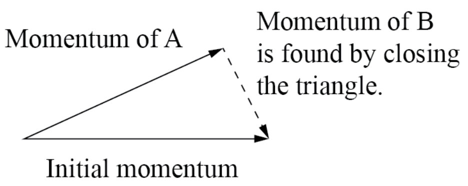
Assessment Schedule – 2012

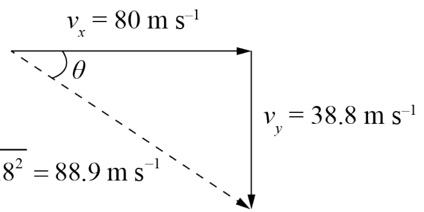
Physics: Demonstrate understanding of mechanical systems (90521)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$\omega = 2\pi f \quad \Rightarrow f = \frac{7.5}{2\pi} = 1.1937$ rotations per second $= 5.97$ rotations in 5 seconds. OR $\theta = \omega t = 7.5 \times 5 = 37.5 \text{ rad} = \frac{37.5}{2\pi} = 5.97$ rotations	[2] Correct answer.		
(b)	$\tau = I\alpha \quad = I\frac{\Delta\omega}{\Delta t} \quad = 5.45 \times \frac{7.50}{0.54} \quad = 5.45 \times 13.89$ $= 75.694 \quad = 75.7$ Nm	[2] Correct answer.		
(c)	Ira's legs are now further away from the centre of rotation than they were, so the rotational inertia has increased. This means she needs to apply a greater torque to achieve the same angular acceleration. As the push force is still being applied at the same place, and so the radius at which it is applied does not change, the force must increase to make the torque increase.	[1] Idea that greater rotational inertia means a greater torque is needed. (*Increase in rotational inertia explained can provide replacement evidence for 1(e)(i).*)	[1] Greater rotational inertia means a greater torque is needed. Angular acceleration must be the same.	[1] Correct and full answer.
(d)	Ira and the chair will rotate more slowly. If 'the system' is Ira, the chair and the book, no external torque is applied and so angular momentum is constant. The mass of the book increases the total mass of the system, so the rotational inertia increases and so ω decreases. When the book lands, friction between Ira's lap and the book (equal and opposite forces) will accelerate the book and cause a torque on Ira and the chair so that they slow down.	[1] Increase in rotational inertia stated and decrease in angular speed explained. OR Increase in rotational inertia explained.	[1] Increase in rotational inertia explained and decrease in angular speed explained.	

(e)(i)	As Ira pulls the book in, the rotational inertia of the system will decrease because she is shifting some of her mass closer to the centre of rotations. Because angular momentum must be conserved (no external torques acting), an increase in rotational inertia will cause a decrease in angular speed.	[1] Decrease in rotational inertia explained.	[1] *Increase in angular speed explained can provide replacement evidence for M1 in 1(d).*	
(ii)	$I_i = 5.45 + (2.1 \times 0.6^2) = 6.206$ $I_f = 5.45 + (2.1 \times 0.05^2) = 5.455$ $\omega_f = \frac{\omega_i I_i}{I_f} = \frac{5.00 \times 6.206}{5.455} = 5.69 \text{ rad s}^{-1}$ The movement of Ira's arms would further decrease *I,* so ω_f would be larger.	[1] Some idea of the rotational inertia of Ira's arm also affecting the final angular speed.	[2] Correct calculation of I_i or I_f	[2] Correct ω_f
TWO (a)	$a = -\omega^2 y \quad \Rightarrow a = 1.45^2 \times 0.80 \quad = 1.682 \quad = 1.68 \text{ m s}^{-2}$	[2] Correct answer.		
(b)	$y = A \cos \omega t \quad = 0.80 \times \cos(1.45 \times 1.8) \quad = -0.6896$ The negative means Daniel's displacement from the equilibrium position is opposite to when he started, which means he has gone through the equilibrium position. $\Rightarrow$ total distance = A + y = 0.80 + 0.6896 = 1.4896 = 1.49 m	[1] Correct equation selected.	[2] Correct displacement value	[2] Correct distance
(c)	If Daniel had pushed off, his speed as he started his swing would not have been zero and so he would have had kinetic energy. His kinetic energy increase as he drops to the lowest position in his swing would be the same and so his maximum kinetic energy would be greater. This means he would rise further before his kinetic energy has been changed to gravitational potential energy, thus increasing the amplitude of his motion. As a swinging pendulum approximates to simple harmonic motion only if the amplitude is small, increasing the amplitude may mean the motion is no longer simple harmonic.	[1] Explanation shows some idea of: increase in **initial** (angular) speed. OR Some increase in energy. OR Increased amplitude means no longer SHM.	[1] Correct explanation for why the energy has increased. OR Correct explanation for why increase in energy means increase in amplitude. OR Correct explanation for why increased amplitude means no longer simple harmonic motion.	[1] Correct explanation for why the energy has increased and why increase in energy means increase in amplitude. OR Correct explanation for why the energy has increased and correct explanation for why increased amplitude means no longer SHM.

(d)	The period of the pendulum depends on its length ($T = 2\pi\sqrt{(L/g)}$). The length of a pendulum is from the pivot point at the top to the centre of mass of the bob, which is Daniel. If Daniel is sitting down his centre of mass will be further down and so the length of the pendulum will be greater and so the period will be longer.	[1] Idea that the period depends on length and that the length will change.	[1] Correct and full explanation.	
THREE (a)	Momentum is conserved in the horizontal direction because there are no external forces. Kinetic energy is not conserved because the elastic potential energy of the spring has been converted into kinetic energy / the kinetic energy of the system has increased.	[1] Momentum is conserved and kinetic energy is not conserved plus some idea why kinetic energy is not conserved. OR kinetic energy not conserved is linked to the explosion of the spring.	[1] Momentum is conserved and kinetic energy is not conserved because energy is gained from the spring. OR Full explanation for why kinetic energy is not conserved.	[1] Correct and full explanation.
(b)	$p_{\text{before}} = p_{\text{after}} = mv = 0.105 \times 67 = 7.035 = 7.04\ \text{kg m s}^{-1}$	[2] Correct answer.		
(c)	 • Momentum of particle A can be calculated: $p_A = m_A v_A$ or $p_A = 0.080 \times 0.080 = 6.40$ • Initial momentum equals final momentum calculated in (b). • Correct method of finding p_B using vectors, could use vector components / scale drawing of triangle / cosine rule. • $p_A = m_B v_B$, so knowing the mass of B from $m_{\text{ball}} - m_A$ ie 0.105 – 0.80 = 0.025 kg $v_B = \dfrac{p_B}{0.025}$	[1 or 2] Momentum vector diagram drawn and each vector labelled with variable name.	[1 or 2] Momentum vector diagram drawn, values given for p_A and p_i, θ_A labelled.	[1 or 2] Momentum vector diagram plus explanation of how to use it to find velocity.

(d)	Impulse is caused by the force of gravity. The effect of the impulse is to increase the vertical momentum but not the horizontal momentum, which means that the total momentum of the ball has increased.	[1] Impulse is caused by the force of gravity. OR Force of gravity causes an increase in vertical momentum.	[1] Impulse is caused by the force of gravity which means the vertical component of the velocity / momentum increases. OR The effect of the impulse is to increase the vertical momentum but not the horizontal momentum.	[1] Impulse is caused by the force of gravity and its effect is to change the final momentum of the ball by increasing its vertical component.
(e)	Impulse = Δp_y Initial p_y is zero, so p_y = impulse = 3.1 Initial $v_y = \frac{p_y}{m} = \frac{3.1}{0.08} = 38.8 \text{ m s}^{-1}$  $v = \sqrt{80^2 + 38.8^2} = 88.9 \text{ m s}^{-1}$ $\tan\theta = \frac{38.8}{80}$ $\theta = 25.9°$ (Question can be answered using momentum vectors.)	[2] Correct vertical velocity.	[2] Correct velocity	[2] Correct velocity and angle.

Judgement Statement

Achievement	Achievement with Merit	Achievement with Excellence
2 **A**^{1} + 2 **A**^{2} + 2 **A**	1 **M**^{1} + 1 **M**^{2} + 2 **M** + 3 **A**	1 **E**^{1} + 1 **E**^{2} + 1 **M**^{1} + 1 **M**^{2} + 3 **A** *OR* 1 **E**^{1} + 1 **E**^{2} + 1 **E** + 1 **M** + 3 **A**

Note: where the criterion is not specified, the required criterion can be from either criterion.