SA-STUDENT

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The best time to plant a tree is twenty years ago.

The second best time is now.

Chinese proverb

QUESTION 4 (Start on a new page.)

Trolley **A** of mass 7,2 kg moves to the right at 0,4 $m \cdot s^{-1}$ in a straight line on a horizontal floor. It collides with a stationary trolley **B** of mass 5,3 kg.

After the collision, the trolleys lock together and move to the right, as shown in the diagram below.

Ignore any frictional effects.

4.1 State the *principle of conservation of linear momentum* in words. (2)

4.2 Calculate the magnitude of the:

4.2.1 Velocity of the trolleys immediately after the collision (3)

4.2.2 Average net force exerted by trolley **A** on trolley **B** during the collision, if the collision time is 0,02 s (3)

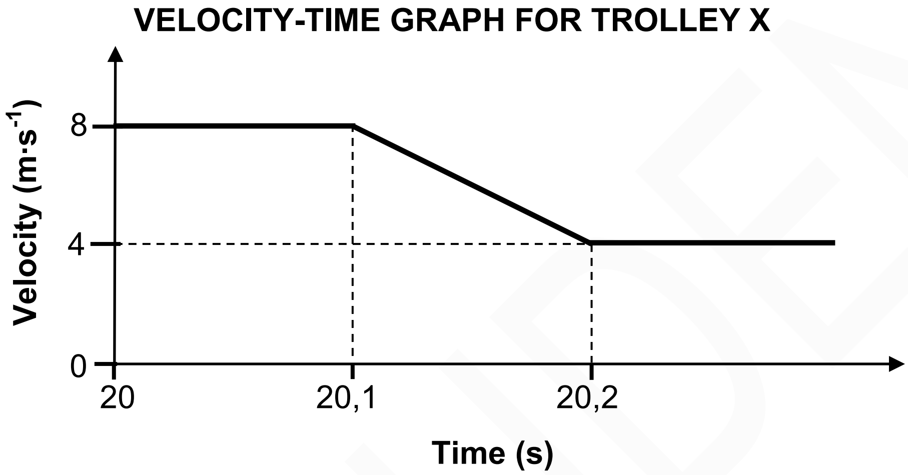
[8]

QUESTION 4 (Start on a new page.)

Trolley X of mass 1,2 kg travels at 8 m·s^{-1} east and collides with trolley Y of mass 0,5 kg which is initially at rest.

Ignore all frictional effects.

The velocity-time graph below shows the velocity of trolley X before, during and after the collision with trolley Y.



4.1 State the *principle of conservation of linear momentum*. (2)

4.2 Calculate the magnitude of the:

4.2.1 Velocity of trolley Y immediately after the collision (4)

4.2.2 Average net force that trolley X exerts on trolley Y during the collision (3)

4.3 Is the collision ELASTIC or INELASTIC?

Explain the answer by means of suitable calculations. (5)
[14]

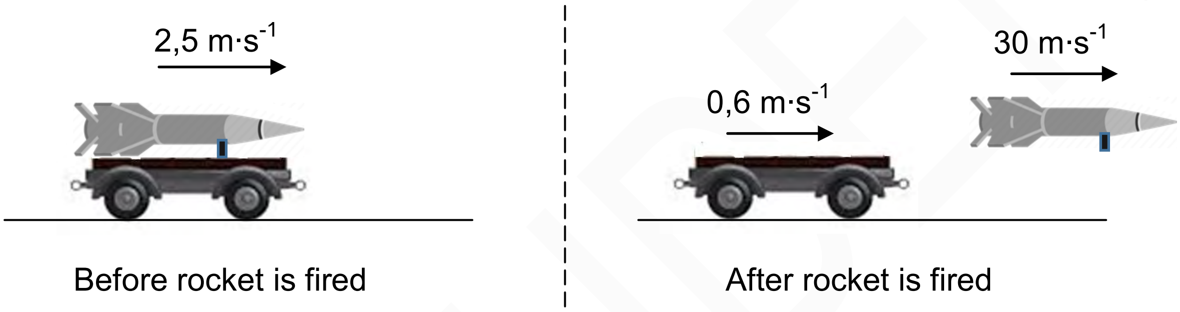
QUESTION 4 (Start on a new page.)

4.1 What is meant by an *isolated system* in physics? (2)

During an experiment, a rocket of unknown mass is mounted on a toy cart of mass 20 kg. The cart-rocket combination moves at a constant speed of 2,5 m·s^{-1} along a horizontal floor.

At a certain instant, the rocket is fired horizontally in the direction of motion at a speed of 30 m·s^{-1}. As a result, the cart slows down to a speed of 0,6 m·s^{-1}, as shown in the diagram below.

Ignore frictional effects.



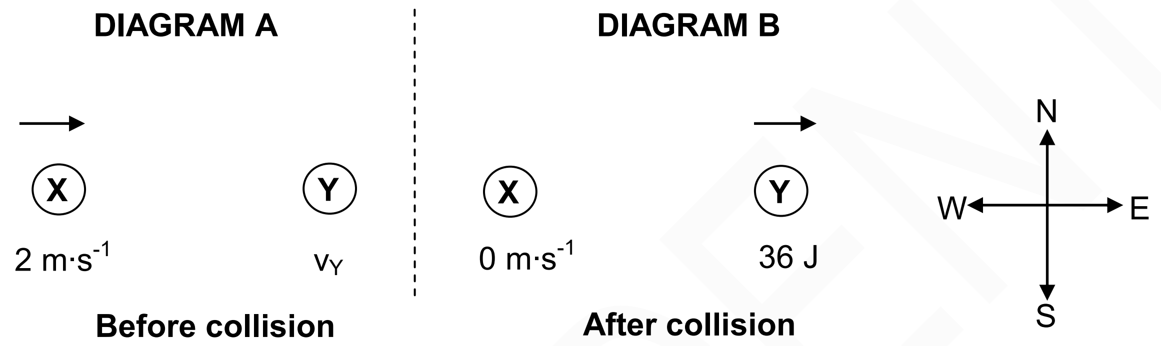
4.2 Use relevant physics principles to explain why the firing of the rocket will slow down the cart. (2)

4.3 Calculate the mass of the rocket at the instant the rocket was fired from the toy cart. (5)
[9]

QUESTION 4 (Start on a new page.)

A ball **X**, of mass 10 kg, is moving eastwards with a velocity of 2 m·s^{-1}. It collides ELASTICALLY with another ball, **Y**, of mass 2 kg which was moving with an unknown velocity v_Y (Diagram **A)**. Immediately after the collision, ball **X** comes to rest and ball **Y** moves eastwards with a kinetic energy of 36 J (Diagram **B**).

Ignore friction.



4.1 Explain the meaning of the term *elastic collision*. (2)

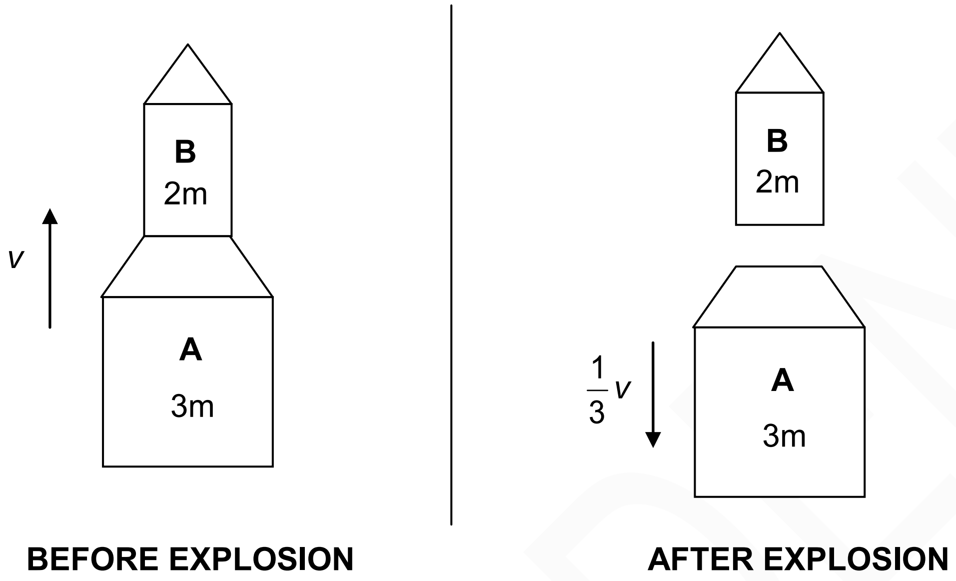
4.2 Calculate velocity v_Y. (5)

The balls were in contact with each other for 0,1 s during the collision.

4.3 Calculate the magnitude of the force that ball **X** exerted on ball **Y** during the collision. (3)
[10]

QUESTION 4 (Start on a new page.)

A simple rocket system consists of two parts, **A** of mass 3m, and **B** of mass 2m, as shown in the diagram below. **B** is stacked on top of **A**.



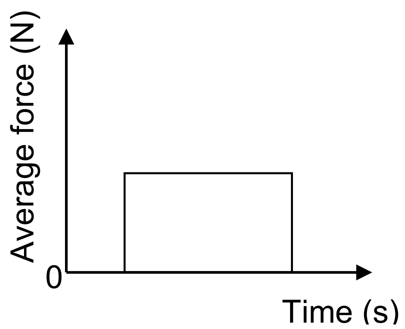
4.1 State the *principle of conservation of momentum* in words. (2)

The rocket is travelling vertically upwards at a constant speed *v* when an internal explosion causes **A** to move DOWNWARDS at a speed $\frac{1}{3}v$.

Ignore ALL external forces on the rocket.

4.2 Calculate the velocity of **B** in terms of *v* immediately after the internal explosion. (5)

The graph below shows the average force exerted by **A** on **B** during the internal explosion as a function of time.



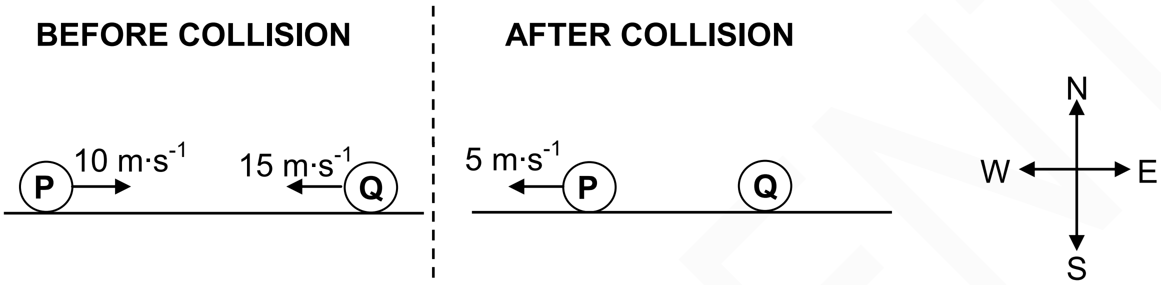
4.3 Name the physical quantity represented by the area under the graph. (1)

4.4 Redraw the graph in your ANSWER BOOK. On the same set of axes, sketch the graph of the average force that **B** exerts on **A** as a function of time. (2)
[10]

QUESTION 4 (Start on a new page.)

Ball **P** of mass 0,16 kg, moving east at a speed of 10 m·s^{-1}, collides head-on with another ball **Q** of mass 0,2 kg, moving west at a speed of 15 m·s^{-1}. After the collision, ball **P** moves west at a speed of 5 m·s^{-1}, as shown in the diagram below.

Ignore the effects of friction and the rotational effects of the balls.



4.1 Define the term *momentum* in words. (2)

4.2 Calculate the:

4.2.1 Velocity of ball **Q** after the collision (5)

4.2.2 Magnitude of the impulse on ball **P** during the collision (3)
[10]

QUESTION 4 (Start on a new page.)

A bullet moves east at a velocity of 480 $m \cdot s^{-1}$. It hits a wooden block that is fixed to the floor. The bullet takes 0,01 s to move through the stationary block and emerges from the block at a velocity of 80 $m \cdot s^{-1}$ east. See the diagram below.

Ignore the effects of air resistance.

Consider the block-bullet system as an isolated system.

Fixed wooden block

4.1 Explain what is meant by an *isolated system* as used in Physics. (2)

The magnitude of the momentum of the bullet before it enters the block is 24 $kg \cdot m \cdot s^{-1}$.

4.2 Calculate the:

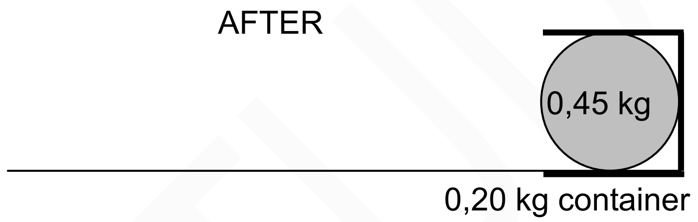
4.2.1 Mass of the bullet (3)

4.2.2 Average net force exerted by the wooden block on the bullet (5)
[10]

QUESTION 4 (Start on a new page.)

A soccer player kicks a ball of mass 0,45 kg to the east. The ball travels horizontally at a velocity of 9 $m \cdot s^{-1}$ along a straight line, without touching the ground, and enters a container lying at rest on its side, as shown in the diagram below. The mass of the container is 0,20 kg.

The ball is stuck in the container after the collision. The ball and container now move together along a straight line towards the east. Ignore friction and rotational effects.



4.1 State the principle of conservation of linear momentum in words. (2)

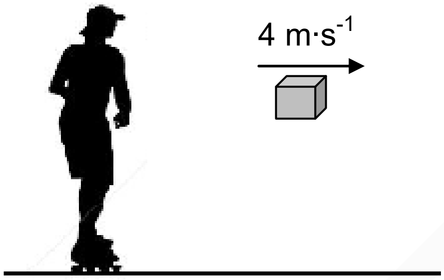
4.2 Calculate the magnitude of the velocity of the ball-container system immediately after the collision. (4)

4.3 Determine, by means of a suitable calculation, whether the collision between the ball and container is elastic or inelastic. (5)

[11]

QUESTION 4 (Start on a new page.)

Initially a girl on roller skates is at rest on a smooth horizontal pavement. The girl throws a parcel, of mass 8 kg, horizontally to the right at a speed of 4 m·s^{-1}. Immediately after the parcel has been thrown, the girl-roller-skate combination moves at a speed of 0,6 m·s^{-1}. Ignore the effects of friction and rotation.



4.1 Define the term *momentum* in words. (2)

4.2 Will the girl-roller-skate combination move TO THE RIGHT or TO THE LEFT after the parcel is thrown?
NAME the law in physics that can be used to explain your choice of direction. (2)

The total mass of the roller skates is 2 kg.

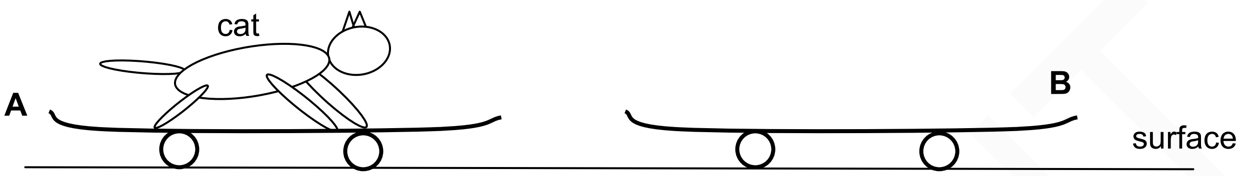
4.3 Calculate the mass of the girl. (5)

4.4 Calculate the magnitude of the impulse that the girl-roller-skate combination is experiencing while the parcel is being thrown. (3)

4.5 Without any further calculation, write down the change in momentum experienced by the parcel while it is being thrown. (2)
[14]

QUESTION 4 (Start on a new page.)

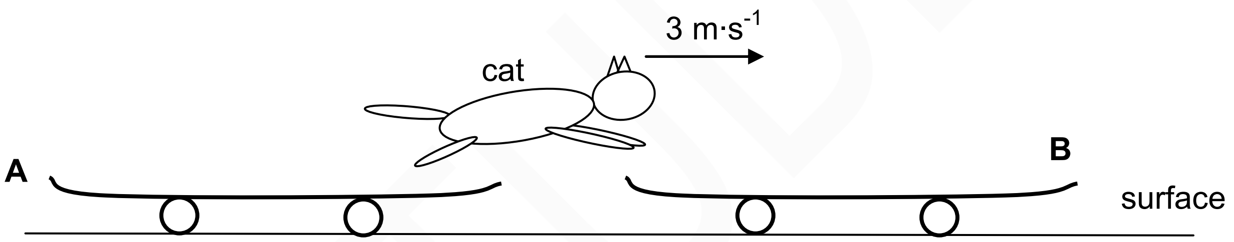
The diagram below shows two skateboards, **A** and **B**, initially at rest, with a cat standing on skateboard **A**. The skateboards are in a straight line, one in front of the other and a short distance apart. The surface is flat, frictionless and horizontal.



4.1 State the *principle of conservation of linear momentum* in words. (2)

EACH skateboard has a mass of 3,5 kg. The cat, of mass 2,6 kg, jumps from skateboard **A** with a horizontal velocity of 3 $m{\cdot}s^{-1}$ and lands on skateboard **B** with the same velocity of 3 $m{\cdot}s^{-1}$.

Refer to the diagram below.



4.2 Calculate the velocity of skateboard **A** just after the cat has jumped from it. (5)

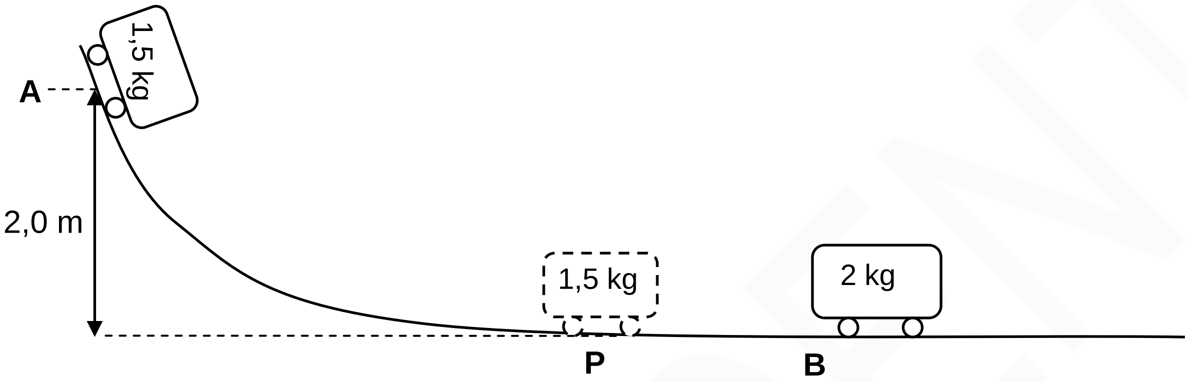
Immediately after the cat has landed, the cat and skateboard **B** move horizontally to the right at 1,28 $m{\cdot}s^{-1}$.

4.3 Calculate the magnitude of the impulse on skateboard **B** as a result of the cat's landing. (3)

[10]

QUESTION 4 (Start on a new page.)

A trolley of mass 1,5 kg is held stationary at point **A** at the top of a frictionless track. When the 1,5 kg trolley is released, it moves down the track. It passes point **P** at the bottom of the incline and collides with a stationary 2 kg trolley at point **B**. Refer to the diagram below. Ignore air resistance and rotational effects.



4.1 Use the principle of conservation of mechanical energy to calculate the speed of the 1,5 kg trolley at point **P**. (4)

When the two trolleys collide, they stick together and continue moving with constant velocity.

4.2 The principle of conservation of linear momentum is given by the incomplete statement below.

In a/an … system, the … linear momentum is conserved.

Rewrite the complete statement and fill in the missing words or phrases. (2)

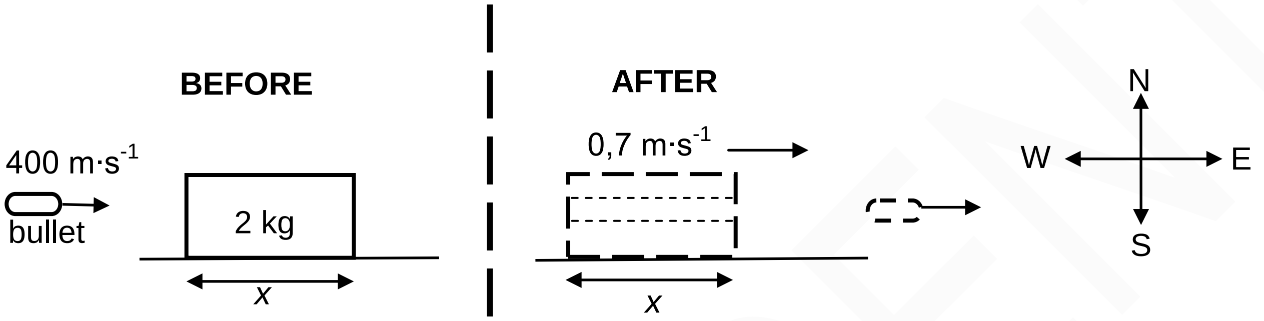
4.3 Calculate the speed of the combined trolleys immediately after the collision. (4)

4.4 Calculate the distance travelled by the combined trolleys in 3 s after the collision. (3)
[13]

QUESTION 4 (Start on a new page.)

A 2 kg block is at rest on a smooth, frictionless, horizontal table. The length of the block is *x*.

A bullet of mass 0,015 kg, travelling east at 400 $m \cdot s^{-1}$, strikes the block and passes straight through it with constant acceleration. Refer to the diagram below. Ignore any loss of mass of the bullet and the block.



4.1 State the *principle of conservation of linear momentum* in words. (2)

The block moves eastwards at 0,7 $m \cdot s^{-1}$ after the bullet has emerged from it.

4.2 Calculate the magnitude of the velocity of the bullet immediately after it emerges from the block. (4)

4.3 If the bullet takes 0,002 s to travel through the block, calculate the length, *x*, of the block. (5)

[11]

QUESTION 4 (Start on a new page.)

A teacher demonstrates the principle of conservation of linear momentum using two trolleys. The teacher first places the trolleys, **A** and **B**, some distance apart on a flat frictionless horizontal surface, as shown in the diagram below. The mass of trolley **A** is 3,5 kg and that of trolley **B** is 6,0 kg.

Trolley **A** moves towards trolley **B** at constant velocity. The table below shows the position of trolley **A** for time intervals of 0,4 s before it collides with trolley **B**.

RELATIONSHIP BETWEEN POSITION AND TIME FOR TROLLEY A				
Position of trolley **A** (m)	0	0,2	0,4	0,6
Time (s)	0	0,4	0,8	1,2

4.1 Use the table above to prove that trolley **A** is moving at constant velocity before it collides with trolley **B**. (3)

4.2 State the principle of conservation of linear momentum in words. (2)

At time t = 1,2 s, trolley **A** collides with stationary trolley **B**. The collision time is 0,5 s after which the two trolleys move off together.

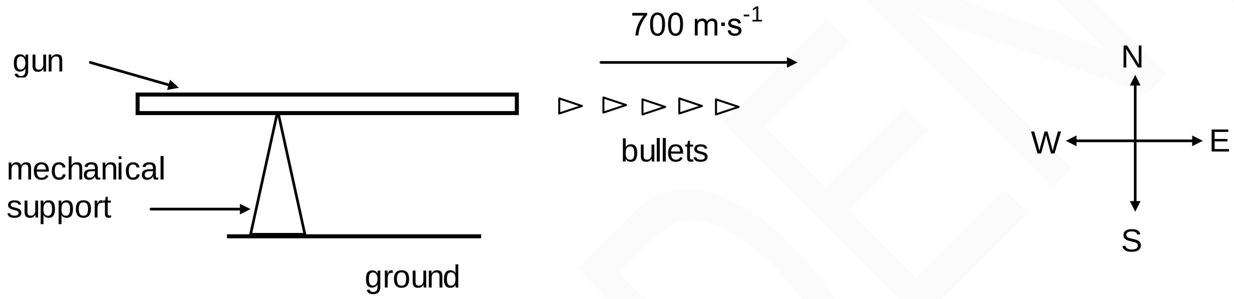
4.3 Calculate the magnitude of the average net force exerted on trolley **B** by trolley **A**. (6)
[11]

QUESTION 4 (Start on a new page.)

4.1 Define the term *impulse* in words. (2)

4.2 The diagram below shows a gun mounted on a mechanical support which is fixed to the ground. The gun is capable of firing bullets rapidly in a horizontal direction.

Each bullet travels at a speed of 700 $m \cdot s^{-1}$ in an easterly direction when it leaves the gun.
(Take the initial velocity of a bullet, before being fired, as zero.)



The gun fires 220 bullets per minute. The mass of each bullet is 0,03 kg.

Calculate the:

4.2.1 Magnitude of the momentum of each bullet when it leaves the gun (3)

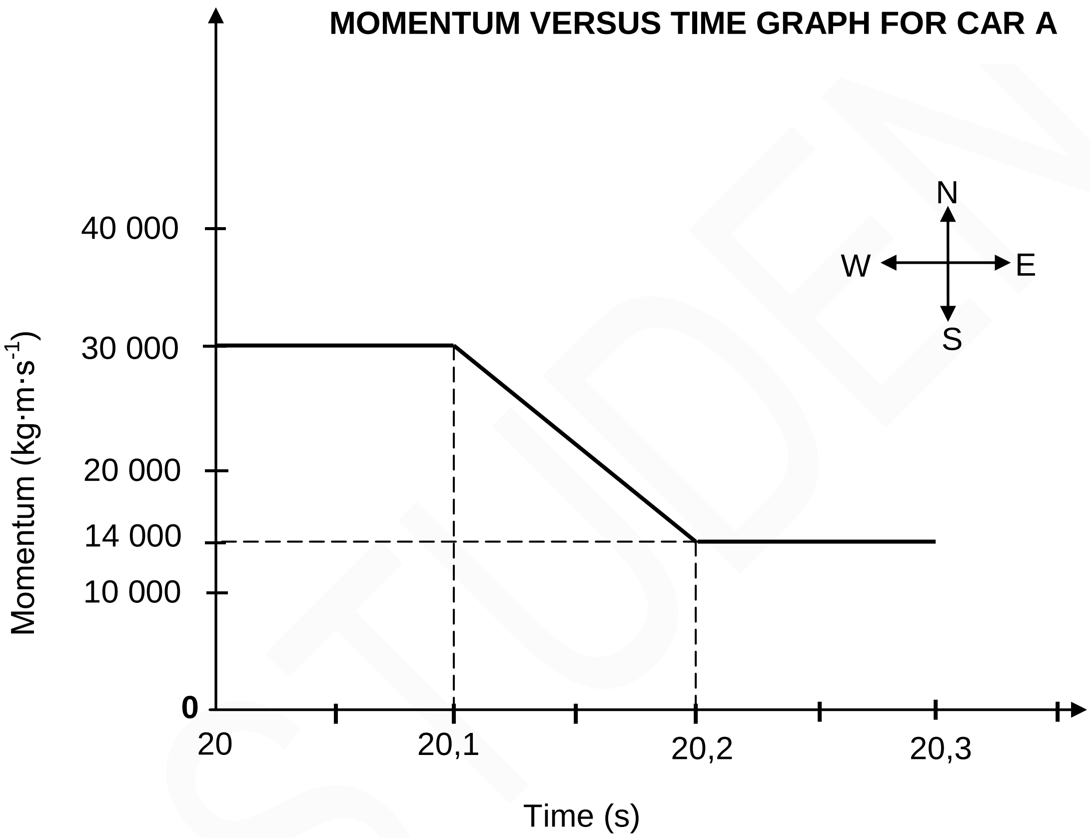
4.2.2 The net average force that each bullet exerts on the gun (5)

4.3 Without any further calculation, write down the net average horizontal force that the mechanical support exerts on the gun. (2)
[12]

QUESTION 4 (Start on a new page.)

The graph below shows how the momentum of car **A** changes with time *just before* and *just after* a head-on collision with car **B**.

Car **A** has a mass of 1 500 kg, while the mass of car **B** is 900 kg.
Car **B** was travelling at a constant velocity of 15 m·s^{-1} west before the collision.
Take east as positive and consider the system as isolated.



4.1 What do you understand by the term *isolated system* as used in physics? (1)

Use the information in the graph to answer the following questions.

4.2 Calculate the:

4.2.1 Magnitude of the velocity of car **A** just before the collision (3)

4.2.2 Velocity of car **B** just after the collision (5)

4.2.3 Magnitude of the net average force acting on car **A** during the collision (4)

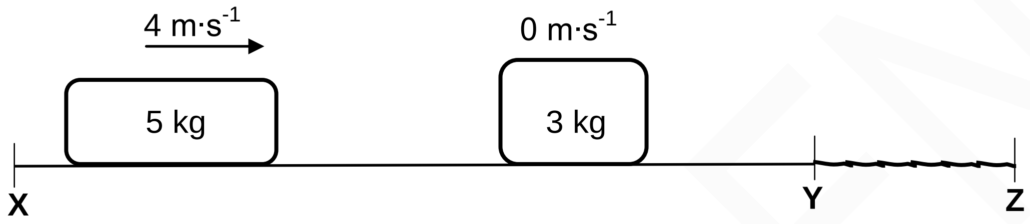
[13]

QUESTION 4 (Start on a new page.)

The diagram below shows two sections, **XY** and **YZ**, of a horizontal, flat surface. Section **XY** is smooth, while section **YZ** is rough.

A 5 kg block, moving with a velocity of 4 m·s^{-1} to the right, collides head-on with a stationary 3 kg block. After the collision, the two blocks stick together and move to the right, past point **Y**.

The combined blocks travel for 0,3 s from point **Y** before coming to a stop at point **Z**.



4.1 State the *principle of conservation of linear momentum* in words. (2)

4.2 Calculate the magnitude of the:

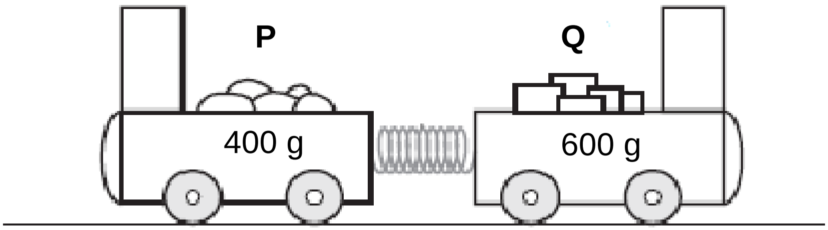
4.2.1 Velocity of the combined blocks at point **Y** (4)

4.2.2 Net force acting on the combined blocks when they move through section **YZ** (4)

[10]

QUESTION 4 (Start on a new page.)

The diagram below shows two trolleys, **P** and **Q**, held together by means of a compressed spring on a flat, frictionless horizontal track. The masses of **P** and **Q** are 400 g and 600 g respectively.



When the trolleys are released, it takes 0,3 s for the spring to unwind to its natural length. Trolley **Q then** moves to the right at 4 $m \cdot s^{-1}$.

4.1 State the *principle of conservation of linear momentum* in words. (2)

4.2 Calculate the:

4.2.1 Velocity of trolley **P** after the trolleys are released (4)

4.2.2 Magnitude of the average force exerted by the spring on trolley **Q** (4)

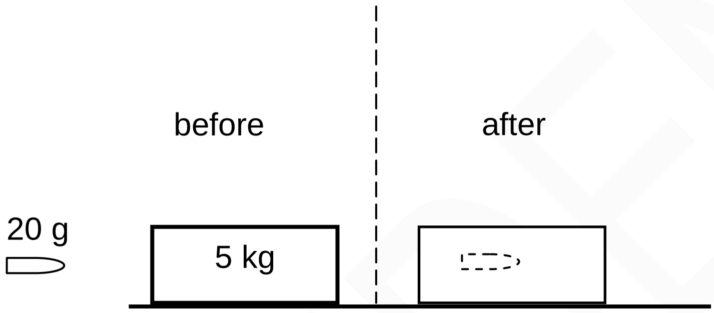
4.3 Is this an elastic collision? Only answer YES or NO. (1)
[11]

QUESTION 4 (Start on a new page.)

A bullet of mass 20 g is fired from a stationary rifle of mass 3 kg. Assume that the bullet moves horizontally. Immediately after firing, the rifle recoils (moves back) with a velocity of 1,4 $m \cdot s^{-1}$.

4.1 Calculate the speed at which the bullet leaves the rifle. (4)

The bullet strikes a stationary 5 kg wooden block **fixed** to a flat, horizontal table. The bullet is brought to rest after travelling a distance of 0,4 m **into the block**. Refer to the diagram below.



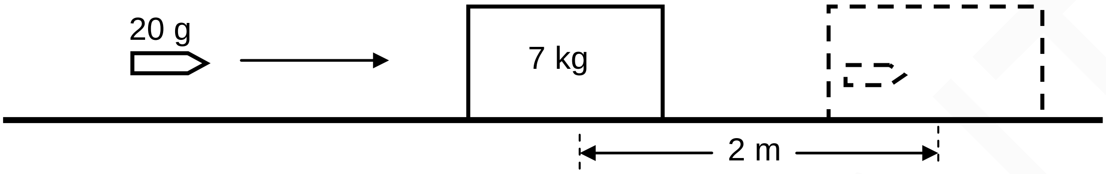
4.2 Calculate the magnitude of the average force exerted by the block on the bullet. (5)

4.3 How does the magnitude of the force calculated in QUESTION 4.2 compare to the magnitude of the force exerted by the bullet on the block? Write down only LARGER THAN, SMALLER THAN or THE SAME. (1)

[10]

QUESTION 4 (Start on a new page.)

The diagram below shows a bullet of mass 20 g that is travelling horizontally. The bullet strikes a stationary 7 kg block and becomes embedded in it. The bullet and block together travel on a rough horizontal surface a distance of 2 m before coming to a stop.



4.1 Use the work-energy theorem to calculate the magnitude of the velocity of the bullet-block system immediately after the bullet strikes the block, given that the frictional force between the block and surface is 10 N. (5)

4.2 State the *principle of conservation of linear momentum* in words. (2)

4.3 Calculate the magnitude of the velocity with which the bullet hits the block. (4)
[11]

QUESTION 4 (Start on a new page.)

Dancers have to learn many skills, including how to land correctly. A dancer of mass 50 kg leaps into the air and lands feet first on the ground. She lands on the ground with a velocity of 5 $m \cdot s^{-1}$. As she lands, she bends her knees and comes to a complete stop in 0,2 seconds.

4.1 Calculate the momentum with which the dancer reaches the ground. (3)

4.2 Define the term *impulse* of a force. (2)

4.3 Calculate the magnitude of the net force acting on the dancer as she lands. (3)

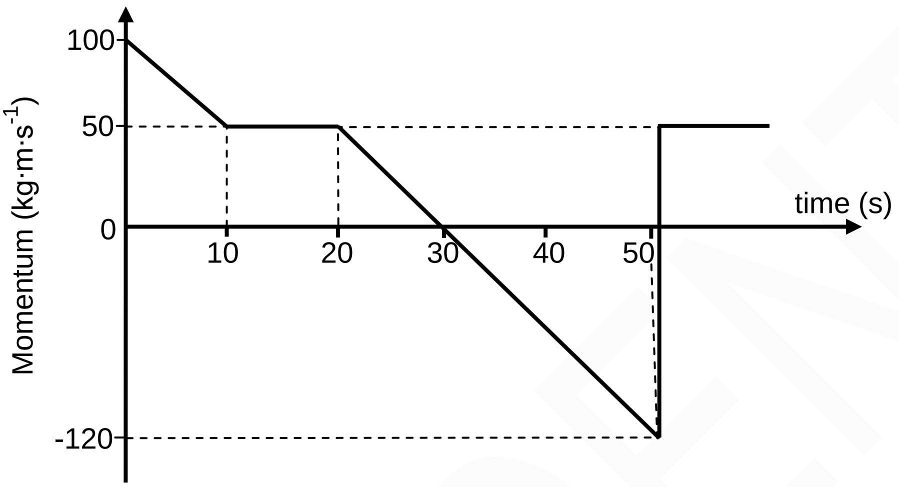
Assume that the dancer performs the same jump as before but lands without bending her knees.

4.4 Will the force now be GREATER THAN, SMALLER THAN or EQUAL TO the force calculated in QUESTION 4.3? (1)

4.5 Give a reason for the answer to QUESTION 4.4. (3)
[12]

QUESTION 4 (Start on a new page.)

The momentum versus time graph of object **A**, originally moving horizontally EAST, is shown below.



4.1 Write down the definition of *momentum* in words. (2)

4.2 *The net force acting on object* ***A*** *is zero between t = 10 s and t = 20 s.*

Use the graph and a relevant equation to explain why this statement is TRUE. (2)

4.3 Calculate the magnitude of the impulse that object **A** experiences between t = 20 s and t = 50 s. (3)

4.4 At t = 50 s, object **A** collides with another object, **B**, which has a momentum of 70 $kg{\cdot}m{\cdot}s^{-1}$ EAST.

Use the information from the graph and the relevant principle to calculate the momentum of object **B** after the collision. (5)

[12]

QUESTION 4 (Start on a new page.)

Two boys, each of mass m, are standing at the back of a flatbed trolley of mass 4 m. The trolley is at rest on a frictionless horizontal surface.

The boys jump off simultaneously at one end of the trolley with a horizontal velocity of 2 $m \cdot s^{-1}$. The trolley moves in the opposite direction.

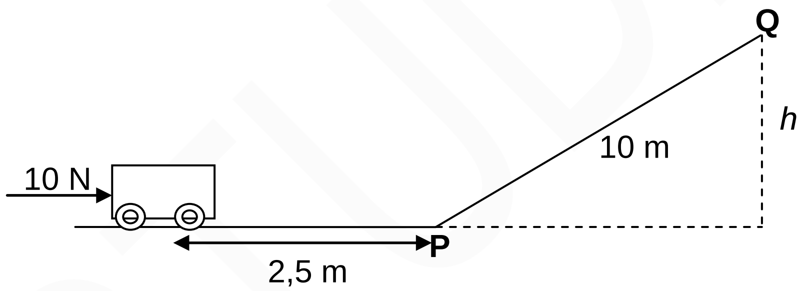
4.1 Write down the *principle of conservation of linear momentum* in words. (2)

4.2 Calculate the final velocity of the trolley. (5)

4.3 The two boys jump off the trolley one at a time. How will the velocity of the trolley compare to that calculated in QUESTION 4.2? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)
[8]

QUESTION 5 (Start on a new page.)

A 3 kg trolley is at rest on a horizontal frictionless surface. A constant horizontal force of 10 N is applied to the trolley over a distance of 2,5 m.



When the force is removed at point **P**, the trolley moves a distance of 10 m up the incline until it reaches the maximum height at point **Q**. While the trolley moves up the incline, there is a constant frictional force of 2 N acting on it.

5.1 Write down the name of a non-conservative force acting on the trolley as it moves up the incline. (1)

5.2 Draw a labelled free-body diagram showing all the forces acting on the trolley as it moves along the horizontal surface. (3)

5.3 State the WORK-ENERGY THEOREM in words. (2)

5.4 Use the work-energy theorem to calculate the speed of the trolley when it reaches point **P**. (4)

5.5 Calculate the height, *h*, that the trolley reaches at point **Q**. (5)
[15]

3.4 Sketch a position versus time graph for the motion of the ball from the moment it is thrown until it reaches its maximum height after the bounce. USE THE FLOOR AS THE ZERO POSITION.

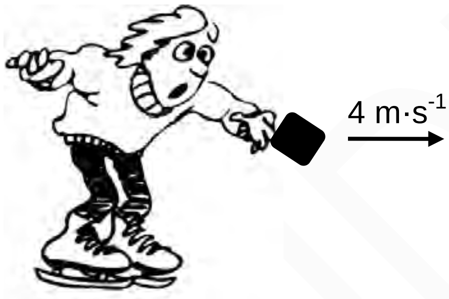
Indicate the following on the graph:

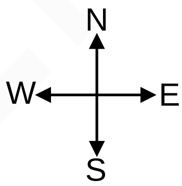
- The height from which the ball is thrown
- Time *t* (4)

[19]

QUESTION 4 (Start on a new page.)

A boy on ice skates is stationary on a frozen lake (no friction). He throws a package of mass 5 kg at 4 m·s^{-1} horizontally east as shown below. The mass of the boy is 60 kg.





At the instant the package leaves the boy's hand, the boy starts moving.

4.1 In which direction does the boy move? Write down only EAST or WEST. (1)

4.2 Which ONE of Newton's laws of motion explains the direction in which the boy experiences a force when he throws the package? Name and state this law in words. (3)

4.3 Calculate the magnitude of the velocity of the boy immediately after the package leaves his hand. Ignore the effects of friction. (5)

4.4 How will the answer to QUESTION 4.3 be affected if:

(Write down INCREASES, DECREASES or REMAINS THE SAME.)

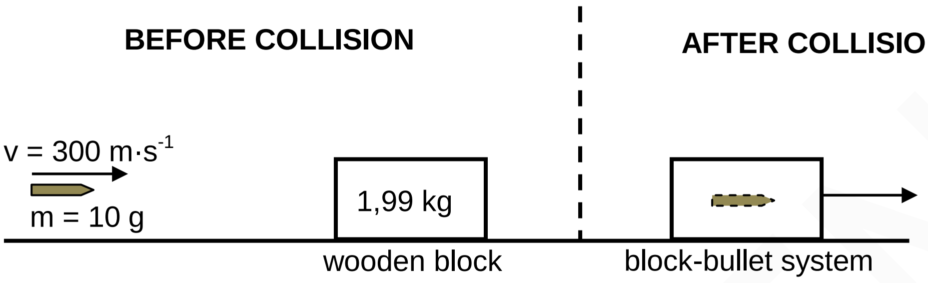
4.4.1 The boy throws the same package at a higher velocity in the same direction (1)

4.4.2 The boy throws a package of double the mass at the same velocity as in QUESTION 4.3. Explain the answer. (3)

[13]

QUESTION 4 (Start on a new page.)

A bullet of mass 10 g, moving at a velocity of 300 $m \cdot s^{-1}$, strikes a wooden block of mass 1,99 kg resting on a flat horizontal surface as shown in the diagram below. The bullet becomes embedded in the block. Ignore the effects of air friction.



4.1 Write down in words the *principle of conservation of linear momentum*. (2)

4.2 Calculate the speed of the block-bullet system immediately after the collision. (4)

4.3 Is this collision elastic or inelastic? Give a reason for the answer. (2)

The floor exerts a constant frictional force of 8 N on the block-bullet system as it comes to rest.

4.4 Calculate the distance that the block-bullet system moves after the collision. (4)
[12]

The object bounces off the balcony at a velocity of 27,13 m·s^{-1} and strikes the ground 6 s after leaving the balcony.

3.3 Sketch a velocity-time graph to represent the motion of the object from the moment it is projected from the ROOF of the building until it strikes the GROUND. Indicate the following velocity and time values on the graph:

- The initial velocity at which the object was projected from the roof of the building
- The velocity at which the object strikes the balcony
- The time when the object strikes the balcony
- The velocity at which the object bounces off the balcony
- The time when the object strikes the ground (6)

[16]

QUESTION 4 (Start on a new page.)

The diagram below shows a car of mass *m* travelling at a velocity of 20 m·s^{-1} east on a straight level road and a truck of mass 2*m* travelling at 20 m·s^{-1} west on the same road. Ignore the effects of friction.

4.1 Calculate the velocity of the car relative to the truck. (2)

The vehicles collide head-on and stick together during the collision.

4.2 State the *principle of conservation of linear momentum* in words. (2)

4.3 Calculate the velocity of the truck-car system immediately after the collision. (6)

4.4 On impact the car exerts a force of magnitude *F* on the truck and experiences an acceleration of magnitude *a.*

4.4.1 Determine, in terms of *F*, the magnitude of the force that the truck exerts on the car on impact. Give a reason for the answer. (2)

4.4.2 Determine, in terms of *a*, the acceleration that the truck experiences on impact. Give a reason for the answer. (2)

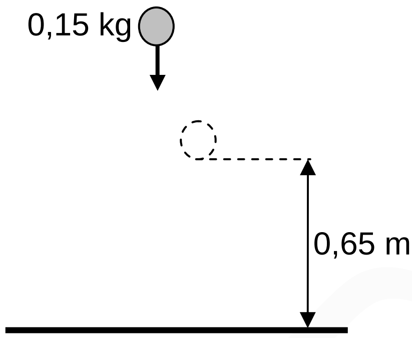
4.4.3 Both drivers are wearing identical seat belts. Which driver is likely to be more severely injured on impact? Explain the answer by referring to acceleration and velocity. (3)

[17]

QUESTION 4 (Start on a new page.)

The bounce of a cricket ball is tested before it is used. The standard test is to drop a ball from a certain height onto a hard surface and then measure how high it bounces.

During such a test, a cricket ball of mass 0,15 kg is dropped from rest from a certain height and it strikes the floor at a speed of 6,2 $m \cdot s^{-1}$. The ball bounces straight upwards at a velocity of 3,62 $m \cdot s^{-1}$ to a height of 0,65 m, as shown in the diagram below. The effects of air friction may be ignored.



4.1 Define the term *impulse* in words. (2)

4.2 Calculate the magnitude of the impulse of the net force applied to the ball during its collision with the floor. (3)

4.3 To meet the requirements, a cricket ball must bounce to one third of the height that it is initially dropped from.

Use ENERGY PRINCIPLES to determine whether this ball meets the minimum requirements. (5)

[10]

QUESTION 4 (Start on a new page.)

A patrol car is moving on a straight horizontal road at a velocity of 10 m·s^{-1} east. At the same time a thief in a car ahead of him is driving at a velocity of 40 m·s^{-1} in the same direction.

v_{PG}: velocity of the **p**atrol car relative to the **g**round
v_{TG}: velocity of the **t**hief's car relative to the **g**round

4.1 Write down the velocity of the thief's car relative to the patrol car. (2)

A person in the patrol car fires a bullet at the thief's car. The bullet leaves the gun with an initial horizontal velocity of 100 m·s^{-1} relative to the patrol car. Ignore the effects of friction.

4.2 Write down the initial velocity of the **b**ullet relative to the **t**hief's car. (2)

While travelling at 40 m·s^{-1}, the thief's car of mass 1 000 kg, collides head-on with a truck of mass 5 000 kg moving at 20 m·s^{-1}. After the collision, the car and the truck move together. Ignore the effects of friction.

4.3 State the *law of conservation of linear momentum* in words. (2)

4.4 Calculate the velocity of the thief's car immediately after the collision. (6)

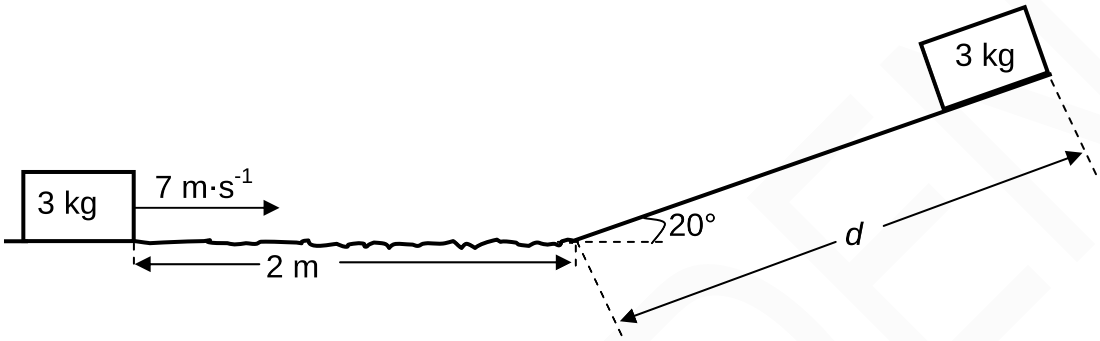
4.5 Research has shown that forces greater than 85 000 N during collisions may cause fatal injuries. The collision described above lasts for 0,5 s.

Determine, by means of a calculation, whether the collision above could result in a fatal injury. (5)
[17]

QUESTION 5 (Start on a new page.)

A 3 kg block slides at a constant velocity of 7 m·s^{-1} along a horizontal surface. It then strikes a rough surface, causing it to experience a constant frictional force of 30 N. The block slides 2 m under the influence of this frictional force before it moves up a frictionless ramp inclined at an angle of 20° to the horizontal, as shown in the diagram below.

The block moves a distance *d* up the ramp, before it comes to rest.



5.1 Show by calculation that the speed of the block at the bottom of the ramp is 3 m·s^{-1}. (5)

5.2 Draw a free-body diagram to show all the forces acting on the block in a direction parallel to the incline, whilst the block is sliding up the ramp. (2)

5.3 Calculate the distance, *d*, the block slides up the ramp. (5)
[12]

QUESTION 6 (Start on a new page.)

A man of mass 87 kg on roller skates, moving horizontally at constant speed in a straight line, sees a boy of mass 22 kg standing directly in his path. The man grabs the boy and they both continue in a straight line at 2,4 m·s^{-1}.

6.1 Calculate the man's speed just before he grabs the boy. Ignore the effects of friction. (4)

6.2 Is the collision elastic? Use a calculation to support your answer. (6)

6.3 After grabbing the boy, they both continue at a velocity of 2,4 m·s^{-1} along a straight line until they arrive at a loose gravel surface near the end of the path. They now move at constant acceleration in a straight line through the loose gravel for 2 m before coming to rest.

Calculate the magnitude of the force exerted by the gravel surface on the man and the boy. (5)
[15]

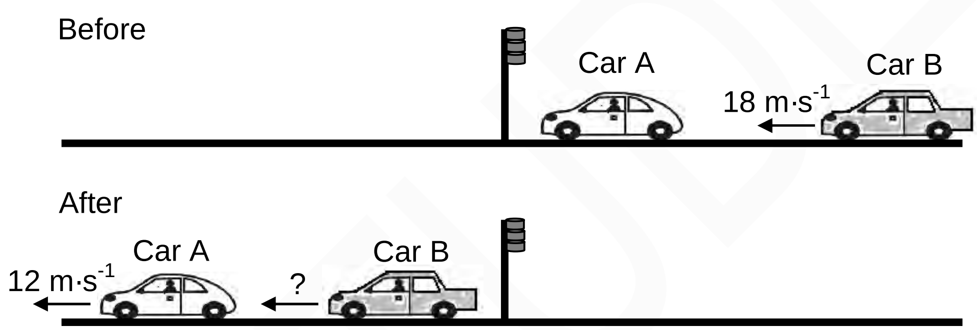
SECTION B

INSTRUCTIONS AND INFORMATION

1. Answer SECTION B in the ANSWER BOOK.
2. The formulae and substitutions must be shown in ALL calculations.
3. Round off your answers to TWO decimal places.

QUESTION 5

The most common reasons for rear-end collisions are too short a following distance, speeding and failing brakes. The sketch below represents one such collision. Car A of mass 1 000 kg, stationary at a traffic light, is hit from behind by Car B of mass 1 200 kg, travelling at 18 $m \cdot s^{-1}$. Immediately after the collision Car A moves forward at 12 $m \cdot s^{-1}$.



5.1 Assume that linear momentum is conserved during this collision. Calculate the speed of Car B immediately after the collision. (4)

5.2 Modern cars are designed to crumple partially on impact. Explain why the assumption made in QUESTION 5.1 may NOT be valid in this case. (2)

5.3 A traffic officer appears at the scene of the accident and mentions the dangers of a head-on collision. He mentions that for cars involved in a head-on collision, the risk of injury for passengers in a heavier car would be less than for passengers in a lighter car.

Use principles of Physics to explain why the statement made by the traffic officer is correct. (3)
[9]