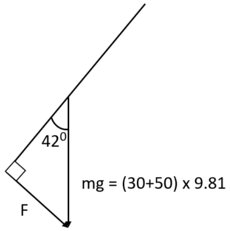
Assessment Schedule – 2021

Physics: Demonstrate understanding of mechanical systems (91524)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$x_{\text{com}} = \dfrac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$ Measuring distances from the centre of mass of the angler: $x_{\text{com}} = \dfrac{0 + (50 \times 14)}{30 + 50} = 8.75\text{ cm}$ Thus the COM is 8.75 –5.00 = 3.75 cm, vertically below the pivot. If calculated with 50 g mass as point of reference then from base x_{com}= 5.25, then ans = 9 – 5.25 cm.	• Correct answer.		

(b)(i)	$\tau = Fr = (30 + 50) \times 10^{-3} \times 9.81 \times 3.75 \times 10^{-2} \times \sin 42°$ $\tau = 0.0197$ Nm Force for torque is calculated at right angles to radius and calculations based on centre of mass position.  OR $\tau = Fr = (0.08 \times 9.81 \times \sin 42°) \times 0.0375$ $= 0.0197$ Nm Could use cos48° instead of sin42° Note: Could have also found the component of *r* instead $r = 0.0375 \times \sin 42° = 0.0251$ $\tau = 0.0251 \times 0.08 \times 9.81 = 0.0197$ OR Ignoring the COM and doing the torques separately: $(0.09 \times 0.05 \times 9.81 \times \sin 42°) - (0.05 \times 0.03 \times 9.81 \times \sin 42°) = 0.0197$ Nm	• sin42° used to find moment arm of the "weight force", or the component of the "weight force". OR Uses $\tau = Fr = (30 + 50) \times 10^{-3} \times 9.81 \times 3.75 \times 10^{-2}$ (must see working including values).	• Shows correct calculation of torque.	
(ii)	$I_{tot} = I_{angler} + I_{fish}$ $I_{tot} = 30 \times 10^{-3} \times (5.00 \times 10^{-2})^2 + 50 \times 10^{-3} \times (14.0 \times 10^{-2} - 5.00 \times 10^{-2})^2$ $= 7.50 \times 10^{-5} + 4.05 \times 10^{-4} = 4.8 \times 10^{-4}$ kg m^2 $\tau = I\alpha$ $\alpha = \frac{\tau}{I} = \frac{0.0197}{4.8 \times 10^{-4}} = 41.04$ rad s^{-2}	• Correctly calculates $I_{tot} = I_{angler} + I_{fish}$ OR • inds acceleration using $\tau = I\alpha$, but incorrect *Itot.* Accept, incorrect conversion for mass or missing off SQR or using 14cm for *r* of fish.	• Calculates $I_{tot} = I_{angler} + I_{fish}$ AND uses $\tau = I\alpha$.	•

(c)	• As the toy oscillates, it transfers energy between **gravitational** potential energy and kinetic energy. • The oscillating system gradually loses energy, due to frictional forces / as heat OR comes to rest at the equilibrium position, where there is no net torque OR the rest position is where it has minimum gravitational potential energy (and no kinetic) OR in this position the toy has minimum energy because the COM is as low as possible. • When the fish is vertically below the pivot, there is no net torque, so $\alpha = 0$ Bullet point 3 can be conversely written as: In all other positions there is a net torque, so the toy will accelerate.	• ONE point.	• TWO points.	• THREE points.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Some physics evidence	1a	2a	3a	1m	2m	1e	1e 1m

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	Circular motion requires a centripetal force, so orbital motion requires a net gravitational force. If the forces were balanced, the satellite would move in a straight line, so move out of orbit.	• Either the argument for a net force or description of the effect of no net force.		
(b)	Answers can be in terms of force or gravitational field strength. At the L1 point: $v=\frac{2\pi r}{T}=\frac{2\pi\times 14.81\times 10^{10}}{31.536\times 10^{6}}=2.95\times 10^{4}\text{ m s}^{-1}$ $g=\frac{v^2}{r}=\frac{\left(2.95\times 10^{4}\right)^2}{14.81\times 10^{10}}=5.88\times 10^{-3}\text{ m s}^{-2}$ OR The gravitational field at L1 is that due to the Sun minus that of the Earth: $g=\frac{GM_S}{R_S{}^2}-\frac{GM_E}{R_E{}^2}=6.67\times 10^{-11}\times\left[\frac{1.99\times 10^{30}}{\left(14.81\times 10^{10}\right)^2}-\frac{5.97\times 10^{24}}{\left(0.15\times 10^{10}\right)^2}\right]$ $=5.88\times 10^{-3}\text{ m s}^{-1}$	• Correct calculation of velocity. OR Stated $g=\frac{GM}{r^2}$ g for both Sun and Earth.	• Correct formulae/substitution to determine g but minor error in calculation. • Correct subtraction (may include error in calculation	• Complete answer.
(c)	Moving the panels further away increases *r* and therefore increases *I*. OR mass is further distributed form the centre of rotation, so *I* increases. *L* is constant / conserved *So* $L = I\omega$, so if *I* increases, ω must decrease. Do not accept v=ωr *justification.*	• Increased *I* decreases angular velocity. OR Justification of rotational inertia increases.	• Complete answer.	

(d)	Increase in angular momentum of the satellite: $\Delta L = I\Delta\omega = 179 \times 0.0124 = 2.2196$ This angular momentum has come from the fragment, so its initial angular momentum about the axis must have been 2.2196. $L = mvr$ $v = \frac{L}{mr} = \frac{2.2196}{0.78 \times 1.42} = 2.00 \text{ m s}^{-1}$	• Calculation of ΔL. OR Recognition that the fragment carried angular momentum.	• Complete answer.	

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Some physics evidence	1a	2a	3a	1m	2m	1e	1e 1m

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$T = 2\pi\sqrt{\frac{m}{k}}$ $k = \frac{4\pi^2 m}{T^2} = \frac{4\pi^2 \times 893}{1.14^2} = 27127 = 2.71\times10^4\ \text{N m}^{-1}$	• Correct method SHOW question.(rearrangement must be shown, evidence of solving must be clear).		
(b)	For SHM: • there must be acceleration proportional to displacement • and in the opposite direction to the displacement. OR $F \propto -y$, where y is displacement.	• ONE condition stated for SHM.	• BOTH conditions stated for SHM.	
(c)	Jon makes the car go down distance given by $F = -ky$: $y = \frac{F}{k} = \frac{mg}{k} = \frac{103\times9.81}{2.71\times10^4} = 0.0373\ \text{m}$ $\omega = \frac{2\pi}{T} = \frac{2\pi}{1.14} = 5.51157$ $\alpha = -\omega^2 y = 5.1157^2 \times 0.0373 = 1.13\ \text{m s}^{-2}$	• Correct y or ω. OR Tried to correct for 4 springs (k is based on all 4 springs). OR Correct acceleration with total mass of car and Jon, 10.94 rads^{-2}.	• Correct answer.	
(d)	Large oscillations build up when the car is shaken at its natural frequency – resonance. The car is travelling so that it hits the speed bumps at this frequency. $T = \frac{d}{v} = \frac{10.5}{8.33} = 1.26\ \text{s}$ The mass of the car plus the passengers must be given in $T = 2\pi\sqrt{\frac{m}{k}}$ $m = \frac{T^2 k}{4\pi^2} = \frac{1.26^2 \times 2.71\times10^4}{4\pi^2} = 1089\ \text{kg}$ Rick's mass is the total minus the car and Jon: $m = 1089 - 893 - 103 = 93$ kg * Accept 95.8 kg if using unrounded values (where total mass = 1091.7 kg).	• Explains resonance. OR Calculates T.	• Explains resonance. AND Calculates T. OR Correct numeric answer without explaining resonance. OR Explains resonance and minor error on calculation.	• Complete answer.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Some physics evidence	1a	2a	3a	1m	2m	1e	1e 1m

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24