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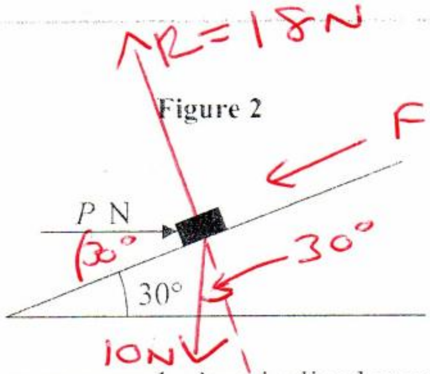
Figure 2



A parcel of weight 10 N lies on a rough plane inclined at an angle of 30° to the horizontal. A horizontal force of magnitude P newtons acts on the parcel, as shown in Figure 2. The parcel is in equilibrium and on the point of slipping up the plane. The normal reaction of the plane on the parcel is 18 N. The coefficient of friction between the parcel and the plane is μ. Find

(a) the value of P, **(4)**

(b) the value of μ. **(5)**

The horizontal force is removed.

(c) Determine whether or not the parcel moves. **(5)**

a) R (↖) perpendicular to plane

$18 - P\sin 30° - 10\cos 30° = 0$

$P\sin 30° = 18 - 10\cos 30°$

$P = \dfrac{18 - 10\cos 30°}{\sin 30°}$

$P = 18.679492$

$P = 18.7\text{N}$ (3 sf)

b) R (↙) parallel to plane

$F + 10\sin 30° - P\cos 30° = 0$

$F = 18.679492\cos 30° - 10\sin 30°$

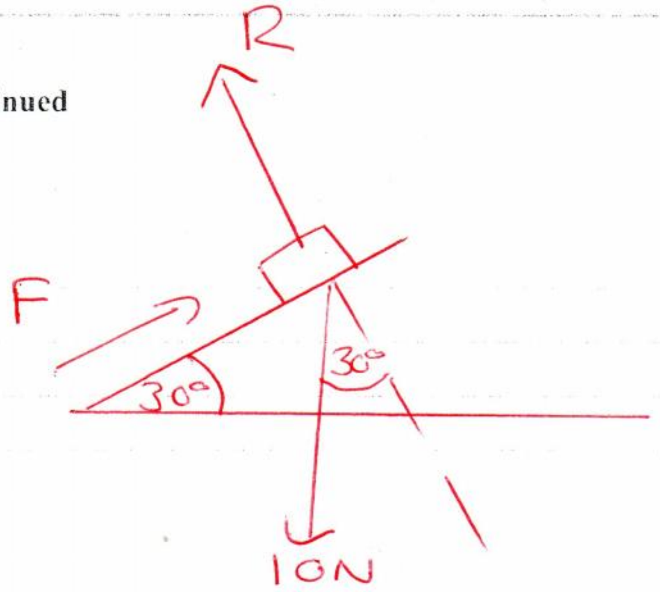
$F = 11.176915 \text{ N}$

But $F = \mu R \therefore \mu = \dfrac{F}{R}$

$\mu = \dfrac{11.176915}{18} = 0.6209397$

$= 0.621$ (3 sf)

Question 5 continued



5c) R (↖) perpendicular to plane

$R - 10\cos 30° = 0$ (no motion perpendicular to plane)

$R = 10\cos 30°$ N

R (↙) parallel to plane to see if weight down plane greater than friction.

$10 \sin 30° - F$ ①

$\therefore 5 - F$

But $F = \mu R$

$F = 0.6209397 \times 10\cos 30°$

$F = 5.3774955$ N ②

Comparing ① and ②

as component of weight down plane is not greater than the friction F, the parcel will not slide down

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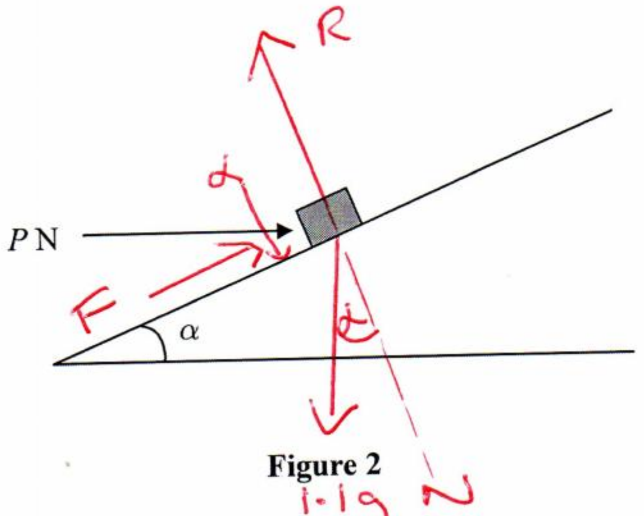
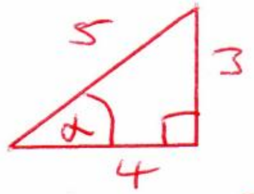


Figure 2



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

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

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)**

a) R (↖) perpendicular to plane

$R - 1.1g\cos\alpha - P\sin\alpha = 0$ ①

R (↗) parallel to plane

$F + P\cos\alpha - 1.1g\sin\alpha = 0$ ②

But $F = \mu R$

$F = 0.5R$ ③

Sub ③ in ② for F

$0.5R + P\cos\alpha - 1.1g\sin\alpha = 0$

$\therefore R + 2P\cos\alpha - 2.2g\sin\alpha = 0$

$\therefore R = 2.2 \times 9.8 \times \frac{3}{5} - 2P \times \frac{4}{5}$

$R = 12.936 - \frac{8}{5}P$

5b) continued

Substitute for R in (i)

$$\left(12.936 - \frac{8}{5}P\right) - \left(1.1 \times 9.8 \times \frac{4}{5}\right) - P \times \frac{3}{5} = 0$$

$$12.936 - \frac{8}{5}P - 8.624 - \frac{3}{5}P = 0$$

$$4.312 = \frac{11}{5}P$$

$$\therefore P = \frac{5 \times 4.312}{11} = 1.96\text{ N}$$

Sub for P in (i)

$$R = 1.1 \times 9.8 \times \frac{4}{5} + \left(1.96 \times \frac{3}{5}\right)$$

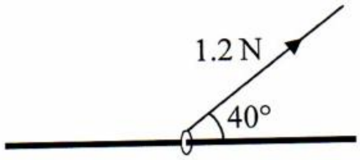
$$R = 8.624 + 1.176$$

$$R = 9.8\text{N}$$

(i) Normal reaction is 9.8 N

(ii) Value of P is 1.96 N

5. **Figure 3**

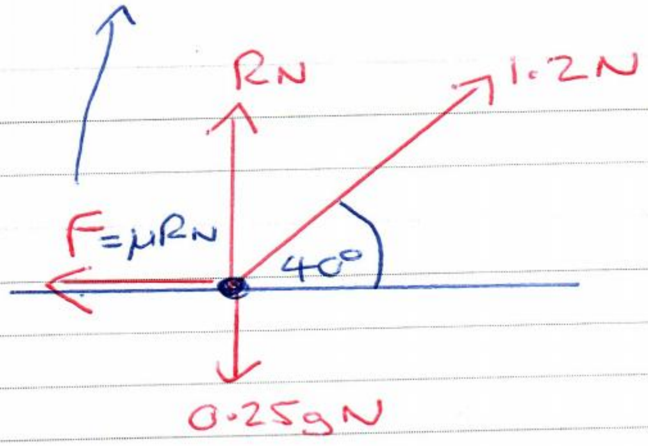


A small ring of mass 0.25 kg is threaded on a fixed rough horizontal rod. The ring is pulled upwards by a light string which makes an angle 40° with the horizontal, as shown in Figure 3. The string and the rod are in the same vertical plane. The tension in the string is 1.2 N and the coefficient of friction between the ring and the rod is μ. Given that the ring is in limiting equilibrium, find

(a) the normal reaction between the ring and the rod, → R **(4)**

(b) the value of μ. Friction opposes motion **(6)**

a)



in equilibrium

R (↑) resolving forces upwards

$R + 1.2 \sin 40° - 0.25g = 0$

$R = 0.25g - 1.2 \sin 40°$

$R = 1.67865...$

$\therefore R = 1.7 N$ (2 sf)

b) R (→)

$1.2 \cos 40° - \mu R = 0$

$1.2 \cos 40° - \mu (1.67865...)$

$\therefore \mu = \frac{1.2 \cos 40°}{1.67865...}$

$\mu = 0.54761...$

$\mu = 0.55$ (2 sf)

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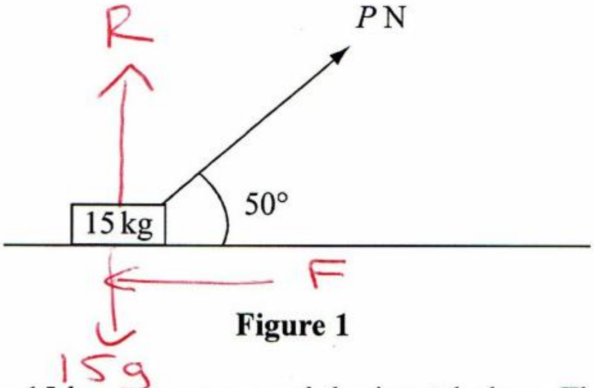

Figure 1

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)

R (↑) $R + P\sin 50° - 15g = 0$ ①

R (→) $P\cos 50° - F = 0$ ②

$F = \mu R$

$F = 0.2R$ ③

sub ③ in ② gives

$P\cos 50° - 0.2R = 0$

$\therefore 0.2R = P\cos 50°$

$R = \dfrac{P\cos 50°}{0.2} = 5P\cos 50°$

substitute R from above in ①

gives $5P\cos 50° + P\sin 50° = 15g$

$P(5\cos 50° + \sin 50°) = 15 \times 9.8$

$P = \dfrac{15 \times 9.8}{5\cos 50° + \sin 50°}$

$= 36.934836$

$P = 37$ N (2sf)

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7.

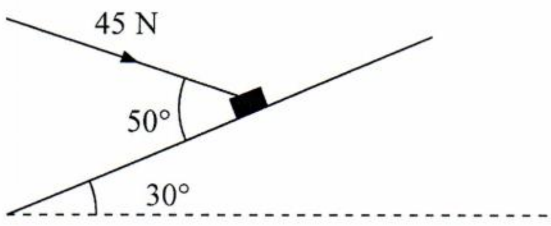


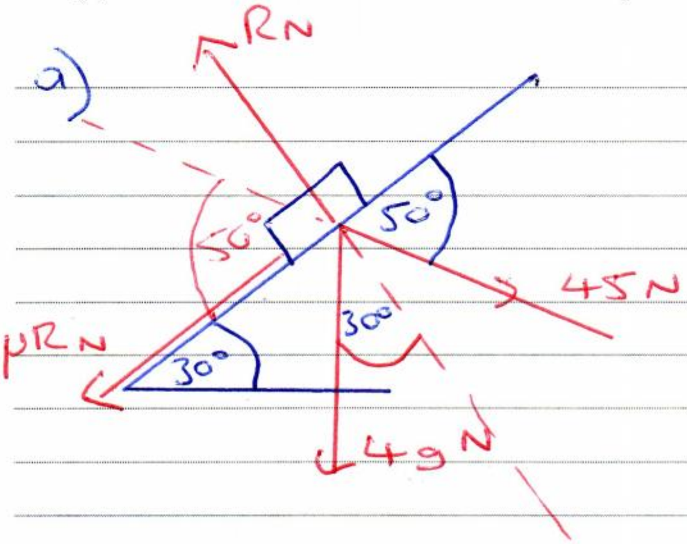
Figure 3

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)



Friction down the slope as package in equilibrium on point of moving up the plane.

R (↖) resolving this as positive direction

$R - 4g\cos 30° - 45\sin 50° = 0$

$\therefore R = 4g\cos 30° + 45\sin 50°$

$\therefore R = 68.420...$

$\therefore R = 68.4\text{ N}$ (3sf)

Question 7 continued

b) R (↙): resolve down the plane taking this direction as +ve

$\mu R + 4g\sin 30 - 45\cos 50° = 0$

$\mu = \dfrac{45\cos 50° - 4g\sin 30°}{68.420...}$ ← non-rounded

$\therefore \mu = 0.1362...$
$= 0.136$ (3sf)

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7a) continued

Solving (4) and (2) simultaneously

(4) + (2) $1.8P = 10.192$

$P = 5.662222$

$P = 5.66\text{ N}$ (3sf)

put $P = 5.662222$ in (2)

$-0.6 \times 5.662222 + R = 3.136$

$R = 3.136 + 3.3973333$

$R = 6.5333$

$R = 6.53\text{ N}$ (3sf)

a) Normal reaction $R = 6.53\text{N}$ (3sf)

b) $P = 5.66\text{ N}$ (3sf)

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7.

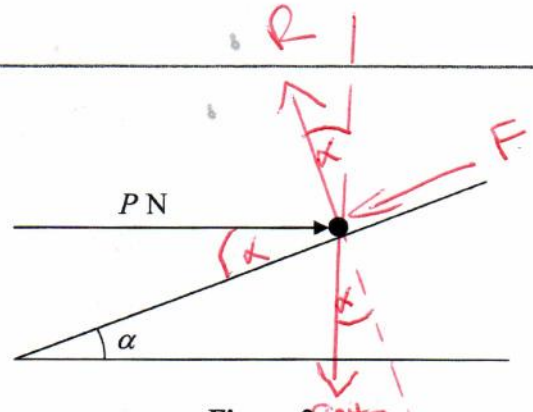
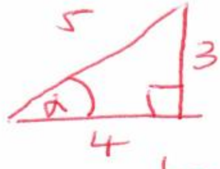


Figure 2



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

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.

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) R (↗) parallel to plane

$P\cos\alpha - 0.4g\sin\alpha - F = 0$

$\frac{4}{5}P - (0.4 \times 9.8 \times \frac{3}{5}) - F = 0$ ①

R (↖) perpendicular to plane

$R - P\sin\alpha - 0.4g\cos\alpha = 0$

$R - P \times \frac{3}{5} - (0.4 \times 9.8 \times \frac{4}{5}) = 0$ ②

also $F = \mu R$

$F = \frac{1}{3}R$ ③

put ③ in ① gives

$0.8P - 2.352 - \frac{1}{3}R = 0$

× through by 3

$2.4P - R = 7.056$ ④

$-0.6P + R = 3.136$ ② rearranged

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