Edexcel Mechanics 1

Statics

Section 1: Forces and equilibrium

Solutions to Exercise

1. (i) Resolving vertically: $P\cos 30° - 10 = 0$

$\frac{1}{2}\sqrt{3}P = 10$

$P = \dfrac{20}{\sqrt{3}}$

Resolving horizontally: $X - P\sin 30 = 0$

$X = \frac{1}{2}P = \dfrac{10}{\sqrt{3}}$

(ii) Resolving horizontally: $6 + 8\cos\theta - 10 = 0$

$8\cos\theta = 4$

$\cos\theta = \frac{1}{2}$

$\theta = 60°$

Resolving vertically: $8\sin\theta - W = 0$

$W = 8\sin 60° = 4\sqrt{3}$

(iii) Resolving perpendicular to the plane:

$R - 30\cos 20° = 0$

$R = 30\cos 20° = 28.2$ (3 s.f.)

Resolving up the plane: $F - 30\sin 20° = 0$

$F = 30\sin 20° = 10.3$ (3 s.f)

(iv) Resolving up the plane: $T\cos\theta - 7 - 10\sin 30° = 0$

$T\cos\theta = 7 + 10 \times \frac{1}{2}$

$T\cos\theta = 12$ (1)

Resolving perpendicular to the plane:

$5 + T\sin\theta - 10\cos 30° = 0$

$T\sin\theta = 10 \times \frac{1}{2}\sqrt{3} - 5$

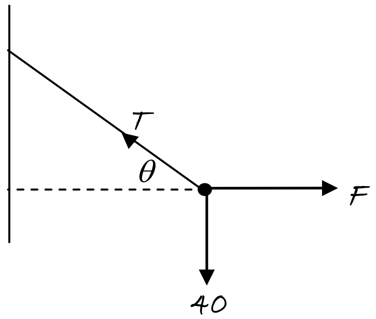
$T\sin\theta = 5\sqrt{3} - 5$ (2)

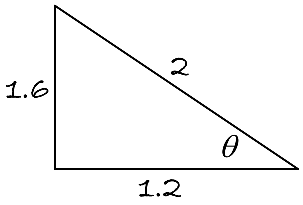
Dividing (2) by (1): $\tan\theta = \dfrac{5\sqrt{3}-5}{12}$

$\theta = 17.0°$ (1 d.p.)

Substituting into (1): $T = \dfrac{12}{\cos\theta} = 12.5$ (3 s.f.)

2.





Resolving vertically: $T\sin\theta - 40 = 0$

$\dfrac{1.6}{2}T = 40$

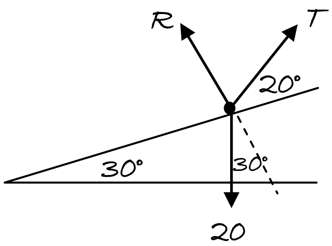
$T = 50$

Resolving horizontally: $F - T\cos\theta = 0$

$F = T\cos\theta = 50 \times \dfrac{1.2}{2} = 30$

The magnitude of F is 30 N and the tension in the string is 50 N.

3.



Resolving parallel to the plane: $T\cos 20° - 20\sin 30° = 0$

$T\cos 20° = 20 \times \tfrac{1}{2}$

$T = \dfrac{10}{\cos 20°} = 10.64$

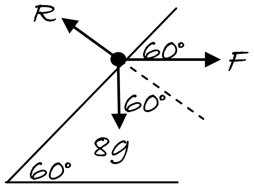
Resolving perpendicular to the plane: $R + T\sin 20° - 20\cos 30° = 0$

$R = 20\cos 30° - T\sin 20°$

$R = 13.7$

The tension in the rope is 10.64 N and the reaction at the plane is 13.7 N.

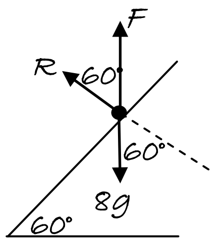
4. (i)



Resolving parallel to the plane:

$$F\cos 60^\circ - 8g\sin 60^\circ = 0$$
$$\tfrac{1}{2}F = 8\times 9.8\times \tfrac{1}{2}\sqrt{3}$$
$$F = 78.4\sqrt{3} = 135.8 \text{ N}$$

(ii)

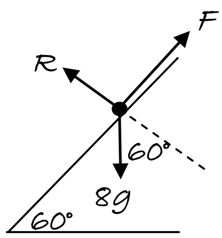


Notice that R must be zero as $F = 8g$ (consider vertical forces). This means that the particle is only just touching the plane.

Resolving parallel to the plane:

$$F\sin 60^\circ - 8g\sin 60^\circ = 0$$
$$F = 8\times 9.8$$
$$F = 78.4 \text{ N}$$

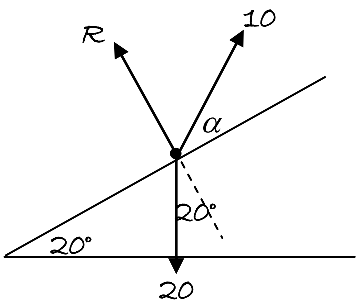
(iii)



Resolving parallel to the plane:

$$F - 8g\sin 60^\circ = 0$$
$$F = 8\times 9.8\times \tfrac{1}{2}\sqrt{3}$$
$$F = 39.2\sqrt{3} = 67.9 \text{ N}$$

5.



Resolving parallel to the plane: $10\cos\alpha - 20\sin 20° = 0$

$$\cos\alpha = 2\sin 20°$$

$$\alpha = 46.8°$$

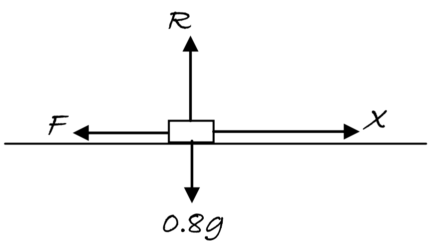
Resolving perpendicular to the plane: $R + 10\sin\alpha - 20\cos 20° = 0$

$$R = 20\cos 20° - 10\sin\alpha$$

$$R = 11.5$$

The value of α is 46.8°
and the reaction between the block and the plane is 11.5 N.

6. (i)



Resolving vertically: $R - 0.8g = 0$

$$R = 0.8 \times 10 = 8$$

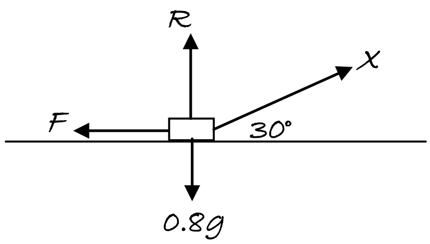
Friction is limiting so $F = \mu R = 0.5 \times 8 = 4$

Resolving horizontally: $X - F = 0$

$$X = F = 4$$

The least force required is 4 N.

(ii)



Resolving vertically: $R + X\sin 30° - 0.8g = 0$

$$R = 0.8 \times 10 - \tfrac{1}{2}X = 8 - 0.5X$$

Friction is limiting so $F = \mu R = 0.5(8 - 0.5X) = 4 - 0.25X$

Resolving horizontally: $X\cos 30° - F = 0$

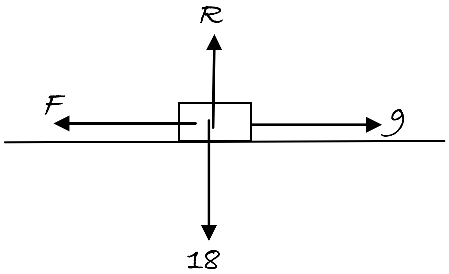
$$\tfrac{1}{2}\sqrt{3}X = 4 - 0.25X$$

$$\sqrt{3}X + 0.5X = 8$$

$$X = \frac{8}{\sqrt{3} + 0.5} = 3.58$$

The least force required is 1.66 N.

7. (i)

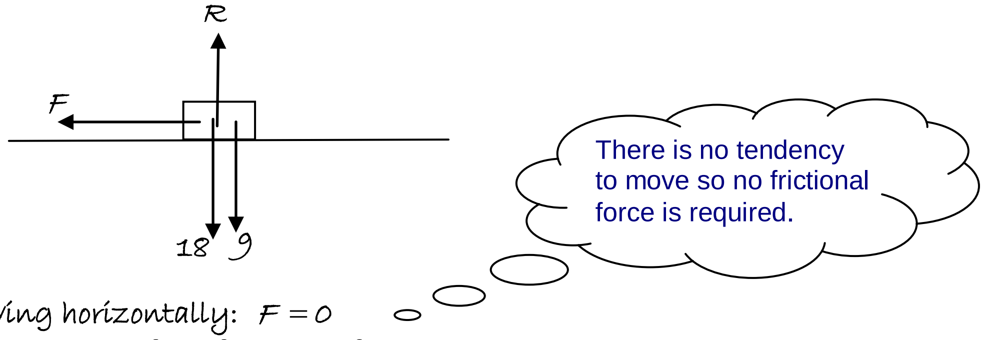


Resolving horizontally: $9 - F = 0$

$F = 9$

The magnitude of the frictional force is 9 N.

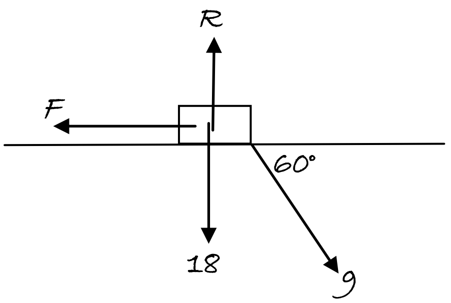
(ii)



Resolving horizontally: $F = 0$

The magnitude of the frictional force is 0 N.

(iii)

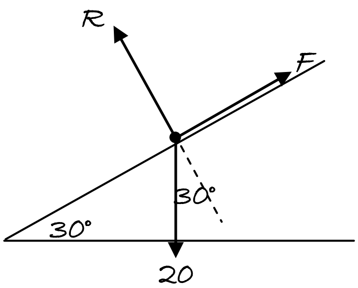


Resolving horizontally: $9\cos 60° - F = 0$

$F = 9 \times \frac{1}{2} = 4.5$

The magnitude of the frictional force is 4.5 N.

8. Since the block is on the point of sliding down the plane, the frictional force acts upwards.



Resolving perpendicular to the plane: $R - 20\cos 30° = 0$

$$R = 20 \times \tfrac{1}{2}\sqrt{3} = 10\sqrt{3}$$

Resolving parallel to the plane: $F - 20\sin 30° = 0$

$$F = 20 \times \tfrac{1}{2} = 10$$

Friction is limiting so $F = \mu R$

$$10 = 10\sqrt{3}\mu$$

$$\mu = \frac{1}{\sqrt{3}} = 0.577$$