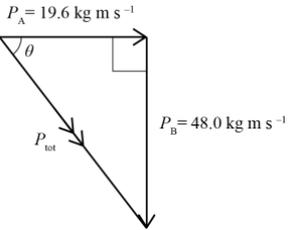# Assessment Schedule – 2025

Physics: Demonstrate understanding of mechanical systems (91524)

Evidence

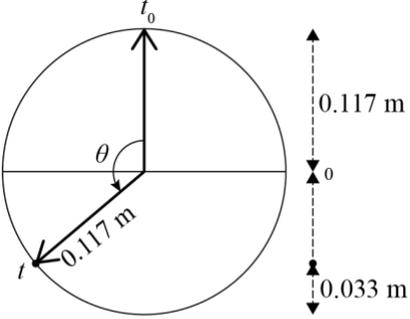| Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$$x_{\text{c.o.m.}} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$ $$x_{\text{c.o.m.}} = \frac{(5.68 \times 10^{26} \times 0) + (1.35 \times 10^{23} \times 1.22 \times 10^9)}{5.68 \times 10^{26} + 1.35 \times 10^{23}} = 289\,895$$ $$= 2.90 \times 10^5 \text{ m}$$	• Calculated with either substitution into an equation or equation with unrounded answer.		
(b)	$p_A = mv = 2.45 \times 8.00 = 19.6 \text{ kg m s}^{-1}$ (to the right) $p_B = mv = 3.20 \times 15.0 = 48.0 \text{ kg m s}^{-1}$ (downward) $\boldsymbol{p_{\text{tot}}^2 = p_A^2 + p_B^2 = 19.6^2 + 48.0^2 = 2688.16 \text{ kg m s}^{-1}}$ $\boldsymbol{P_{\text{tot}} = 51.8474 = 51.8 \text{ kg m s}^{-1}}$ $P_A = 19.6 \text{ kg m s}^{-1}$ θ $P_B = 48.0 \text{ kg m s}^{-1}$ P_{tot} $$\tan \theta = \frac{48.0}{19.6}$$ $$\theta = \tan^{-1}\left(\frac{48.0}{19.6}\right) = 67.7881 = \boldsymbol{67.8°} \quad (1.183 \text{ radians to 4 sig fig})$$ 67.8° anticlockwise from the initial direction of A.	• Calculated ONE of: - Correct momenta for A and B. - Labelled Momentum vector diagram with correct orientation of vectors. - Correct angle only - Total pi=67.6kg m s^{-1} if linear addition.	• Calculated correct answer (size and angle from A).	

| (c) | $F_c = F_g \quad \dfrac{mv^2}{r} = \dfrac{GMm}{r^2} \quad v^2 = \dfrac{GM}{r}$

 $v = \sqrt{\dfrac{6.67 \times 10^{-11} \times 5.68 \times 10^{26}}{1.22 \times 10^9}} = 5572.59 \text{ m s}^{-1}$

 $v = \dfrac{d}{t} = \dfrac{2\pi r}{T} \quad T = \dfrac{2\pi r}{v} = \dfrac{2\pi \times 1.22 \times 10^9}{5572.59} = 1.375569 \times 10^6$

 $T = 1.38 \times 10^6 \text{ s}$ (15.9 days) | • Showed $F_c = F_g$. (some evidence of understanding)
 OR
 Showed $v = \dfrac{2\pi r}{T}$.
 OR
 Fg=3.4383 x10²¹N | Showed $v^2 = \dfrac{GM}{r}$, either algebraically, or as part of numerical working.
 OR
 Correct method to find T with incorrect v.
 OR $T^2 = (4\pi^2 r^3)/GM$ | • Correct answer with units.
 • Or correct T with use of v= ω r |
| (d) | To maintain a circular orbit, an object requires a centripetal force (directed towards the centre of the Earth). The entire required centripetal force for the ISS and astonaut to orbit is provided solely by the Earth's gravitational force. Fg=Fc.

 The ISS and the astronaut are both in (perpetual) free fall, falling toward Earth with the same acceleration. They both experience the same Fc so have the same acceleration. (wtte).

 Weight is the force due to gravity. The feeling of weight/apparent weight is provided by a reaction force acting against Fw.

 As ISS and the astronaut are both in free fall, falling/accelerating at the same rate, there is no reaction force acting back on the astronaut (no floor pushing up) and so they feel weightless.
 At the altitude of the ISS g is approximately 8.7 m s⁻² | • Stated one of:
 - freefall
 - no reaction force
 - F_g provides F_c **(can be written as Fc=Fg but must be contextually correct).** | **2 complete bullet points**

 Or one complete and two partial. | • Full explanation: |

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response, no relevant evidence.	1a	2a 1m	3a or 1a + 1m or 1e	4a or 2a + 1m or 1a + 1e	2m 2a + 1e	3m Or 2m 2a or 1m + 1e	1a+ 1m + 1e or 2m + 1e or 2e 1a	1m + 2e or 2a + 2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$\theta = \left(\dfrac{\omega_f + \omega_i}{2}\right)t \quad 4.00 \times 2\pi = \dfrac{\omega_f}{2} \times 12.0$ $\omega_f = 4.1887 = 4.19 \text{ rad s}^{-1}$ Could use: $\theta = \omega_i t + \frac{1}{2}\alpha t^2 \quad \text{with} \quad \omega_f = \omega_i + \propto t$ α=0.35rads^{-2}	• Calculated with either substitution into an equation or equation with unrounded answer.		
(b)	$\omega_f = \omega_i + \alpha t$ $0 = 4.1887 + \alpha(19.2)$ $\alpha = \dfrac{-4.19}{19.2}$ $= -0.218166$ $= -0.218 \text{ rad s}^{-2}$ $\tau = I\alpha$ $\tau = 430(-0.218166)$ $= -93.81145$ $= -93.8 \text{ N m}$ *Negative indicates torque is slowing the roundabout.*	• Calculated ONE of: - Correct angular acceleration. - Correct torque using wrong angular acceleration. ($\tau = I\alpha$)	• Calculated correct torque.	

(c)	$L_{\text{Jane}} = mvr$
	$= 52.0 \times 6.39 \times 1.20$
	$= 398.736$
	
	$I_{\text{Jane}} = mr^2$
	$= 52.0 \times 1.20^2$
	$= 74.880$
	
	$I_T = 430 + 74.88$
	$= 504.88$
	
	$L_i = L_f$
	$L = I\omega$
	$389.736 = 504.88\omega$
	$\omega = \dfrac{398.736}{504.88}$
	$= 0.78968 = 0.790 \text{ rad s}^{-1}$
		Alternate method:
		
		$L_i = L_f$
		$mvr + I_R\omega_i = (I_R + mr^2)\omega_f$
		$(52 \times 6.39 \times 1.20) + (43 \times 0) = (430 + (52 \times 1.2)^2)\omega_f$
		$398.736 = 504.88\omega_f$
		$\omega_f = \dfrac{398.736}{504.88}$
		$= 0.78968$
		$= 0.790 \text{ rad s}^{-1}$
			• Calculated ONE of:
			  - L_i of Jane
			  - I of Jane.
			  - If used Jane's L and I.
			    ω = 5.325 rads⁻¹)
			  - If used I= 430, ω = 0.927 rads⁻¹
			
			OR
			  - *Momentum conserved/*
			    $L_i = L_f$
				• Minor error (correct method).
				• Must have reference to the inertia of roundabout and Jane in Lf.
					• Correct working and answer.

(d)	• As Rīhari moves inwards, his mass is **closer to the axis of rotation**, ($I \propto mr^2$) the total rotational inertia decreases. (Not moves to centre of mass). • States that angular momentum is **conserved** (not constant) **either** because it is a closed system **or** no external net torque. • Since **L=I ω** a decrease in rotational inertia results in a (proportional) increase in angular velocity. • $E_{\text{k(rot)}} = \frac{1}{2}I\omega^2$, even though I decreases proportionally, because ω is squared, the rotational kinetic energy increases overall. OR $E_{\text{k(rot)}} = \frac{1}{2}\frac{L^2}{I}$, I is reduced, so $E_{\text{k (rot)}}$ will increase.		• Recognised I decreases. OR Recognised that angular momentum is conserved so angular velocity increases. OR Recognised that due to the movement of mass inwards, angular velocity/rotational kinetic energy increases.	• Two concepts explained correctly with links.	• All four concepts explained and linked.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response, no relevant evidence.	1a	2a 1m	3a or 1a + 1m or 1e	4a or 2a + 1m or 1a + 1e	2m 2a + 1e	3m Or 2m 2a or 1m + 1e	1a+ 1m + 1e or 2m + 1e or 2e 1a	1m + 2e or 2a + 2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$\sin\theta = \dfrac{A}{l}$ $A = 1.20\sin 5.60$ $= 0.117099$ $= 0.117$ m	• correct answer using sin.		
(b)	$T = 2\pi\sqrt{\dfrac{l}{g}} = 2\pi\sqrt{\dfrac{1.20}{9.81}} = 2.197536$ s $\omega = 2\pi f = \dfrac{2\pi}{T} = \dfrac{2\pi}{2.197536} = 2.859195 = 2.86$ rad s^{-1}	• calculated correct period. Or • with wrong T worked out ω	• calculated ω with correct working and answer (show question required evidence of understanding).	
(c)	 $y = -0.117 + 0.033 = -0.084$ m $= A\cos(\omega t)$ $-0.084 = 0.117\cos(2.86t)$ $\cos(2.86t) = \left(\dfrac{-0.084}{0.117}\right)$ $2.86t = \cos^{-1}\left(\dfrac{-0.084}{0.117}\right)$ $t = 0.82924$ $t = 0.829$ s	• calculated ONE of: - Correct displacement y. (-0.084) - Reference circle with phasors in correct start and finish positions. - Used trig for angle past equilibrium $\theta = 0.801$ rad. Or 45.9º - Total θ= 2.3716 rad. Or 135.885º - If two errors max grade is a. e.g. If y= 0.033, t=0.449s **-If use L for y and 0.33 for A, then grade is n.**	Calculation with one error e.g. • Calculation used correct method with incorrect amplitude or displacement **(y = 1.2m not accepted).** • If y= -0.033, t=0.649s. • Used sin not cos to get t = 0.28s • θ correctly calculated as 2.3734 rad and incorrect calculation of t. • Correct y, no negative gave $t = 0.269$s (calculation error) • Calculator in degrees t = 47.5s	• Calculated correct answer. Or alternative complete solutions: $\theta = 135.9$ $(135.9/360) = t/T$ So $(135.9/360) = t/2.1975$ $t = 0.829$, assuming correct phasor diagram has been used. Or If used $y = A\sin(wt)$ and determined the time by $t = \sin^{-1}(0.084/0.117) = 0.280$ and then added T/4.

| (d) | Rīhari's horizontal hand movement provides a driving force. Resonance occurs when Rīhari adjusts his hand movement so that the **frequency of the driving force** matches the pendulum's natural frequency. (in phase towards equilibrium). When $f = f_0$, this increases the **Ek** of the system, leading to an increase **Egp** and so A increase. When $f = f_0$, the rate of energy input from Rīhari's hand is greater than the rate of energy dissipation by damping (Loss due to friction), the total energy stored in the oscillating system (as KE and GPE) builds up over time. **Could also have the opposite:** When the frequency of the driving force is out of time (too fast or too slow) then the applied force is against the restoring force at certain times, removing energy from the system along with energy removed by friction. Less energy can build up in the system and so the amplitude is less. | • States ONE of:
- resonance
- hand is applying driving force.
- hand is adding energy to the system
- friction removes energy from the system
- force "in time" adds energy into the system/ increase A (or vice versa)
- $f = f_0$ (driving frequency/resonant frequency=natural frequency is ok here.) | Forces: **Frequency of the driving force** matches the natural frequency linked to increased amplitude.

Or

Energy When $f = f_0$, this increases the **Ek** (lin) of the system, leading to an increase **Egp** and so A increase. | Complete answer. |

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response, no relevant evidence.	1a	2a 1m	3a or 1a + 1m or 1e	4a or 2a + 1m or 1a + 1e	2m 2a + 1e	3m Or 2m 2a or 1m + 1e	1a+ 1m + 1e or 2m + 1e or 2e 1a	1m + 2e or 2a + 2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 – 18	19– 24