

1

(a) Resolving horizontally:

- $T \sin 25 = 20$ (M1)
- $T = \frac{20}{\sin 25} = 47.3 \text{ N}$ (A1)

(b) Resolving vertically:

- $T \cos 25 = W$ (M1)
- $W = 47.32... \times \cos 25$ (M1)
- $W = 42.9 \text{ N}$ (A1)

(Total for question 1 is 5 marks)

2

- (a)
- Resolving horizontally: $T_A \cos 50 = T_B \cos 35 \Rightarrow T_B = \frac{T_A \cos 50}{\cos 35}$ (M1)
 - Resolving vertically: $T_A \sin 50 + T_B \sin 35 = 10g$ (M1)
 - Substituting T_B : $T_A \sin 50 + \left(\frac{T_A \cos 50}{\cos 35}\right) \sin 35 = 10g$ (M1)
 - $T_A(\sin 50 + \cos 50 \tan 35) = 10g$ (M1)
 - $T_A = 81 \text{ N}$ (A1)

- (b)
- $T_B = \frac{80.58... \times \cos 50}{\cos 35}$ (M1)
 - $T_B = 63.1 \text{ N}$ (A1)
 - Final answer 63 N (2 sf) (A1)

(Total for question 2 is 8 marks)

3

- Resolving vertically: $R + F \sin 20 = 25g$ (M1)
- Resolving horizontally: $F \cos 20 = \mu R$ (M1)
- $F \cos 20 = 0.4(25g - F \sin 20)$ (M1)
- $F \cos 20 = 10g - 0.4F \sin 20$ (M1)
- $F(\cos 20 + 0.4 \sin 20) = 10g$ (M1)
- $F = \frac{10g}{\cos 20 + 0.4 \sin 20}$ (M1)
- $F = 91 \text{ N}$ (2 sf) (A2)

(Total for question 3 is 8 marks)

- 4
- Resolving perpendicular to plane: $R = 10 \cos 26$ (M1)
 - Resolving parallel to plane: $10 \sin 26 = \mu R$ (M1)
 - $\mu = \frac{10 \sin 26}{10 \cos 26}$ (M1)
 - $\mu = \tan 26$ (M1)
 - $\mu = 0.488$ (3 sf) (A4)

(Total for question 4 is 8 marks)

- 5
- $\tan \theta = 0.75 = \frac{3}{4} \Rightarrow \sin \theta = \frac{3}{5}, \cos \theta = \frac{4}{5}$ (B1)
 - Resolving perpendicular to plane: $R = 2g \cos \theta = 2g(\frac{4}{5}) = \frac{8}{5}g$ (M1)
 - Equation of motion parallel to plane: $2g \sin \theta - \mu R = 2a$ (M1)
 - $2g(\frac{3}{5}) - 0.2(\frac{8}{5}g) = 2a$ (M1)
 - $\frac{6}{5}g - \frac{8}{25}g = 2a$ (M1)
 - $\frac{22}{25}g = 2a$ (M1)
 - $a = \frac{11}{25}g$ or 4.31 ms^{-2} (A3)

(Total for question 5 is 9 marks)

- 6
- (a)
- Resolving perpendicular: $R = 10 \cos 30 = 5\sqrt{3}$ (M1)
 - Resolving parallel: $12 = 10 \sin 30 + \mu R$ (M1)
 - $12 = 5 + \mu(5\sqrt{3})$ (M1)
 - $7 = 5\sqrt{3}\mu$ (M1)
 - $\mu = \frac{7}{5\sqrt{3}}$ (M1)
 - $\mu = 0.808$ (3 sf) (A1)
- (b)
- Component of weight down plane = $10 \sin 30 = 5 \text{ N}$ (M1)
 - Max friction $F_{\max} = \mu R = 0.808 \times 5\sqrt{3} = 7 \text{ N}$ (M1)
 - Since $5 < 7$, the brick does not move (A1)

(Total for question 6 is 9 marks)

7

- (a)
- Resolving perpendicular: $R = 10 \cos 30 + 12 \sin 30$ (M1)
 - $R = 5\sqrt{3} + 6 = 14.66\dots$ (M1)
 - Resolving parallel: $12 \cos 30 = 10 \sin 30 + \mu R$ (M1)
 - $6\sqrt{3} = 5 + \mu(14.66\dots)$ (M1)
 - $10.39\dots = 5 + 14.66\dots\mu$ (M1)
 - $\mu = \frac{5.39\dots}{14.66\dots}$ (M1)
 - $\mu = 0.368$ (3 sf) (A1)
- (b)
- New $R = 10 \cos 30 = 5\sqrt{3}$ (M1)
 - Max friction $F_{max} = 0.368 \times 5\sqrt{3} = 3.19$ N (M1)
 - Weight component down plane $= 10 \sin 30 = 5$ N (M1)
 - Since $5 > 3.19$, the brick moves (accelerates down the plane) (A1)

(Total for question 7 is 11 marks)

8

- (a)
- Resolving vertically: $R + 20 \sin 25 = 12g$ (M1)
 - $R = 12(9.8) - 20 \sin 25 = 109.1\dots$ N (M1)
 - Equation of motion: $20 \cos 25 - \mu R = 12a$ (M1)
 - $20 \cos 25 - 0.1(109.1\dots) = 12a$ (M1)
 - $18.126\dots - 10.91\dots = 12a$ (M1)
 - $a = 0.60 \text{ ms}^{-2}$ (2 sf) (A1)
- (b)
- Pushing down increases the normal reaction force R ($R = 12g + 20 \sin 25$) (B1)
 - Since $F = \mu R$, the friction force increases, which reduces the resultant force and thus the acceleration (B1)

(Total for question 8 is 8 marks)

9

- (a)
- $\tan \alpha = \frac{5}{12} \Rightarrow \sin \alpha = \frac{5}{13}, \cos \alpha = \frac{12}{13}$ (B1)
 - Resolving perpendicular: $R = mg \cos \alpha = \frac{12}{13}mg$ (M1)
 - Equation of motion: $mg \sin \alpha - \mu R = ma$ (M1)
 - $mg(\frac{5}{13}) - \frac{2}{5}(\frac{12}{13}mg) = ma$ (M1)
 - $g(\frac{25}{65} - \frac{24}{65}) = a$ (M1)
 - $a = \frac{1}{65}g \text{ ms}^{-2}$ (A1)
- (b)
- The acceleration would be the same (B1)
 - Mass m cancels out from both sides of the $F = ma$ equation (B1)

(Total for question 9 is 8 marks)

10

- (a)
- Resolving perpendicular: $R = mg \cos \alpha$ (M1)
 - Resolving parallel: $\mu R = mg \sin \alpha$ (M1)
 - $0.15mg \cos \alpha = mg \sin \alpha$ (M1)
 - $0.15 = \tan \alpha$ (M1)
 - $\alpha = 8.5^\circ$ (1 dp) (A1)
- (b)
- The block moves with constant speed (0.4 ms^{-1}) (B1)
 - Because the forces are balanced (resultant force is zero) (B1)

(Total for question 10 is 7 marks)
