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

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NZQA | 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.

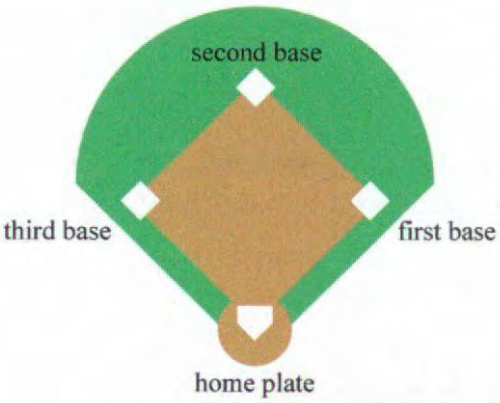
Do not write in any cross-hatched area (DO NOT WRITE IN THIS AREA DO NOT WRITE). This area will be cut off when the booklet is marked.

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

Achievement 11

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/

$v_i = 0$ $t = 6.61$

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}. $v_f = 5.45$

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

$v_f = v_i + at$

$5.45 = 0 + 6.61t$

$5.45 = 6.61t$

$0.825 = t$ $\therefore t = 0.825\ ms^{-2}$

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

$v_f^2 = v_i^2 + 2ad$

$5.45^2 = 0 + 2(0.825)d$

$29.703 = 1.65d$ $\therefore d = 18m$

$d = 18m$

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

Because the actual acceleration may be different from the calculated average acceleration. There may also be external factors such as air resistance and friction.

(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?

Impulse is how much force an object feels at a certain time.

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

~~Impulse = Fat~~ $F = ma$ $a = \frac{v}{t}$ $a = \frac{44.4}{0.51}$

$F = (0.18)(87.1)$ $a = 87.1\ ms^{-2}$

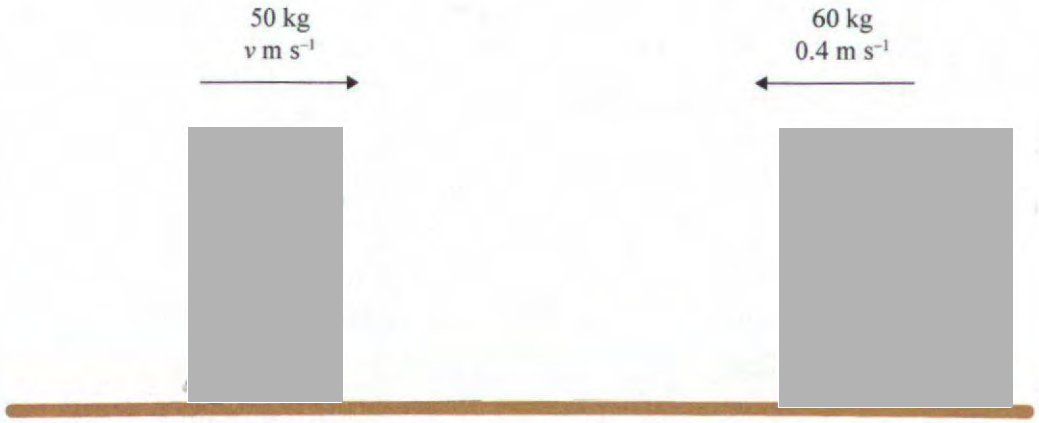
$F = 15.678$

$F = 15.7N$ (1d.p.)

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

Because $\Delta p = FAt$, when the time of the impact is increased and total momentum stays constant, this means that F (the Force) will ~~decrease~~ decrease. By having a relaxed arm and padded gloves, both of these factors would ~~increase~~ increase the total time of impact, resulting in less force felt by the players arm.

(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 m s^{-1}. The two players collide and stick together and move to the right at 2 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?

The player's ~~weight~~ total momentum

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

$p = mv$ $\quad mv = mv$

$(60 \times 0.4) = (50v)$

$24 = 50v$

$0.48 = v$

∴ Initial speed, v of the 50kg player is $0.48 ms^{-1}$.

QUESTION TWO: CORNERING

m=55 v=7

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. r=15

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

$F_c = \frac{mv^2}{r}$

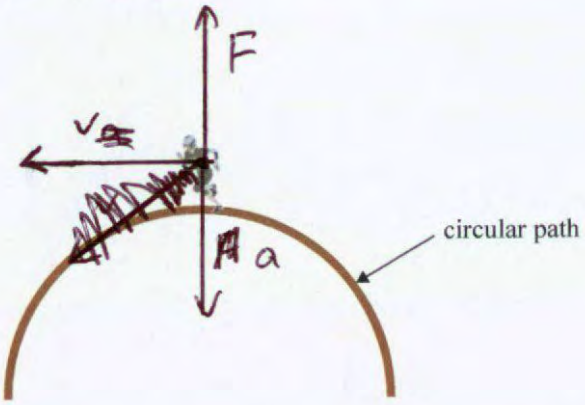
$F_c = \frac{(55)(7^2)}{15}$

$F_c = \frac{2695}{15}$

$F_c = 179.\dot{6}7$

$F_c = 180\text{N}$ (1 s.f.)

(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.

Acceleration (towards the centre of the circle)

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

Because the player moving in a circle is constantly changing direction. So the ~~accelec~~ speed will be constant, but the acceleration will constantly change.

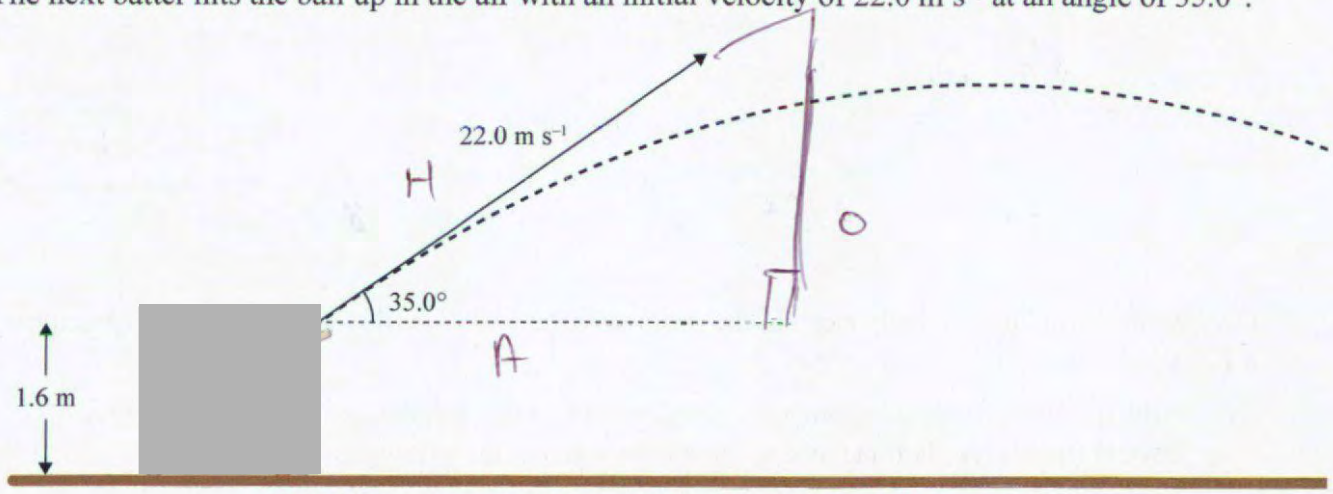
(d) The player runs onto a large slippery, muddy patch while rounding the base.

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

Before the player runs onto the slippery patch, they still have friction with the ground, which allows them to stay on the ~~to~~ path they ~~plla~~ ~~planned~~ planned, but as soon as they hit the slippery patch, all the friction between the player and the ground is gone, which means the player will either fall or go straight on.

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}.

~~CAH~~ ~~22 cos 35°~~ = ~~H~~ SOH $22 \sin 35°$

$= 12.62$ *

$v_i = 12.6 \text{ m s}^{-1}$ (1 d.p.)

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

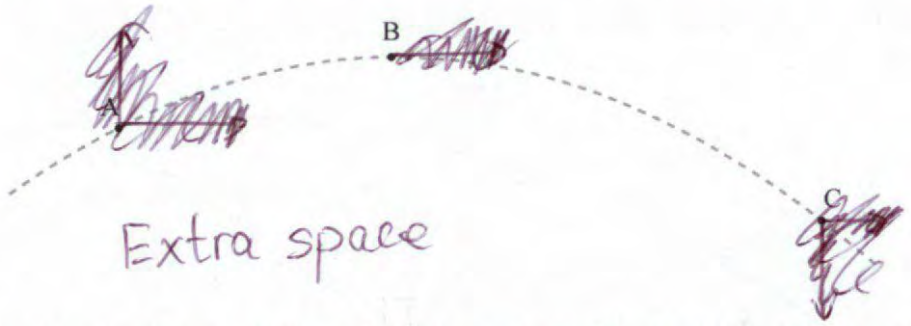
$v_f^2 = v_i^2 + 2ad$

$0 = 158.76 + 19.6d$

$158.76 = 19.6d$ *

$d = 8.1 \text{ m}$

(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.

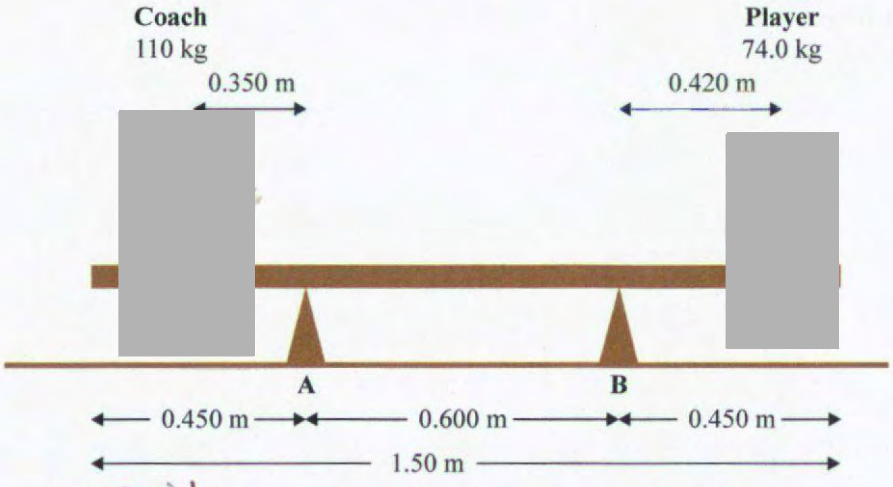
Forces:

Acceleration:

Horizontal velocity: At all points, if air resistance is neglected, then the horizontal velocity is always remaining constant.

Vertical velocity: At point A, the vertical velocity goes upwards. At point B there is no vertical velocity because it is at turning point. At point C, the vertical velocity is downwards.

(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.



0.75 mid

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.

$\tau = Fd$ $\tau = (110+74+40)(0.75)(9.8)$

$\tau = 1646.4 Nm^{-1}$ Total

B

$\tau = (0.42)(74)(9.8)$

$\tau = 304.6 Nm^{-1}$ (1 d.p.)

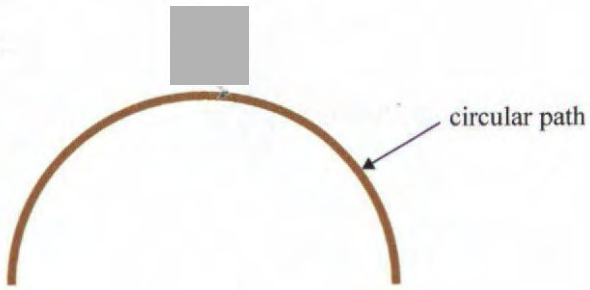
A

$\tau = (110)(0.35)(9.8)$

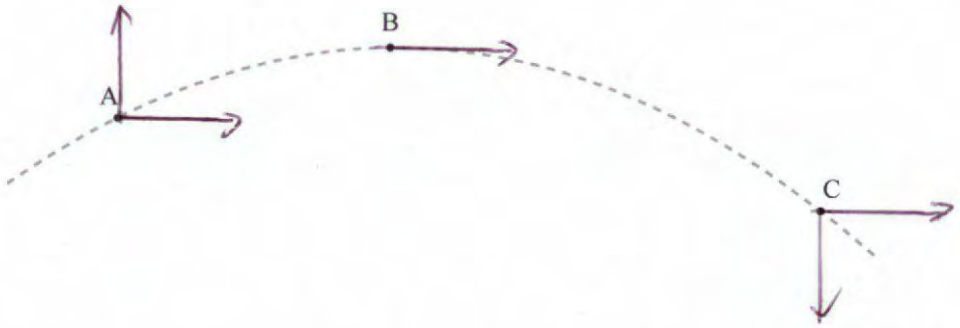
$\tau = 377.3 Nm^{-1}$

SPARE DIAGRAMS

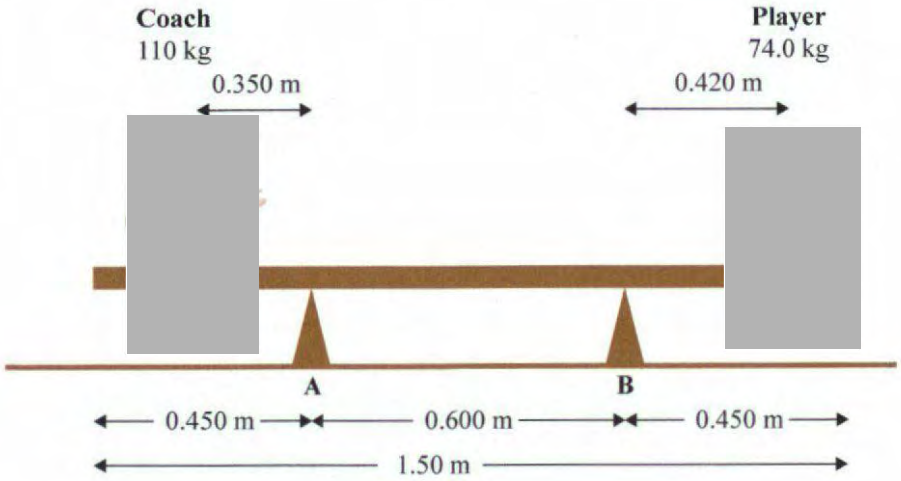
If you need to redraw your response to Question Two (b), use the diagram below. Make sure it is clear which answer you want marked.



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

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

QUESTION NUMBER

Standard	91171			Total score	11
Q	**Grade score**	**Marker commentary**			
1	A4	This response is clearly at the Achieved level of demonstrating an understanding of mechanics. The candidate is able to perform straightforward calculations in 1(a), 1(b)(i) and 1(c)(ii) accurately. The explanation of the concept of impulse for 1(c)(iii) suggests some greater depth of comprehension. However, the stock-standard answer 'external factors such as friction' for 1(b)(ii) exhibits lack of thought, as do the missing terms in the momentum calculation			
2	A4	Partially correct responses to 2(b), 2(c)(ii) and 2(d) demonstrate some understanding, clearly at the Achieved level. Without knowing the direction of centripetal force, or of what may supply that force (friction), in-depth understanding is not in evidence here			
3	A3	The straightforward answers to 3(a) and the first part of 3(b), together with a superficial understanding of projectile velocities for 3(c)(ii) illustrate a clear example of an Achieved level response. Not uncommonly, adding the additional height in 3(b) is omitted. The diagram for 3(c)(i) is entirely wrong, while little attempt is made at 3(d)			