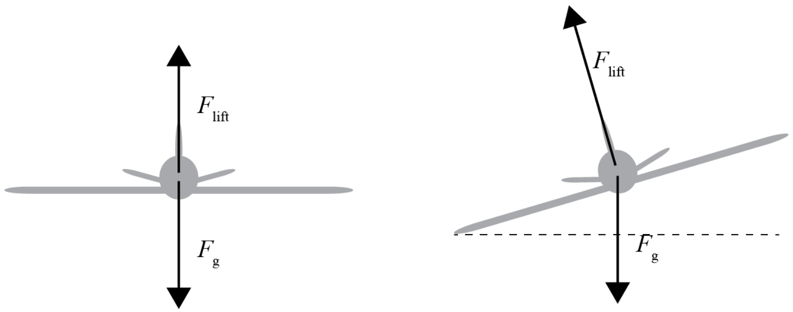
Assessment Schedule – 2020

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 1A +3M or 3A + 1E- or 1A +1M + 1E-	2M+1E- or 2A +1M + 1E- or A + 2M + 1E-	A + 2M +E

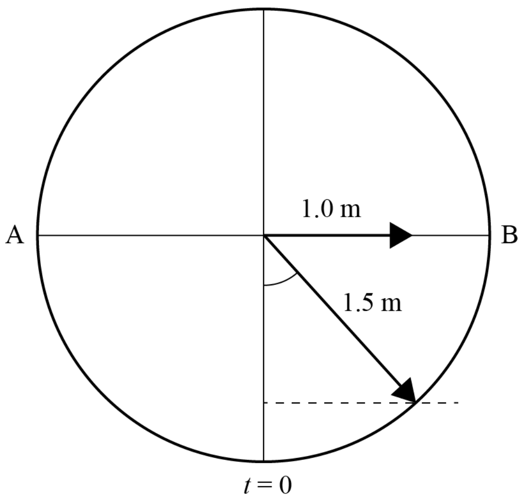
Other combinations are also possible using a=1, m=2 and e=3. However, for M5 and M6, at least one Merit question needs to be correct (maximum 6). For E7 or E8, at least one Excellence needs to be correct (maximum 8). **Note: E- and E only applies to the E7 and E8 decision.**

Q	Evidence	Achievement	Merit	Excellence
ONE (a)		• BOTH correct.		
(b)	In the horizontal position, gravity force = reaction (support) force, and forces are balanced. When flying in a circle, the gravity force remains the same, but the lift force increases. This is because the horizontal component of the lift force provides the centripetal force for circular motion. Vertical component of lift = gravity force Horizontal component = F_c So overall lift force increases when added as vectors.	• One situation explained with correct reasons.	• BOTH situations explained with correct reasons.	

(c)	$F_g = 7.50\times10^4 \times 9.81 = 735\,750$ N $F_{lift} = \frac{735\,750}{\cos 35°} = 898\,185$ N $F_c = 898\,185 \sin 35° = 515\,178$ N $F_c = \frac{mv^2}{r} \rightarrow r = \frac{7.50\times10^4 \times 54.0^2}{515\,178} = 425$ m OR $F_c = \frac{mv^2}{r} = F_{lift}\sin\theta$ $F_g = mg = F_{lift}\cos\theta$ $\frac{F_c}{F_g} = \frac{v^2}{rg} = \tan\theta$ $r = \frac{v^2}{g\tan\theta} = \frac{54.0^2}{6.869} = 425$ m OR $a_c = g\tan\theta = 9.81\times\tan 35° = 6.869$ m s^{-2} $a_c = \frac{v^2}{r} \rightarrow r = \frac{v^2}{a_c} = \frac{54.0^2}{6.869} = 9.79$ N kg^{-1}	• Weight force correct. OR States vertical component of lift = weight force. OR States horizontal component of lift force = centripetal force. OR Correct vector diagram including labels and angle.	• Correct derivation for the radius but numerical answer wrong or absent (this covers follow on error) OR Calculates centripetal force correctly. OR Calculates centripetal acceleration correctly.	• All correct including a reasonable explanation. (E) (A reasonable explanation could occur by showing all steps in the working from first principles, such as an appropriate vector diagram – such as lift, weight and centripetal forces OR acceleration due to gravity and centripetal acceleration) • All correct including a reasonable explanation with calculator in radians. (E-)
(d)	$F_g = mg = \frac{GMm}{r^2}$ $g = \frac{GM}{r^2} = \frac{6.674\times10^{-11}\times5.98\times10^{24}}{(6370\,000+12\,800)^2} = 9.79$ N kg^{-1}	• Missed the square on r OR Did not include the full height from the centre of the Earth to the plane (giving g = 9.83 or 9.84 N kg^{-1}). OR • Calculates gravitational force as 734 to 735 kN.	• Correct calculation.	

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	This is a show question: $I = \frac{2}{5}mr^2 \rightarrow I = \frac{2}{5} \times 60 \times 0.20^2 = 0.96 \text{ kg m}^2$ $L = I\omega \rightarrow L = 0.96 \times 9.56 = 9.1776 \text{ kg m}^2 \text{ s}^{-1}$	Calculates I correctly as $0.96 kgm^2$ OR Calculates L correctly with incorrect I (Error Carried Forward or ECF)	• Correct working (Note, NOT answer as this is a SHOW question).	
(b)	• Straightening her body increases rotational inertia, as rotational inertia depends on mass distribution. • Straightening her body will mean her mass is further away from the axis of rotation. • Since there are no external torques, angular momentum is conserved. Since $L = I\omega$, angular velocity decreases. • Since angular velocity decreases, rotational kinetic energy decreases overall as the change in angular velocity is squared and this outweighs the increase in I since $E_{K-rotational} = \frac{1}{2}I\omega^2$ OR $E_{\text{K-rotational}} = \frac{1}{2} \times \frac{L^2}{I}$, I is increased, so $E_{\text{K-rotational}}$ will decrease. (This is sufficient for Merit only because it does not address the instruction to talk about angular velocity). However, if the candidate USES L=Iω to DERIVE the formula, then award full marks)	• Recognises I increases. OR Recognises that angular momentum is conserved so angular velocity decreases. OR Recognises that angular velocity decreases because mass is getting farther from 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.*
(c)	$L = I\omega_f \rightarrow \omega_f = \frac{L}{4.80} = \frac{9.1776}{4.80} = 1.912 \text{ rad s}^{-1}$ $\alpha = \frac{\omega_f - \omega_i}{t} = \frac{1.912 - 9.56}{0.280} = -27.3 \text{ rad s}^{-2}$	• Correct final angular velocity of 1.912 rad s^{-1}. OR • Attempts to calculate angular acceleration but with incorrect final angular velocity (ECF).	• Correct answer and working.	
(d)	$\theta = 2 \times 2\pi = 12.57 \text{ rad}$ $\omega = \frac{\Delta\theta}{\Delta t} = \frac{12.57}{1.25} = 10.1 \text{ rad s}^{-1}$	• Correct answer.		

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$T = 2\pi\sqrt{\frac{3.0}{9.81}} = 3.4746\text{ s}$	• Correct working. (Note: NOT answer as this is a SHOW question.)		
(b)	When Serena stands up, the centre of mass shifts upwards, reducing the effective length of the swing. Since T is proportional to square root length ($T \alpha \sqrt{L}$), decreasing the length will decrease period. So it will take less time to complete one swing.	• Idea about length reducing due to shift in COM. OR Correct relationship described or stated. ($T \propto \sqrt{L}$)	• Complete answer with link and reasoning.	
(c)	• The straight line through the origin shows that the restoring force is directly proportional to displacement. • The negative gradient shows that the restoring force is in opposite direction to displacement These are the two conditions necessary for SHM. OR • The equation for SHM gives $a = -\omega^2 y$. Here, the equation is multiplied by m to give F. • Mass is a constant, positive scalar so the equation becomes F= negative constant.y, which is the equation for the line given.	ONE correct statement. OR Accept equations as evidence e.g. $a = -\omega^2 y$ or $F = -m\omega^2 y$ or $a \alpha - y$ or $F \alpha - y$	• BOTH correct statements from EITHER viewpoint, restoring force or the governing equation.	

(d)	Displacement = 1.50 – 0.500 = 1.00 m  $\theta = \sin^{-1}\frac{1.0}{1.5} = 41.8°$ (Calculator in degrees) $\omega = \frac{2\pi}{T} = 1.80$ rad s^{-1} $v_{max} = A\omega = 1.5 \times 1.80 = 2.69$ m s^{-1} $v = A\omega\cos\omega t$ or $v = A\omega\cos\theta$ $v = 1.5 \times 1.80\cos 41.8°$ $v = 2.01$ m s^{-1} OR $\theta = \sin^{-1}\frac{1.0}{1.5} = 0.7297$ rad (Calculator in radians) $\omega = \frac{2\pi}{T} = 1.80$ rad s^{-1} $v_{max} = A\omega = 1.5 \times 1.80 = 2.69$ m s^{-1} $v = A\omega\cos\omega t$ or $v = A\omega\cos\theta$ $v = 1.5 \times 1.80\cos 41.8°$ $v = 2.01$ m s^{-1}	Any of the following: • Correct diagram with labels. OR Selected a correct equation as $v = A\omega\cos\omega t$ or $v = A\omega\cos\theta$ $v = -A\omega\sin\omega t$ or $v = -A\omega\sin\theta$ OR Correct angle in either degrees or radians. OR Correct angular frequency.	Attempts to calculate the velocity using a correct method but with incorrect angle or angular frequency BUT NOT BOTH.	• Correct working and answer for velocity with unit. (E) • Correct working and answer for velocity without unit. (E-)

Cut Scores

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