Assessment Schedule – 2019

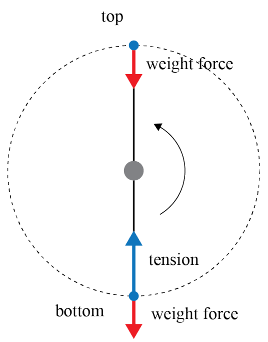
Physics: Demonstrate understanding of mechanical systems (91524)

Evidence Statement

NØ	N1	N2	A3	A4	M5	M6	E7	E8
0	1A	2A or 1M	3A or 1A +1M or 1E-	4 A or 2A + M or 2M or 1A+1E-	1A + 2M or 1M+1E- or 3A +1M or 2A + 1E-	2A + 2M or 3M or 3A + 1E- or 1A +1M + 1E-	2M+1E- or 2A +1M + 1E- or A + 2M + 1E-	A + 2M +E

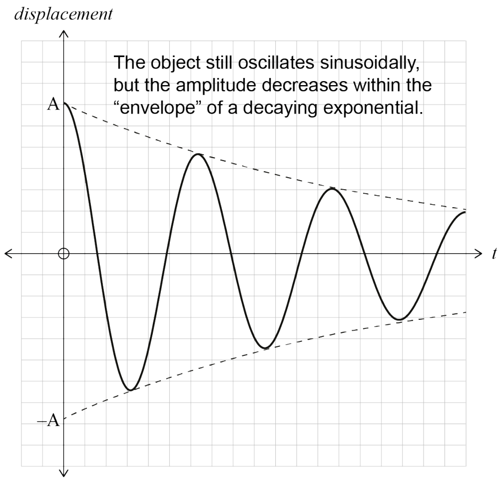
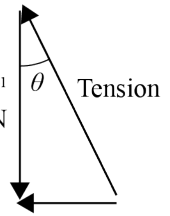
Other combinations are also possible using a=1, m=2 and e=3. However, for M5 and M6, at least one Merit question needs to be correct (maximum 6). For E7 or E8, at least one Excellence needs to be correct (maximum 8). **Note: E- and E only applies to the E7 and E8 decision.**

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Linear momentum, velocity of CoM, total energy. *(Accept Momentum, even if it is not described as linear momentum)*	• Any ONE.		
(b)	Total p before = 60 × 1.8 = 108 kg m s^{-1} = total p after (conservation of momentum law) $p_{\text{Ally}} = \sqrt{108^2 - 66^2} = 85.486$ kg m s^{-1} $v_{\text{Ally}} = \frac{p}{m} = \frac{85.486}{50} = 1.70972 = 1.71 \text{ m s}^{-1}$	• Calculates Chris's momentum before. OR • Calculates total momentum before. OR • Calculates Ally's velocity with incorrect momentum.	• Correct working. (Note, NOT answer as this is a SHOW question).	

(c)	radius of circle = 0.700 m mass = 60.0 kg $g = 9.81\ \text{m s}^{-2}$ F_c at top at minimum speed = mg = 588.6 N $v = \sqrt{\frac{F_c r}{m}} = \sqrt{\frac{588.6 \times 0.7}{60.0}} = 2.62\ \text{m s}^{-1}$ OR $F_c = F_g$ $\frac{mv^2}{r} = mg$ $v^2 = rg$ $v = 2.62\ \text{m s}^{-1}$	• F_c at top minimum speed = $F_{gravity}$. OR Attempts to calculate speed correctly but with incorrect F_c.	• Correct working and answer.	
(d)	• The weight force is constant and downward at all points in the motion. • At the bottom, tension is upward and much larger than the weight force, as the tension must overcome the weight force to provide an upward centripetal force. • At the top, the tension will be zero. At the top, the F_c is provided entirely by the weight force, since Chris is travelling with the minimum possible speed.  	• Weight force drawn or described as constant and downward at both top and bottom points. OR Tension force drawn bigger than the downwards weight force at the bottom. OR Equation stated for $F_c = F_T - F_w$ (bottom) OR Equation stated for $F_c = F_w$ (top)	• Tension force drawn or described as larger than weight force at bottom and non-existent at the top. OR Stating that $F_c = F_T - F_w$ (bottom) AND $F_c = F_w$ (top).	• Forces correctly identified and described, with justifications in relation to the centripetal force and minimum speed with diagram included. (E) • Forces correctly identified and described, with justifications in relation to the centripetal force and minimum speed without diagram. (E–)

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	Total $I = I_{MGR} + I_{children} = 271 + (3 \times 28.0 \times 2.10^2) = 641.44$ kg m^2	• Correct WORKING (Note, NOT answer as this is a SHOW question)		
(b)(i) (ii)	At max velocity $E_{k(rot)} = ½ I\omega^2 = 388$ J $388 = ½\ 641\ \omega^2$ $\omega_{max} = 1.10$ rad s^{-1} $v = \omega r = 1.10 \times 2.10 = 2.31$ m s^{-1}	• Correct working for $\omega_{max} = 1.1$ rads^{-1} (Note, NOT answer as this is a SHOW question). OR Correct working for v= 2.31 m s^{-1}. (NB: NOT answer as this is a SHOW question.)	• All correct.	
(c)	$\alpha = \frac{\Delta\omega}{t} = \frac{0-1.10 \text{ rad s}^{-1}}{2.80 \text{ s}} = 0.393 \text{ rad s}^{-2}$ $\tau = I\alpha = 641.44 \text{ kg m}^2 \times 0.393 \text{ rad s}^{-2} = 252 \text{ N m}$	• $\alpha = 0.393$ rad s^{-2} OR Calculates torque correctly with incorrect α value.	• All correct.	
(d)	• As the children move inward the mass distribution decreases, thus rotational inertia decreases. kg m^2 s^{-1} • States that angular momentum is conserved because it is a closed system or because the external torques sum to zero. • Assuming angular momentum is conserved a decrease in rotational inertia results in a proportional increase in angular velocity. • $E_{K\text{-rotational}} = ½ I\omega^2$, even though I decreases proportionally, because ω is squared, the rotational kinetic energy increases overall. OR $E_{K\text{-rotational}} = \frac{1}{2} \times \frac{L^2}{I}$, I is reduced, so $E_{K\text{-rotational}}$ will increase.	• Recognises I decreases. OR Recognises that angular momentum is conserved so angular velocity increases. OR Recognises that angular velocity increases because mass is getting closer to the centre. *Accept inertia in place of rotational inertia.*	• Two concepts explained correctly with links. *Accept inertia in place of rotational inertia*	• All four concepts explained and linked. (E) • Three or more concepts explained and linked (including bullet point 4) but without the justification of the conservation of angular momentum. (E–) *Accept inertia in place of rotational inertia.*

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$v_{max} = Aw = 0.310\text{ m} \times \frac{2\pi}{2.40} = 0.811578\text{ m s}^{-1} = 0.812\text{ m s}^{-1}$	• Correct answer.		
(b)	Time to get from equilibrium to 0.200 m: $y = A\sin wt$ $0.200\text{ m} = 0.310\text{ m} \times \sin(2.618t)$ $t = 0.2679\text{ s}$ Time displacement is LESS than 0.200 m $= 4t = 4 \times 0.2679\text{ s} = 1.071\text{ s}$ Time displacement is GREATER than 0.200 m $= 2.40\text{ s} - 1.071\text{ s} = 1.33\text{s}$ OR y = 0.200m and A=0.310m drawn on ref circle $\theta = \cos^{-1}\left(\frac{0200}{0.310}\right) = 49.22°$ $t = \left(\frac{49.822°}{90°}\right) \times 2.4\text{ s} = 0.33\text{ s}$ OR $y = \cos\left(\frac{0200}{0.310}\right)$ $\theta = \cos^{-1}\left(\frac{0200}{0.310}\right) = 0.86956\text{ rad}$ $\theta = \omega t$ $t = \frac{\theta}{\omega} = \frac{0.86596}{2.618} = 0.33\text{ s}$ Time displacement greater than 0.200 m $= 0.33\text{ s} \times 4 = 1.33\text{ s}$	• Correct setup of reference circle for amplitude and displacement. OR Correct angular frequency $\omega = 2.618 rads^{-1}$used in the calculation.	• Correct answer and working.	

(c)	Starting at max. disp = +/– 0.310 m with values on graph for 3 periods (2.4/4.8/7.2), three periods only, disp showing exponential decay. 	• Correct starting max and shape showing decay. OR • Correct time values and shape showing decay *NOTE: Must have:* *(1) Three full cycles* *(2) Exponential decay*	Correct damped shape for 3 complete cycles, constant period, correct starting max and at least one value on each of the axes (A = 0.310 m, and T = 2.4 s)	
(d)	$F_c = \frac{mv^2}{r} = \frac{70.0\text{ kg} \times \left(2.61\text{ m s}^{-1}\right)^2}{0.411\text{ m}} = 1160\text{ N}$ Weight = 70.0 kg × 9.81 N kg^{-1} = 686.7 N $F_{net} = F_{centripetal} = 1160$ N $F_{tension}{}^2 = 686.7^2 + 1160^2$ $F_{tension} = 1348$ N = 1350 N $\theta = \tan^{-1}\frac{1160\text{ N}}{686.7\text{ N}} = 59.34°$ from vertical *(Accept 1.04 radians as angle also)*	• Calculates $F_{centripetal}$.(1160N) OR • Recognises $F_{net} = F_{centripetal}$.	• Correct labelled vector diagram. OR • Calculates the Tension force only correctly. OR • Tension force wrong but θ correct.	• Tension magnitude and angle from vertical. (E) • Tension magnitude and angle calculated with calculator in radians mode (giving the angle as being 1.04 but given degrees as unit. (E–)

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 18	19 – 24