1

(a)

- Use $s = ut + \frac{1}{2}at^2$ with $s = 3, u = 0, t = 2.5$ **M1**
- $3 = \frac{1}{2}a(2.5)^2$ **M1**
- $a = \frac{3}{3.125} = 0.96 \text{ ms}^{-2}$ **A1**

(b)

- Equation of motion for A: $2g - T = 2a$ **M1**
- $T = 2(9.8) - 2(0.96) = 17.68$ **A1**
- Equation of motion for B: $T - mg = ma$ **M1**
- $17.68 = m(0.96 + 9.8)$ **M1**
- $m = \frac{17.68}{10.76} = 1.643...$ **A1**
- $m = 1.64 \text{ kg}$ **A1**

(c)

- The acceleration of both particles is the same. **B1**

(Total for question 1 is 10 marks)

2

(a)

- For B: $4g - T = 4a$ **M1**
- For A: $T = 5a$ **M1**
- Substitute $a = T/5$ into B's equation: $4g - T = 4(T/5)$ **M1**
- $20g - 5T = 4T \Rightarrow 9T = 20g \Rightarrow T = \frac{20}{9}g$ **A1**

(b)

- Find acceleration: $a = T/5 = \frac{4}{9}g$ **M1**
- Use $s = ut + \frac{1}{2}at^2$ with $s = 1.4, u = 0$ **M1**
- $1.4 = \frac{1}{2}(\frac{4}{9}g)t^2$ **M1**
- $t^2 = \frac{2.8 \times 9}{4g} = \frac{25.2}{39.2} = 0.6428...$ **M1**
- $t = 0.80$ seconds **A1**

(Total for question 2 is 9 marks)

3

(a)

- Total force = $1600 - 250 - 100 = 1250$ **M1**
- Total mass = $750 + 300 = 1050$ **M1**
- $a = 1250/1050 = 1.19 \text{ ms}^{-2}$ **A1**

(b)

- Equation for trailer: $T - 100 = 300(1.19)$ **M1**
- $T = 100 + 357.14...$ **M1**
- $T = 457 \text{ N}$ **A1**

(c)

- For trailer: $-80 - 100 = 300a$ **M1**
- $a = -180/300 = -0.6 \text{ ms}^{-2}$ **A1**
- For car: $80 - 250 - F = 750a$ **M1**
- $80 - 250 - F = 750(-0.6)$ **M1**
- $-170 - F = -450$ **M1**
- $F = 450 - 170$ **M1**
- $F = 280 \text{ N}$ **A1**

(Total for question 3 is 13 marks)

4

(a)

- $2380 - 630 - 280 = (1400 + 700)a$ **M1**
- $1470 = 2100a$ **M1**
- $a = 0.7 \text{ ms}^{-2}$ **A1**

(b)

- For trailer: $T - 280 = 700(0.7)$ **M1**
- $T = 280 + 490$ **M1**
- $T = 770 \text{ N}$ **A1**

(c)

- The mass is concentrated at a single point and rotational forces have been ignored. **B1**

(d)

- New acceleration for car: $2380 - 630 = 1400a$ **M1**
- $a = 1750/1400 = 1.25 \text{ ms}^{-2}$ **A1**
- Use $s = ut + \frac{1}{2}at^2$ with $u = 12, t = 4, a = 1.25$ **M1**
- $s = 12(4) + \frac{1}{2}(1.25)(4^2)$ **M1**
- $s = 48 + 10$ **M1**
- $s = 58 \text{ m}$ **A1**

(Total for question 4 is 13 marks)

5

(a)
- $30 - 4 - 2 = (4 + 6)a$ **M1**
- $24 = 10a$ **M1**
- $a = 2.4 \text{ ms}^{-2}$ **A1**

(b)
- $v = u + at$ **M1**
- $v = 0 + 2.4(5) = 12 \text{ ms}^{-1}$ **A1**

(c)
- For P: $T - 2 = 4(2.4)$ **M1**
- $T = 2 + 9.6$ **M1**
- $T = 11.6 \text{ N}$ **A1**

(d)
- New acceleration: $-4 - 2 = 10a \Rightarrow a = -0.6 \text{ ms}^{-2}$ **M1**
- $v^2 = u^2 + 2as$ with $v = 0, u = 12, a = -0.6$ **M1**
- $0 = 12^2 + 2(-0.6)s$ **M1**
- $1.2s = 144 \Rightarrow s = 120 \text{ m}$ **A1**

(e)
- For Q: $T - 4 = 6(-0.6)$ **M1**
- $T = 4 - 3.6$ **M1**
- $T = 0.4 \text{ N}$ **A1**

(Total for question 5 is 15 marks)

6
- Sum of i components = 0: $3 - 2 + 4q = 0$ **M1**
- $4q = -1 \Rightarrow q = -1/4$ **A1**
- Sum of j components = 0: $2p + 5 + 5 = 0$ **M1**
- $2p = -10 \Rightarrow p = -5$ **A1**

(Total for question 6 is 4 marks)

7

(a)
- $\tan\theta = 5/3 \Rightarrow \theta = 59.03...^\circ$ **M1**
- Angle with positive i-axis = $180 - 59 = 121^\circ$ **A1**

(b)
- $F = 0.8(-3\mathbf{i} + 5\mathbf{j}) = -2.4\mathbf{i} + 4\mathbf{j}$ **M1**
- $|F| = \sqrt{(-2.4)^2 + 4^2}$ **M1**
- $|F| = 4.66 \text{ N}$ **A1**

(Total for question 7 is 5 marks)

8

(a)
- $\mathbf{a} = (\mathbf{v} - \mathbf{u})/t = ((7\mathbf{i} + 2\mathbf{j}) - (-2\mathbf{i} + 6\mathbf{j}))/4$ **M1**
- $\mathbf{a} = (9\mathbf{i} - 4\mathbf{j})/4 = 2.25\mathbf{i} - \mathbf{j}$ **A1**
- $|a| = \sqrt{2.25^2 + (-1)^2} = 2.46 \text{ ms}^{-2}$ **A1**

(b)
- F is in the same direction as a. **M1**
- $\tan\theta = 1/2.25$ **M1**
- $\theta = 24.0^\circ$ **A1**

(Total for question 8 is 6 marks)

9
- $2p + 3q = 1$ **M1**
- $4p - 4q = -14 \Rightarrow 2p - 2q = -7$ **M1**
- Subtract equations: $5q = 8 \Rightarrow q = 8/5 = 1.6$ **M1**
- $2p + 3(1.6) = 1 \Rightarrow 2p = -3.8 \Rightarrow p = -1.9$ **A1**
- $p = -19/10, q = 8/5$ **A1**

(Total for question 9 is 5 marks)

10

(a)
- $|v| = \sqrt{4^2 + (-1)^2}$ **M1**
- $|v| = \sqrt{17} = 4.12 \text{ ms}^{-1}$ **A1**

(b)
- $\tan\theta = 1/4 \Rightarrow \theta = 14.03...^\circ$ **M1**
- Bearing = $90 + 14 = 104^\circ$ **A2**

(Total for question 10 is 5 marks)

11
- $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ **M1**
- $(-5\mathbf{i} + 2\mathbf{j}) = \mathbf{u} + 3(3\mathbf{i} - 4\mathbf{j})$ **M1**
- $\mathbf{u} = (-5\mathbf{i} + 2\mathbf{j}) - (9\mathbf{i} - 12\mathbf{j})$ **M1**
- $\mathbf{u} = -14\mathbf{i} + 14\mathbf{j}$ **A1**
- $u = \sqrt{(-14)^2 + 14^2} = 19.8$ **A1**

(Total for question 11 is 5 marks)

12
- Resultant $R = (3 + p)\mathbf{i} + (-2 + 2p)\mathbf{j}$ **M1**
- Parallel to $\mathbf{i} + \mathbf{j}$ means i-component = j-component **M1**
- $3 + p = -2 + 2p$ **M1**
- $p = 5$ **A2**

(Total for question 12 is 5 marks)

13

(a)

- The string is inextensible. **B1**

(b)

- For A: $5mg - T = 5m(3/4g)$ **M1**
- $T = 5mg - 15/4mg$ **M1**
- $T = 5/4mg$ **A1**

(c)

- For B: $T - kmg = km(3/4g)$ **M1**
- $5/4mg - kmg = 3/4kmg$ **M1**
- $5/4 = 7/4k \Rightarrow k = 5/7$ **A1**

(Total for question 13 is 7 marks)

14

(a)

- For B: $1.8g - T = 1.8a$ **M1**
- For A: $T = 1.4a$ **M1**
- $1.8g = 3.2a$ **M1**
- $a = 1.8g/3.2 = 9/16g$ **M1**
- $a = 5.5$ ms^{-2} (2sf) **A1**

(b)

- Phase 1 (B falling): $s = 0.6, u = 0, a = 9/16g$ **M1**
- $0.6 = 1/2(9/16g)t_1^2 \Rightarrow t_1 = 0.467...$ s **A1**
- Velocity when B hits floor: $v = at_1 = (9/16g)(0.467) = 2.57...$ ms^{-1} **M1**
- Phase 2 (A moving alone): $s = 1.5 - 0.6 = 0.9, v = 2.57, a = 0$ **M1**
- $t_2 = 0.9/2.57 = 0.35$ s **M1**
- Total time = $0.47 + 0.35 = 0.82$ seconds **A1**

(c)

- The table would not be completely smooth. **B1**

(Total for question 14 is 12 marks)

15

(a)

- For A: $3g - T = 3a$ **M1**
- For B: $T - 2g = 2a$ **M1**
- $a = (3g - T)/3$ and $a = (T - 2g)/2$ **M1**
- $2(3g - T) = 3(T - 2g)$ **M1**
- $6g - 2T = 3T - 6g$ **M1**
- $5T = 12g \Rightarrow T = 12g/5$ **A1**
- Force on pulley = $2T$ **M1**
- Force = $24g/5$ N **A1**

(b)

- The string would not be light or inextensible. **B1**

(Total for question 15 is 9 marks)