Connected Particles and Newton's Third Law (From OCR 4761)

Q1, (Jan 2005, Q2)

Particles of mass 2 kg and 4 kg are attached to the ends X and Y of a light, inextensible string. The string passes round fixed, smooth pulleys at P, Q and R, as shown in Fig. 2. The system is released from rest with the string taut.

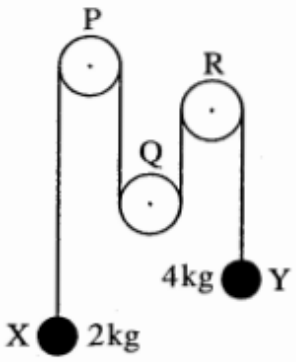

Fig. 2

(i) State what information in the question tells you that

(*A*) the tension is the same throughout the string,

(*B*) the magnitudes of the accelerations of the particles at X and Y are the same. [2]

The tension in the string is T N and the magnitude of the acceleration of the particles is a m s^{-2}.

(ii) Draw a diagram showing the forces acting at X and a diagram showing the forces acting at Y. [1]

(iii) Write down equations of motion for the particles at X and at Y. Hence calculate the values of T and a. [5]

Q2, (Jan 2006, Q4)

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}.

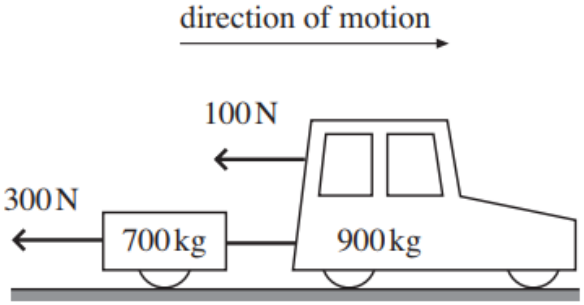

Fig. 4

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

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

Q3, (Jan 2007, Q5)

A block of mass 4 kg slides on a horizontal plane against a constant resistance of 14.8 N. A light, inextensible string is attached to the block and, after passing over a smooth pulley, is attached to a freely hanging sphere of mass 2 kg. The part of the string between the block and the pulley is horizontal. This situation is shown in Fig. 5.

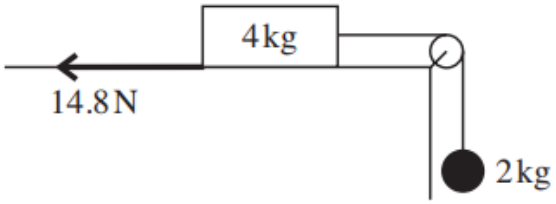

Fig. 5

The tension in the string is T N and the acceleration of the block and of the sphere is a m s^{-2}.

(i) Write down the equation of motion of the block and also the equation of motion of the sphere, each in terms of T and a. [3]

(ii) Find the values of T and a. [3]

Q4, (Jun 2007, Q3)

Fig. 3 shows a system in equilibrium. The rod is firmly attached to the floor and also to an object, P. The light string is attached to P and passes over a smooth pulley with an object Q hanging freely from its other end.

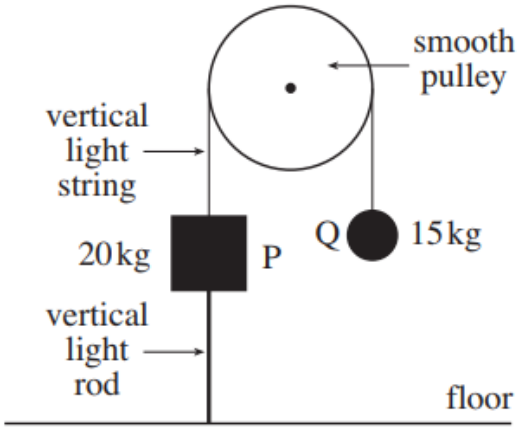

Fig. 3

(i) Why is the tension the same throughout the string? [1]

(ii) Calculate the force in the rod, stating whether it is a tension or a thrust. [3]

Q5, (Jun 2007, Q4)

Two trucks, A and B, each of mass 10 000 kg, are pulled along a straight, horizontal track by a constant, horizontal force of P N. The coupling between the trucks is light and horizontal. This situation and the resistances to motion of the trucks are shown in Fig. 4.

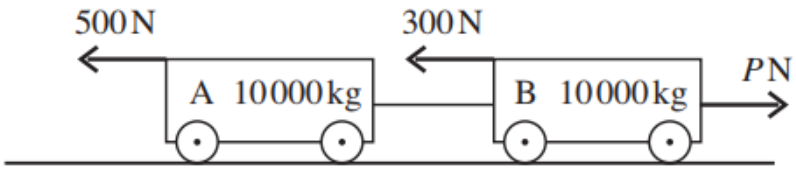

Fig. 4

The acceleration of the system is 0.2 m s^{-2} in the direction of the pulling force of magnitude P.

(i) Calculate the value of P. [3]

Truck A is now subjected to an extra resistive force of 2000 N while P does not change.

(ii) Calculate the new acceleration of the trucks. [2]

(iii) Calculate the force in the coupling between the trucks. [2]

Q6, (Jun 2010, Q4)

As shown in Fig. 4, boxes P and Q are descending vertically supported by a parachute. Box P has mass 75 kg. Box Q has mass 25 kg and hangs from box P by means of a light vertical wire. Air resistance on the boxes should be neglected.

At one stage the boxes are slowing in their descent with the parachute exerting an upward vertical force of 1030 N on box P. The acceleration of the boxes is a m s^{-2} upwards and the tension in the wire is T N.

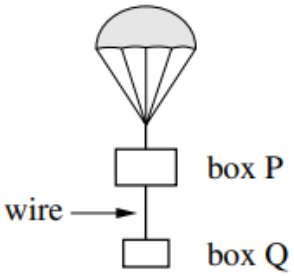

Fig. 4

(i) Draw a labelled diagram showing all the forces acting on box P and another diagram showing all the forces acting on box Q. **[2]**

(ii) Write down separate equations of motion for box P and for box Q. **[3]**

(iii) Calculate the tension in the wire. **[2]**

Q7, (Jun 2013, Q5)

Fig. 5 shows blocks of mass 4 kg and 6 kg on a smooth horizontal table. They are connected by a light, inextensible string. As shown, a horizontal force F N acts on the 4 kg block and a horizontal force of 30 N acts on the 6 kg block.

The magnitude of the acceleration of the system is $2\,\text{m s}^{-2}$.

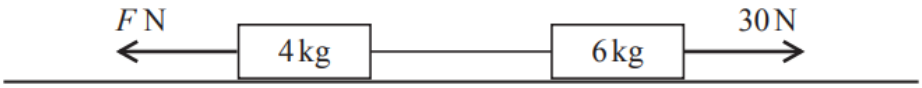

Fig. 5

(i) Find the two possible values of F. **[4]**

(ii) Find the tension in the string in each case. **[3]**

Q8, (Jun 2015, Q2)

Fig. 2 shows a 6 kg block on a smooth horizontal table. It is connected to blocks of mass 2 kg and 9 kg by two light strings which pass over smooth pulleys at the edges of the table. The parts of the strings attached to the 6 kg block are horizontal.

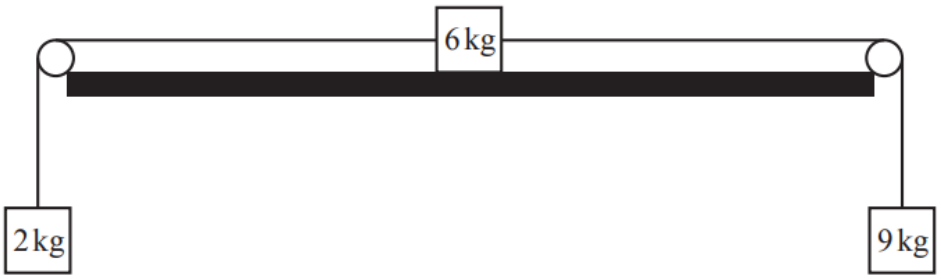

Fig. 2

(i) Draw three separate diagrams showing all the forces acting on each of the blocks. **[3]**

(ii) Calculate the acceleration of the system and the tension in each string. **[5]**
