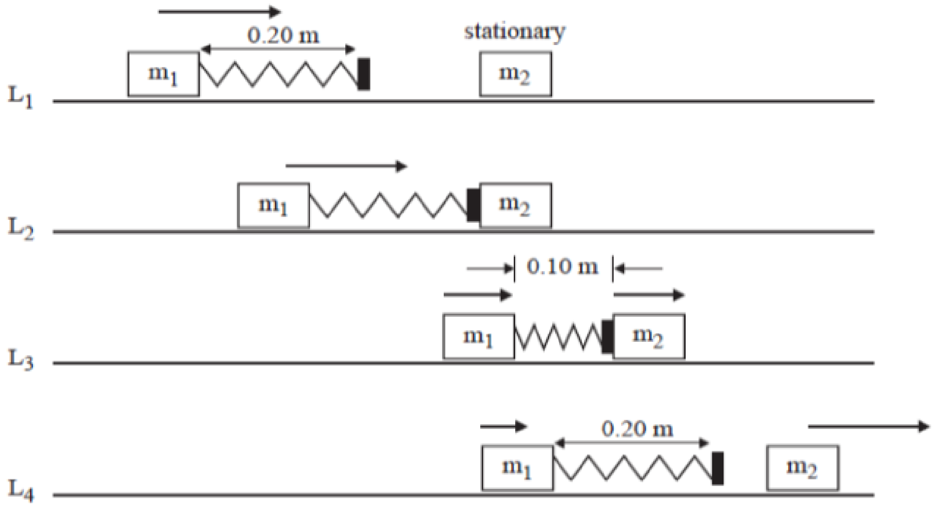
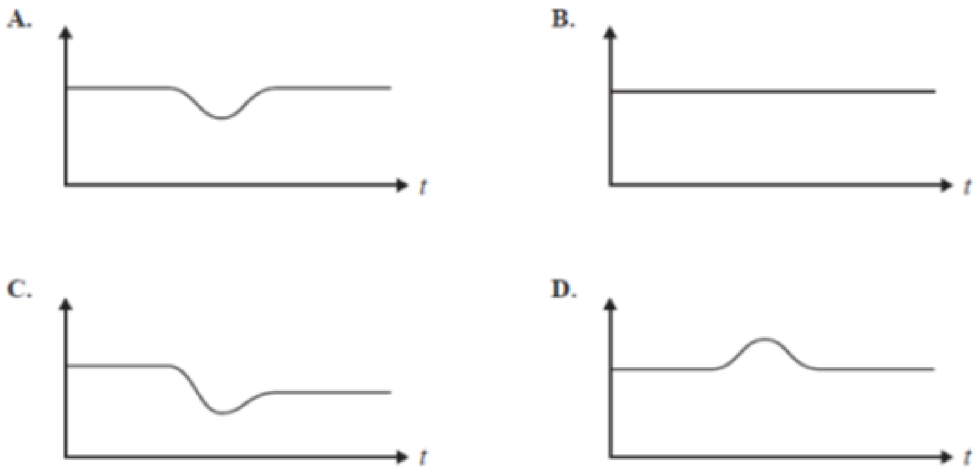
Multiple choice questions

Physics students are conducting a collision experiment using two trolleys, m_1 of mass 0.40 kg and m_2 of mass 0.20 kg.

- Trolley m_1 has a light spring attached to it.
- When uncompressed, this spring has a length 0.20 m.
- Trolley m_1 is initially moving to the right. Trolley m_2 is stationary.
- The trolleys collide, compressing the spring to a length of 0.10 m.
- The trolleys then move apart again, and the spring reverts to its original length (0.20 m), and both trolleys move off to the right.
- The collision is elastic.
- The trolleys do not experience any frictional forces.





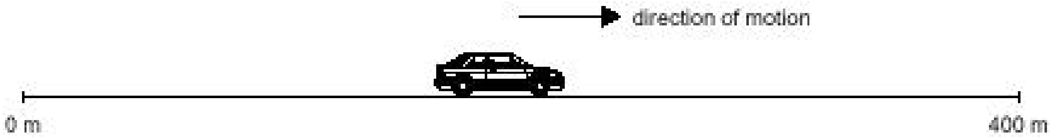
Example 1 (2010 Question 16, 2 marks), 59%

Which graph best shows how the total momentum of the system varies with time before, during and after the collision?

Example 2 (2010 Question 17, 2 marks), 37%

If the collision had been inelastic, which graph would best show how the magnitude of the total momentum of the system varies with time before, during and after the collision?

The “standing 400 m” time for a car is the time that it takes to travel 400 m on a level road, accelerating from rest. The standing 400 m time of a car was 16.0 s.

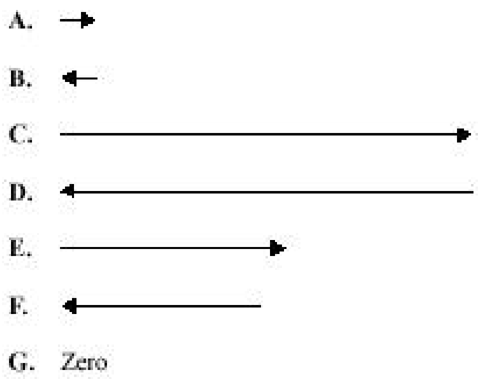


The test on the car was repeated in the **opposite direction** and the standing 400 m time was 18.0 s.

The momentum of the car at the end of the first 400 m may be represented in magnitude and direction by the vector shown below.

Example 3 (2000 Question 3, 1 mark)

Which **one** of the vectors **(A – G**) best represents the **momentum change** of the car, between the **end** of the first and the **end** of the second run?



A car is stationary at a stop sign when it is hit directly from behind by a truck of mass 3000 kg which was travelling at a speed of 9 m s^{-1} immediately before the collision. The two vehicles lock together and move forward with an initial speed of 6 m s^{-1}. Both drivers were wearing correctly adjusted seatbelts at the time of the accident, and the vehicles had strong supporting seat backs with head restraints.

Example 4 (1994 Question 7, 1 mark)

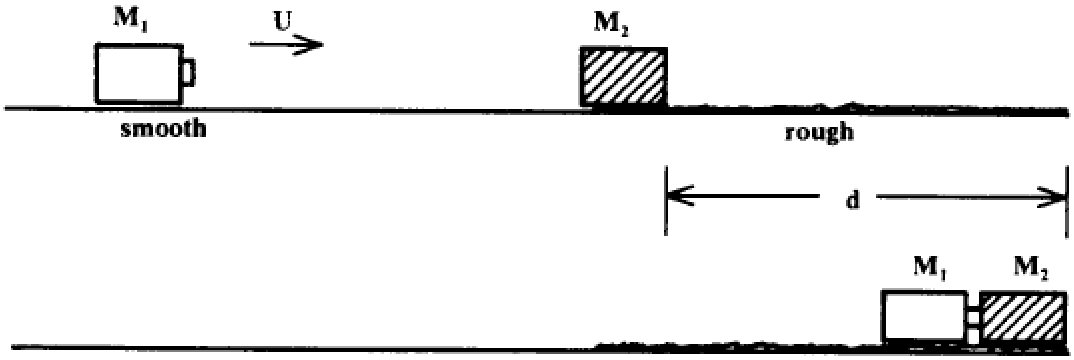
Which statement (A - D) below best describes the forces arising from the impact, which act on the drivers?

A. Each driver felt an increased force due to the seatbelts.

B. The driver of the car felt an increased force due to the seatbelt, but the driver of the truck felt an increased force due to the back of the seat.

C. Each driver felt an increased force due to the back of the seat.

D. The driver of the truck felt an increased force due to the seatbelt, but the driver of the car felt an increased force due to the back of the seat.



A block of wood, with a piece of putty attached (total mass M_1) is travelling at a constant speed U over a frictionless surface. It strikes a second block (M_2) and the two move off together with an initial velocity V and initial kinetic energy K. The blocks are subjected to a constant frictional force F, and come to rest after travelling a distance d.

Example 5 (1982 Question 12, 1 mark)

Which of the following statements about the total momentum of the blocks is correct?

A. Some of it is lost during the impact because the collision is inelastic; after that no momentum is lost, only kinetic energy.

B. Some of it is transferred (without loss) from M_1 to M_2 during the impact; the frictional force then causes the blocks to transfer momentum to the earth.

C. Some of it is lost during the impact, and the remainder is lost as the blocks travel along the rough surface.

D. The total momentum of the two masses remains the same.

Example 6 (1982 Question 13, 1 mark)

Which of the following expressions relating to the kinetic energy of the system is correct?

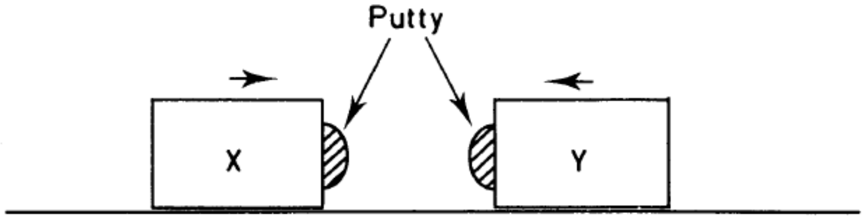
A. $\frac{1}{2}M_1U^2 = Fd$

B. $\frac{1}{2}M_1U^2 = \frac{1}{2}(M_1 + M_2)V^2$

C. $\frac{1}{2}M_1U^2 > Fd$

D. $\frac{1}{2}(M_1 + M_2)V^2 - \frac{1}{2}M_1U^2 = Fd$

E. $\frac{1}{2}(M_1 + M_2)V^2 > Fd$



Two identical blocks, **X** and **Y,** are moving towards each other on a frictionless surface, with equal speeds. A piece of putty on the end of each block results in their sticking together on contact.

Example 7 (1980 Question 30, 1 mark)

What has happened to the total momentum of the two blocks as a result of the interaction?

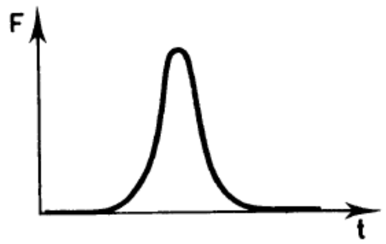
A. All the momentum has been lost; the collision is inelastic, so the momentum is dissipated as heat.

B. It has been transferred to the earth.

C. It is now stored in the molecules of the blocks and the putty.

D. Nothing has happened: it remains zero.

A cricket ball, travelling horizontally, is hit by a batsman so that it quickly returns to the bowler. The graph represents the variation of the force of the bat on the ball with time.



Example 8 (1978 Question 9, 1 mark)

The area under this graph represents:

A. The impulse of the bat on the ball

B. The change in kinetic energy of the ball

C. The change in momentum of the ball

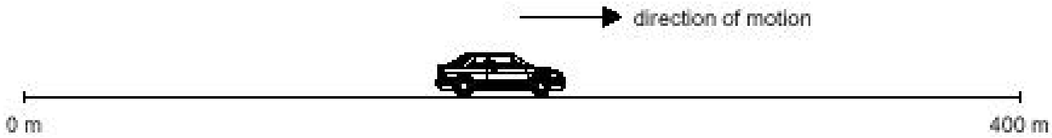
D. The average force on the ball during the time of contact

E. The work done on the ball.

(one or more answers)

Extended answer questions

The "standing 400 m" time for a car is the time that it takes to travel 400 m on a level road, accelerating from rest.



The standing 400 m time of a car was 16.0 s.

Example 9 (2000 Question 1, 2 marks)

Calculate the acceleration of the car, assuming constant acceleration for the entire journey.

Example 10 (2000 Question 2, 2 marks)

Assuming constant acceleration, calculate the speed of the car at the end of 400 m.

In a car the driver's head is moving horizontally at 8.0 m s^{-1} and collides with an air bag as illustrated below. The time taken for the driver's head to come to a complete stop is 1.6×10^{-1} s. This collision may be modelled as a simple horizontal collision between the head of mass 7.0 kg and the air bag.

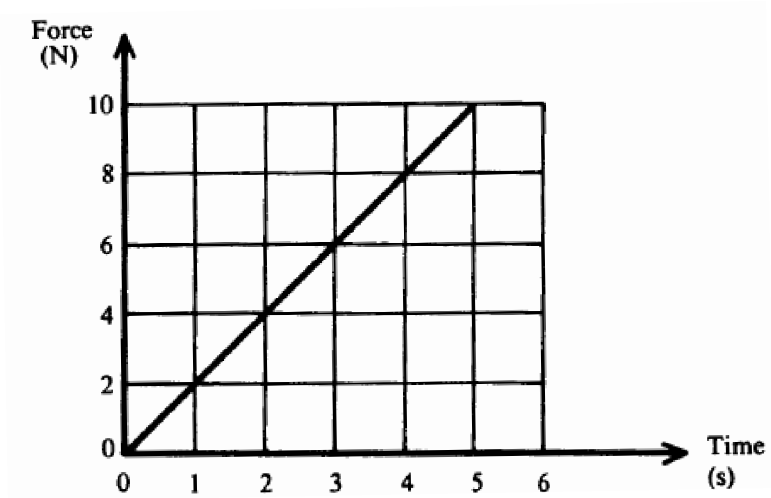
Example 11 (1999 Question 1, 4 marks)

Calculate the magnitude of the average contact force that the air bag exerts on the driver's head during this collision.

Example 12 (1999 Question 2, 4 marks)

Explain why the driver is less likely to suffer head injury in a collision with the air bag than if his head collided with the car dashboard, or other hard surface.

A body of mass 2.0 kg moves from rest, in a straight line, under the action of a net force that increases with time as shown in the graph below.



Example 13 (1985 Question 11, 1 mark)

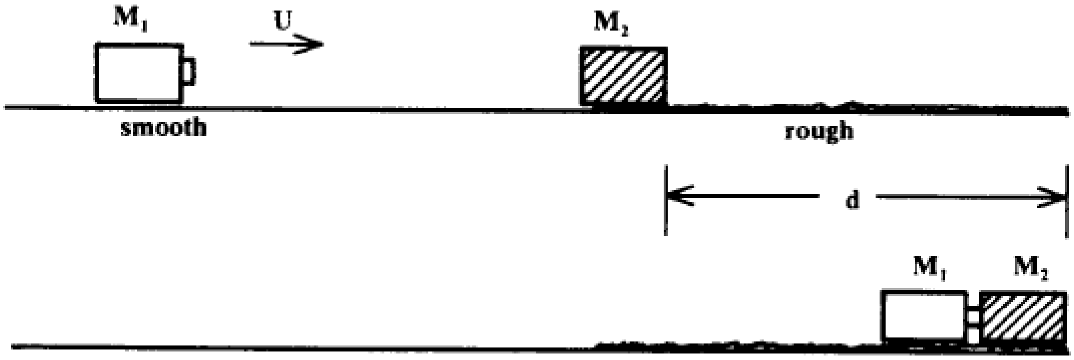
What is the acceleration of the body at time t = 3.0 s?

Example 14 (1985 Question 12, 1 mark)

What is the change in momentum of the body in the first 5.0 s?

Example 15 (1985 Question 13, 1 mark)

How much work is done on the body during the first 5.0 s?



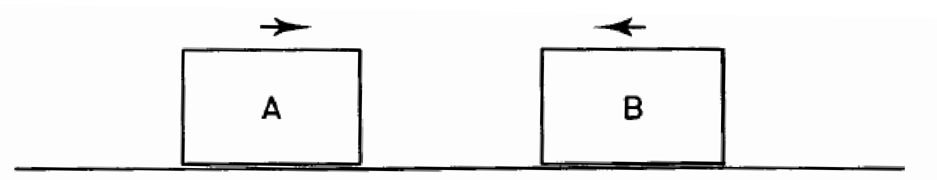
A block of wood, with a piece of putty attached (total mass M_1) is travelling at a constant speed *U* over a frictionless surface. It strikes a second block (M_2) and the two move off together with an initial velocity *V* and initial kinetic energy *K*. The blocks are subjected to a constant frictional force *F*, and come to rest after travelling a distance *d*.

Example 16 (1982 Question 11, 1 mark)

Write an expression for *V* in terms of M_1, M_2 and *U*.

Example 17 (1982 Question 21, 1 mark)

An ice skater of mass 60 kg travelling **north** at 5 m s^{-1}, is carrying a parcel of mass 10 kg. The skater drops the parcel to the floor. What is the velocity of the skater now (magnitude and direction)?



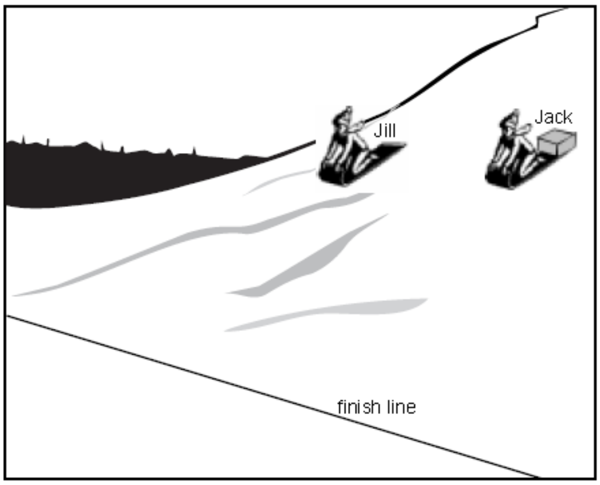
Example 18 (1980 Question 31, 1 mark)

A pair of identical pucks, A and B, move towards each other on a frictionless surface with equal speeds. The pucks move apart after colliding'

During the interaction, $\frac{3}{4}$ of the total kinetic energy that the two pucks had before the collision is lost.

What is the value of the ratio $\dfrac{\text{magnitude of momentum of A before the collision}}{\text{magnitude of momentum of A after the collision}}$

Jack and Jill are racing their toboggans down an icy hill. Jack and Jill are of similar mass and are using the same type of toboggan. When Jack is a certain distance from the end of the race they are travelling with the same velocity. Jack is behind Jill and decides that if he is going to win the race he must lighten his toboggan, so he pushes a box containing their ice-skating gear off the side of his toboggan.



Example 19 (2001 Question 11, 4 marks)

Explain, giving clear reasons, whether this will be a successful way for Jack to catch up to Jill and help him win the race.

A car – truck crash can be modelled as a 'head-on' collision between a truck of mass 4000 kg travelling at 15 m s^{-1} and a stationary car of mass 1000 kg. After the collision the truck continues moving forward at 10 m s^{-1}.

Example 20 (1998 Question 4, 3 marks)

Calculate the speed of the car immediately after the collision.

Example 21 (1997 Question 9, 4 marks)

Modern cars are designed to crumple progressively (crush over a period of time) when they have a head-on collision as described above. **Using suitable physics**, explain the purpose of the crumple section of the car. Your answer should include the ideas of force and momentum.

A car is stationary at a stop sign when it is hit directly from behind by a truck of mass 3000 kg which was travelling at a speed of 9 m s^{-1} immediately before the collision. The two vehicles lock together and move forward with an initial speed of 6 m s^{-1}.

Example 22 (1994 Question 6, 1 mark)

What is the mass of the car?

Each driver had a mass of 72.0 kg. During the collision, the driver of the car experienced an average force of 8 000 N.

Example 23 (1994 Question 8, 1 mark)

How long did the collision take?

Example 24 (1994 Question 9, 1 mark)

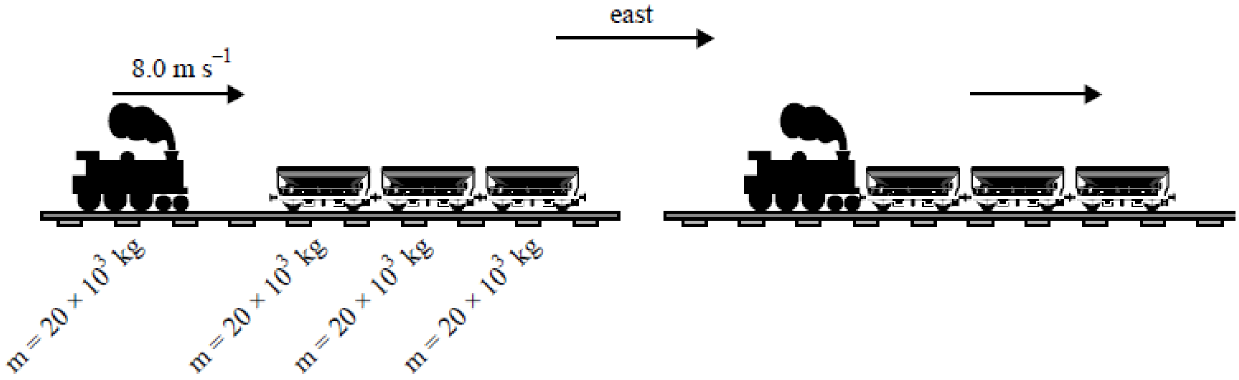
What was the magnitude of the force experienced by the driver of the truck?

Example 25 (1994 Question 10, 2 marks)

If the car had been designed with a crumple zone, explain, in correct physics terms, why this might reduce the risk of injury to the driver.

Use the following information to answer Q's 8–11.

A locomotive, of mass 20×10^3 kg, moving at 8.0 m s^{-1} east, collides with and couples to three trucks, each of mass 20×10^3 kg, initially stationary, as shown below.



Example 26 (2008 Question 8, 2 marks)

What is the speed of the coupled locomotive and trucks after the collision? You must show your working.

Example 27 (2008 Question 9, 3 marks)

What is the impulse given **to** the locomotive **by** the trucks in the collision (magnitude and direction)? You must show your working.

Example 28 (2008 Question 10, 3 marks)

Was this collision elastic or inelastic?
Support your conclusion by appropriate calculation.

During the collision, the magnitude of the average force exerted by the locomotive on the trucks is F_L and the magnitude of the average force exerted by the trucks on the locomotive is F_T.

Example 29 (2008 Question 11, 2 marks)

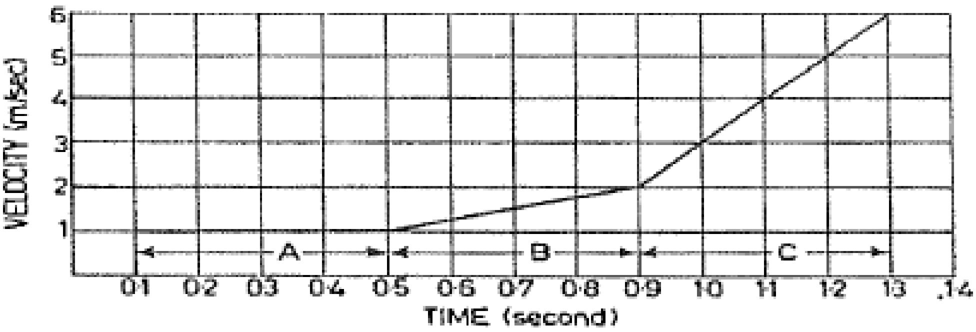
Will F_L be greater, equal to, or less than F_T?
Explain your answer.

A meteor assumed to be of constant mass 1 kg, moving with a speed 12,000 m s^{-1}, is travelling vertically down towards a planet. The planet's dense atmosphere slows it down to 10,000 m s^{-1} in 4 secs.

Example 30 (1969 Question 10, 1 mark) 61%

At the end of this 4 seconds when the meteor has slowed to 10,000 m s^{-1}, the meteor strikes a space vehicle of mass 200 kg which is moving horizontally at a speed of 10,000 m s^{-1}. The collision takes place in such a way that the meteor lodges in the space vehicle. What is the tangent of the angle θ to the horizontal with which the vehicle continues its course immediately after the collision?

A sled carrying *seven* bricks was pulled along a horizontal floor, in a straight line, by a rope which exerts a constant force on the sled.
The velocity-time graph is shown in the diagram. In the part of the motion represented by section A of the graph the sled was pulled across a carpeted floor ; in sections B and C the floor surface was smooth (i.e. friction was negligible here). At the end of section B, several bricks fell from the sled.
Mass of 1 brick = mass of sled = 2·0 kg.



Example 31 (1969 Question 28, 1 mark) 55%

How far did the sled travel between t = 0.1 and t = 1.3?

Example 32 (1969 Question 29, 1 mark) 56%

What was the magnitude of the frictional force of the carpet on the sled over section A?

Example 33 (1969 Question 30, 1 mark) 69%

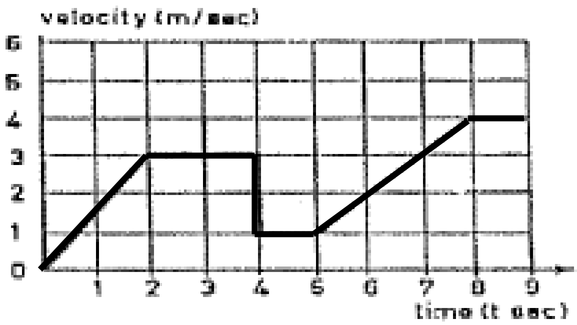
What was the impulse given to the loaded sled during section B?

Example 34 (1969 Question 31, 1 mark) 48%

How much work was done on the loaded sled during section B?

Example 35 (1969 Question 32, 1 mark) 53%

How many bricks fell off the sled at the end of section B?



The above graph represents a plot of velocity against time of a cart of initial mass 1 kg as it travels in a straight line across a level surface.

At some instant during the 9 seconds, an additional mass was dropped vertically on to the cart.

Example 36 (1967 Question 15, 1 mark) 96%

At what time did this occur?

Example 37 (1967 Question 16, 1 mark) 67%

What was the value (in kg) of the additional mass dropped vertically on to the cart?

Example 38 (1967 Question 17, 1 mark) 93%

What was the net force (in newton) acting on the cart at t = 1 sec?

Example 39 (1967 Question 18, 1 mark) 90%

What was the kinetic energy (in joule) of the cart at t = 3 sec?

Example 40 (1967 Question 19, 1 mark) 88%

How far (in meters) did the cart travel between t = 0 and t = 4 sec?