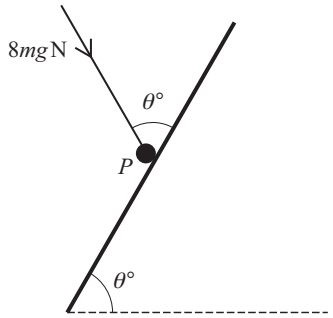
1 A car of mass 900 kg is moving along a straight horizontal road against a constant resistance to motion of 350 N. At an instant when the car is moving at $15\,\text{m s}^{-1}$ its acceleration is $0.25\,\text{m s}^{-2}$.

(a) Find the driving force of the car's engine at this instant. [2]

(b) Find the power of the car's engine at this instant. [2]

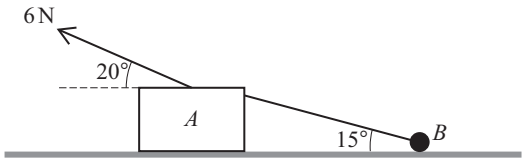
5



A particle P of mass m kg is in equilibrium on a rough plane inclined at an angle $\theta°$ to the horizontal. The equilibrium of P is maintained by a force of magnitude $8mg$ N making an angle $\theta°$ with a line of greatest slope (see diagram). The coefficient of friction between P and the plane is 0.5 and P is on the point of slipping down the plane.

Find the value of θ. [6]

8



A block A of mass 2 kg and a particle B of mass 0.5 kg are connected by a light inextensible string inclined at 15° to the horizontal. They are pulled across a horizontal surface with acceleration $1.2\,\text{m s}^{-2}$ by a force of magnitude 6 N, applied to A, acting at 20° above the horizontal as shown in the diagram. The string and the force applied to A are in the same vertical plane.

The contact between B and the surface is smooth and the contact between A and the surface is rough.

(a) Find the tension in the string. [2]

(b) Find the coefficient of friction between A and the surface. [6]

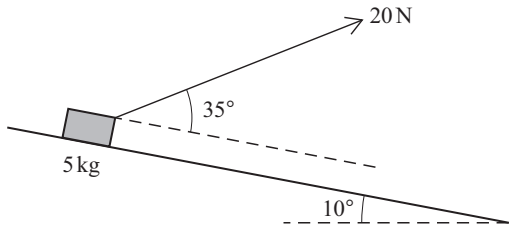
Additional page

If you use the following page to complete the answer to any question, the question number must be clearly shown.

2 A railway locomotive of mass 240 000 kg is towing a coach of mass 36 000 kg down a hill inclined at an angle of $\sin^{-1} 0.04$ to the horizontal. The driving force produced by the locomotive is 450 000 N and there are resistances to motion of 120 000 N on the locomotive and 15 000 N on the coach. The coupling between the locomotive and the coach is light, rigid and parallel to the hill.

Find the acceleration of the locomotive and the tension in the coupling. [5]

5



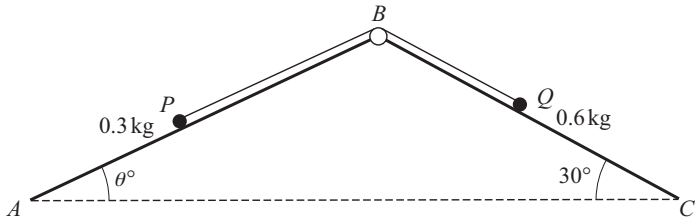
A block of mass 5 kg is being pulled straight down a line of greatest slope of a rough plane by a force of magnitude 20 N. The plane is inclined at an angle of 10° to the horizontal and the 20 N force acts at an angle of 35° above the line of greatest slope of the plane (see diagram). The coefficient of friction between the block and the plane is 0.4. The speed of the block when it passes a point O is $2\,\text{m s}^{-1}$.

Find the speed of the block when it has moved 3 m down the plane from O. [6]

1 A block of mass 12 kg is being pulled by a rope up a rough plane. The plane is inclined at an angle of 20° above the horizontal. The rope pulling the block is parallel to a line of greatest slope of the plane. The coefficient of friction between the block and the plane is 0.4. The acceleration of the block is $2\,\text{m s}^{-2}$.

Find the tension in the rope. [4]

6



Two particles, P and Q, of masses 0.3 kg and 0.6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth pulley fixed at a point B where the inclined planes AB and BC meet. P lies on the smooth plane AB which is inclined at an angle $\theta°$ to the horizontal where $\sin\theta° = 0.4$. Q lies on the plane BC which is inclined at 30° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes (see diagram). The particles are released from rest.

(a) It is given that the plane BC is smooth.

Find the tension in the string and the acceleration of Q. [5]

(b) It is given instead that the plane BC is rough. The work done against the frictional force when Q moves 2 m down the plane is 1.8 J. You should assume that P does **not** reach the pulley and that Q does **not** reach C.

Use an energy method to find the speed of Q when it has moved 2 m down the plane. [4]