6

1

Mass	Velocity	Time	Momentum
Power	kinetic energy	Displacement	Weight

(a) Choose the vector quantities from the box above.

(Velocity, momentum), (displacement, weight) — B2

B1 B1 any 2 → 1 mark . [2]

(b) A student goes to two weighing machines and tries to find out his mass. He steps on each weighing scale twice just to confirm the readings. Below is a table showing the values from the two different weighing machines. The mass is given in kilograms.

Scale	Trial 1	Trial 2
A	66 kg	67 kg
B	79.0 kg	78.7 kg

If the actual mass of the student is 65.5 kg comment on the accuracy and precision of both weighing machines.

Accuracy

Scale A is more accurate than Scale B — B1

Average weight using scale A = 66.5 kg
Scale B = 78.85 kg — B1

or scale A closer to actual value.

Precision

Scale B is more precise than Scale A. — B1

Scale B can measure to a degree of precision of 0.1 kg
Scale A → degree of precision is 1 kg — B1 [4]

(iii) By finding the average mass, calculate the % uncertainty of the mass measurements taken using scale **B**, given the absolute uncertainty of Scale **B** is ± 0.1kg.

Average mass $= \frac{78.7 + 79.0}{2} = 78.85$ —— M1

% uncertainty $= \frac{0.1}{78.85} \times 100 \approx$

uncertainty = 0.13 % [2] —— A1

2 An aircraft accelerates horizontally from rest and takes off when its speed is 82 ms^{-1}. The mass of the aircraft is 5.6×10^4 kg and its engines provide a constant thrust of 1.9×10^5 N.

(a) Calculate

(i) the initial acceleration of the aircraft

$a = \frac{F}{m}$

$= \frac{1.9 \times 10^5}{5.6 \times 10^4}$ —— C1

acceleration = 3.39 or 3.4 ms^{-2} [2] —— B1 A1

(ii) the minimum length of runway required, assuming the acceleration is constant.

$v^2 = u^2 + 2aS$

$S = \frac{v^2}{2a} = \frac{82^2}{2 \times 3.4}$ —— C1

length = 992 or 989 m [2] —— B1 A1

[Turn over

(b) In practice, the acceleration is unlikely to be constant. State a reason for this and explain what effect will this have on the minimum length of runway required.

Net force is not constant as air resistance increases with speed. B1

Hence runway required will be longer. B1

[2]

3 Figure 3.1 shows a vertical force, F, being applied to raise a wheelbarrow which has a total weight of 500 N.

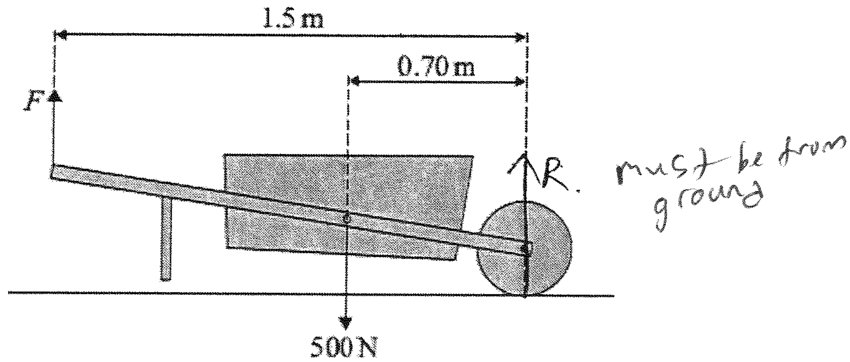


Figure 3.1

(a) On Figure 3.1 draw an arrow to represent $\boldsymbol{R}$, the force exerted by the ground on the wheel.

Correct label, R — B1 [1]

(b) Calculate the minimum value of the vertical force, $\boldsymbol{F}$, needed to raise the legs of the wheelbarrow off the ground.

Take moments about R.

$F \times 1.5 = 500 \times 0.7$ — B1

force = 233 N [2] — A1

(c) Calculate the magnitude of R when the legs of the wheelbarrow have just left the ground.

Net upward force = Net downward force.

$R + 233 = 500$ — B1

R = 267 N [2] — A1

4 A steady stream of water strikes a wall horizontally without rebounding and, as a result, exerts a force on the vertical wall. Water arrives at the wall at a rate of 18 kgs^{-1}. It strikes the wall horizontally, at a speed of 7.2 ms^{-1} without rebounding.

(a) Calculate

(i) the change in momentum of the water in one second

$p = mv$

$= 18 \times 7.2$ — B1 C1

change in momentum = 130 $kgms^{-1}$ [2] — A1

(ii) the force exerted by the water on the wall.

Force = change in momentum in 1 second — B1

force = 130 N [2] — A1

(b) State and explain the effect on the magnitude of the force if the water rebounds after striking the wall.

Magnitude is greater — B1

Because there is a bigger rate of change in momentum. — B1

[2]

5 (a) Distinguish between the structure of crystalline and non-crystalline solids, making reference to appropriate examples.

Crystalline { Particles show regular arrangement / basic structure repeats — B1
itself over long distance. exam. metal, NaCl — B1

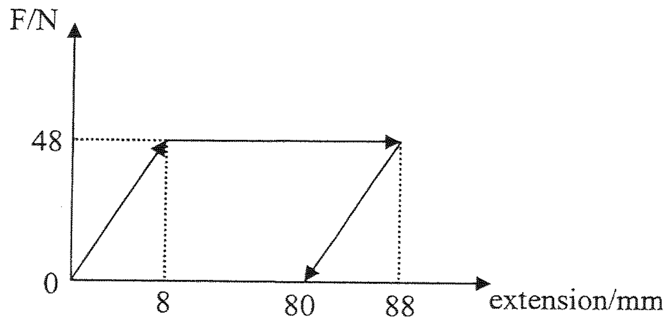
Non-Cryc. { Structure contains little order / little regularity — B1
exam. glass, wax, ceramics. — B1 [4]

(b) Define the terms stress and strain as applied to a wire being stretched.

Stress - force acting normally per unit cross-sectional area — B1

Strain - extension per unit original length — B1 [2]

(c) A wire, made of a ductile material of density 7.6×10^3 kg m^{-3}, has an area of cross section 2.5×10^{-7} m^2 and initial length 2.00 m. It is stretched by applying a tensile force to it. The force increases to 48 N, at which value the extension increases from 8.0 mm to 88 mm, as shown in the figure below. Once the extension has reached 88 mm the force is removed and the wire is then seen to have been permanently stretched by 80 mm.



Calculate the

(i) mass of the wire,

$m = \rho V$

$= (7.6\times10^{3})(2.5\times10^{-7})(2)$ — C1

$= 3.8\times10^{-3}$ kg — A1

mass = ... kg [2]

(ii) strain in the wire when the extension is 8.0 mm,

$e = \dfrac{8\times10^{-3}}{2}$ — C1

$= 4.0\times10^{-3}$ — A1

strain = ... [2]

(iii) work done on the wire

1. while the extension increases from zero to 8.0 mm,

Work done $= \frac{1}{2}Fx$

$= \frac{1}{2}(48)(8\times10^{-3})$ — C1

$= 0.192$ (or 2sf) — A1

work done = ... J

2. while the extension increases from 8.0 mm to 88 mm.

Work done $= (88-8)\times10^{-3}\times 48$ — C1

$= 3.84$ J — A1

work done = ...J [4]

(iv) Discuss how the work done which you calculated in the two parts of (iii), is transformed to different forms of energy.

increases the internal energy / Loss as heat energy. —— B1

~~molecules slide across each other~~ —— B1 [2]

Some stored as elastic Potential energy

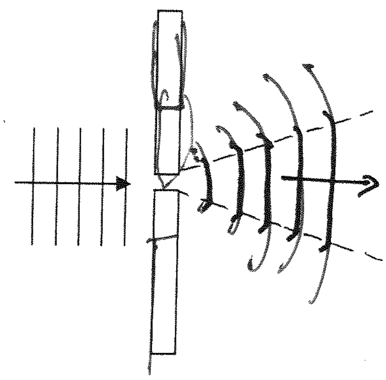
6 (a) (i) State what is meant by the diffraction of a wave.

(into the shadow regions) B1

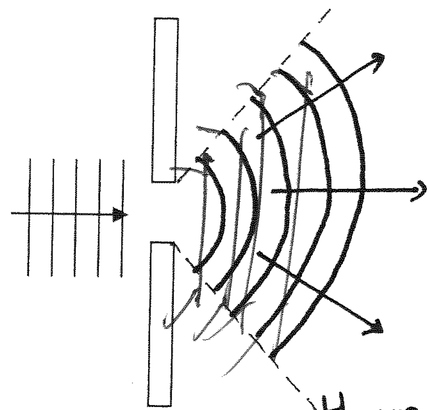
Spreading of waves/when passes through a gap —— B1

or going round a obstacle B1 [2]

(ii) The diagram of Figure 6.1 and Figure 6.2 represent plane wavefronts approaching a wide gap and a narrow gap respectively.



Narrow Gap
Fig 6.1



Wide Gap
Fig 6.2

pattern —— B1

equally spaced —— B1

B1

Draw on each diagram lines, illustrating diffraction, to represent the wavefronts after passing through the gaps. [3]

(b) Parallel monochromatic light is incident normally on a diffraction grating having 3.0×10^5 lines per meter. A meter rule positioned 2.00 m from the grating and parallel to its plane as shown below.

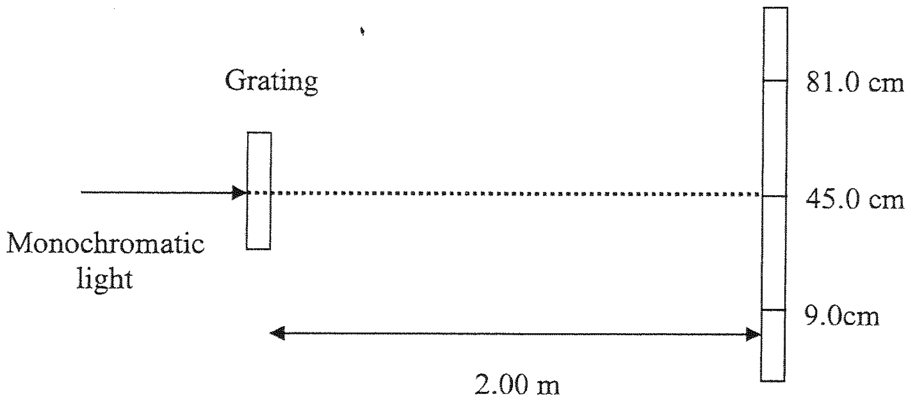


Fig 6.3

The axis of the rule is normal to the lines of the grating. Bright lines are observed on the rule at the 9.0 cm, 45.0 cm and 81.0 cm marks. Calculate the wavelength of the light.

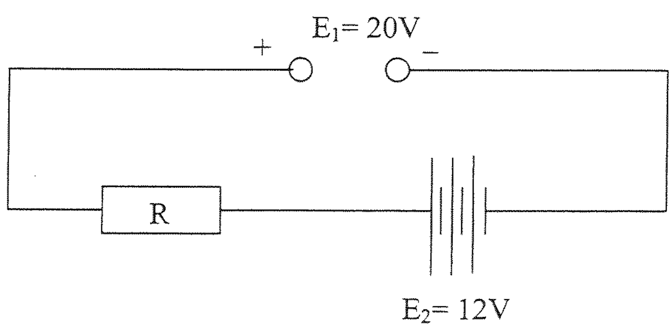
$n\lambda = d\sin\theta$ $\qquad \theta = \tan^{-1}\left(\frac{0.36}{2}\right)$

$\lambda = \left(\frac{1}{3\times10^5}\right)(\sin\theta)$ —— C1

$= 591\ \text{nm}$ —— A1

wavelength = ... m [2]

7



[Turn over

A generator of e.m.f. 20 V and internal resistance 0.05 Ω is used to charge a car battery of e.m.f. 12 V and internal resistance 0.10 Ω. They are connected in series together with a resistance R whose value is adjusted to give a charging current of 2.0 A. Calculate the

(a) value of R, ~~According to conservation of energy~~ B1

l1

$$(20-12) = 2(0.05 + 0.10 + R) \quad \text{— C1}$$

$$8 = 2(0.15 + R)$$

$$R = 4 - 0.15$$

$$= 3.85 \quad \text{— A1}$$

R = ... Ω [3]

(b) power of the generator

$$P = (20)(2) \quad \text{— C1}$$

$$= 40\ \text{W} \quad \text{— A1}$$

power = ...W [2]

(c) total rate of dissipation of electrical energy.

$$P = I^2R$$

$$= (2)^2(0.05 + 0.10 + 3.85) \quad \text{— C1}$$

$$= 16\ \text{W} \quad \text{— A1}$$

power = ... W [2]

(d) rate at which the battery stores chemical energy

$P = (12)(2)$ —— C1

$= 24\ W$ —— A1

power = …………………… W [2]

8 Certain types of nuclei may spontaneously lose a small amount of mass by the process known as radioactivity.

Describe the nature of the radiations which may be emitted during the process.

Alpha α, He^4_2 particle, + charge —— B1

Beta β, e^0_{-1} particle, - charge —— B1

γ-ray, electromagnet radiation, neutral —— B1

or other relevent points. [3]