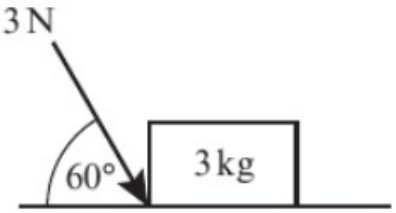
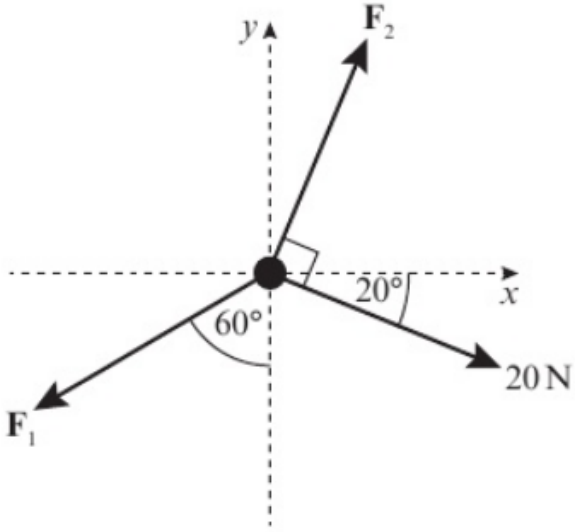
1 A box of mass 3 kg lies on a smooth horizontal floor. A force of 3 N is applied at an angle of 60° to the horizontal, causing the box to accelerate horizontally along the floor.



a Find the magnitude of the normal reaction of the floor on the box.

b Find the acceleration of the box.

2 A system of forces acts upon a particle as shown in the diagram. The resultant force on the particle is $(3\mathbf{i} + 2\mathbf{j})$ N. Calculate the magnitudes $\mathbf{F}_1$ and $\mathbf{F}_2$.



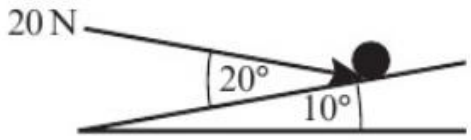
3 A force of 20 N is pulling a particle of mass 2 kg up a rough slope that is inclined at 45° to the horizontal. The force acts parallel to the slope, and the resistance due to friction is constant and has magnitude 4 N.

a Draw a force diagram to represent all the forces acting on the particle.

b Work out the normal reaction between the particle and the plane.

c Show that the acceleration of the particle is 1.1 m s^{-2} (2 s.f.).

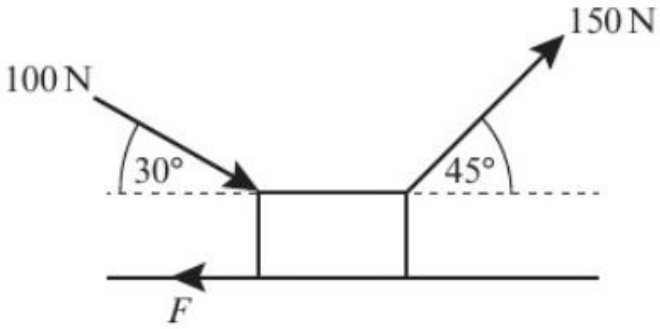
4 A particle of mass 5 kg sits on a smooth slope that is inclined at 10° to the horizontal. A force of 20 N acts on the particle at an angle of 20° to the plane, as shown in the diagram.
Find the acceleration of the particle.



(5 marks)

5 A box is being pushed and pulled across a rough surface by constant forces as shown in the diagram.
The box is moving at a constant speed. By modelling the box as a particle, show that the magnitude of the resistance due to friction F is $25(3\sqrt{2} + 2\sqrt{3})$ N.

(4 marks)



6 A trailer of mass 20 kg sits at rest on a rough horizontal plane. A force of 20 N pulls the trailer at an angle of 30° above the horizontal. Given that the trailer is in limiting equilibrium, work out the value of the coefficient of friction. **(6 marks)**

7 A particle of mass 2 kg is moving down a rough plane that is inclined at α to the horizontal, where $\tan\alpha = \frac{3}{4}$. A force of P N acts horizontally upon the particle towards the plane.
Given that the coefficient of friction is 0.3 and that the particle is moving at a constant velocity, calculate the value of P. **(7 marks)**

8 A particle of mass 0.5 kg is being pulled up a rough slope that is angled at 30° to the horizontal by a force of 5 N. The force acts at an angle of 30° above the slope. Given that the coefficient of friction is 0.1, calculate the acceleration of the particle. **(7 marks)**

9 A car of mass 2150 kg is travelling down a rough road that is inclined at 10° to the horizontal. The engine of the car applies a constant driving force of magnitude 700 N, which acts in the direction of travel of the car. Any friction between the road and the tyres is initially ignored, and air resistance is modelled as a single constant force of magnitude F N that acts to oppose the motion of the car.

a Given that the car is travelling in a straight line at a constant speed of 22 m s^{-1}, find the magnitude of F. **(3 marks)**

The driver brakes suddenly. In the subsequent motion the car continues to travel in a straight line, and the tyres skid along the road, bringing the car to a standstill after 40 m. The driving force is removed, and the force due to air resistance is modelled as remaining constant.

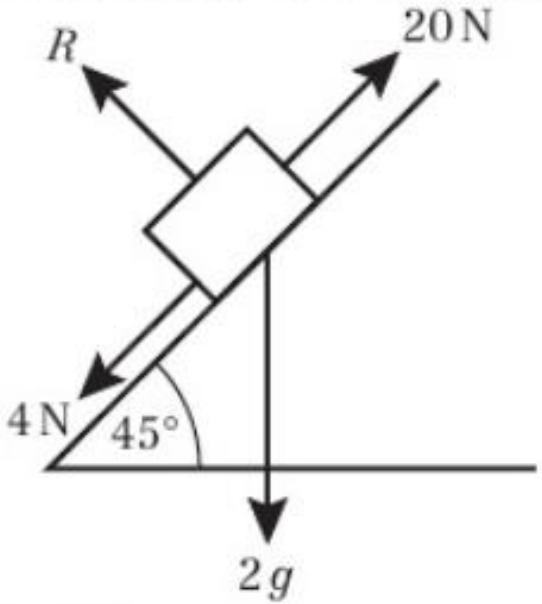
b Find the coefficient of friction between the tyres and the road. **(7 marks)**

c State one limitation of the model used for air resistance. **(1 mark)**

1 **a** 32.0 N (3 s.f.) **b** 0.5 m s^{-2}

2 $F_1 = 27.8\,\text{N}$, $F_2 = 24.2\,\text{N}$ (3 s.f.)

3 **a**



b 13.9 N (3 s.f.)

c Res (↗): $16 - 2g\sin 45 = 2a$

$$a = \frac{16 - 2g\sin 45}{2} = 1.1\,\text{ms}^{-2}\ (2\ \text{s.f})$$

4 2.06 ms^{-2} (3 s.f.)

5 R(→): $F = 150\cos 45 + 100\cos 30$

$$= \frac{150\sqrt{2}}{2} + \frac{100\sqrt{3}}{2}$$

$$= 25(3\sqrt{2} + 2\sqrt{3})\,\text{N}$$

6 $\mu = \frac{5\sqrt{3}}{93}$

7 7.2 N

8 3.41 ms^{-2} (3 s.f.)

9 **a** 4400 N (2 s.f.)

b 0.59 (2 s.f.)

c e.g. The force due to air resistance will not remain constant in the subsequent motion of the car.