GRADE 12 REVISION 2013
MECHANICS: MOMENTUM AND FRAMES OF REFERENCE

TERMS AND DEFINITIONS	
Newton's Third Law of motion	When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.
Contact forces	Arise from the physical contact between two objects, e.g. a soccer player kicking a ball.
Non-contact forces	Arise even if two objects do not touch each other, e.g. the force of attraction of the earth on a parachutist even when the earth is not in direct contact with the parachutist.
Momentum	The product of an object's mass and its velocity.
Newton's Second Law of motion in terms of momentum	The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force. In symbols: $F_{net} = \frac{\Delta p}{\Delta t}$
Law of conservation of linear momentum	The total linear momentum of an isolated system remains constant (is conserved).
Isolated (closed) system	The net external force acting on the system is zero.
Impulse	The product of the average net force and the time interval during which the force acts. In symbols: $F_{net}\Delta t = \Delta p$
Elastic collision	Both momentum and kinetic energy are conserved during the collision.
Inelastic collision	Only momentum is conserved during the collision.
Frame of reference	A coordinate system or set of axes relative to which the position and motion of objects are measured.
Relative velocity	The vector difference between the velocities of two objects measured from the same frame of reference. For example, if the velocity of object A relative to the ground is v_{AG} and the velocity of object B relative to the ground is v_{BG}, then the velocity of object A relative to object B can be given as $v_{AB} = v_{AG} - v_{BG}$.

IMPORTANT NOTES:

Momentum and impulse

1. Indicate the choice of direction before starting the calculation.
2. Remember to include the direction (positive or negative sign) when substituting vectors in an equation.
3. Remember to interpret the sign obtained in the final answer of a calculation e.g. if *east* was chosen as positive, then a negative answer means the direction is *west*.
4. Use the same wording for direction as given in the question e.g. if west and east are used, give the direction in the final answer in terms of east or west.
5. Do not omit key words such as TOTAL and ISOLATED when stating the law of conservation of momentum in words.

Frames of Reference
1. Indicate the choice of direction before starting the calculation.
2. Correct formulae as per the scenario given.

TYPICAL QUESTIONS

ONE WORD ITEMS: MOMENTUM AND IMPULSE

Give ONE word/term for each of the following descriptions.

1. Change in momentum
2. The physical quantity that is equivalent to the change in the momentum of a body
3. The type of collision in which kinetic energy is conserved
4. A system that experiences no external net forces.
5. The product of the mass and velocity of a body
6. The general term used to describe a system on which no external forces act
7. The rate of change of momentum

ONE WORD ITEMS: FRAMES OF REFERENCE

8. The vector difference of two velocities measured from the same frame of reference
9. A set of axes relative to which the position and motion of objects are measured

MULTIPLE-CHOICE QUESTIONS: MOMENTUM AND IMPULSE

1. A car of mass m moves along a straight line with a velocity of magnitude *v*. The driver sees an obstruction and immediately applies the brakes. The car stops uniformly in *t* seconds from the moment that the brakes are applied. The car does not hit the obstruction.

Which ONE of the following represents the MAGNITUDE of the average force exerted on the car during the braking period of t seconds?

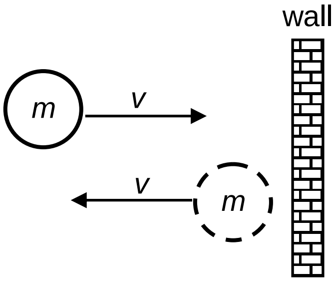
A $\frac{v}{t}$

B mv

C $\frac{mv}{t}$

D mvt

2. A ball of mass m strikes a wall perpendicularly at a speed v. Immediately after the collision the ball moves in the opposite direction at the same speed v, as shown in the diagram below.



Which ONE of the following represents the magnitude of the change in momentum of the ball?

A 0

B mv

C $2mv$

D $3mv$

3. A horizontal net force *F* acts on each of two separate objects, **P** and **Q**, as shown below. The mass of **Q** is THREE TIMES that of **P**. Ignore the effect of friction.

What is the rate of change in momentum of object **P** if the rate of change in momentum of object **Q** is equal to *x*?

A $\frac{1}{9}x$
B $\frac{1}{3}x$
C x
D $3x$

4. The magnitude of the velocity at which a rifle recoils when you fire a shot is much less than the magnitude of the velocity of the bullet. Which ONE of the following statements best describes this phenomenon?
A The momentum of the bullet is greater than the momentum of the rifle.
B The momentum of the rifle is greater than the momentum of the bullet.
C Momentum is conserved and the mass of the rifle is greater than the mass od the bullet.
D The momentum of the system increases because the rifle exerts a force on the bullet.

5. Impulse is equal to the …
A initial momentum of a body.
B final momentum of a body.
C change in momentum of a body.
D rate of change in momentum of a body.

6. Two motor cars, **A** and **B**, with mass m and 2m respectively, collide with each other head on. Car **A** experiences a change in momentum of x $kg·m·s^{-1}$ due to the collision. The change in momentum of car **B** during the collision is …
A x $kg·m·s^{-1}$
B -x $kg·m·s^{-1}$
C 2x $kg·m·s^{-1}$
D -2x $kg·m·s^{-1}$

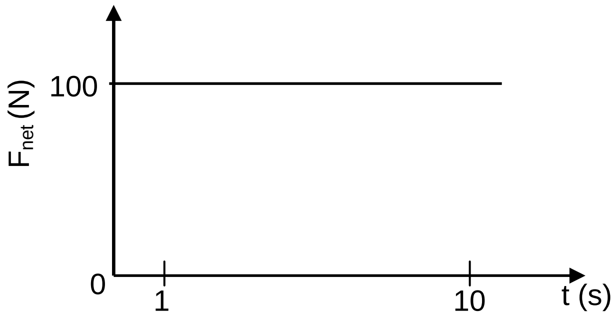
7. Which ONE of the following physical quantities represents the RATE OF CHANGE OF MOMENTUM of an object?
A Force
B Kinetic energy
C Impulse
D Acceleration

8. A car of mass m collides head-on with a truck of mass 2*m*. If the car exerts a force of magnitude *F* on the truck during the collision, the magnitude of the force that the truck exerts on the car is …
A $\frac{1}{2}F$.
B *F*.
C 2*F*.
D 4*F*.

9. Which ONE of the following is an example of a contact force?

A Frictional force
B Magnetic force
C Electrostatic force
D Gravitational force

10. The sketch graph below may be used to calculate the impulse of a constant net force of 100 N that acts on an object over a period of time.



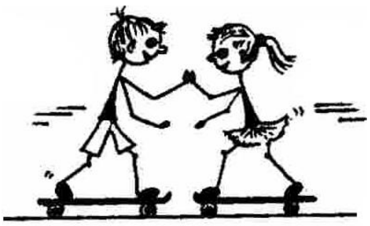
Which ONE of the following can be used to calculate the impulse (in $kg \cdot m \cdot s^{-1}$) of the force for the time interval t = 1 s to t = 10 s?

A 100 x 1
B 100 x 10
C 100 x 9
D 10 x 9

11. The net force acting on an object is equal to the ...

A mass of the object.
B acceleration of the object.
C change in momentum of the object.
D rate of change in momentum of the object.

12. A boy, mass *2m*, and a girl, mass *m*, are facing each other on roller skates. With their hands, they push off against one another. The boy experiences a force *F* and an acceleration *a* to the left.

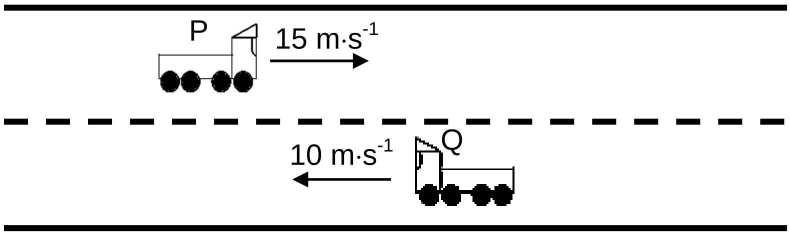


Which ONE of the following best describes the magnitudes of the force and acceleration experienced by the girl? Ignore the effects of friction.

	FORCE	ACCELERATION
A	$\frac{1}{2}F$	$2a$
B	F	$2a$
C	F	$\frac{1}{2}a$
D	$2F$	$\frac{1}{2}a$

MULTIPLE-CHOICE QUESTIONS: FRAMES OF REFERENCE

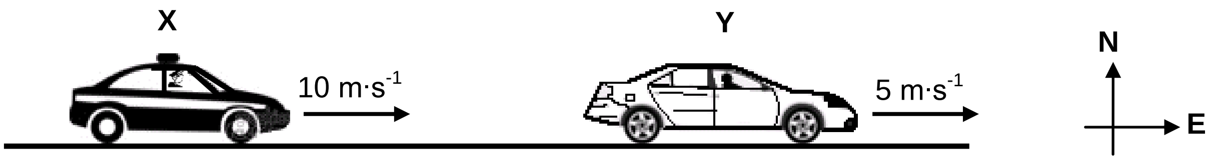
13. The diagram below shows two trucks, **P** and **Q**, travelling in opposite directions along a straight level road. Truck **P** travels at 15 m·s^{-1} and truck **Q** travels at 10 m·s^{-1}.



A passenger on truck **P** will observe truck **Q** travelling at …

A 5 m·s^{-1}
B 10 m·s^{-1}
C 15 m·s^{-1}
D 25 m·s^{-1}

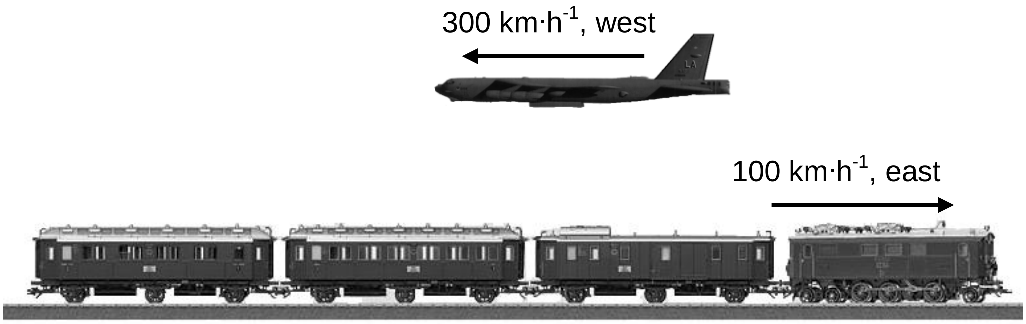
14. Two cars, **X** and **Y**, are travelling in an easterly direction along a straight level road as shown in the diagram below. The velocity of car **X** is 10 m·s^{-1} relative to the ground and the velocity of car **Y** is 5 m·s^{-1} relative to the ground.



The velocity of car **X** relative to car **Y** is …

A 5 m·s^{-1} east.
B 5 m·s^{-1} west.
C 15 m·s^{-1} east.
D 15 m·s^{-1} west.

15. A girl sits in a train travelling east at 100 km·h^{-1}. An aeroplane, travelling west at 300 km·h^{-1}, passes overhead.



Which ONE of the following is the description of how the aeroplane is moving relative to the girl in the train?

	Magnitude of velocity of aeroplane (km·h^{-1})	Direction of velocity of aeroplane
A	400	west
B	200	east
C	200	west
D	400	east

16. Car **P** moves west at speed *v*. Car **Q** moves east at speed 2*v* along the same straight road. The velocity of Car **P** relative to Car **Q** is:

A 3*v* west
B 3*v* east
C *v* east
D *v* west

STRUCTURED QUESTIONS: MOMENTUM AND IMPULSE

QUESTION 1

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.

1.1 Use principles in Physics to explain how air bags can reduce the chance of death or injury.

1.2 In a crash test, a car of mass 1,2 x 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:

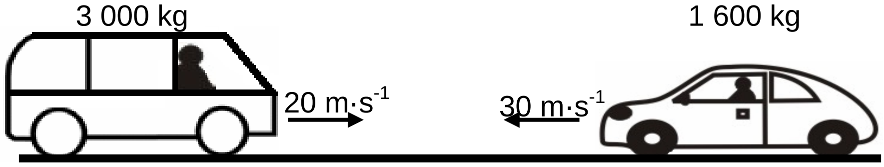
1.2.1 Impulse of the car during the accident

1.2.2 Average force exerted on the car

1.3 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.

QUESTION 2

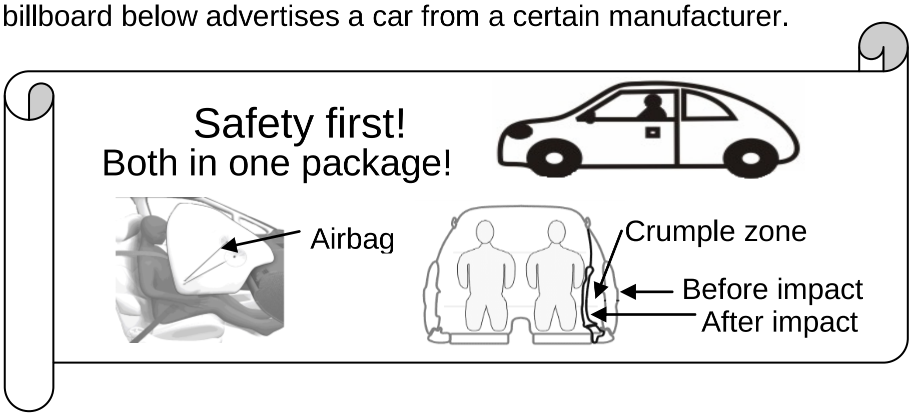
Collisions happen on the roads in our country daily. In one of these collisions, a car of mass 1 600 kg, travelling at a speed of 30 $m \cdot s^{-1}$ to the left, collides head-on with a minibus of mass 3 000 kg, travelling at 20 $m \cdot s^{-1}$ to the right. The two vehicles move together as a unit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



2.1 Calculate the velocity of the two vehicles after the collision.

2.2 Do the necessary calculations to show that the collision was inelastic.

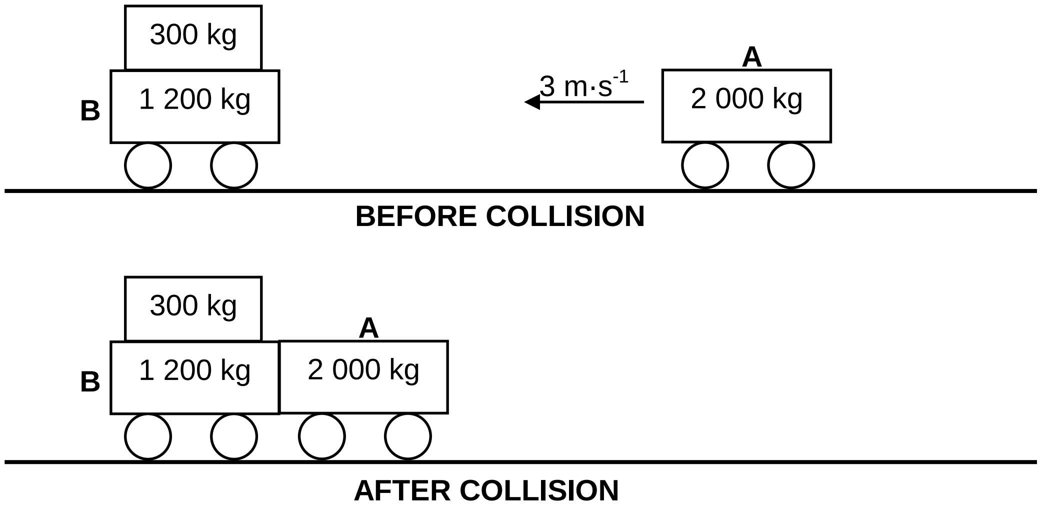
2.3 The billboard below advertises a car from a certain manufacturer.



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

QUESTION 3

A railway truck **A** of mass 2 000 kg moves westwards with a velocity of 3 m·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.



3.1 Write down magnitude and direction of the 'reaction force' to the weight of truck **A**.

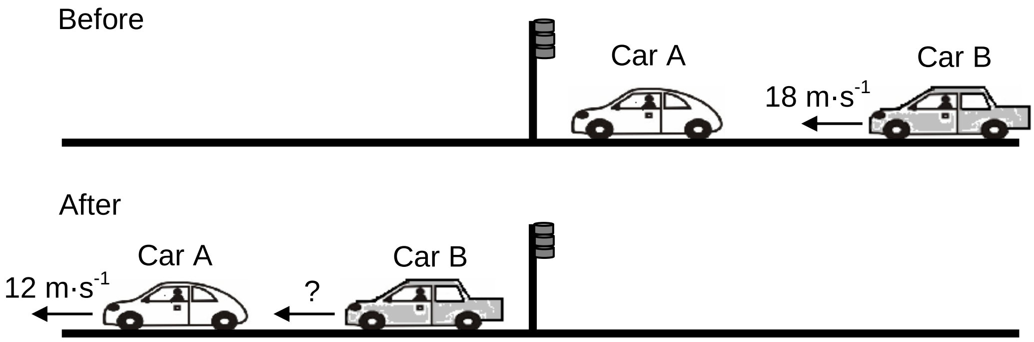
3.2 Calculate the velocity of truck **B** after the collision.

3.3 Calculate the magnitude of the force that truck **A** exerts on truck **B** if the collision lasts for 0,5 s.

3.4 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.

QUESTION 4

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·s^{-1} Immediately after the collision Car **A** moves forward at12 m·s^{-1}.



4.1 Assume that linear momentum is conserved during this collision. Calculate the speed of Car **B** immediately after the collision.

4.2 Modern cars are designed to crumple partially on impact. Explain why the assumption made in QUESTION 4.1 may NOT be valid in this case.

4.3 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.

QUESTION 5

The diagram shows the situation just before two vehicles crash head-on. The car, mass 1000 kg, and a mini-bus, mass 3 200 kg, are moving in opposite directions on a straight road where the speed limit is 90 km·h^{-1}. During the collision the vehicles are locked together and the combination comes to rest on the road after the collision. The police have correctly determined that the mini-bus was travelling at a speed of 10 m·s^{-1} when the collision took place.

5.1 Use the principle of the conservation of linear momentum to calculate whether the driver of the car exceeded the speed limit.

5.2 During the collision the mini-bus comes to rest in 0,4 s. Calculate the average resultant force on the mini-bus to bring it to rest.

5.3 A woman in the front seat of the mini-bus is wearing a safety-belt. She is also holding a young child, mass 20 kg, in her arms. Explain, by referring to a relevant law of physics, why it is dangerous for the child NOT to be fastened.

QUESTION 6

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}.

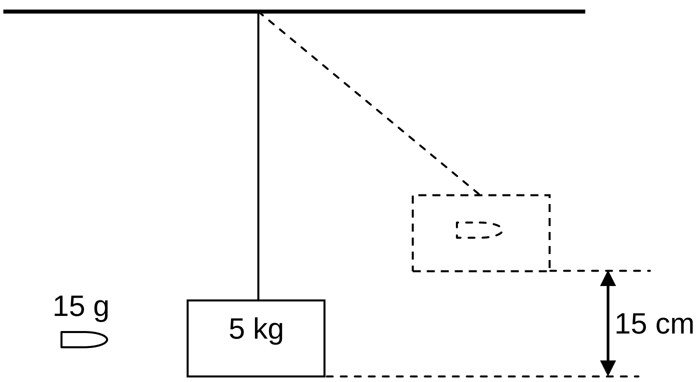
6.1 Calculate the man's speed just before he grabs the boy.
Ignore the effects of friction.

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

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.

QUESTION 7

During an investigation a police officer fires a bullet of mass 15 g into a stationary wooden block, of mass 5 kg, suspended from a long, strong cord. The bullet remains stuck in the block and the block-bullet system swings to a height of 15 cm above the equilibrium position, as shown below. (Effects of friction and the mass of the cord may be ignored.)



7.1 State the law of conservation of momentum in words.

7.2 Use energy principles to show that the magnitude of the velocity of the block-bullet system is 1,71 m·s^{-1} immediately after the bullet struck the block.

7.3 Calculate the magnitude of the velocity of the bullet just before it strikes the block.

7.4 The police officer is pushed slightly backwards by the butt of the rifle, which he is holding against his shoulder, whilst firing the rifle. Use the relevant law of motion to explain why this happens.

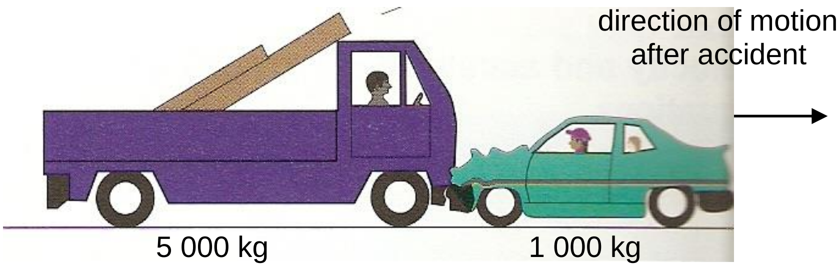
QUESTION 8

Read the following accident report and answer the questions that follow.

A head-on collision is the worst crash most of us can think of. Thankfully, they are relatively rare.

A young mother was travelling in a car, mass 1 000 kg, on the highway, with her sister and her child. She had very good visibility. In front of her was a dry pavement, wide shoulders and straight road. A snake slithered out onto the road. Rather than hitting the snake, she swerved slightly to the right and crashed into the front-end of an oncoming truck, mass 5 000 kg, at **72 km·h^{-1}** (20 m·s^{-1}) RELATIVE TO THE ROAD.

All three were killed instantly in a collision that equaled running into a solid wall at **180 km·h^{-1}** (50 m·s^{-1}). When emergency crews arrived, the truck driver was wandering around, telling everybody he was so close when she swerved, that he had no time to turn his wheel and take evasive action. Witnesses at the scene of the accident reported that the truck and the car STUCK TOGETHER ON IMPACT and moved in the same direction as the original direction in which the truck was travelling (the right in the diagram below).



8.1 The accident report says that a head-on collision is the "worst crash most of us can think of". Use your knowledge of relative velocities to explain the relevance of this comment.

8.2 Use the information in the article to calculate the velocity of the truck RELATIVE TO THE ROAD before it hit the car. Give your answer in m·s^{-1} and take the DIRECTION in which the truck WAS GOING AS POSITIVE.

8.3 Calculate the magnitude of the velocity of the truck and car after the collision.

QUESTION 9

Head-on collisions lead to fatal injuries in many cases. Car A, mass 1 630 kg, is travelling at a velocity of 20 m·s^{-1} due west. The driver loses control and crashes head-on with car B, mass 1 200 kg, which is travelling at a velocity of 35 m·s^{-1} due east. The two cars become entwined during the collision and continue to move together.

9.1 Calculate the velocity of the wreckage immediately after the collision.

9.2 A learner asserts that it is less dangerous to be in a heavier car during a collision. Refer to PRINCIPLES OF PHYSICS to explain whether the learner is correct or not.

QUESTION 10

10.1 A cricket ball moves at a velocity of 95 $km \cdot h^{-1}$ towards a batsman. The batsman swings the bat and before it makes contact with the cricket ball, the bat moves at a velocity of 40 $km \cdot h^{-1}$ in the opposite direction to the cricket ball. Just after contact with the cricket ball the bat moves at a velocity of 30 $km \cdot h^{-1}$ in its original direction, whilst the cricket ball moves at a velocity of 100 $km \cdot h^{-1}$ away from the batsman

10.1.1 Calculate the velocity of the cricket ball relative to the bat before it makes contact with the bat.

10.1.2 Calculate the velocity of the bat relative to the cricket ball after contact

10.2 A company is testing a special material that can possibly be used in protective wear for policemen. A bullet with a mass of 9 g is fired at a layer of the material and hits it perpendicularly at a velocity of 365 $m \cdot s^{-1}$. The bullet is brought to a standstill by the material in 1×10^{-4} s.

10.2.1 Calculate the magnitude of the average force needed to stop the bullet.

10.2.2 If the force calculated in QUESTION 10.2.1 is represented by F, write down the magnitude of the force (in terms of F) if:

(a) The mass of the bullet is doubled, whilst its initial velocity and the time to come to rest remain the same

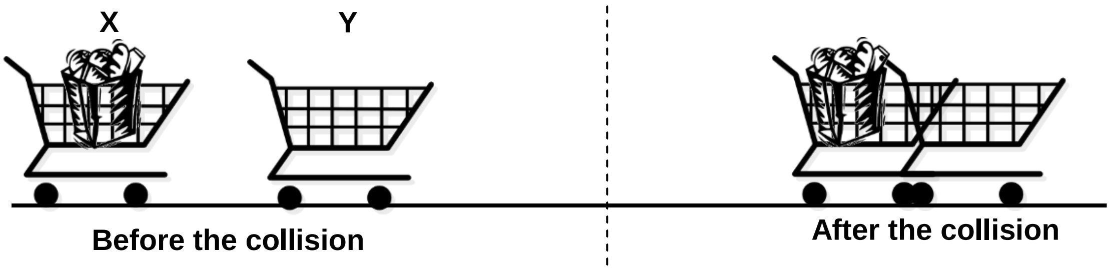
(b) The bullet takes twice as long to come to rest, whilst its initial velocity and mass remain the same.

QUESTION 11

Two shopping trolleys, **X** and **Y**, are both moving to the right along the same straight line. The mass of trolley **Y** is 12 kg and its kinetic energy is 37,5 J.

11.1 Calculate the speed of trolley **Y**.

Trolley **X** of mass 30 kg collides with trolley **Y** and they stick together on impact. After the collision, the combined speed of the trolleys is 3,2 $m \cdot s^{-1}$. (Ignore the effects of friction.)



11.2 Write down the principle of conservation of linear momentum in words.

11.3 Calculate the speed of trolley **X** before the collision.

During the collision, trolley **X** exerts a force on trolley **Y**. The collision time is 0,2 s.

11.4 Calculate the magnitude of the force that trolley **X** exerts on trolley **Y**.

QUESTION 12

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

12.1 Write down the velocity of the thief's car relative to the patrol car.

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.

12.2 Write down the initial velocity of the bullet relative to the thief's car.

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.

12.3 State the law of conservation of linear momentum in words.

12.4 Calculate the velocity of the thief's car immediately after the collision.

12.5 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.

QUESTION 13

A car, mass 560 kg and travelling at a speed of 30 m·s^{-1}, fails to turn a corner and continues straight to hit a concrete wall ahead. After hitting the wall, the car bounces back at a speed of 2 m·s^{-1} before it stops.

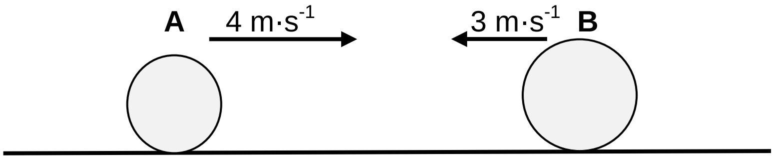
13.1 Calculate the change in the car's momentum during this collision.

13.2 Calculate the magnitude of the force exerted by the wall on the car if the collision lasts for 0,1 s.

13.3 Modern cars are equipped with "crumple zones" as a safety measure during collisions. Explain, by using physics principles, how crumple zones contribute to the safety of the passengers in a car during a collision.

QUESTION 14

Two metal balls A and B are rolling along in a horizontal straight line towards each other in a closed system. A with mass 0,75 kg is rolling at a speed of 4 m·s$^{-1.}$ B with a mass of 1,25 kg collides head on with A at a speed of 3 m·s^{-1}. After collision A rolls in the direction opposite to its initial direction at a speed of 2,5 m·s^{-1}



14.1 Explain the term closed system.

14.2 Calculate the change in momentum experienced by ball A due to the collision

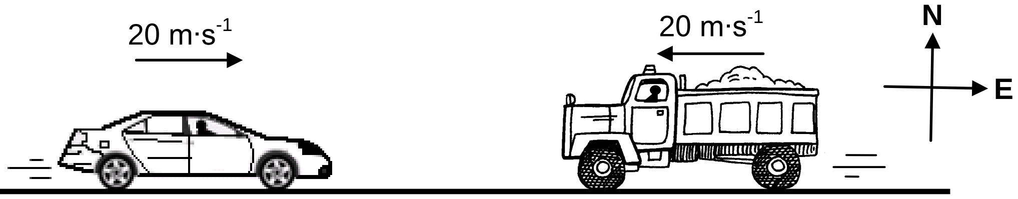
14.3 Determine the change in momentum experienced by B due to the collision.

14.4 What is the net change in momentum for the whole system (ball A and ball B)?

14.5 Calculate the magnitude of the force that A and B exert on each other during collision if the two balls are in contact with each for 0,2 s

QUESTION 15

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 2m travelling at 20 m·s^{-1} west on the same road. Ignore the effects of friction.



15.1 Calculate the velocity of the car relative to the truck.

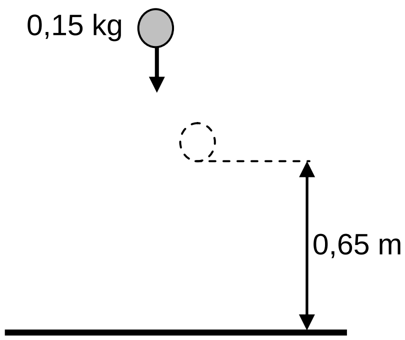
The vehicles collide head-on and stick together during the collision.

15.2 State the principle of conservation of linear momentum in words.
15.3 Calculate the velocity of the truck-car system immediately after the collision
15.4 On impact the car exerts a force of magnitude **F** on the truck and experiences an acceleration of magnitude a.
15.4.1 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.
15.4.2 Determine, in terms of **a**, the acceleration that the truck experiences on impact. Give a reason for the answer.
15.4.3 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.

QUESTION 16

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.

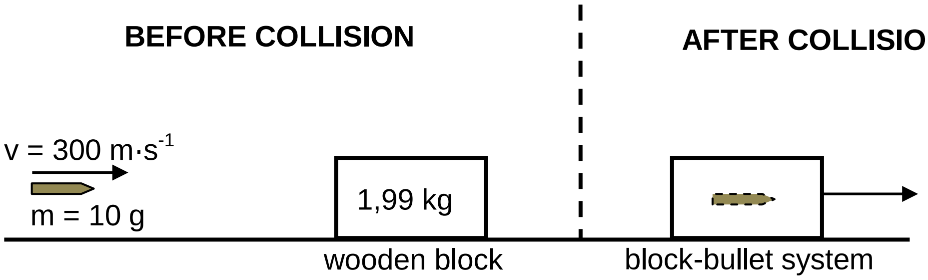
During such a test, a cricket ball of mass 0,15 kg is dropped from rest from a certain height and it strikes the floor at a speed of 6,2 m·s^{-1}. The ball bounces straight upwards at a velocity of 3,62 m·s^{-1} to a height of 0,65 m, as shown in the diagram below. The effects of air friction may be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



16.1 Define the term impulse in words.
16.2 Calculate the magnitude of the impulse of the net force applied to the ball during its collision with the floor.
16.3 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.

QUESTION 17

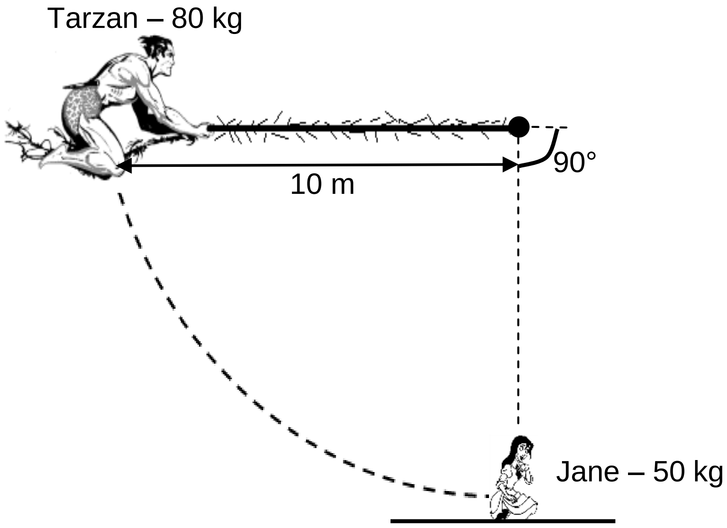
A bullet of mass 10 g, moving at a velocity of 300 $m \cdot s^{-1}$, strikes a wooden block of mass 1,99 kg resting on a flat horizontal surface as shown in the diagram below. The bullet becomes embedded in the block. Ignore the effects of air friction.



17.1 Write down in words the principle of conservation of linear momentum.
17.2 Calculate the speed of the block-bullet system immediately after the collision.
17.3 Is this collision elastic or inelastic? Give a reason for the answer.
The floor exerts a constant frictional force of 8 N on the block-bullet system as it comes to rest.
17.4 Calculate the distance that the block-bullet system moves after the collision.

QUESTION 18

Tarzan, of mass 80 kg, swings from rest on a rope of length 10 m that is horizontal when he starts, as shown in the diagram below. At the bottom of his swing, he picks up Jane, sitting on the ground, in an inelastic collision. Jane has a mass of 50 kg. They then swing upwards as one unit. The mass of the rope and the effects of air friction may be ignored.



18.1 State the principle of conservation of linear momentum in words.
18.2 Calculate the combined speed of Tarzan and Jane just after he picks her up.
18.3 Will Tarzan and Jane reach a height of 10 m on their upward swing? Give a reason for your answer.
18.4 If Jane is holding on to a bag of bananas at the time when Tarzan picks her up, how will their combined speed compare to that obtained in QUESTION 18.2? Write only GREATER THAN, SMALLER THAN or EQUAL TO.

QUESTION 19

Head-on collisions lead to fatal injuries in many cases. Car **A** (mass = 2 200 kg) which is travelling at a velocity of 14 $m \cdot s^{-1}$ in an eastern direction loses control and crashes head-on a second oncoming car, Car **B** (mass = 1 200 kg), which is travelling at a velocity of 40 $m \cdot s^{-1}$ in a western direction. The two cars become entwined with the impact and continue to move together.

19.1 During collision sound and heat are released. What type of collision is described here

19.2 State the principle that you need to calculate the velocity of the wreckage after the collision.

19.3 Calculate the velocity of the wreckage after the collision

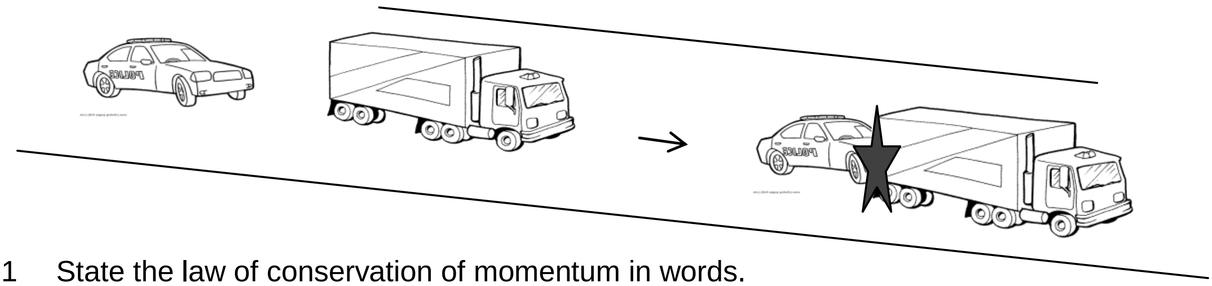
19.4 A learner states that it is less dangerous to be in a heavier car during a collision. Answer the following questions relating to this statement.

19.4.1 How will the change in momentum of the heavier car **A** compare to that of the lighter car **B**?

19.4.2 Use principles of Physics and explain why the statement made by the learner could be correct.

QUESTION 20

A police car, mass 670 kg and travelling at a speed of 30 $m \cdot s^{-1}$, collides with a stationary truck, mass 15 000 kg, while chasing an escaping robber. The car and the truck combine during the collision.



20.1 State the law of conservation of momentum in words.

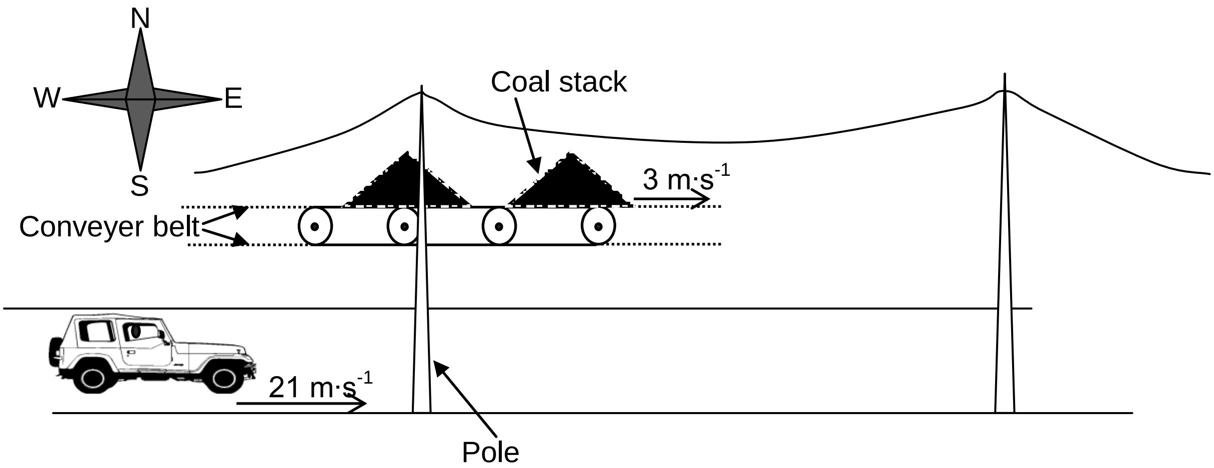
20.2 Calculate the speed of the truck after the collision.

20.3 During the collision a passenger in the front seat of the police car is thrown against the windscreen. Explain how the passenger could have avoided this.

STRUCTURED QUESTIONS: FRAMES OF REFERENCE

QUESTION 21

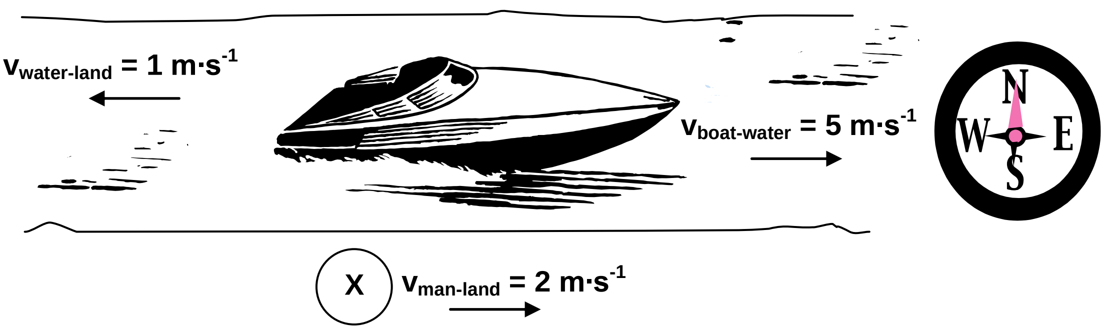
Coal is taken from a mine to the processing site by a conveyer belt. A coal stack on a conveyer belt is moving eastwards at 3 m·s^{-1} RELATIVE to the GROUND. The driver of a Jeep and a passenger drive past the conveyer belt, also eastwards, at 21 m·s^{-1} RELATIVE to the GROUND.



21.1 Determine the velocity of the passenger relative to the driver of the Jeep.
21.2 Determine the velocity of the Jeep relative to the coal stack.
21.3 Determine the velocity of the pole which supports the electric cable, relative to the Jeep.

QUESTION 22

The water in a river flows from east to west at a velocity of 1 m·s^{-1} relative to the land. A boat is moving upstream, that is, from west to east, at a velocity of 5 m·s^{-1} relative to the water. A man, X in the diagram below, is walking alongside the river from west to east at a velocity of 2 m·s^{-1} relative to the land.



Calculate the velocity of the boat relative to the man. Show all your working.