Questions - Test 2 2020

2. A football of mass **0.42kg** is thrown at a stationary student of mass **50.0kg** who is wearing roller blades as shown below.

When she catches the ball she moves to the right.

The instantaneous speed after she catches the ball is **0.10ms^{-1}**.

Calculate the speed of the ball just before it is caught.

4. A shell of mass **6.0kg** travelling with an unknown speed v travelling horizontally explodes into two parts. One part of mass **4.0kg** continues in the original direction with a speed of **80ms^{-1}** and the other part continues in the same direction with a speed of **140ms^{-1}**.

Calculate the **initial unknown speed v**.

7. A **white pool ball** of mass **200g** is hit with a velocity of **1.6ms^{-1}** and collides with a stationary striped ball of the same mass.

If the striped ball moves off with a velocity of **1.9ms^{-1}** then calculate or find:

a) **Velocity** of the **white ball** after the collision.
b) Show by calculation **which type of collision is taking place**.

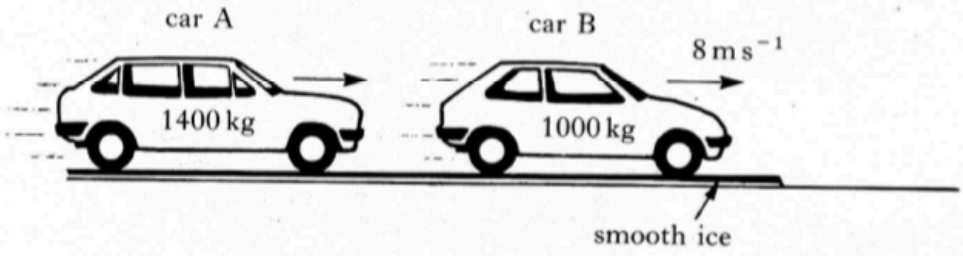
9. A **bullet** of mass **8g** is stationary in the barrel of a **gun** of mass **4kg**.

The trigger is pulled and a force of **2.8kN** is exerted on the bullet for **1.7ms**.

Calculate or find:

a) **Velocity of the bullet** as it leaves the barrel of the gun.
b) **Recoil velocity of the gun**.
c) Show by calculation **which type of collision** is taking place.

(*b*) Two cars, travelling in the same direction, skid on a patch of smooth, level ice.
Car A, of mass 1400 kg, skids straight into the back of car B, of mass 1000 kg.
The two cars become entangled after the impact and continue to move in the same straight line.



Immediately before the impact, car B is moving with a speed of $8\,m\,s^{-1}$.
Immediately after the impact, both cars are moving with a speed of $15\,m\,s^{-1}$.

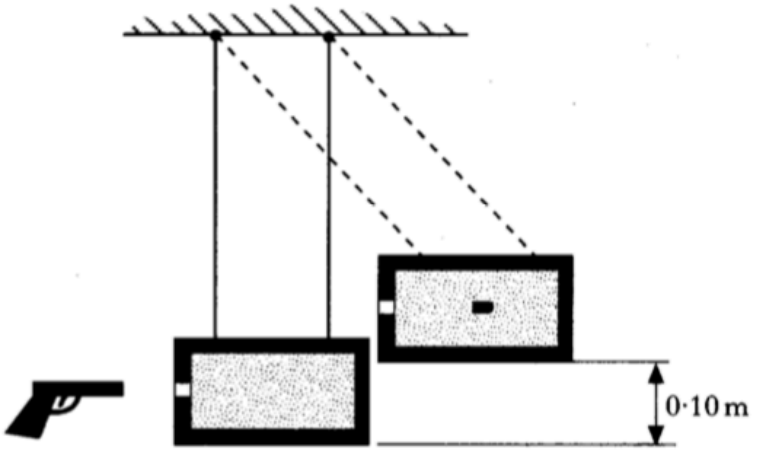
(i) Calculate the speed of car A just before the collision takes place.

(ii) After the collision, the cars leave the patch of ice and continue skidding along the road. They come to rest in a distance of 20 metres after leaving the ice.
Calculate the average frictional force acting on the cars as they come to rest.

(iii) State what happens to the kinetic energy of the cars after they leave the ice.

(*a*) A bullet of mass 25 g is fired horizontally into a sand-filled box which is suspended by long strings from the ceiling. The combined mass of the bullet, box and sand is 10 kg.

After impact, the box swings upwards to reach a maximum height as shown in the diagram.



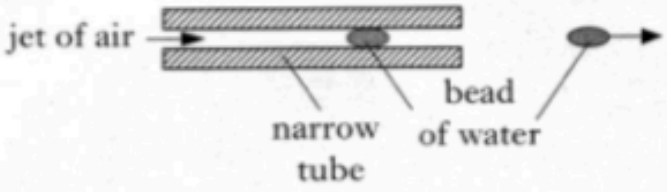
Calculate:

(i) the maximum velocity of the box after impact;

(ii) the velocity of the bullet just before impact.

Beads of liquid moving at high speed are used to move threads in modern weaving machines.

(*a*) In one design of machine, beads of water are accelerated by jets of air as shown in the diagram.



Each bead has a mass of $2{\cdot}5 \times 10^{-5}$ kg.

When designing the machine, it was estimated that each bead of water would start from rest and experience a constant unbalanced force of 0·5 N for a time of 3·0 ms.

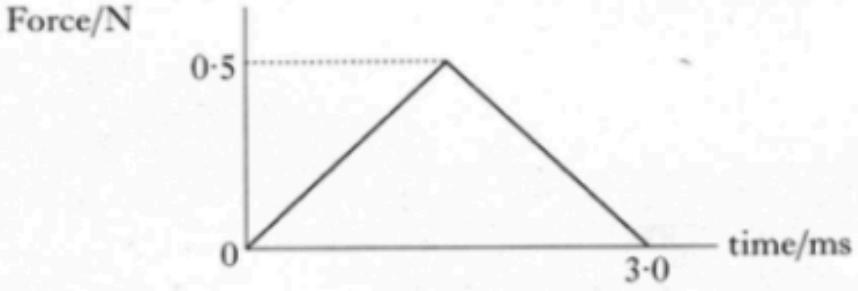
(i) Calculate:

(A) the impulse on a bead of water;

(B) the speed of the bead as it emerges from the tube.

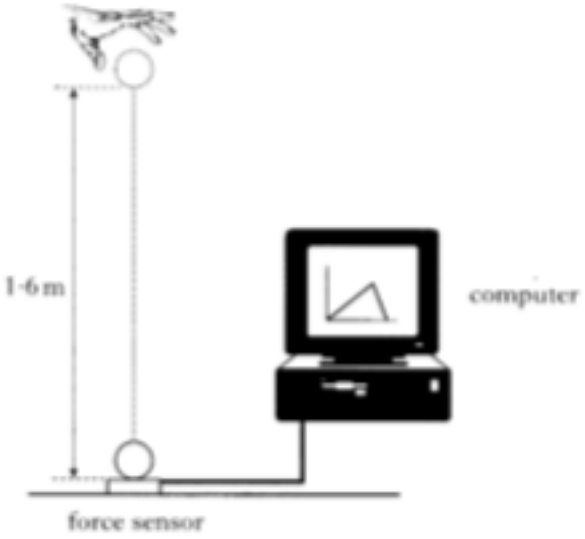
(ii) In practice the force on a bead varies.

The following graph shows how the actual unbalanced force exerted on each bead of water varies with time.

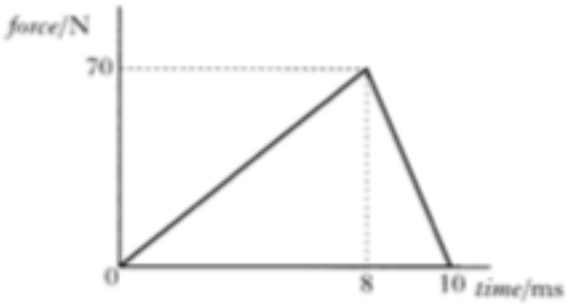


Use information from this graph to show that the bead leaves the tube with a speed equal to half of the value calculated in part (i)(B).

A force sensor is used to investigate the impact of a ball as it bounces on a flat horizontal surface. The ball has a mass of 0·050 kg and is dropped vertically, from rest, through a height of 1·6 m as shown.



(*a*) The graph shows how the force on the ball varies with time during the impact.



(i) Show by calculation that the magnitude of the impulse on the ball is 0·35 N s.

(ii) What is the magnitude and direction of the change in momentum of the ball?

(iii) The ball is travelling at 5·6 m s^{-1} just before it hits the force sensor. Calculate the speed of the ball just as it leaves the force sensor.

WORKED EXAMPLE 9: THE ROLLER COASTER

QUESTION

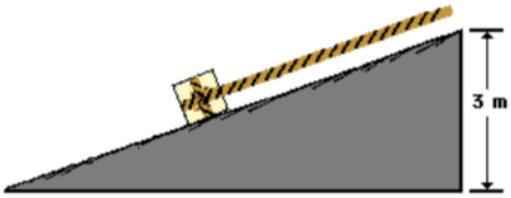
A roller coaster ride at an amusement park starts from rest at a height of $50\ \text{m}$ above the ground and rapidly drops down along its track. At some point, the track does a full 360° loop which has a height of $20\ \text{m}$, before finishing off at ground level. The roller coaster train itself with a full load of people on it has a mass of $850\ \text{kg}$.

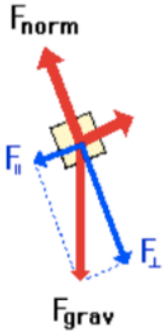
If the roller coaster and its track are frictionless, calculate:

1. the velocity of the roller coaster when it reaches the top of the loop

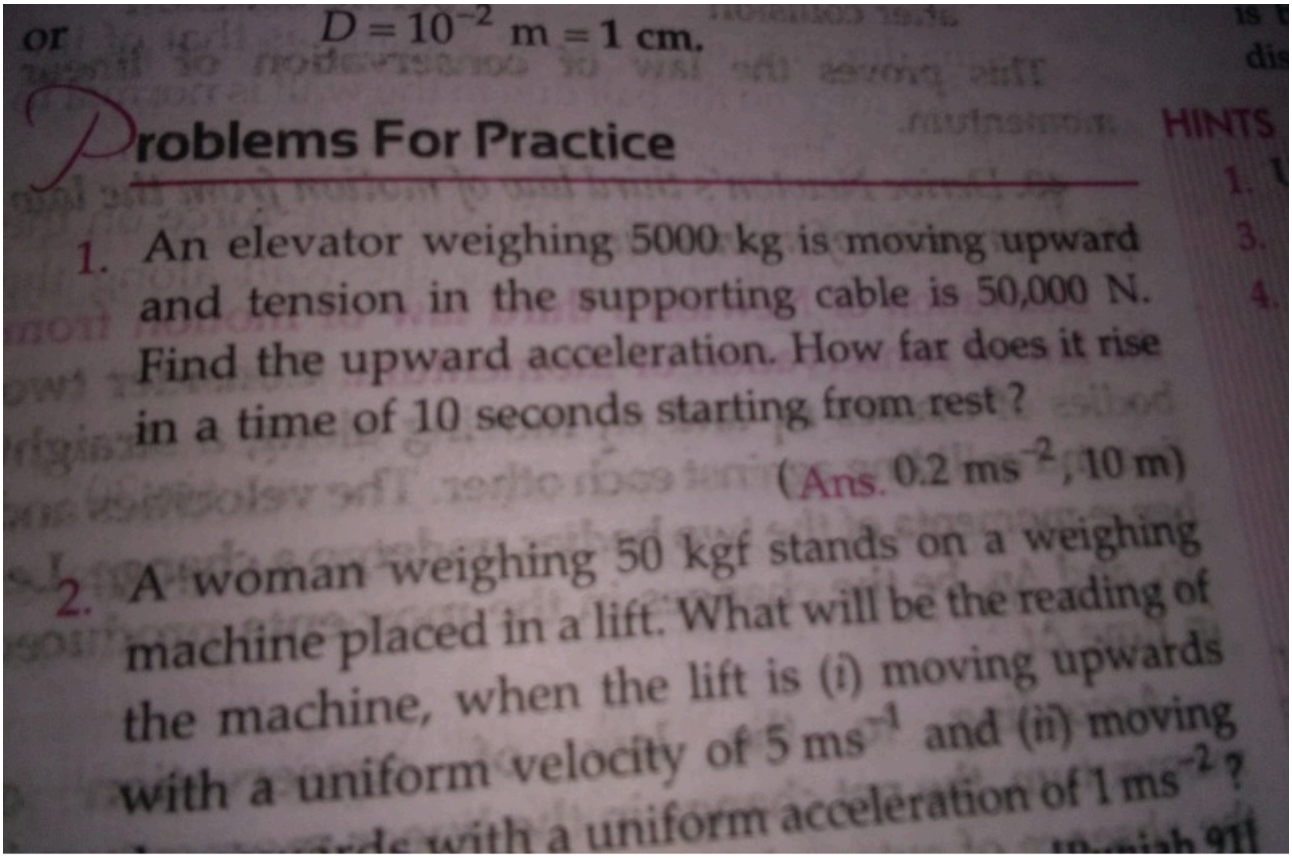
2. the velocity of the roller coaster at the bottom of the loop (i.e. ground level)

14. A rope is attached to a 50.0-kg crate to pull it up a frictionless incline at constant speed to a height of 3-meters. A diagram of the situation and a free-body diagram are shown below. Note that the force of gravity has two components (parallel and perpendicular component); the parallel component balances the applied force and the perpendicular component balances the normal force.





Of the forces acting upon the crate, which one(s) do work upon it?



or $D = 10^{-2}$ m = 1 cm.

Problems For Practice

HINTS

1. An elevator weighing 5000 kg is moving upward and tension in the supporting cable is 50,000 N. Find the upward acceleration. How far does it rise in a time of 10 seconds starting from rest?

(Ans. 0.2 ms^{-2}, 10 m)

2. A woman weighing 50 kgf stands on a weighing machine placed in a lift. What will be the reading of the machine, when the lift is (i) moving upwards with a uniform velocity of 5 ms^{-1} and (ii) moving with a uniform acceleration of 1 ms^{-2}?

1. A 70.0 kg man is riding an elevator **up** 5 stories.
   a. Draw a free body diagram of the man.
   b. What is the man's weight? **686 N**
   c. If he accelerates at 1.87 m/s² on the way up, what is his apparent weight? **816.9 N**
   d. If he slows down with an acceleration of –2.14 m/s² to stop at his floor, what is his apparent weight? **536.2 N**

2. A 47.5 kg woman is riding an elevator **down** 3 stories.
   a. Draw a free body diagram of the woman.
   b. What is the woman's weight? **465.5 N**
   c. If her apparent weight as the elevator begins moving down is 390 N what is her acceleration? **-1.589 m/s²**
   d. If her apparent weight as the elevator is slowing down is 500 N, what is her acceleration? **+0.726 m/s²**