Name: ....   Set Don(circle): WEB MJR

WINCHESTER

COLLEGE

Physics Mock Paper 2

Block C WEB/MJR
Thursday 7th January 2016

Time allowed: 1 hour 30 minutes

DO NOT turn over until told that you may do so. Write your name and circle your set don 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.

You may use a calculator.

There is a list of physical constants on the inside cover, followed by a list of formulae.

This paper consists of **9 questions. All questions should be attempted.**
90 marks are available.

For Examiner's Use

1 (a) State and explain the difference between the activity of a radioactive source and the count rate from a counter placed near to that source.

....

....

.... [1]

(b) A count rate from a counter near a radioactive source is $7.6 \times 10^{8}\,s^{-1}$. The decay constant of the source is $4.6 \times 10^{-3}\,s^{-1}$.

Calculate

(i) the half-life of the source,

half-life = ... s [1]

(ii) the time taken for the count rate to fall to $8.3 \times 10^{3}\,s^{-1}$.

time = ... s [3]

(c) At a distance x from a radioactive source, a counter records an average rate of 234 counts per minute.

Assuming that the source is radiating uniformly in all directions, deduce the average count rate when the counter is at a distance $3x$ from the source.

average count rate = ... counts per minute [2]

[Total: 7]

(iii) **1.** Show that the kinetic energy E_K of an object of mass m is related to its momentum p by the expression

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$$E_K = \frac{p^2}{2m}.$$

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in **(ii) part 1** to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

....

....[1]

[Total: 6]

2 A spring is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

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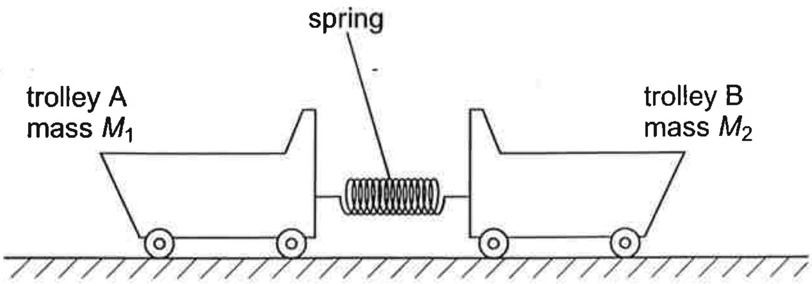


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

(i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

....

....

....

.... [2]

(ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2.
Write down

1. an equation, based on momentum, to relate V_1 and V_2,

....

.... [1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

....

.... [1]

3 An electric heater is to be made from nichrome wire. Nichrome has a resistivity of $1.0 \times 10^{-6}\,\Omega\,m$ at the operating temperature of the heater.
The heater is to have a power dissipation of 60W when the potential difference across its terminals is 12V.

For Examiner's Use

(a) For the heater operating at its designed power,

(i) calculate the current,

current = ... A [2]

(ii) show that the resistance of the nichrome wire is 2.4 Ω.

[2]

(b) Calculate the length of nichrome wire of diameter 0.80 mm required for the heater.

length = ... m [3]

[Total: 7]

For Examiner's Use

4 **(a)** Define, for a wire,

(i) *stress*,

....

.... [1]

(ii) *strain*.

....

.... [1]

(b) A wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

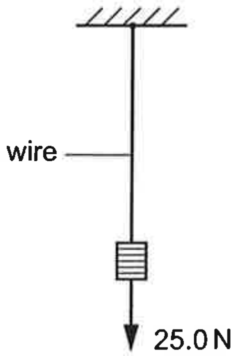


Fig. 4.1

The wire has cross-sectional area $5.74 \times 10^{-8}\,m^2$ and is made of a material that has a Young modulus of 1.60×10^{11} Pa. A load of 25.0 N is hung from the wire.

(i) Calculate the extension of the wire.

extension = ... m [3]

(ii) The same load is hung from a second wire of the same material. This wire is twice the length but the **same volume** as the first wire. State and explain how the extension of the second wire compares with that of the first wire.

....

....

.... [3]

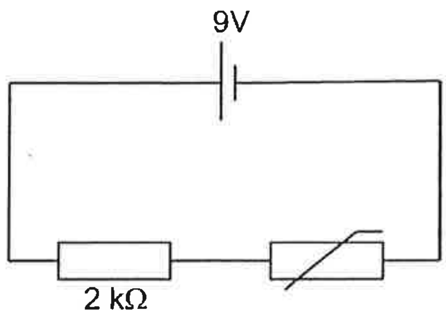
5 (a) The resistance of a thermistor at 0 °C is 3840 Ω. At 100 °C the resistance is 190 Ω. When the thermistor is placed in water at a particular constant temperature, its resistance is 2300 Ω.

For Examiner's Use

(i) Assuming that the resistance of the thermistor varies linearly with temperature, calculate the temperature of the water.

temperature = ... °C [1]

(ii) The thermistor is placed in the circuit shown below. Calculate the potential difference across the thermistor at 0 °C.



p.d. = ... [2]

(b) A polystyrene cup contains a mass of 95 g of water at 28 °C.

A cube of ice of mass 12 g is put into the water. Initially, the ice is at 0 °C. The water, of specific heat capacity 4.2×10^3 J kg^{-1} K^{-1}, is stirred until all the ice melts.

Assuming that the cup has negligible mass and that there is no heat exchange with the atmosphere, calculate the final temperature of the water.

The specific latent heat of fusion of ice is 3.3×10^5 J kg^{-1}.

temperature = ... °C [4]

[Total: 7]

6 A clean magnesium plate is placed in an evacuated glass container and illuminated with ultra-violet radiation of wavelength 250 nm, as shown in Fig. 7.1. Another metal plate is at the opposite end of the container and the two plates are connected through a microammeter to a variable d.c. supply. The polarity of the variable d.c. supply can be reversed.

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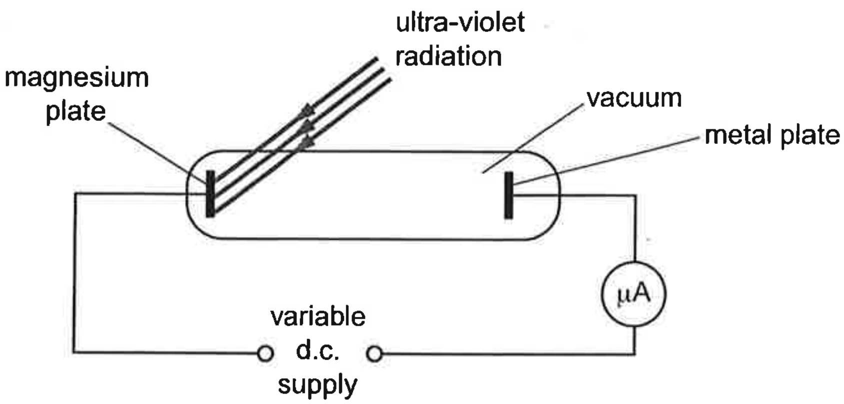

Fig. 7.1

(a) State the name of the effect that causes electrons to be emitted from the magnesium plate.

.... [1]

(b) Calculate the photon energy of the ultra-violet radiation

(i) in joules,

energy = ... J [2]

(ii) in electron-volts.

energy = ... eV [1]

(c) The work function of magnesium is 3.69 eV. Calculate the maximum energy, in eV, of electrons emitted from the magnesium plate.

energy = ... eV [1]

(d) Sketch a graph on the axes of Fig 7.2 to show how the current I in the microammeter will vary with the potential difference V between the two metal plates.

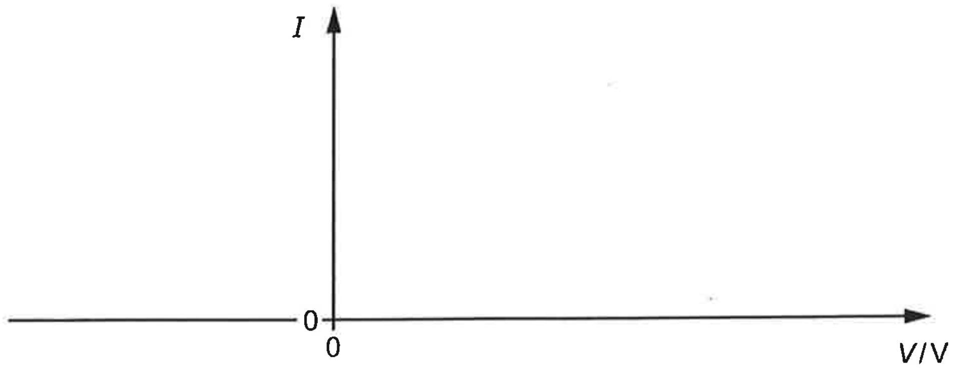

Fig. 7.2

[3]

(e) Add another line on your sketch graph to show the effect of reducing the intensity of the ultra-violet radiation. Label this line 'lower intensity'. [2]

(f) Explain why the answer to **(e)** was so unexpected when the experiment was first performed.

....

....

....

....

....

....

.... [3]

For Examiner's Use

7 **(a)** Describe the basic difference between the following terms. You may use diagrams to illustrate your answers.

(i) a *transverse* wave and a *longitudinal* wave

....

....[2]

(ii) a *polarised* and a *non-polarised* wave

....

....[2]

(iii) a *standing* wave and a *progressive* wave

....

....[3]

For Examiner's Use

(b) (i) The light from a sodium lamp is analysed using an instrument containing a diffraction grating. The diffraction grating has 500 lines per millimetre. A spectral line in the second order spectrum is at an angle of 36.09°.

Use the equation $n\lambda = d\sin\theta$ to calculate the wavelength of the light causing this spectral line.

wavelength = ... m [3]

(ii) There is another second order spectral line at 36.13°.

Calculate the wavelength of the light causing this line.

wavelength = ... m [1]

(iii) The spectral lines are viewed using a lens of aperture *b*.

Use the Rayleigh criterion, $\theta \approx \lambda/b$, to find the approximate minimum size of the aperture that is able to resolve the two spectral lines.

minimum size = ... m [3]

[Total: 14]

8 Galileo used a simple pendulum to time the motion of objects rolling down an inclined plane. Fig. 9.1 shows a simple pendulum.

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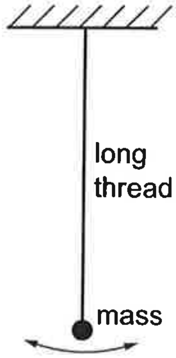

Fig. 9.1 (not to scale)

(a) A simple pendulum mass oscillates with simple harmonic motion.

State the general conditions necessary for simple harmonic motion.

....

....

....

.... [2]

(b) The displacement *x* of the mass at time *t* is given by the relationship

$$x = A \cos \omega t$$

where *A* is the amplitude of the oscillation and ω is the angular velocity.

This relationship is a solution to the differential equation that describes the condition for simple harmonic motion. State that equation.

.... [1]

(c) The pendulum is displaced to one side and then released at time $t = 0$. Fig. 9.2 shows the positions of the mass at various times during a single oscillation.

For Examiner's Use

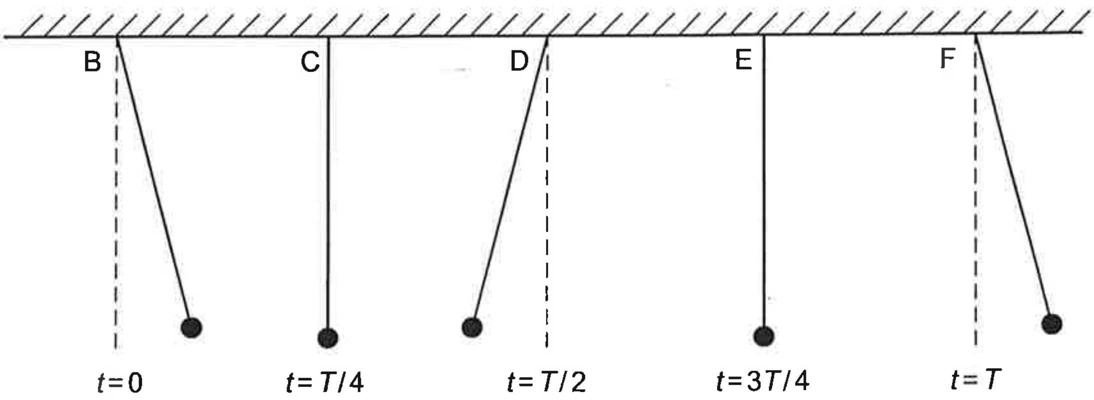

Fig. 9.2 (not to scale)

Complete the table below to describe the directions of the displacement, velocity and acceleration of the mass at times B to F using the symbols +, 0 and –.

Apply the convention that displacements, velocities and accelerations to the right are positive.

	B	C	D	E	F
displacement					
velocity					
acceleration					

[4]

(d) Fig. 9.3 shows the variation of displacement x with time t for a particular pendulum.

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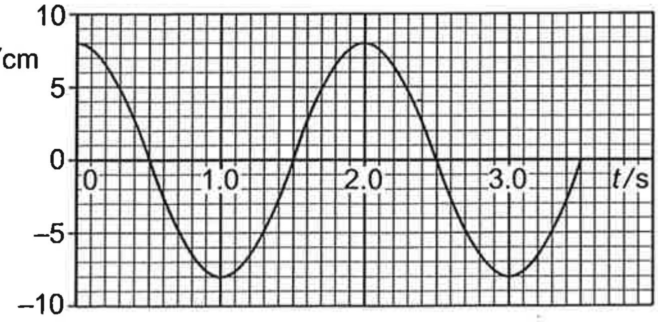


Fig. 9.3

(i) Use information from the graph to determine

1. the amplitude,

amplitude = ... cm

2. the frequency of oscillation.

frequency = ... Hz [1]

(ii) The mass m of the pendulum is 20 g.

1. Calculate the maximum force exerted on the mass.

maximum force = ... N [2]

2. On Fig. 9.4, sketch a graph to show how, for the time period given in Fig. 9.3, the force F varies with time t.

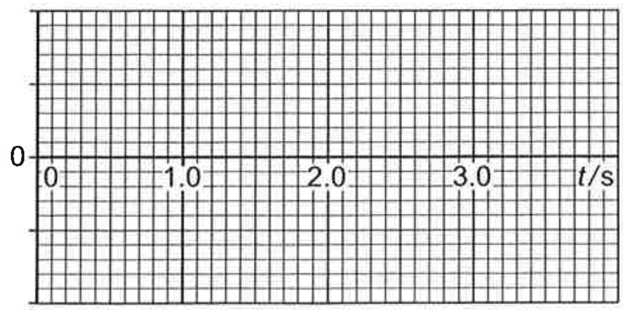


Fig. 9.4

[2]

(e) A rod is rolled down an inclined plane as shown in Fig. 9.5.

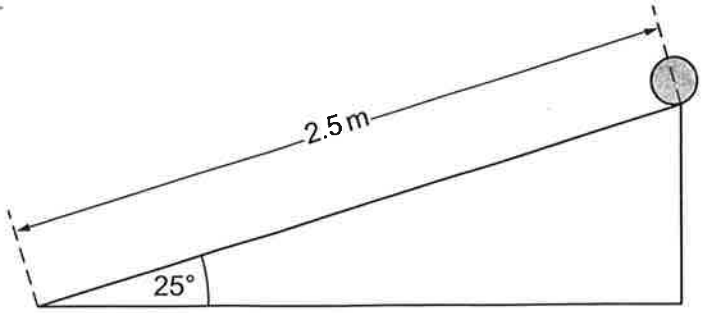
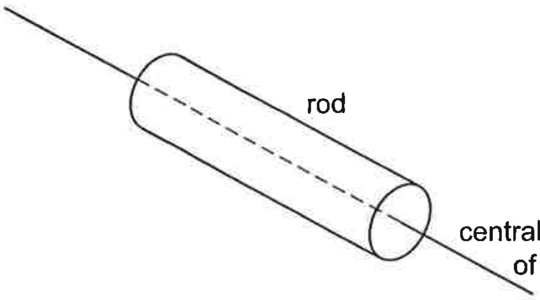


Fig. 9.5 (not to scale)

The plane of length 2.5 m is inclined at an angle of 25° to the horizontal.

(i) The rod has a radius R and a moment of inertia I about its central axis.

Briefly explain what is meant by the phrase *moment of inertia about its central axis*. You may add to the diagram below to help illustrate your answer.



....

....

....

.... [2]

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(ii) The rod has a mass M of 0.20 kg and its moment of inertia I is $0.10 \times 10^{-4}\,\text{kg}\,\text{m}^2$. It starts from rest and rolls down the inclined plane without slipping.

Determine the angular speed ω of the rod at the bottom of the inclined plane where its linear speed v is $3.72\,\text{m}\,\text{s}^{-1}$.

angular speed = ... $\text{rad}\,\text{s}^{-1}$ [4]

[Total: 18]

For Examiner's Use

9 (a) State what is meant by

(i) a *free* oscillation,

....

....

.... [1]

(ii) a *damped* oscillation,

....

....

.... [1]

(iii) a *forced* oscillation.

....

....

.... [1]

(b) A car component of mass 0.0460 kg rattles at a resonant frequency of 35.5 Hz.

Fig. 2.1 shows how the amplitude of the oscillation varies with frequency.

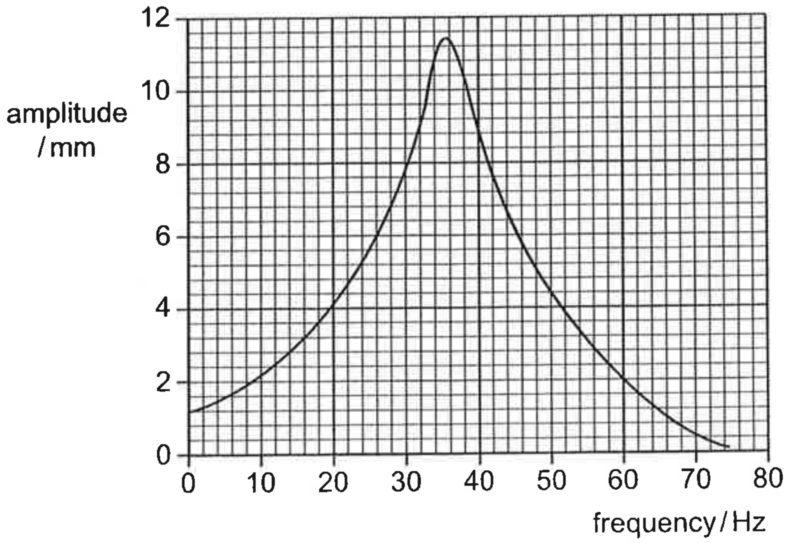

Fig. 2.1

(i) Calculate the energy stored in the oscillation of the component when oscillating

1. at the resonant frequency,

energy = ... J [3]

2. at a frequency of 20.0 Hz.

energy = ... J [2]

(ii) On Fig. 2.1, draw a line to show the effect of supporting the component on a rubber mounting. [2]

[Total: 10]

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END OF PAPER