

- 1
- (a)
- Resolves forces vertically: $R_A = 20g$ (M1)
 - Uses $F = \mu R$: $F = 0.4 \times 20g = 8g$ N (A1)
- (b)
- Resolves forces horizontally: $R_B = F = 8g$ (B1)
 - Takes moments about A: $2.5 \times 20g \cos \theta = 5R_B \sin \theta$ (M1)
 - Substitutes R_B : $50g \cos \theta = 40g \sin \theta$ (M1)
 - Simplifies to $\tan \theta = 1.25$ (A1)
 - Final answer $\theta = 51.3^\circ$ (A1)
- (Total for question 1 is 7 marks)

- 2
- (a)
- Takes moments about A: $1(3g) = 2(T \sin \theta)$ (M1)
 - Finds $\sin \theta = \frac{1.5}{2.5} = \frac{3}{5}$ (B1)
 - Solves for T : $3g = \frac{6}{5}T \Rightarrow T = 2.5g$ N (A1)
- (b)
- Resolves vertically: $T \sin \theta + R_V = 3g \Rightarrow R_V = 1.5g$ (M1)
 - Resolves horizontally: $R_H = T \cos \theta = 2.5g \times 0.8 = 2g$ (M1)
 - Calculates magnitude: $\sqrt{(1.5g)^2 + (2g)^2} = 2.5g$ (M1)
 - Calculates direction: $\tan \phi = \frac{1.5g}{2g} = 0.75 \Rightarrow \phi = 36.9^\circ$ (M1)
 - Final magnitude $2.5g$ N (A1)
 - Final direction 36.9° above horizontal (A1)
- (Total for question 2 is 9 marks)

- 3
- Takes moments about A: $3 \times 10g \cos \theta = 4R_C$ (M1)
 - Finds $\cos \theta = \frac{5}{\sqrt{29}}$ and $\sin \theta = \frac{2}{\sqrt{29}}$ (B1)
 - Calculates $R_C = \frac{30g \times 5}{4\sqrt{29}} \approx 68.2$ N (A1)
 - Resolves vertically: $R_A + R_C \cos \theta = 10g \Rightarrow R_A = 10g - 68.2(\frac{5}{\sqrt{29}}) \approx 34.6$ N (M1)
 - Resolves horizontally: $\mu R_A = R_C \sin \theta$ (M1)
 - Substitutes values: $\mu(34.6) = 68.2(\frac{2}{\sqrt{29}})$ (M1)
 - Solves for μ : $\mu \approx 0.73$ (A1)
- (Total for question 3 is 9 marks)

4

- (a)
- Takes moments about A: $1(Mg) + 1.5(2Mg) = 2(T \sin \alpha)$ (M1)
 - Uses $\sin \alpha = 0.6$: $4Mg = 1.2T$ (M1)
 - Solves for T : $T = \frac{10}{3}Mg$ (A1)
- (b)
- Resolves horizontally: $R_H = T \cos \alpha = \frac{10}{3}Mg \times 0.8 = \frac{8}{3}Mg$ (M1)
 - Resolves vertically: $R_V + T \sin \alpha = 3Mg \Rightarrow R_V = 3Mg - 2Mg = Mg$ (M1)
 - Calculates angle: $\tan \theta = \frac{R_V}{R_H} = \frac{Mg}{8/3Mg} = \frac{3}{8}$ (M1)
 - Solves for θ : $\theta = 20.6^\circ$ (A1)
 - States direction: 20.6° above the horizontal (A1)

(Total for question 4 is 8 marks)

5

- (a)
- Takes moments about A: $\frac{1}{2}a(Mg) + x(3Mg) = a(5Mg \sin 30)$ (M1)
 - Simplifies: $0.5a + 3x = 2.5a$ (M1)
 - Solves for x : $3x = 2a \Rightarrow x = \frac{2}{3}a$ (A2)
- (b)
- Resolves horizontally: $R_H = 5Mg \cos 30 = \frac{5\sqrt{3}}{2}Mg$ (M1)
 - Resolves vertically: $R_V + 5Mg \sin 30 = 4Mg \Rightarrow R_V = 4Mg - 2.5Mg = 1.5Mg$ (M1)
 - Calculates $\tan \theta = \frac{R_V}{R_H} = \frac{1.5}{2.5\sqrt{3}}$ (M1)
 - Simplifies: $\tan \theta = \frac{3}{5\sqrt{3}} = \frac{\sqrt{3}}{5}$ (A1)
 - Note: Markscheme solution shows $R_V = 3.5Mg$ and $R_H = \frac{\sqrt{3}}{2}Mg$ leading to $\frac{7\sqrt{3}}{3}$.
Following the provided solution logic: $\tan \theta = \frac{7/2}{\sqrt{3}/2} = \frac{7}{\sqrt{3}} = \frac{7\sqrt{3}}{3}$ (A1)

(Total for question 5 is 9 marks)

6

- (a)
- Equation of motion for B : $3g - T = 3(2)$ (M1)
 - Solves for T : $T = 3g - 6$ (A1)
 - Final answer 23.4 N (A1)
- (b)
- Normal reaction $R = 2g \cos 40$ (B1)
 - Equation of motion for A : $T - \mu R - 2g \sin 40 = 2(2)$ (M1)
 - Substitutes T and R : $(3g - 6) - \mu(2g \cos 40) - 2g \sin 40 = 4$ (M1)
 - Solves for μ : $\mu \approx 0.45$ (A1)
- (c)
- Resultant force $F = 2T \cos(\frac{90-40}{2}) = 2T \cos 25$ (M1)
 - Substitutes T : $2(23.4) \cos 25$ (M1)
 - Final answer 42 N (A1)

(Total for question 6 is 9 marks)

7

- Normal reaction $R = 4g \cos \theta = 3.2g$ (B1)
- Equation for P : $T - 4g \sin \theta - 0.2(3.2g) = 4a \Rightarrow T - 3.04g = 4a$ (M1)
- Equation for Q : $5g - T = 5a$ (M1)
- Solves for a : $5g - (4a + 3.04g) = 5a \Rightarrow 1.96g = 9a \Rightarrow a = 2.13 \text{ m/s}^2$ (A1)
- Uses $v^2 = u^2 + 2as$: $v^2 = 0 + 2(2.13)(2)$ (M1)
- Solves for v : $v = 2.9 \text{ m/s}$ (A1)

(Total for question 7 is 9 marks)

8

- (a)
- Equation for P : $6g \sin 30 - T = 6a \Rightarrow 3g - T = 6a$ (M1)
 - Normal reaction for Q : $R = 2g \cos 45 = \sqrt{2}g$ (B1)
 - Equation for Q : $T - 0.3R - 2g \sin 45 = 2a \Rightarrow T - 1.3\sqrt{2}g = 2a$ (M1)
 - Eliminates a : $3g - T = 3(T - 1.3\sqrt{2}g)$ (M1)
 - Solves for T : $4T = 3g + 3.9\sqrt{2}g$ (M1)
 - Final answer $T = 21 \text{ N}$ (A2)
- (b)
- Substitutes T into equation for P : $a = \frac{3g-21}{6}$ (M1)
 - Calculates $a = 1.4 \text{ m/s}^2$ (A1)
 - Direction: P moves down the plane, Q moves up (B1)

(Total for question 8 is 9 marks)

9

- Finds $\cos \alpha = \frac{5}{13}$ and $\sin \alpha = \frac{12}{13}$ (B1)
- Takes moments about A: $2.5(10g \cos \alpha) = 4R_C$ (M1)
- Solves for R_C : $R_C = \frac{25g(5/13)}{4} = \frac{125g}{52} \approx 23.6 \text{ N}$ (A1)
- Resolves vertically: $R_A + R_C \cos \alpha = 10g \Rightarrow R_A = 10g - 23.6(\frac{5}{13}) \approx 88.9 \text{ N}$ (M1)
- Resolves horizontally: $\mu R_A = R_C \sin \alpha$ (M1)
- Substitutes values: $\mu(88.9) = 23.6(\frac{12}{13})$ (M1)
- Solves for μ : $\mu \approx 0.24$ (A2)

(Total for question 9 is 8 marks)

10

- (a)
- Equation for B: $3g - T = 3a$ (M1)
 - Normal reaction for A: $R = 2g \cos \theta = 1.6g$ (B1)
 - Friction for A: $F = \frac{5}{8}(1.6g) = g$ (B1)
 - Equation for A: $T - 2g \sin \theta - g = 2a \Rightarrow T - 2.2g = 2a$ (M1)
 - Eliminates a : $T - 2.2g = 2(\frac{3g-T}{3})$ (M1)
 - Solves for T : $3T - 6.6g = 6g - 2T \Rightarrow 5T = 12.6g$ (M1)
 - Final answer $T = \frac{63}{25}g$ or 24.7 N (A1)
- (b)
- Max friction $F_{max} = \mu R = g$ (B1)
 - Component of weight down plane $W_x = 2g \sin \theta = 1.2g$ (M1)
 - Since $1.2g > g$, the block will not remain at rest and will accelerate down the plane. (A1)
- (c)
- Include friction in the pulley (B1)
 - Model the string as having mass (not light) (B1)
 - Model the blocks as having dimensions (not particles) (B1)
 - Use a more accurate value for g (B1)

(Total for question 10 is 11 marks)