Assessment Schedule – 2022

Physics: Demonstrate understanding of mechanical systems (91524)

Evidence

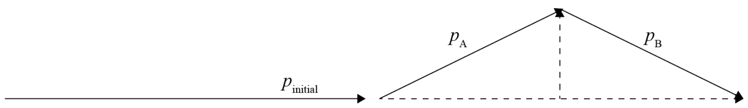
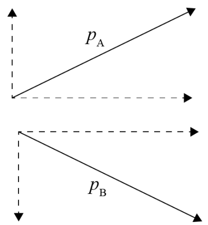
Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$\omega_{\text{i}} = \frac{2\pi}{T} = \frac{2\pi}{1.23} = 5.11 \text{ rad s}^{-1}$	• Complete show (correct equation and substitution required).		
(b)	$\omega_{\text{f}} = \frac{2\pi}{T} = \frac{2\pi}{2.04} = 3.08 \text{ rad s}^{-1}$ $\alpha = \frac{\Delta\omega}{\Delta T} = \frac{3.08 - 5.11}{30.0} = -0.0677 \text{ rad s}^{-2}$ $\tau = I\alpha = 57.6 \times -0.677 = -3.898 \text{ N m}$ Final answer rounded to 3.89 N m or 3.90 N m.	• Correct angular acceleration or correct equations used with mistake.	• Complete correct answer, negative sign or appropriate rounding not required.	
(c)	The friends can move towards the middle of the turn table / reduce their distance from the axis of rotation and therefore: • They decrease the (total) rotational inertia (*I*) of the roundabout since the mass is distributed closer to the rotational axis • Since there is no external torques, angular momentum (*L*) is <u>conserved</u>. • $L = I\omega$. Since *I* decreases, ω increases. (also accept equivalent argument using $K_{\text{k(rot)}} = \frac{1}{2}I\omega^2$ and work done)	• Friends move to the middle (not CoM) therefore *I* decreases.	• Achieved plus: Justification with reference to mass distribution from rotational axis (not CoM) for decreased I OR Justifies I decreases so ω increases with reference to $L = I\omega$ / conservation of angular momentum.	• Complete answer including conservation of angular momentum.

(d)	A with reason: fast as possible needs maximum increase in τ (or L). Since $\tau = Fr$: • Assuming the applied force is the same, the perpendicular distance to the rotational axis is larger at A so r increases and therefore τ increases. • The component of the force perpendicular to r is greatest at A, therefore τ is greatest. • Greatest τ is when F is perpendicular to r, i.e position A. Since $L = mvr$, maximum angular momentum is given to the system when the component of velocity perpendicular to r is greatest. Slipping off does not affect the speed because she does not exert a torque on the roundabout (because any friction force is along the radius of the roundabout so is directed through the axis). Or when she slips, she does not remove angular momentum from the roundabout, she only removes her own angular momentum from being on the roundabout. Thus the roundabout does not change its angular velocity. i.e. $L_{system} = L_M + L_R$	• (i) Identifies A, with reason in terms of either greatest torque or greatest angular momentum, or force is applied perpendicular to r, or velocity is perpendicular to r, or all of $E_{k(lin)}$ is transformed into $E_{k(rot)}$. Allow "A, because the friction force from her shoes will produce a bigger torque because it is further from the axis". This is not a good answer because the friction is not the same for A and B. OR (ii) Recognises that ω remains constant.	• Complete explanation for either jumping on (equation plus one bullet point) or slipping off.	• Complete explanations for both jumping on and slipping off.

In order to get E7 or E8, the Excellence answer needs to be correct.

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

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$x_{com} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$ $x_{com} = \frac{100 \times 4000 + 300 \times 0}{100 + 300} = 1000\text{ m}$ OR Masses have a 1:3 ratio, so the centre of mass must be 3:1 (so that *mx* is the same for both), thus the centre of mass must be 1000 m from the larger mass.	• Correct answer.		
(b)	$F = \frac{GMm}{r^2} = \frac{6.67 \times 10^{-11} \times 100 \times 300}{10^2} = 2.00 \times 10^{-8}\text{ N}$ $\text{acceleration of the 100 kg rock} = \frac{2.00 \times 10^{-8}}{100}$ $= 2.00 \times 10^{-10}\text{ m s}^{-2}$ Justified comment about validity of assumption. E,g, The assumption that velocity is constant is valid because the rate of acceleration is very small. OR Invalid because there is an acceleration, so it is not constant.	• Correct force. OR Correct process using $F_g = \frac{GMm}{r^2}$ for calculating a with minor error, e.g. incorrect *r* or not squaring *r*.	• Correct answer. AND • Justified Comment aboutvalidity of assumption.	
(c)	Total momentum is conserved so: Since the initial total momentum is horizontal, the vertical components of momentum of both rocks must be equal and opposite / add to zero and since the angle to the horizontal is the same, the size of the momentum is the same. OR Justifies isosceles triangle when using vector addition triangle; refer to diagrams in d) – must include reference to two equal angles and a non-right-angle OR Algebraic proof / calculation e.g. $\frac{p_{A(hor)}}{\cos 20} = \frac{p_{B(hor)}}{\cos 20}$, so $p_A = p_B$ (accept equivalent using vertical components) OR Since the mass of both rocks are the same and the angle to the horizontal is the same, they must have the same velocity therefore same momentum.	• States any of the following reasoning: The total momentum must be the same before and after the collision (evidence can be taken from d). OR Vector addition diagram with labels (not mass) and both 20° angles. OR Initially there is zero momentum in the y direction so the sum of the momenta of the two rocks in the y direction must be zero. OR Mass and angles are the same.	• Conservation of momentum (evidence may be taken from d)) plus one correct point.	

(d)	Total initial momentum $p_i = mv = 100 \times 500 = 50\,000 \text{ kg m s}^{-1}$ Final momentum must be the same (assuming no external forces). Momentum of one fragment in the x direction: $p = mv\cos 20° = 200 \times v\cos 20°$ The total of the two fragments' momentum in the x direction must equal p_i. $2 \times 200 \times v\cos 20° = 50000 \text{ kg m s}^{-1}$ $v = \dfrac{50000}{\cos 20° \times 2 \times 200} = 133 \text{ m s}^{-1}$ Note: evidence required for (d) may be taken from (c).   	• Correct calculation of initial momentum and recognition that momentum is conserved. OR $v = 125 \text{ m s}^{-1}$	• Correct method but makes one error. OR Correct process to calculate v but uses radians (answer: $v = 306 \text{ m s}^{-1}$) OR $v = 266 \text{ m s}^{-1}$	• Complete correct answer. (Can be solved using the sine rule.)

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

In order to get E7 or E8, the Excellence answer needs to be correct.

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$T=2\pi\sqrt{\frac{l}{g}}=2\pi\sqrt{\frac{1.83}{3.72}}=4.4069\text{ s}$	• Complete show (correct substitution required).		
(b)	$\omega=\frac{2\pi}{T}=\frac{2\pi}{4.407}=1.43\text{ s}^{-1}$ $\theta=\omega t=1.43\times 2=2.86\text{ rad}$ $x=0.300\cos 2.86=-0.288\text{ m}$ distance from release point $=0.300+0.288=0.588\text{ m}$ If calculator is set to degrees, $x=0.299$ m	• Correct ω. OR Uses $A\cos(\omega t)$ with incorrect ω. OR $x=0.299$	• Correct x. (Note that there are many possible methods.) OR Correct process but uses $A\sin(\omega t)$. OR $x=0.299$ plus correct reference point.	• Correct total distance. OR Correct x with reference point.
(c)	Since acceleration is proportional to displacement, a smaller amplitude causes a decreased acceleration therefore, a smaller distance is covered as a slower speed, so T remains constant. OR $T=2\pi\sqrt{\frac{l}{g}}$; l and g are constant therefore T is constant and independent of A.	• Travels less distance. OR Speed decreased. OR Acceleration decreased. • Correct equation with statement that: T is independent of A or l is constant. OR T is dependent on l and g which are constant (no equation).	• Complete answer.	
(d)	$\text{Energy}=\frac{1}{2}mv^2$ Max $v=A\omega=0.3\times 1.43=0.429$ $\text{Energy}=\frac{1}{2}\times 2.30\times 0.429^2=0.212\text{ J}$ Later Max $v=A\omega=0.2\times 1.43=0.286$ $\text{Energy}=\frac{1}{2}\times 2.30\times 0.286^2=0.0941\text{ J}$ Energy lost $=0.212-0.094=0.118\text{ J}$	• Correct calculation of v using $v_{max}=A\omega$. • Correct process for ΔE_k using SHM equations with error. (OR correct calculation of h; $h_1=1.82$ m, $h_2=1.81$ m)	• Complete answer. (or complete answer using $\Delta E_p=mg\Delta h$ with $g=3.72\text{ N kg}^{-1}$	

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

In order to get E7 or E8, the Excellence answer needs to be correct.

Cut Scores

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