Mr Cowen's answers

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

Wednesday 13 January 2010
Morning

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, however additional paper may be used if necessary.

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**.

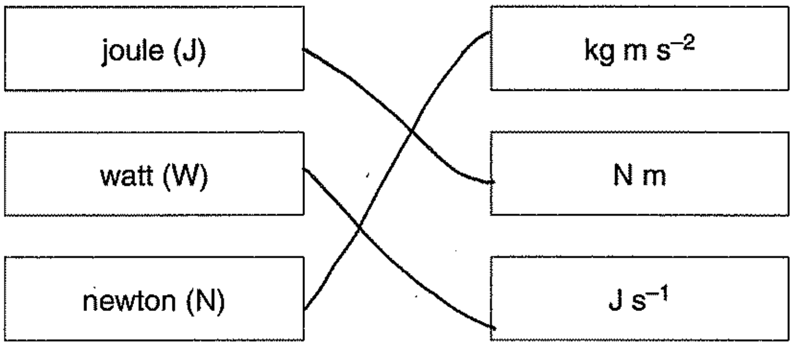
Where you see this icon you will be awarded marks for the quality of written communication in your answer.

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.

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.



[2]

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

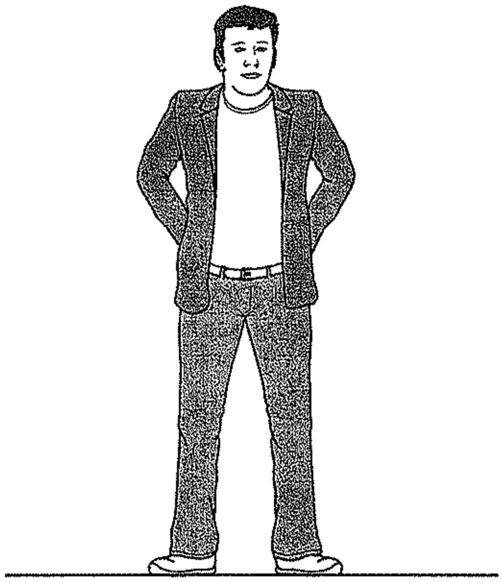


Fig. 1.1

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

weight = 750 N **[1]**

200 → 1200

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

Each foot: $30cm \times 10cm = 0.03 m^2$

$\times 2 = 0.06 m^2$

area = 0.06 m^2 **[1]**

0.01 → 0.08

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

~~F = P/A~~ $p = \frac{F}{A} = \frac{750}{0.06} = 12500$

pressure = 12500 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.

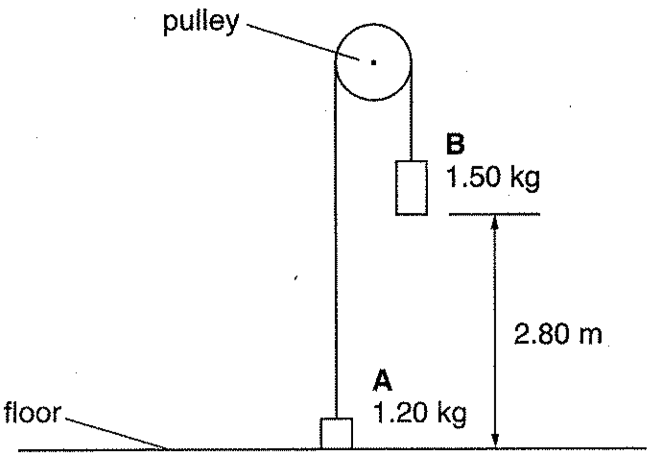


Fig. 2.1

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

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

$W = mg = 1.50 \times 9.81 = 14.7$

weight = 14.7 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*.

A ~~ret~~ vertical force is acting upwards on B (tension) due to the weight of A. **[1]**

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

$a = 1.09\,ms^{-2}, \; s = 1.40\,m, \; u = 0, \; t = ?$

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

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1.40}{1.09}} = 1.60\,s$

time = 1.60 s **[3]**

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

$V = ?$

$V^2 = \cancel{u^2} + 2as$

$V = \sqrt{2as} = \sqrt{2 \times 1.09 \times 1.40} = 1.75\ ms^{-1}$

velocity = 1.75 $m\,s^{-1}$ **[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.

$u = 2.47,\ v = -1.50,\ t = 3.0 \times 10^{-2},\ a = ?$

$v = u + at$

$a = \frac{v-u}{t} = \frac{-1.50 - 2.47}{3.0 \times 10^{-2}} = -132\ ms^{-2}$

acceleration = 132 $m\,s^{-2}$ **[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 $3.0\,kg\,m^{-1}$.

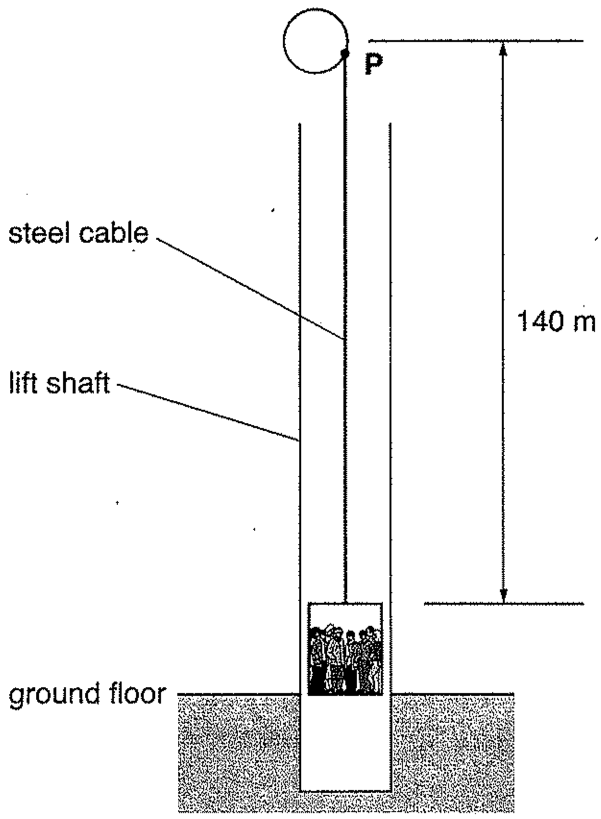


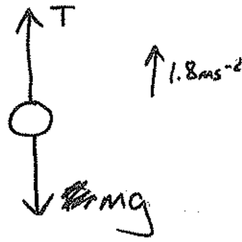
Fig. 3.1

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

$m = 3.0 \times 140 = 420kg$

[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 $1.7 \times 10^4\,\mathrm{N}$.



$\cancel{F = ma = (500 + 560 + 420) \times 1.8}$

$T - mg = ma$

$T = ma + mg = m(a + g) = (500 + 560 + 420)(1.8 + 9.81)$

$= \underline{1.7 \times 10^4\,\mathrm{N}}$

[4]

(ii) Calculate the maximum stress in the cable.

$\text{stress} = \dfrac{F}{A} = \dfrac{1.7 \times 10^4}{3.8 \times 10^{-4}} = 4.52 \times 10^7\ \mathrm{Pa}$

stress = 4.52×10^7 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.

As the velocity of the ~~acceleration~~ electron increases, the mass must be increasing. $F = ma$, so for constant force if the acceleration falls the mass must increase.

approaches $c = 3\times10^8\,ms^{-1}$

[2]

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

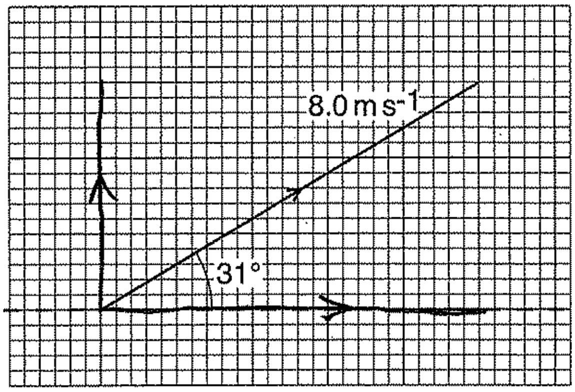


Fig. 4.1

(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.

$V_x = V\cos(31) = 8\cos 31 = 6.9\,ms^{-1}$

velocity = 6.9 m s^{-1} **[1]**

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

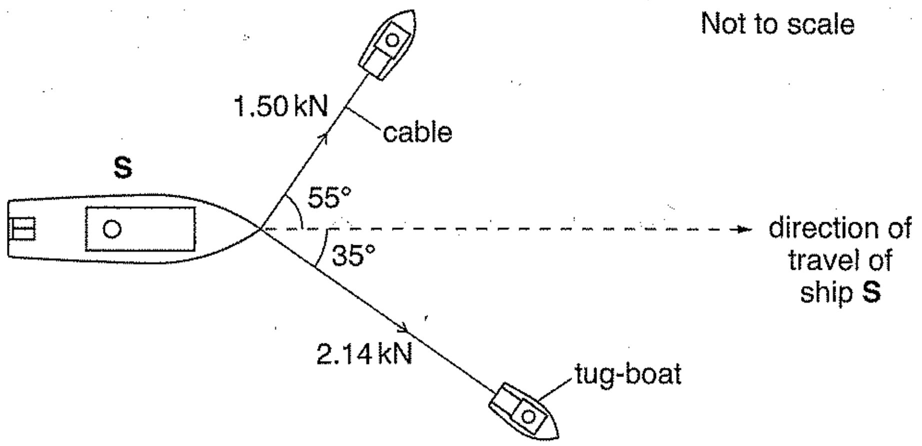


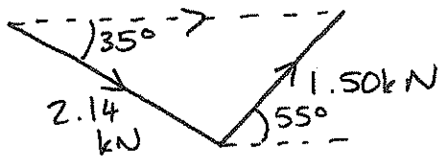
Fig. 4.2

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.

$F = 1.50\cos 55 + 2.14\cos 35$

$F = 2.61\ \text{kN}$



resultant force = 2.61 kN **[3]**

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

2.61kN. This is because the ship has a constant velocity, so the net force must be 0. **[2]**

[Total: 10]

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

Energy cannot be created or destroyed, only transferred from one form to another. [1]

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

In a stretched spring. [1]

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

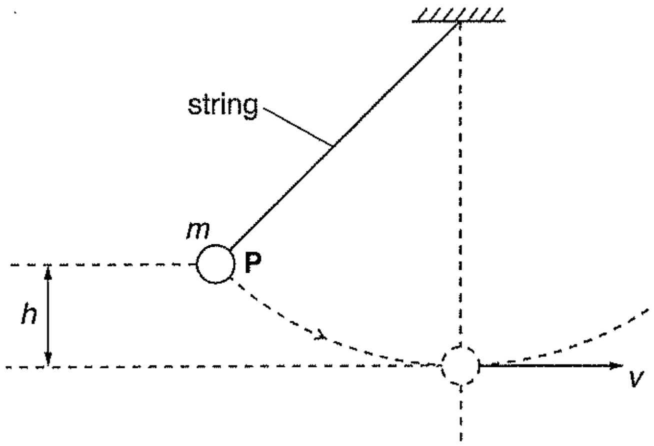


Fig. 5.1

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.

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$ [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.

$E_p = E_k$

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$gh = \frac{1}{2}v^2$

$v^2 = 2gh$ [2]

$v = \sqrt{2gh}$

(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.

volume $= 1.2\times10^{-2} \times 2.0\times10^{7} = 2.4\times10^{5}\ m^3$

mass $= 2.4\times10^{5} \times 1.0\times10^{3} = \underline{2.4\times10^{8}\ kg}$

[2]

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

$E_p = 0.3 \times mgh = 0.3 \times 2.4\times10^{8} \times 9.81 \times 2.5\times10^{3}$

$= 1.77\times10^{12}\ J$

$P = \frac{E_p}{t} = \frac{1.77\times10^{12}}{900} = \cancel{\$}2.00\times10^{9}\ W$

$= 2\ GW$

[3]

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

The power is not supplied constantly

[1]

[Total: 11]

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

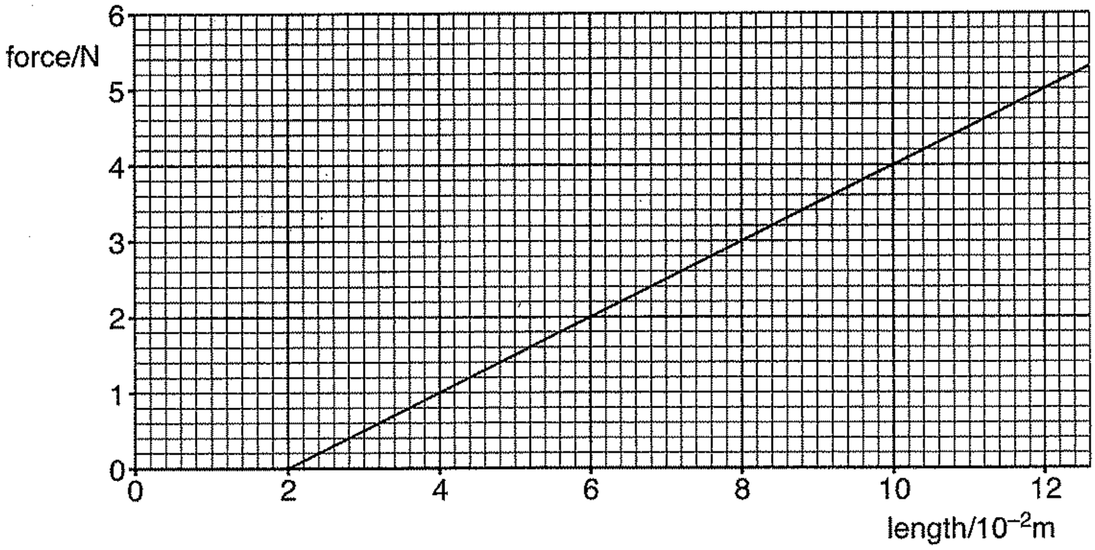


Fig. 6.1

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

The unstretched spring has a length of 2×10^{-2} m.
.... **[1]**

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

Straight line relationship between force and length.
.... **[1]**

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

$$\text{grad} = \frac{5-0}{(12-2)\times 10^{-2}} = \frac{5}{10\times 10^{-2}} = \cancel{0.8}\ 50$$

force constant = ~~0.8~~ 50 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.

$$E = \frac{1}{2}kx^2 = \frac{1}{2} \times 50 \times (6 \times 10^{-2})^2$$
$$= 9 \times 10^{-2}\ \text{J}$$

work done = ~~9×10^{-4}~~ 0.09 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.

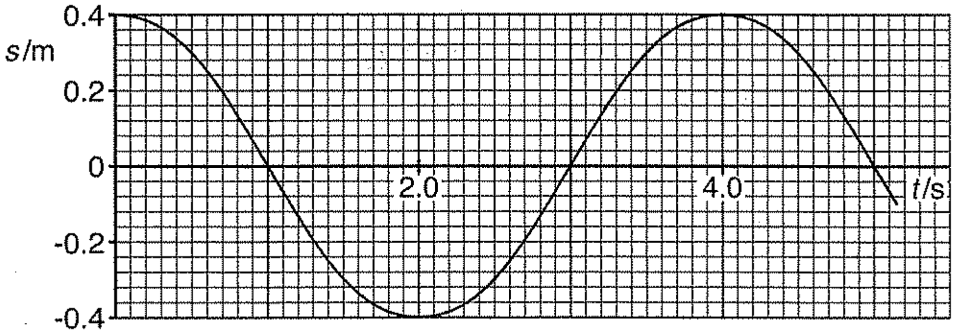


Fig. 6.2

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

Maximum speed is when the gradient is steepest - when s=0. (t=1.0, 3.0, 5.0)
Draw tangent at t=1.0 and calculate gradient. **[2]**

[Total: 8]

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

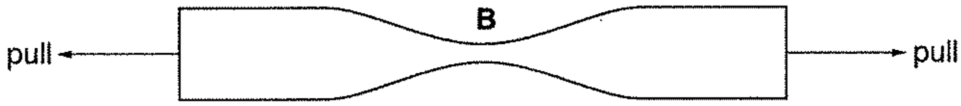


Fig. 7.1

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

Stress ∝ ~~cross-sectional~~ area. Stress is therefore greatest at point B. [1]

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

The tape will deform ~~elastically~~ plastically beyond the elastic limit. This means it will not return to its original size and shape when the force is removed. [1]

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

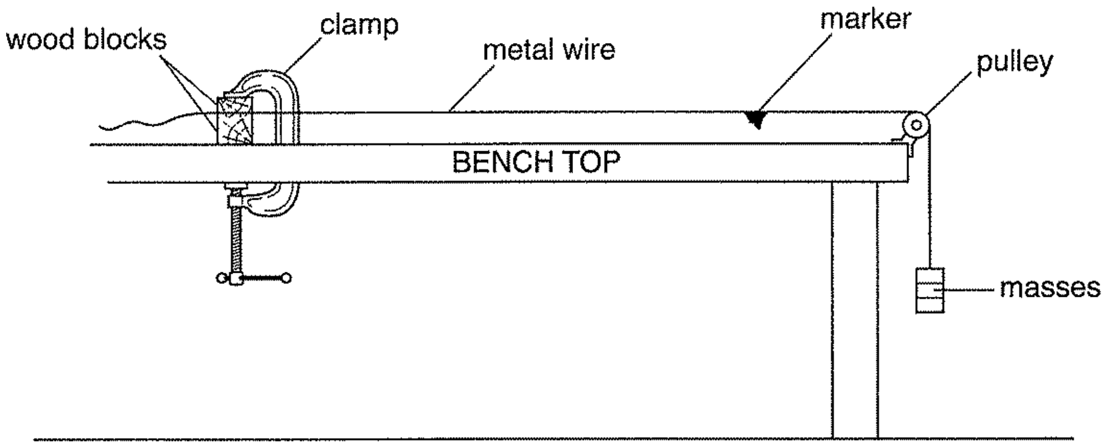


Fig. 7.2

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.

Cross-sectional area of the wire (diameter)
Original Length of the wire.
Extension of the wire.
Force applied (weight of masses)

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

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

Micrometer to measure ~~CSA~~ diameter.
Ruler to measure length + extension.
Electronic balance to measure mass
- to allow calculation of weight.

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

Calculate: $\text{stress} = \frac{\text{force}}{\text{CSA}} = \frac{\text{force}}{\left(\pi \frac{D^2}{4}\right)}$

$\text{strain} = \cancel{\text{original length}}\ \frac{\text{extension}}{\text{original length}}$

$\text{Young mod} = \frac{\text{stress}}{\text{strain}}$

[8]

[Total: 10]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE