QUESTION 6 (Start on a new page)

A space shuttle consisting of a rocket motor with a mass of 600 kg and a capsule with a mass of 280 kg, while travelling in space at 6 800 $m.s^{-1}$ relative to the earth, releases its rocket motor. As a result, the capsule is projected in the opposite direction at 7 300 $m.s^{-1}$ relative to the earth.

6.1 State the principle of conservation of momentum. (2)

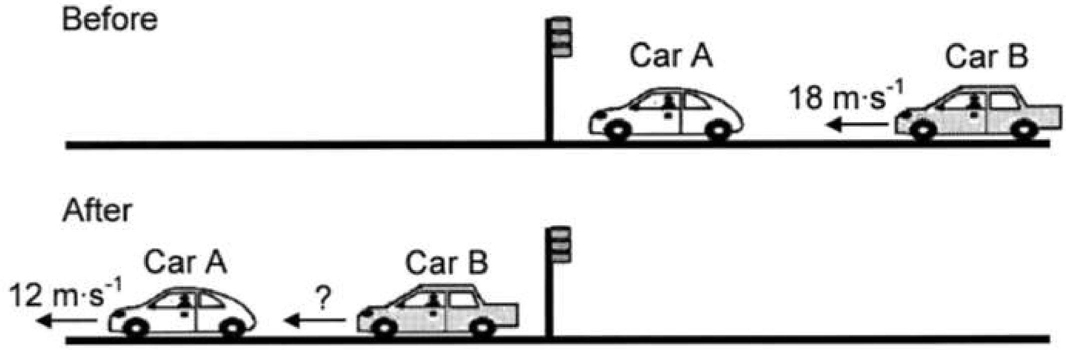
6.2 Calculate the speed of the rocket motor immediately after it is released from the capsule. (4)

6.3 Is the collision in QUESTION 6.2 elastic or inelastic? Support your answer with a calculation. (5)

[11]

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)

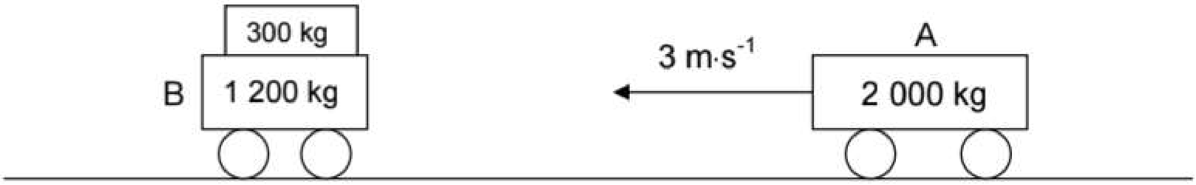
5.3 A traffic officer appears at the scene of the accident and mentions the dangers of a head-on collision. He mentions that for cars involved in a head-on collision, the risk of injury for passengers in a heavier car would be less than for passengers in a lighter car.

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

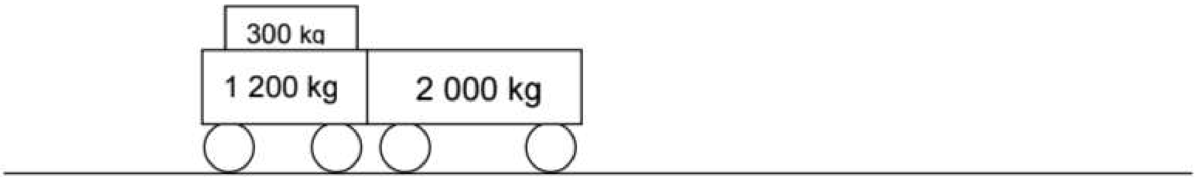
[9]

QUESTION 6

A railway truck A of mass 2 000 kg moves westwards with a velocity of 3 $m \cdot s^{-1}$. It collides with a stationary truck B of mass 1 200 kg, loaded with electronic equipment of mass 300 kg. The two trucks combined after the collision. Ignore the effects of friction.



BEFORE COLLISION



AFTER COLLISION

6.1 Write down magnitude and direction of the 'reaction force' to the weight of truck A. (2)

6.2 Calculate the velocity of truck B after the collision. (5)

6.3 Calculate the magnitude of the force that truck A exerts on truck B if the collision lasts for 0,5 s. (4)

6.4 The electronic equipment on the stationary truck is wrapped in bubble plastic (plastic filled with air bubbles).

Use physics principles to explain why bubble plastic is preferred to ordinary plastic. (3)

[14]

QUESTION 6

New cars have a crumple zone to help minimise injuries during accidents. In addition seat belts, air bags and padded interiors can reduce the chance of death or serious injury.

6.1 Use principles in Physics to explain how air bags can reduce the chance of death or injury. (3)

6.2 In a crash test, a car of mass $1,2 \times 10^3$ kg collides with a wall and rebounds as illustrated below. The initial and final velocities of the car are $12\ m \cdot s^{-1}$ to the left and $2\ m \cdot s^{-1}$ to the right respectively. The collision lasts 0,1 s.

Calculate the:

6.2.1 Impulse of the car during the accident (4)

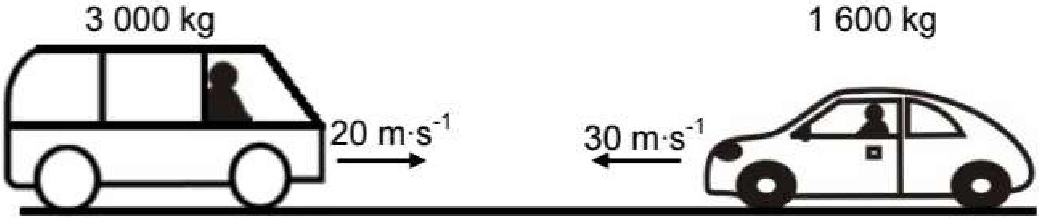
6.2.2 Average force exerted on the car (3)

6.3 How will the magnitude of the force exerted on the car be affected if the time interval of the collision remains 0,1 s, but the car does not bounce off the wall? Write down only INCREASES, DECREASES or REMAINS THE SAME. Explain your answer. (2)

[12]

QUESTION 6

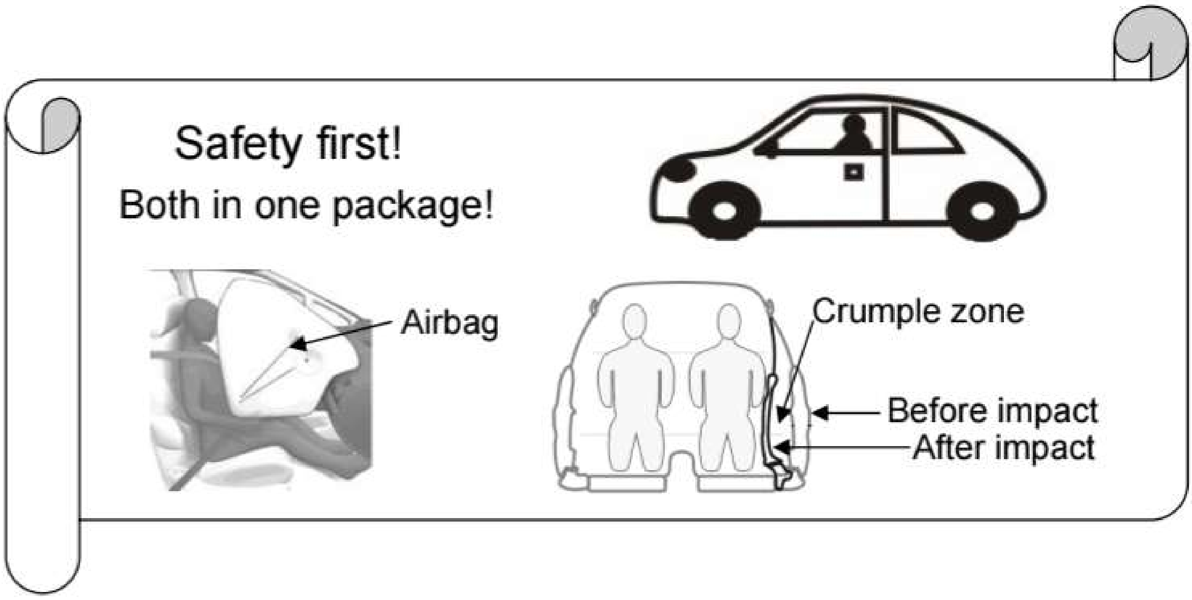
Collisions happen on the roads in our country daily. In one of these collisions, a car of mass 1 600 kg, travelling at a speed of 30 m·s^{-1} to the left, collides head-on with a minibus of mass 3 000 kg, travelling at 20 m·s^{-1} to the right. The two vehicles move together as a unit in a straight line after the collision.



6.1 Calculate the velocity of the two vehicles after the collision. (6)

6.2 Do the necessary calculations to show that the collision was inelastic. (6)

6.3 The billboard below advertises a car from a certain manufacturer.

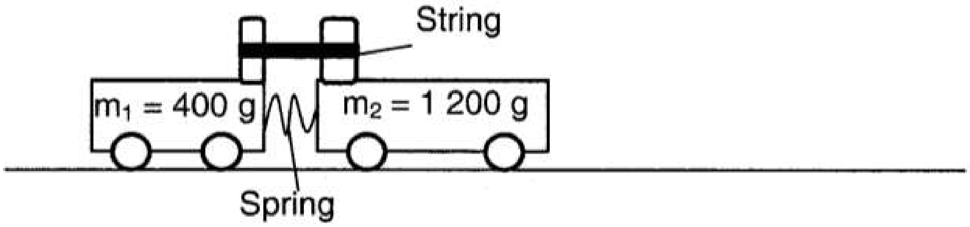


Use your knowledge of momentum and impulse to justify how the safety features mentioned in the advertisement contribute to the safety of passengers. (3)

[15]

QUESTION 4 (Start on a new page.)

Two carts, m_1 and m_2 of masses 400 g and 1 200 g are free to move on a frictionless horizontal surface. The carts are joined by a compressed spring and tied together by a string. The carts are initially at rest as shown in the figure below.



When the string between them is cut, the spring between them is released. The carts then move away from each other.

4.1 While the spring is expanding:

4.1.1 Compare the magnitudes of the forces acting on carts m_1 and m_2 at any instant.

Write $\mathbf{F_{m1} > F_{m2}}$, $\mathbf{F_{m1} < F_{m2}}$ or $\mathbf{F_{m1} = F_{m2}}$ (1)

4.1.2 Name the law or principle used to obtain the above answer. (1)

4.2 After the spring has expanded:

4.2.1 How do the magnitudes of the velocity of the carts m_1 and m_2 compare?

Write $\mathbf{v_{m1} > v_{m2}}$, $\mathbf{v_{m1} < v_{m2}}$ **or** $\mathbf{v_{m1} = v_{m2}}$ (1)

4.2.2 Name the law or principle applied to obtain the above answer. (1)

4.3 If 0,225 J of energy is imparted to the carts when the spring between them is released, show that the final speed of m_2 is 0,31 $m \cdot s^{-1}$. Assume that there was no loss of energy. (6)

[10]

A soccer ball of mass 430 g is moving at 20 $m \cdot s^{-1}$ horizontally towards the head of a waiting soccer player. The ball is "headed" back, in the opposite direction, along the same straight line, at 25 $m \cdot s^{-1}$. Ignore the effects of air resistance.

3.1 Define *impulse of a force* in words. (2)

3.2 Calculate the impulse exerted on the ball while the head is in contact with the ball. (3)

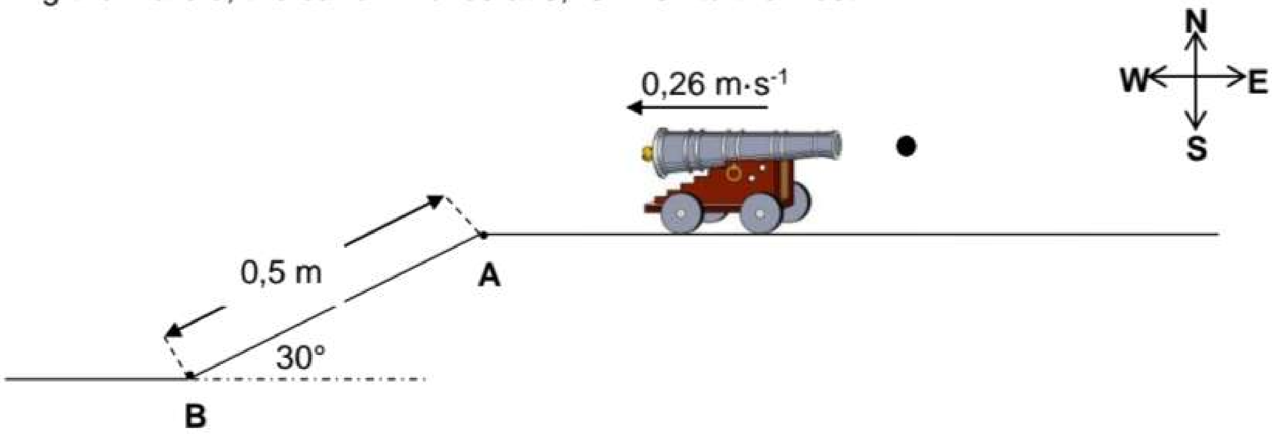
3.3 Using the answer in QUETION 3.2, calculate the time for which the ball must be in contact with the head of the player in order to experience a force of magnitude 300 N. (3)

3.4 Is the collision of the soccer ball with the head of the player elastic or inelastic? Give a reason for the answer.

(2)
[10]

QUESTION 4 (Start on a new page)

A toy canon, mass 1,6 kg, is at rest on a rough horizontal surface as shown in the diagram. A steel marble, mass 0,8 kg, is fired horizontally to the east from the canon. Immediately after firing the marble, the canon moves at 0,26 $m \cdot s^{-1}$ to the west.



4.1 Calculate the speed of the steel marble immediately after firing the marble. (4)

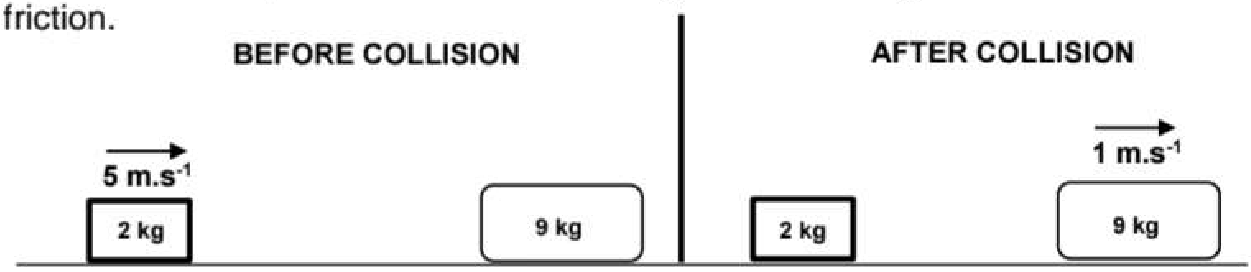
4.2 The steel marble experiences a force **F** during the firing. Explain in terms of **F** how the force experienced by the CANON compares with that experienced by the steel marble. (3)

The canon reaches point **A** with a speed of 0,2 $m \cdot s^{-1}$ and then moves down a rough 0,5 m long slope **AB**.

4.3 Explain why this is NOT a closed system. (1)

QUESTION 4 (Start on a new page)

A wooden block of mass 2 kg, moving at a velocity of 5 m.s^{-1}, collides with a crate of mass 9 kg resting on a flat horizontal surface as shown in the diagram below. After the collision, the crate moves to the right at 1 m.s^{-1}. Ignore the effects of friction.



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

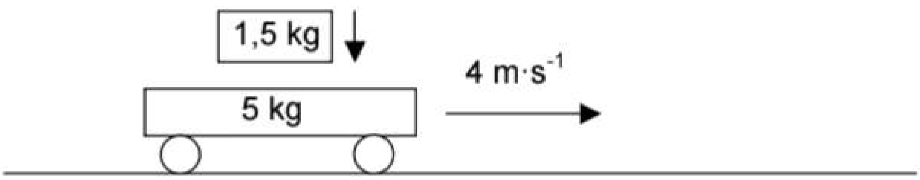
4.2 Calculate the magnitude of the velocity of the wooden block immediately after the collision. (4)

4.3 If the collision lasts 0,6 seconds, calculate the force the wooden block exerts on the crate during the collision. (4)

[10]

QUESTION 4 (Begin on a new page.)

A trolley, mass 5 kg, moves at 4 $m \cdot s^{-1}$ east across a frictionless horizontal surface. A brick of mass 1,5 kg is dropped onto the trolley.



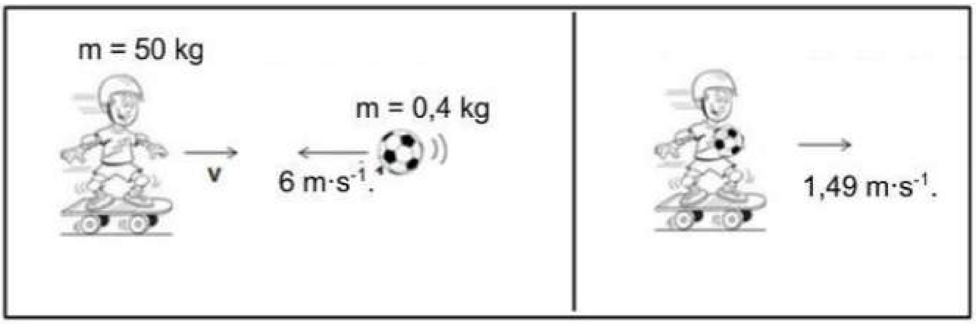
4.1 Define in words the *Law of Conservation of Momentum*. (2)

4.2 State the condition for an elastic collision. (1)

4.3 Calculate the change in momentum of the 5 kg trolley. (5)
[8]

QUESTION 3 [START ON A NEW PAGE]

A boy on a skateboard moves to the right at constant velocity. The joint mass of the boy and skateboard is 50 kg. He catches a ball with of mass 0,4 kg that is travelling horizontally to the left at a velocity of 6 $m \cdot s^{-1}$. After the boy catches the ball, they both move to the right at 1,49 $m \cdot s^{-1}$.

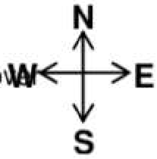


Before boy catches ball — After boy catches ball

3.1	Define the term **impulse.**	(2)
3.2	Calculate the magnitude of the average force that the boy exerts on the ball when he catches it, if he and the ball exert a force for a period of 0,1 s on each other.	(3)
3.3	Write down the Principle of Conservation of Momentum.	(2)
3.4	Calculate the magnitude of the velocity **v** of the boy before he catches the ball.	(3)
3.5	Prove with the necessary calculation that this is an *inelastic* collision.	(5)
		[15]

QUESTON 4 (Start on a new page)

A boy on roller blades with his hands on a fully loaded trolley, mass 18 kg, moves west at 5 $m \cdot s^{-1}$ over a frictionless surface as shown in the sketch. The boy now pushes the trolley so that he moves at 1 $m \cdot s^{-1}$ east after this push. The mass of the boy and his roller blades is 45 kg.



4.1 State the conservation principle that is applicable during the interaction between the boy and the trolley. (2)

4.2 Calculate the velocity of the trolley directly after the boy pushed it. (4)

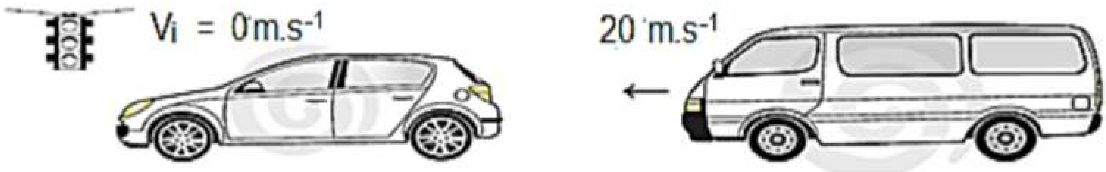
4.3 During the pushing motion of the boy on the trolley, the trolley experiences an impulse. How does the magnitude of the impulse that the boy experiences compare to that of the trolley? Write down INCREASES, DECREASES or REMAINS THE SAME and explain your answer. (3)

4.4 If the force exerted on the trolley lasts 0,4 s, calculate the force that the boy exerts on the trolley. (4)
[13]

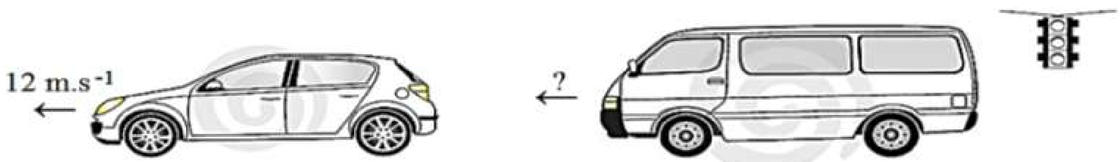
QUESTION 3 (Start on a new page.)

A car of mass 1 500 kg is stationary at a traffic light. It is hit from behind by a minibus of mass 2 000 kg travelling at a speed of 20 m•s^{-1}. Immediately after the collision the car moves forward at 12 m•s^{-1}.

BEFORE



AFTER



3.1 State the LAW OF CONSERVATION OF LINEAR MOMENTUM in words. (2)

3.2 Calculate the speed of the minibus immediately after the collision. (4)

3.3 The driver of the minibus is NOT wearing a seatbelt.

Describe the motion that the driver undergoes immediately after the collision. (1)

3.4 State the law of physics which can be used to explain your answer about the motion of the driver in QUESTION 3.3. (2)

[9]

A soccer ball of mass 430 g is moving at 20 $m \cdot s^{-1}$ horizontally towards the head of a waiting soccer player. The ball is "headed" back, in the opposite direction, along the same straight line, at 25 $m \cdot s^{-1}$. Ignore the effects of air resistance.

3.1 Define *impulse of a force* in words. (2)

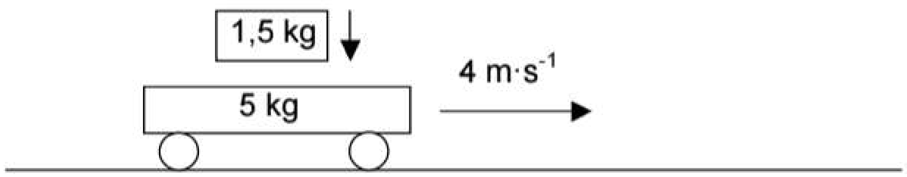
3.2 Calculate the impulse exerted on the ball while the head is in contact with the ball. (3)

3.3 Using the answer in QUETION 3.2, calculate the time for which the ball must be in contact with the head of the player in order to experience a force of magnitude 300 N. (3)

3.4 Is the collision of the soccer ball with the head of the player elastic or inelastic? Give a reason for the answer. (2)

[10]

A trolley, mass 5 kg, moves at 4 $m \cdot s^{-1}$ east across a frictionless horizontal surface. A brick of mass 1,5 kg is dropped onto the trolley.



4.1 Define in words the *Law of Conservation of Momentum*. (2)

4.2 State the condition for an elastic collision. (1)

4.3 Calculate the change in momentum of the 5 kg trolley. (5)

[8]