



Statics and Dynamics in 2d With Friction (Sheet 2)

Q1.

A particle of mass 0.8 kg is held at rest on a rough plane. The plane is inclined at 30° to the horizontal. The particle is released from rest and slides down a line of greatest slope of the plane. The particle moves 2.7 m during the first 3 seconds of its motion. Find

- (a) the acceleration of the particle, (3)
- (b) the coefficient of friction between the particle and the plane. (5)

The particle is now held on the same rough plane by a horizontal force of magnitude X newtons, acting in a plane containing a line of greatest slope of the plane, as shown in Figure 3. The particle is in equilibrium and on the point of moving up the plane.

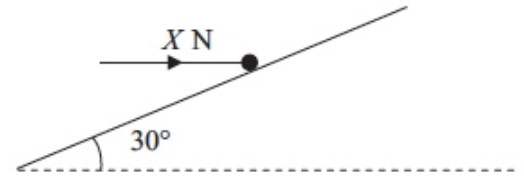


Figure 3

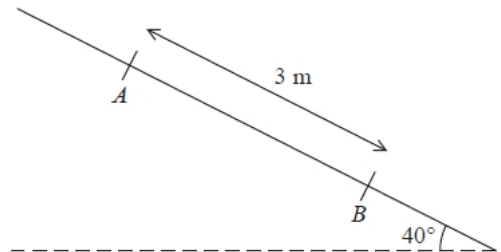
- (c) Find the value of X . (7)

(Total 15 marks)

Q2.

A rough plane is inclined at 40° to the horizontal. Two points A and B are 3 metres apart and lie on a line of greatest slope of the inclined plane, with A above B , as shown in Figure 2. A particle P of mass m kg is held at rest on the plane at A . The coefficient of friction between P and the plane is $\frac{1}{2}$. The particle is released.

- (a) Find the acceleration of P down the plane.



(5)

- (b) Find the speed of P at B .

(2)

(Total 7 marks)

Q3.

A lifeboat slides down a straight ramp inclined at an angle of 15° to the horizontal. The lifeboat has mass 800 kg and the length of the ramp is 50 m. The lifeboat is released from rest at the top of the ramp and is moving with a speed of 12.6 m s^{-1} when it reaches the end of the ramp. By modelling the lifeboat as a particle and the ramp as a rough inclined plane, find the coefficient of friction between the lifeboat and the ramp.

(9)

(Total 9 marks)

Q4.

A small brick of mass 0.5 kg is placed on a rough plane which is inclined to the horizontal at an angle θ , where $\tan \theta = \frac{4}{3}$ and released from rest. The coefficient of friction between the brick and the plane is $\frac{1}{3}$.

Find the acceleration of the brick.

(9)

(Total 9 marks)

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Q5.

A particle of mass 0.4 kg is held at rest on a fixed rough plane by a horizontal force of magnitude P newtons. The force acts in the vertical plane containing the line of greatest slope of the inclined plane which passes through the particle. The plane is inclined to the horizontal at an angle a , where $\tan a = \frac{3}{4}$, as shown in Figure 2.

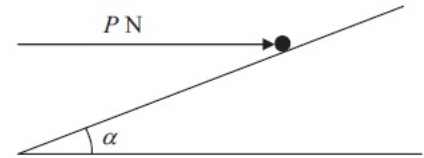


Figure 2

The coefficient of friction between the particle and the plane is $\frac{1}{3}$

Given that the particle is on the point of sliding up the plane, find

- (a) the magnitude of the normal reaction between the particle and the plane,
- (b) the value of P .

(5)

(5)

(Total 10 marks)

Q6.

A particle P of mass 6 kg lies on the surface of a smooth plane. The plane is inclined at an angle of 30° to the horizontal. The particle is held in equilibrium by a force of magnitude 49 N, acting at an angle θ to the plane, as shown in Figure 1. The force acts in a vertical plane through a line of greatest slope of the plane.

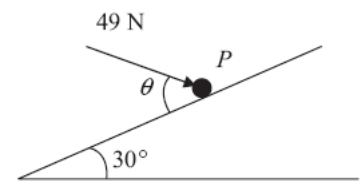


Figure 1

- (a) Show that $\cos \theta = \frac{3}{5}$.

(3)

- (b) Find the normal reaction between P and the plane.

(4)

The direction of the force of magnitude 49 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical plane through a line of greatest slope of the plane.

- (c) Find the initial acceleration of P .

(4)

(Total 11 marks)



Q7.

Unless otherwise indicated, whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

A rough plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$.

A particle of mass m is placed on the plane and then projected up a line of greatest slope of the plane.

The coefficient of friction between the particle and the plane is μ .

The particle moves up the plane with a constant deceleration of $\frac{4}{5}g$.

(a) Find the value of μ .

(6)

The particle comes to rest at the point A on the plane.

(b) Determine whether the particle will remain at A , carefully justifying your answer.

(2)

(Total for question = 8 marks)

Q8.

A rough plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$.

A small block B of mass 5 kg is held in equilibrium on the plane by a horizontal force of magnitude X newtons, as shown in Figure 1.

The force acts in a vertical plane which contains a line of greatest slope of the inclined plane.

The block B is modelled as a particle.

The magnitude of the normal reaction of the plane on B is 68.6 N .

Using the model,

(a) (i) find the magnitude of the frictional force acting on B ,

(3)

(ii) state the direction of the frictional force acting on B .

(1)

The horizontal force of magnitude X newtons is now removed and B moves down the plane.

Given that the coefficient of friction between B and the plane is 0.5

(b) find the acceleration of B down the plane.

(6)

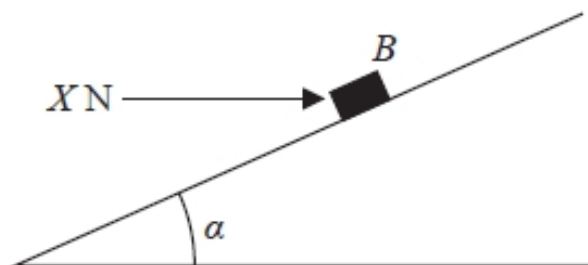


Figure 1

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(Total for question = 10 marks)

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