Assessment Schedule – 2024

Physics: Demonstrate understanding of mechanical systems (91524)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$v = r\omega$ $0.850 = 0.007\omega$ $\omega = 121.429$ $\omega = 121 \text{ rad s}^{-1}$	• Correct answer.		
(b)	$F_w - F_R$ provides F_c. At max speed $F_R = 0$ $mg = \frac{mv^2}{r}$ $9.81(0.0350) = v^2$ $v = 0.58596$ $v = 0.586 \text{ m s}^{-1}$	• $F_R = 0$ F_w provides F_c.	• Correct answer.	
(c)	F_{net} provides F_c In both positions, F_w is downwards and remains constant. At position X: • F_c is directed upwards towards the centre of the circle. • F_R is directed upwards and must be larger than F_w to provide F_c. • As F_w is directed away from the centre of the circle, $F_c = F_R - F_w$. At position Y: • F_c is directed downwards towards the centre of the circle. • F_R is directed upwards and must be smaller than F_w for F_w to provide F_c • As F_w is directed to the centre of the circle, $F_c = F_w - F_R$.	• ONE of: - F_{net} provides F_c - F_c at X is greater than F_c at Y - F_w down, F_R up at X and Y - F_w constant is stated - $F_c = F_R - F_w$ (at X) - $F_c = F_w - F_R$ (at Y) - Correct free-body force diagram for one position. - $F_{R(X)}$ is greater that $F_{R(Y)}$	• One position explained (incl. link to and direction of $F_{net)}$ OR Relative sizes and directions of F_R and F_g described at **both** positions. *An accurate free-body force diagram may be used as part of the evidence.*	• Full answer. *An accurate free-body force diagram may be used as part of the evidence.*

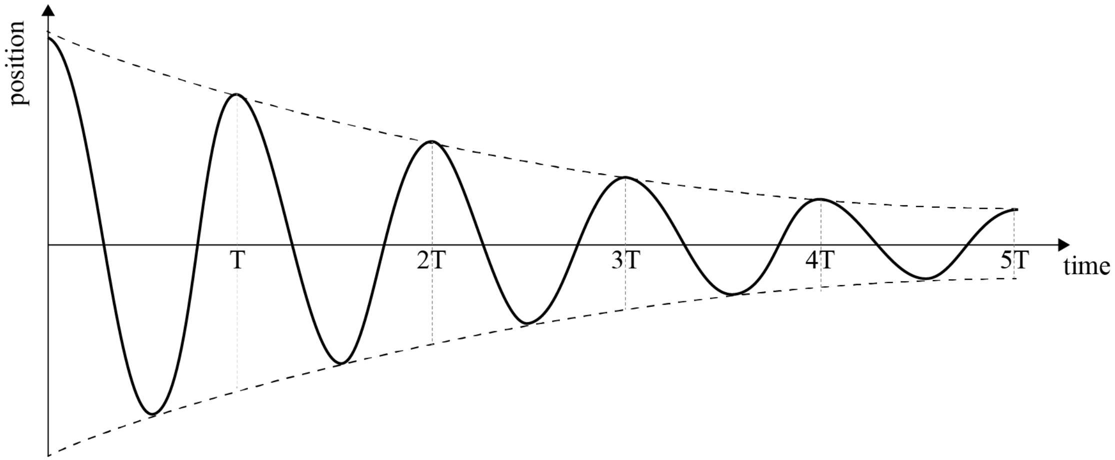
(d)	Method (a) $E_{GP} = E_{k(lin)} + E_{k(rot)}$ $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ $mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2$ $gh = \frac{1}{2}v^2 + \frac{1}{5}v^2$ $gh = \frac{7}{10}v^2$ $h = \frac{7v^2}{10g}$ $h = \frac{7(0.58596)^2}{10(9.81)}$ $h = 0.0245\text{ m}$ Method (b) $I = 219.52 \times 10^{-9}$ $v = r\omega$ $0.58596 = 0.007\omega$ $\omega = 83.70867$ $E_{k(rot)} = \frac{1}{2}I\omega^2$ $E_{k(rot)} = \frac{1}{2}(219.52 \times 10^{-9})\,83.709^2$ $E_{k(rot)} = 769.1 \times 10^{-6}$ $E_{k(lin)} = \frac{1}{2}mv^2$ $E_{k(lin)} = \frac{1}{2}0.0112(0.58596)^2$ $E_{k(lin)} = 0.00192276$ $mgh = E_T$ $0.0112(9.81)h = 0.00269186$ $h = 0.0245\text{ m}$	• Attempts to solve using conservation of energy. • $E_{GP} = E_{k(lin)} + E_{k(rot)}$ • ONE correct energy calculation: $E_{k(lin)} = 1.92276 \times 10^{-3}\text{ J}$ $E_{k(rot)} = 7.69104 \times 10^{-4}\text{ J}$ • $\omega = 83.70867\text{ rad s}^{-1}$	• One error in correct process. E.g. Method (a). attempts simplification $mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2$ Method (b). TWO correct energy calculations of $E_{GP}, E_{k(lin)}, E_{k(rot)}$ *(must have attempted all three)* OR $h = 7.00 \times 10^{-3}\text{ m}$	• Correct answer.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a	2a 1m	3a 1a + 1m 1e	4a 2a + 1m 1a + 1e	2m 3a + 1m 2a + 1e	3m 1m + 1e 1a + 2m	1a + 1m + 1e 2m + 1e 2e	1m + 2e 2a + 2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$a = r\alpha$ $1.83 = 0.11\alpha$ $\alpha = 16.6363$ $\alpha = 16.6 \text{ rad s}^{-2}$	• Correct answer and substitution.		
(b)	$d = r\theta$ $0.75 = 0.11\theta$ $\theta = 6.8181818$ $\omega_f^2 = \omega_i^2 + 2\alpha\theta$ $\omega_f^2 = 0^2 + 2(16.6363)(6.81818)$ $\omega_f = \sqrt{226.86}$ $\omega_f = 15.1 \text{ rad s}^{-1}$	• Correct angular displacement. OR $v_f = 1.6568 \text{ m s}^{-1}$ OR Correct ω_f for incorrect θ.	• Correct answer, OR Alternatively calculates $v_f^2 = 0^2 + 2(1.83)(0.75)$ $v_f = 1.6568$ $v = r\omega$ $1.6568 = 0.11\omega$ $\omega = 15.0618$	
(c)	$\tau = Fd$ $\tau = (mg - ma)d$ $\tau = (0.046)(9.81 - 1.83)(0.11)$ $\tau = 0.0403788$ $\tau = I\alpha$ $0.0403788 = I(16.6363)$ $I = 0.00243 \text{ kg m}^2$	• Tension force identified (may be in diagram). • Uses $\tau = Fd$ OR Uses $\tau = I\alpha$	• One error. E.g. uses mg rather than tension to calculate $I = 2.9838 \times 10^{-3}$ N m	• Correct answer.

(d)	As $I \propto mr^2$, if the disc is the same diameter and mass as the flywheel, then only the distribution of mass is changing. As the distribution of mass is on average closer to the axis of rotation, then the rotational inertia will decrease. As $\tau = I\alpha$, then angular acceleration will increase. As $a = r\alpha$, then the (linear) aceleration of the cup / ball will increase. Therefore if a increases, then the final (linear) velocity will increase. (Note τ is not constant, as tension will decrease as a increases.) OR: Justifies decrease in I. Decrease in I causes increase in a using: $\tau = I\alpha$ $r(mg - ma) = I\frac{a}{r}$ $mg = a\left(m + \frac{I}{r^2}\right)$ Therefore if a increases, the the final (linear) velocity will decrease.	• I decreases • v_f increases	Links distribution of mass closer to **axis of rotation** to I decreasing using I $\propto mr^2$ OR Links lower I to greater angular acceleration using $\tau = I\alpha$.	• Correct answer. *Accept valid energy justification.* *Ignore mention of constant torque.*

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a	2a 1m	3a 1a + 1m 1e	4a 2a + 1m 1a + 1e	2m 3a + 1m 2a + 1e	3m 1m + 1e 1a + 2m	1a + 1m + 1e 2m + 1e 2e	1m + 2e 2a + 2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$a \propto -y$, $F_{\text{rest}} \propto -y$ The restoring force / acceleration is proportional to the displacement from the equilibrium position AND the restoring force / acceleration acts toward the equilibrium position / is in the opposite direction to displacement.	• Both points. OR Equation.		
(b)	$\omega = 2\pi f$ $\omega = \frac{2\pi}{0.882}$ $\omega = 7.1238$ $y = A\cos\omega t$ $y = 0.04\cos(7.1238(1.2))$ $y = -0.025602$ $y = -0.0256$ m	• Correct value for angular frequency.	• Minor mistake.	• Correct answer.
(c)		• One of: - Exponential decay. - y starts at max A. - T constant.	• Correct answer.	

(d)	As the ball bearing oscillates, E_{gp} transforms to E_k and vice versa / at any point, $E_{total} = E_{gp} + E_k$. Over time, (kinetic) energy is lost from the system as heat due to friction, therefore, total energy is decreases. A decrease in total energy / kinetic energy means that maximum gravitational potential energy decreases (causing the maximum height to decrease) and so the amplitude will decrease. This is known as damping.	• One of: - Loss of energy due to friction. - Amplitude decreases. - Damping.	• Damping AND (kinetic) energy is lost from the system **as heat due to friction** OR Links less E_{total} / E_k to less E_{gp} so smaller amplitude.	Full answer.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a	2a 1m	3a 1a + 1m 1e	4a 2a + 1m 1a + 1e	2m 3a + 1m 2a + 1e	3m 1m + 1e 1a + 2m	1a + 1m + 1e 2m + 1e 2e	1m + 2e 2a + 2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 06	07 – 13	14 – 18	19 – 24