

Answer **all** the questions in the spaces provided.

- 1 (a) The diameter d of a cylinder is measured as $0.0125 \text{ m} \pm 1.6\%$.

Calculate the absolute uncertainty in this measurement.

absolute uncertainty = m [1]

- (b) The cylinder in (a) stands on a horizontal surface. The pressure p exerted on the surface by the cylinder is given by

$$p = \frac{4W}{\pi d^2}.$$

The measured weight W of the cylinder is $0.38 \text{ N} \pm 2.8\%$.

- (i) Calculate the pressure p .

$p = \dots\dots\dots \text{Nm}^{-2}$ [1]

- (ii) Determine the absolute uncertainty in the value of p .

absolute uncertainty = Nm^{-2} [2]

[Total: 4]

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

.....
[1]

- (b) A car of mass 850 kg tows a trailer in a straight line along a horizontal road, as shown in Fig. 2.1.

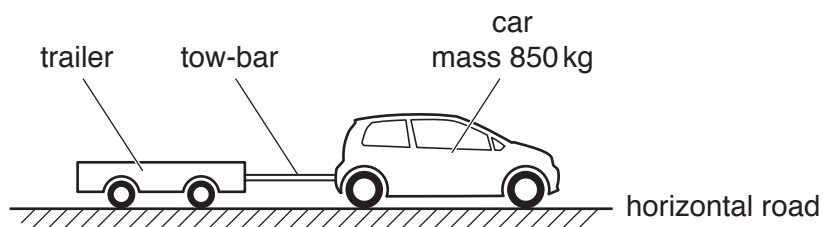


Fig. 2.1

The car and the trailer are connected by a horizontal tow-bar.

The variation with time t of the velocity v of the car for a part of its journey is shown in Fig. 2.2.

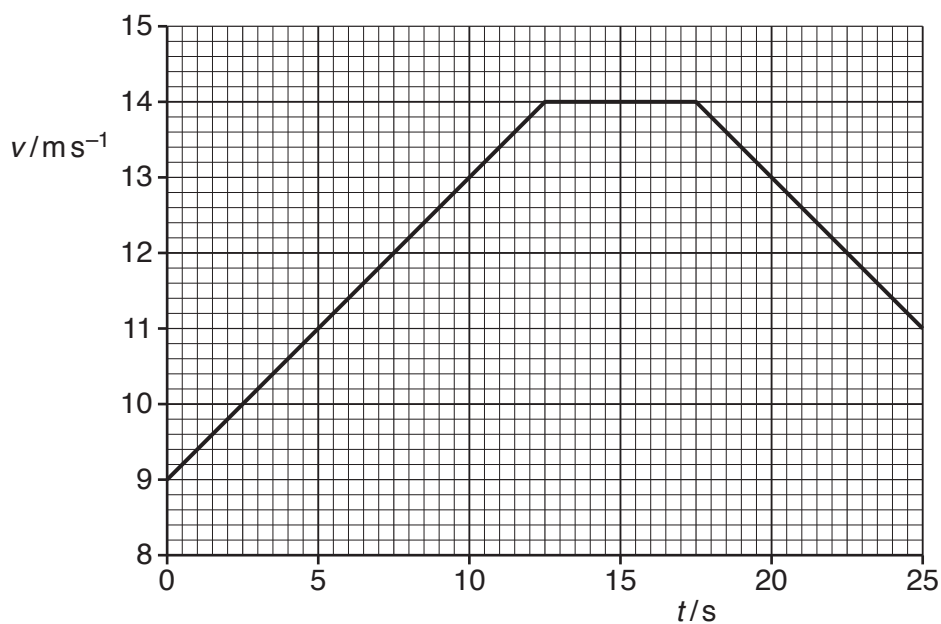


Fig. 2.2

- (i) Calculate the distance travelled by the car from time $t = 0$ to $t = 10$ s.

distance = m [2]

- (ii) At time $t = 10$ s, the resistive force acting on the car due to air resistance and friction is 510 N. The tension in the tow-bar is 440 N.

For the car at time $t = 10$ s:

1. use Fig. 2.2 to calculate the acceleration

acceleration = ms^{-2} [2]

2. use your answer to calculate the resultant force acting on the car

resultant force = N [1]

3. show that a horizontal force of 1300 N is exerted on the car by its engine

[1]

4. determine the useful output power of the engine.

output power = W [2]

- (c) A short time later, the car in (b) is travelling at a constant speed and the tension in the tow-bar is 480 N.

The tow-bar is a solid metal rod that obeys Hooke's law. Some data for the tow-bar are listed below.

$$\text{Young modulus of metal} = 2.2 \times 10^{11} \text{ Pa}$$

$$\text{original length of tow-bar} = 0.48 \text{ m}$$

$$\text{cross-sectional area of tow-bar} = 3.0 \times 10^{-4} \text{ m}^2$$

Determine the extension of the tow-bar.

$$\text{extension} = \dots\dots\dots \text{ m [3]}$$

- (d) The driver of the car in (b) sees a pedestrian standing directly ahead in the distance. The driver operates the horn of the car from time $t = 15 \text{ s}$ to $t = 17 \text{ s}$. The frequency of the sound heard by the pedestrian is 480 Hz. The speed of the sound in the air is 340 m s^{-1} .

Use Fig. 2.2 to calculate the frequency of the sound emitted by the horn.

$$\text{frequency} = \dots\dots\dots \text{ Hz [2]}$$

[Total: 14]

- 3 (a) State what is meant by the *centre of gravity* of a body.

.....
[1]

- (b) A uniform square sign with sides of length 0.68 m is fixed at its corner points A and B to a wall. The sign is also supported by a wire CD, as shown in Fig. 3.1.

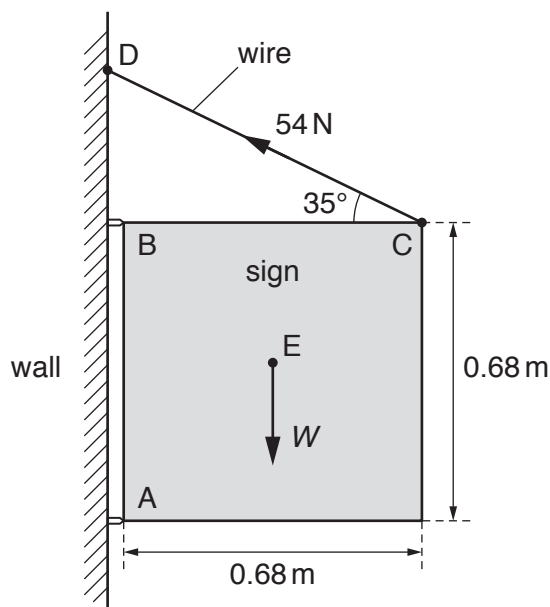


Fig. 3.1 (not to scale)

The sign has weight W and centre of gravity at point E. The sign is held in a vertical plane with side BC horizontal. The wire is at an angle of 35° to side BC. The tension in the wire is 54 N.

The force exerted on the sign at B is only in the vertical direction.

- (i) Calculate the vertical component of the tension in the wire.

vertical component of tension = N [1]

- (ii) Explain why the force on the sign at B does not have a moment about point A.

.....
[1]

- (iii) By taking moments about point A, show that the weight W of the sign is 150 N.

[2]

- (iv) Calculate the total vertical force exerted by the wall on the sign at points A and B.

total vertical force = N [1]

- (c) The sign in (b) is held together by nuts and bolts. One of the nuts falls vertically from rest through a distance of 4.8 m to the pavement below. The nut lands on the pavement with a speed of 9.2 m s^{-1} .

Determine, for the nut falling from the sign to the pavement, the ratio

$$\frac{\text{change in gravitational potential energy}}{\text{final kinetic energy}}.$$

ratio = [4]

[Total: 10]

- 4 (a) For a progressive water wave, state what is meant by:

(i) *displacement*

.....
.....[1]

(ii) *amplitude*.

.....
.....[1]

- (b) Two coherent waves X and Y meet at a point and superpose. The phase difference between the waves at the point is 180° . Wave X has an amplitude of 1.2 cm and intensity I . Wave Y has an amplitude of 3.6 cm.

Calculate, in terms of I , the resultant intensity at the meeting point.

intensity = [2]

- (c) (i) Monochromatic light is incident on a diffraction grating. Describe the diffraction of the light waves as they pass through the grating.

.....
.....
.....[2]

- (ii) A parallel beam of light consists of two wavelengths 540 nm and 630 nm. The light is incident normally on a diffraction grating. Third-order diffraction maxima are produced for each of the two wavelengths. No higher orders are produced for either wavelength.

Determine the smallest possible line spacing d of the diffraction grating.

$$d = \dots\dots\dots \text{ m [3]}$$

- (iii) The beam of light in (c)(ii) is replaced by a beam of blue light incident on the same diffraction grating.

State and explain whether a third-order diffraction maximum is produced for this blue light.

.....
.....
.....[2]

[Total: 11]

- 5 (a) State Kirchhoff's second law.

.....
[2]

- (b) A battery of electromotive force (e.m.f.) 5.6 V and internal resistance r is connected to two external resistors, as shown in Fig. 5.1.

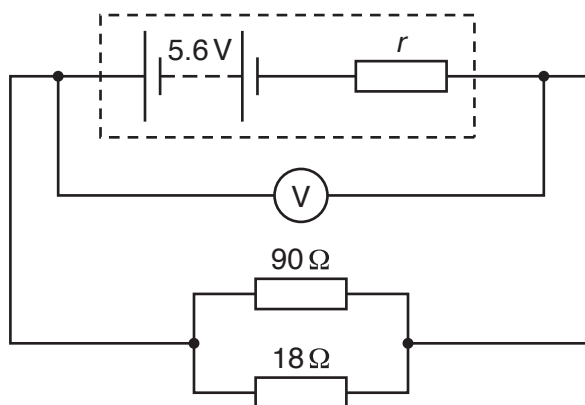


Fig. 5.1

The reading on the voltmeter is 4.8 V .

- (i) Calculate:

1. the combined resistance of the two resistors connected in parallel

combined resistance = Ω [2]

2. the current in the battery.

current = A [2]

- (ii) Show that the internal resistance r is 2.5Ω .

[2]

(iii) Determine the ratio

$$\frac{\text{power dissipated by internal resistance } r}{\text{total power produced by battery}}.$$

ratio = [3]

- (c) The battery in (b) is now connected to a battery of e.m.f. 7.2 V and internal resistance 3.5 Ω . The new circuit is shown in Fig. 5.2.

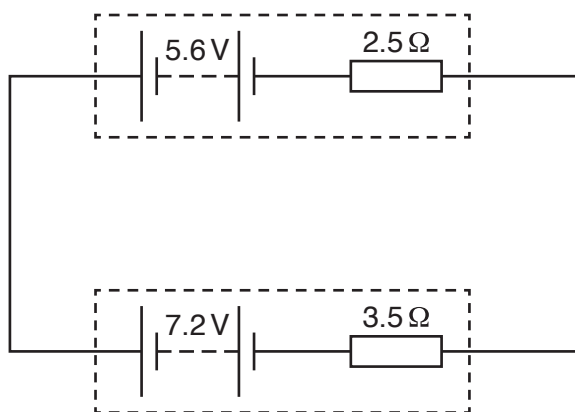


Fig. 5.2

Determine the current in the circuit.

current = A [2]

[Total: 13]

- 6 (a) State what is meant by a *field line* (*line of force*) in an electric field.

.....
[1]

- (b) An electric field has two different regions X and Y. The field strength in X is less than that in Y. Describe a difference between the pattern of field lines (lines of force) in X and in Y.

.....
[1]

- (c) A particle P has a mass of 0.15 u and a charge of $-1e$, where e is the elementary charge.

- (i) Particle P and an α -particle are in the same uniform electric field. Calculate the ratio

$$\frac{\text{magnitude of acceleration of particle P}}{\text{magnitude of acceleration of } \alpha\text{-particle}} .$$

ratio = [3]

- (ii) Particle P is a hadron composed of only two quarks. One of them is a down (d) quark.

By considering charge, determine a possible type (flavour) of the other quark.
 Explain your working.

.....
[3]

[Total: 8]

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