Revision – Forces and Motion (Year 12 Maths)

1.

A breakdown van of mass 2000 kg is towing a car of mass 1200 kg along a straight horizontal road. The two vehicles are joined by a tow bar which remains parallel to the road. The van and the car experience constant resistances to motion of magnitudes 800 N and 240 N respectively. There is a constant driving force acting on the van of 2320 N. Find

(*a*) the magnitude of the acceleration of the van and the car,

(3)

(*b*) the tension in the tow bar.

(4)

2.

A car which has run out of petrol is being towed by a breakdown truck along a straight horizontal road. The truck has mass 1200 kg and the car has mass 800 kg. The truck is connected to the car by a horizontal rope which is modelled as light and inextensible. The truck's engine provides a constant driving force of 2400 N. The resistances to motion of the truck and the car are modelled as constant and of magnitude 600 N and 400 N respectively. Find

(*a*) the acceleration of the truck and the ear,

(3)

(*b*) the tension in the rope.

(3)

When the truck and car are moving at 20 m s^{-1}, the rope breaks. The engine of the truck provides the same driving force as before. The magnitude of the resistance to the motion of the truck remains 600 N.

(*c*) Show that the truck reaches a speed of 28 m s^{-1} approximately 6 s earlier than it would have done if the rope had not broken.

(7)

3.

A car of mass 1000 kg is travelling along a straight, level road.

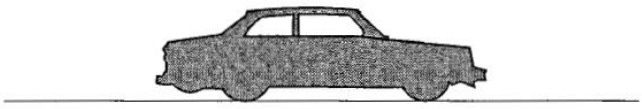


Fig. 6.1

(i) Calculate the acceleration of the car when a resultant force of 2000 N acts on it in the direction of its motion.

How long does it take the car to increase its speed from 5 ms^{-1} to 12.5 ms^{-1}? **[3]**

The car has an acceleration of $1.4\,m\,s^{-2}$ when there is a driving force of 2000 N.

(ii) Show that the resistance to motion of the car is 600 N. [2]

A trailer is now atached to the car, as shown in Fig. 6.2. The car still has a driving force of 2000 N and resistance to motion of 600 N. The trailer has a mass of 800 kg. The tow-bar connecting the car and the trailer is light and horizontal. The car and trailer are accelerating at $0.7\,m\,s^{-2}$.

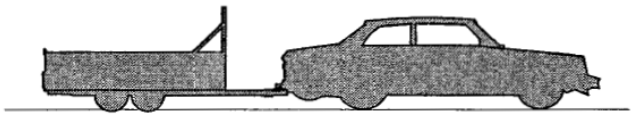


Fig. 6.2

(iii) Show that the resistance to the motion of the trailer is 140 N. [3]

(iv) Calculate the force in the tow-bar. [3]

The driving force is now removed and a braking force of 610 N is applied to the car. All the resistances to motion remain as before. The trailer has no brakes.

(v) Calculate the new acceleration. Calculate also the force in the tow-bar, stating whether it is a tension or a thrust (compression). [6]

4.

A car and its trailer travel along a straight, horizontal road. The coupling between them is light and horizontal. The car has mass 900 kg and resistance to motion 100 N, the trailer has mass 700 kg and resistance to motion 300 N, as shown in Fig. 4. The car and trailer have an acceleration of $1.5\,m\,s^{-2}$.

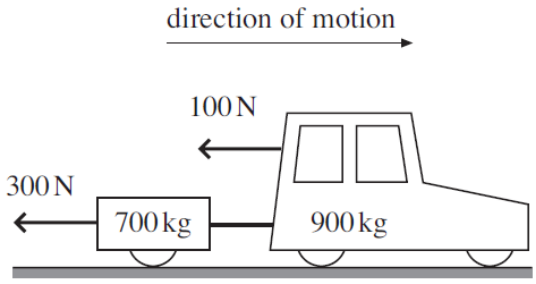


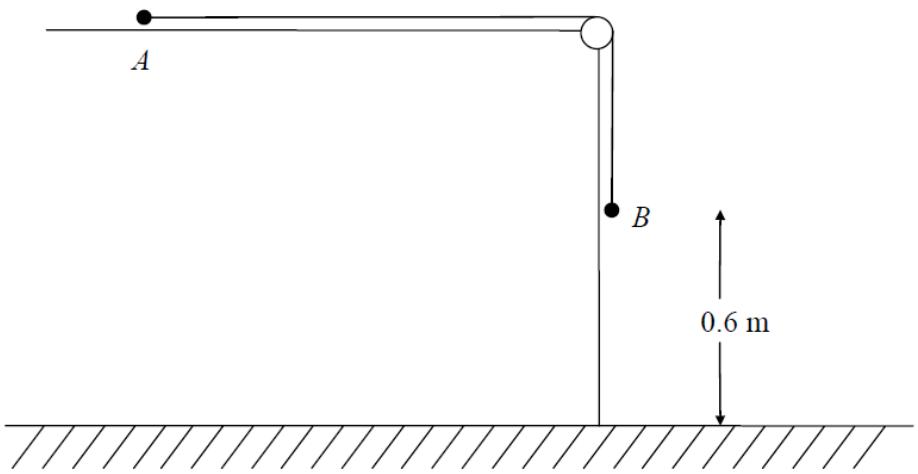
Fig. 4

(i) Calculate the driving force of the car. [3]

(ii) Calculate the force in the coupling. [2]

5.

Figure 4



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, as shown in Fig. 4. The system is released from rest with the string taut and with B at a height of 0.6 m above the ground. In the 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,

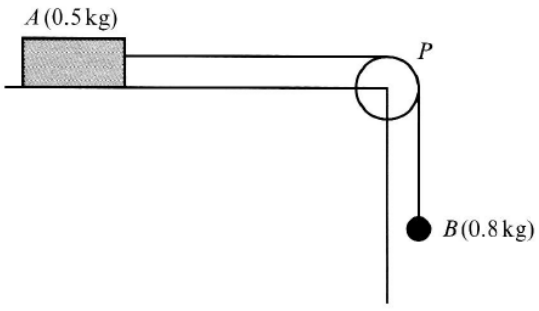
(5)

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

(3)

6.

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, as shown in the figure. The resistance to motion of A from the rough table has a constant magnitude F N. The system is released from rest with the string taut. After release, B descends a distance of 0.4 m in 0.5 s. Modelling A and B as particles, calculate:



a the acceleration of B **(3 marks)**

b the tension in the string **(4 marks)**

c the value of F. **(3 marks)**

d State how in your calculations you have used the information that the string is inextensible. **(1 mark)**

7.

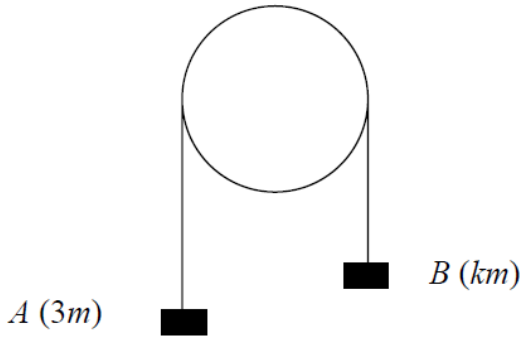


Fig. 3

Two particles A and B have masses $3m$ and km respectively, where $k > 3$. They are connected by a light inextensible string which passes over a smooth fixed pulley. The system is released from rest with the string taut and the hanging parts of the string vertical, as shown in Fig. 3. While the particles are moving freely, A has an acceleration of magnitude $\frac{2}{5}g$.

(a) Find, in terms of m and g, the tension in the string. **(3 marks)**

(b) State why B also has an acceleration of magnitude $\frac{2}{5}g$. **(1 mark)**

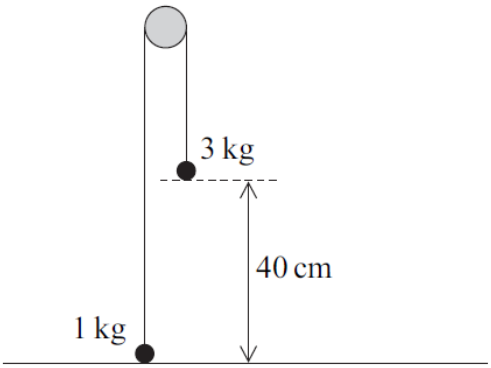
(c) Find the value of k. **(4 marks)**

(d) State how you have used the fact that the string is light. **(1 mark)**

Question 8 is on the next page.

8.

Two particles are connected by a light inextensible string that passes over a smooth peg. The particles have masses of 3 kg and 1 kg. The 1 kg particle is pulled down to ground level, where it is 40 cm below the level of the 3 kg particle, as shown in the diagram.



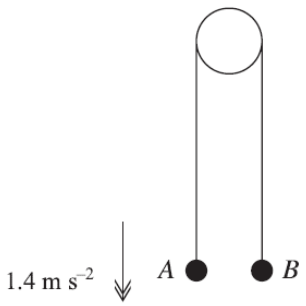
The particles are released from rest with the string vertical above each particle. Assume that no resistance forces act on the particles as they move.

(a) By forming two equations of motion, one for each particle, find the magnitude of the acceleration of the particles after they have been released but before the 3 kg particle hits the ground. *(5 marks)*

(b) Find the speed of the 1 kg particle when the 3 kg particle hits the ground. *(2 marks)*

(c) After the 3 kg particle has hit the ground, the 1 kg particle continues to move and the string is now slack. Find the maximum height above ground level reached by the 1 kg particle. *(3 marks)*

9.



Particles A and B are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The particles are released from rest, with the string taut, and A and B at the same height above a horizontal floor (see diagram). In the subsequent motion, A descends with acceleration $1.4\,\text{m s}^{-2}$ and strikes the floor 0.8 s after being released. It is given that B never reaches the pulley.

(i) Calculate the distance A moves before it reaches the floor and the speed of A immediately before it strikes the floor. [4]

(ii) Show that B rises a further 0.064 m after A strikes the floor, and calculate the total length of time during which B is rising. [4]

(iii) Sketch the (t, v) graph for the motion of B from the instant it is released from rest until it reaches a position of instantaneous rest. [2]

(iv) Before A strikes the floor the tension in the string is 5.88 N. Calculate the mass of A and the mass of B. [4]

(v) The pulley has mass 0.5 kg, and is held in a fixed position by a light vertical chain. Calculate the tension in the chain

(a) immediately before A strikes the floor, [2]

(b) immediately after A strikes the floor. [1]