MECHANICS: NEWTONS LAWS QUESTIONS

THE HIGH JUMP (2010;3)

Lucy is competing in a high jump event. She runs up to the bar, jumps over it and lands on the mat.

(a) She starts her run-up by accelerating from rest at 2.21 m s^{-2} for 2.0 s. Calculate the **distance** she travels in this time. Write your answer to the correct number of **significant figures**.

(b) Explain why you have used this number of significant figures.

(c) Use physics principles to explain why it is better for Lucy to land on the padded mat than it is to land on grass.

THE SHOT PUT (2010;3)

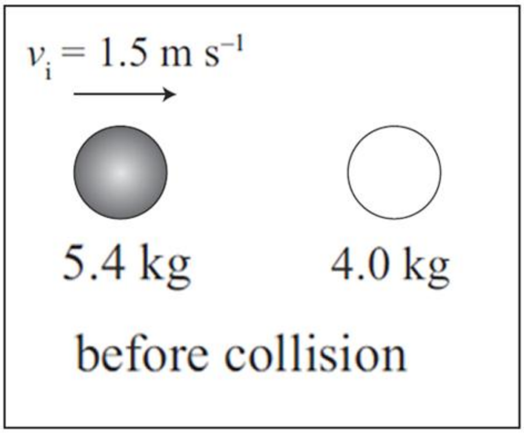
Hamish is competing in the shot put. This involves throwing a 5.4 kg iron ball (the shot) as far as possible.

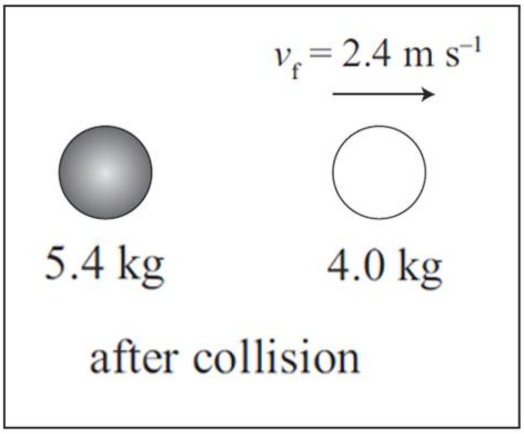
(a) The shot starts from rest and accelerates for 0.25 s. Calculate the average force that Hamish exerts on the shot if it leaves his hand at 11 ms^{-1}.

When the shot lands, it rolls along the ground at 1.5 ms^{-1} and collides head-on with a stationary shot which has a mass of 4.0 kg. The friction force is negligible during the collision. After the collision, the 4.0 kg shot rolls forward at 2.4 ms^{-1} in the same direction that the 5.4 kg shot was initially rolling.

(b) Without doing any calculations, what can you say about the **total momentum** and the **momentum of the 4.0 kg shot** during the collision? Discuss your answer.

(c)





Calculate the velocity (size and direction) of the 5.4 kg shot after the collision.

EQUILIBRIUM, MOMENTUM AND SPRINGS (2009;3)

One of the games that Harry plays is cricket.

(a) The ball approaches the batsman with a speed of 21 ms^{-1}. The ball has a mass of 0.161 kg. The batsman hits the ball hard with an average force of 2560 N, and the ball moves away in the opposite direction at 30.0 ms^{-1}. Calculate the time the ball was in contact with the bat.

(b) Express your answer to (a) to the correct number of significant figures. State the reason for your choice of significant figures for your final answer.

(c) Harry is a fielder near the batsman. Explain, using physics principles, why Harry usually pulls back his hand while catching a ball.

THE SOCCER MATCH (2008;1)

Louise is playing soccer for her 1st XI soccer team. Louise has a mass of 65 kg.

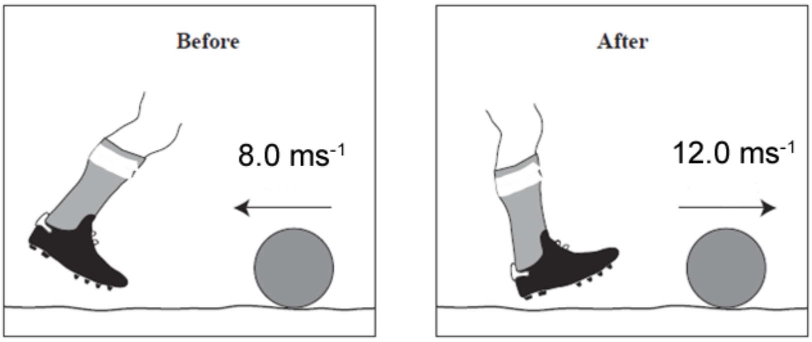
(a) Calculate the size of Louise's momentum while she is running at 8.0 ms^{-1}. Write your answer with the correct units.

(b) Determine the size of the average net force acting on her when she is running at constant speed. Explain your answer.

Louise kicks the ball vertically up, as shown in the diagram. It rises and then falls. You may assume air resistance is negligible.

(c) Describe and explain what happens to (i) the force on the ball (ii) the ball's acceleration (iii) the ball's velocity after the ball is kicked and as it rises and falls.

A while later, the ball is rolling towards Louise at a speed of 8.0 ms^{-1} as shown in the diagram below. She kicks it and it rolls in the opposite direction with a speed of 12.0 ms^{-1}. The ball's mass is 450 g. Her foot is in contact with the ball for 0.10 s.

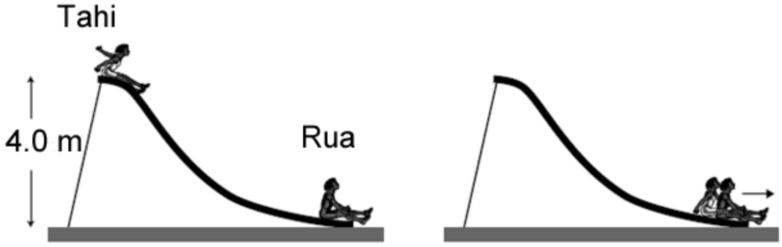


(d) Calculate the size of the unbalanced force on the ball.

(e) State the size and direction of the force of the ball on her foot.

GOING TO THE PLAYGROUND (2008;2)

Tahi then climbs to the top of a slide. The slide is 4.0 m high. He slides down. Assume all the gravitational potential energy is converted into kinetic energy. At the bottom he collides with Rua, who is initially stationary. Tahi's mass is 55 kg and Rua's mass is 65 kg.

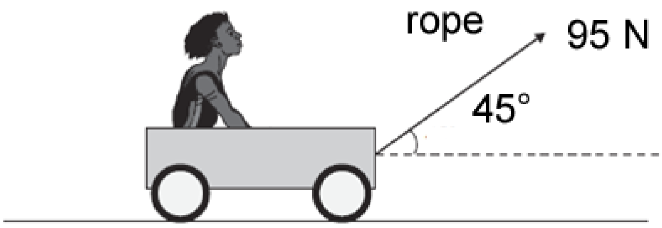


(a) This collision is inelastic. State what this means.

(b) Calculate their combined speed if they stick together after the collision.

(c) Is Tahi's momentum conserved as he moves down the slide? Explain your answer.

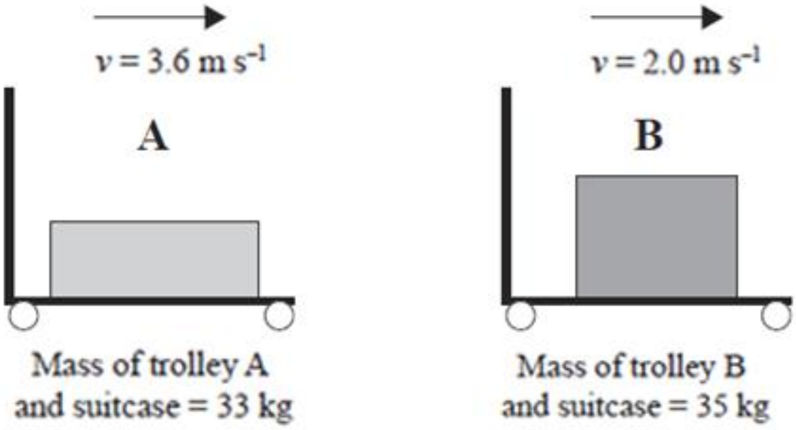
Rua then climbs onto a trolley and Tahi tows him with a rope, as shown in the diagram below. Rua's mass is 65 kg, the mass of the trolley is 11 kg.
The tension force in the rope attached to the trolley is 95 N, and the rope is at an angle of 45° to the ground. There is a 35 N friction force on the trolley.



(a) Calculate the size of the trolley's acceleration.

THE BAGGAGE SECTION (2007;3)

(a) A suitcase is put on trolley A. The total mass of trolley A and the suitcase is 33 kg. Trolley A with the suitcase is moving with a speed of 3.6 ms^{-1} when it collides inelastically with trolley B moving in the same direction with a speed of 2.0 ms^{-1}. The total mass of trolley B and its suitcase is 35 kg.



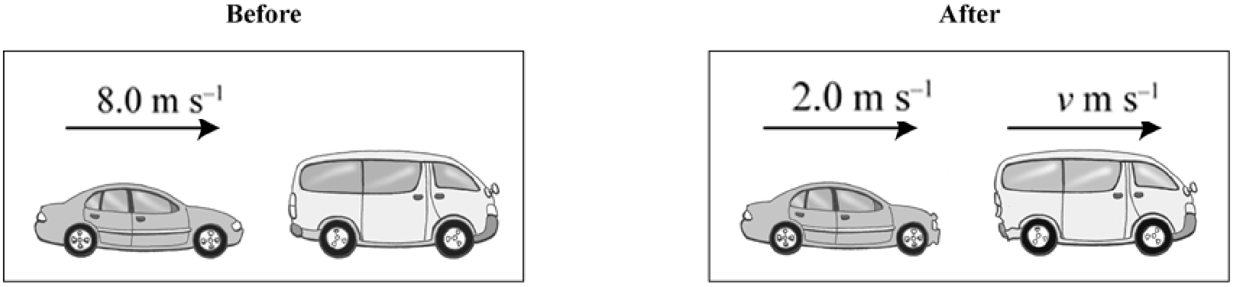
After the collision, trolley A is moving with a speed of 2.4 ms^{-1} in the same direction. Calculate the kinetic energy of trolley B and its suitcase after the collision.

(b) What assumptions did you make in order to answer the above question?
(c) This collision is described as inelastic. Explain clearly what happens to momentum and kinetic energy in both elastic and inelastic collisions.

MOMENTUM (2006;4)

Marama is driving her car home after her event, when she collides with a stationary van. Assume there are no outside horizontal forces acting during the collision.

(a) Name the physical quantity that is conserved in this collision.



The mass of the car is 950 kg and the mass of the van 1700 kg.
The car is travelling at 8.0 ms^{-1} before the collision and 2.0 ms^{-1} immediately after the collision, as shown in the diagram.

(b) Calculate the size and direction of the car's momentum change.
(c) Calculate the speed of the van immediately after the collision.
(d) If the average force that the van exerts on the car is 3800 N, calculate how long the collision lasts.
(e) Marama had a bag resting on the front seat.Use relevant physics concepts to explain why the bag fell onto the floor during the collision.
(f) The front of modern cars is designed to crumple or gradually compress during a collision. Use the idea of impulse to explain why this is an advantage for the people in the car.

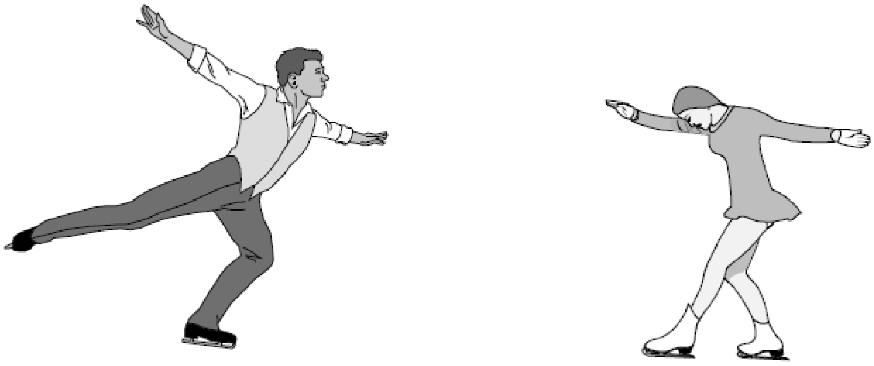
A COLLISION (2006;2)

A car and its driver have a combined mass of 1200 kg. The car collided with a stationary van of mass 1500 kg.
The car and van locked together after impact and from the marks on the road the police were able to deduce that the wreckage moved at 4.0 ms^{-1} immediately after the collision.

(a) Calculate the speed of the car just before it collided with the van.
(b) State what physical quantity is conserved in the collision.
(c) State the condition necessary for the quantity you have named in (b) to be conserved.
(d) The impact lasted for 0.50 seconds. Calculate the average force that the car exerted on the van during the collision.
(e) Explain TWO features that a car has in order to reduce injury to the driver during a collision.
(f) Use calculations to explain whether the collision was elastic or inelastic.

SCHOOL TRIP - ICE SKATING (2004;4)

Ana and Jon are now practising ice skating routines.
Jon (mass 75 kg) skates at 6.0 ms^{-1} towards Ana (mass 55 kg) who is standing still on the frictionless ice. Jon collides with Ana and they move off together in the same straight line that Jon was moving before the collision.



(a) Calculate the speed of the skaters after the collision.
(b) Explain the physics involved in finding the answer to (a), including a statement of any assumption made.