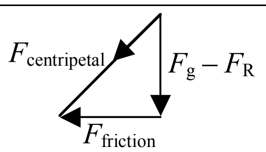
Assessment Schedule

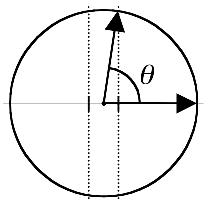
Level Three Physics: Demonstrate understanding of mechanical systems (90521)

Evidence Statement

Judgements in italics indicate replacement evidence and so are not counted for sufficiency.

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
1(a)	$F = \frac{mv^2}{r} = \frac{1.0\times10^4 \times 0.26^2}{68} =$ 9.94118 N **9.9 N**	Correct answer. A2		
1(b)	$v = r\omega \Rightarrow \omega = 0.26 \div 68$ $= 3.82353 \times 10^{-3}$ rad s^{-1}	Correct answer. A2		
1(c)	$T = \frac{1}{f}$, $\omega = 2\pi f \Rightarrow T = \frac{2\pi}{\omega}$ $= \frac{2\pi}{3.82353\times10^{-3}} = 1643.29$ = **1600 s or 27 minutes**		Correct answer. M2	
1(d)	$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{3.82353\times10^{-3}}{2.3}$ $= 1.66240 \times 10^{-3}$ **= 1.7 × 10^{-3} rad s^{-2}**	Correct answer. A2		
1(e)	$\theta = \frac{(\omega_i + \omega_f)}{2}t$ $= \frac{3.82353\times10^{-3}}{2} \times 2.3$ $= 4.39706 \times 10^{-3}$ rad $= 180 \div \pi \times 4.39706 \times 10^{-3}$ = 0.25193 **0.25°**		Correct answer. Accept any valid method. M2	
1(f)	$\tau = I\alpha$ $\Rightarrow I = 46 \times 10^6 \div 1.66240 \times 10^{-3}$ $= 2.76708 \times 10^{10}$ **2.8 × 10^{10} kg m^2**	Correct answer. A2		
1(g)	As the capsules increase speed, the frictional forces acting against their motion also increase, causing the unbalanced torque and hence angular acceleration to decrease. When the torque of these frictional forces becomes equal to the applied torque, the torques will be balanced and so the wheel will no longer be accelerating.	One correct and relevant statement: frictional torques act against the motion / at constant speed the torques are balanced. A1	Explanation shows recognition that, even though the wheel is travelling at constant speed, a torque must still be applied to balance the torque of frictional forces. M1	*Explanation includes the idea of **increasing** frictional torque.* E1
1(h)	At the rim of the wheel.	Idea that the point should be as far from the centre of rotation as possible. A1	.	

1(i)	The wheel is travelling at constant speed, so there is no change in kinetic energy. The gain and loss in gravitational potential energy are the same, so there is no net change. The only energy transformation produces heat due to all the frictional effects that are acting against the motion of the wheel.	*One correct and relevant statement: friction converts energy to heat / no change in kinetic energy / no change in gravitational potential energy.* A1	Recognition that the constant speed of the wheel means there is no change in kinetic energy. / Gain and loss in gravitational potential energy of the capsules is balanced out. / Only energy change is to heat by friction. M1	*No change in kinetic and gravitational potential energies fully and clearly explained.* E1
1(j) (i)	$\theta = \omega t \quad = 3.82353 \times 10^{-3} \times 29.0$ $= 0.110882$ **0.11 rad (6.4°)**	Correct answer. A2		
1(j) (ii)	$2 \times d = r\theta = 68 \times 0.110882$ $= 7.54 \quad \Rightarrow d = 3.77$ **3.8 m**		Correct answer. (Accept if $d = vt$ is used.) M2	
1(k)	Angular momentum is not conserved because $L = I\omega$. Rotational inertia has increased because the total mass has increased but the angular speed, ω, stays constant because the speed of the capsules is constant.	One correct and relevant statement: change in mass causes change in angular momentum / rotational inertia increases / angular speed stays constant. A1	Explanation clearly links changing mass to a change in angular momentum of each capsule. M1	Explanation is clear, concise and complete. E1
1(l)	$E_{K(ROT)} = \frac{1}{2} I\omega^2 \quad I = 2 \times E_{K(ROT)} \div \omega^2$ $E_{K(ROT)} = E_{K(LIN)} = \frac{1}{2} mv^2$ $\Rightarrow I = 2 \times \frac{1}{2} mv^2 \div \frac{v^2}{r^2} \quad = mv^2 \times \frac{r^2}{v^2}$ $= mr^2$	*recognition that $\frac{1}{2} I\omega^2$ can be equated to $\frac{1}{2} mv^2$* A1	*I expressed in terms of angular velocity.* M1	Correct relationship derived. E1
1(m)	$L = mvr \quad = 65 \times 0.26 \times 68$ $= 1149.2 =$ **1100 kg m^2 s^{-1}**	Correct answer. A2 (Accept if $L = I\omega$ is used.)		
1(n)		Recognition that gravity and another force contribute to the centripetal force. A1	Diagram shows the gravity force and another force combining to give a centripetal force that acts towards the centre of the wheel. M1	*The "other" force is recognised to be friction acting on the person's feet.* E1
2(a)	$A \quad = \frac{1}{2} \times 0.150 \quad = 0.0750$ **0.0750 m**	Correct answer. A2		
2(b)	$a = \omega^2 A \quad = 1.8^2 \times 0.0750$ $= 0.243$ **0.24 m s^{-2}**	Rounded to 2 sig. fig. plus 6 answers given with correct unit. A1	Correct answer. M2	
2(c)	0.075 m / at the amplitude / at maximum displacement.	A1 Correct statement.		
2(d)	As the timing starts from the end position the "sine" form of the formula must be used. $v = A\omega \sin\omega t$	*Recognition that the "sine" form of the formula must be used.* A1	*Correct answer consistent with calculator in degree mode.* M2	Correct answer. E2

	$= 1.5 \times 1.8 \times \sin(1.8 \times 0.75)$ $= 2.63445$ **2.6 m s^{-1}**			
2(e)	$a = \omega^2 y$. This shows that the acceleration depends only on the displacement and angular speed. As the natural frequency is the same for both damped and undamped motion, the angular speed will stay the same.	*One correct and relevant statement: a is proportional to y / ω is constant.* A1	*Recognition that acceleration depends on displacement **only**.* M1	Link made between the acceleration depending on displacement and angular speed only, and constant angular speed implies α depends on y only. E1
2(f)	$T = 2\pi/\omega \quad = 2\pi/1.8 \quad = 3.49066$ **3.5 s**		Correct answer. M2	
2(g)	 Every $\frac{1}{4}$ cycle the displacement phasor rotates through angle θ while the displacement is outside the maximum damped displacement. $\cos\theta = \frac{\frac{1}{2}\times 0.150}{\frac{1}{2}\times 3.0}$ $= 87.134°$ (1.52078 rad) total angle turned by displacement phasor in a complete cycle = $4 \times \theta$ = 348.536° (6.08310) $t = \frac{4\theta}{360} \times T \qquad (t = \frac{4\theta}{\omega})$ $t = 3.37950 \qquad (t = 3.3795)$ **= 3.4 s**		*Correctly calculated θ.* M2	Correct answer. E2

Judgement Statement

Criterion 1

Achievement	Achievement with Merit	Achievement with Excellence
FOUR opportunities answered at Achievement level or higher. 4 × A1	FOUR opportunities answered with TWO at Merit level or higher. [The two Merit opportunities cannot be both 1(l) and 1(n)] 2 × M1 *plus* 2 × A1	FIVE opportunities answered with ONE at Excellence level and TWO at Merit level or higher. 1 × E1 *plus* 2 × M1 *plus* 2 × A1

Criterion 2

Achievement	Achievement with Merit	Achievement with Excellence
FOUR opportunities answered at Achievement level or higher. 4 × A2	SEVEN opportunities answered with THREE at Merit level or higher. 3 × M2 *plus* 4 × A2	SEVEN opportunities answered with ONE at Excellence level and THREE at Merit level or higher. 1 × E2 *plus* 3 × M2 *plus* 3 × A2