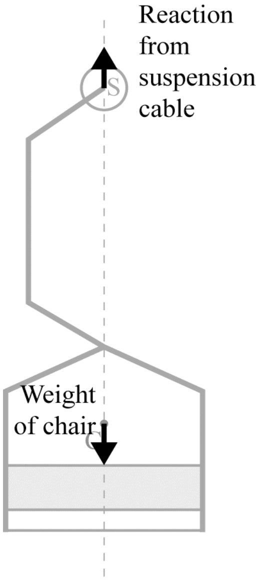
Assessment Schedule – 2008

Physics: Demonstrate understanding of mechanical systems (90521)

Evidence Statement

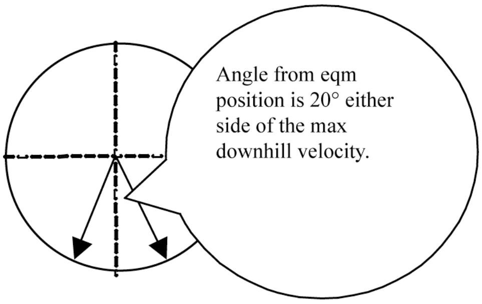
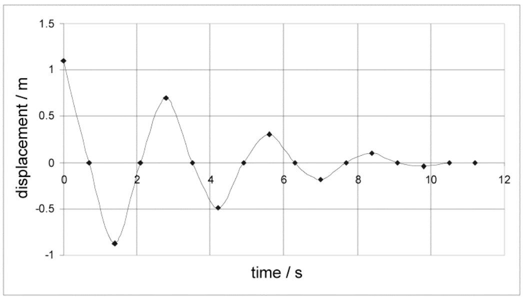
Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)	$\tau = Fr$ = 132 N × 0.83 m = 109.56 [= 110 Nm (2sf)]	[2] **SHOW** question. Correct working shown.		
(b)	$\tau = I\alpha$ $I = \frac{\tau}{\alpha} = \frac{110}{0.48} = 229 = 230\ \text{kg m}^2$ If you use 109.56 you get 228.25.	[2] **SHOW** question. Correct working.		
(c)	$_{\text{final}}\ E_{\text{K(ROT)}} = \frac{1}{2}I\omega^2$ $= ½ × 230 × 0.58^2$ = 39 J (2 sf) OR 38 J (2sf) (109.56 × 0.35) = 38.39 J)	[2]Correct numerical answer for E_k.	If uses work = 109.56 × 0.35 OR uses I = 228.25 then rounding will be 38 J Otherwise 39 J	
	Correct **sf and units**	[1]		
(d)	The **force** moved a **distance**: so **work** (Fd) was done that **transferred energy** to the door. (assuming F constant) OR the force caused a **torque** ($\tau = Fr$) which moved through an **angle** so **work** ($\tau\theta$) was done and **transferred energy.** **(1) Links force to work in context.** $F \rightarrow \tau \rightarrow work^{(a)} \rightarrow \Delta KE$ $F \rightarrow work^{(b)} \rightarrow \Delta KE$ (a) work could be torque and rotation / angle / tuning (b) work is force and distance moved. **(2) Links work to change in energy.** Work causes the (change in) energy (kinetic energy). **(3) Links force to acceleration and then work.** $F \rightarrow \tau \rightarrow \alpha \rightarrow \Delta\omega \rightarrow (\Delta)KE$ Argument must be a rotational one (not linear).		[1] Any of (1) OR (2) OR (3) If have not explained the gain in KE of the door OR explanation (3) is almost complete.	[1] BOTH of (1) AND (2) OR (3) They must explain the **gain in KE** for Excellence

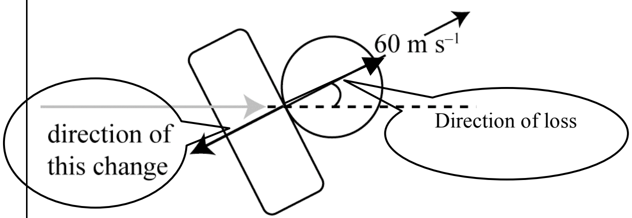
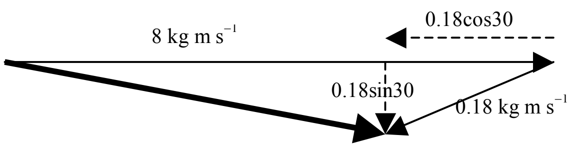
(e)	Yes because: If torque is the same, as $\tau = Fr$, if r is bigger, ***F* is smaller** The reason why torque must be the same is because this causes - same time and same velocity - or the same angular acceleration.		[1] Torque constant and therefore as radius (r) increases F decreases	[1] Justifies why the torque must be constant, eg: - Constant τ gives angular acceleration. OR - Constant τ gives same time and same velocity
(f)	Angle travelled during acceleration $\omega_f^2 = \omega_i^2 + 2\alpha\theta \quad \omega_i = 0$ $\frac{\omega_f^2}{2\alpha} = \theta = \frac{0.58^2}{2 \times 0.48} = 0.35 \text{ radian}$ so after she stops pushing angle is 2.0 – 0.35 = **1.65 rad.**	[2]Correct calc of angle travelled during acceleration. (0.35 rad)	[2]Correct answer.	
(g)	$t_{tot} = t_1 + t_2$ t_1 is the time to accelerate $\omega_f = \omega_i + \alpha t$ or similar $t_1 = \frac{\omega}{\alpha}$ t_2 is the time to rotate freely use $\omega = \frac{\Delta\theta}{\Delta t}$ or similar $t_2 = \frac{\theta_2}{\omega}$ So $t_{total} = \frac{\omega}{\alpha} + \frac{\theta_2}{\omega}$	**SHOW** question [1] States or implies that $t_{total} = t_{acc} + t_{const}$ Substitution with values (**N**).	[1] Derives one of the two terms correctly. Derives means to take from one form to another form OR shows a step from something else to this.	[1] Correct answer.
TWO (a)		[1] Forces correctly labelled Can be through COM. (should be roughly equal in length).		

(b)	Chair moves because of unbalanced torque. Due to centre of mass to the right of the suspension cable / weight of skier causes torque. Torque is force × distance between the line of action of the force and the pivot. Net torque causes angular acceleration. Hangs in new position where new centre of mass is below suspension point, so there is no net torque and no angular acceleration.	[1] Any of: COM moved to the right (towards X) → The **new** COM now (moved to be) below the suspension point Weight of person causes a torque → A "couple: causes a torque	[1] Reason for movement Produces a torque → Torque causes rotation of the chair (in clockwise direction) about pivot →	[1]Reason for equilibrium Gives reason why the chair is in equilibrium using torques (see below) Justifies why the COM is now under the pivot - balanced torque - no resultant torque

THREE (c)			**V_{max} SHM**		
			1.5 or uses cos formula	**2.69**	
	V_{max} **Linear**	**1.0**	48° .78 rads $t = 0.361$ s	68° 1.19 rads $t = 0.551$ s	
		1.2	37° 0.64 rads $t = 0.296$ s	64° 1.11 rads $t = 0.514$ s	
		0.2	82° 1.43 rads $t = 0.662$ s	86° 1.50 rads $t = 0.695$ s	
		1.4	**E2** **21°** **0.37 rads** $t =$ **0.162 s**	59° 1.0 2rads $t = 0.472$ s	

THREE (a)	$T = 2\sqrt{\frac{l}{g}}$ $T = 2\sqrt{\frac{2.1}{9.81}} = 2\pi \times 0.46291 = 2.9070 = 2.9$ s	A **SHOW** question [2]Correct substitution into correct equation		
(b)	$\omega = 2\ f = \frac{2}{t} = \frac{2}{0.91} = 2.16$ rad s^{-1} $V_{max} = r\omega$ $= 0.69 \times 2.16 = 1.49$ m s^{-1} Max speed is when the swing and the whole chair are going up: $V = 1.5 + 1.2 = 2.7$ m s^{-1}	[2] ω correctly calculated OR Adds their (incorrect) V_{max} to 1.2ms^{-1} .	[2] V_{max} =1.49 ms^{-1} OR Consistent V_{max} calculated from their incorrect ω	[2] Correct answer 2.7 ms^{-1}

(c)	The chair will be travelling at 0.2 m s^{-1} down hill velocity when its velocity relative to the equilibrium position is 1.2 + 0.2 m s^{-1} down the hill. ie when v is 1.4 m s^{-1} to the right relative to the pivot. $v = A\omega\cos\omega t$ $1.4 = 0.69 \times 2.16 \times \cos\omega t$ $\omega t = \cos^{-1}\left(\frac{1.4}{0.69 \times 2.16}\right) = 0.35 \text{ rad} = 20^{o}$ OR $21°$  	[2]Correct calculation of v relative to the pivot. (1.4 m s^{-1})	[2] Consistent answer from an incorrect Vmax OR uses sin (instead of cos) to get 70° (1.22 or 1.21 rads)	[2] Correct answer of 20° or 21°.
(d)	 	[1]Graph shows amplitude decreasing over 4 oscillations.	[1] Achieved and starts the graph at correct position AND shows period is the same.	

FOUR (a)	$F = \frac{GMm}{r^2} = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 3.0 \times 10^{-3}}{\left[(6.38+0.35)\times 10^{6}\right]^2}$ $= 2.6 \times 10^{-2}$ N $(= 2.63749 \times 10^{-2}$ N)	[2]Correct radius used (6.73 x 10^6 m)	[2] Correct answer.	Watch for 0.029348N **(N)**
(b)	For a stable orbit **(1)** centripetal force = gravitational force (**Stability)** (2) $\frac{mv^2}{r} = \frac{GMm}{r^2}$ (**mass**) *m*'s cancel so orbit speed is independent of mass (3) acceleration due to gravity is independent of mass, so the two objects so both (free) fall at same rate towards Earth - so they stay together (**mass**) (4) $v^2 = \frac{GM_{\text{Earth}}}{r}$ or $v^2 \alpha \frac{1}{r}$ so same radius gives same velocity (**Same Velocity**)	[1] Uses: (1) Stability argument OR Explains why speed is constant, eg there is no friction. Force of gravity is at right angles to velocity.	[1] Uses: (2) or (3) Mass argument made OR (4) Same velocity argument.	[1] Uses: (4) Same velocity argument AND Mass argument (2) or (3)
(c)(i)	Momentum gained by the ball $p = mv = 3 \times 10^{-3} \times 60 = 0.18$ kg m s^{-1}, this equals momentum lost. 	[2] Correct calculation of *p* (0.18 kgm/s) OR Correct direction Accept either directions: Δ*p* or mtm loss	[2] Both magnitude and direction correct Accept either directions: Δ*p* or mtm loss	
(c)(ii)	Initial $p = 40 \times 0.2 = 8$ kg m s^{-1} to the right.  $p_{\text{final}}^2 = (8 - 0.18\cos30)^2 + (18\sin30)^2 = 61.5$ $v = \frac{p_{\text{final}}}{m} = \frac{7.85}{0.2} = 39.25$ m s^{-1} (or use cosine rule) $\theta = \tan^{-1}\left(\frac{0.18\sin30}{8 - 0.18\cos30}\right) = 0.88^{\circ}$	[2] Has incorrect vector diagram but uses it to give some explanation about why change is negligible Must use mtm diagram as part of their explanation (not just a velocity diagram)	[2] A correct consistent vector diagram or analysis (from 4c(i)	[2] A correct vector diagram or analysis and uses correct explanation about why change negligible

(c)(iii)	Because (in the collision) the change of momentum of the club head and the golf ball is unchanged and the ball is much lighter, the gain in speed of the ball is much greater than the decrease in *v* of the club head. or The club and the head experience the same force. However as the mass of the club head is greater than the mass of the ball the acceleration of the ball will be higher ($F = ma$) Therefore the ball will travel faster	[1] States that momentum is conserved	[1] relates change of mtm of golf club head to golf balls velocity Or Mentions that any of these is the same in collision –*F* force –*Ft* impulse –Δp change in mtm. on ball and club head	
(d)	As he starts to rotate the club, he will rotate in the opposite direction (the total angular momentum will remain constant). As he hits the ball, he will recoil (total linear momentum will remain constant).	[1] Rotation or Translation Watch for incorrect directions **(N)**		

Judgement Statement

Achievement	Achievement with Merit	Achievement with Excellence
$4 \times$ A1	$4 \times$ A1 + $2 \times$ M1	$4 \times$ A1 + $2 \times$ M1 + $1 \times$ E1
$5 \times$ A2	$4 \times$ A2 + $3 \times$ M2	$4 \times$ A2 + $2 \times$ M2 + $1 \times$ E2