Question			Answer	Marks	Guidance
1	(a)	(i)	(linear momentum =) mass x <u>velocity</u>	B1	**Allow**: momentum = *m v* where *m* is <u>mass</u> and *v* is <u>velocity</u> **Not**: mass x speed
		(ii)	Any **two** from: momentum / vector has magnitude and direction velocity is a vector A product of a scalar and vector is a vector	B1 x 2	
	(b)		$a = \Delta v / \Delta t = 7.5 / 0.28$ $a = 27$ (m s^{-2})	A1	Ignore sign
		2	$F = ma$ $F = 850 \times 27$ $= 2.3 \times 10^4$ (N)	C1 A1	Possible ecf from b(i) for acceleration
		(ii)	$E = \frac{1}{2}mv^2$ $0.45 \times 10^6 = ½ \times 850 \times v^2$ $v = \sqrt{(2 \times 0.45 \times 10^6 / 850)}$ $v = 33$ (m s^{-1})	C1 A1	Mark is for correct substitution **Note**: Possible POT error
	(c)		$m_1u = (m_1 + m_2)v$ $850 \times 7.5 = (850 + 1200)\ v$ $v = 850 \times 7.5 / 2050$ $v = 3.1$ (m s^{-1})	C1 A1	Mark is for correct substitution
			Total	**10**	

Question	Expected Answers	Marks	Additional guidance
2 (a)(i)	Total momentum is constant/conserved For a closed system/provided no external forces (WTTE)	B1 B1	"total momentum before = total momentum after" Allow $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ or equivalent Do not accept "momentum is constant" Do not accept "momentum is conserved"
(a)(ii)	Some loss of kinetic energy (OR KE OR E_K)(during the collision)	B1	Allow answers in terms of Coeff't of Res. Coeff't of Restitution < 1 e.g. speed of separation/speed of approach
(a)(iii) 1	(2.4x3.0) –(1.2x2.0) = 3.6*v* *v* = **1.3 m s^{-1}**	C1 A1	must see –ve sign hence 2.67 scores ZERO Allow 4/3 ms^{-1} and 1.34 but not 1.4
(a)(iii) 2	Any KE correctly calculated: 10.8J, 2.4J, (or 13.2 or 8.4), 3.18J **13.2** and **3.18** (or any value between 3.2 and 3.0) seen	C1 A1	ECF from a(iii)1 If 1.3 ms^{-1} is used KE after is 3.04 ECF from a(iii)1 provided final KE is less than initial KE Allow answers in terms of Coeff't of Res. e.g. speed of separation/speed of approach = 0/5 =0
(b)(i)	valid sub^n in V = πr^2h: e.g. π x 5.0^{2}x12 x 5.0 (= 1500π /4710 m^3) m = Vρ = π x 5.0^2 x 12 x 5.0 x 1.3 = **6126** kg	C1 A1	 Do not accept a bald answer of 6000
(b)(ii) 1	momentum = 6130 x 12 = **7.4 (or 7.36) x 10^4 (**kg m s^{-1})	B1	Allow 7.2x10^4 if 6000 kg used & ecf from (b)(i).
(b)(ii) 2	F = 73600/5 F = **14700 N**	C1 A1	 Accept 14400 if 7.2x10^4 is calculated in 1
(b)(ii) 3	mass of helicopter = 14700/9.81 = **1500** kg	B1	Allow ecf from (b)(ii)2. Allow g=10 N/kg
	Total	**13**	

Question			Expected Answers	Marks	Additional guidance
3	a	i	Force is proportional to the rate of change of **momentum** *(QWC This mark can only be scored if momentum is spelled correctly)*	B1	Allow "equal" instead of proportional, allow "change in momentum over time" (WTTE) Do not allow F = ma or in words
		ii	When one body exerts a force on another the other body exerts an equal (in magnitude) and opposite (in direction) force on the first body (WTTE)	B1	Must refer to two bodies. Do not allow a bare "Action and reaction are equal and opposite".
	b	i	*area*: number of squares correctly counted: 20 - 24 (500 – 600) = **2.2** Ns {allow 2.0 to 2.4}	C1 A1	First mark for correct number of squares Second mark for correct conversion to Ns If 2 Δs assumed, area = 1.68 Ns and scores 1 mark 1680 scores 0 (2 errors) but 2200 scores 1 mark
		ii	**Impulse** QWC must be spelled correctly	B1	No not allow change of momentum.
		iii	recall of Impulse = change in momentum OR I = mv OR mv –mu (mv = 2.2 hence v = 2.2/0.046) v = **47.8** ms^{-1} (hence about 50) (2.0 gives 43.5, 2.1 45.7, 2.3 50, 2.4 52.2)	C1 A1	Allow 'Area = mv' Allow ecf from cand's value for (b)(i): e.g. mv = 1.68 v = 36.5 ms^{-1} and scores 2 marks mv = 2200 v = 47800 ms^{-1} also scores 2marks! (ecf)
		iv	initial horizontal velocity = 50cos42 = (37.2 ms^{-1}) initial vertical velocity = 50sin42 = (33.5 ms^{-1}) time taken to reach maximum height = 33.5/9.8 (= 3.41 s) total time to reach ground = 2x 3.41 = 6.82 s hence distance = 50cos42xtotal time = 37.2x6.82 = **253** m any valid assumption: eg no air resistance / horizontal velocity is constant/ acceleration due to gravity is 9.8 (or 10) ms^{-2} / ball follows a parabolic or symmetrical path (WTTE).	C1 C1 C1 A1 B1	Allow 1 mark for correct identification of cosine and sine components of v, without substitution. Allow ecf for cand's value of v throughout e.g if 47.8 is used for v, distance = **232** m and this scores four marks. if 47800 is used distance = 2.32 x 10^8 m! Also allow "only the gravitational force is acting" "no friction" "only gravity"
			Total	**12**	