SUPERVISOR'S USE ONLY

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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.

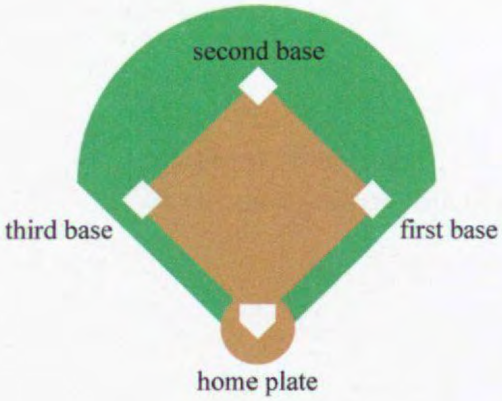
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Merit

16

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}.

$$a = \frac{\Delta V}{\Delta t}$$

$$a = \frac{5,45\,ms^{-1}}{6,61\,s} = 0,825\,ms^{-2}$$

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

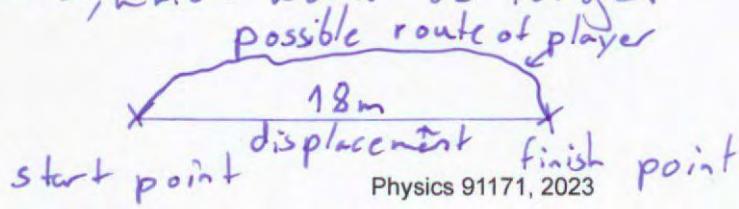
$V_f^2 = V_i^2 + 2ad \quad |-V_i^2 \quad |:2a \quad 18m = d$

$(V_f^2 - V_i^2) : 2a = d$

$((5,45\,ms^{-1})^2 - 0^2) : 2 \cdot 0,825\,ms^{-2} = d$

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

Because the 18m is only the displacement of the player and not the distance. 18m is the distance from his start point until his finish point. This means he could have run a curve, which would be longer.



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(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 a force acting on something

(ii) Calculate the average force of the ball on the padded glove on impact. t, m, v

$p = mv$ $\qquad$ $\Delta p = F\Delta t \quad 1 : \Delta t$

$p = 0{,}180\,kg \cdot 44{,}4\,ms^{-1}$ $\qquad$ $\Delta p : \Delta t = F$

$p = 7{,}99\,Ns^{-1}$ $\qquad$ $7{,}99\,Nm^{-1} : 0{,}510\,s = F$ ✗

$15{,}7\,N = F$

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

With both the padded glove and the relaxed arm the time of the impact of the ball is increased. If the arm is relaxed it can give in. Also the padding gives in. A increased time, reduces the fore, which acts on the arm. $\left(F = \frac{\Delta p}{\Delta t} \right)$. The momentum of the ball stays the same no matter the time it is applied to the arm. If the force ~~is~~ acting on the arm, the rist of injuries is reduced.

(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?

It is asumed that no energy is lost.

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

$E_k = \frac{1}{2} m v^2$

$60kg \rightarrow 0{,}4 m \cdot s^{-1}$
$50kg \rightarrow$

$E_{kb} = \frac{1}{2} \cdot (50kg + 60kg) \cdot (2 m s^{-1})^2$

$E_{kb} = 240 J$

$E_{K both} = E_{k50} + E_{k60}$

$240 J = \frac{1}{2} \cdot 50kg \cdot (v)^2 + \frac{1}{2} \cdot 60kg \cdot (0{,}4 m s^{-1})^2$
$240 J = 25 \cdot v^2 + 4{,}8 J \quad | -4{,}8 J$

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.

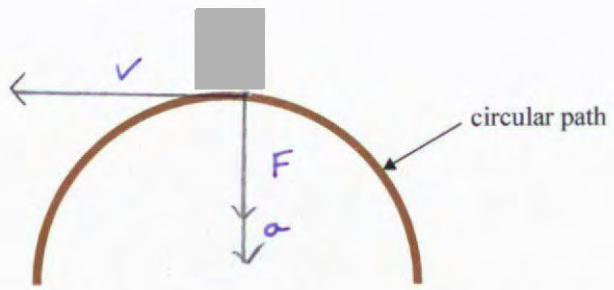
The radius of their circular path is 15.0 m.

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

$F_c = \frac{mv^2}{r}$ $F_c = \frac{55kg \cdot (7ms^{-1})^2}{15m}$

$F_c = 25,7 \text{ N}$

(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

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

Acceleration is velocity over time. Even though his speed is constant his velocity isn't. Velocity is displacement over time. The displacement isn't constant, because he is changing his direction ~~an~~ and the displacement is meswred from his start point until his finish point. So if he runs one round its 0. Because of this the velocity isn't constant, which makes him accelerate.

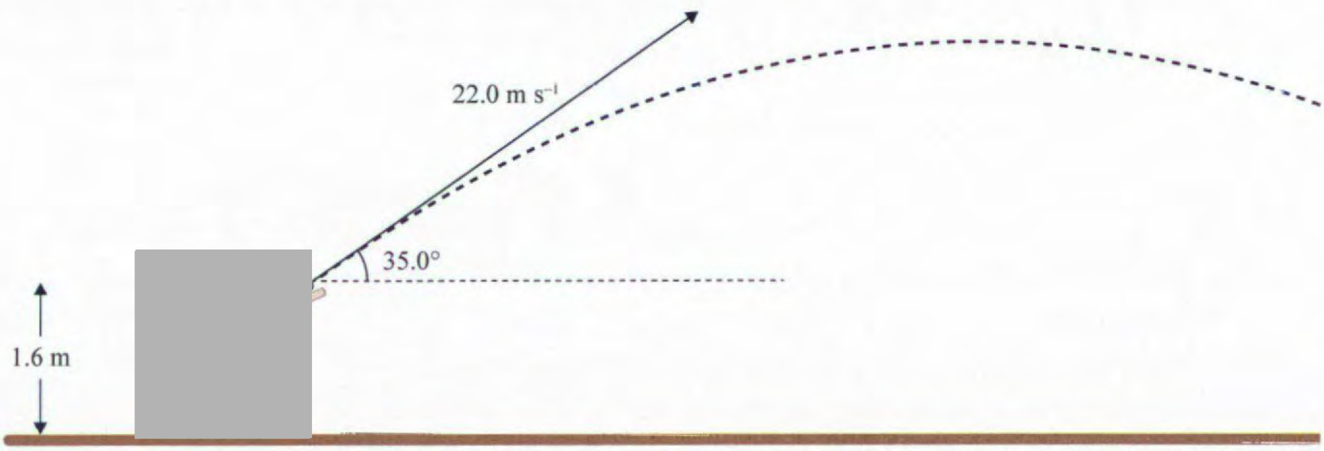
(d) The player runs onto a large slippery, muddy patch while rounding the base.

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

The slippery mud could cause the player to slip and fall. ~~With~~ With the mud on th patch the player can't create as much friction as with a normal, dry patch. This friction between his foot and the ground is necessary, because it creates an ~~inwd~~ inwards force. This inwards force on the player is required, because he is running in a circle. Without this force he can't keep ~~the~~ on the circle and falls in the direction of his velocity, which is on a tangent to the circle. ~~Because~~ He needs the inwards force, because he is running in a circle so constantly changing his direction. Newtons laws state that to change the direction of an moving object (the player) a force is required.

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}.

$\sin(\theta) = \frac{V_v}{V_t}$

$\sin(35^\circ) = \frac{V_v}{22ms^{-1}}$ $/ \cdot 22ms^{-1}$

$12{,}6ms^{-1} = V_v$

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

$a = -9{,}8ms^{-2}$ $\quad V_f{}^2 = v_i{}^2 + 2ad$ $/ - v_i{}^2$

$V_i = 12{,}6ms^{-1}$ $\quad V_f{}^2 - v_i{}^2 = 2ad$ $/ : 2a$

$V_f = 0ms^{-1}$ $\quad \frac{V_f{}^2 - v_i{}^2}{2a} = d$

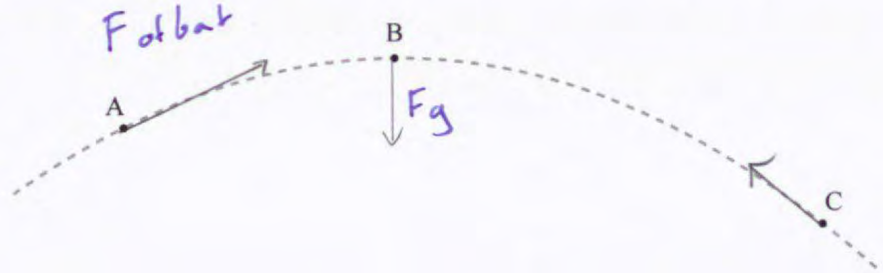
$\frac{(0ms^{-1})^2 - (12{,}6ms^{-1})}{2 \cdot -9{,}8ms^{-2}} = d$

$\frac{(12{,}6ms^{-1})^2}{19{,}4ms^{-2}} = d$

$8{,}2m + 1{,}6m = 7{,}8m$ $\quad 8{,}18m = d$

A: The ball reaches a maximum height of 7,8m

(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.

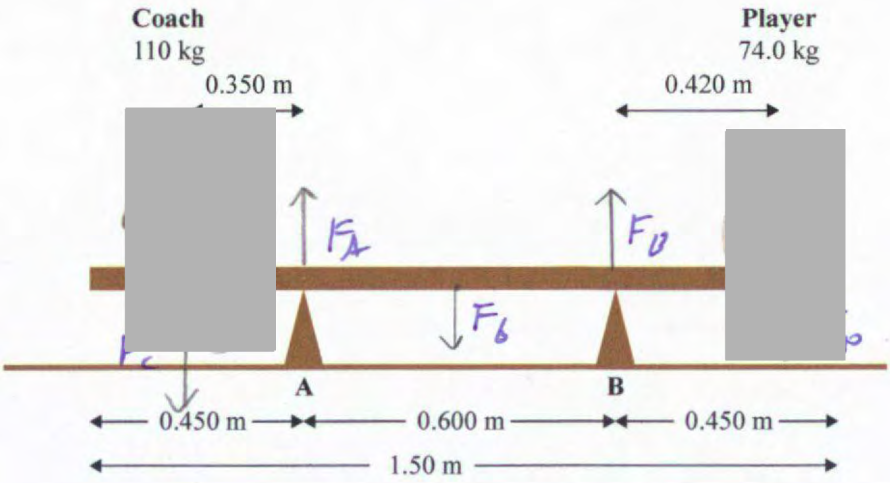
Forces: The inital Force acting on the ball to set it into movement, is applied by the bat. After that gravity is 'pulling' the ball down. The last force applied to the ball is from the graund to stop its motion.

Acceleration: The acceleration of the ball is gravity. First the ball is decelerating due to gravity. After its highest point its accelerating again due to gravity.

Horizontal velocity: The balls horizontal velocity is near constant. The only factor, which is acting on it, is air resistance. If this is neglected the ball is moving at a constant horizontal velocity until it hits the ground.

Vertical velocity: The vertical velocity is decreasing from the point of its release until it reaches zero at the highest point of the parabola. After that the vertical velocity is increasing again through to gravity until it hits the ground

(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.

$\tau_{clockwise} = \tau_p + \tau_A$

$\tau_{clockwise} = 74kg \cdot 9,8ms^{-2} \cdot 0,450m + 0,6m \cdot F_A$

$= 326,34 Nm + 0,6m \cdot F$

$\tau_{anticlockwise} = \tau_c + \tau_b$

$= 110kg \cdot (0,6m + 0,35m) \cdot 9,8ms^{-2} + 40kg \cdot 0,3m \cdot 9,8ms^{-2}$

$= 1024,1 Nm + 117,6 Nm$

$= \underline{1141,7 Nm}$

$\tau_{clockwise} = \tau_{anticlockwise}$

$336,34Nm + 0,6m \cdot F_A = 1141,7Nm \quad | -336,34Nm$

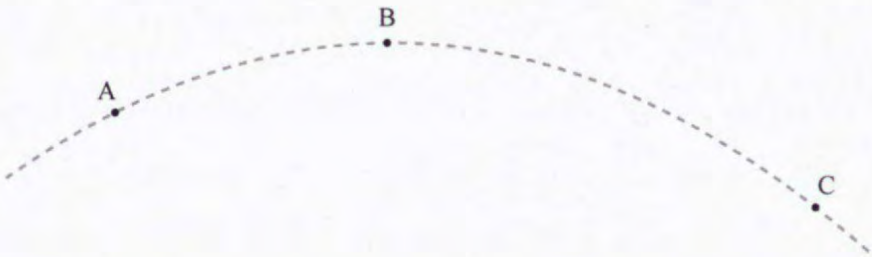
$0,6m \cdot F_A = 805,36Nm \quad | :0,6m$

$\underline{F_A = 1342,27 N}$

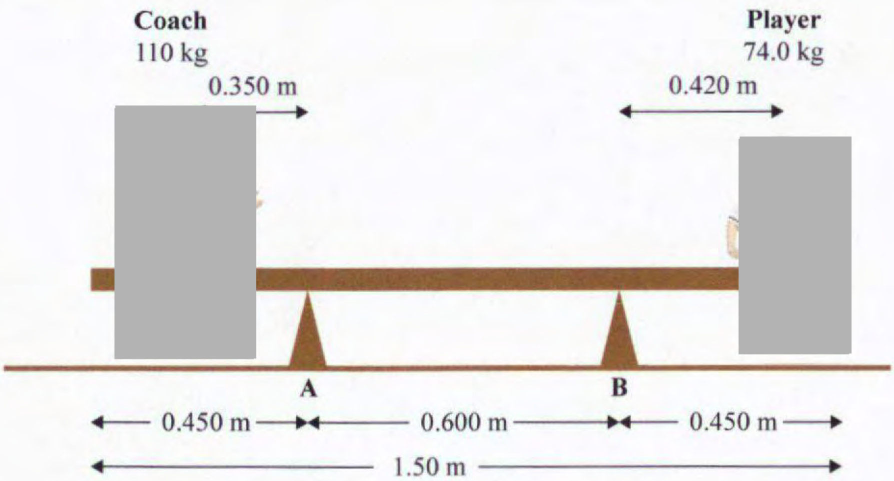
SPARE DIAGRAMS

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

91171

Standard	91171			Total score	16
Q	**Grade score**	**Marker commentary**			
1	M5	Drawing a sketch to illustrate the response to 1(b)(ii) demonstrates in-depth understanding of the difference between distance and displacement. Calculations in 1(a), 1(b)(i) and 1(c) are done efficiently, again showing Merit level understanding. However, knowing neither the meaning of the term impulse nor which physical quantity is conserved in a collision show a lack of comprehensive understanding.			
2	M6	A common calculation error is made in 2(a) - omitting to square a term - but a clearly drawn diagram is presented for 2(b). The explanation written for 2(c)(ii), while containing many correct facts, does not answer the question. The response to 2(d) demonstrates comprehensive understanding as it is well adapted to a somewhat unfamiliar context.			
3	M5	In-depth understanding at the Merit level is illustrated in the numerical parts of this response, with the errors in 3(b) and 3(d) being minor. The explanation in 3(c)(ii) demonstrates comprehensive understanding of forces, acceleration and velocities in projectile motion, unfortunately marred by an incorrect diagram.			