Connected Particles Review Solutions

Boxes A and B slide on a smooth, horizontal plane. Box A has a mass of 4 kg and box B a mass of 5 kg. They are connected by a light, inextensible, horizontal wire. Horizontal forces of 9 N and 135 N act on A and B in the directions shown in Fig. 5.

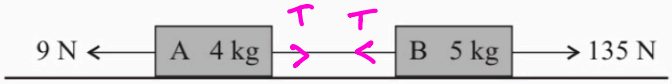


Fig. 5

Calculate the tension in the wire joining the boxes. [4]

N2L whole system $F = ma$

$$135 - 9 = 9a$$
$$126 = 9a$$
$$\frac{126}{9} = a$$
$$a = 14\ ms^{-2}$$

N2L for A

$$T - 9 = 4 \times 14$$
$$T = 56 + 9$$
$$T = 65\ N$$

Alternatively,

N2L for B

$$135 - T = 5 \times 14$$
$$135 - 70 = T$$
$$65\ N = T$$

2 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.

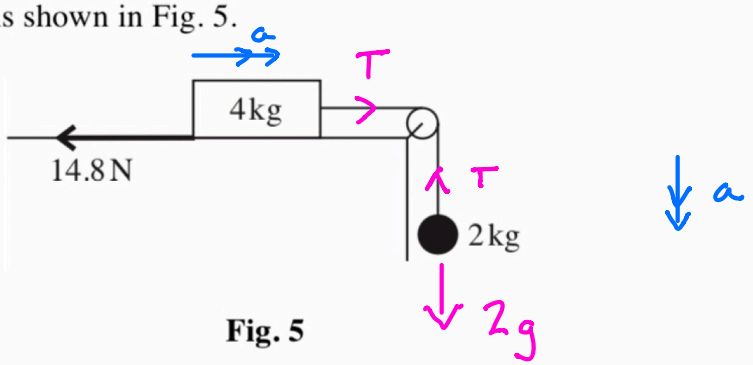


Fig. 5

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]

i) $T - 14.8 = 4a$ Block

$2g - T = 2a$ Sphere

ii) Adding $2g - 14.8 = 6a$

$$\frac{2 \times 9.8 - 14.8}{6} = a$$

$$a = 0.8 \text{ ms}^{-2}$$

Sub for a

$T - 14.8 = 4 \times 0.8$

$T = 3.2 + 14.8$

$T = 18 \text{ N}$

3 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.

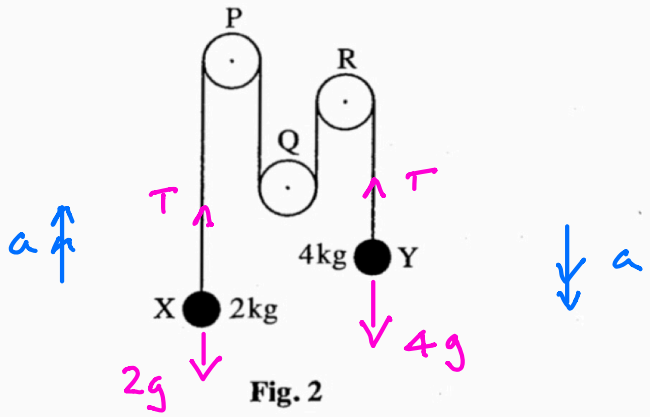


Fig. 2

(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]

i) A) Smooth pulleys

B) Inextensible string

---

ii) Forces shown on diagram above.

---

iii)

For X $\quad T - 2g = 2a$

For Y $\quad 4g - T = 4a$

Add equations $\quad 2g = 6a$

$$\frac{2 \times 9.8}{6} = a$$

$$a = 3.27 \text{ ms}^{-2}$$

Sub for a

$$T - 2g = 2 \times 3.27$$

$$T = 2 \times 3.27 + 2 \times 9.8$$

$$T = 26.1 \text{ N}$$

4. A man of mass 75 kg is standing in a lift. He is holding a parcel of mass 5 kg by means of a light inextensible string, as shown in Fig. 5. The tension in the string is 55 N.

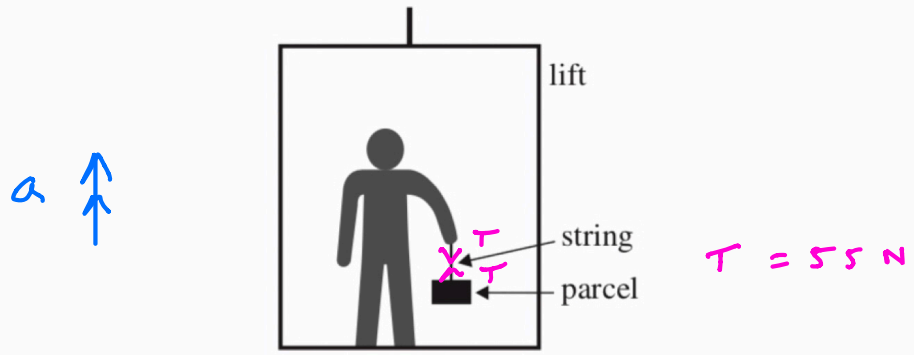


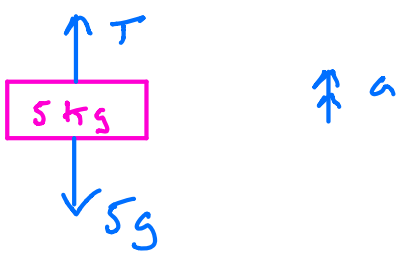
Fig. 5

(i) Find the upward acceleration. **[3]**

(ii) Find the reaction on the man of the lift floor. **[2]**

i) For parcel

N2L



$$T - 5g = 5a$$

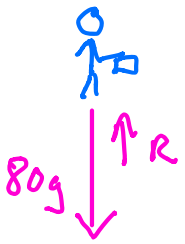
$$\frac{55 - 5 \times 9.8}{5} = a$$

$$a = 1.2 \text{ ms}^{-2}$$

ii)

Now treat man and parcel as single object mass $75 + 5 = 80$ kg

$a = 1.2\ ms^{-2}$ ↑



N 2L

$$R - 80g = 80a$$

$$R = 80 \times 1.2 + 80 \times 9.8$$

$$R = 880\,N$$