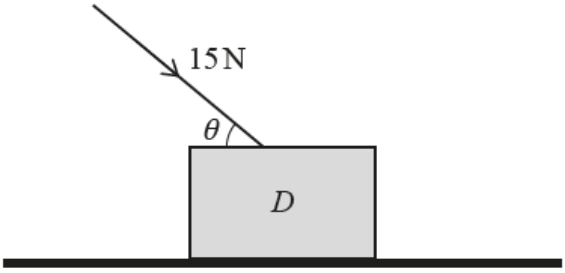
Forces and Newton's Laws – 2021/20 GCE Mechanics Mathematics A

1. Nov/2021/Paper_H240/03/No.10



A block D of weight 50N lies at rest in equilibrium on a fixed rough horizontal surface. A force of magnitude 15N is applied to D at an angle θ to the horizontal (see diagram).

(a) Complete the diagram in the Printed Answer Booklet showing all the forces acting on D. **[1]**

It is given that D remains at rest and the coefficient of friction between D and the surface is 0.2.

(b) Show that

$$15\cos\theta - 3\sin\theta \leqslant 10.$$ **[5]**

2. Nov/2021/Paper_H240/03/No.13

In this question the unit vectors **i** and **j** are in the directions east and north respectively.

At time t seconds, where $t \geqslant 0$, a particle P of mass 2kg is moving on a smooth horizontal surface under the action of a constant horizontal force $(-8\mathbf{i} - 54\mathbf{j})$N and a variable horizontal force $(4t\mathbf{i} + 6(2t-1)^2\mathbf{j})$N.

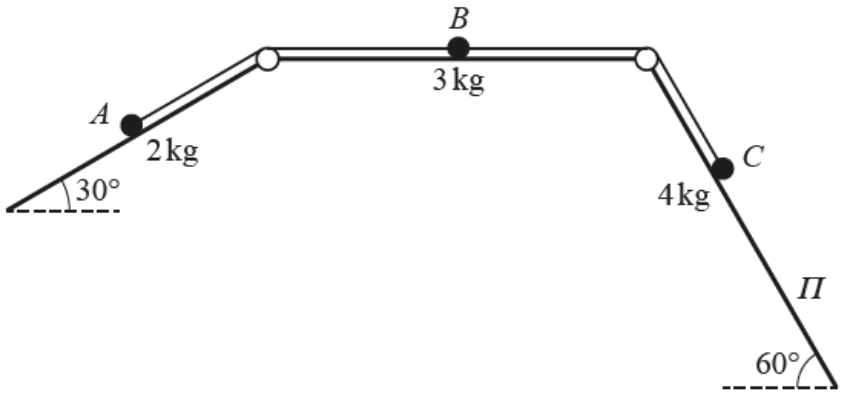
(a) Determine the value of t when the forces acting on P are in equilibrium. **[2]**

It is given that P is at rest when $t = 0$.

(b) Determine the speed of P at the instant when P is moving due north. **[6]**

(c) Determine the distance between the positions of P when $t = 0$ and $t = 3$. **[5]**

3. Nov/2021/Paper_H240/03/No.14



One end of a light inextensible string is attached to a particle A of mass 2 kg. The other end of the string is attached to a second particle B of mass 3 kg. Particle A is in contact with a smooth plane inclined at 30° to the horizontal and particle B is in contact with a rough horizontal plane.

A second light inextensible string is attached to B. The other end of this second string is attached to a third particle C of mass 4 kg. Particle C is in contact with a smooth plane Π inclined at an angle of 60° to the horizontal.

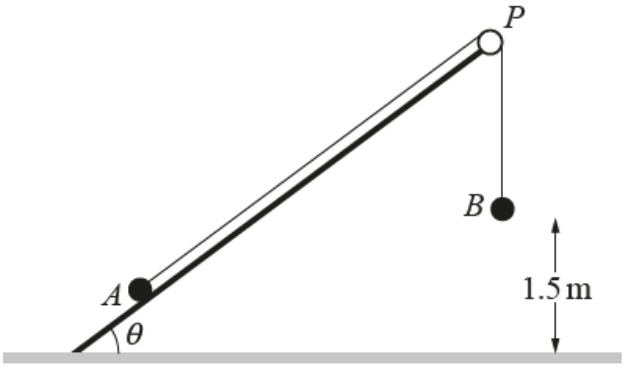
Both strings are taut and pass over small smooth pulleys that are at the tops of the inclined planes. The parts of the strings from A to the pulley, and from C to the pulley, are parallel to lines of greatest slope of the corresponding planes (see diagram).

The coefficient of friction between B and the horizontal plane is μ. The system is released from rest and in the subsequent motion C moves down Π with acceleration $a\,\text{m s}^{-2}$.

(a) By considering an equation involving μ, a and g show that $a < \frac{1}{9}g(2\sqrt{3}-1)$. **[7]**

(b) Given that $a = \frac{1}{9}g$, determine the magnitude of the contact force between B and the horizontal plane. Give your answer correct to **3** significant figures. **[4]**

4. Nov/2020/Paper_H240/03/No.9



One end of a light inextensible string is attached to a particle A of mass 2 kg. The other end of the string is attached to a second particle B of mass 2.5 kg. Particle A is in contact with a rough plane inclined at θ to the horizontal, where $\cos\theta = \frac{4}{5}$. The string is taut and passes over a small smooth pulley P at the top of the plane. The part of the string from A to P is parallel to a line of greatest slope of the plane. Particle B hangs freely below P at a distance 1.5 m above horizontal ground, as shown in the diagram.

The coefficient of friction between A and the plane is μ. The system is released from rest and in the subsequent motion B hits the ground before A reaches P. The speed of B at the instant that it hits the ground is $1.2\,\text{m s}^{-1}$.

(a) For the motion before B hits the ground, show that the acceleration of B is $0.48\,\text{m s}^{-2}$. **[1]**

(b) For the motion before B hits the ground, show that the tension in the string is 23.3 N. **[3]**

(c) Determine the value of μ. **[5]**

After B hits the ground, A continues to travel up the plane before coming to instantaneous rest before it reaches P.

(d) Determine the distance that A travels from the instant that B hits the ground until A comes to instantaneous rest. **[4]**