1

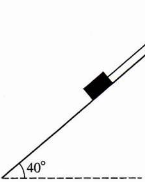


Fig. 1

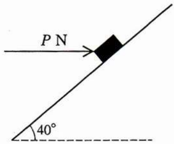


Fig. 2

A small block of weight 12 N is at rest on a smooth plane inclined at 40° to the horizontal. The block is held in equilibrium by a force of magnitude P N. Find the value of P when

(i) the force is parallel to the plane as in Fig. 1, [2]

(ii) the force is horizontal as in Fig. 2. [2]

2 A lorry of mass 15 000 kg moves with constant speed $14\,\text{m s}^{-1}$ from the top to the bottom of a straight hill of length 900 m. The top of the hill is 18 m above the level of the bottom of the hill. The total work done by the resistive forces acting on the lorry, including the braking force, is 4.8×10^6 J. Find

(i) the loss in gravitational potential energy of the lorry, [1]

(ii) the work done by the driving force. [1]

On reaching the bottom of the hill the lorry continues along a straight horizontal road against a constant resistance of 1600 N. There is no braking force acting. The speed of the lorry increases from $14\,\text{m s}^{-1}$ at the bottom of the hill to $16\,\text{m s}^{-1}$ at the point X, where X is 2500 m from the bottom of the hill.

(iii) By considering energy, find the work done by the driving force of the lorry while it travels from the bottom of the hill to X. [3]

3 A car of mass 1250 kg travels along a horizontal straight road with increasing speed. The power provided by the car's engine is constant and equal to 24 kW. The resistance to the car's motion is constant and equal to 600 N.

(i) Show that the speed of the car cannot exceed $40\,\text{m s}^{-1}$. [3]

(ii) Find the acceleration of the car at an instant when its speed is $15\,\text{m s}^{-1}$. [3]

4 A particle moves up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\cos \alpha = 0.96$ and $\sin \alpha = 0.28$.

(i) Given that the normal component of the contact force acting on the particle has magnitude 1.2 N, find the mass of the particle. [2]

(ii) Given also that the frictional component of the contact force acting on the particle has magnitude 0.4 N, find the deceleration of the particle. [3]

The particle comes to rest on reaching the point X.

(iii) Determine whether the particle remains at X or whether it starts to move down the plane. [2]

5

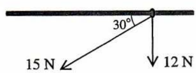


Fig. 1

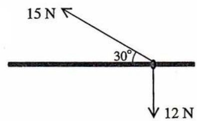


Fig. 2

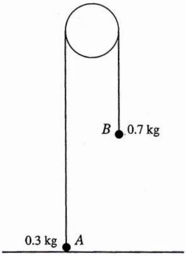
A small ring of weight 12 N is threaded on a fixed rough horizontal rod. A light string is attached to the ring and the string is pulled with a force of 15 N at an angle of 30° to the horizontal.

(i) When the angle of 30° is **below** the horizontal (see Fig. 1), the ring is in limiting equilibrium. Show that the coefficient of friction between the ring and the rod is 0.666, correct to 3 significant figures. [5]

(ii) When the angle of 30° is **above** the horizontal (see Fig. 2), the ring is moving with acceleration $a\,\mathrm{m\,s^{-2}}$. Find the value of a. [4]

[Questions 6 and 7 are printed on the next page.]

6



Particles A and B, of masses 0.3 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle A is held on the horizontal floor and particle B hangs in equilibrium. Particle A is released and both particles start to move vertically.

(i) Find the acceleration of the particles. [3]

The speed of the particles immediately before B hits the floor is $1.6\,\mathrm{m\,s^{-1}}$. Given that B does not rebound upwards, find

(ii) the maximum height above the floor reached by A, [3]

(iii) the time taken by A, from leaving the floor, to reach this maximum height. [3]

7 A motorcyclist starts from rest at A and travels in a straight line. For the first part of the motion, the motorcyclist's displacement x metres from A after t seconds is given by $x = 0.6t^2 - 0.004t^3$.

(i) Show that the motorcyclist's acceleration is zero when $t = 50$ and find the speed $V\,\mathrm{m\,s^{-1}}$ at this time. [5]

For $t \geqslant 50$, the motorcyclist travels at constant speed $V\,\mathrm{m\,s^{-1}}$.

(ii) Find the value of t for which the motorcyclist's average speed is $27.5\,\mathrm{m\,s^{-1}}$. [5]