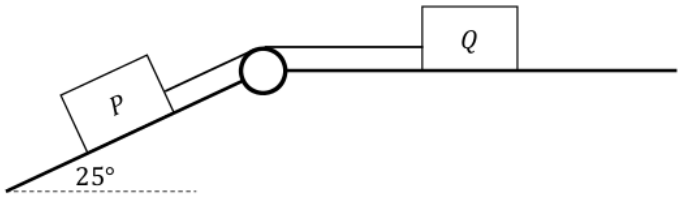
Connected Particles Exam Questions

Note These exam questions are given in reverse chronological order as they appear in exam papers; 2023 paper, Sample paper, 2022 (deferred), 2022, and so on back to 2015. Only questions from the old syllabus relevant to the new syllabus are included, including those that are not Q4 but have enough of a Connected Particles component to be considered worthwhile when revising the topic.

Question — 2023 Q5 (a).

Question 5

(a) Block P (of mass 6.3 kg) and block Q (of mass 2.5 kg) are held at rest on a rough surface. They are connected by a light inextensible string which passes over a smooth fixed pulley. Block Q lies on the horizontal part of the surface and block P lies on the part of the surface that is inclined at 25° to the horizontal, as shown in the diagram.



The coefficient of friction between each block and the surface is 0.2.

The blocks begin to move when they are released.

(i) Show, on separate diagrams, the forces acting on the blocks while they are moving.

(ii) Calculate the acceleration of the blocks.

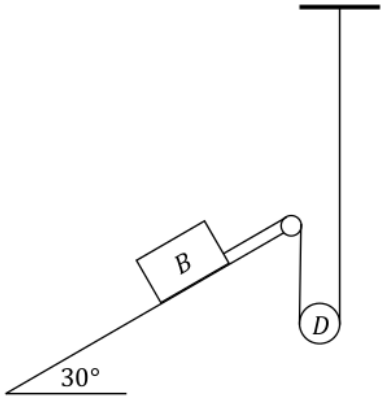
Question — Sample Q7 (b).

(b) A small smooth moveable disk D, of mass 0.2 kg, rests on a light inextensible string. One end of the string is connected to block B, of mass 4 kg, which rests on a rough plane inclined at $30°$ to the horizontal.
The other end of the string is connected vertically to a fixed point.

The coefficient of friction between block B and the inclined plane is $\frac{1}{10}$.

When the system is released from rest, D moves upwards with acceleration a.

The tension in the string is T.



(i) Show, on separate diagrams, the forces acting on block B and disk D while they are moving.

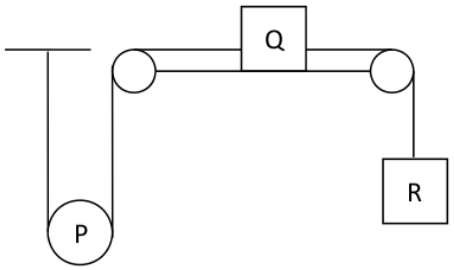
(ii) Explain why the acceleration of B is $2a$.

(iii) Calculate a and T.

Question — 2022 (Deferred) Q4 (a).

(a) A taut light inelastic string is fixed at one end and passes under a moveable pulley, P, of mass 4 kg which hangs vertically. The other end of the string is attached to Q, a mass of 4 kg which lies on a rough horizontal surface.

A second inelastic string connects Q to R, a mass of 10 kg which hangs vertically.



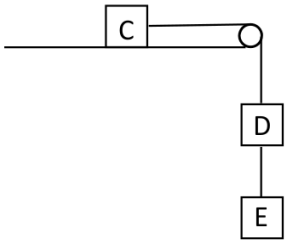
The fixed pulleys are smooth and light and the coefficient of friction between Q and the surface is $\frac{1}{2}$.

The system is released from rest.

Find the accelerations of P, Q and R in terms of g.

Question — 2022 Q4 (a).

(a) A block C of mass $6m$ rests on a rough horizontal table.



It is connected by a light inextensible string which passes over a smooth fixed pulley at the edge of the table to a block D of mass $3m$. D is connected by another light inextensible string to a block E of mass $2m$, as shown in the diagram.

The coefficient of friction between C and the table is $\frac{1}{3}$.

The system is released from rest.

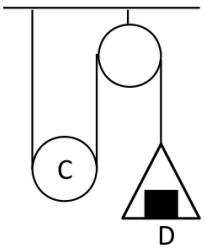
(i) Show on separate diagrams the forces acting on each block.

(ii) Find the acceleration of C.

(iii) Find the tension in each string.

Question — 2021 Q4 (a).

(a) The diagram shows a light inextensible string having one end fixed, passing under a smooth movable pulley C of mass km kg and then over a fixed smooth pulley. The other end of the string is attached to a light scale pan. A bock D of mass m kg is placed symmetrically on the centre of the scale pan.
The system is released from rest. The scale pan moves upwards.



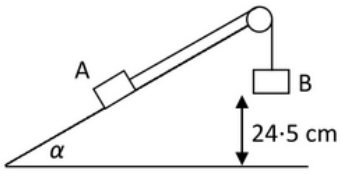
(i) Show that $k > 2$.

(ii) Find, in terms of k and m, the tension in the string.

(iii) Find, in terms of k and m, the reaction between D and the scale pan.

Question — 2020 Q4.

4. (a) A block A of mass $10m$ on a smooth plane inclined at an angle α with the horizontal, where $\tan\alpha = \frac{3}{4}$, is connected by a light inextensible string which passes over a smooth pulley to a second block B of mass $10m$. B is 24·5 cm above an inelastic horizontal floor, as shown in the diagram.



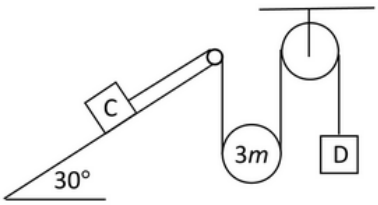
The system is released from rest.

Find

(i) the acceleration of B

(ii) the time that B remains in contact with the floor.

(b) A particle C of mass $2m$ rests on a rough plane which is inclined at 30° to the horizontal. The coefficient of friction between C and the plane is $\frac{\sqrt{3}}{21}$. A light inextensible string which passes under a smooth movable pulley of mass $3m$ connects C to a particle D of mass m, as shown in the diagram.



The system is released from rest. C moves up the plane.

(i) Show, on separate diagrams, the forces acting on the moveable pulley and on each of the masses.

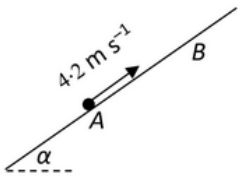
(ii) Find in terms of m the tension in the string.

Question — 2019 Q1 (a).

1. (a) A particle P, of mass 3 kg, is projected along a rough inclined plane from the point A with speed 4·2 m s^{-1}. The particle comes to instantaneous rest at B.

The plane is inclined at an angle α to the horizontal where $\tan\alpha = \frac{9}{40}$.

The coefficient of friction between the particle and the plane is $\frac{3}{20}$.



(i) Show that the deceleration of P is $\frac{15g}{41}$.

(ii) Find $|AB|$.

After reaching B the particle slides back down the plane.

(iii) Find the speed of P as it passes through A on its way back down the plane.

Question — 2019 Q4 (a).

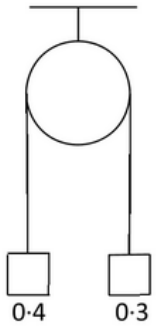
4. **(a)** Two particles of masses 0·4 kg and 0·3 kg are attached to the ends of a light inextensible string which passes over a light smooth fixed pulley. They are held at the same level, as shown in the diagram.

The system is released from rest.

Find

(i) the tension in the string

(ii) the speed of the 0·4 kg mass when it has descended 0·7 m.

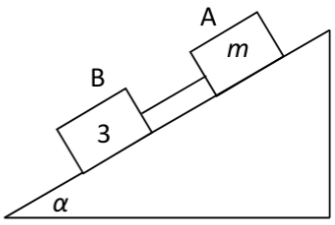


Question — 2018 Q1 (a).

(a) A parcel rests on the horizontal floor of a van.
The van is travelling on a level road at 14 m s^{-1}.
It is brought to rest by a uniform application of the brakes.
The coefficient of friction between the parcel and the floor is $\frac{2}{5}$.
Show that the parcel is on the point of sliding forward on the floor of the van if the stopping distance is 25 m.

Question — 2018 Q4.

(a) A block A of mass *m* is connected by a light inextensible string to a second block B of mass 3 kg.
They slide down a rough inclined plane which makes an angle α with the horizontal where $\tan\alpha = \frac{3}{4}$.
The string remains taut in the subsequent motion.
The coefficient of friction between A and the plane is $\frac{3}{4}$.
The coefficient of friction between B and the plane is $\frac{1}{3}$.
The system is released from rest.

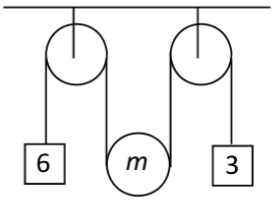


Find

(i) the acceleration of B, in terms of *m*

(ii) the value of *m* if the tension in the string is 3·92 N.

(b) A moveable pulley of mass *m* is suspended on a light inextensible string between two fixed pulleys as shown in the diagram. Masses of 6 kg and 3 kg are attached to the ends of the string.
The system is released from rest.



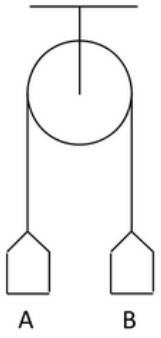
(i) Show, on separate diagrams, the forces acting on the moveable pulley **and** on each of the masses.

(ii) Find in terms of *m* the tension in the string.

(iii) For what value of *m* will the acceleration of the moveable pulley be zero?

Question — 2017 Q4 (a).

4. **(a)** Two scale pans A and B, each of mass m kg, are attached to the ends of a light inextensible string which passes over a light smooth fixed pulley. They are held at the same level, as shown in the diagram. A mass of $3m$ kg is now placed on A.



The system is released from rest.

Find

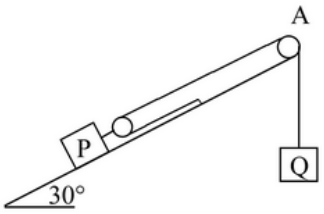
(i) the tension in the string in terms of m

(ii) how far B has risen when it reaches a speed of 0·4 m s^{-1}

(iii) the reaction on the $3m$ kg mass in terms of m.

Question — 2016 Q4.

4. **(a)** The block P has a light pulley fixed to it. The two blocks P and Q, of mass 40 kg and 30 kg respectively, are connected by a taut light inextensible string passing over a light smooth fixed pulley, A, as shown in the diagram.



P is on a rough plane which is inclined at 30° to the horizontal. The coefficient of friction between P and the inclined plane is $\frac{1}{4}$.

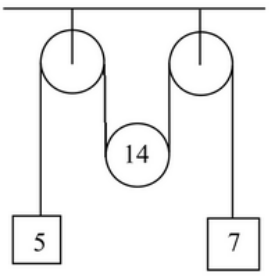
Q is hanging freely. The system is released from rest.

Find

(i) the acceleration of P and the acceleration of Q

(ii) the speed of P when it has moved 30 cm.

(b) A light inextensible string passes over a small smooth fixed pulley, under a small smooth moveable pulley, of mass 14 kg, and then over a second small smooth fixed pulley. A 5 kg mass is attached to one end of the string and a 7 kg mass is attached to the other end.



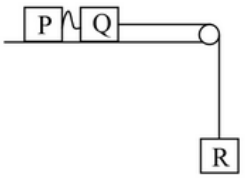
The system is released from rest.

(i) Find the tension in the string.

(ii) If instead of the system starting from rest, the moveable pulley is given an initial upward velocity of 0·8 m s^{-1}, find the time taken until the moveable pulley reverses direction.

Question — 2015 Q4 (a).

(a) Two particles P and Q, of mass 4 kg and 7 kg respectively, are lying 0.5 m apart on a smooth horizontal table. They are connected by a string 3.5 m long. Q is 6 m from the edge of the table and is connected to a particle R, which is of mass 3 kg and is hanging freely, by a taut light inextensible string passing over a light smooth pulley.



The system is released from rest.

Find

(i) the initial acceleration of Q and R

(ii) the speed of Q when it has moved 3 m

(iii) the speed with which P begins to move.