TEMASEK JUNIOR COLLEGE

2015 Preliminary Examination
Higher 1

CANDIDATE NAME	

CIVICS GROUP		INDEX NUMBER	

PHYSICS

8866/02

Paper 2 Structured Questions

28 August 2015
2 hours

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

READ THESE INSTRUCTION FIRST
Write your Civics group, index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

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	
8	
Total	

This booklet consists of **26** printed pages.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant,	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg
acceleration of free fall,	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
hydrostatic pressure,	p	$= \rho gh$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** the questions in this section.

1 A projectile is launched horizontally from a cliff on a distant planet. Fig. 1.1 below plots the horizontal (x) and vertical (y) positions of the projectile every 0.50 s.

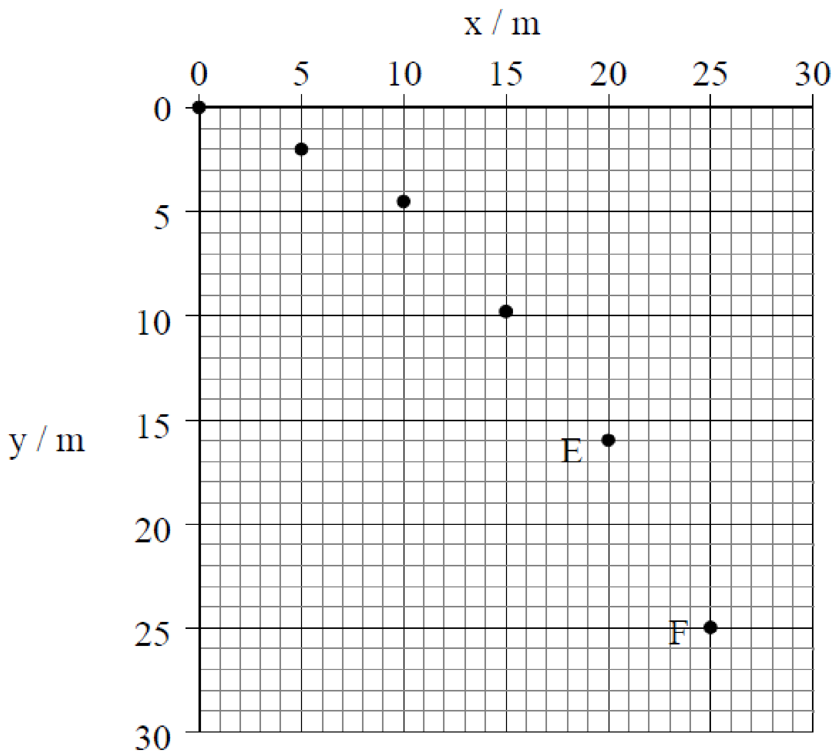


Fig. 1.1

(a) State an evidence from the plotted data that the planet's atmosphere had no significant effect on the motion of the projectile.

....

.... [1]

(b) **(i)** Draw on Fig. 1.1, the displacement vector of the projectile between points E and F of the motion. Label this vector D.

[1]

(ii) Determine the vertical component of the average velocity of the projectile between points E and F.

vertical component of average velocity = ... m s^{-1} [2]

(c) **(i)** Using the values of *y* at E, calculate the acceleration due to gravity on this planet.

acceleration due to gravity = ... m s^{-2} [2]

(ii) Assume that the planet has the same density as Earth. From your answer in **(c)(i)**, state and explain whether the radius of the planet is bigger or smaller than that of the Earth. (Given that acceleration due to gravity, $g \propto \frac{M}{r^2}$ where M is the mass of Earth and r is the radius of Earth.)

....

.... [2]

(d) Another projectile is fired at half the speed of the first one. On Fig 1.1, plot the positions of this projectile for time intervals of 0.50 s.

[2]

2 **(a)** Distinguish between the *moment of a force* and the *torque of a couple*.

moment of a force ....

....

....

torque of a couple ....

....

.... [2]

(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 2.1.

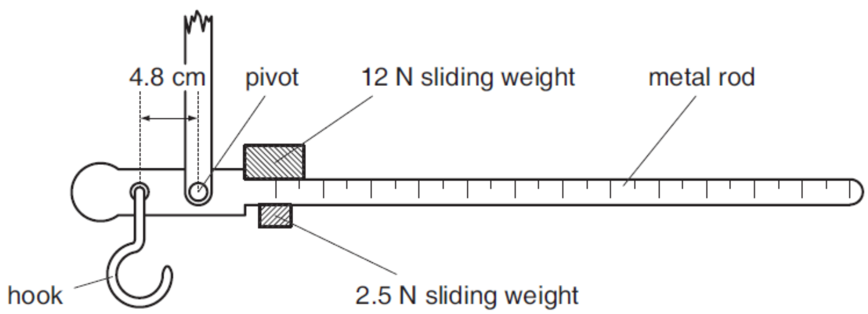


Fig. 2.1.

The two sliding weights can be moved independently along the rod.

With no load on the hook and the sliding weights at the zero mark on the metal rod, the metal rod is horizontal. The hook is 4.8 cm from the pivot.

A sack of flour is suspended from the hook. In order to return the meta l rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N weight is moved 72 cm.

(i) Calculate the weight of the sack of flour.

weight = ... N [2]

(ii) Suggest why this steelyard would be imprecise when weighing objects with a weight of about 25 N.

....

.... [1]

3 **(a)** The variation with thermodynamic temperature T of the resistance R of a thermistor is shown in Fig. 3.1.

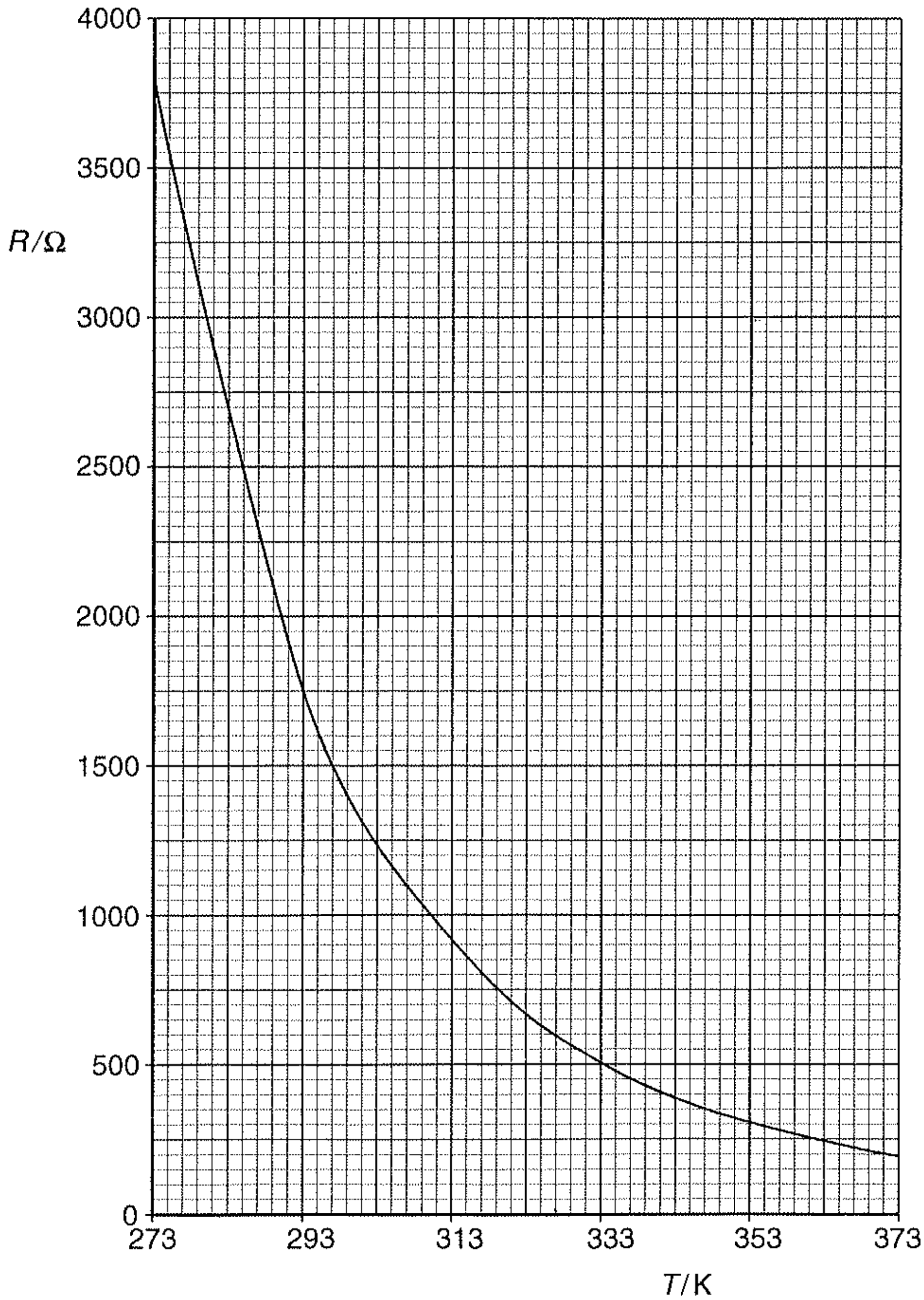


Fig. 3.1

Suggest, with a reason, why the thermistor, used as a thermometer, is more appropriate for measuring temperatures in the range 273 K to 293 K than in the range 353 K to 373 K.

....

....

.... [2]

(b) The thermistor is connected into the circuit of Fig. 3.2.

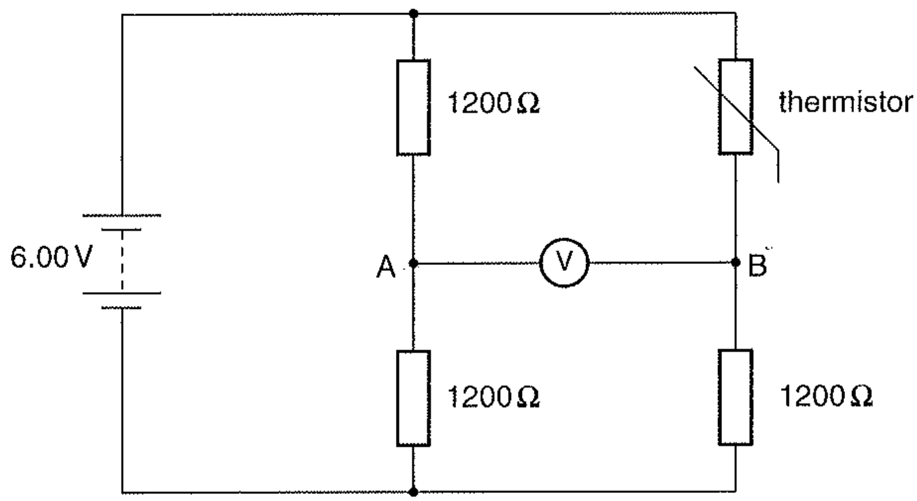


Fig. 3.2

The voltmeter connected between A and B has infinite resistance. The battery has e.m.f. 6.00 V and negligible internal resistance. The resistors each have a resistance of 1200 Ω.

(i) Determine the thermodynamic temperature at which the voltmeter reads zero. Explain your working.

temperature = ... K [3]

(ii) The temperature of the thermistor is now changed to 282 K. Determine the voltmeter reading. State whether A or B has the higher potential.

voltmeter reading = ... V

higher potential .... [4]

4 A coil of wire consisting of two loops is suspended from a fixed point as shown in Fig. 4.1.

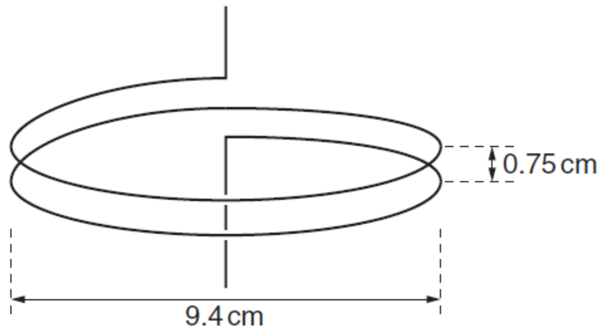


Fig. 4.1

Each loop of wire has diameter 9.4 cm and the separation of the loops is 0.75 cm.
The coil is connected into a circuit such that the lower end of the coil is free to move.

(a) Explain why, when a current is switched on in the coil, the separation of the loops of the coil decreases.

....

....

....

....

.... [3]

(b) Each loop of the coil may be considered as being a long straight wire.
In SI units, the magnetic flux density *B* at a distance *x* from a long straight wire carrying a current *I* is given by the expression

$$B = 2.0 \times 10^{-7} \frac{I}{x}$$

When the current in the coil is switched on, a mass of 0.26 g is hung from the free end of the coil in order to return the loops of the coil to their original separation.
Calculate the current in the coil.

current = ... A [3]

5 Echoes are produced by the reflection of sound waves from a surface such as a wall or a cliff. The persistence of sound after the source ceases is known as reverberation time. When the reflecting surface is far away from the source then the echo may be heard as a separate sound. Multiple echoes or prolonged reverberation arise when several reverberations of the sound occur.

Recording studios and music halls are acoustically designed to cover the walls with sound absorbing surfaces such as a perforated panel as shown in Fig. 5.1. In many cases it is necessary to absorb certain frequencies more than others, and one way to do this is to use the resonant frequencies of these perforated panels. Figure 5.2 shows how one such perforated panel is attached to the wall.

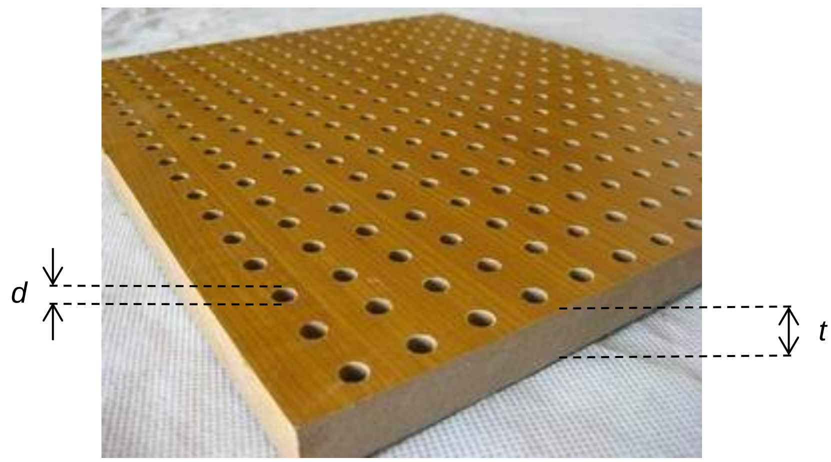


Fig. 5.1

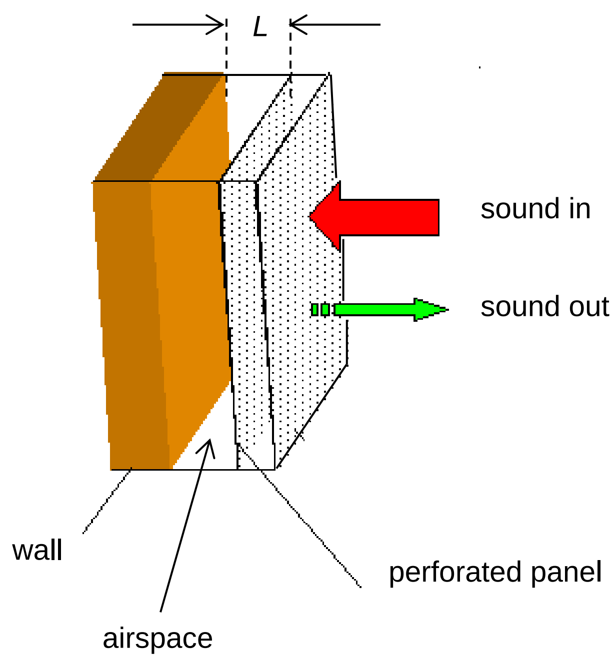


Fig. 5.2

It is found that a panel made of hardboard resonates at a particular frequency and absorbs sound of that frequency more than others. An approximate expression for this frequency is given by

$$f = 5000\sqrt{\frac{P}{L\left(t + 0.8\,d\right)}}$$

where f = resonant frequency
L = depth of airspace
t = thickness of panel
d = hole diameter
P = percentage of open area
(all measurements are made in mm)

A panel with 10 % open area, with various hole diameters are tested and the resonant frequencies f, together with values of $\frac{1}{f^2}$ obtained are shown in Fig. 5.3.

d/ mm	f/ Hz	$\frac{1}{f^2}/10^{-6}\ s^2$
1.0	1600	0.39
2.0	1480	0.46
3.0	1350	0.55
4.0	1280	
5.0	1180	0.72
6.0	1140	0.77

Fig. 5.3

(a) **(i)** Complete Fig. 5.3 for the resonant frequency of 1280 Hz. [1]

(ii) Fig. 5.4 is a graph of some of the data of Fig. 5.3.

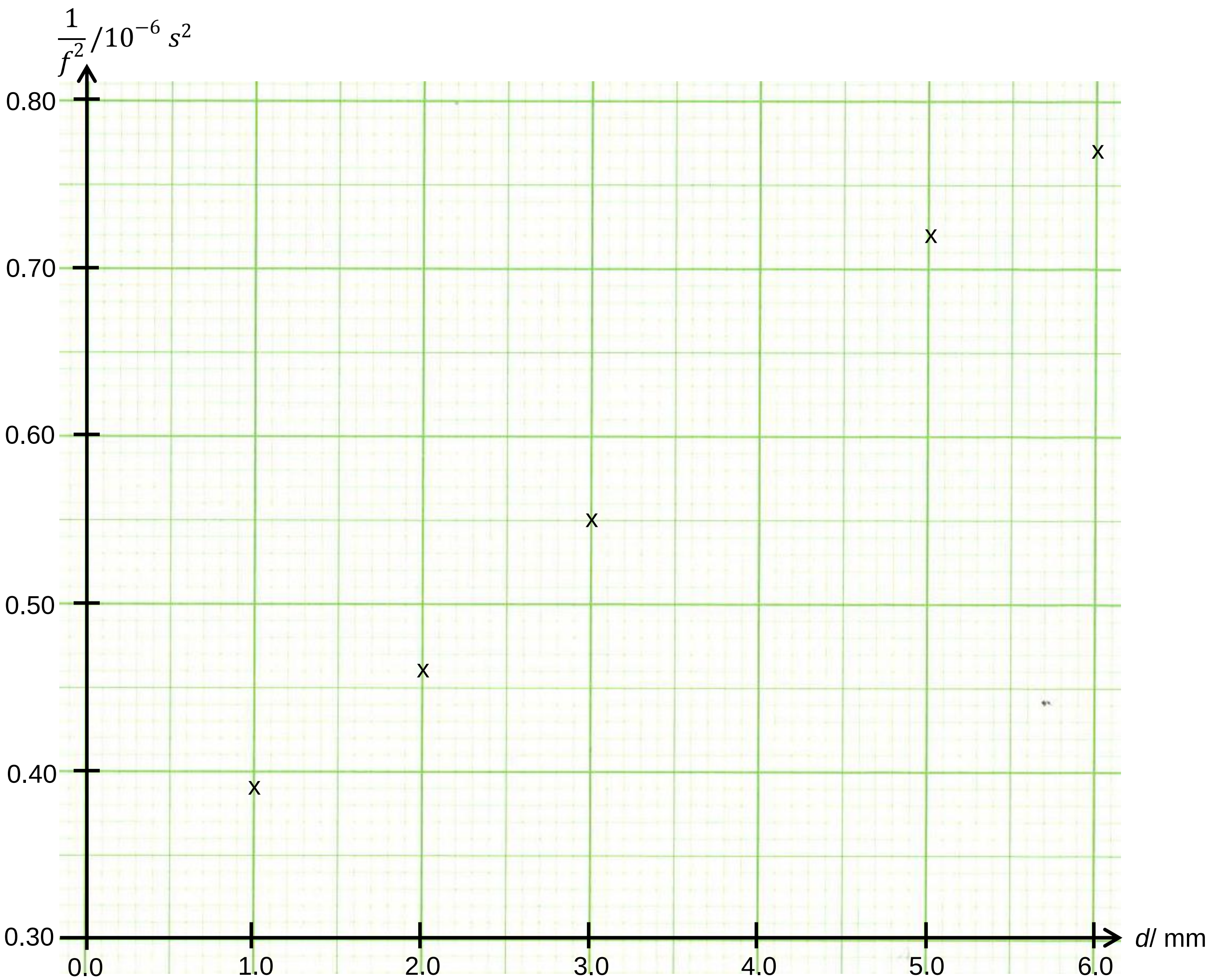


Fig. 5.4

On Fig. 5.4,

1. plot the point corresponding to f = 1280 Hz, [1]

2. Draw the line of best fit for all the points. [1]

(iii) **1.** Use Fig. 5.4 to determine the gradient of the line drawn in **(c)(ii)**.

gradient = ... $s^2\ mm^{-1}$ [2]

2. Hence find the depth L of the airspace.

L = ... mm [2]

(b) The panel with 5.0 mm holes is selected and tested with its airspace filled with two different absorbers. The absorption characteristics shown in Fig 5.5 were obtained.

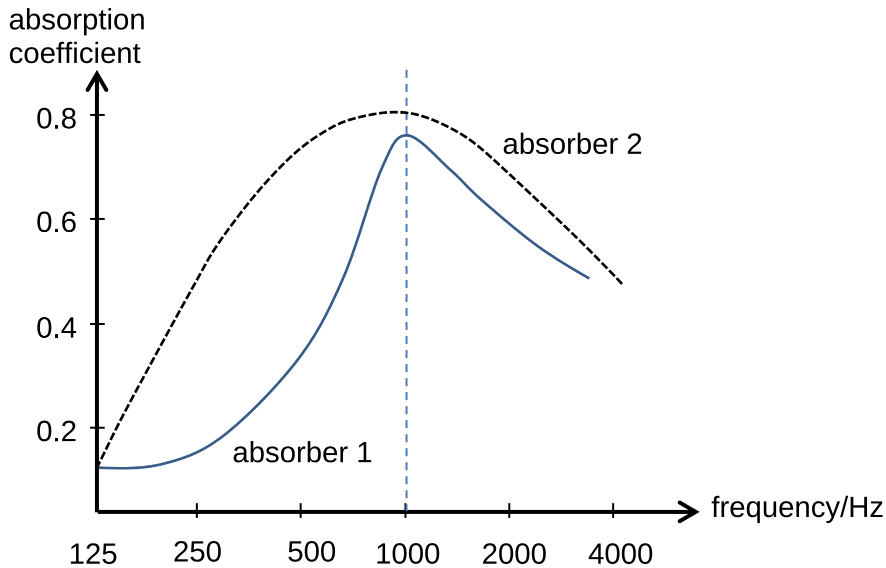


Fig. 5.5

(i) With reference to Fig. 5.3 and Fig. 5.5, state the effect absorbers have on the resonant frequencies when they were inserted in the airspace.

....

.... [1]

(ii) State and explain which absorber is more suitable for use in a recording studio.

....

....

....

.... [2]

Section B

Answer any **two** questions in this section.

6 **(a)** **(i)** Define *power*.

....

.... [1]

(ii) Starting with the definition of power, derive power as the product of force and velocity.

.

[2]

(b) A cyclist travels along a horizontal road. The variation with time t of speed v is shown in Fig. 6.1.

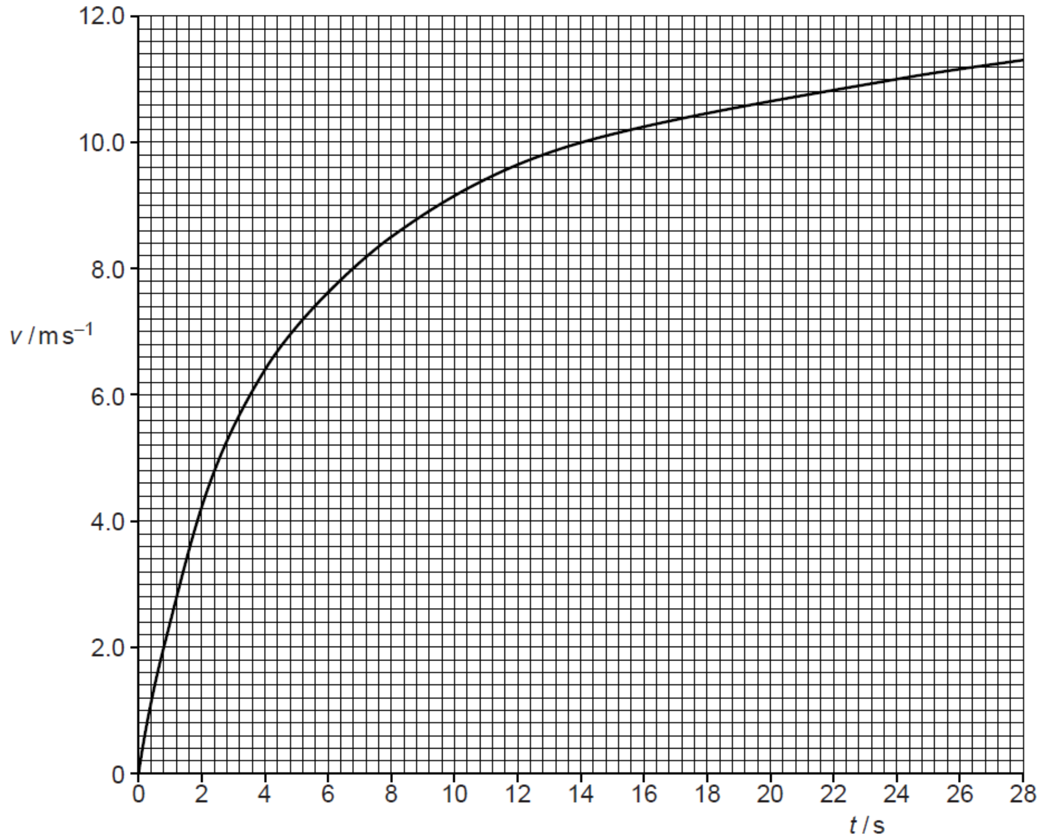


Fig. 6.1

The cyclist maintains a constant power and after some time reaches a constant speed of 12 m s^{-1}.

(i) Describe and explain the motion of the cyclist.

....

....

....

....

.... [3]

(ii) When the cyclist is moving at a constant speed of 12 m s^{-1} the resistive force is 48 N. Show that the power of the cyclist is about 600 W. Explain your working.

[2]

(iii) Use Fig. 6.1 to show that the acceleration of the cyclist when his speed is 8.0 m s^{-1} is about 0.5 m s^{-2}.

[2]

(iv) The total mass of the cyclist and bicycle is 80 kg. Calculate the resistive force *R* acting on the cyclist when his speed is 8.0 m s^{-1}. Use the value for the acceleration given in **(iii)**.

R = ... N [3]

(v) Use the information given in **(ii)** and your answer to **(iv)** to show that, in this situation, whether the resistive force *R* is proportional to the speed *v* of the cyclist.

[2]

(vi) The cyclist now travels at a higher constant speed. Explain why the cyclist needs to provide a greater power.

....

....

....

.... [2]

(c) It is often stated that many forms of transport transform chemical energy into kinetic energy. Explain why a cyclist travelling at constant speed is not making this transformation. Explain what transformations of energy are taking place.

....

....

....

....

.... [3]

7 (a) (i) State what is meant by *diffraction* of a wave.

....

.... [1]

(ii) Outline briefly an experiment that may be used to demonstrate diffraction of a transverse wave.

....

....

....

.... [3]

(iii) Suggest how your experiment in **(ii)** may be changed to demonstrate diffraction of a longitudinal wave.

....

....

....

.... [3]

(b) (i) State what is meant by a *progressive wave*.

....

....

.... [1]

(ii) The variation with distance *x* along a progressive wave of a quantity *y*, at a particular time, is shown in Fig. 7.1.

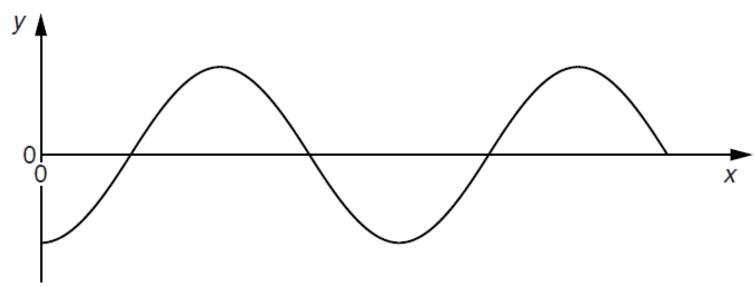


Fig. 7.1

1. State what the quantity *y* could represent.

.... [1]

2. Distinguish between the quantity *y* for a transverse wave and a longitudinal wave.

....

....

....

.... [2]

(c) **(i)** State the *principle of superposition of waves*.

....

....

.... [2]

(ii) Coherent light of wavelength 590 nm is incident normally on a double slit, as shown in Fig. 7.2.

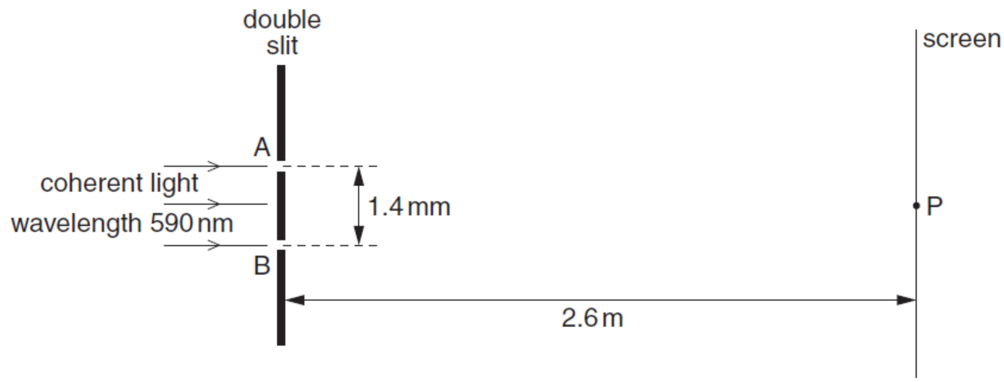


Fig. 7.2

The separation of the slits A and B is 1.4 mm. Interference fringes are observed on a screen placed parallel to the plane of the double slit. The distance between the screen and the double slit is 2.6 m.

At point P on the screen, the path difference is zero for light arriving at P from the slits A and B.

Determine the separation of bright fringes on the screen near to point P.

separation = ... mm [3]

(iii) The variation with time of the displacement x of the light wave arriving at point P on the screen from slit A and from slit B is shown in Fig. 7.3a and Fig 7.3b respectively.

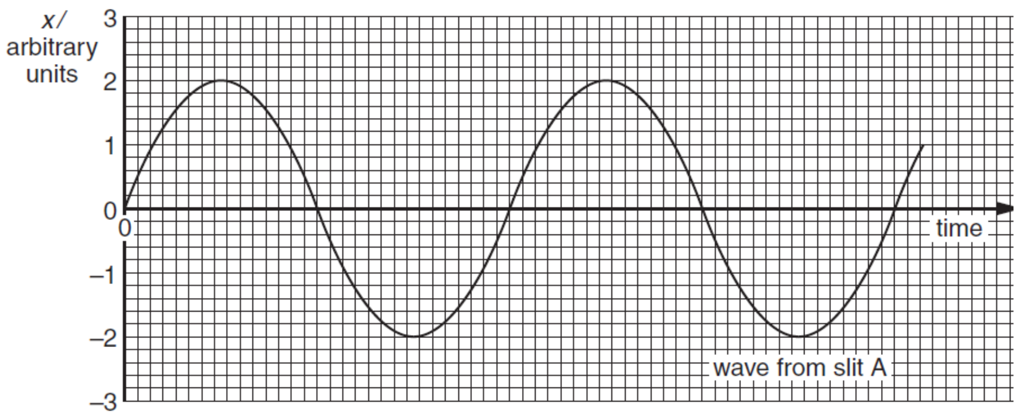


Fig. 7.3a

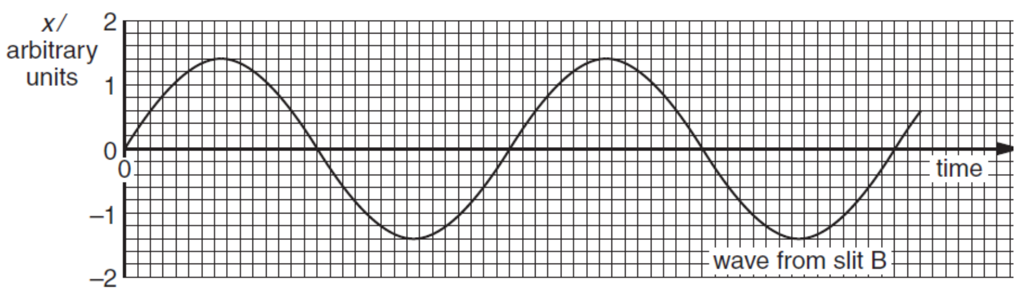


Fig. 7.3b

1. State the phase difference between waves forming the dark fringe on the screen that is next to point P.

phase difference = ... ° [1]

2. Determine the ratio

$$\frac{\text{intensity of light at a bright fringe}}{\text{intensity of light at a dark fringe}}$$

ratio = ... [3]

8 **(a)** **(i)** State what is meant by the *photoelectric effect*.

....

....

.... [1]

(ii) State three pieces of evidence provided by the photoelectric effect for the particulate nature of electromagnetic radiation.

1. ....

....

2. ....

....

3. ....

.... [3]

(iii) **1.** By reference to photoelectric effect, state what is meant by *work function* of a metal.

....

.... [1]

2. The surface of a zinc plate has a work function of 5.8×10^{-19} J.

In a particular laboratory experiment, ultraviolet light of wavelength 120 nm is incident on the zinc plate. A photoelectric current I is detected. In order to view the apparatus more clearly, a second lamp emitting light of wavelength 450 nm is switched on. No change is made to the ultraviolet lamp.

Using appropriate calculations, state and explain the effect on the photoelectric current of switching on this second lamp.

....

....

.... [4]

(b) (i) Briefly describe an experiment to observe a line emission spectrum. You may use a diagram to illustrate your answer.

....

....

....

.... [2]

(ii) Explain how a line emission spectrum leads to an understanding of the existence of discrete energy levels in atoms.

....

....

....

.... [3]

(iii) Three electron energy levels in atomic hydrogen are represented in Fig. 7.1.

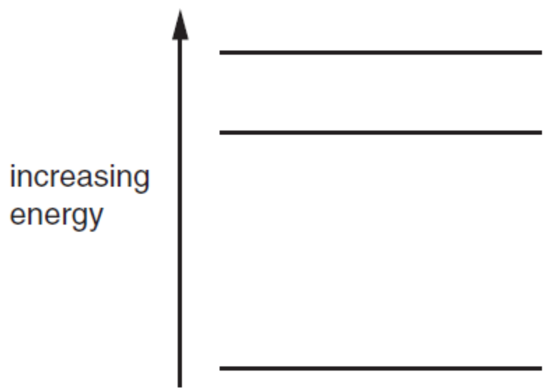


Fig. 7.1

The wavelengths of the spectral lines produced by electron transitions between these three energy levels are 486 nm, 656 nm and 1880 nm.

1. On Fig. 7.1, draw arrows to show the electron transitions between the energy levels that would give rise to these wavelengths. Label each arrow with the wavelength of the emitted photon. .

[3]

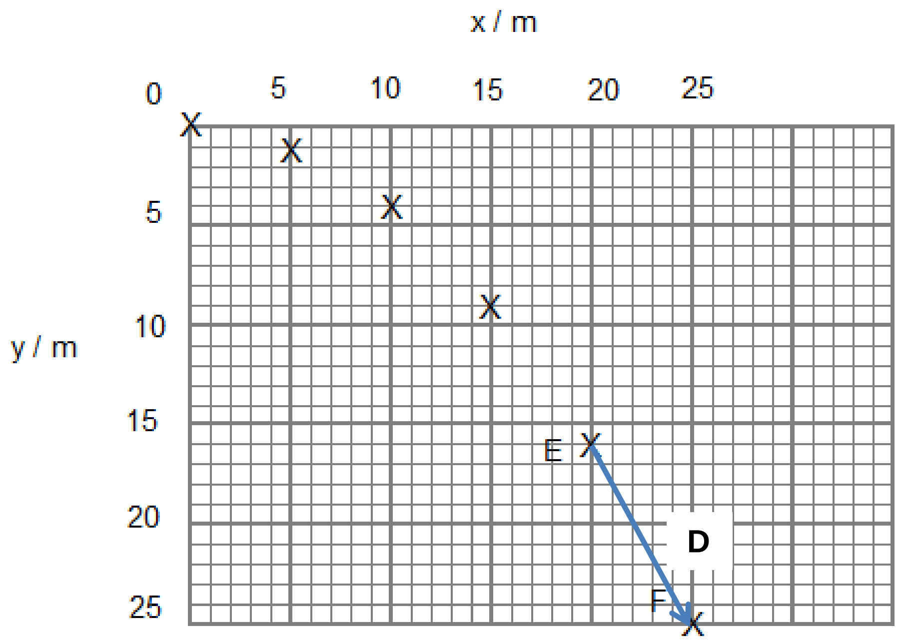
2. Calculate the maximum change in energy of an electron when making transitions between these levels.

energy = ... J [3]

Solution to 2015 H1 Paper 2

1 **(a)** Horizontal displacement travelled between consecutive plotted data is always the same. [1]

(b) **(i)**



Correct displacement vector D [1]

(ii) Vertical displacement of 9.0 m in 0.50 s;
v =18 m s^{-1} [2]

(c) **(i)** Using y = ½ g t^2
16.0 = ½ g (2.0)^2
g = 8.0 m s^{-2} [2]

(ii)

Since $g = \dfrac{G(\rho \frac{4}{3}\pi R^3)}{R^2} = \dfrac{4}{3}G\rho\pi R$

g α R, the planet has a smaller radius than that of Earth. [1]

(d) half previous horizontal spacing for each plotted data
same vertical positions at each time interval [2]

2 **(a)** moment: force × perpendicular distance of force from pivot / axis / point [1]
couple: (magnitude of) one force × perpendicular distance between the two forces [1]

(i) $W \times 4.8 = (12 \times 84) + (2.5 \times 72)$ [1]
$W = 250$ N (248 N) [1]

(ii) either friction at the pivot or small movement of weights [1]

3 **(a)** The change in resistance per unit rise in temperature is much greater in the range 273 K to 293 K than in the range 353 K to 373 K. [1]
Hence the thermometer is more sensitive to temperature changes. [1]

(b) **(i)** When voltmeter reads zero, potential at A = potential at B.
So p.d. across thermistor = p.d. across 1200 Ω resistor of left branch. [1]
Hence resistance of thermistor = 1200 Ω [1]
From Fig. 3.1, temperature = 304 K. [1]

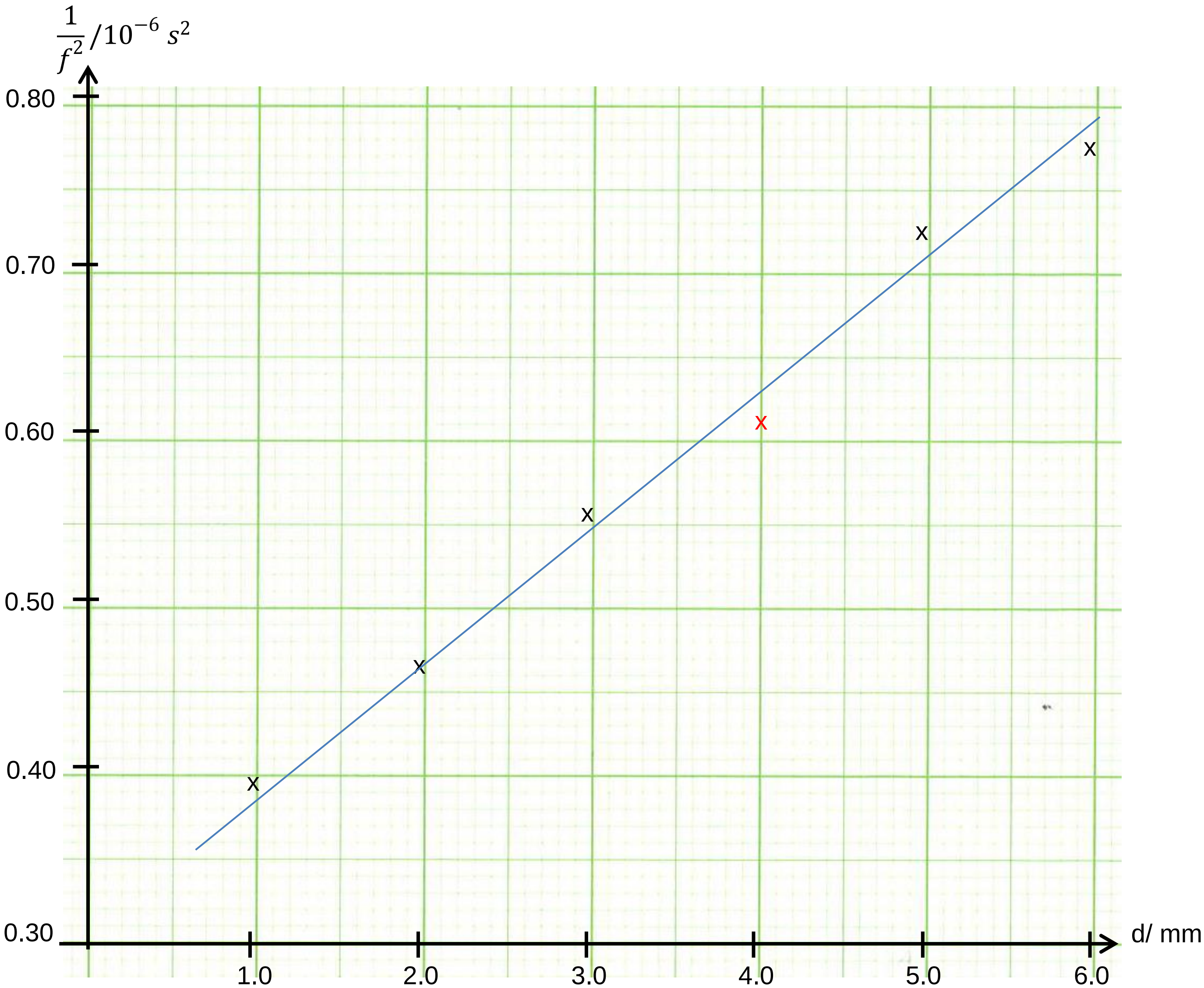
(ii) From Fig. 3.1, resistance of thermistor = 2800 Ω [1]
p.d. across thermistor = 2800/(2800 + 1200) × 6.00 = 4.20 V [1]
potential at A is higher than potential at B by 3.00 – 1.80 = 1.20 V [1]
voltmeter reading = 1.20 V [1]

4 **(a)** The magnetic field due to current flowing in one loop produces magnetic field in the other loop. [1]
This cause a force on second loop. [1]
By Newton's 3rd gives rise to attraction and hence the separation of the loops of the coil decreases. [1]

(b) $B = 2 \times 10^{-7}\ I/0.75 \times 10^{-2}$ $(= 2.67 \times 10^{-5}\ I)$ [1]
force $= 0.26 \times 10^{-3} \times 9.81$ $(= 2.55 \times 10^{-3}$ N$)$

$F = BIL$
$2.55 \times 10^{-3} = 2.67 \times 10^{-5} \times I^2 \times 2\pi \times 4.7 \times 10^{-2}$ [1]
$I = 18$ A [1]

5 (a) (i) f = 1280 Hz, $1/f^2 = 0.71 \times 10^{-6}$ s^2 [1]



(iii) 1.

$$\text{Gradient} = \frac{(0.700-0.400)\times10^{-6}}{(5.00-1.30)} = 0.0811\times10^{-6}\ \text{s}^2\ \text{mm}^{-1}$$

[2]

2.

$$\text{Gradient} = \frac{0.8L}{5000^2P}, \text{ sub P} = 10$$

L = 25.3 mm

Accept 22.0 mm, L , 26.0 mm [2]

(b) (i) Resonant frequencies will be reduced. [1]

(ii) Absorber 2 will be more suitable since it absorbs a wide range of frequencies more effectively. Reverberation times must be short in a recording studio so that echoes from previous sounds will not interfere with present sound waves. [2]

6 **(a)** **(i)** Power is the rate of doing work. [1]

(ii) The instantaneous power P delivered is defined as

$$P = \frac{\mathrm{d}W}{\mathrm{d}t} = \frac{F\mathrm{d}x}{\mathrm{d}t}$$ [1]

$$= Fv \quad \text{where } v \text{ is the instantaneous velocity}$$ [1]

(b) **(i)** -as the speed increases drag / air resistance increases [1]
-resultant force reduces hence acceleration is less [1]
-constant speed when resultant force is zero [1]
(allow one mark for speed increases and acceleration decreases)

(ii) force from cyclist = drag force (resistive force) [1]
$P = Fv = 12 \times 48$
$P = 576$ W [1]

(iii) tangent drawn at speed = 8.0 m s^{-1} [1]
gradient values that show acceleration between 0.44 to 0.48 m s^{-2} [1]

(iv) $F - R = ma$ [1]
$600 / 8 - R = 80 \times 0.5$ [using P = 576] $576 / 8 - R = 80 \times 0.5$ [1]
$R = 75 - 40 = 35$ N $R = 72 - 40 = 32$ N [1]

(v) at 12 m s^{-1} drag is 48 N, at 8 m s^{-1} drag is 35 or 32 N [1]
R / v calculated as 4 and 4 or 4.4
and consistent response for whether R is proportional to v or not [1]

(vi) -At higher speed, drag increases. [1]
-From $P = Fv$, since both speed and force increases. power increases [1]

(c) -Constant speed means kinetic energy remains constant. [1]
-Chemical Energy from the muscle is transformed into internal energy (heat) such as friction between the tyres and the road, the gearing systems and the surrounding air (and perhaps into sound.) [2]

7 (a) (i) Bending and spreading of wave when wave is incident at an edge / aperture / slit / obstacle [1]

(ii) Suitable apparatus e.g. [1]

-laser & slit / point source & slit / lamp and slit & slit
-microwave source & slit
-water / ripple tank, source & barrier

Suitable detector e.g. [1]
-screen
-aerial / microwave probe
-strobe / lamp

Description of what is observed [1]

(ii) Suitable apparatus e.g. [1]

- loudspeaker, and slit / edge

Suitable detector e.g. [1]
- microphone & c.r.o. / ear

Description of what is observed [1]

(b) (i) transfer / propagation of energy as a result of oscillations / vibrations [1]

(ii) 1. displacement / velocity / acceleration (of particles in the wave) [1]

2. Transverse wave- displacement/oscillation of particles is normal to direction of energy transfer [1]
Longitudinal wave- displacement/oscillation of particles is along same direction as the direction of energy transfer [1]

(c) (i) when two or more waves meet at a point, [1]
the resultant displacement is the vector sum of individual displacements [1]

(ii) $\lambda = ax / D$ [1]
$590 \times 10^{-9} = (1.4 \times 10^{-3}\, x) / 2.6$ [1]
$x = 1.1$ mm [1]

(iii) 1. 180° [1]

at maximum, amplitude is 3.4 units and at minimum, 0.6 units [1]
intensity α amplitude2 [1]

2. ratio = $3.4^2 / 0.6^2 = 32$ [1]

8 **(a)** **(i)** Photoelectric effect is the emission of electrons from the surface of a metal when electromagnetic radiation of <u>sufficiently high frequency</u> is shone on it. [1]

(ii) 'instantaneous' emission (of electrons) [1]

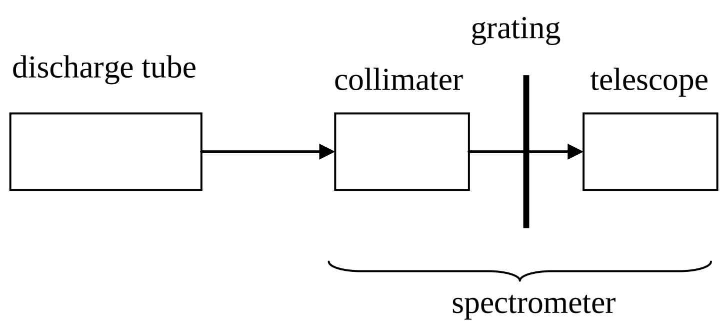
existence of threshold frequency below which no emission of electrons occur [1]

(max) electron energy dependent on frequency and not dependent on intensity [1]

(iii) **1.** Work function is the minimum energy required to remove electron from the surface of the metal [1]

2. $E = hc / \lambda$ or $E = hf$ and $c = f\lambda$ [1]
either threshold wavelength = $(6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (5.8 \times 10^{-19})$
= 340 nm
or energy of 450 nm photon = 4.4×10^{-19} J
or threshold frequency = 8.7×10^{14} Hz
or 450 nm → 6.7×10^{14} Hz [1]
appropriate comment comparing wavelengths / energies / frequencies [1]
so no effect on photo-electric current [1]

(b) **(i)**



When gases like hydrogen or neon are placed in a discharge tube at low pressure and a high voltage is applied between the ends of the tube, the gas starts to glow and light is emitted from the electric discharge tube. If this light is examined through a diffraction grating with a spectrometer, a spectrum consisting of well defined, distinct lines is observed. It consists of discrete **bright lines** of different colours on a **dark background**. This type of spectrum is called an **emission line spectrum**. [2] [1]

(ii) each line corresponds to a (specific) photon energy [1]
photon emitted when electron changes its energy level [1]
discrete energy changes so discrete levels. [1]

(c) **(i)1.** three energy changes shown correctly [1]
arrows 'pointing' in correct direction [1]
wavelengths correctly identified [1]

(i)2. chooses λ = 486 nm [1]
$\Delta E = hc / \lambda$
$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (4.86 \times 10^{-9})$ [1]
$= 4.09 \times 10^{-19}$ J [1]