10.6) Pulleys

Worked example

Particles P and Q, of masses $5m$ and $4m$, are attached to the ends of a light inextensible string. The string passes over a small smooth fixed pulley and the masses hang with the string taut. The system is released from rest.

(a) Write down an equation of motion for P and for Q.
(b) Find the acceleration of each mass.
(c) Find the tension in the string.
(d) Find the force exerted on the pulley by the string.
(e) Find the distance moved by P in the first 2 s, assuming that Q does not reach the pulley.

Your turn

Particles P and Q, of masses $2m$ and $3m$, are attached to the ends of a light inextensible string. The string passes over a small smooth fixed pulley and the masses hang with the string taut. The system is released from rest.

(a) Write down an equation of motion for P and for Q.
(b) Find the acceleration of each mass.
(c) Find the tension in the string.
(d) Find the force exerted on the pulley by the string.
(e) Find the distance moved by Q in the first 4 s, assuming that P does not reach the pulley.

a) For P, $R(\uparrow): T - 2mg = 2ma$
For Q, $R(\downarrow): 3mg - T = 3ma$

b) $a = \frac{1}{5}g = 2.0\ ms^{-2}$ (2 sf)

c) $T = \frac{12}{5}mg\ N$

d) $\frac{24}{5}mg\ N$

e) $15.7\ m$ (3 sf)

Worked example

Two particles A and B of masses 0.8kg and 1.6kg respectively are connected by a light inextensible string. Particle A lies on a rough horizontal table 9m 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, 1m above horizontal ground. A frictional force of magnitude 0.16g opposes the motion of particle A. The system is released from rest. Find:

(a) The acceleration of the system

(b) The time taken for B to reach the ground

(c) The total distance travelled by A before it first comes to rest.

Your turn

Two particles A and B of masses 0.4kg and 0.8kg respectively are connected by a light inextensible string. Particle A lies on a rough horizontal table 4.5m 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, 0.5m above horizontal ground. A frictional force of magnitude 0.08g opposes the motion of particle A. The system is released from rest. Find:

(a) The acceleration of the system

(b) The time taken for B to reach the ground

(c) The total distance travelled by A before it first comes to rest.

a) $0.6g = 5.9\ ms^{-2}$ (2 sf)

b) $0.41\ s$ (2 sf)

c) $2.0\ m$ (2 sf)

Worked example

Two particles A and B have masses $10m$ and km respectively, where $k < 10$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane.
The system is released from rest.

After release, A descends with acceleration $\frac{1}{2}g$.

After descending for 2.4 s, the particle A reaches the plane.
It is immediately brought to rest by the impact with the plane.
The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.
Find the greatest height reached by B above the plane.

Your turn

Two particles A and B have masses $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane.
The system is released from rest.

After release, A descends with acceleration $\frac{1}{4}g$.

After descending for 1.2 s, the particle A reaches the plane.
It is immediately brought to rest by the impact with the plane.
The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.
Find the greatest height reached by B above the plane.

$4.0\ m$