TAYLOR'S UNIVERSITY COLLEGE
Wisdom · Integrity · Excellence

Mark Scheme

Class	Student Number	Name

CAMBRIDGE A LEVEL PROGRAMME
AS TRIAL EXAMINATION AUGUST/SEPTEMBER 2009
(January & March 2009 Intakes)

Wednesday **9 September 2009** **9.45 am – 10.45 am**

PHYSICS

9702/22

PAPER 22 AS Structured Questions

1 hour

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and student number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
Total	

This document consists of **12** printed pages.

1 (a) Define

(i) systematic errors

Errors in measurement that result in a constant overestimation or underestimation of the true value. [1] B1

(ii) random errors

Errors in measurement that result in a scatter of readings about the mean value. [1] B1

(b) A student set up the circuit shown in Fig. 1.1 in order to determine the resistance of a wire and hence the resistivity of the metal of the wire.

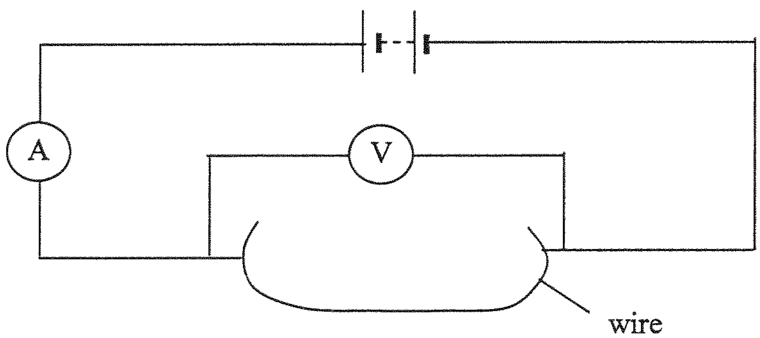


Fig. 1.1

The ammeter and voltmeter were both digital.

(i) State one possible random error which could occur in the use of the digital meters. How could this error be kept to a minimum value?

Reading on meter not constant B1
Take the average reading over a period of time. [2] B1

(ii) Explain why the voltmeter must have a resistance much greater than that of the wire in order to avoid a systematic error in the use of the ammeter.

Not all measured current would pass through the wire as some will pass through voltmeter. B1 If voltmeter resistance >> wire resistance, error would [3] be small B1 because there would be little current in the voltmeter. B1

(c) The following readings were obtained for the experiment in (b).

Reading of voltmeter	= (1.30 ± 0.01) V
Reading of ammeter	= (0.76 ± 0.01) A
Length of wire	= (75.4 ± 0.2) cm
Diameter of wire	= (0.54 ± 0.02) mm

Calculate, with its actual uncertainty, the value of

(i) the resistance of the wire,

$$R = \frac{V}{I} = \frac{1.3}{0.76} = 1.71\,\Omega.$$ C1

$$\Delta R = \left(\frac{\Delta V}{V} + \frac{\Delta I}{I}\right) R = \left(\frac{0.01}{1.30} + \frac{0.01}{0.76}\right) 1.71 = 0.036$$ C1

Resistance = 1.71 ± 0.04 A1 Ω [3]

(ii) the resistivity of the metal of the wire,

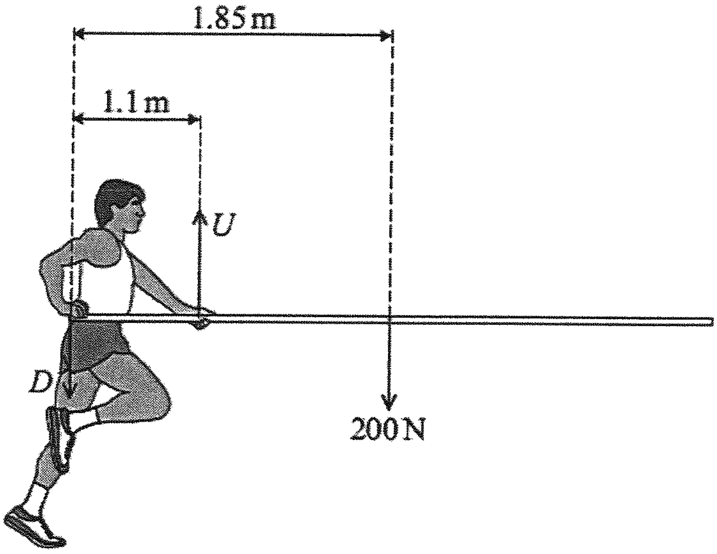
$$\rho = \frac{RA}{l} = \frac{1.71 \times \pi \times (0.27 \times 10^{-3})^2}{0.754} = 5.194 \times 10^{-7}\,\Omega m$$ C1

$$\frac{\Delta \rho}{\rho} = \left(\frac{\Delta R}{R} + \frac{\Delta A}{A} + \frac{\Delta l}{l}\right) = \frac{0.04}{1.71} + \frac{2(0.02)}{0.54} + \frac{0.2}{75.4}$$

$$\Delta \rho = 0.5 \times 10^{-7}$$ A1 C1

Resistivity = $(5.2 \pm 0.5) \times 10^{-7}$ Ωm [3]

2 Fig. 2.1 shows a pole vaulter holding a uniform pole horizontally. He keeps the pole in equilibrium by exerting an upward force, U, with his leading hand, and a downward force, D, with his trailing hand.



weight of pole = 200 N
length of pole = 3.7 m

Fig. 2.1

(a) Calculate for the situation shown in Fig. 2.1,

(i) the force, U,

Taking moments about D:
$U \times 1.1 = 200 \times 1.85$ C1
$U = 340$

$U =$ ....340.... N [2] A1

(ii) the force, D

$D = 340 - 200$ C1
$= 140$

$D =$ ....140.... N [2] A1

(b) State and explain the effect on the magnitudes of U and D if the vaulter moves his leading hand closer to the centre of gravity of the pole and the pole is still in equilibrium.

U must decrease B1

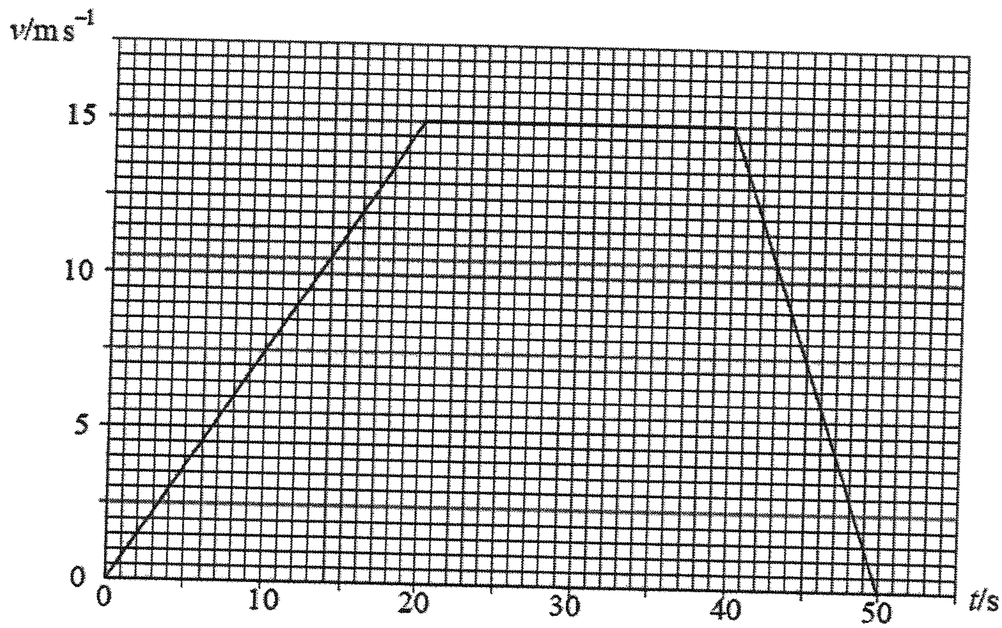
because greater distance B1

D must decrease B1

as U has decreased but weight of pole remains the same B1

[4]

3 The graph shows how the velocity, v, of a car varies with time, t.



(a) Describe the motion of the car for the 50 s period.

The car accelerates uniformly for first 20 s (B1)
then travels at constant speed of 15 m s^{-1}
for 20 s (B1)
then decelerates uniformly to rest in 10 s. (B1)

[3]

(b) The mass of the car is 1200 kg. Calculate for the first 20 s of motion,

(i) the change in momentum of the car,

$$\Delta p = 1200 \times 15 \quad \text{(C1)}$$
$$= 18000$$

(A1)

change in momentum = 18000 kg m s^{-1} [2]

(ii) the rate of change of momentum,

$$F = \frac{18000}{20} \quad \text{(C1)}$$
$$= 900$$

(A1)

rate of change of momentum = 900 N [2]

(iii) the distance travelled.

$$\text{distance} = \frac{1}{2} \times 20 \times 15 \quad \text{(C1)}$$
$$= 150$$

(A1)

distance = 150 m [2]

4 Fig. 4.1 shows the experimental set up to determine the Young modulus of steel.
Two long and thin steel wires are hung from the ceiling. One wire carries a main scale and the other carries a vernier scale and a load.

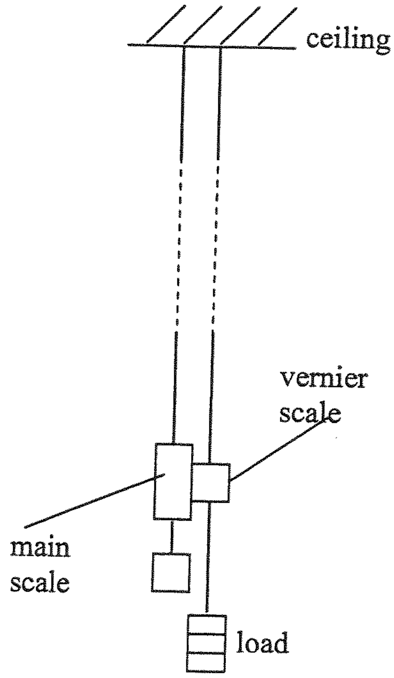


Fig. 4.1

(a) What is meant by *Young modulus*?

ratio of stress to strain [1] (B1)

(b) Explain why, in the experimental set-up above

(i) two identical wires are used,

Compensation for (i) yielding of support for load increases
(ii) change in length for temp. changes } Any one (B1) [1]

(ii) the wires are long and thin.

large extension
or large strain [1] (B1)

(c) Describe briefly how the Young modulus of steel is determined from this experiment.

Measure L } B1
Measure r & determine A }

Vary load and measure extension B1

stress = $\frac{F}{A}$, strain = $\frac{x}{l}$

Plot graph of stress - strain (or diagram) B1

Young modulus = gradient B1

OR Plot graph of load - extension

Young modulus = gradient $\times \frac{L}{A}$ [4]

(If no graphical method, max 2/4)

5 A beam of light containing violet light and red light is directed perpendicularly at a diffraction grating having 455 lines per mm. The first order violet light emerges at an angle of 11.8° and the first order red light at an angle of 15.8°.

(a) Calculate

(i) the grating spacing

$$d = \frac{1\times 10^{-3}}{455}$$

$$= 2.20\times 10^{-6}\ m$$ A1

grating spacing = ... m [1]

(ii) the wavelengths of these two colours.

violet: $2.20\times 10^{-6} \sin 11.8 = 1\times\lambda$ C1

$\lambda = 4.50\times 10^{-7}\ m$ A1

Red: $2.20\times 10^{-6} \sin 15.8 = 1\times\lambda$

$\lambda = 5.99\times 10^{-7}\ m$ A1

wavelength of red light = ... m

wavelength of violet light = ... m [3]

(b) At a certain angle, the red and the violet light overlap for the first time. At this angle, the nth order of the red light coincides with the adjacent order of the violet light.

(i) Calculate the ratio of the nth order of red light to that of the violet light. Express your answer in the ratio of 2 integers.

$d \sin\theta = n_v \times 4.50 \times 10^{-7}$

$d \sin\theta = n_R \times 5.99 \times 10^{-7}$ C1

$\frac{n_R}{n_v} = \frac{3}{4}$ A1

ratio = ... [2]

(ii) Hence find the angle at which the red light and the violet light overlap.

$2.20 \times 10^{-6} \sin\theta = 3 \times 5.99 \times 10^{-7}$

OR $2.20 \times 10^{-6} \sin\theta = 4 \times 4.50 \times 10^{-7}$ C1

$\theta = 54.8°$ A1

angle = ...° [2]

6 Fig. 6.1 shows two large vertical parallel plates separated by a distance of 3.0 cm. Plate **X** is connected to a potential of +50 V and plate **Y** is connected to a potential of -50 V.

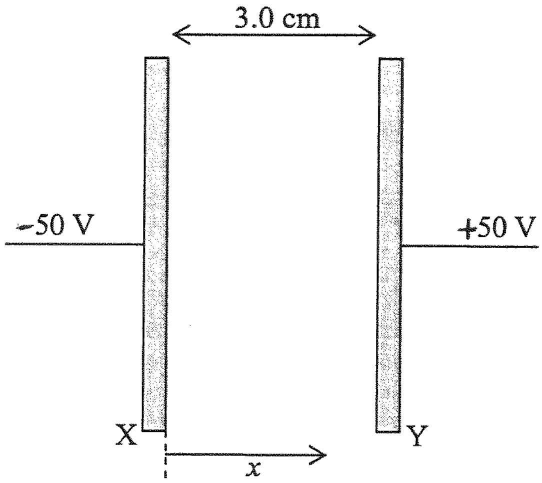


Fig. 6.1

(a) Calculate the electric field E in the region between the plates.

$$E = \frac{100}{3\times10^{-2}}$$
$$= 3.33\times10^{3}\ \mathrm{Vm^{-1}}$$

A1

$E =$ .... V m^{-1} [1]

(b) An electron is released from rest at plate **X**. Just before the electron strikes the plate **Y**, what is its

(i) kinetic energy?

$$\text{k.e.} = qV$$
$$= e\times100$$
$$= 1.60\times10^{-17}\ \mathrm{J}$$

A1

kinetic energy = ... J [1]

(ii) its velocity?

$\frac{1}{2}mv^2 = 1.60\times10^{-17}$

$v = 5.93\times10^{6}\ ms^{-1}$ A1

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

(c) Deduce, for the electron, the relationship between
(i) its kinetic energy E_k and the distance x from plate X, [2]

$eV = E_k$

$E_k = e(Ex)$ ← for $V=Ex$ or implied B1

$= e\times3.33\times10^{3}x$

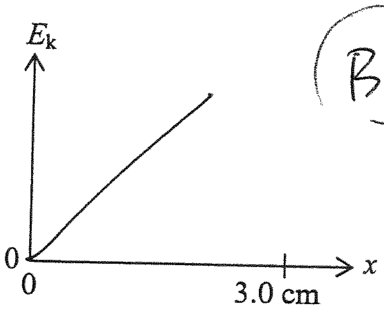
$E_k = 5.3\cancel{4}\times10^{-16}x$ B1

(ii) its velocity v and the distance x from plate X. [1]

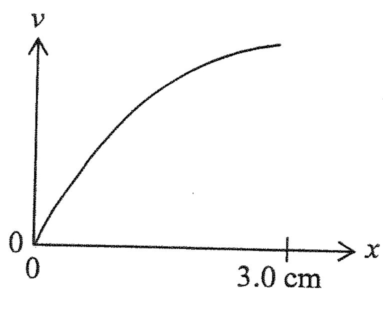
$\frac{1}{2}mv^2 = 5.34\times10^{-16}x$

$v^2 = 1.17\times10^{15}x$ B1

(d) Hence, sketch in the space given below, a graph each, showing the variation of
(i) kinetic energy E_k
(ii) velocity v,
against distance x from plate X. [2]



B1



B1

7 **(a)** State Kirchhoff's laws and its related conservation principles: name

(i) first law:

Algebraic sum of current at a junction = 0 B1

(conservation of charge) B1

.... [2]

(ii) second law:

For a close loop, algebraic sum of e.m.f. B1

= sum of p.d.

(conservation of energy) [2] B1

(b) Fig. 7.1 shows two cells of e.m.f. 4 V and 2 V and internal resistance 2 Ω and 1 Ω respectively connected to a 4 Ω resistor.

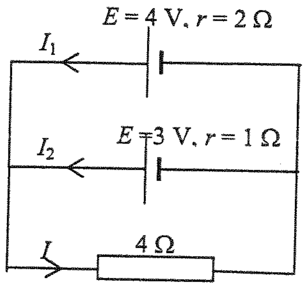


Fig. 7.1

Write down 3 equations relating I_1, I_2 and I. You need **not** solve the equations. [3]

$$I = I_1 + I_2$$
$$4 = 4I + 2I_1$$
$$3 = 4I + I_2$$
$$1 = 2I_1 - I_2$$

any 3. B3