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91171

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Draw a cross through the box (☒) if you have NOT written in this booklet

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Physics 2023

91171 Demonstrate understanding of mechanics

Credits: Six

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of mechanics.	Demonstrate in-depth understanding of mechanics.	Demonstrate comprehensive understanding of mechanics.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Sheet L2–PHYSR.

In your answers use clear numerical working, words, and/or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

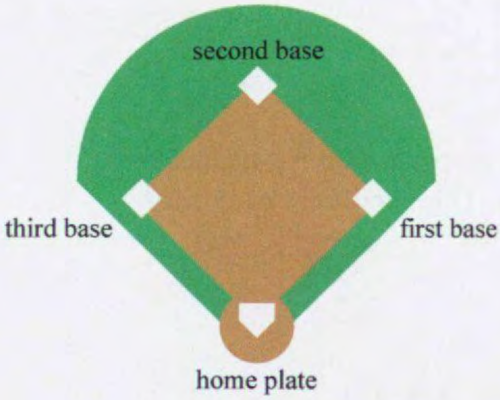
Do not write in any cross-hatched area (DO NOT WRITE). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence | 22

QUESTION ONE: SOFTBALL MATCH

The following diagram shows the layout of a softball game.



http://thesportdigest.com/2017/03/ten-ways-to-prevent-injuries-in-softball/

A stationary player accelerates from the home plate to first base.

The player takes 6.61 s to get to first base and arrives moving at 5.45 m s^{-1}.

(a) Show that the average acceleration is 0.825 m s^{-2}.

$v_f = v_i + at$

$5.45 ms^{-1} = 0 ms^{-1} + (6.61s \times a)$

$5.45 = 6.61a$

$a = 0.825 ms^{-2}$ (3dp)

(b) (i) Calculate the maximum displacement between the home plate and first base.

$d = \frac{v_i + v_f}{2} t$

$d = 0ms^{-1} + 5.45ms^{-1} / 2 \times 6.61s$

$d = 18.0m$ (1dp)

(ii) Why might this displacement be different from the actual distance travelled by the player?

The player may not run in the straighest most direct route to first base.

(c) The softball has a mass of 0.180 kg, is thrown at 44.4 m s^{-1}, and is caught and brought to a stop at first base.

The catcher's arm is relaxed, and the ball and padded glove move backwards a little once the ball collides with the padded glove.

The ball takes 0.510 s to stop. This results in an impulse.

(i) What does the term impulse mean?

It is a change in momentum

(ii) Calculate the average force of the ball on the padded glove on impact.

$\Delta p = 7,99 \text{ kgms}^{-1}$ $\Delta p = F\Delta t$

$F = 7.99\text{kgms}^{-1} / 0.51\text{s}$

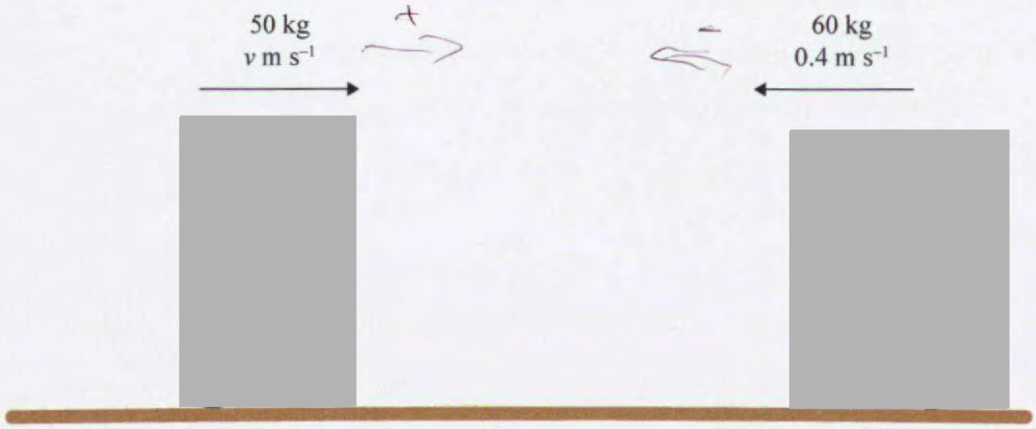
$F = 15.7\text{N}$ (3sf)

(iii) Use physics principles to explain the advantages of catching a ball using a relaxed arm and a padded glove.

When the arm is relaxed and the catcher is wearing a padded glove there is a cushioning to the impact, it increses the overall time of impact. Through the impulse equation $\Delta p = F\Delta t$, the increase of time of impact (Δt) means that there is a decrease of force felt on impact (F). This is because Δp stays the same as the ball doesn't lose ~~weig~~ mass. Therefore as a relaxed arm and padded glove increase the time of impact there is

* continued on back

(d) Later in the game, a 50 kg player moving to the right at speed v collides with a 60 kg player who is moving to the left at $0.4\ \text{m s}^{-1}$. The two players collide and stick together and move to the right at $2\ \text{m s}^{-1}$ after the collision.



Adapted from: https://ggcathletics.com/news/2020/3/24/softball-grizzlies-scattered-across-naia-stats-school-records.aspx

(i) What physical quantity is assumed to be conserved during the collision?

Momentum

(ii) Calculate the initial speed, v, of the 50 kg player.

$p_i = p_f$

$(50v) + (60 \times -0.4) = (50 \times 2) + (60 \times 2)$

$50v - 24\text{kgms}^{-1} = 220\text{kgms}^{-1}$

$50v = 244\text{kgms}^{-1}$

$v = 244\text{kgms}^{-1} / 50\text{kg}$

$v = 4.88\ \text{ms}^{-1}$

QUESTION TWO: CORNERING

A player with a mass of 55.0 kg, moving at a constant speed of 7.00 m s^{-1}, follows a circular path as they round second base.

The radius of their circular path is 15.0 m.

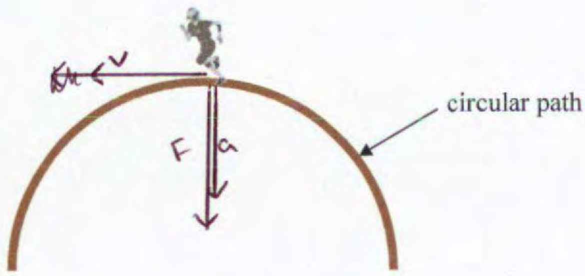
(a) Calculate the centripetal force acting on the player as they round the base.

$F_c = mv^2/r$

$F_c = 55kg \times 7^2 ms^{-1} / 15m$

$F_c = 180N$ (3sf)

(b) Add labelled arrows to the diagram below to show the direction of the force, acceleration, and velocity of the player.



If you need to redraw your response, use the diagram on page 10.

(c) (i) Name the force that supplies the centripetal force acting on the player as they move in a circle.

Friction centripetal force

(ii) Explain why the player can be moving at a constant speed, and yet be accelerating at the same time.

As the player is always changing direction around the circular path they are accelerating inwards of the circuler motion. This keeps the speed of the player constant ~~due~~ (in a tangental line) due to the change in direction around the circleular path.

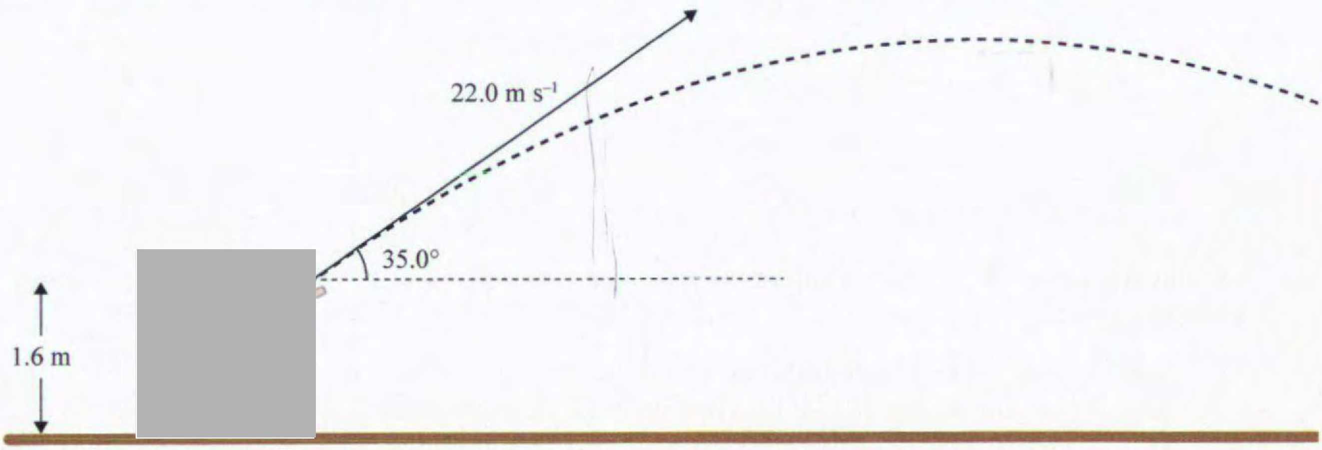
(d) The player runs onto a large slippery, muddy patch while rounding the base.

Describe and explain fully, using physics principles, the effect(s) the slippery mud will have on the player's motion.

The centripetal force acting inwards is a friction force in this sceneario. When the player runs onto a large slippery, muddy patch there is less friction in the ground and player's movement. ~~Wh~~ With less centripetal force due to the decrease of friction in this patch the circular path with become wider (with a larger radius) or the player will just continue ~~on~~ along the tangental line of their velocity.

QUESTION THREE: PROJECTILES

The next batter hits the ball up in the air with an initial velocity of 22.0 m s^{-1} at an angle of 35.0°.



Adapted from: www.vectorstock.com/royalty-free-vectors/baseball-poses-vectors

(a) Show that the vertical component of the initial velocity of the ball is 12.6 m s^{-1}.

$\sin\theta = o/h$

$v_y = 22 ms^{-1} \times \sin 35°$

$v_y = 12.6 ms^{-1}$

(b) Calculate the maximum height reached by the ball above the ground.

$v_F^2 = v_i^2 +$ a~~t~~d

$0^2 ms^{-1} = 12.6^2 ms^{-1} + (-9.8 ms^{-2} \times d)$

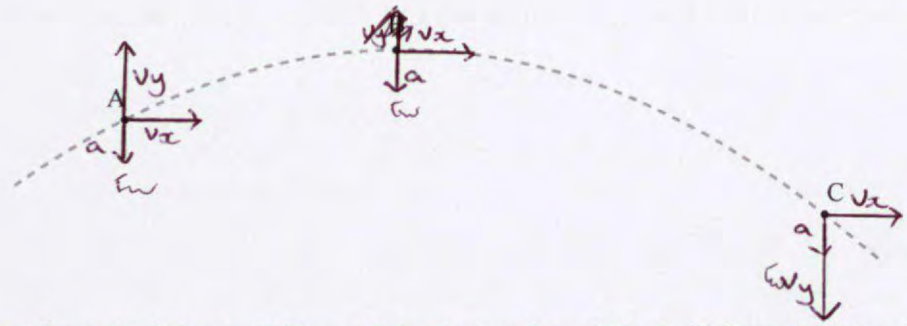
$-158.76 = -9.8d$

$d = 16.2m$

$+1.6m$

$\therefore$ maximum height $= 17.8m$ above ground

(c) The ball's motion can be tracked and can be shown as the parabola motion below.



If you need to redraw your response, use the diagram on page 10.

Use physics principles to fully explain the motion of the ball from the time it leaves the bat until it hits the ground.

(i) Add labelled arrows of appropriate length to show the force(s) on the ball at A (leaves the bat), B (maximum height), and C (just before it hits the ground).

(ii) Describe and explain how the forces, acceleration, and horizontal and vertical velocities of the ball change throughout its flight.

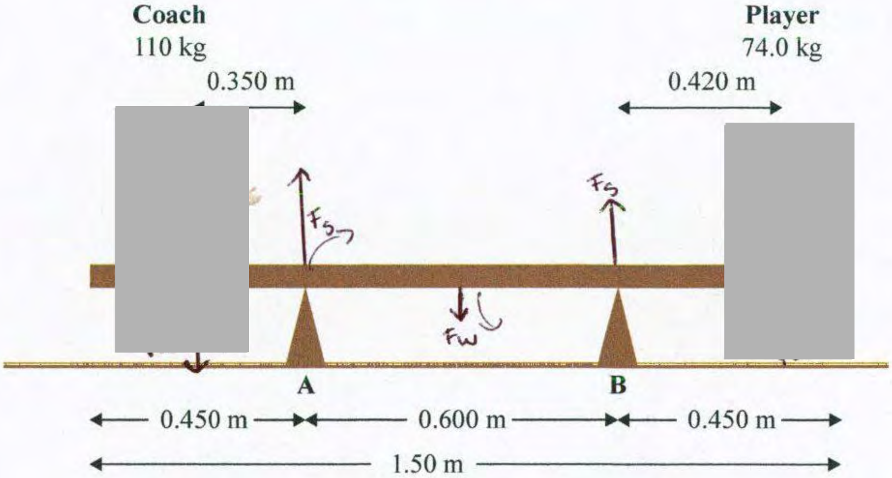
Forces: Assuming air resistance is non-existant, the weight force works with the acceleration of gravity to ~~at~~ contianuously acting downwards which stops it from never coming down.

Acceleration: The acceleration of gravity acting on the ball never changes. It is always acting downwards to the ball bringing ~~a~~ it on a downwards tradjectory after hitting $v_y = 0ms^{-1}$.

Horizontal velocity: The horizontal velocity (v_x) also doesn't change. It is a ~~scalar~~ constant value which helps to determine distance (horizontally) travelled

Vertical velocity: When the ball is first hit the vertical velocity is great. As it travels upwards v_y decreases until at peak ($0ms^{-1}$) where is begin to speed up again (negative value as
* continued on back

(d) The 110 kg coach and a substitute player of mass 74.0 kg sit on a uniform bench. The mass of the bench is 40.0 kg.



Source: https://www.alamy.com/stock-photo/

If you need to redraw your response, use the diagram on page 10.

(i) On the above diagram, add arrows to show all the forces acting on the bench.

(ii) By calculating torques about support B or otherwise, determine the values of the support forces at A and B.

clockwise: $\tau_{CLOCK} = 305 + 0.6F$

$\tau_P = 74kg \times 9.8ms^{-2} \times 0.42m = 305Nm$ (3s.f)

$\tau_A = F \times 0.6m$

anticlockwise: $\tau_{ANTI} = 1141.6$ Nm

$\tau_C = 110kg \times 9.8ms^{-2} \times$ ~~0.235~~ 0.95m = 1024 Nm (4sf)

τ_{Bench} $40kg \times 9.8ms^{-2} \times 0.3 = 117.6Nm$

$\tau_{CLOCK} = \tau_{ANTI}$

$305 + 0.6F = 1141.6Nm$

$0.6F =$ ~~[illegible]~~ 836.6

$F_A =$ ~~[illegible]~~ 1394N = 1390N (3sf)

$F_{support} = F_{WEIGHT}$

$1390N + F_B = 2195.2N$

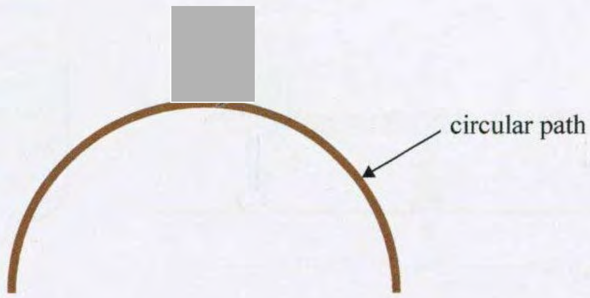
$F_B = 805.2$

$F_B = 805N$ (3sf)

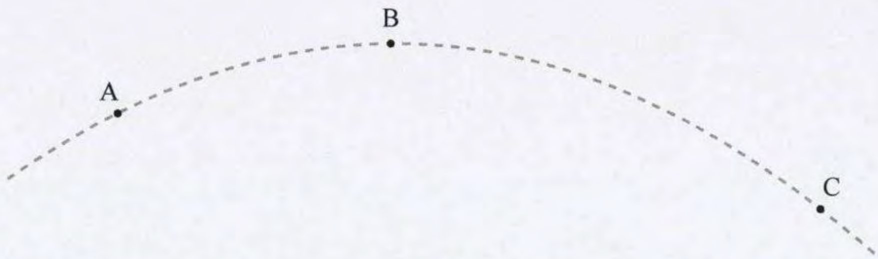
n.d may be some rounding error

SPARE DIAGRAMS

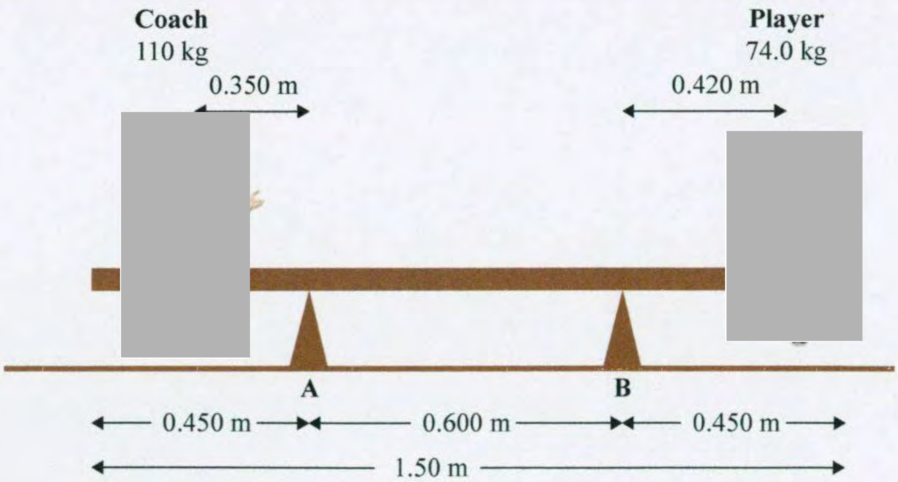
If you need to redraw your response to Question Two (b), use the diagram below. Make sure it is clear which answer you want marked.



If you need to redraw your response to Question Three (c), use the space below. Make sure it is clear which answer you want marked.



If you need to redraw your response to Question Three (d), use the space below. Make sure it is clear which answer you want marked.



Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

1ciii decrease in impact force which is advertageous for the catcher

3cii speed is downwards opposing initial upwards value). It ~~meo~~ reaches fastest speed (with help from gravity acceleration to pull in downwards) right before hitting the grond.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

91171

Standard	91171			Total score	22
Q	**Grade score**	**Marker commentary**			
1	E8	This is a well organised response exemplifying understanding at the Excellence level. It is very logically written with no extraneous material and exhibits clear comprehension.			
2	E7	Ample evidence is demonstrated for Excellence in this response: the diagram is drawn clearly and labelled carefully while the explanation of the loss of friction in 2(d) demonstrates comprehensive understanding of the phenomenon. The response to 2(c)(ii) would be improved had the candidate referred to the properties of vector and scalar quantities.			
3	E7	The numerical parts of this response are presented clearly and concisely, demonstrating comprehensive understanding of the underlying principles. The response to 3(c)(i) does not follow instructions and includes extraneous material, while the argument in 3(c)(ii) lacks total clarity.			