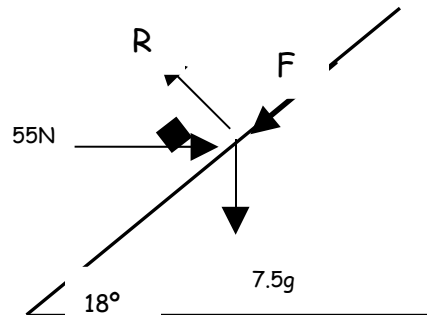


Statics

Solutions to Exam type questions

1



A box of mass 7.5kg is held in limiting equilibrium on a rough plane by the action of a horizontal force of magnitude 55N acting in a vertical plane through a line of greatest slope. The plane is inclined at an angle of 18° to the horizontal, as shown in the diagram above. By modeling the box as a particle and noting that it is on the point of moving up the slope:

- find the normal reaction R .
- find the coefficient of friction between the box and the plane.

a) Resolving perpendicular to the plane gives:

$$R = 7.5g \times \cos 18 + 55 \times \sin 18$$

$$R = 90.5\text{N}$$

(b) Resolving parallel to the plane gives:

$$F + 7.5g \times \sin 18 = 55 \times \cos 18$$

$$F = 30.4\text{N}$$

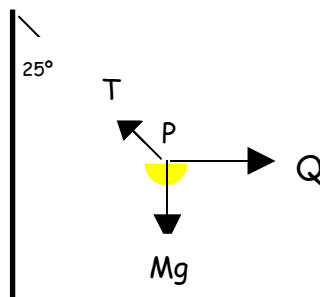
Using $F = \mu R$:

$$30.4 = \mu \times 90.5$$

$$\mu = 0.336$$

2 A swing ball is attached to one end of a light inextensible string; the other end of the string is attached to the top of a fixed vertical pole. A child applies a horizontal force, Q , of magnitude 45N to the particle P . P is in equilibrium under gravity with the string making an angle 25° with the vertical pole. By modeling the ball as a particle find:

- the tension, T , in the string.
- the weight of the ball.



a) All problems of this type can be solved by resolving forces into their components.

Resolving horizontally:

$$Q = T \cos 65^\circ$$

$$T = \frac{45}{\cos 65^\circ}$$

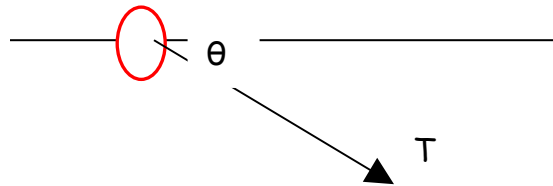
$$T = 106\text{N}$$

b) Resolving vertically:

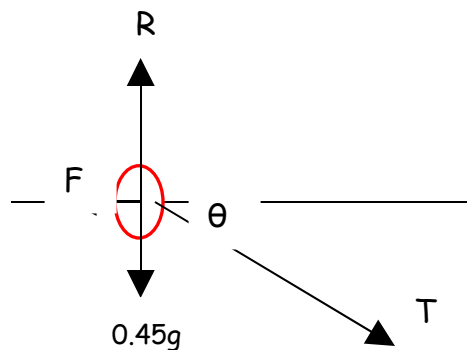
$$Mg = T \sin 65^\circ$$

$$Mg = 96.5\text{N}$$

3 A ring of mass 0.45kg is threaded onto a fixed, rough horizontal pole. A light inextensible string is attached to the ring. The string and the pole lie in the same vertical plane. The ring is pulled downwards by the string which makes an angle θ with the horizontal, where $\tan \theta = \frac{3}{4}$. The tension in the string is 2.2N . Find the coefficient of friction between the ring and the pole.



Adding the weight, the reaction and frictional forces to the diagram gives:



Resolving vertically gives:

$$0.45g + T \sin \theta = R$$

Given that $\tan \theta = \frac{3}{4}$ hence $\sin \theta = \frac{3}{5}$

Therefore: $R = 0.45g + 2.2 \times 0.6$

$$R = 5.73\text{N}$$

Resolving horizontally gives:

$$T \cos \theta = F$$

Given that $\tan \theta = \frac{3}{4}$ hence $\cos \theta = \frac{4}{5}$

$$F = 2.2 \times 0.8$$

$$F = 1.76$$

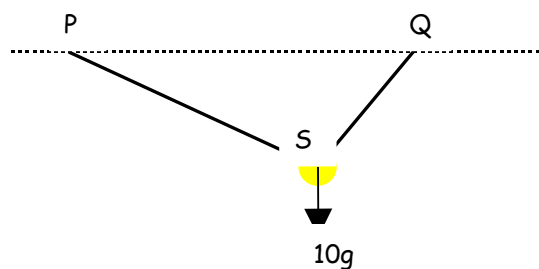
Using $F = \mu R$

$$1.76 = \mu \times 5.73$$

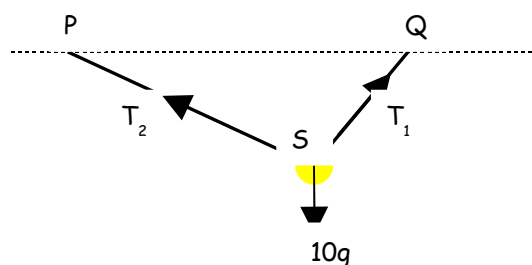
$$\mu = 0.307$$

4 A particle of weight 98 is attached at S to the ends of two light inextensible strings PS and QS. The other ends of the string are attached to two fixed points P and Q on a horizontal ceiling. The particle hangs in equilibrium with PS and QS inclined to the horizontal at angles of 25 and 60 degrees respectively.

Calculate the tension in both strings.



Adding the two tension forces to the diagram gives:



Seeing as the object is in equilibrium then the forces must resolve to zero

Resolving horizontally gives:

$$T_2 \cos 25^\circ = T_1 \cos 60^\circ$$

Therefore: $T_2 = 0.552T_1$ (1)

Resolving vertically gives:

$$T_2 \sin 25^\circ + T_1 \sin 60^\circ = 10g$$

Using (1) from above:

$$\sin 25^\circ \times 0.552T_1 + T_1 \sin 60^\circ = 10g$$

$$T_1 = 89.2\text{N}$$

Therefore: $T_2 = 49.2\text{N}$