



Yr2 Connected Particles With Friction (Sheet 2)

Q1.



Figure 3

Two particles A and B , of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough horizontal table. The string passes over a small smooth pulley P fixed on the edge of the table. The particle B hangs freely below the pulley, as shown in Figure 3. The coefficient of friction between A and the table is μ . The particles are released from rest with the string taut. Immediately after release, the magnitude of the acceleration of A and B is $\frac{4}{9}g$. By writing down separate equations of motion for A and B ,

(a) find the tension in the string immediately after the particles begin to move, (3)

(b) show that $\mu = \frac{2}{3}$. (5)

When B has fallen a distance h , it hits the ground and does not rebound. Particle A is then a distance $\frac{1}{3}h$ from P .

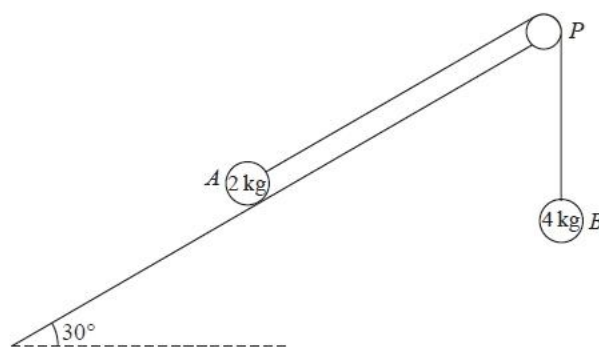
(c) Find the speed of A as it reaches P . (6)

(d) State how you have used the information that the string is light. (1)

(Total 15 marks)

Q2.

A fixed rough plane is inclined at 30° to the horizontal. A small smooth pulley P is fixed at the top of the plane. Two particles A and B , of mass 2 kg and 4 kg respectively, are attached to the ends of a light inextensible string which passes over the pulley P . The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs freely below P , as shown in Figure 2. The coefficient of friction between A and the plane is $\frac{1}{\sqrt{3}}$. Initially A is held at rest on the plane. The particles are released from rest with the string taut and A moves up the plane.



Find the tension in the string immediately after the particles are released.

(9)

(Total 9 marks)



Q3.

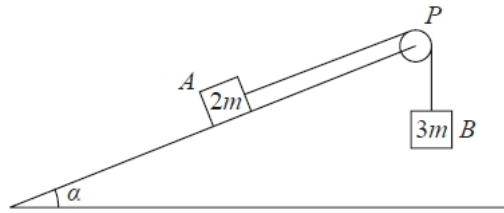


Figure 1

Two blocks, A and B , of masses $2m$ and $3m$ respectively, are attached to the ends of a light string. Initially A is held at rest on a fixed rough plane.

The plane is inclined at angle α to the horizontal ground, where $\tan \alpha = \frac{5}{12}$

The string passes over a small smooth pulley, P , fixed 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. Block B hangs freely below P , as shown in Figure 1.

The coefficient of friction between A and the plane is $\frac{2}{3}$

The blocks are released from rest with the string taut and A moves up the plane.

The tension in the string immediately after the blocks are released is T .

The blocks are modelled as particles and the string is modelled as being inextensible.

(a) Show that $T = \frac{12mg}{5}$ (8)

After B reaches the ground, A continues to move up the plane until it comes to rest before reaching P .

(b) Determine whether A will remain at rest, carefully justifying your answer. (2)

(c) Suggest two refinements to the model that would make it more realistic. (2)

(Total for question = 12 marks)



Q4.

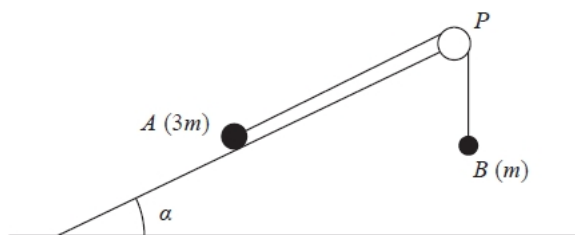


Figure 1

A small stone A of mass $3m$ is attached to one end of a string.

A small stone B of mass m is attached to the other end of the string.

Initially A is held at rest on a fixed rough plane.

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

The string passes over a pulley P that is fixed 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.

Stone B hangs freely below P , as shown in Figure 1.

The coefficient of friction between A and the plane is $\frac{1}{6}$

Stone A is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before B reaches the pulley,

(a) write down an equation of motion for A

(2)

(b) show that the acceleration of A is $\frac{1}{10}g$

(7)

(c) sketch a velocity-time graph for the motion of B , from the instant when A is released from rest to the instant just before B reaches the pulley, explaining your answer.

(2)

In reality, the string is not light.

(d) State how this would affect the working in part (b).

(1)

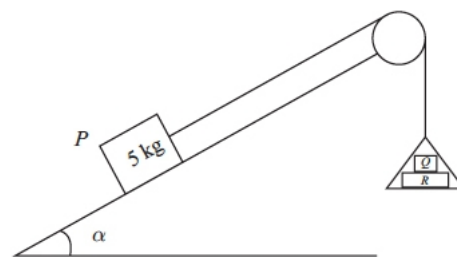
(Total for question = 12 marks)



Q5.

Figure 3

One end of a light inextensible string is attached to a block P of mass 5 kg. The block P is held at rest on a smooth fixed plane which is inclined to the horizontal at an angle α , where $\sin \alpha = \frac{3}{5}$. The string lies along a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane. The other end of the string is attached to a light scale pan which carries two blocks Q and R , with block Q on top of block R , as shown in Figure 3. The mass of block Q is 5 kg and the mass of block R is 10 kg. The scale pan hangs at rest and the system is released from rest. By modelling the blocks as particles, ignoring air resistance and assuming the motion is uninterrupted, find



- (a) (i) the acceleration of the scale pan,
 (ii) the tension in the string,

(8)

- (b) the magnitude of the force exerted on block Q by block R ,

(3)

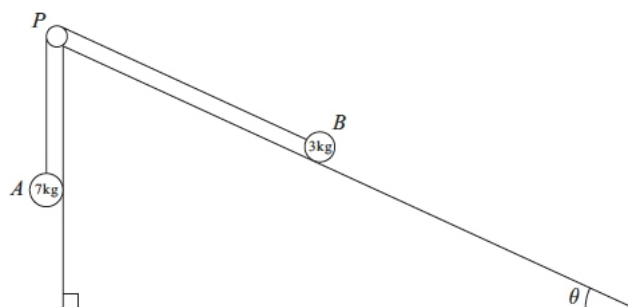
- (c) the magnitude of the force exerted on the pulley by the string.

(5)

(Total 16 marks)

Q6.

Two particles A and B , of mass 7 kg and 3 kg respectively, are attached to the ends of a light inextensible string. Initially B is held at rest on a rough fixed plane inclined at angle θ to the horizontal, where $\tan \theta = \frac{5}{12}$. The part of the string from B to P is parallel to a line of greatest slope of the plane. The string passes over a small smooth pulley, P , fixed at the top of the plane. The particle A hangs freely below P , as shown in above. The coefficient of friction between B and the plane is $\frac{2}{3}$. The particles are released from rest with the string taut and B moves up the plane.



- (a) Find the magnitude of the acceleration of B immediately after release.

(10)

- (b) Find the speed of B when it has moved 1 m up the plane.

(2)

When B has moved 1 m up the plane the string breaks. Given that in the subsequent motion B does not reach P ,

- (c) find the time between the instants when the string breaks and when B comes to instantaneous rest.

(4)

(Total 16 marks)

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Q7.

Figure 5 shows two particles A and B , of mass $2m$ and $4m$ respectively, connected by a light inextensible string. Initially A is held at rest on a rough inclined plane which is fixed to horizontal ground. The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between A and the plane is $\frac{1}{4}$. The string passes over a small smooth pulley P which is fixed 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 and B hangs vertically below P . The system is released from rest with the string taut, with A at the point X and with B at a height h above the ground.

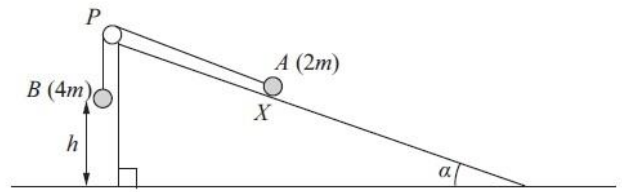


Figure 5

For the motion until B hits the ground,

- (a) give a reason why the magnitudes of the accelerations of the two particles are the same, (1)
- (b) write down an equation of motion for each particle, (4)
- (c) find the acceleration of each particle. (5)

Particle B does not rebound when it hits the ground and A continues moving up the plane towards P . Given that A comes to rest at the point Y , without reaching P ,

- (d) find the distance XY in terms of h . (6)

(Total 16 marks)

Q8.

Two particles P and Q have mass 4 kg and 0.5 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough plane, which is inclined to the horizontal at an angle α

where $\tan \alpha = \frac{4}{3}$. The coefficient of friction between P and the plane is 0.5 . The string lies along the plane and passes over a small smooth light pulley which is fixed at the top of the plane. Particle Q hangs freely at rest vertically below the pulley. The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 4. Particle P is released from rest with the string taut and slides down the plane.

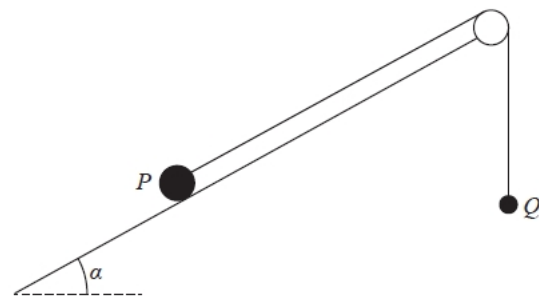


Figure 4

Given that Q has not hit the pulley, find

- (a) the tension in the string during the motion, (11)
- (b) the magnitude of the resultant force exerted by the string on the pulley. (4)

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(Total for question = 15 marks)

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