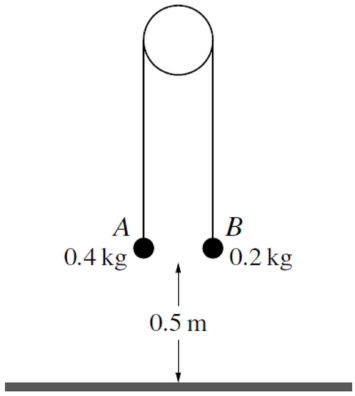
Pulleys

Thursday, 12 January 2023 10:33 PM

M/J/2019/Q5



Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string which passes over a fixed smooth pulley. Both A and B are 0.5 m above the ground. The particles hang vertically (see diagram). The particles are released from rest. In the subsequent motion B does not reach the pulley and A remains at rest after reaching the ground.

(i) For the motion before A reaches the ground, show that the magnitude of the acceleration of each particle is $\frac{10}{3}$ m s^{-2} and find the tension in the string. [4]

(ii) Find the maximum height of B above the ground. [4]

O/N/2011/Q5

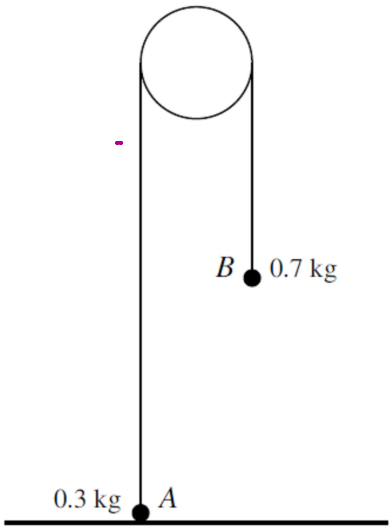
Particles A and B, of masses 0.9 kg and 0.6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley. The system is released from rest with the string taut, with its straight parts vertical and with the particles at the same height above the horizontal floor. In the subsequent motion, B does not reach the pulley.

(i) Find the acceleration of A and the tension in the string during the motion before A hits the floor. [4]

After A hits the floor, B continues to move vertically upwards for a further 0.3 s.

(ii) Find the height of the particles above the floor at the instant that they started to move. [4]

O/N/2009/Q6



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.

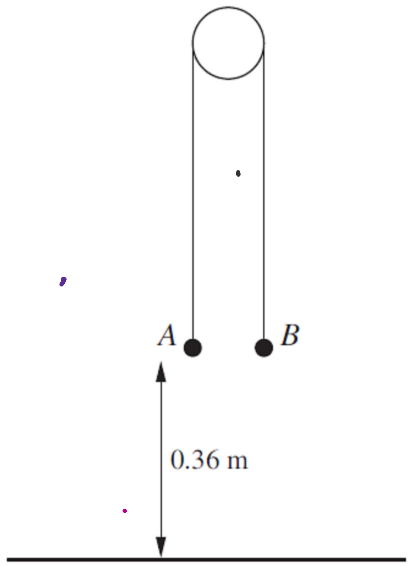
(i) Find the acceleration of the particles. [3]

The speed of the particles immediately before B hits the floor is $1.6\,\text{m s}^{-1}$. 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]

M/J/2009/Q6



Particles A and B are attached to the ends of a light inextensible string which passes over a smooth pulley. The system is held at rest with the string taut and its straight parts vertical. Both particles are at a height of 0.36 m above the floor (see diagram). The system is released and A begins to fall, reaching the floor after 0.6 s.

(i) Find the acceleration of A as it falls. [2]

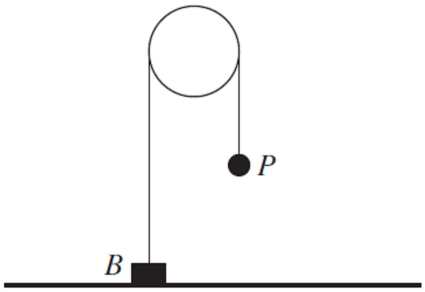
The mass of A is 0.45 kg. Find

(ii) the tension in the string while A is falling, [2]

(iii) the mass of B, [3]

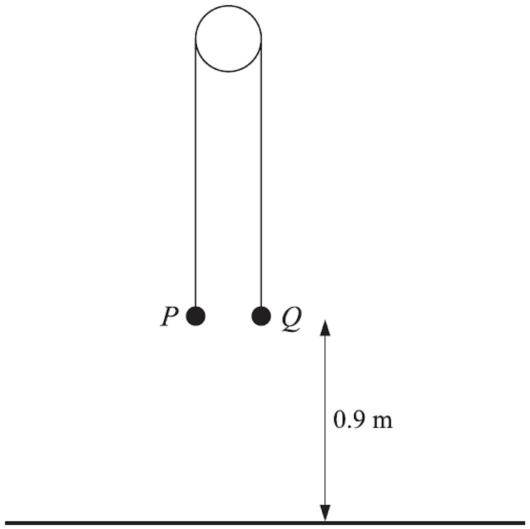
(iv) the maximum height above the floor reached by B. [3]

M/J/2009/Q1



A block B of mass 5 kg is attached to one end of a light inextensible string. A particle P of mass 4 kg is attached to other end of the string. The string passes over a smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on the ground (see diagram). State the tension in the string and find the force exerted on B by the ground. [3]

M/J/2007/Q4

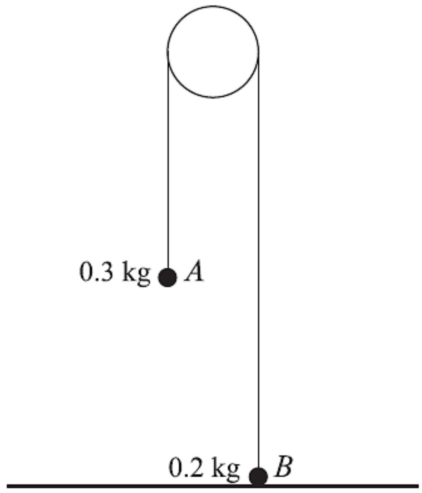


Particles P and Q, of masses 0.6 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed peg. The particles are held at rest with the string taut. Both particles are at a height of 0.9 m above the ground (see diagram). The system is released and each of the particles moves vertically. Find

(i) the acceleration of P and the tension in the string before P reaches the ground, [5]

(ii) the time taken for P to reach the ground. [2]

O/N/2005/Q7



Two particles A and B, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle B is held on the horizontal floor and particle A hangs in equilibrium. Particle B is released and each particle starts to move vertically with constant acceleration of magnitude a m s^{-2}.

(i) Find the value of a. [4]

Particle A hits the floor 1.2 s after it starts to move, and does not rebound upwards.

(ii) Show that A hits the floor with a speed of 2.4 m s^{-1}. [1]

(iii) Find the gain in gravitational potential energy by B, from leaving the floor until reaching its greatest height. [5]

M/J/2015/Q6

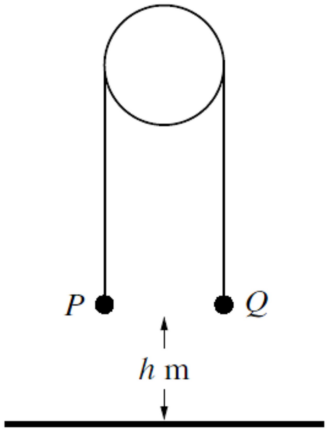


Fig. 1

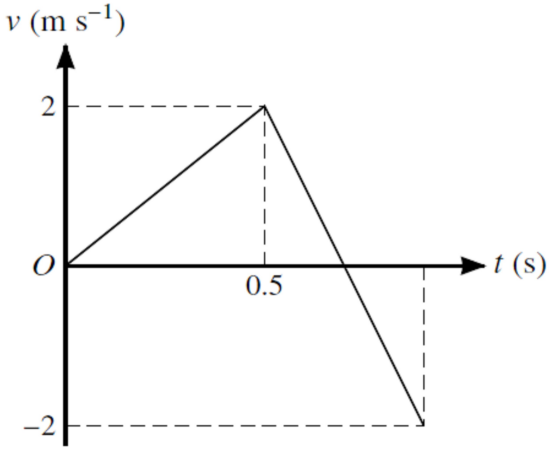


Fig. 2

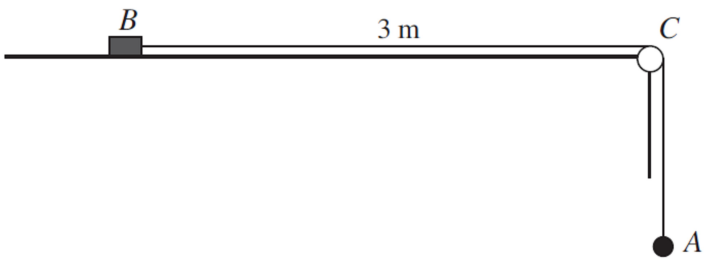
Two particles P and Q have masses m kg and $(1 - m)$ kg respectively. The particles are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. P is held at rest with the string taut and both straight parts of the string vertical. P and Q are each at a height of h m above horizontal ground (see Fig. 1). P is released and Q moves downwards. Subsequently Q hits the ground and comes to rest. Fig. 2 shows the velocity-time graph for P while Q is moving downwards or is at rest on the ground.

(i) Find the value of h. [2]

(ii) Find the value of m, and find also the tension in the string while Q is moving. [6]

(iii) The string is slack while Q is at rest on the ground. Find the total time from the instant that P is released until the string becomes taut again. [3]

M/J/2008/Q5

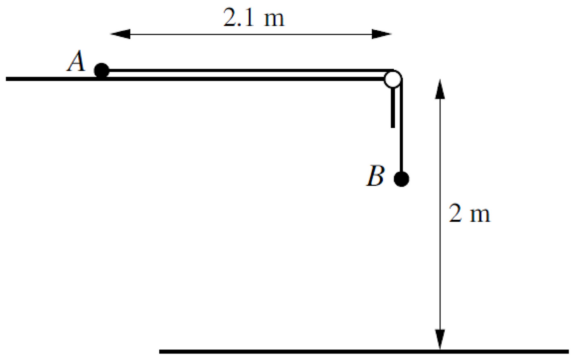


A block B of mass 0.6 kg and a particle A of mass 0.4 kg are attached to opposite ends of a light inextensible string. The block is held at rest on a rough horizontal table, and the coefficient of friction between the block and the table is 0.5. The string passes over a small smooth pulley C at the edge of the table and A hangs in equilibrium vertically below C. The part of the string between B and C is horizontal and the distance BC is 3 m (see diagram). B is released and the system starts to move.

(i) Find the acceleration of B and the tension in the string. [6]

(ii) Find the time taken for B to reach the pulley. [2]

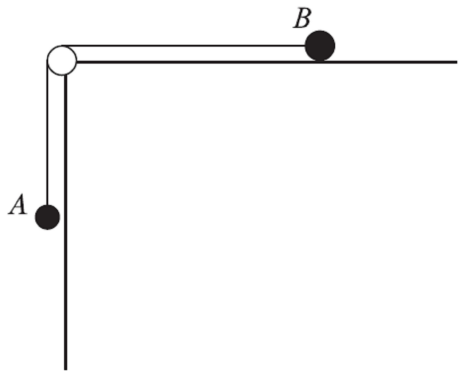
M/J/2010/Q6



Particles A and B, of masses 0.2 kg and 0.45 kg respectively, are connected by a light inextensible string of length 2.8 m. The string passes over a small smooth pulley at the edge of a rough horizontal surface, which is 2 m above the floor. Particle A is held in contact with the surface at a distance of 2.1 m from the pulley and particle B hangs freely (see diagram). The coefficient of friction between A and the surface is 0.3. Particle A is released and the system begins to move.

(i) Find the acceleration of the particles and show that the speed of B immediately before it hits the floor is 3.95 m s^{-1}, correct to 3 significant figures. [7]

(ii) Given that B remains on the floor, find the speed with which A reaches the pulley. [4]



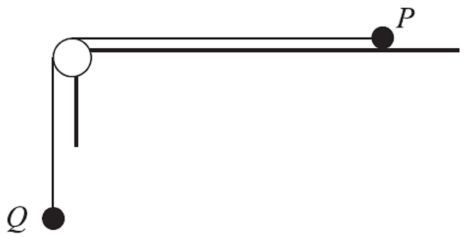
Particles A and B, of masses 0.2 kg and 0.3 kg respectively, are connected by a light inextensible string. The string passes over a smooth pulley at the edge of a rough horizontal table. Particle A hangs freely and particle B is in contact with the table (see diagram).

(i) The system is in limiting equilibrium with the string taut and A about to move downwards. Find the coefficient of friction between B and the table. [4]

A force now acts on particle B. This force has a vertical component of 1.8 N upwards and a horizontal component of X N directed away from the pulley.

(ii) The system is now in limiting equilibrium with the string taut and A about to move **upwards**. Find X. [3]

M/J/2006/Q5



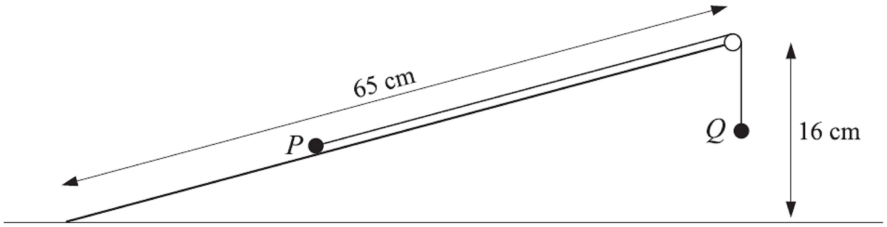
Particles P and Q are attached to opposite ends of a light inextensible string. P is at rest on a rough horizontal table. The string passes over a small smooth pulley which is fixed at the edge of the table. Q hangs vertically below the pulley (see diagram). The force exerted on the string by the pulley has magnitude $4\sqrt{2}$ N. The coefficient of friction between P and the table is 0.8.

(i) Show that the tension in the string is 4 N and state the mass of Q. [2]

(ii) Given that P is on the point of slipping, find its mass. [2]

A particle of mass 0.1 kg is now attached to Q and the system starts to move.

(iii) Find the tension in the string while the particles are in motion. [4]

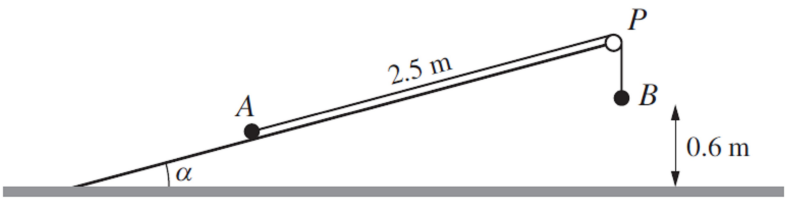


A rough inclined plane of length 65 cm is fixed with one end at a height of 16 cm above the other end. Particles P and Q, of masses 0.13 kg and 0.11 kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley at the top of the plane. Particle P is held at rest on the plane and particle Q hangs vertically below the pulley (see diagram). The system is released from rest and P starts to move up the plane.

(i) Draw a diagram showing the forces acting on P during its motion up the plane. [1]

The coefficient of friction between P and the plane is 0.6.

(iii) Find the acceleration of P. [6]

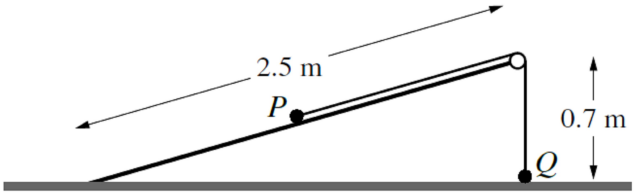


Particles A of mass 0.26 kg and B of mass 0.52 kg are attached to the ends of a light inextensible string. The string passes over a small smooth pulley P which is fixed at the top of a smooth plane. The plane is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{16}{65}$ and $\cos\alpha = \frac{63}{65}$. A is held at rest at a point 2.5 metres from P, with the part AP of the string parallel to a line of greatest slope of the plane. B hangs freely below P at a point 0.6 m above the floor (see diagram). A is released and the particles start to move. Find

(i) the magnitude of the acceleration of the particles and the tension in the string, [5]

(ii) the speed with which B reaches the floor and the distance of A from P when A comes to instantaneous rest. [6]

O/N/2015/Q5

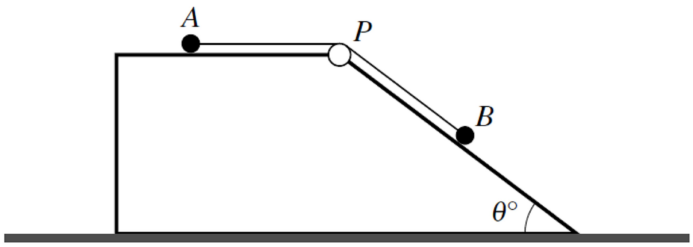


A smooth inclined plane of length 2.5 m is fixed with one end on the horizontal floor and the other end at a height of 0.7 m above the floor. Particles P and Q, of masses 0.5 kg and 0.1 kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley fixed at the top of the plane. Particle Q is held at rest on the floor vertically below the pulley. The string is taut and P is at rest on the plane (see diagram). Q is released and starts to move vertically upwards towards the pulley and P moves down the plane.

(i) Find the tension in the string and the magnitude of the acceleration of the particles before Q reaches the pulley. [5]

At the instant just before Q reaches the pulley the string breaks; P continues to move down the plane and reaches the floor with a speed of $2\,\text{m}\,\text{s}^{-1}$.

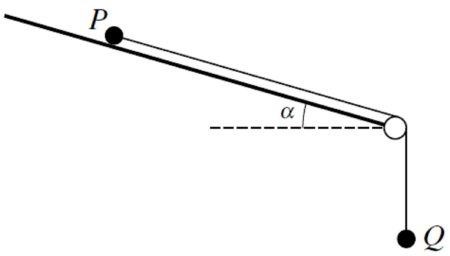
(ii) Find the length of the string. [3]



The diagram shows a fixed block with a horizontal top surface and a surface which is inclined at an angle of $\theta°$ to the horizontal, where $\sin\theta = \frac{3}{5}$. A particle A of mass 0.3 kg rests on the horizontal surface and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the block. The other end of the string is attached to a particle B of mass 1.5 kg which rests on the sloping surface of the block. The system is released from rest with the string taut.

(i) Given that the block is smooth, find the acceleration of particle A and the tension in the string. [5]

(ii) It is given instead that the block is rough. The coefficient of friction between A and the block is μ and the coefficient of friction between B and the block is also μ. In the first 3 seconds of the motion, A does not reach P and B does not reach the bottom of the sloping surface. The speed of the particles after 3 s is 5 m s^{-1}. Find the acceleration of particle A and the value of μ. [9]



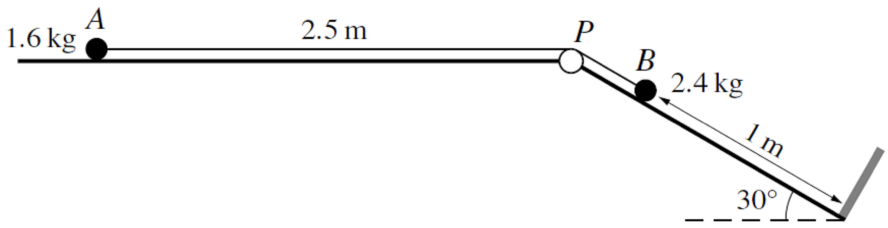
Two particles P and Q, each of mass m kg, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a rough plane. The plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{7}{24}$. Particle P rests on the plane and particle Q hangs vertically, as shown in the diagram. The string between P and the pulley is parallel to a line of greatest slope of the plane. The system is in limiting equilibrium.

(i) Show that the coefficient of friction between P and the plane is $\frac{4}{3}$. [5]

A force of magnitude 10 N is applied to P, acting up a line of greatest slope of the plane, and P accelerates at $2.5\ \text{m s}^{-2}$.

(ii) Find the value of m. [5]

M/J/2018/Q7

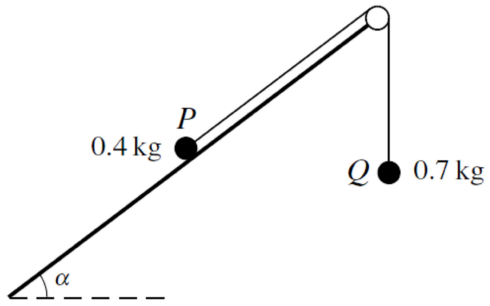


As shown in the diagram, a particle A of mass 1.6 kg lies on a horizontal plane and a particle B of mass 2.4 kg lies on a plane inclined at an angle of 30° to the horizontal. The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the inclined plane. The distance AP is 2.5 m and the distance of B from the bottom of the inclined plane is 1 m. There is a barrier at the bottom of the inclined plane preventing any further motion of B. The part BP of the string is parallel to a line of greatest slope of the inclined plane. The particles are released from rest with both parts of the string taut.

(i) Given that both planes are smooth, find the acceleration of A and the tension in the string. [5]

(ii) It is given instead that the horizontal plane is rough and that the coefficient of friction between A and the horizontal plane is 0.2. The inclined plane is smooth. Find the total distance travelled by A. [9]

O/N/2018/Q4

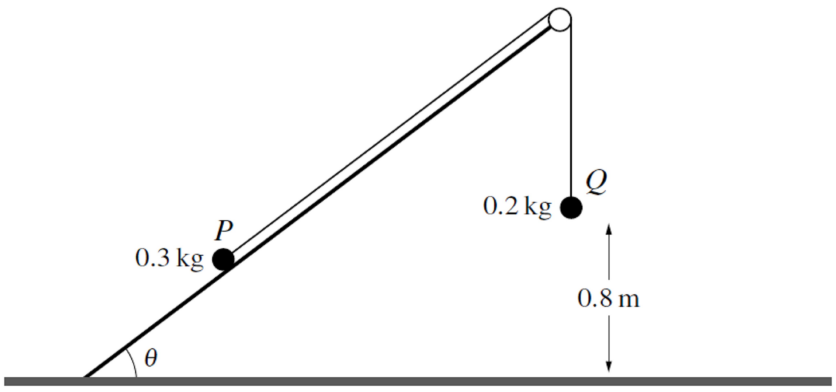


Two particles P and Q, of masses 0.4 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a rough plane. The coefficient of friction between P and the plane is 0.5. The plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. Particle P lies on the plane and particle Q hangs vertically. The string between P and the pulley is parallel to a line of greatest slope of the plane (see diagram). A force of magnitude X N, acting directly down the plane, is applied to P.

(i) Show that the greatest value of X for which P remains stationary is 6.2. [4]

(ii) Given instead that $X = 0.8$, find the acceleration of P. [4]

O/N/2019/Q7



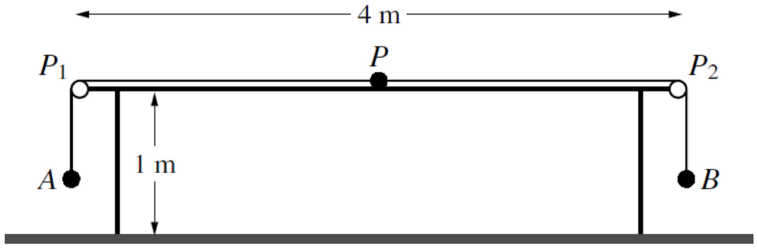
Two particles P and Q, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a smooth plane. The plane is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. P lies on the plane and Q hangs vertically below the pulley at a height of 0.8 m above the floor (see diagram). The string between P and the pulley is parallel to a line of greatest slope of the plane. P is released from rest and Q moves vertically downwards.

(i) Find the tension in the string and the magnitude of the acceleration of the particles. [5]

Q hits the floor and does not bounce. It is given that P does not reach the pulley in the subsequent motion.

(ii) Find the time, from the instant at which P is released, for Q to reach the floor. [2]

M/J/2014/Q7



A light inextensible string of length 5.28 m has particles A and B, of masses 0.25 kg and 0.75 kg respectively, attached to its ends. Another particle P, of mass 0.5 kg, is attached to the mid-point of the string. Two small smooth pulleys P_1 and P_2 are fixed at opposite ends of a rough horizontal table of length 4 m and height 1 m. The string passes over P_1 and P_2 with particle A held at rest vertically below P_1, the string taut and B hanging freely below P_2. Particle P is in contact with the table halfway between P_1 and P_2 (see diagram). The coefficient of friction between P and the table is 0.4. Particle A is released and the system starts to move with constant acceleration of magnitude $a\,\text{m s}^{-2}$. The tension in the part AP of the string is T_A N and the tension in the part PB of the string is T_B N.

(i) Find T_A and T_B in terms of a. [3]

(ii) Show by considering the motion of P that $a = 2$. [3]

(iii) Find the speed of the particles immediately before B reaches the floor. [2]

(iv) Find the deceleration of P immediately after B reaches the floor. [2]