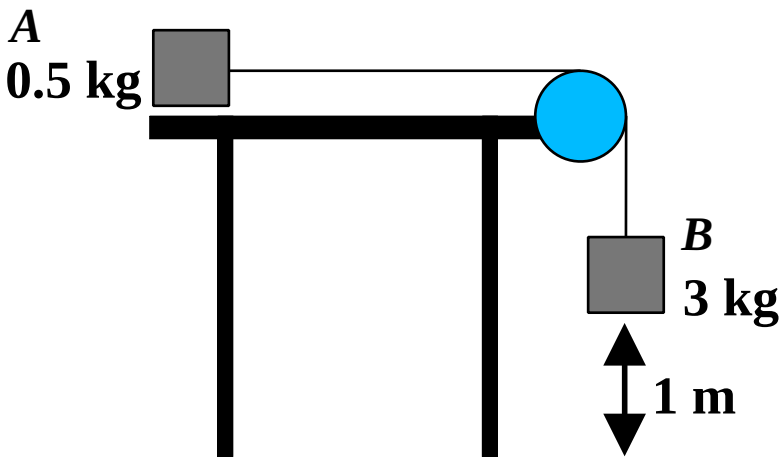
Lesson 6

A-Level Applied Mathematics
Mechanics : Dynamics I : Year 1

6.1 Over The Edge

Example

Particles *A* and *B* of mass 0.5 kg and 3 kg respectively are connected by a light inextensible string over a smooth pulley. *A* rests on a rough horizontal table. Both particles are initially at rest. Particle *B* is held 1 metre above the ground and is then released. It takes 10 seconds for *B* to hit the ground. Assuming there is at least 1 metre between particle *A* and the pulley, find the magnitude of the friction force F_r

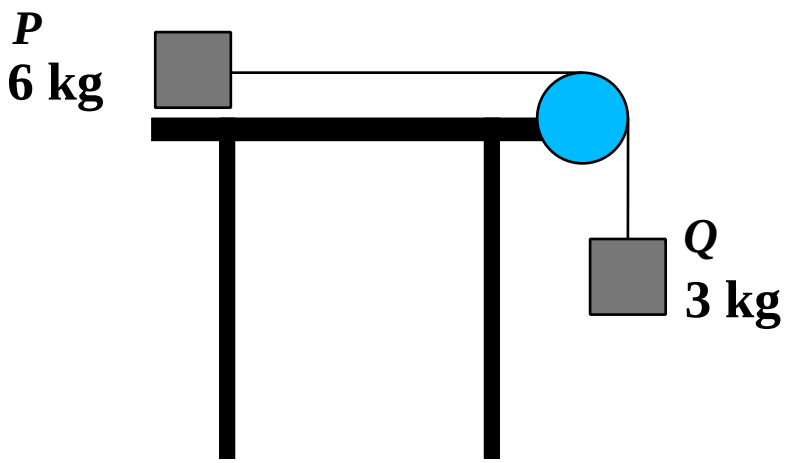


Write out a solution whist watching/pausing the video.
http://www.NumberWonder.co.uk/Video/v9083(6).mp4

6.2 Exercise

Question 1

A particle P of mass 6 kg rests on a rough horizontal plane. P is connected by a light inextensible string passing over a smooth fixed pulley at the edge of the plane to a second particle Q of mass 3 kg which hangs freely. The resistance to motion between P and the horizontal plane is 25 Newtons.
The system is released from rest.



Let the tension in the string be T N and the acceleration of the particles be a m s^{-2}

(i) Write down an equation of motion for P

(ii) Write down an equation of motion for Q

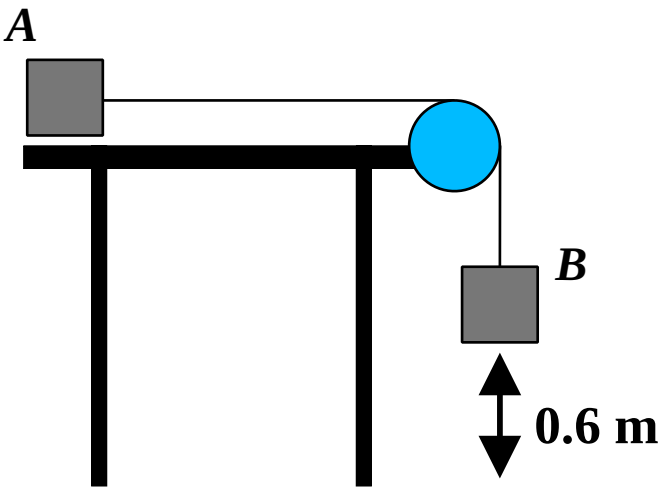
(iii) By solving the two equations of motion simultaneously determine the tension in the string, T, and the acceleration, a

(iv) Find the distance moved by each of the particles in the first 3 seconds of the subsequent motion given that *P* does not reach the pulley.

(v) After 3 seconds *Q* hits the ground and the string then goes slack.
With what speed did *Q* hit the ground ?

(vi) *P* now continues to slide, until it stops, 7 cm before it would otherwise have reached the pulley.
When the system was released from rest, how far was *P* from the pulley ?

Question 2



A particle *A* of mass 0.8 kg rests on a horizontal table 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 table. The other end of the string is attached to a particle *B* of mass 1.2 kg which hangs freely below the pulley. The system is released from rest with the string taut and with *B* at a height of 0.6 m above the ground. In subsequent motion *A* does not reach *P* before *B* reaches the ground. In an initial model of the situation the table is assumed to be smooth.

Using this model, find

(a) the tension in the string before *B* reaches the ground

[5 marks]

(b) the time taken by *B* to reach the ground

[3 marks]

In a refinement of the model, it is assumed that the table is rough and that the resistance to motion between A and the table is 5.6 N

Using this refined model,

(c) find the time taken by B to reach the ground

[8 marks]

Question 3

Two particles *A* and *B* of masses 0.4 kg and 0.8 kg respectively are connected by a light inextensible string. Particle *A* lies on a rough horizontal table 4.5 metres from a small smooth pulley which is fixed at the edge of the table. The string passes over the pulley and *B* hangs freely, with the string taut, 0.5 m above horizontal ground. The resistance to motion between *A* and the table is 0.8 N. The system is released from rest.

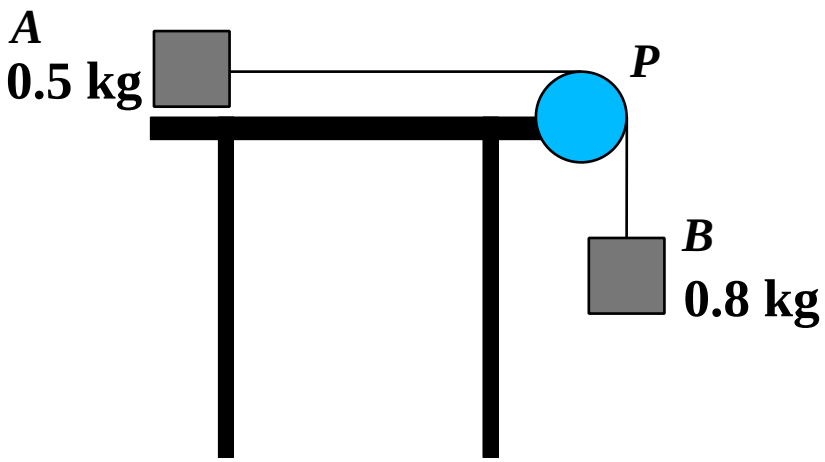
(i) Determine the acceleration of the system

(ii) What is the time taken for *B* to reach the ground ?

(iii) Calculate the total distance travelled by *A* before it first comes to rest.

Question 4

Examination Question from January 2005, M1, Q5



A block of wood *A* of mass 0.5 kg rests on a rough horizontal table 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 table. The other end of the string is attached to a ball *B* of mass 0.8 kg which hangs freely below the pulley.

The resistance to motion of *A* from the rough table has a constant magnitude F_r N

The system is released from rest with the string taut. After release, *B* descends a distance of 0.4 metres in 0.5 seconds. *A* and *B* are to be modelled as particles.

(i) Determine the acceleration of *B*

[3 marks]

(ii) Find the tension in the string

[4 marks]

(iii) Calculate the value of F_r

[3 marks]

(iv) State how in your calculations you have used the information that the string is inextensible

[1 mark]