1

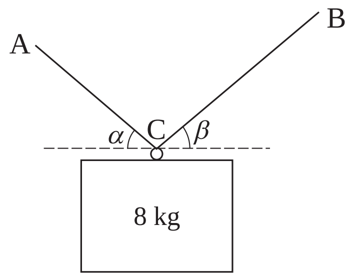

Fig. 7.1

A box of mass 8 kg is supported by a continuous light string ACB that is fixed at A and at B and passes through a smooth ring on the box at C, as shown in Fig. 7.1. The box is in equilibrium and the tension in the string section AC is 60 N.

(i) What information in the question indicates that the tension in the string section CB is also 60 N? [2]

(ii) Show that the string sections AC and CB are equally inclined to the horizontal (so that $\alpha = \beta$ in Fig. 7.1). [2]

(iii) Calculate the angle of the string sections AC and CB to the horizontal. [5]

In a different situation the same box is supported by two separate light strings, PC and QC, that are tied to the box at C. There is also a horizontal force of 10 N acting at C. This force and the angles between these strings and the horizontal are shown in Fig. 7.2. The box is in equilibrium.

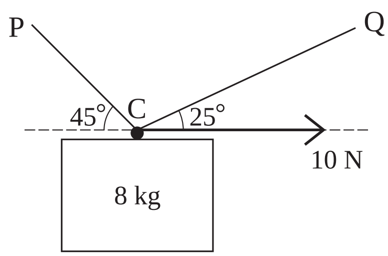

Fig. 7.2

(iv) Calculate the tensions in the two strings. [8]

2 Robin is driving a car of mass 800 kg along a straight horizontal road at a speed of $40\,\mathrm{m\,s^{-1}}$.

Robin applies the brakes and the car decelerates uniformly; it comes to rest after travelling a distance of 125 m.

(i) Show that the resistance force on the car when the brakes are applied is 5120 N. **[4]**

(ii) Find the time the car takes to come to rest. **[2]**

For the rest of this question, assume that when Robin applies the brakes there is a constant resistance force of 5120 N on the car.

The car returns to its speed of $40\,\mathrm{m\,s^{-1}}$ and the road remains straight and horizontal.

Robin sees a red light 155 m ahead, takes a short time to react and then applies the brakes.

The car comes to rest before it reaches the red light.

(iii) Show that Robin's reaction time is less than 0.75 s. **[2]**

The 'stopping distance' is the total distance travelled while a driver reacts and then applies the brakes to bring the car to rest. For the rest of this question, assume that Robin is still driving the car described above and has a reaction time of 0.675 s. (This is the figure used in calculating the stopping distances given in the Highway Code.)

(iv) Calculate the stopping distance when Robin is driving at $20\,\mathrm{m\,s^{-1}}$ on a horizontal road. **[3]**

The car then travels down a hill which has a slope of 5° to the horizontal.

(v) Find the stopping distance when Robin is driving at $20\,\mathrm{m\,s^{-1}}$ down this hill. **[6]**

(vi) By what percentage is the stopping distance increased by the fact that the car is going down the hill? Give your answer to the nearest 1%. **[1]**

3 A trolley C of mass 8 kg with rusty axle bearings is initially at rest on a horizontal floor.

The trolley stays at rest when it is pulled by a horizontal string with tension 25 N, as shown in Fig. 8.1.

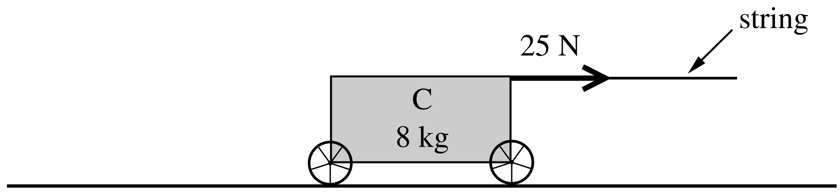

Fig. 8.1

(i) State the magnitude of the horizontal resistance opposing the pull. **[1]**

A second trolley D of mass 10 kg is connected to trolley C by means of a light, horizontal rod.

The string now has tension 50 N, and is at an angle of 25° to the horizontal, as shown in Fig. 8.2. The two trolleys stay at rest.

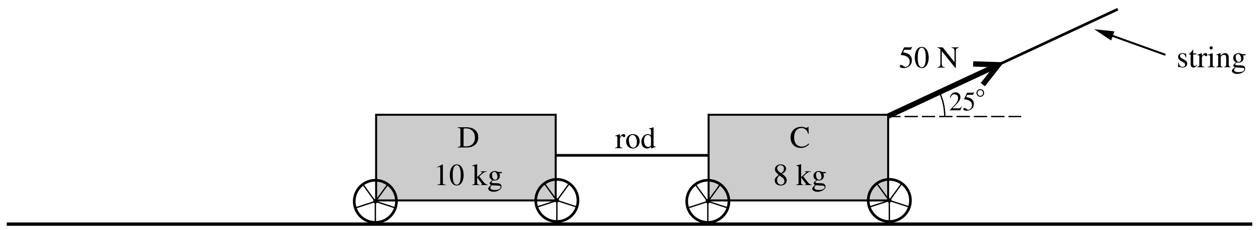

Fig. 8.2

(ii) Calculate the magnitude of the total horizontal resistance acting on the two trolleys opposing the pull. **[2]**

(iii) Calculate the normal reaction of the floor on trolley C. **[3]**

The axle bearings of the trolleys are oiled and the total horizontal resistance to the motion of the two trolleys is now 20 N. The two trolleys are still pulled by the string with tension 50 N, as shown in Fig. 8.2.

(iv) Calculate the acceleration of the trolleys. **[3]**

In a new situation, the trolleys are on a slope at 5° to the horizontal and are initially travelling down the slope at $3\,\text{m}\,\text{s}^{-1}$. The resistances are 15 N to the motion of D and 5 N to the motion of C. There is no string attached. The rod connecting the trolleys is parallel to the slope. This situation is shown in Fig. 8.3.

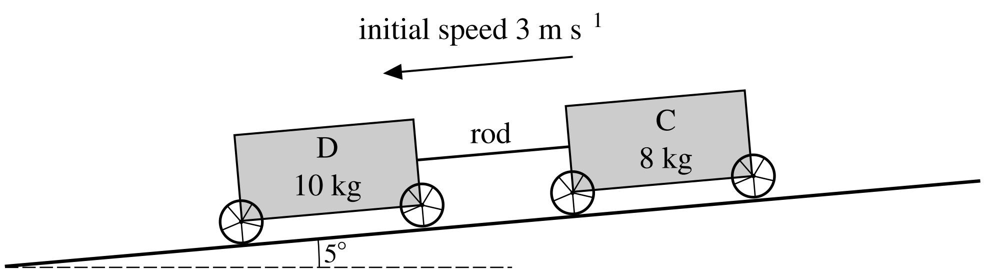

Fig. 8.3

(v) Calculate the speed of the trolleys after 2 seconds and also the force in the rod connecting the trolleys, stating whether this rod is in tension or thrust (compression). **[9]**