Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
13	(a)		Centre of gravity/Weight of cyclist (and normal reaction) and bicycle acts though the base of the wheel	1			1		
	(b)	(i)	The moment of inertia about an axis is the sum (1) Of mass × radius^2 (distance from the axis) (1) Or $I = \sum mr^2$ (1) and symbols explained – see above (1) accept Moment (1) per unit angular acceleration (1)	2			2		
		(ii)	Calculating M of I = $\frac{1}{12}60 \times 1.68^2 = 14.112$ kg m^2 (1) Rearranging $\omega = \frac{J}{I} = \frac{92.1}{14.112}$ (1) Angular velocity = 6.53 rad s^{-1} (1)		3		3	2	
		(iii)	Applying conservation of angular momentum (1) Substitution of values $\omega = \frac{92.1}{2.7}$ (1) Angular velocity = 34.1 rad s^{-1} (1)	1	1 1		3	2	
	(c)	(i)	Substitution into torque $\tau = I\alpha$ or $\tau = \frac{\Delta(I\omega)}{t}$ or $\tau = \frac{I\Delta\omega}{t}$ (1) Substitute values for $\alpha = \frac{220-170}{0.310}$ or $\Delta(I\omega)=1.10\times(-50)$ [ignore sign] (1) $\tau = 177$ N m (1)	1	1 1		3	2	
		(ii)	Substitution into rotational KE = $\frac{1}{2}I\omega^2$ (1) Factor ×4 (four wheels) (1) Rotational KE lost = 42.9 × 10^3 J (1)	1	1 1		3	2	
	(d)		Converting km hr^{-1} to m s^{-1} correctly (1) Substituting values in $F = \frac{mv-mu}{t}$ or $a = \frac{v-u}{t}$ (1) F = 64.5 kN or 58 kN for car or 6.4 kN for driver or a = 90.9 m s^{-2}(1) Acceleration/Force is large/Need to reduce F or a (1) Grass or gravel area will increase the time or slow down before impact with wall etc.(1)			5	5	2	
			Question 13 total	**6**	**9**	**5**	**20**	**10**	**0**

#2

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
13	(a)		Anticlockwise moments = $T\sin 18° \times 0.14$ (1) Clockwise moments = $(39 \times 0.35) + (19.6 \times 0.8)$ (1) $T = 678$ [N] (1)	1	1 1		3	2	
	(b)	(i)	Angular acceleration is rate of change of angular velocity	1			1		
		(ii)	$\omega = 2\pi f = 2\pi \times 2.3$ (1) Angular acceleration = 53 [rad s^{-2}] (1)		2		2	1	
		(iii)	Use of torque $\tau = I\alpha$ (1) Moment of inertia = 0.0121 [kg m^2] (1) $\tau = 0.648$ [N m] (1)	1	1 1		3	2	
	(c)	(i)	Using 24 sin 38° (1) Height = $\frac{u^2}{2g}$ sub into equation (1) Height = 11.1 [m] (1) Maximum height = 12.3 [m] [1]	1 1	1 1		4	2	
		(ii)	Using Bernoulli equation $p = p_o - \frac{1}{2}\rho v^2$ (1) Determining difference in pressure = $\frac{1}{2}\rho(v_1^2 - v_2^2)$ (1) Difference in pressure = 28 [Pa] (1) Force = pA = 1.1 [N] [or weight equivalent pressure = 516 Pa] (1) Horizontal distance will remain approximately unchanged because weight is far greater (1) (accept increase slightly and allow ecf)			5	5	2	
		(iii)	$\frac{1}{2}\rho A v^2 C_D$ stated or $F_D \propto v^2$ (1) Factor increase = 2.25 (1)	1	1		2	1	
			Question 13 total	**6**	**9**	**5**	**20**	**10**	**0**

#3

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Using 44cos7° as horizontal component of velocity (1) Range calculated correctly = 17.9 [m] (1) Conclusion – ball in play (1)			3	3	2	
		(ii)	Use of $F = \frac{mv-mu}{t}$ (1) $F = \frac{0.056 \times 44}{0.006} = 411$ [N] (1)	1	1		2	1	
	(b)	(i)	Relative velocity after a collision = (1) 0.74 × relative velocity before a collision (1) **Alternative:** The ratio of the rebound speed (1) to the impact speed is 0.74 (1)	2			2		
		(ii)	Use of $e = \sqrt{\frac{h}{H}}$ or e used with speed/velocity (1) Height after first bounce = 1.07 [m] (1) Height after second bounce = 0.58 [m] **ecf** on height of first bounce (1)	1	1 1		3	2	
	(c)	(i)	Drag opposing motion and weight shown (1) Lift (Magnus force) shown at 90° to motion (up + left) (1) Lift keeps ball in air longer/gives greater height (1) Lift or drag vary/decrease during flight as speed/spin changes (1)	1	1	1 1	4		
		(ii)	Angular velocity = 367 rad s^{-1} (1) Moment of inertia = 4.6×10^{-5} kg m^2 (1) Total KE = linear + rotational (1) Total KE = 10.60 [J] **ecf** on rotational KE (1)	1	1 1 1		4	3	
		(iii)	$A = 3.8 \times 10^{-3}$ m^2 or $\pi \times (3.5 \times 10^{-2})^2$ (1) $F = 0.33$ [N] (1)		2		2	2	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Moment of inertia of a body about a given axis is defined as $I = \Sigma mr^2$ for all points in the body (1) where m is the mass and r is the distance of each point from the axis (1) accept radius of cricket ball	2			2		
		(ii)	Rotational Kinetic energy = $\frac{1}{2}I\omega^2$ (1) Angular velocity = (30 × 2π) (1) Moment of inertia = 8.3 × 10^{-5} [kg m^2] (1)	1	1 1		3	2	
	(b)	(i)	Vertical component = 12.5 [m s^{-1}] and horizontal component = 21.7 [m s^{-1}] (1) Time taken for ball to travel 5.6 m = 0.25 s ($\frac{5.6}{21.7}$) (1) Correct substitution of values into $x = ut + \frac{1}{2}at^2$ to determine height after 0.25 s (**ecf**) **OR** calculating times at which height is 2.4 m (1) Height = 2.8 [m] **OR** time is around 0.21 [s] (1) So ball cannot be caught by fielder (1)			5	5	4	
		(ii)	Moving hand in direction of ball will <u>increase time</u> of contact **OR** distance of contact (1) According to $F = \frac{mv-mu}{t}$; **OR** $F = \frac{Wd}{x}$ this will reduce force (1)		2		2		
		(iii)	Re-arranging to determine bounce height as e^2H (1) Bounce height = 0.32 [m] (1)		2		2	2	
	(c)	(i)	Forces of drag and weight drawn or discussed (1) Lift or Magnus force shown or discussed (1) Resultant of these forces decides motion (1)	3			3		
		(ii)	Effective area of sphere = πr^2 = 4.07 × 10^{-3} m^2 (1) Substituting values into $F_D = \frac{1}{2}\rho v^2 A C_D$ (1) Drag force = 1.19 [N] (1)		3		3	2	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**