Name:_____

**Assignment due:**

St Patrick's College, Silverstream

# PHYSICS

## Mechanics Assignment 4

## Momentum, Impulse

**Level 2**

90255 Demonstrate understanding of mechanics

You may find the following formulae useful

$$v = \frac{\Delta d}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t} \qquad v_f = v_i + at$$

$$d = v_i t + \frac{1}{2}at^2 \qquad d = \frac{v_i + v_f}{2}t \qquad v_f^2 = v_i^2 + 2ad$$

$$a_c = \frac{v^2}{r}$$

$$F = ma \qquad \tau = Fd \qquad F = -kx$$

$$F_c = \frac{mv^2}{r} \qquad p = mv \qquad \Delta p = F\Delta t$$

$$E_p = \frac{1}{2}kx^2 \qquad E_k = \frac{1}{2}mv^2 \qquad \Delta E_p = mg\Delta h$$

$$W = Fd \qquad P = \frac{W}{t}$$

$g = 9.8 ms^{-2}$

NZIP 2008

**QUESTION ONE: SKATEBOARDING**

The diagram shows Rowena is skateboarding in a park. She starts from rest and reaches a uniform velocity of 2.0 $ms^{-1}$ in 8.5 seconds.

(b) Rowena has a mass of 26.0kg and her skateboard has a mass of 2.5kg. She is travelling on her skateboard at a uniform speed of 2.0 $ms^{-1}$. Show that the **combined** momentum of Rowena and the skateboard is 57 kg $ms^{-1}$.

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Rowena sees a garden edging on her path. To avoid collision, she leans forward and jumps off the front of the skateboard in her direction of travel. The skateboard immediately comes to a complete stop well away from the garden edging as shown in the diagram.

(c) Calculate the speed at which Rowena leaves the skateboard. Give your answer to the correct number of significant figures.

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speed = _____

(d) Explain, using physics principles, why the skate board comes to an immediate stop as she jumps off the front of the board.

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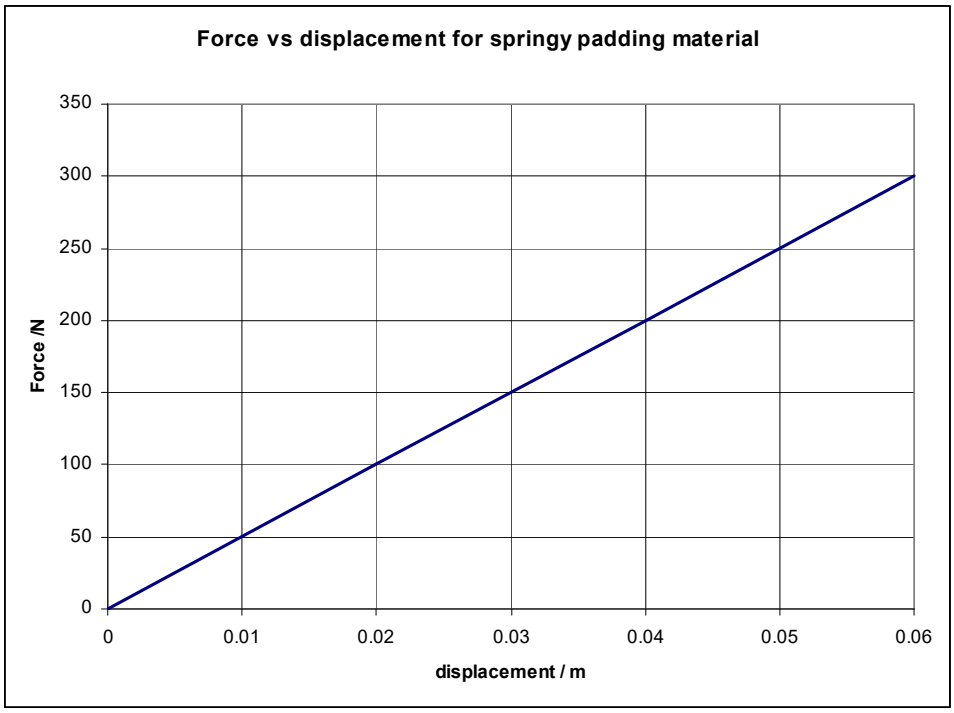
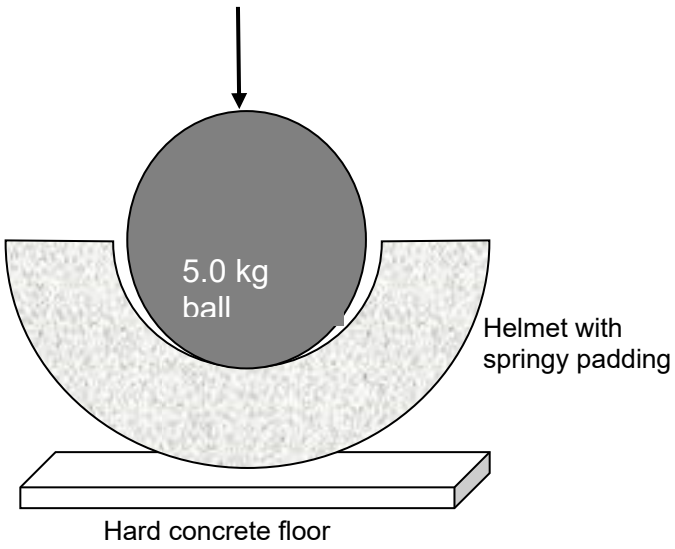
NZIP 2008

**QUESTION THREE: CRASH HELMET TESTING**

For safety reasons crash helmets are lined with padding materials. The padding material used inside a helmet was tested for its cushioning effect in a laboratory. The result is shown in the graph.



A high impact crash helmet is glued onto a floor and a 5.0 kg steel ball is dropped from a certain height into the helmet padding as shown in the diagram. The ball hits the helmet padding at 0.85 $ms^{-1}$. The spring constant of the padding material is 35 kN $m^{-1}$.




(c) Use the concept of impulse to explain how the padding inside a helmet reduces the maximum force experienced by the ball when it hits the floor.

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NZIP 2007

**QUESTION FOUR: MOMENTUM**


The diagram shows a hunter just before and just after he has fired his rifle. Assume there are no outside horizontal forces acting during the firing.

(a) Assuming that the rifle and bullet form an isolated system, determine the value of the total momentum of this system just after the firing. Explain your reasoning.

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The mass of the rifle is 12.4 kg and the mass of the bullet is 0.0245 kg.

The bullet is travelling at 184 m $s^{-1}$ as it leaves the rifle and the rifle recoils at a velocity v immediately after the firing, as shown in the diagram above.

(b) Calculate the **size** and **direction** of the bullet's **momentum change**. Give the answer to the **correct number of significant figures**. Give the **correct unit**.

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(c) Calculate the **recoil velocity** $v$ of the rifle immediately after the firing.

(d) The time of firing the rifle is 54.3 ms (1 ms = $10^{-3}$ s). Calculate the **force** exerted on the bullet during the firing.

(e) Determine the **force** exerted on the rifle during the firing. **Explain your reasoning**.

(f) The shooter fires a bullet at a metal plate. Explain whether or not the bullet exerts a greater impulse on the plate if it bounces off the plate or embeds itself in the plate.

NZIP 2006

Tamarah and Aaron went to a cricket match.

**QUESTION ONE: THE OPENING BOWLER**

The opening bowler bowled fast. The speed of each bowl was measured and shown on a screen. The speed of the first bowl was measured to be **140** kilometres per hour.

This speed is **39** metres per second.

(c) A cricket ball has a mass of **156**g (**0.156kg**). Calculate the momentum of the ball as it is travelling down the pitch. State the SI unit for momentum with your answer.

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_____ Momentum = _____

SI unit _____

**QUESTION TWO: THE BATTER IN TROUBLE**

(a) One bowl hit the batter on the pads and the fielding team appealed loudly. Explain how the leg pads protect the batter's legs.

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(g) The fourth bowl was bowled at **35ms$^{-1}$**. The Batter tried to hit it but missed and the ball went through to the keeper who caught it in his gloves. It took a time of t = **0.42s** from when the ball first contacted the gloves until it was completely stopped. Calculate the average deceleration of the ball as it is being caught. ($m_{BALL}$ = 0.156kg).

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_____ Average deceleration = _____

The batter is bowled out by a particularly good bowl. The ball collides with the middle stump and sends the bails flying.

(h) Describe changes to the velocities of the ball and the wicket when the collision occurs and what causes these velocity changes.

| Object | Velocity Change | Cause |
|---|---|---|
| Ball | | |
| Wicket and bails | | |

(i) Comment on the momentum changes associated with this situation.

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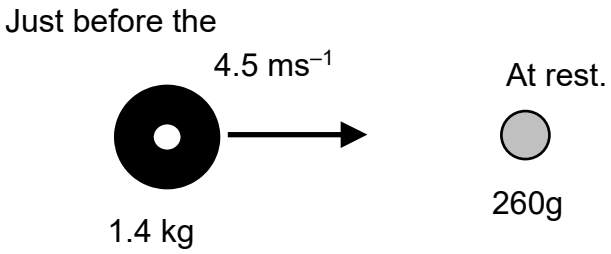
**NZIP 2005**

**QUESTION FIVE: LAWN BOWLS**

Lindsay is competing in the 'singles' competition for lawn bowls. The diagram shows that he has delivered a 1.4 kg lawn bowl that collided with the jack which was stationary. The jack is a smaller ball of mass 260g. The collision was such that both the jack and the lawn bowl travel in the same direction as the lawn bowl was travelling before the collision.




(a) Show that the momentum of the lawn bowl before the collision was 6.3 and state the SI Unit for momentum.

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_____SI unit _____

(b) Momentum was conserved in this collision. Explain what this statement means and implies about the forces in this situation.

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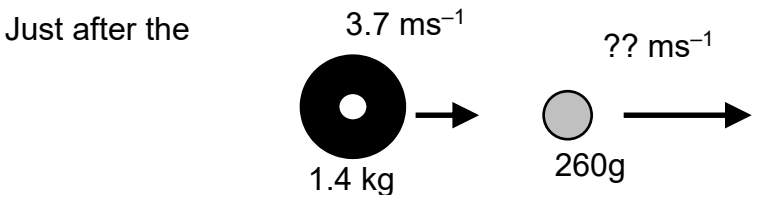

After the collision the lawn bowl was travelling at 3.7ms$^{-1}$.

(d) The force applied to the jack during the contact of the collision was 9.3N. What was the length of time that the lawn bowl and jack were in contact?

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_____ Time for collision = _____

(e) The force on the lawn bowl by the jack is also 9.3N. Justify this statement and describe the effect of each of these forces.

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(f) The information in the table below shows that this collision was inelastic.

| **Object** | **Kinetic Energy** |
|---|---|
| Lawn bowl before collision. | 14 J |
| Lawn bowl after the collision. | 9.6 J |
| Jack after collision. | 2.4 J |

Explain what is meant by "inelastic collision"

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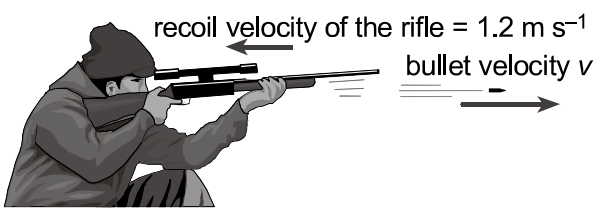
**NZIP 2004**

**QUESTION FIVE: TARGET SHOOTING**

A hunter practises shooting by firing at a target. The mass of the rifle without the bullet is **9.2 kg**.

The diagram below shows the recoil of a rifle as a hunter fires it. The recoil velocity of the rifle is **1.2 ms$^{-1}$.**

The mass of the bullet is **0.086 kg.**



Asses sor's use only

(a) Write down the value of the total momentum of the rifle and bullet **just before firing**.

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(b) Write down the value of the **total momentum** of the rifle and bullet just **after** firing. Explain clearly the principle you used to find this value.

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(c) Show that the velocity of the bullet as it leaves the rifle is **128.4 $ms^{-1}$.**

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(d) If the firing of the bullet took **0.037 s**, calculate the value of the average **force** acting on the bullet during this time.

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Force = _____