

Mechanics 4 – Forces: Solutions

Section 1

- $a = 41.7 \text{ ms}^{-2}$ (3sf), $t = 2.4 \text{ s}$
 - $t = 5 \text{ s}$, $s = 30 \text{ m}$
 - $u = 42 \text{ ms}^{-1}$, $a = -3 \text{ ms}^{-2}$
 - $v = 14 \text{ ms}^{-1}$, $t = 10 \text{ s}$
- Initial speed = 8 ms^{-1} and speed after one minute = 23 ms^{-1}
- Using $u = 10$, $v = -14.5$ and $a = -g$ and then $v^2 = u^2 + 2as$, distance = 5.63 m (3sf)
- Use the journey from A to B to set up one equation and the journey from A to C to set up another (u and a being the same in both). So $110 = 10u + 50a$ and $690 = 30u + 450a$, leading to (a) Acceleration = 1.2 ms^{-2} (b) Speed at B = 17 ms^{-1} (c) Time = 40 s

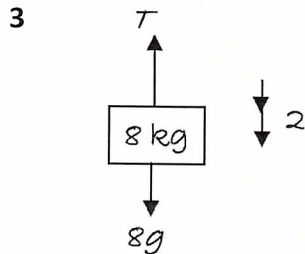
Section 2

- vertically downwards: $10g - X = 10a$
 $X = 10 \times 9.8 - 10 \times 4 = 58 \text{ N}$ ✓
 - vertically upwards: $X - 10g = 10a$
 $X = 10 \times 9.8 + 10 \times 4 = 138 \text{ N}$ ✓
 - vertically upwards: $X - 10g = 0$
 $X = 10 \times 9.8 = 98 \text{ N}$
 Horizontally: $Y = 10a = 10 \times 4 = 40 \text{ N}$ ✓
 - vertically downwards: $mg - 20 = ma$
 $9.8m - 20 = 4m$
 $5.8m = 20$ ✓
 $m = 3.45 \text{ kg}$ (3 s.f.) ✓
 - vertically upwards: $196 - mg = ma$
 $196 - 9.8m = 4m$
 $13.8m = 196$ ✓
 $m = 14.2 \text{ kg}$ (3 s.f.) ✓

(3 + 3 + 5 + 4 + 4 = 19 marks)

- 2 $F = ma$
 $40 = 2m$ ✓
 $m = 20$
 The value of m is 20. ✓

(2 marks)



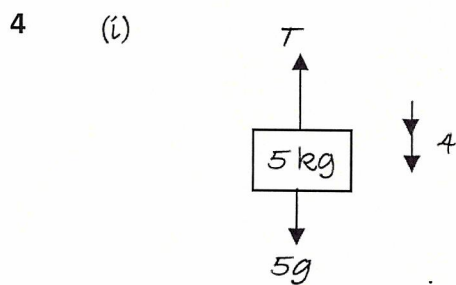
$$F = ma$$

$$8g - T = 8 \times 2$$

$$T = 8 \times 9.8 - 16 = 62.4$$

The tension is 62.4 N. ✓

(3 marks)



$$F = ma$$

$$5g - T = 5 \times 4$$

$$T = 5 \times 9.8 - 20 = 29$$

The tension is 29 N. ✓

(ii) The pail is moving at constant speed, so the acceleration is zero.



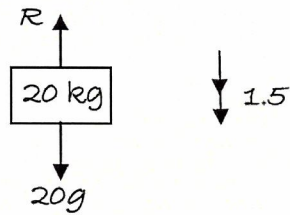
$$15g - T = 0$$

$$T = 15 \times 9.8 = 147$$

The tension is 147 N. ✓

(3 + 3 = 6 marks)

5 First stage: acceleration



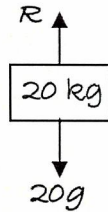
$$F = ma$$

$$20g - R = 20 \times 1.5$$

$$R = 20 \times 9.8 - 20 \times 1.5 = 166$$

The reaction force is 166N. ✓

Second stage: constant speed (so acceleration is zero)

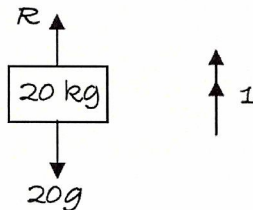


$$20g - R = 0$$

$$R = 20 \times 9.8 = 196$$

The reaction force is 196N. ✓

Third stage: retardation (i.e. negative acceleration)



$$F = ma$$

$$R - 20g = 20 \times 1$$

$$R = 20 \times 9.8 + 20 \times 1 = 216$$

The reaction force is 216N. ✓

(3 + 3 + 3 = 9 marks)

6

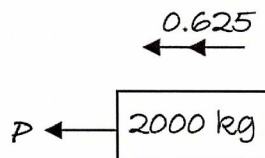
$$90 \text{ kmh}^{-1} = \frac{90000}{3600} = 25 \text{ ms}^{-1}$$

$$s = 500 \quad v^2 = u^2 + 2as \quad \checkmark$$

$$u = 25 \quad 0 = 25^2 + 2a \times 500 \quad \checkmark$$

$$v = 0 \quad 1000a = -625$$

$$a = ? \quad a = -0.625 \quad \checkmark$$



$$F = ma$$

$$P = 2000 \times 0.625 = 1250 \quad \checkmark$$

$$v = u + at \quad \checkmark$$

$$0 = 25 - 0.625t \quad \checkmark$$

$$t = 40$$

It takes 40 seconds to come to rest. ✓

(9 marks)

7. (a) $X - 250 = 5 \times 0$
 $X = 250 \text{ N}$
- (b) $X - 250 = 5 \times 2$
 $X = 260 \text{ N}$
- (c) $s = 2, u = 0, v = ?, a = ?, t = 0.5$
 $s = ut + \frac{1}{2}at^2$
 $2 = 0.5 \times a \times 0.5^2$
 $a = 16$
 $X - 250 = 5 \times 16$
 $X = 330 \text{ N}$

(3 + 3 + 6 = 12 marks)

(Total 60 Marks)

SECTION 3

Question Number	Scheme	Marks
•	(a) $16^2 = 20^2 - 2 \times a \times 24 \Rightarrow a = \underline{3 \text{ m s}^{-2}}$	M1 A1 (2)
	(b) $v^2 = 20^2 - 2 \times 3 \times 30$ $v = \underline{\sqrt{220} \text{ or } 14.8 \text{ m s}^{-1}}$	M1 A1√ A1 (3)
	(c) $0.3 = m \times 3 \Rightarrow m = 0.1 \text{ kg } (*)$	M1 A1 (2)