AS trial P2 (June 09 Meake)

1. **(a)** State what is meant by a base unit.

It is a unit that cannot be expressed in terms of any other units (B1)

.....[1]

(b) For the physical quantities given below, state whether each of them is a scalar or a vector, together with its **SI** and **base** units. An example is illustrated for the first physical quantity.

Physical quantity	Scalar / vector	SI unit	Base units
1. pressure	**scalar**	**pascal**	**$kgm^{-1}s^{-2}$**
2. Moment of a force	vector	newton-metre	kgm^2s^{-2}
3. Potential difference	Scalar	volt	$kgm^2s^{-3}A^{-1}$

each column B(1) B(1) B(1)

[3]

2. **(a)** State Newton's second law of motion.

The rate of change of momentum of an object is directly proportional to the external applied force and the change of momentum is in the direction of the applied force. (B1) (B1)

[2]

(b) A ball of mass 0.56 kg falls from rest from a height of 15 m on to a horizontal metal plate placed on the ground. It rebounds to a height of 9.0 m. The time of contact between ball and plate is 0.24 s. Calculate

(i) the speed with which the ball hits the plate

$\frac{1}{2}mv^2 = mgh$ ~~B1~~ C1

$v = \sqrt{2gh}$ C1

$= \sqrt{2 \times 9.81 \times 15}$

$= 17.2 ms^{-1}$ A1

speed = 17.2 ms^{-1} [3]

(ii) the speed with which the ball rebounds from plate

$\frac{1}{2}mu^2 = mgh$

$u = \sqrt{2gh}$

$= \sqrt{2 \times 9.81 \times 9.0}$ C1

$= 13.3\,ms^{-1}$ A1

speed = ...13.3..........ms^{-1} [2]

(iii) the magnitude and direction of the resultant force on ball exerted by the plate

$F = \frac{m(v-u)}{t}$ ~~B1~~ C1

$= \frac{0.56(13.3+17.2)}{0.24}$ C1

$= 71.2\,N$ A1

Magnitude = ...71.2..........N

Direction: vertically upwards [4] B1

3. **(a)** State the conditions necessary for a system to be in static equilibrium.

1. Sum of forces along any direction must be zero. B1

2. Sum of moments about any point must be zero. B1

....[2]

(b) A wheel of radius 0.5 m is about to be pushed over a kerb of height 0.2 m by a horizontal force of 200 N applied at the axle, as shown in Fig.1 below.

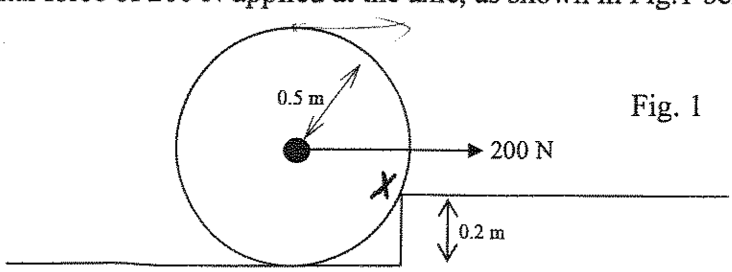


Fig. 1

Calculate

(i) the weight of the wheel Let weight be W.

Taking moments about X,

$W(0.4) = 200(0.3)$ C1

d = 0.4

C1

$W = \frac{3}{4} \times 200$

$= 150 N$ A1

weight = ...150............N [3]

(ii) the minimum force required to push this wheel over the kerb

ecf

Let minimum force be F. location of F. B1

$F(0.8) = W(0.4)$ C1

$F = \frac{150 \times 4}{8}$ or

= A1

75N $= 120$

minimum force = ...120............N [3]

4. (a) Define stress, strain and Young modulus of elasticity of a material.

Stress: ...tensile force acting normally per unit cross-sectional area... B1

Strain: ...extension per unit original length... B1

Young modulus: ...ratio of stress to strain... B1

....[3]

(b) A load of 16.3 kg causes an extension of 3.84 mm in a wire of cross-sectional area 1.0 mm^2 and 6.0 m long.
Calculate

(i) the Young modulus of the material

$$E = \frac{Fl}{eA}$$

$$= \frac{16.3 \times 9.81 \times 6.0}{3.84 \times 10^{-3} \times 1.0 \times 10^{-6}} \quad \text{C1}$$

$$= 2.50 \times 10^{11}\ Pa. \quad \text{A1}$$

Young modulus = 2.50×10^{11} ....Pa [2]

(ii) the force constant for this wire

$$K = \frac{F}{e}$$

$$= \frac{16.3 \times 9.81}{3.84 \times 10^{-3}} \quad \text{C1}$$

$$= 4.16 \times 10^{4}\ Nm^{-1} \quad \text{A1}$$

Force constant = 4.16×10^{4} ....Nm^{-1}[2]

5. A double-slit interference experiment is set up using coherent blue light as illustrated in **Fig. 5.1.**

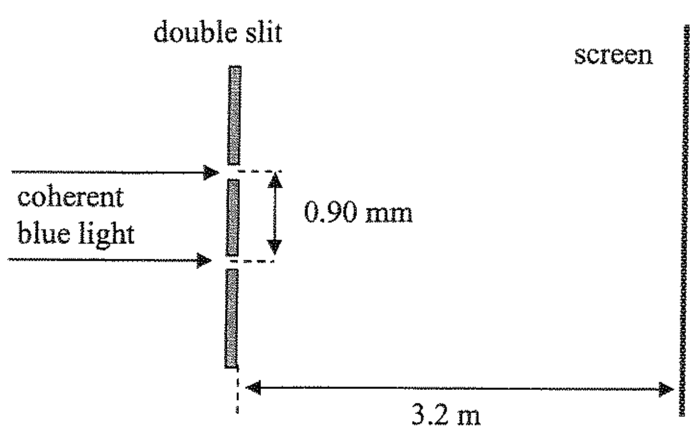


Fig. 5.1 (not to scale)

The separation of slits is 0.90 mm.
The distance of the screen from the double slit is 3.2 m.
A series of light and dark fringes is observed on the screen.

(a) State what is meant by *coherent* light.

light sources have constant phase difference. B1

....[1]

(b) Estimate the separation of the dark fringes on the screen. ~~380 780~~ 380 → 530 nm

estimate λ of red : ~~600 - 700~~nm B1
(range) →

$x = \frac{\lambda}{a} L$ C1 ~~1.96×10^{-3}~~ → 2.67×10^{-3}

$= \frac{\cancel{650 \times 10^{-9}}}{0.90 \times 10^{-3}} \times 3.2$

$= \cancel{0.00231}$ m   0.00124 → 0.00196   A1

$1.24 \times 10^{-3} \rightarrow 1.96 \times 10^{-3}$

Separation = 2.31 mm [3]

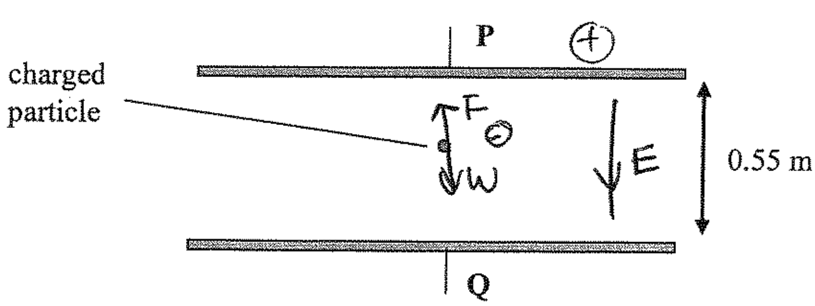
1.24 → 1.96

(c) Initially, the light passing through each slit has the same intensity. The intensity of light passing through one slit is now doubled.
Suggest and explain the effect, if any, on the dark fringes observed on the screen.

total cancellation doesn't occur as the amplitudes of two waves reaching the screen are different, M1

Hence, the dark fringes appear brighter. A1 [2]

6. Two parallel metal plates **P** and **Q** are separated by a distance of 0.55 m in a vacuum. A negatively charged particle of mass 4.5 x 10^{-15} kg is situated between the plates which are arranged vertically as illustrated in **Fig. 6.1**.



each 1 mark

Fig. 6.1

The potential difference between the plates is adjusted until the particle remains stationary.

(a) Draw arrows, with labels, to indicate the direction of:
(i) the weight W of the charge
(ii) the electric force F acting on the charge
(iii) the electric field strength E [3]

(b) State, with a reason, which plate, **P** or **Q**, is positively charged.
weight acts downwards & is balanced by the electric force which is acting upwards on a negatively charged particle. So, upper plate i.e. P is positively charged. [2] M1 A1

(c) The potential difference required for the particle to be stationary between the plates is found to be 500 V.

Calculate
(i) the electric field strength between the plates,

$$E = \frac{500}{0.55}$$ C1

$$= 909 \text{ NC}^{-1}$$ A1

field strength = 909 NC^{-1} [2]

(ii) the charge on the particle.

electric force balances the weight ~~B1~~ C1

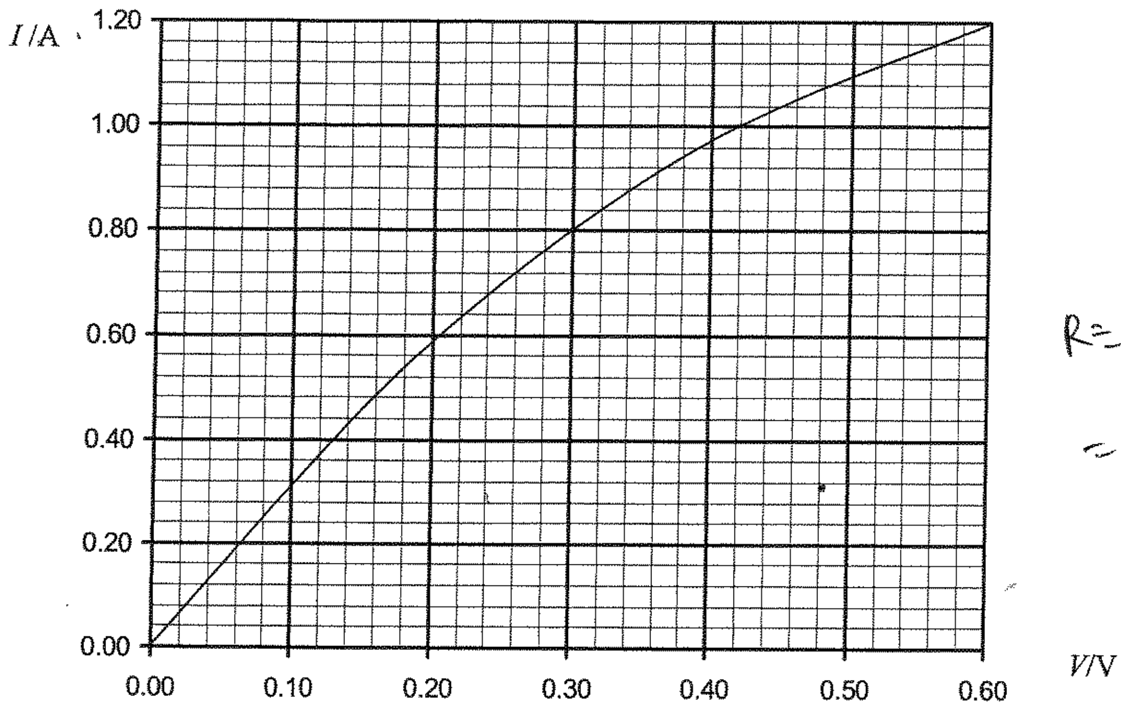
$F_{elec} = W$ C1

$Eq = mg$

$$q = \frac{4.5\times10^{-15}\times 9.81}{909.09} = 4.86\times10^{-17}\text{ C}$$ A1

charge = 4.86×10^{-17} C [3]

7. The variation with potential difference V of the current I in a lamp is shown in **Fig. 7.1**.



$R = \frac{0.6}{1.2}$
$= 0.5$

Fig. 7.1

(a) Calculate the resistance of the lamp for a potential difference across the lamp of 0.30 V.

$R = \frac{V}{I} = \frac{0.3}{0.8} = 0.375$

C1
A1

resistance = 0.375 Ω [2]

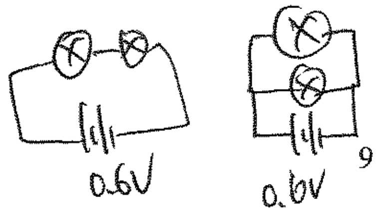
(b) By reference to **Fig. 7.1**, state and explain qualitatively the change in the resistance of the lamp as the potential difference across the lamp is changed.

R = increases.

The ratio of $\frac{V}{I}$ is increasing as p.d increases

A1
~~B1~~ M1

....[2]



(c) Two lamps, each having the *I-V* characteristic shown in **Fig. 7.1,** are connected first in series and then in parallel with a battery of e.m.f. 0.60 V and negligible internal resistance.
Complete the table of **Fig. 6.2** for the lamps connected to the battery.

	p.d. across each lamp/ *V*	Resistance of each lamp/ Ω	total Power output/W ~~Combined resistance of lamps / Ω~~
lamps connected in series	0.3 V	0.375	~~0.75~~ 0.48
lamps connected in parallel	0.6 V	0.50	~~0.25~~ 1.44
	A1	A1	A1 ecf for power

Fig. 7.2. [3]

each column 1 mark.

8. The spontaneous and random decay of a radioactive substance involves the emission of either α-radiation or β-radiation and/or γ-radiation.

(a) Explain what is meant by

(i) *spontaneous* decay,

the process is independent of environmental factors, e.g. B1
temperature, pressure etc. [2] B1

(ii) *random* decay.

there is a (constant) probability for a (large) sample of B1
radioactive substance to decay (per unit time) [2] B1

(b) State the type of emission, one in each case, that

(i) is not affected by electric and magnetic fields,

gamma rays B1 [1]

(ii) produces the greatest density of ionisation in a medium,

alpha particles B1 [1]

(iii) does not directly result in a change in the proton number of the nucleus,

gamma rays B1 [1]