2: Motion – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
2	2017	June	21
3	2017	March	22
5	2017	March	22

The mark scheme for each question is provided at the end of the document.

2 **(a)** State the two conditions for a system to be in equilibrium.

1. ....

....

2. ....

.... [2]

(b) A paraglider P of mass 95 kg is pulled by a wire attached to a boat, as shown in Fig. 2.1.

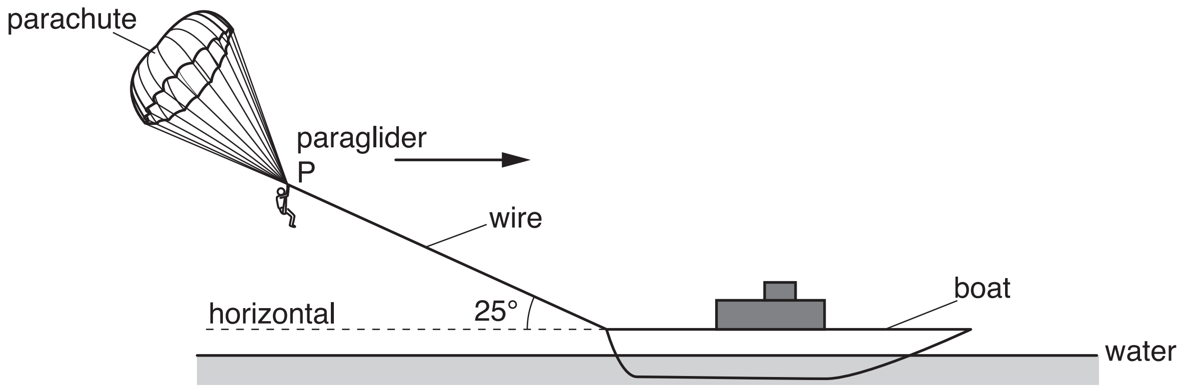

Fig. 2.1

The wire makes an angle of 25° with the horizontal water surface. P moves in a straight line parallel to the surface of the water.

The variation with time t of the velocity v of P is shown in Fig. 2.2.

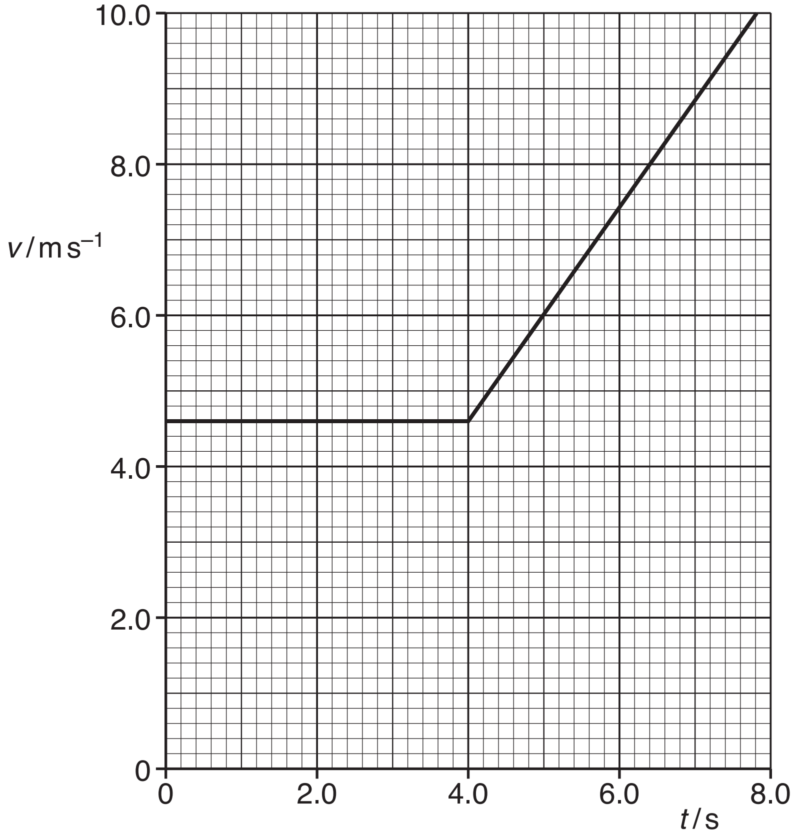

Fig. 2.2

(i) Show that the acceleration of P is 1.4 $m\,s^{-2}$ at time $t = 5.0\,s$.

[2]

(ii) Calculate the total distance moved by P from time $t = 0$ to $t = 7.0\,s$.

distance = ... m [2]

(iii) Calculate the change in kinetic energy of P from time $t = 0$ to $t = 7.0\,s$.

change in kinetic energy = ... J [2]

(iv) The tension in the wire at time $t = 5.0\,s$ is 280 N.

Calculate, for the horizontal motion,

1. the vertical lift force F supporting P,

F = ... N [3]

2. the force R due to air resistance acting on P in the horizontal direction.

R = ... N [3]

[Total: 14]

3 **(a)** Define *velocity*.

....

....[1]

(b) A car travels in a straight line up a slope, as shown in Fig. 3.1.

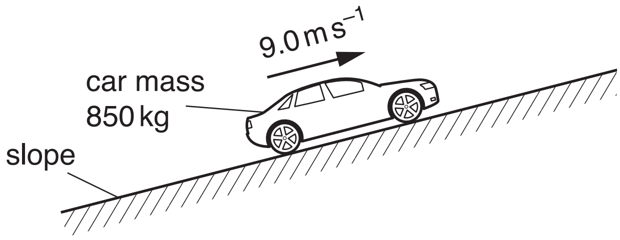

Fig. 3.1

The car has mass 850 kg and travels with a constant speed of $9.0\,\mathrm{m\,s^{-1}}$. The car's engine exerts a force on the car of 2.0 kN up the slope.

A resistive force F_D, due to friction and air resistance, opposes the motion of the car.

The variation of F_D with the speed v of the car is shown in Fig. 3.2.

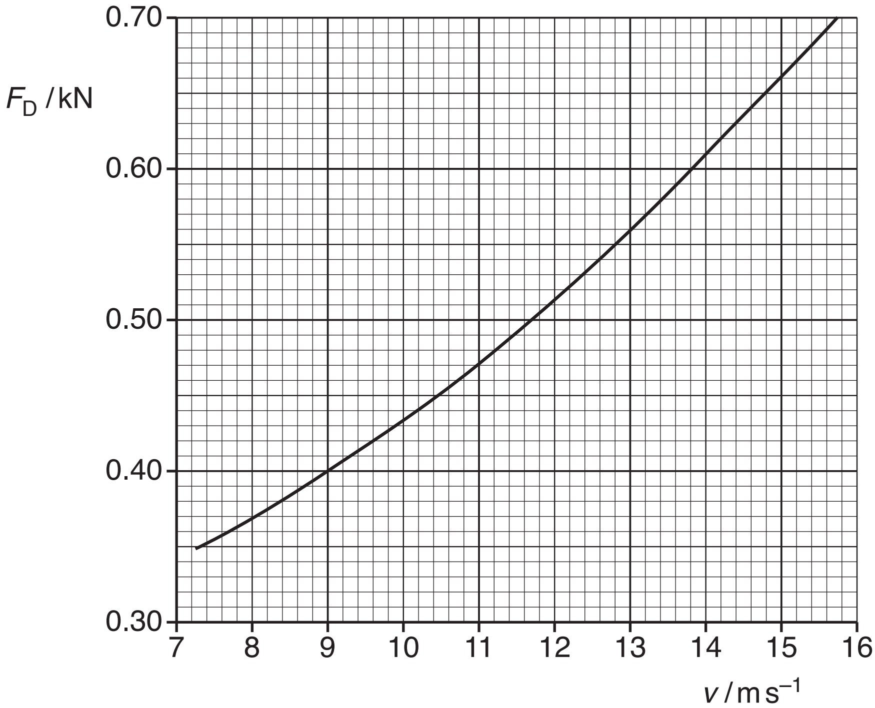

Fig. 3.2

(i) State and explain whether the car is in equilibrium as it moves up the slope.

....

....

....[2]

(ii) Consider the forces that act along the slope. Use data from Fig. 3.2 to determine the component of the weight of the car that acts down the slope.

component of weight = ... N [2]

(iii) Show that the power output of the car is 1.8×10^4 W.

[2]

(iv) The car now travels along horizontal ground. The output power of the car is maintained at 1.8×10^4 W. The variation of the resistive force F_D acting on the car is given in Fig. 3.2.

Calculate the acceleration of the car when its speed is $15\,\mathrm{m\,s^{-1}}$.

acceleration = ...$\mathrm{m\,s^{-2}}$ [3]

[Total: 10]

5 An electron is travelling in a straight line through a vacuum with a constant speed of $1.5 \times 10^7\,\mathrm{m\,s^{-1}}$.

The electron enters a uniform electric field at point A, as shown in Fig. 5.1.

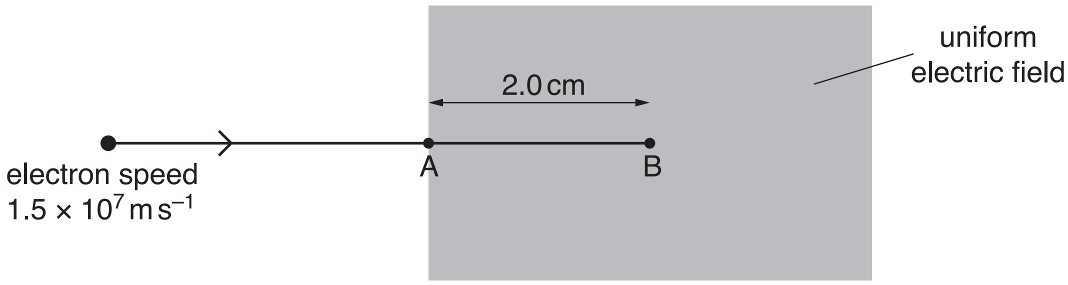

Fig. 5.1

The electron continues to move in the same direction until it is brought to rest by the electric field at point B. Distance AB is 2.0 cm.

(a) State the direction of the electric field.

....[1]

(b) Calculate the magnitude of the deceleration of the electron in the field.

deceleration = ... $\mathrm{m\,s^{-2}}$ [2]

(c) Calculate the electric field strength.

electric field strength = ... $\mathrm{V\,m^{-1}}$ [3]

(d) The electron is at point A at time $t = 0$.

On Fig. 5.2, sketch the variation with time t of the velocity v of the electron until it reaches point B. Numerical values of v and t do not need to be shown.

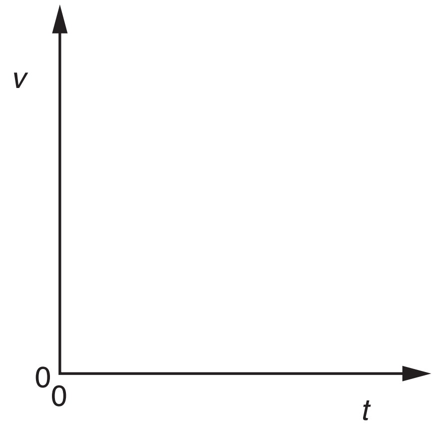

Fig. 5.2

[1]

[Total: 7]

Question	Answer	Marks
2 (a)	resultant force (in any direction) is zero	**1**
	resultant torque/moment (about any point) is zero	**1**
2 (b) (i)	$a = (v - u) / t$ **or** gradient **or** $\Delta v / (\Delta) t$	**1**
	e.g. a = (8.8 – 4.6) / (7.0 – 4.0) = 1.4 m s^{-2}	**1**
2 (b) (ii)	s = 4.6 × 4 + [(8.8 + 4.6) / 2] × 3	**1**
	= 18.4 + 20.1 = 39 (38.5) m	**1**
2 (b) (iii)	ΔE = ½ × 95 [$(8.8)^2$ – $(4.6)^2$]	**1**
	= 3678 – 1005 = 2700 (2673) J	**1**
2 (b) (iv) 1	weight = 95 × 9.81 (= 932 N)	**1**
	vertical tension force = 280 sin 25° **or** 280 cos 65° (=118.3 N)	**1**
	F = 932 + 118 = 1100 (1050) N	**1**
2 (b) (iv) 2	horizontal tension force = 280 cos 25° **or** 280 sin 65° (= 253.8 N)	**1**
	resultant force = 95 × 1.4 (= 133 N)	**1**
	133 = 253.8 – R R = 120 (120.8) N	**1**
		Total: 14
3 (a)	change of displacement / time (taken)	**1**
3 (b) (i)	constant velocity, so resultant force is zero	**1**
	(so car is) in (dynamic) equilibrium	**1**
3 (b) (ii)	F_D = 0.40 (kN) or 0.40 × 10^3 (N)	**1**
	component of weight = 2.0 × 10^3 – 0.40 × 10^3 = 1.6 × 10^3 N	**1**
3 (b) (iii)	$P = Fv$	**1**
	= 2.0 × 10^3 × 9.0 = 1.8 × 10^4 W	**1**
3 (b) (iv)	(driving) force = 1.8 × 10^4 / 15 (= 1.2 × 10^3)	**1**
	F_D = 0.66 (kN) or 0.66 × 10^3 (N)	**1**
	acceleration = (1.2 × 10^3 – 0.66 × 10^3) / 850 = 0.64 (0.635) m s^{-2}	**1**
		Total: 10

Question	Answer	Marks
5 (a)	to the right / from the left / from A to B / in the same direction as electron velocity	**1**
5 (b)	$v^2 = u^2 + 2as$ a = (1.5 × 107)^2 / (2 × 2.0 × 10^{-2}) Other alternative calculations for this mark: e.g. a = 1.5×10^7 / 2.67×10^{-9} e.g. a = [(1.5×10^7 × 2.67×10^{-9}) – 2.0×10^{-2}] × [2 / (2.67×10^{-9})^2] e.g. a = (2.0×10^{-2} × 2) / (2.67×10^{-9})^2	**1**
	= 5.6 × 10^{15} m s^{-2}	**1**
5 (c)	$E = F / Q$	**1**
	= (9.1 × 10^{-31} × 5.6 × 10^{15}) / 1.6 × 10^{-19}	**1**
	= 3.2 × 104 V m–1	**1**
5 (d)	straight line with negative gradient starting at an intercept on the v-axis and ending at an intercept on the t-axis.	**1**
		Total: 7

Notes about the mark scheme are available separately.