

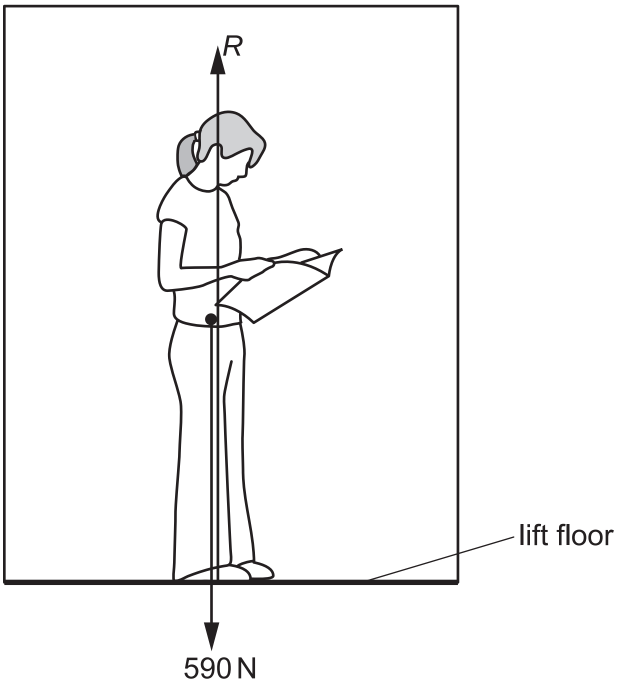

Fig. 5.1

There are only two forces acting on the person. The weight of the person is 590 N. The vertical contact force acting on the person from the floor of the lift is R.

(a) Show that the mass of the person is 60 kg.

[1]

(b) The lift starts from rest. It has a constant upward acceleration of 0.50 m s^{-2}. Calculate the magnitude of the contact force R.

R = ... N **[2]**

(c) After a short period of acceleration, the lift travels upwards at a constant velocity. Explain why the force *R* is equal to the weight of the person when the lift travels at a constant velocity.

....

....

.... **[1]**

(d) State and explain how the force *R* changes at the instant the lift starts to decelerate.

....

....

....

.... **[2]**

[Total: 6]

6 **(a)** State *Hooke's law*.

....

.... **[1]**

(b) Fig. 6.1 shows a force against extension graph for a spring.

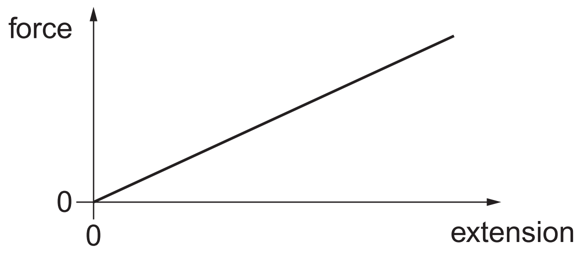

Fig. 6.1

Describe how such a force against extension graph can be used to determine

(i) the *force constant* of the spring

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(ii) the *work done* on the spring.

....

.... **[1]**

(c) Two identical springs are connected end-to-end (series). The force constant of each spring is *k*. The free ends of the springs are pulled apart as shown in Fig. 6.2.

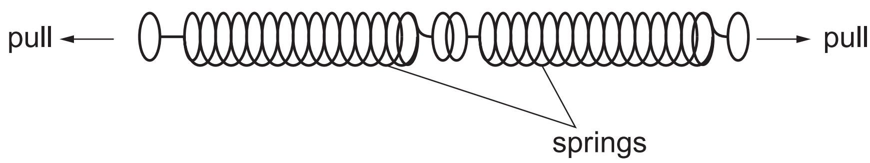

Fig. 6.2

Explain why the force constant of this combination of two springs in series is $\frac{k}{2}$.

....

....

.... **[2]**

(d) (i) Define the *Young modulus* of a material and state the condition when it applies.

....

....

.... **[2]**

(ii) A guitar string has length 0.70 m and cross-sectional area 0.20 mm^2. A constant tension of 4.2 N is applied to the string causing a strain of 0.015. Calculate

1 the stress in the string

stress = ... Pa **[2]**

2 the Young modulus of the material of the string

Young modulus = ... Pa **[2]**

3 the elastic potential energy (stored energy) in the string.

energy = ... J **[3]**

[Total: 14]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

Thursday 17 May 2012 – Morning

AS GCE PHYSICS A

G481 Mechanics

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator
- Ruler (cm/mm)
- Protractor

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
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-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 **(a)** State **one** difference between a scalar quantity and a vector quantity.

....

.... **[1]**

(b) Fig. 1.1 shows two sets of quantities listed as 'scalars' and 'vectors' by a student.

scalars	**vectors**
acceleration	displacement
pressure	energy
stress	power
time	velocity
volume	weight

Fig. 1.1

(i) State the one quantity that has been incorrectly listed as a scalar.

.... **[1]**

(ii) State two quantities that have been incorrectly listed as vectors.

1. ....

2. .... **[1]**

(iii) State two quantities listed as scalars that have the same unit. Name this unit.

1. ....

2. ....

unit: .... **[2]**

(c) Circle the correct value for the prefix tera (T) in the list below.

10^6 10^9 10^{12} 10^{15} **[1]**

(d) Rearrange the following prefixes in the order of smallest to largest.

μ c p k

.... **[1]**

[Total: 7]

2 Fig. 2.1 shows the path of a metal ball fired at a velocity of $24\,\mathrm{m\,s^{-1}}$ at an angle of 30° to the horizontal.

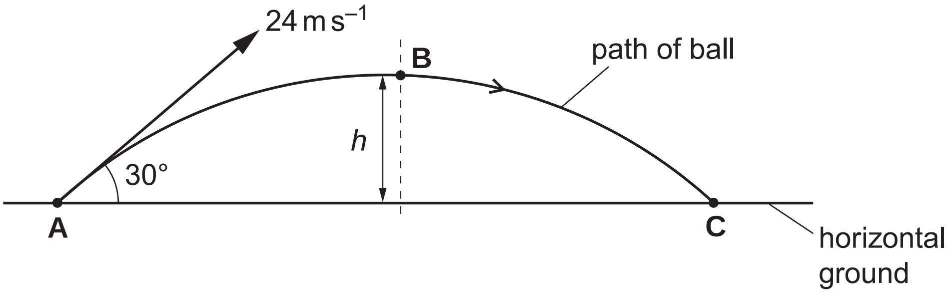


Fig. 2.1

Air resistance has negligible effect on the motion of the metal ball. The ball is fired from point **A** and it reaches its maximum height at point **B**. The mass of the ball is 450 g.

(a) State the direction of the acceleration of the ball during its flight.

.... **[1]**

(b) Calculate the horizontal and vertical components of the velocity of the ball at **A**.

horizontal velocity = ... $\mathrm{m\,s^{-1}}$

vertical velocity = ... $\mathrm{m\,s^{-1}}$ **[2]**

(c) Explain why the gravitational potential energy gained by the ball as it moves from **A** to **B** is not equal to its initial kinetic energy at **A**.

....

....

.... **[1]**

(d) Calculate the maximum vertical height *h* of the ball.

h = ... m **[3]**

[Total: 7]

3 (a) Define *velocity*.

....

.... **[1]**

(b) Define *work done* by a force.

....

.... **[2]**

(c) Fig. 3.1 shows a rider on a sledge sliding down an icy slope.

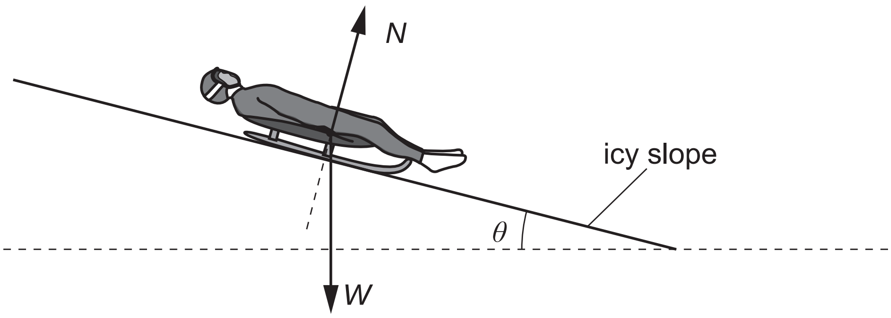


Fig. 3.1

The frictional forces acting on the sledge and the rider are negligible. The normal contact force N and the total weight W of the sledge and rider are shown.

(i) Explain why the force N does no work on the sledge as it slides down the slope.

....

.... **[1]**

(ii) State and explain the force that causes the sledge and rider to accelerate down the slope.

....

.... **[1]**

(d) Fig. 3.2 shows the velocity against time graph for the sledge and rider in **(c)** sliding down the icy slope.

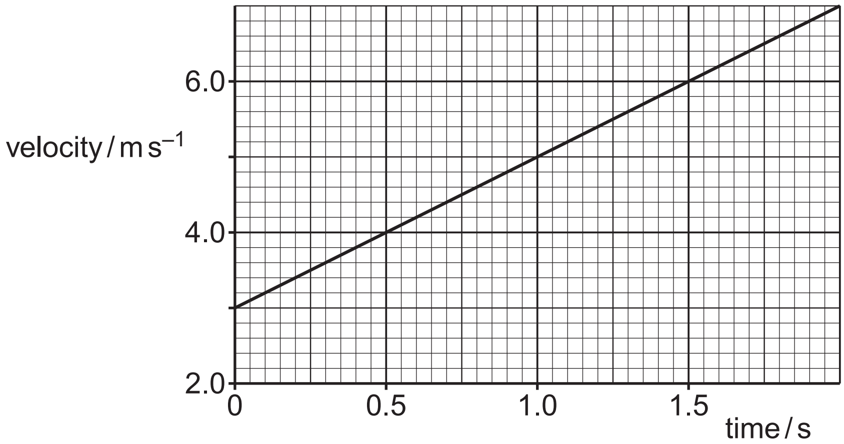


Fig. 3.2

(i) Use Fig. 3.2 to determine

1 the acceleration of the sledge and rider down the slope

acceleration = ... m s^{-2} **[2]**

2 the angle made by the slope to the horizontal.

angle = ...° **[2]**

(ii) The sledge crashes into a foam barrier at the bottom of the slope.

The velocity of the sledge just before the impact is $15\,\text{m}\,\text{s}^{-1}$. The sledge and rider take 3.5 s to stop. The average decelerating force on the sledge and rider is 510 N.

Calculate the total mass of the sledge and rider.

mass = ... kg **[3]**

[Total: 12]

4 **(a)** Define the following terms:

(i) *couple*

....

.... **[1]**

(ii) *torque of a couple*.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) Fig. 4.1 shows a satellite in space moving from left to right.

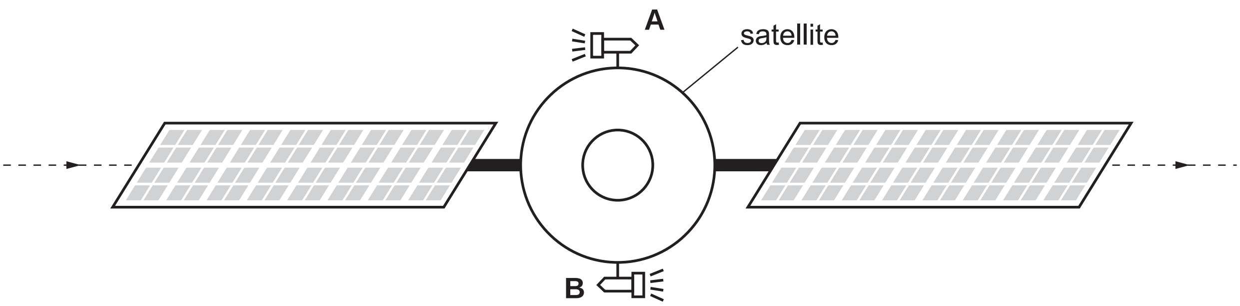


Fig. 4.1

The satellite has two small rockets **A** and **B** mounted at opposite ends of a diameter. When fired, each rocket motor provides the **same** constant force, but in **opposite** directions.

Describe the change in the motion of the satellite when

(i) both rocket motors are fired

....

....

.... **[2]**

(ii) only rocket motor **A** is fired.

....

....

.... **[2]**

[Total: 6]

5 Fig. 5.1 shows the vertical forces acting on a helium-filled weather balloon just before lift off.

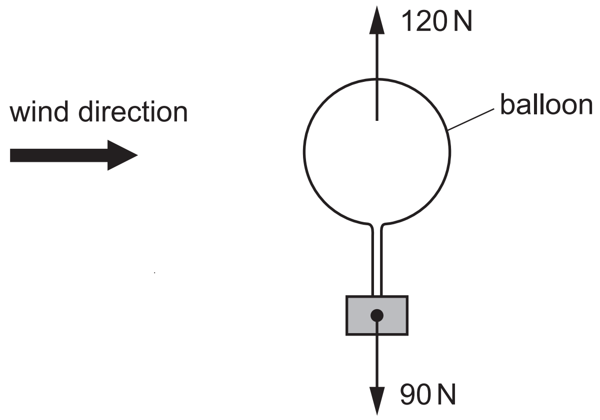


Fig. 5.1

The balloon experiences an upward vertical force (upthrust) equal to 120 N. The weight of the balloon and its contents is 90 N. The magnitude of the horizontal force provided by the wind is 18 N.

(a) Determine the magnitude of the resultant force acting on the balloon and the angle this resultant force makes with the horizontal.

net force = ... N

angle = ... °
[4]

(b) As the balloon rises through the air, it experiences a drag force. State two factors that affect the magnitude of the drag force on this balloon.

1. ....

2. .... **[2]**

[Total: 6]

6 **(a)** Fig. 6.1 shows the stress against strain graphs of two materials **X** and **Y**.

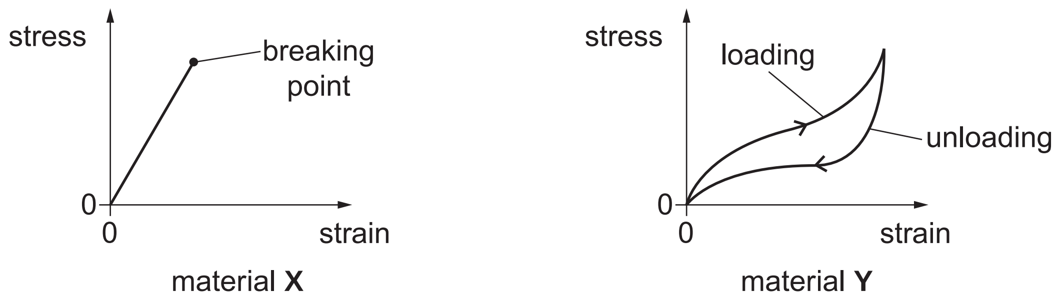


Fig. 6.1

Describe the properties of materials **X** and **Y**.

In your answer, you should use appropriate technical terms, spelled correctly.

material **X** ....

....

....

....

....

material **Y** ....

....

....

....

.... **[5]**

(b) You are given a spring, a metre rule and a 100 g mass. Describe how you would determine the force constant *k* of the spring.

....

....

....

....

.... **[3]**

(c) A glider of mass 0.180 kg is placed on a horizontal frictionless air track. One end of the glider is attached to a compressible spring of force constant $50\,N\,m^{-1}$. The glider is pushed against a fixed support so that the spring compresses by 0.070 m, see Fig. 6.2. The glider is then released.

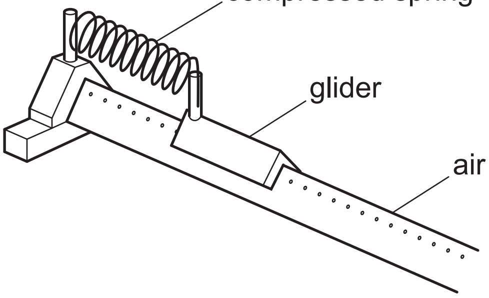


Fig. 6.2

(i) Calculate the horizontal acceleration of the glider **immediately** after release.

acceleration = ... $m\,s^{-2}$ **[3]**

(ii) After release, the spring exerts a force on the glider for a time of 0.094 s. Calculate the average rate of work done by the spring on the glider.

average rate of work done = ... $J\,s^{-1}$ **[2]**

[Total: 13]

7 Fossil fuels will eventually run out. This has led to scientists looking for alternative sources of energy. Tidal stream systems use the kinetic energy of seawater to generate electrical energy during the incoming and outgoing tides. Fig. 7.1 shows a twin-turbine system in which flowing seawater turns the turbine blades.

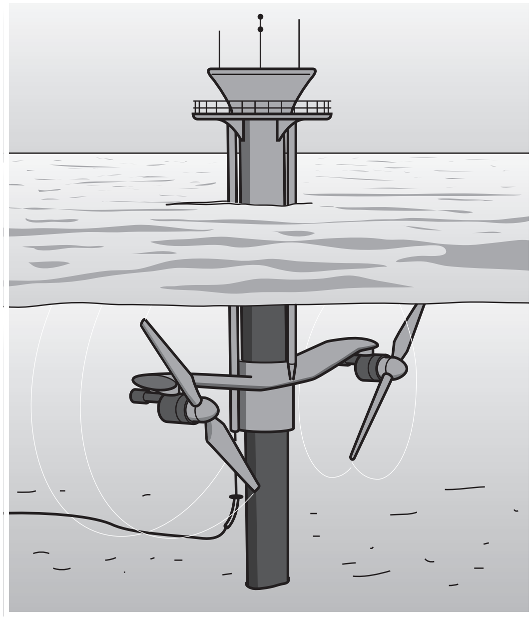


Fig. 7.1

When operating, 9.7×10^5 kg of seawater travelling at a speed of $3.0\,\mathrm{m\,s^{-1}}$ passes through each turbine every second. Each turbine generates 1.2×10^6 W of electrical power.

(a) Define *power*.

....

.... **[1]**

(b) The input power to each turbine is the kinetic energy of the seawater that flows through each turbine in one second.

Show that the input power to each turbine is 4.4×10^6 W.

[2]

(c) Calculate the percentage efficiency of each turbine.

efficiency = ... % **[1]**

(d) In one second, a cylinder of seawater of mass 9.7×10^5 kg passes through each turbine at a speed of $3.0\,m\,s^{-1}$. Calculate the radius of each turbine. The density of seawater is $1030\,kg\,m^{-3}$.

radius = ... m **[3]**

(e) Tidal stream systems require less space than conventional wind turbines that are found in windy regions of this country.

(i) Explain why a tidal stream turbine system of identical size to a wind turbine system will produce greater power for the same water or wind speed.

....

....

.... **[1]**

(ii) Suggest one further advantage of tidal stream systems over conventional wind farms.

....

.... **[1]**

[Total: 9]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

Friday 11 January 2013 – Afternoon

AS GCE PHYSICS A

G481/01 Mechanics

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator
- Protractor
- Ruler (cm/mm)

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

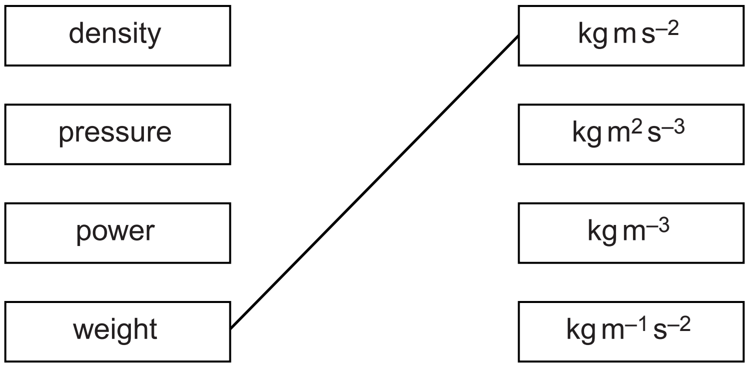
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Draw a line from each quantity on the left-hand side to the correct unit on the right-hand side. One quantity (weight) has already been matched to its unit.



[2]

[Total: 2]

2 **(a)** Speed is a scalar quantity and velocity is a vector quantity. State one difference and one similarity between speed and velocity.

difference: ....

....

similarity: ....

.... **[2]**

(b) Fig. 2.1 shows a toy locomotive on a circular track.

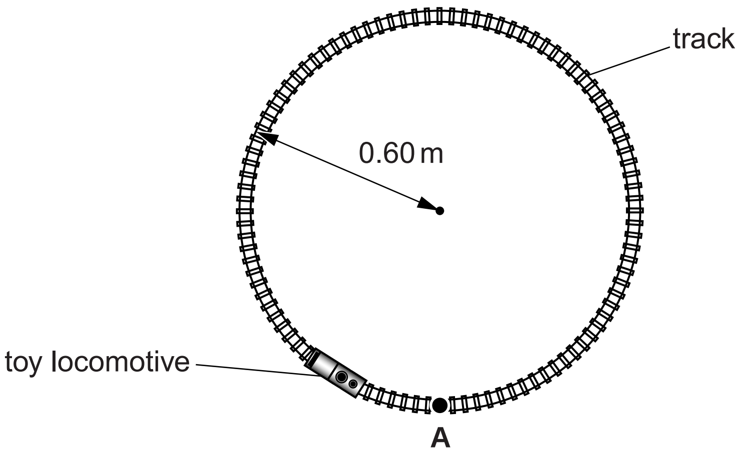


Fig. 2.1

The locomotive travels at constant speed round the track in a clockwise direction. It takes 12 s to travel completely round the track. At time t = 0, the locomotive is at point **A**.

(i) Calculate the speed of the locomotive.

speed = ... m s^{-1} **[2]**

(ii) Calculate the magnitude of the displacement s of the locomotive from point **A** after it has travelled one quarter of the way round the track.

s = ... m **[2]**

(iii) Explain why the average velocity of the locomotive is zero after a time of 12 s.

....

.... **[1]**

(iv) Explain why the velocity of the locomotive changes even though its speed is constant.

....

.... **[1]**

[Total: 8]

3 A car of mass 1200 kg is travelling at 18 m s^{-1} along a horizontal road. A constant braking force of 3600 N brings it to rest.

(a) Calculate the magnitude of the deceleration of the car.

deceleration = ... m s^{-2} **[1]**

(b) Calculate the distance travelled by the car during the deceleration.

distance = ... m **[3]**

(c) The same car travels **down** a slope at the same speed of 18 m s^{-1}, see Fig. 3.1.

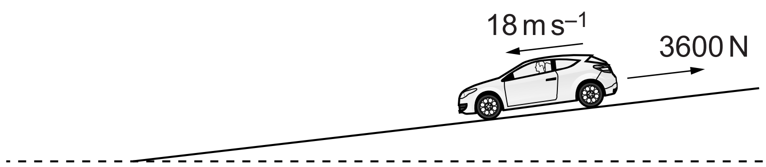


Fig. 3.1

The car is brought to rest by applying the brakes. The same resistive force of 3600 N acts on the car. Explain whether the distance travelled by the car before it stops is greater than, smaller than or the same as your answer to **(b)**.

....

....

....

....

....

....

.... **[3]**

(d) Many cars are fitted with Global Positioning System (GPS) devices.

Describe how geostationary satellites are used to track the location of cars on the Earth's surface.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

....

....

....

....

....

....

....

....

....

.... **[4]**

[Total: 11]

4 **(a)** Define *acceleration*.

....

.... **[1]**

(b) State the **two** factors that affect the acceleration of an object.

....

.... **[1]**

(c) Fig. 4.1 shows the variation of velocity v with time t for a small rocket.

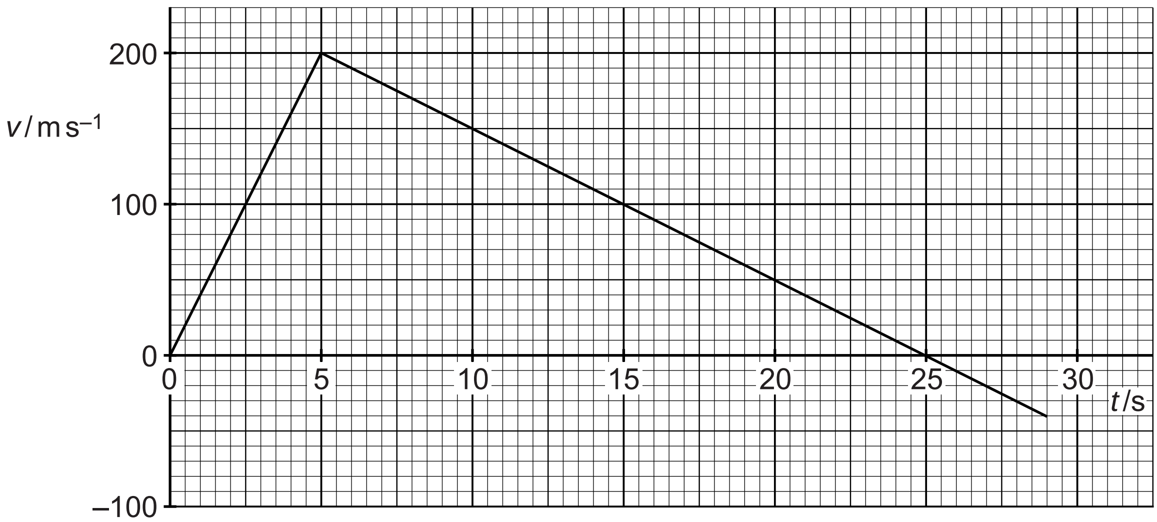


Fig. 4.1

The rocket is initially at rest and is fired vertically upwards from the ground. All the rocket fuel is burnt after a time of 5.0 s when the rocket has a vertical velocity of 200 m s^{-1}. Assume that air resistance has a negligible effect on the motion of the rocket.

(i) Without doing any calculations, describe the motion of the rocket

1 from $t = 0$ to $t = 5.0\,s$

....

....

2 from $t = 5.0\,s$ to $t = 25\,s$.

....

....

.... **[3]**

(ii) Calculate the maximum height reached by the rocket.

height = ... m **[3]**

(iii) Explain why the rocket has a speed greater than $200\,m\,s^{-1}$ as it hits the ground.

....

....

....

.... **[1]**

[Total: 9]

5 **(a)** State how the magnitude of the drag force on an object is affected by its speed.

....

.... **[1]**

(b) Describe the experiments Galileo carried out which overturned Aristotle's ideas of motion.

....

....

....

....

....

....

....

....

....

.... **[3]**

(c) A skydiver is falling towards the ground at a terminal velocity of $50\,m\,s^{-1}$.

(i) State the **two** main forces acting on the skydiver and how they are related at terminal velocity.

....

.... **[1]**

(ii) The skydiver opens her parachute. After some time, the skydiver reaches a lower terminal velocity of $4.0\,m\,s^{-1}$. Describe and explain how the magnitude of the deceleration of the skydiver changes as her velocity reduces from $50\,m\,s^{-1}$ to $4.0\,m\,s^{-1}$.

....

....

....

....

....

....

....

....

....

.... **[4]**

[Total: 9]

6 **(a)** Define *work done* by a force.

....

.... **[1]**

(b) Fig. 6.1 shows a water slide.

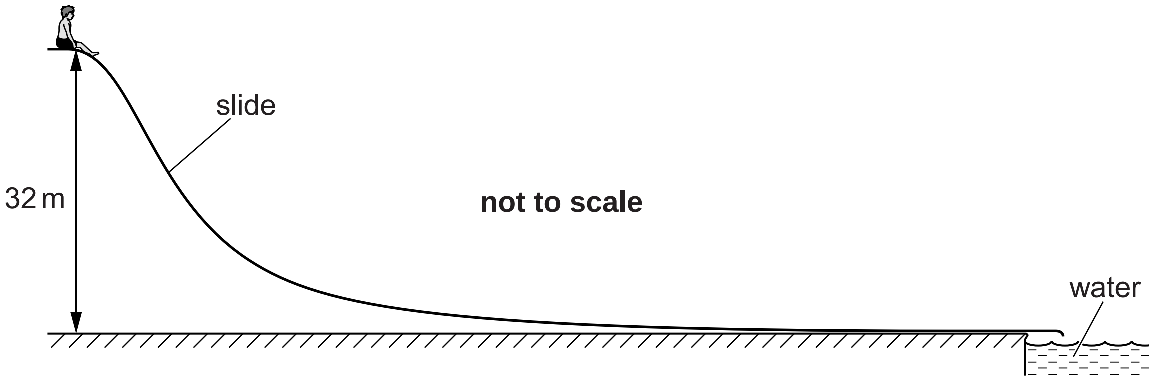


Fig. 6.1

The top of the slide is 32 m above the bottom of the slide. The total distance along the slide is 120 m. A person of weight 700 N, initially at rest at the top, slides down. His speed at the end of the slide is 15 m s^{-1}.

(i) Calculate his kinetic energy at the end of the slide.

kinetic energy = ... J **[2]**

(ii) Calculate the average resistive force acting on him as he travels down to the end of the slide.

average resistive force = ... N **[3]**

[Total: 6]

7 **(a)** Fig. 7.1 shows several forces acting on an object that is free to move.

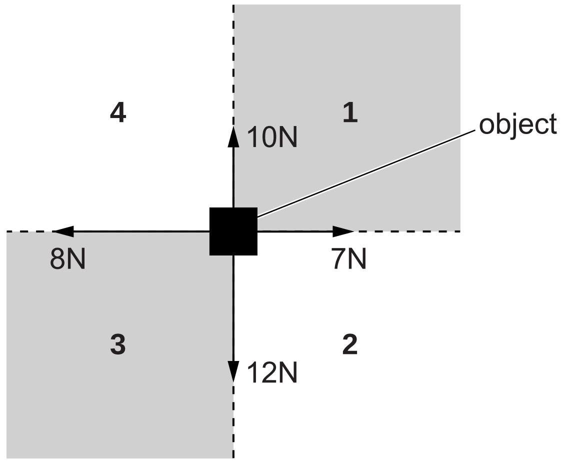


Fig. 7.1

Using simple calculations, deduce whether the object will move into region **1**, **2**, **3** or **4**. Briefly explain your reasoning.

....

....

.... **[2]**

(b) State the *principle of moments*.

....

....

.... **[1]**

(c) Fig. 7.2 shows the forces acting on a suitcase with wheels as it is held stationary.

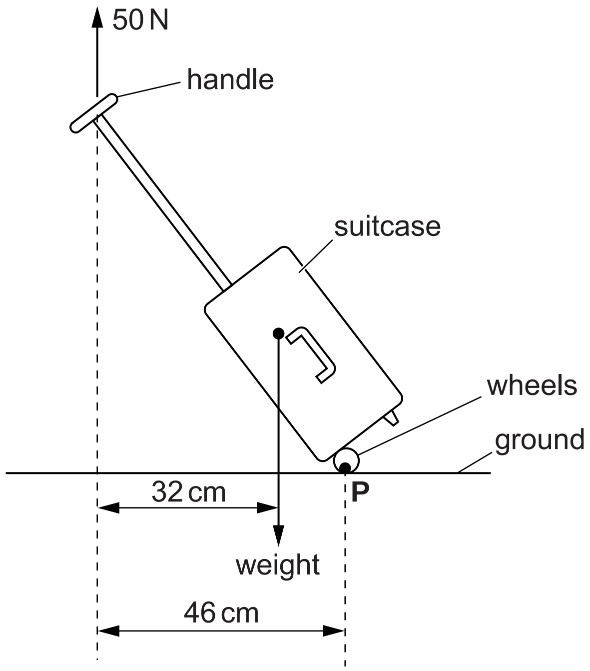


Fig. 7.2

A vertical force of 50 N is applied to the top of the handle in order to keep the suitcase stationary in the position shown in Fig. 7.2. The line of action of this force acts at a perpendicular distance of 46 cm from **P**, the point of contact with the ground. The line of action of the weight of the suitcase acts at a perpendicular distance of 32 cm from the top of the handle.

By taking moments about **P**, calculate the mass *m* of the suitcase.

m = ... kg **[3]**

[Total: 6]

8 A sample of wire is tested in the laboratory. Fig. 8.1 shows the force, F against extension, x graph for this wire.

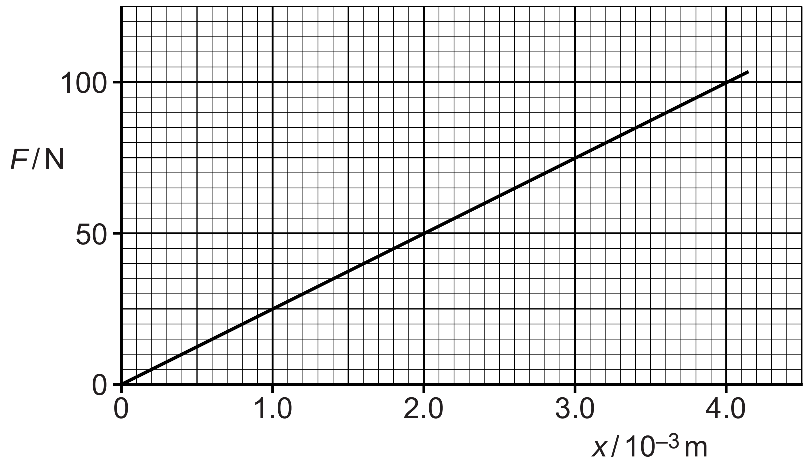


Fig. 8.1

(a) Explain how the graph shows that the wire obeys Hooke's law.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) State what the gradient of the graph represents.

.... **[1]**

(c) The initial length of the wire is 1.60 m. The radius of the wire is 2.8×10^{-4} m. Use the graph and this information to determine the Young modulus of the material of the wire.

Young modulus = ... Pa **[3]**

(d) The test is repeated for another wire made from the same material, having the same length but **half** the diameter. Explain how the force against extension graph for this wire will differ from the graph of Fig. 8.1.

....

....

....

....

.... **[2]**

(e) It is very dangerous if the wire under stress suddenly breaks. The elastic potential energy of the strained wire is converted into kinetic energy. Show that the 'whiplash' speed v of the wire is directly proportional to the extension x of the wire.

....

....

.... **[2]**

[Total: 9]

END OF QUESTION PAPER

Data

Values are given to three significant figures, except where more are useful.

speed of light in a vacuum	c	3.00×10^{8} m s^{-1}
permittivity of free space	ε_0	8.85×10^{-12} C^{2} N^{-1} m^{-2} (F m^{-1})
elementary charge	e	1.60×10^{-19} C
Planck constant	h	6.63×10^{-34} J s
gravitational constant	G	6.67×10^{-11} N m^{2} kg^{-2}
Avogadro constant	N_A	6.02×10^{23} mol^{-1}
molar gas constant	R	8.31 J mol^{-1} K^{-1}
Boltzmann constant	k	1.38×10^{-23} J K^{-1}
electron rest mass	m_e	9.11×10^{-31} kg
proton rest mass	m_p	1.673×10^{-27} kg
neutron rest mass	m_n	1.675×10^{-27} kg
alpha particle rest mass	m_α	6.646×10^{-27} kg
acceleration of free fall	g	9.81 m s^{-2}

Conversion factors

unified atomic mass unit	$1\ \text{u} = 1.661 \times 10^{-27}$ kg
electron-volt	$1\ \text{eV} = 1.60 \times 10^{-19}$ J
	$1\ \text{day} = 8.64 \times 10^{4}$ s
	$1\ \text{year} \approx 3.16 \times 10^{7}$ s
	$1\ \text{light year} \approx 9.5 \times 10^{15}$ m

Mathematical equations

arc length = $r\theta$

circumference of circle = $2\pi r$

area of circle = πr^2

curved surface area of cylinder = $2\pi rh$

volume of cylinder = $\pi r^2 h$

surface area of sphere = $4\pi r^2$

volume of sphere = $\frac{4}{3}\pi r^3$

Pythagoras' theorem: $a^2 = b^2 + c^2$

For small angle $\theta \Rightarrow \sin\theta \approx \tan\theta \approx \theta$ and $\cos\theta \approx 1$

$\lg(AB) = \lg(A) + \lg(B)$

$\lg(\frac{A}{B}) = \lg(A) - \lg(B)$

$\ln(x^n) = n\ln(x)$

$\ln(e^{kx}) = kx$

Formulae and relationships

Unit 1 – Mechanics

$F_x = F\cos\theta$
$F_y = F\sin\theta$

$a = \dfrac{\Delta v}{\Delta t}$

$v = u + at$

$s = \dfrac{1}{2}(u + v)t$

$s = ut + \dfrac{1}{2}at^2$

$v^2 = u^2 + 2as$

$F = ma$

$W = mg$

moment = Fx

torque = Fd

$\rho = \dfrac{m}{V}$

$p = \dfrac{F}{A}$

$W = Fx\cos\theta$

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

$E_p = mgh$

efficiency = $\dfrac{\text{useful energy output}}{\text{total energy input}} \times 100\%$

$F = kx$

$E = \dfrac{1}{2}Fx \qquad E = \dfrac{1}{2}kx^2$

stress = $\dfrac{F}{A}$

strain = $\dfrac{x}{L}$

Young modulus = $\dfrac{\text{stress}}{\text{strain}}$

Unit 2 – Electrons, Waves and Photons

$\Delta Q = I\Delta t$

$I = Anev$

$W = VQ$

$V = IR$

$R = \dfrac{\rho L}{A}$

$P = VI \qquad P = I^2R \qquad P = \dfrac{V^2}{R}$

$W = VIt$

e.m.f. = $V + Ir$

$V_{\text{out}} = \dfrac{R_2}{R_1 + R_2} \times V_{\text{in}}$

$v = f\lambda$

$\lambda = \dfrac{ax}{D}$

$d\sin\theta = n\lambda$

$E = hf \qquad E = \dfrac{hc}{\lambda}$

$hf = \phi + \text{KE}_{\text{max}}$

$\lambda = \dfrac{h}{mv}$

$R = R_1 + R_2 + \ldots$

$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$