Name:_____

**Assignment due:**

St Patrick's College, Silverstream

# PHYSICS

## Mechanics Assignment 3

## Newton's Laws, torque and equilibrium

**Level 2**

90255 Demonstrate understanding of mechanics

You may find the following formulae useful

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

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

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

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

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

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

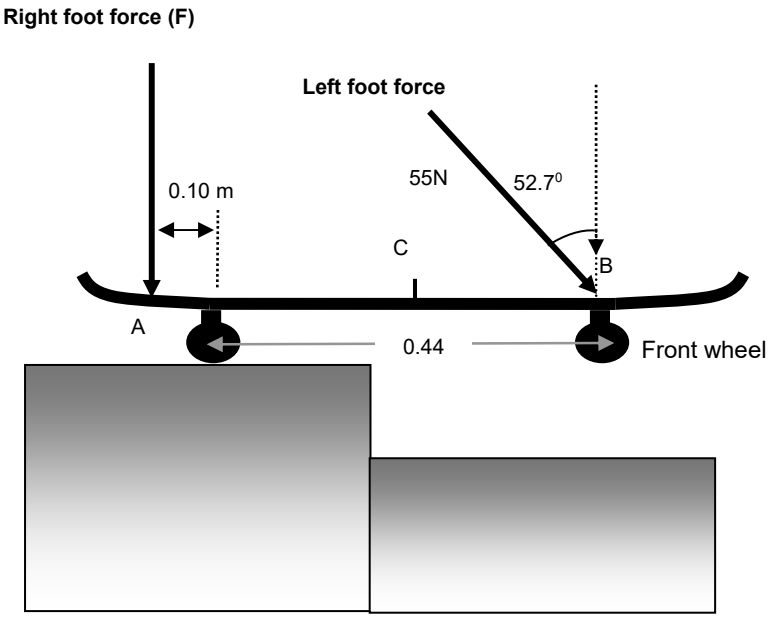
$$W = Fd \qquad P = \frac{W}{t}$$

$g = 9.8 ms^{-2}$

NZIP 2008

## QUESTION TWO: SKATEBOARD SKILLS AND THRILLS

Monica balances herself on her skateboard on top of a step. One wheel of the skateboard is on a step and the other wheel is hanging in the air as shown in the diagram below. The skateboard is balanced horizontally.




The above diagram shows the directions of forces exerted by Monica's right and left feet. The point C is the middle of the skateboard and the wheels are at equal distance from C.

(a) On the above diagram draw two labelled arrows:

- one arrow to show the direction of the weight of the skateboard, and
- another arrow to show the direction of the support force on the skateboard

(b) To balance the skateboard horizontally, Monica's left foot exerts a force of 55 N at an angle of $52.7^0$ to the vertical as shown in the diagram. Show that the vertical component of this force is 33.3 N.

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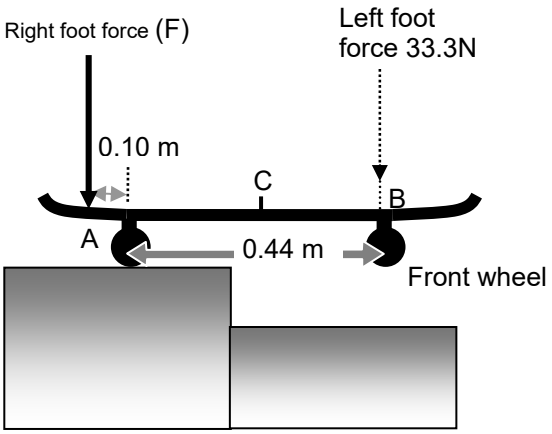
Monica's right foot exerts a force of F Newton vertically down at 0.10 m from the back wheel as shown in the diagram below. The distance from the centre of the back wheel to the centre of the front wheel is 0.44 m. The board has a mass of 2.5 kg. The point C is the middle of the skateboard and both wheels are at equal distance from C. The skateboard is balanced horizontally.




(c) Calculate the size of the force (F) exerted by the right foot on the skateboard to hold it horizontally.

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force = _____

(d) In order to balance the skateboard horizontally on one wheel Monica must move her body so that a greater proportion of her weight is on her right foot than on her left foot. Explain why the force applied from her right foot must be much greater than that applied from her left foot to maintain equilibrium.

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NZIP 2006

Tamarah and Aaron went to a cricket match.

## 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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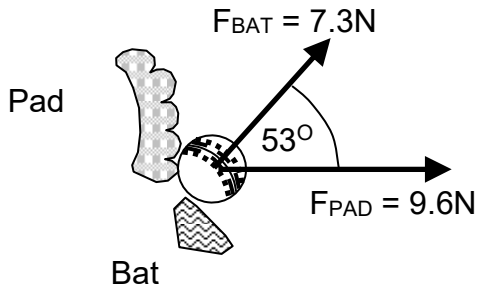
The next ball hit the batter on one pad just as she hit it with the edge of her bat. The ball experienced forces from both the pad and the bat at the same time. The forces were: $F_{PAD}$ = **9.6N** and $F_{BAT}$ = **7.3N**



(b) Sketch a vector diagram that will help you find the resultant force on the ball.

(c) Calculate the net or resultant force on the ball.

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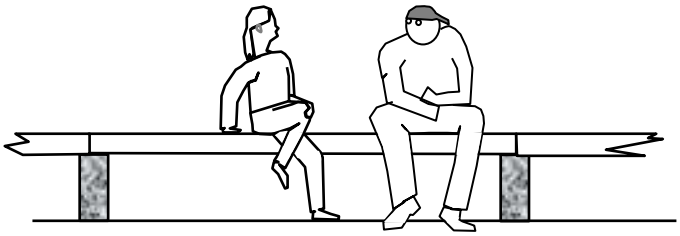
_____ Resultant Force = _____

NZIP 2006

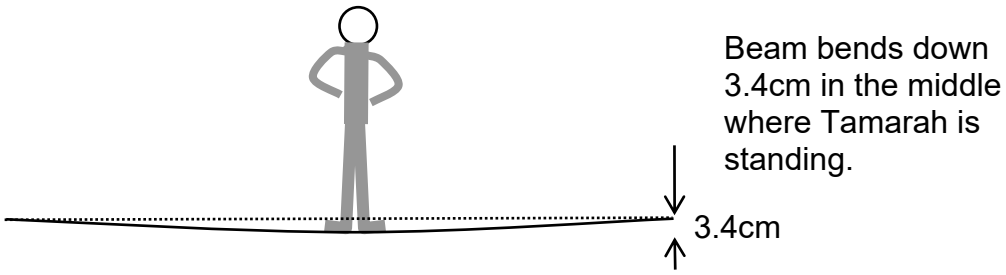
**QUESTION FOUR: SITTING IN THE STAND**

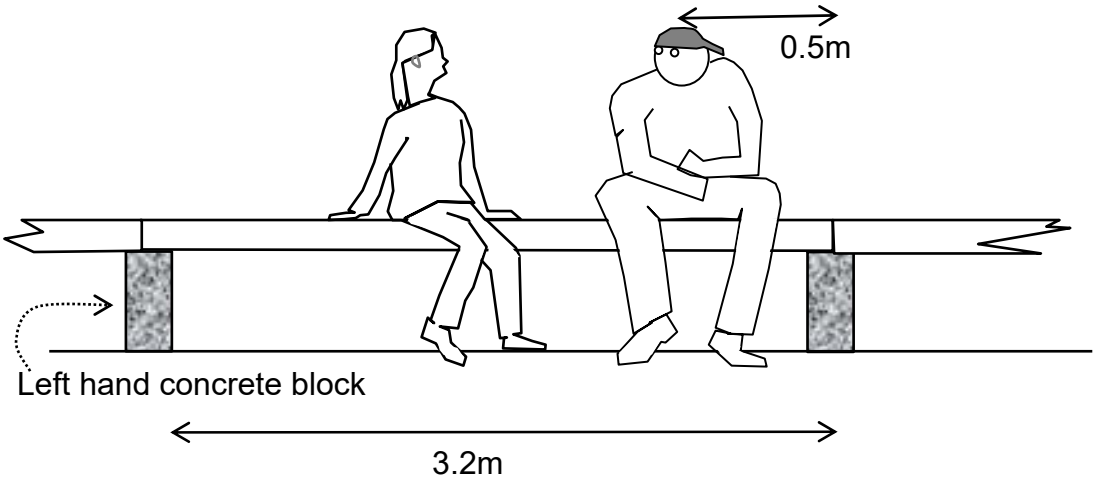
Aaron and Tamarah sat on a wooden seat in the stand to watch the cricket.



The wooden seat consisted of a **3.2m** long beam which had a weight of **130N**. When Tamarah, whose weight was **520N**, stood on the beam at the mid point the beam bent **3.4cm**.

(a) Draw and label arrows onto the diagram below to show the forces acting in this situation.






(d) Calculate the support force supplied by the left hand concrete block when Tamarah is sitting in the middle and Aaron is sitting **0.5m** from the other end. For simplicity assume they are not touching the ground with their feet and the beam supports all of their weight. (Tamarah's weight = 520N, Aaron's weight = 680N)

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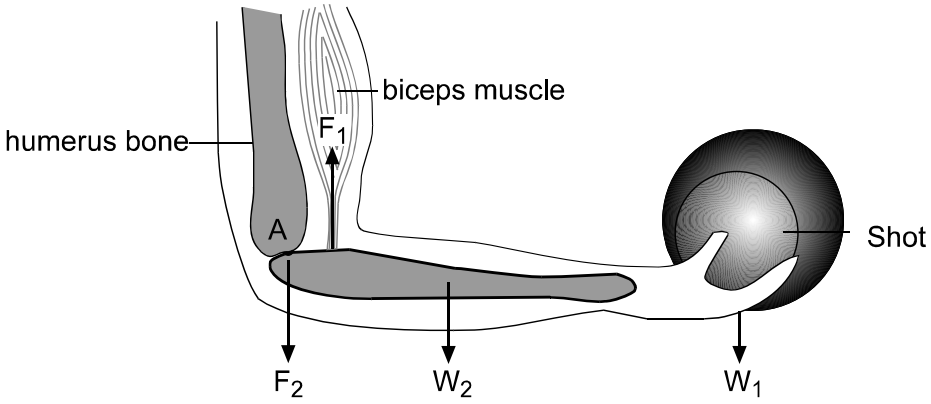
_____ Support force = _____

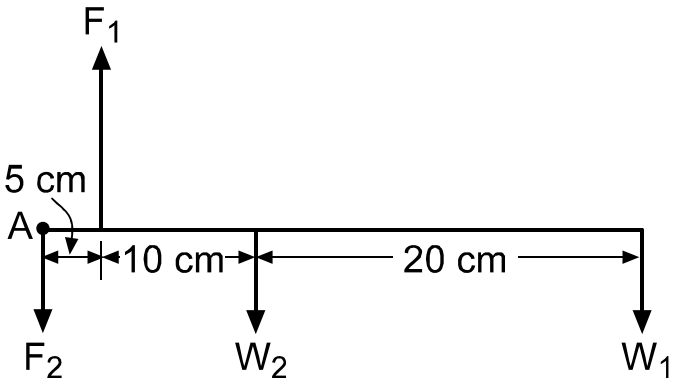
**NZIP 2005**

**QUESTION ONE: FORCES AND EQUILIBRIUM. The shot putter**

A shot putter holds a shot of mass 7.0kg in the palm of her hand. Her upper arm is vertical and her forearm (mass 1.5kg) is horizontal. The diagram shows the forces exerted on the forearm. $F_1$ is the upward force exerted by the biceps muscle. $F_2$ is the downward force exerted by the humerus bone.




The following diagram simplifies this.




$W_1$, the weight of the shot, is 69N and $W_2$, the weight of the forearm, is 15N.

(a) Calculate the torque exerted by $W_2$, the weight of the forearm, about the pivot. State your answer with the correct SI unit.

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_____Torque = _____Unit_____

(b) By taking moments or torques about the elbow joint (point A) calculate $F_1$, the upward force exerted by the biceps.

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_____ Force, $F_1$ = _____

(c) Calculate $F_2$ the force exerted by the humerus on the forearm.

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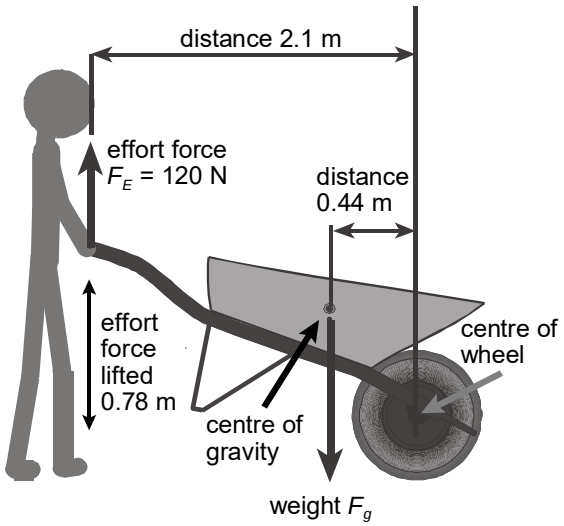
_____ Force, $F_2$ = _____

**NZIP 2004**

**QUESTION TWO: FORCES ON A WHEELBARROW**

The diagram shows a person lifting the handles of a wheelbarrow by exerting an effort force ($F_E$ ) of **120 N** through a vertical height of **0.78 m**. The weight of the load (including the wheel barrow) is $F_g$.




(c) Calculate the size of the **torque** exerted by the effort force $F_E$ about the centre of the wheelbarrow's wheel. Give a unit with your answer.

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Torque = _____Unit =_____

(d) When the person has lifted the wheelbarrow, the person and the loaded wheelbarrow are in equilibrium. Calculate the combined **mass** of the load and wheelbarrow.
Acceleration due to gravity is 10 m $s^{-2}$.

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Mass = _____

(e) Give a clear explanation of the physical principle used to solve the problem in (d).

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