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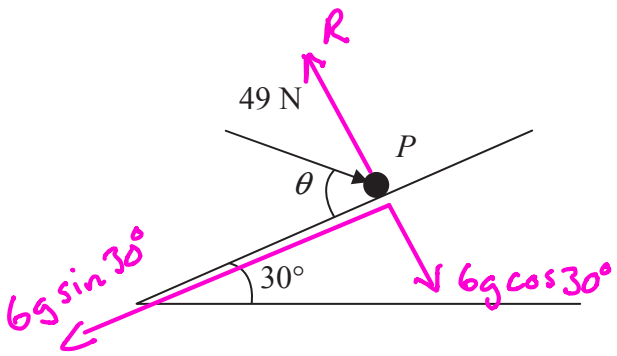

Figure 1

A particle P of mass 6 kg lies on the surface of a smooth plane. The plane is inclined at an angle of 30° to the horizontal. The particle is held in equilibrium by a force of magnitude 49 N, acting at an angle θ to the plane, as shown in Figure 1. The force acts in a vertical plane through a line of greatest slope of the plane.

(a) Show that $\cos\theta = \frac{3}{5}$.

(3)

(b) Find the normal reaction between P and the plane.

(4)

The direction of the force of magnitude 49 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical plane through a line of greatest slope of the plane.

(c) Find the initial acceleration of P.

(4)

a) // to slope $\quad 49\cos\theta = 6g\sin 30°$

$\cos\theta = \dfrac{6 \times 9.8 \times \frac{1}{2}}{49}$

$\cos\theta = \dfrac{3}{5}$

b) $\perp$ to slope $\quad R = 49\sin\theta + 6g\cos 30°$

$\sin\theta = \dfrac{4}{5}$ $\quad R = 49 \times \dfrac{4}{5} + 6 \times 9.8\cos 30°$

$R = 90.1\text{ N}$

M 2 6 3 3 1 A 0 1 0 2 8

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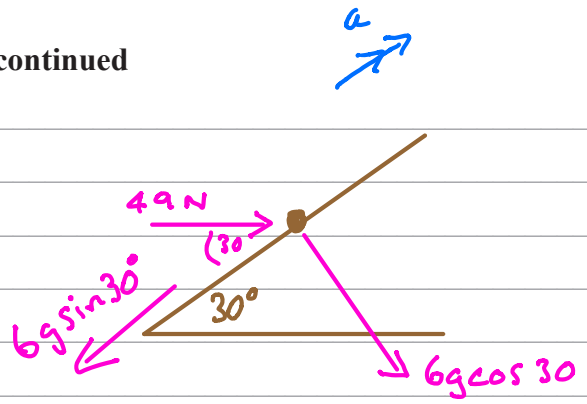
Question 4 continued



$F = ma$

$49\cos 30^\circ - 6g\sin 30 = 6a$

$\dfrac{49\cos 30^\circ - 6 \times 9.8\sin 30^\circ}{6} = a$

$a = 2.17\ ms^{-2}$

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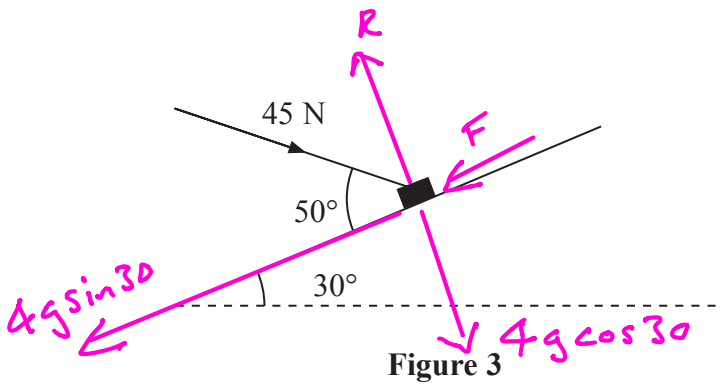

Figure 3

A package of mass 4 kg lies on a rough plane inclined at 30° to the horizontal. The package is held in equilibrium by a force of magnitude 45 N acting at an angle of 50° to the plane, as shown in Figure 3. The force is acting in a vertical plane through a line of greatest slope of the plane. The package is in equilibrium on the point of moving up the plane. The package is modelled as a particle. Find

(a) the magnitude of the normal reaction of the plane on the package,

(5)

(b) the coefficient of friction between the plane and the package.

(6)

a) $\perp$ to slope

$45 \sin 50^\circ + 4g\cos 30 = R$

$R = 68.42$

$R = 68.4$ N

b) $F = \mu R$ on point of slipping

$\parallel$ to slope

$\mu R + 4g \sin 30 = 45 \cos 50^\circ$

$\mu = \dfrac{45\cos 50^\circ - 4g \sin 30^\circ}{68.42}$

$\mu = 0.136$

$\mu = 0.14$

H 2 9 4 9 2 A 0 1 6 2 4

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5.

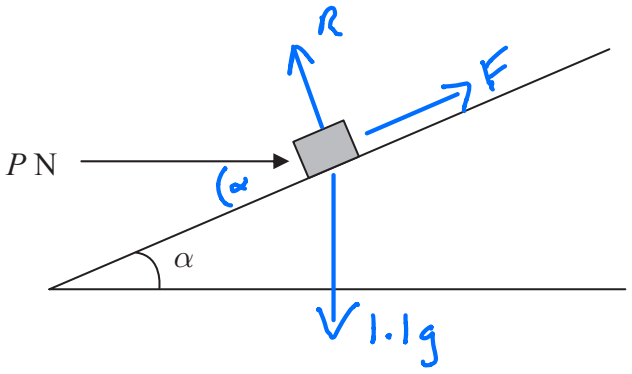

Figure 2

A small package of mass 1.1 kg is held in equilibrium on a rough plane by a horizontal force. The plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The force acts in a vertical plane containing a line of greatest slope of the plane and has magnitude P newtons, as shown in Figure 2.

The coefficient of friction between the package and the plane is 0.5 and the package is modelled as a particle. The package is in equilibrium and on the point of slipping down the plane.

(a) Draw, on Figure 2, all the forces acting on the package, showing their directions clearly.

(2)

(b) (i) Find the magnitude of the normal reaction between the package and the plane.

(ii) Find the value of P.

(11)

$\tan\alpha = \frac{3}{4}$ $\mu = 0.5$

$\Rightarrow \sin\alpha = \frac{3}{5}$ $\cos\alpha = \frac{4}{5}$

$\perp$ to slope

b) $P\sin\alpha + 1.1g\cos\alpha = R$ (1)

$\parallel$ to slope

$1.1g\sin\alpha = \mu R + P\cos\alpha$ (2)

From (1) $\frac{3}{5}P - R = -1.1 \times g \times \frac{4}{5}$ (3)

From (2) $\frac{4}{5}P + 0.5R = 1.1 \times 9.8 \times \frac{3}{5}$ (4)

N 2 9 4 1 1 A 0 1 2 2 4

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Question 5 continued

Solving ③ and ④ by calculator

iii) $P = \frac{49}{25} = 1.96$ N

ii) $R = \frac{49}{5} = 9.8$ N

N 2 9 4 1 1 A 0 1 3 2 4

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5.

$\mu = 0.2$

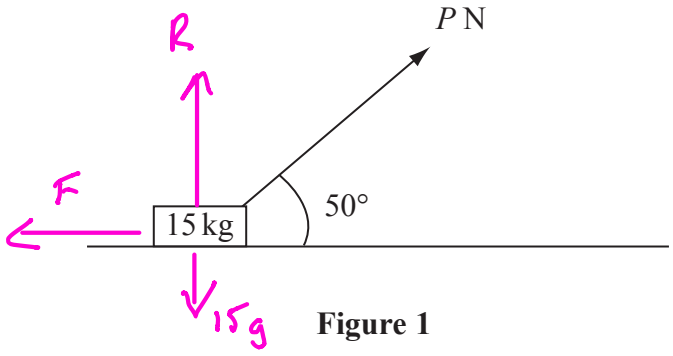

Figure 1

A small box of mass 15 kg rests on a rough horizontal plane. The coefficient of friction between the box and the plane is 0.2. A force of magnitude P newtons is applied to the box at 50° to the horizontal, as shown in Figure 1. The box is on the point of sliding along the plane.

Find the value of P, giving your answer to 2 significant figures.

(9)

$\updownarrow$ $R + P\sin 50^\circ = 15 \times 9.8$ (1)

$\leftrightarrow$ $\mu R = P\cos 50^\circ$

$0.2R - P\cos 50^\circ = 0$ (2)

Solve (1) and (2) by calculator

$R = 119$ N

$P = 36.9$ N

$P = 37$ N

N 3 4 2 7 5 A 0 1 0 2 4

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3.

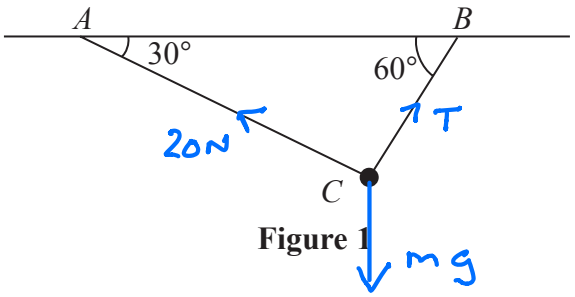

Figure 1

A particle of mass m kg is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 30° and 60° respectively, as shown in Figure 1.

Given that the tension in AC is 20 N, find

(a) the tension in BC,

(4)

(b) the value of m.

(4)

a) $\updownarrow$ $20\sin 30^\circ + T\sin 60^\circ = mg$ (1)

$\leftrightarrow$ $20\cos 30^\circ = T\cos 60^\circ$ (2)

From (2)

$$T = \frac{20\cos 30^\circ}{\cos 60^\circ} = 20\sqrt{3}\text{ N}$$

Tension in BC = 34.6 N

Sub in (1)

$$\frac{20\sin 30^\circ + 20\sqrt{3}\sin 60^\circ}{9.8} = m$$

$m = 4.08$ kg

M 3 5 1 0 4 A 0 6 2 4

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5. A particle of mass 0.8 kg is held at rest on a rough plane. The plane is inclined at 30° to the horizontal. The particle is released from rest and slides down a line of greatest slope of the plane. The particle moves 2.7 m during the first 3 seconds of its motion. Find

(a) the acceleration of the particle,

(3)

(b) the coefficient of friction between the particle and the plane.

(5)

The particle is now held on the same rough plane by a horizontal force of magnitude X newtons, acting in a plane containing a line of greatest slope of the plane, as shown in Figure 3. The particle is in equilibrium and on the point of moving up the plane.

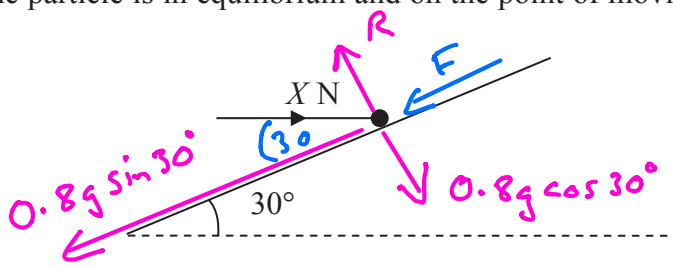
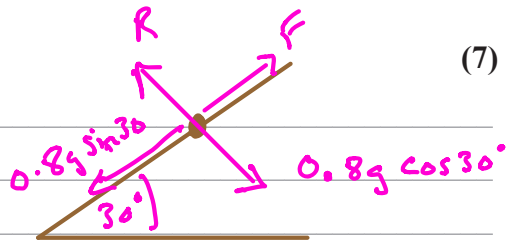


Diagram for part c

Figure 3

(c) Find the value of X.

(7)



a) $s = ut + \frac{1}{2}at^2$

$2.7 = 0 + \frac{1}{2}a \times 3^2$

$5.4 = 9a$

$\frac{5.4}{9} = a$

$a = 0.6\ ms^{-2}$

b) Resultant Force $= ma$

$0.8g \sin 30° - \mu R = 0.8 \times 0.6$

$0.8 \times 9.8 \sin 30° - 0.48 = \mu \times 0.8 \times 9.8 \cos 30°$

$\frac{0.8 \times 9.8 \sin 30° - 0.48}{0.8 \times 9.8 \cos 30°} = \mu$

$\mu = 0.507$

$\mu = 0.51$

M 3 5 1 0 4 A 0 1 2 2 4

Leave blank

Question 5 continued

c) $\perp$ to slope

$$0.8g\cos 30^\circ + X\sin 30 = R$$

$$R - X\sin 30^\circ = 0.8g\cos 30^\circ \quad (1)$$

$\parallel$ to slope

$$X\cos 30^\circ = 0.8g\sin 30^\circ + \mu R$$

$$0.507R - X\cos 30^\circ = -0.8g\sin 30^\circ \quad (2)$$

Solve (1) and (2) by calculator

$$R = 12.8 \text{ N}$$

$$X = 12.0 \text{ N}$$

$$X = 12.0 \text{ N}$$

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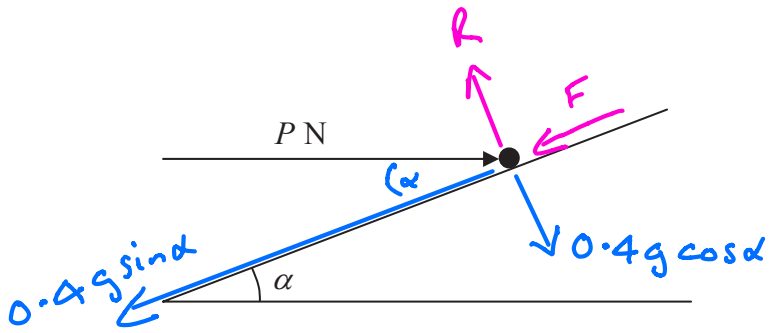

Figure 2

A particle of mass 0.4 kg is held at rest on a fixed rough plane by a horizontal force of magnitude P newtons. The force acts in the vertical plane containing the line of greatest slope of the inclined plane which passes through the particle. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$, as shown in Figure 2.

$\sin\alpha = \frac{3}{5}$ $\cos\alpha = \frac{4}{5}$

The coefficient of friction between the particle and the plane is $\frac{1}{3}$.

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

Given that the particle is on the point of sliding up the plane, find

(a) the magnitude of the normal reaction between the particle and the plane,

(5)

(b) the value of P.

(5)

a) $\perp$ to slope

$P\sin\alpha + 0.4g\cos\alpha = R$

$R - P\sin\alpha = 0.4g\cos\alpha$

$R - \frac{3}{5}P = 0.4g \times \frac{4}{5}$ ①

$\parallel$ to slope

$P\cos\alpha = 0.4g\sin\alpha + \mu R$

$\frac{1}{3}R - \frac{4}{5}P = -0.4g \times \frac{3}{5}$ ②

Solve ① and ② by Calculator

$R = 6.53$ N

$P = 5.66$ N

N 3 5 3 9 0 A 0 2 0 2 8