

- 1 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.

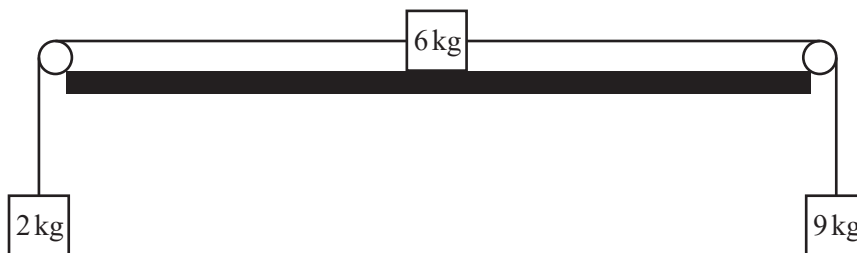


Fig. 2

- (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]

2 The battery on Carol and Martin's car is flat so the car will not start. They hope to be able to "bump start" the car by letting it run down a hill and engaging the engine when the car is going fast enough. Fig. 6.1 shows the road leading away from their house, which is at A. The road is straight, and at all times the car is steered directly along it.

- From A to B the road is horizontal.
- Between B and C, it goes up a hill with a uniform slope of 1.5° to the horizontal.
- Between C and D the road goes down a hill with a uniform slope of 3° to the horizontal. CD is 100 m. (This is the part of the road where they hope to get the car started.)
- From D to E the road is again horizontal.

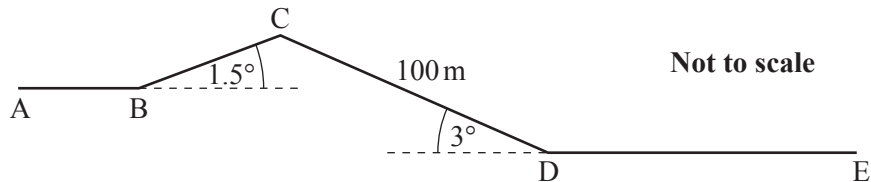


Fig. 6.1

The mass of the car is 750 kg, Carol's mass is 50 kg and Martin's mass is 80 kg.

Throughout the rest of this question, whenever Martin pushes the car, he exerts a force of 300 N along the line of the car.

- (i) Between A and B, Martin pushes the car and Carol sits inside to steer it. The car has an acceleration of 0.25 m s^{-2} .

Show that the resistance to the car's motion is 100 N. [3]

Throughout the rest of this question you should assume that the resistance to motion is constant at 100 N.

- (ii) They stop at B and then Martin tries to push the car up the hill BC.

Show that Martin cannot push the car up the hill with Carol inside it but can if she gets out.

Find the acceleration of the car when Martin is pushing it and Carol is standing outside. [6]

- (iii) While between B and C, Carol opens the window of the car and pushes it from outside while steering with one hand. Carol is able to exert a force of 150 N parallel to the surface of the road but at an angle of 30° to the line of the car. This is illustrated in Fig. 6.2.

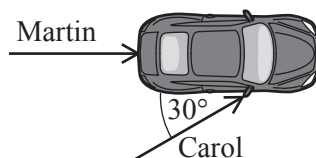


Fig. 6.2

Find the acceleration of the car. [4]

- (iv) At C, both Martin and Carol get in the car and, starting from rest, let it run down the hill under gravity. If the car reaches a speed of 8 m s^{-1} they can get the engine to start.

PhysicsAndMathsTutor.com speed before it reaches D?

[5]

3 Fig. 7 illustrates a train with a locomotive, L, pulling two trucks, A and B.

The locomotive has mass 90 tonnes and is subject to a resistance force of 2000 N.

Each of the trucks A and B has mass 30 tonnes and is subject to a resistance force of 500 N.

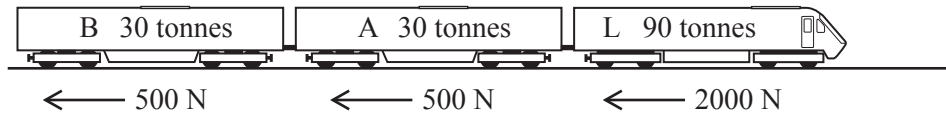


Fig. 7

Initially the train is travelling along a straight horizontal track. The locomotive is exerting a driving force of 12 000 N.

- (i) Find the acceleration of the train. [3]
- (ii) Find the tension in the coupling between trucks A and B. [3]

When the train is travelling at 10 m s^{-1} , a fault occurs with truck A and the resistance to its motion changes from 500 N to 5000 N.

The driver reduces the driving force to zero and allows the train to slow down under the resistance forces and come to a stop.

- (iii) Find the distance the train travels while slowing down and coming to a stop.

Find also the force in the coupling between trucks A and B while the train is slowing down, and state whether it is a tension or a thrust. [7]

The fault in truck A is repaired so that the resistance to its motion is again 500 N. The train continues and comes to a place where the track goes up a uniform slope at an angle of α° to the horizontal.

- (iv) When the train is on the slope, it travels at uniform speed. The driving force remains at 12 000 N. Find the value of α . [3]
- (v) Show that the force in the coupling between trucks A and B has the same value that it had in part (ii). [2]

- 4 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 m s^{-2} .

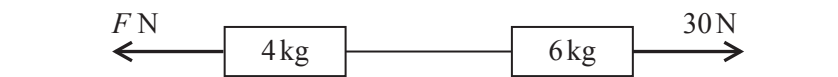


Fig. 5

- (i) Find the two possible values of F . [4]
- (ii) Find the tension in the string in each case. [3]

- 5 Fig. 8.1 shows a sledge of mass 40 kg. It is being pulled across a horizontal surface of deep snow by a light horizontal rope. There is a constant resistance to its motion.

The tension in the rope is 120 N.



Fig. 8.1

The sledge is initially at rest. After 10 seconds its speed is 5 m s^{-1} .

- (i) Show that the resistance to motion is 100 N. [4]

When the speed of the sledge is 5 m s^{-1} , the rope breaks.

The resistance to motion remains 100 N.

- (ii) Find the speed of the sledge

(A) 1.6 seconds after the rope breaks, [3]

(B) 6 seconds after the rope breaks. [1]

The sledge is then pushed to the bottom of a ski slope. This is a plane at an angle of 15° to the horizontal.

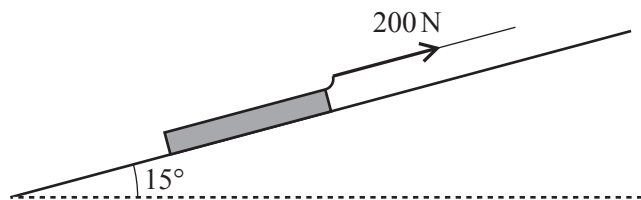


Fig. 8.2

The sledge is attached by a light rope to a winch at the top of the slope. The rope is parallel to the slope and has a constant tension of 200 N. Fig. 8.2 shows the situation when the sledge is part of the way up the slope.

The ski slope is smooth.

- (iii) Show that when the sledge has moved from being at rest at the bottom of the slope to the point when its speed is 8 m s^{-1} , it has travelled a distance of 13.0 m (to 3 significant figures). [4]

When the speed of the sledge is 8 m s^{-1} , this rope also breaks.

- (iv) Find the time between the rope breaking and the sledge reaching the bottom of the slope. [6]