Section 1: Friction

Section test

Throughout this test, take g = 9.8 ms^{-2}.

1. A block of mass 10 kg rests on a rough horizontal surface. The coefficient of friction between the mass and the surface is 0.6.
   Find the magnitude of a horizontal force which just moves the block.
   Find the magnitude of a force acting at 30° above the horizontal which just moves the block.

2. A horizontal force of 30 N applied to a mass of 8 kg is just enough to move the mass along a rough horizontal surface. Find the coefficient of friction between the mass and the surface.

3. A block of mass 5 kg rests on a rough plane inclined at 27° to the horizontal. A force of 35 N acts parallel to the plane, and the block is on the point of moving up the plane.
   What is the reaction force between the block and the plane?
   What is the coefficient of friction between the block and the plane?

4. A mass of 5 kg is placed on a rough plane inclined at 25° to the horizontal. A force of 15 N, acting parallel to the plane, can just prevent the mass of 5 kg from sliding down the plane. The force is increased until the mass is on the point of sliding up the plane.
   What is the new value of the force?
   What is the value of the coefficient of friction?

5. A mass of 5 kg is on a rough slope inclined at 15° to the horizontal. The coefficient of friction is 0.2. The mass is attached to a light string, which makes an angle of 25° above the slope. The mass is just about to start to move up the slope.
   Find the tension in the string.
   Find the reaction force between the mass and the plane.
   Find the frictional force.

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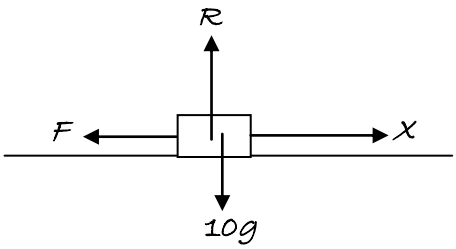
Solutions to section test

1.



Resolving vertically: $R - 10g = 0$

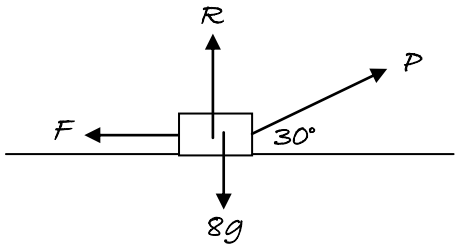
$R = 10g = 98$

Friction is limiting so $F = \mu R = 0.6 \times 98 = 58.8$

Resolving horizontally: $X - F = 0$

$X = F = 58.8$

The force has magnitude 58.8 N.



Resolving vertically: $R + P\sin 30° - 10g = 0$

$R = 10g - P\sin 30° = 98 - 0.5P$

Friction is limiting so $F = \mu R = 0.6(98 - 0.5P) = 58.8 - 0.3P$

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

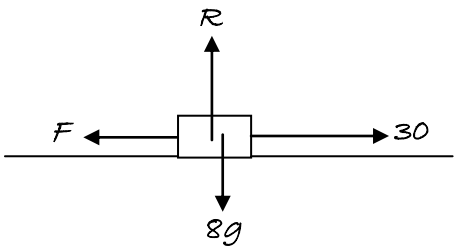
$0.5\sqrt{3}P - (58.8 - 0.3P) = 0$

$P\left(0.5\sqrt{3} + 0.3\right) = 58.8$

$P = 50.4$

The force has magnitude 50.4 N (3 s.f.).

2.



Resolving horizontally: $30 - F = 0$

$F = 30$

Resolving vertically: $R - 8g = 0$

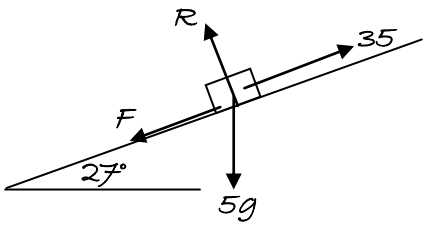
$R = 78.4$

Friction is limiting so $F = \mu R$

$30 = 78.4\mu$

$\mu = 0.383$ (3 s.f.)

3.



Resolving perpendicular to the plane: $R - 5g\cos 27° = 0$

$R = 49\cos 27° = 43.7$

The reaction force is 43.7 N (3 s.f.)

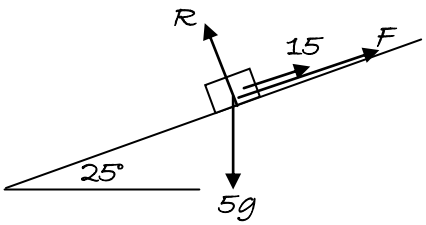
Resolving parallel to the plane: $35 - F - 5g\sin 27° = 0$

$F = 35 - 49\sin 27°$

Friction is limiting so $F = \mu R$

$$\mu = \frac{35 - 49\sin 27°}{49\cos 27°} = 0.292 \text{ (3 s.f.)}$$

4. When the force just prevents the mass from sliding down, friction is at its maximum value and acting up the plane, opposing the tendency to motion.



Resolving parallel to the plane: $15 + F - 5g\sin 25° = 0$

$F = 49\sin 25° - 15$

When the mass is about to slide up the plane, friction is at its maximum value but acting down the slope, against the tendency to move.

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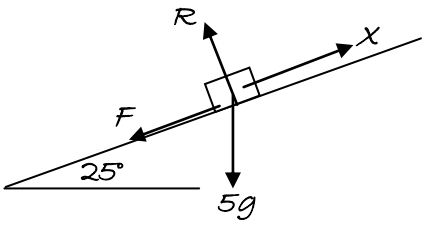


Resolving parallel to the plane: $X - F - 5g\sin 25° = 0$

$$X = F + 49\sin 25°$$
$$= 49\sin 25° - 15 + 49\sin 25°$$
$$= 26.4$$

The new value of the force is 26.4 N (3 s.f.).

Resolving perpendicular to the plane: $R - 5g\cos 25° = 0$

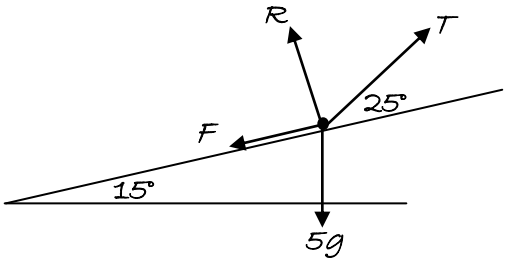
$$R = 49\cos 25°$$

Friction is limiting so $F = \mu R$

$$\mu = \frac{49\sin 25° - 15}{49\cos 25°} = 0.129$$

The coefficient of friction is 0.129 (3 s.f.)

5.



Resolving perpendicular to slope: $R + T\sin 25° - 5g\cos 15° = 0$

$$R = 49\cos 15° - T\sin 25°$$

Friction is limiting so $F = \mu R$

$$F = 0.2(49\cos 15° - T\sin 25°)$$

Resolving parallel to slope: $T\cos 25° - F - 5g\sin 15° = 0$

$$T\cos 25° - 0.2(49\cos 15° - T\sin 25°) - 49\sin 15° = 0$$
$$T\cos 25° - 9.8\cos 15° + 0.2T\sin 25° - 49\sin 15° = 0$$
$$T(\cos 25° + 0.2\sin 25°) = 49\sin 15° + 9.8\cos 15°$$
$$T = 22.4 \text{ (3 s.f.)}$$

The tension in the string is 22.4 N (3 s.f.)

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$R = 49\cos 15° - T\sin 25° = 37.9$

The reaction force between the mass and the plane is 37.9 N (3 s.f.)

$F = 0.2(49\cos 15° - T\sin 25°) = 7.58$

The frictional force is 7.58 N (3 s.f.)