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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 2025

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 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (). 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 TOTAL 13

QUESTION ONE: ACCELERATION

A rugby player accelerates uniformly from rest at 0.680 m s^{-2} and runs 22.0 m.

Source: https://www.odt.co.nz/sport/rugby/black-ferns-sevens-win-cape-town

(a) How long did it take to run the 22.0 m?

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

$v_f = v_i + at$ $\quad v_f^2 = 0^2 + 2 \times 0.68 \times 22$

$5.469 = 0 + 0.68 \times t$ $\quad v_f = 5.469$

$t = 8.04$ seconds

(b) While stopping, a player runs into a tackle bag at speed v. The tackle bag compresses a distance x like a spring as the player comes to a stop.

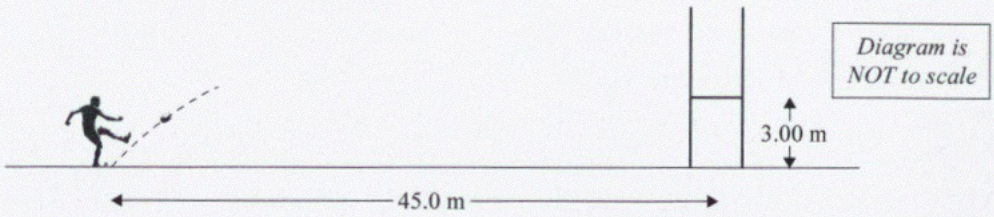
Source: https://www.canterburysports.co.nz/product/silver-fern-tackle-bag-junior/

Assuming all the player's energy is transferred to the bag, state and justify what would happen to the distance the bag was compressed if the player was moving at twice the speed.

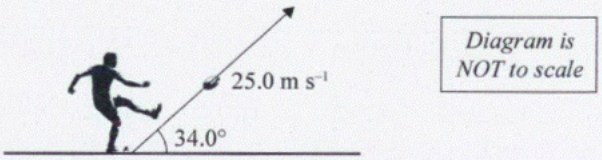
Since $E_K = E_p$, $mv^2 = kx^2$, therefore $x = \sqrt{\frac{2 \times 4^2}{k}}$

As velocity increase the total distance the bag was compressed would increased. If the velocity was doubled then the distance the bag was compressed would be doubled.

(c) To take a penalty shot, the ball is placed on the ground and kicked towards the goal posts. To make the penalty shot, the ball must go over the crossbar, which is 3.00 m above the ground and 45.0 m from where the ball is kicked.



A player taking a penalty shot kicks the ball at 25.0 m s^{-1} at 34.0° to the ground.



By performing appropriate calculations, decide whether the ball makes it over the crossbar before hitting the ground. *

$25 \sin 34 = 13.97$ V_y

$25 \cos 34 = 20.7$ V_x

$V_f^2 = V_i^2 + 2ad$

$25^2 = 0^2 + (2 \times 9.8) \times d$

$d = 31.88$ m max height

$31.88 \div 20.7$

(d) The player from part (c) replaces the ball with one from a different manufacturer. The new ball is heavier.

The player kicks the new ball towards the posts so that it leaves the ground at the same speed and angle as before.

Ignoring any effects from air friction and without using calculations compare the path of the new ball to that of the original ball.

Your answer should consider:

- the time in the air
- the acceleration of the balls in the air
- the initial vertical and horizontal speeds
- the horizontal distances travelled.

The two balls will have the same time in air despite one being heavier than the other - ignoring air resistance. The balls will both have the same initial vertical and horozontal speeds, as both balls are kicked with the same speed and angle. The heavier ball will have less accelleration than the lighter ball during their upwards motion but the heavier ball will have more acceleration during the downwards motion equating to the same time in air. The heavier ball will travel a shorter horizontal distance than the lighter ball as it's acceration is greater on the second half of it's journey.

QUESTION TWO: MOMENTUM

A 80.0 kg player moves at 4.30 m s^{-1}.

(a) Calculate the player's momentum and give the correct unit.

$p = mv \quad 80 \times 4.3 = 344$

Momentum: 344 Unit: $kgms^{-1}$

(b) Explain why using momentum to study collisions is more useful than using kinetic energy.

Kinetic Energy measures how much work in done in motion. Momentum is how the combinded effect of mass and velocity determinds the ~~dma~~ movement and force following a collision. Momentum is more accurate than Kinetic energy ~~than~~ in describing motion following a collision

(c) The mass of the All Black scrum is 883 kg. The mass of the Argentinian scrum is 850 kg.

As the scrum is set, the All Blacks move forward at 0.354 m s^{-1}, and the Argentinians move forward at 0.378 m s^{-1}. The two scrums collide and stick together.

Argentina: 850 kg, 0.378 m s^{-1} All Blacks: 883 kg, 0.354 m s^{-1}

Source: https://www.florugby.com/articles/6006062-round-3-in-the-rugby-championship-looms

Calculate the speed and direction of the combined scrums immediately after they collide and stick together.

$p = (m_1 \times v_1) + (m_2 \times v_2)$

$p = (883 \times 0.354) \quad (850 \times 0.378)$

$312.582 \qquad 321.3$

$321.3 - 312.582$

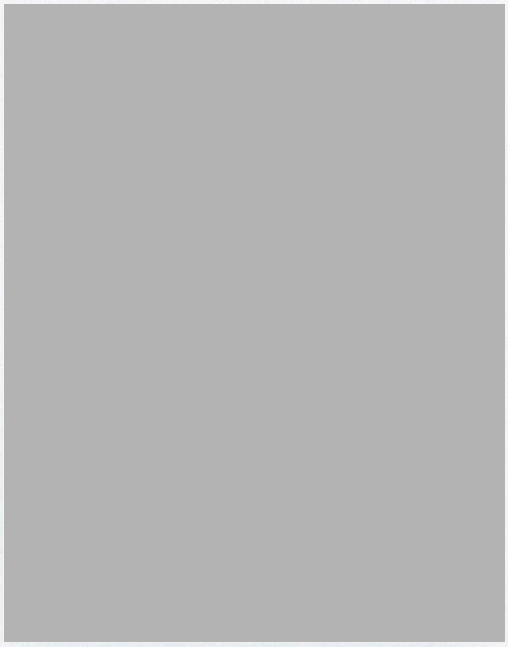
~~$883 - 850 = 33$~~

$850 - 883 = -33$

$-33 \times -0.024 = 0.792$ $-0.378 + 0.354 = -0.024$

0.792 ms^{-1} to the right

(d) The ball comes out of the scrum and a player sprints towards the line. The player is tackled and brought to a stop by colliding with thick pads (cushions) that are on the bottom of the goalpost.



Source: https://www.perennial.co.nz/products/rugby-post-pads

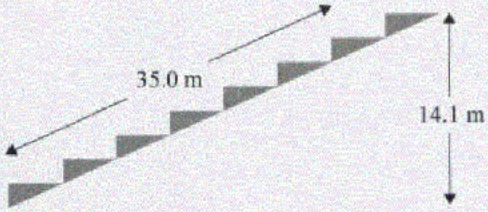
Explain how having these pads on the post help protect a player when they collide with the post.

Having pads on the post protect a player during collisions by increasing the time of collision. Since $\Delta p = F\Delta t$, $F = \frac{\Delta p}{\Delta t}$ as time increases, The amount of force within the collision decreases. Less force in the collision results in less force acted onto a player. This means the player experiences less force, therefore are less likely to be hurt during the collision. ∴ the player is protected.

QUESTION THREE: ENERGY

When warming up, players run up the stairs.

Source: https://www.abc.net.au/news/2016-10-07/top-three-exercises-youre-probably-doing-wrong/7909150



(a) Calculate the work done by a 68.3 kg player who runs up the stairs once.

$W = Fd$

$W = (68.3 \times 9.8) \times 35$

$W = 669.34 \times 35$

$W = 23426.9 = 23400.0\ J$ 3.S.f

(b) Another warm up activity is short sprints.

During one sprint, the 68.3 kg player accelerates from rest to 7.52 m s^{-1} in 4.35 s.

Calculate the average power produced by the player during this sprint.

$P = \frac{W}{t} = \frac{E_K}{t}$

$E_K = \frac{1}{2} \times 68.3 \times 7.52^2$

$= 34.15 \times 56.55$

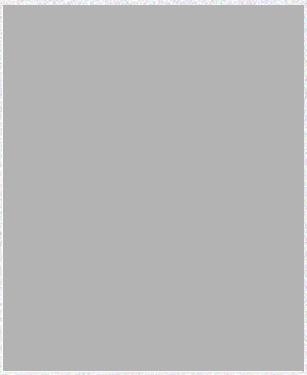
$E_K = 1931.19$

$= 2000\ J$ 3.sf

$P = \frac{1931}{4.35}$

$P = 443.95$

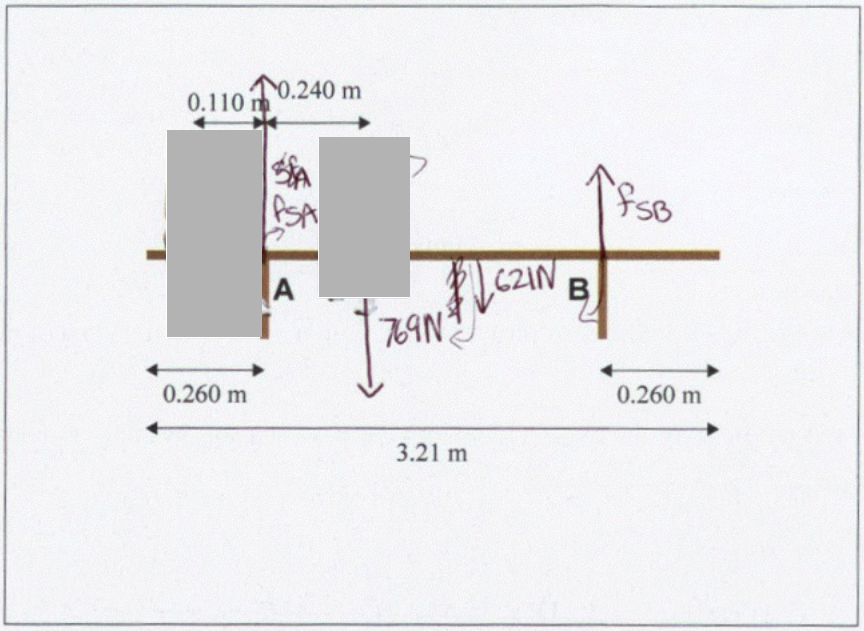
$P = 444.00\ W$ 3.S.f



Source: https://www.bbc.com/sport/rugby-union/61819827

(c) While waiting to play, two players sit on a uniform bench.

The bench is 621 N and 3.21 m long. A 669 N player sits 0.110 m to the left of support A, and a 769 N player sits 0.240 m to the right of support A.



If you need to redraw your response, use the diagram on page 11.

Source: https://www.gettyimages.co.nz/detail/news-photo/england-womens-rugby-players-celia-quansah-and-megan-jones-news-photo/1248571622

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

(ii) By calculating torques about support A, calculate the value of the forces acting on the bench at A and B.

$B = 621 \times 1.345 = 835.245$

$P_L = 669 \times 0.110 = 73.59$

$P_R = 769 \times 0.240 = 184.56$

Forces up = Forces dow

$2059 = S_A + S_B$

$2059 - 214.5 = SA$

$SA = 1844.46$

$SA = 1840\ N$

$SB = 214.5\ N$

Torque clockwise = torque anti

$73.59 + 184.56 + SB = 835.245$

$258.15 + SB = 835.245$

$SB = 577.095$

$577.095 \div 2.69 = 214.5$

Question Three continues on the following page.

(d) Just before the players enter the game, they use one more warm-up activity, where two players hold hands and move around in a circle at constant speed.

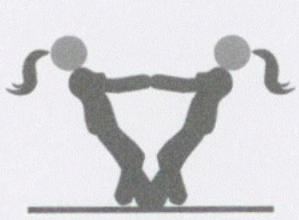


Figure A

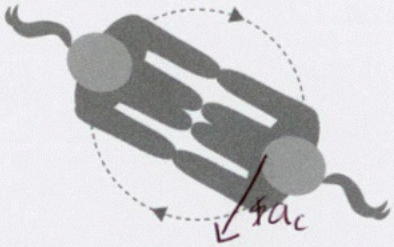


Figure B

If you need to redraw your response, use the diagram on page 11.

(i) Add an arrow to the Figure B above to show the direction of acceleration on one of the players.

(ii) Explain how it is possible for the players to be moving at a constant speed yet accelerating.

Acceleration is resulting on the vector ~~use~~ quanity velocity as $a = \frac{\Delta v}{\Delta t}$. Velocity is a vector quanity as it requires both magnitute and direction $v = \frac{\Delta d}{\Delta t}$, If the direction ~~of velocity chan~~ changes then velocity will change. Since ~~velocity is~~ acceleration is a rate at which velocity changes, and velocity is constantly changing as they travell in a circle (direction is changing) ∴ they are constantly accelerating despite the speed never chenging.

Achievement

Subject: L2 Physics

Standard: 91171

Total score: 13

Q	Grade score	Marker commentary
One	M5	Candidate made a very basic error in reverting to incorrect value of speed in the projectile calculation and had showed limited understanding of acceleration in the descriptive question.
Two	A4	In (c) the candidate crossed out a partially correct answer, but otherwise showed understanding of momentum concepts.
Three	A4	In (a), the candidate made the very common error of failing to use the distance in the direction parallel to the force. The lengthy calculation typical of a torque question proved challenging, while in (d), correct ideas were insufficiently specific to the question.