CAMBRIDGE INTERNATIONAL AS & A LEVEL • PHYSICS 9702

Topical Questions

Units 2 & 3: Kinematics, Dynamics and Linear Momentum

Past Papers 2021 – 2025

MARK SCHEME 46 Questions

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Question 1 — Mark Scheme

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Question	Answer	Mark
1(a)	acceleration: vector work: scalar power: scalar *Three correct scores 2 marks. Two correct scores 1 mark.*	**B2**
1(b)(i)	$a = (v - u) / t$ or a = gradient or $a = \Delta v / (\Delta)t$ e.g. $a = (1.40 - 0.70) / 4.0$	**C1**
	$= 0.18\ \text{m s}^{-2}$	**A1**
1(b)(ii)	distance $= 0.5 \times (0.70 + 1.40) \times 4.0$ or $(0.70 \times 4.0) + (0.5 \times 0.70 \times 4.0)$	**C1**
	$= 4.2\ \text{m}$	**A1**
1(c)(i)	(force equal to) rate of change of momentum	**B1**
1(c)(ii)	horizontal line starting from $t = 0$ and ending at $t = 4.0$ s at a positive value of F	**B1**
	horizontal line starting from $t = 4.0$ s and ending at $t = 8.0$ s at $F = 0$	**B1**
	horizontal line starting from $t = 8.0$ s and ending at $t = 12.0$ s at a negative value of F and the magnitude of F is larger than from $t = 0$ to 4.0 s	**B1**

Question 2 — Mark Scheme

Question	Answer	Marks
2(a)	$v^2 = u^2 + 2as$ $u^2 = 8.7^2 - (2 \times 9.81 \times 1.5)$	**C1**
	$u = 6.8\ \text{m s}^{-1}$	**A1**
2(b)	(magnitude of) force on ball (by ground) equal to force on ground (by ball)	**B1**
	(direction of) force on ball (by ground) opposite to force on ground (by ball)	**B1**
2(c)(i)	(p =) 0.059×8.7 **or** 0.059×5.4	**C1**
	change in momentum = 0.059 (8.7 + 5.4) = 0.83 N s	**A1**
2(c)(ii)	resultant force = 0.83 / 0.091 **or** 0.059 [(8.7 + 5.4) / 0.091] = 9.1 N	**A1**
2(c)(iii)	(W =) 0.059×9.81	**C1**
	(W =) 0.58 (N) force = 9.1 + 0.58 = 9.7 N	**A1**
2(d)	straight line with a positive gradient and starting from a non-zero value of speed at $t = 0$ and ending when $t = T$	**B1**
2(e)	air resistance increases	**B1**
	resultant force/acceleration decreases so gradient (of curve) decreases	**B1**

Question 3 — Mark Scheme

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Question	Answer	Marks
2(a)	change in velocity / time (taken)	**B1**
2(b)(i)	air resistance increases (with speed/with time)	**B1**
	resultant force decreases (as speed increases/with time) so acceleration decreases (as speed increases/with time)	**B1**
	when air resistance equals the weight the speed/velocity/v becomes constant	**B1**
2(b)(ii)	speed = 36 m s^{-1}	**A1**
2(b)(iii)	height given by area under the curve	**C1**
	height = 950 m *Round to two significant figures and award 2 marks for a value in the range 920–980 m and 1 mark for a value in the range 900–910 m or 990–1000 m.*	**A2**
2(b)(iv)	line starting at (0, 9.8)	**B1**
	curve with negative gradient between t = 0 and t = 20 s	**B1**
	line showing zero acceleration between t = 20 s and t = 30 s	**B1**

Question 4 — Mark Scheme

Question	Answer	Marks
2(a)	mass × velocity	**B1**
2(b)(i)	kinetic energy = $\frac{1}{2}mv^2$	**C1**
	= $\frac{1}{2} \times 0.24 \times 2.3^2$	**C1**
	= 0.63 J	**A1**
2(b)(ii)	change in momentum = $\frac{1}{2} \times 240 \times 5.0 \times 10^{-3}$	**C1**
	= 0.60 N s	**A1**
2(b)(iii)	(change in velocity of Y) = 0.60 / 0.12 (= 5.0 m s^{-1})	**C1**
	final velocity of Y = 5.0 – 2.3 = 2.7 m s^{-1}	**A1**
	or	
	(final momentum of Y) = 0.60 – 0.12 × 2.3 (= 0.324 N s)	**(C1)**
	final velocity of Y = 0.324 / 0.12 = 2.7 m s^{-1}	**(A1)**
2(c)	sloping straight line from (0, 0) to t = 3.0 ms **and** another straight line continuous with the first from t = 3.0 ms to (5.0, 0)	**B1**
	lines showing maximum force of magnitude 240 N	**B1**
	lines wholly in the negative F region of the graph	**B1**

Question 5 — Mark Scheme

Question	Answer	Marks
3(a)	change in displacement / time (taken)	**B1**
3(b)	by calculation: $v^2 = 42^2 + 23^2 - (2 \times 42 \times 23 \times \cos 54°)$ **or** $v^2 = (42 - 23 \cos 54°)^2 + (23 \sin 54°)^2$ **or** $v^2 = (42 - 23 \sin 36°)^2 + (23 \cos 36°)^2$	**C1**
	$v = 34\ \text{m s}^{-1}$	**A1**
	or	
	by scale diagram: triangle of vector velocities drawn	**(C1)**
	$v = 34\ \text{m s}^{-1}$ (*allow* ± $1\ \text{m s}^{-1}$ *if scale diagram used*)	**(A1)**
3(c)(i)	$(\Delta)E = mg(\Delta)h$ **or** $(\Delta)E = W(\Delta)h$	**C1**
	$h = 6100/46$ (= 133 m)	**C1**
	$\theta = \sin^{-1}(133/280)$ $= 28°$	**A1**
3(c)(ii)	force = 6100 / 280 **or** 46 sin 28°	**C1**
	= 22 N	**A1**
3(d)	$v_{(s)} = 280 / 14$ (= $20\ \text{m s}^{-1}$)	**C1**
	$f_o = f_s\, v / (v - v_s)$ $f_s = 450 \times (340 - 20) / 340$	**C1**
	= 420 Hz	**A1**

Question 6 — Mark Scheme

Question	Answer	Marks
2(a)	force (on droplet of water) in horizontal direction is zero.	B1
2(b)	(time taken =) 3.5 / 6.6 = 0.53 (s)	A1
2(c)	$s = ut + \frac{1}{2}at^2$ $s = \frac{1}{2} \times 9.81 \times 0.53^2$	C1
	h = 1.4 m	A1

Question	Answer	Marks
2(d)	displacement is straight-line distance (from P to Q) so less (than distance along path) or displacement is the shortest distance (from P to Q).	B1
2(e)	$(\text{displacement})^2 = 3.5^2 + 1.4^2$	C1
	displacement = 3.8 m	A1

Question 7 — Mark Scheme

Question	Answer	Marks
3(a)	$(m =) \rho V$	C1
	$= 1.0 \times 10^{3} \times 1.5 \times 10^{-4} \times 5.0 \times 1.6 = 1.2$ (kg)	A1
3(b)(i)	$(\Delta)p = 1.2 \times 5.0$ $= 6.0$ N s	A1
3(b)(ii)	$F = 6.0 / 1.6$ or $1.2 \times 5.0/1.6$ $= 3.8$ N	A1
3(c)	Newton's third law applies (so) 3.8 N.	B1
3(d)	$p = F / A$ $= 3.8 / 1.5 \times 10^{-4}$	C1
	$= 2.5 \times 10^{4}$ Pa	A1

Question 8 — Mark Scheme

Question	Answer	Marks
1(a)	change in displacement / time (taken)	**B1**
1(b)(i)	(displacement =) area under graph	**C1**
	(at t = 4.0 s) v = (–) 2.4	**C1**
	height = ½ × 2.5 × 4.0 – ½ × 1.5 × 2.4 = 3.2 m	**A1**
1(b)(ii)	change in momentum = 7.5 (–4.0 – 2.4)	**C1**
	= (–) 48 N s	**A1**
1(b)(iii)	$W = \Delta p / (\Delta)t$ **or** $\Delta mv / (\Delta)t$	**C1**
	= 48 / 4.0 = 12 N	**A1**
	or	
	$W = ma$ **or** mg **or** $m(v – u) / t$	**(C1)**
	= 7.5 × 1.6 **or** 7.5 × (4 + 2.4) / 4.0 = 12 N	**(A1)**
1(c)	speed/velocity decreases so viscous force decreases	**B1**
	viscous force decreases (and weight constant) so resultant force decreases	**B1**

Question 9 — Mark Scheme

Question	Answer	Marks
2(c)	$(\Delta)E = mg(\Delta)h$ **or** $(\Delta)E = W(\Delta)h$	**C1**
	$(\Delta)h = (-)\ 77 / 32$	**C1**
	$(\Delta)h = (-)\ 2.4$ final height = 6.2 – 2.4 = 3.8 m	**A1**
2(d)(i)	$T = kx$ where k is a constant **or** $T = (EA / L)x$ where A is (cross-sectional) area, E is Young modulus, L is (original/unstretched) length	**B1**
2(d)(ii)	$E = \frac{1}{2}kx^2$ **or** $E = \frac{1}{2}Fx$ **and** $F = kx$	**C1**
	$E = 0.65 \times 2^2$ $= 2.6$ J	**A1**
	or	
	$E = \frac{1}{2}Fx$ $0.65 = \frac{1}{2} \times 270 \times x$ and so $x = 4.8 \times 10^{-3}$ m $k = F / x = 270 / 4.8 \times 10^{-3}$ $= 5.6 \times 10^4$	**(C1)**

Question	Answer	Marks
2(d)(ii)	final $E = \frac{1}{2} \times 540 \times 9.6 \times 10^{-3}$ **or** $E = \frac{1}{2} \times (270 \times 2) \times (4.8 \times 10^{-3} \times 2)$ **or** $E = \frac{1}{2} \times 5.6 \times 10^{4} \times (9.6 \times 10^{-3})^{2}$ $= 2.6\,\text{J}$	**(A1)**

Question 10 — Mark Scheme

Question	Answer	Marks
3(a)	$v^2 = u^2 + 2as$ $s = 5.6^2 / (2 \times 9.81)$	C1
	(max height =) $3.1 + 5.6^2 / (2 \times 9.81) = 4.7$ (m)	A1
3(b)	$s = ut + \frac{1}{2}at^2$ $4.7 = \frac{1}{2} \times 9.81 \times t^2$	C1
	$t = 0.98$ s	A1
3(c)	line drawn from a non-zero speed at $t = 0$ to a greater speed at $t = T$	B1
	a single sloping straight line drawn from $t = 0$ to $t = T$	B1
	line starts with a positive non-zero value of v and ends with a negative non-zero value of v	B1
3(d)	acceleration (of the ball)	B1
3(e)(i)	(magnitudes of accelerations are) equal / same	B1
3(e)(ii)	(speeds are) equal / same	B1

Question 11 — Mark Scheme

Question	Answer	Marks
4(a)	sum/total momentum before = sum/total momentum after **or** sum/total momentum (of a system of objects) is constant	**M1**
	if no (resultant) external force/for a closed system	**A1**
4(b)(i)	$(3.0 \times 4.0 \times \cos\theta)$ **or** $(2.5 \times 4.8 \times \cos\theta)$ **or** (5.5×3.7)	**C1**
	$(3.0 \times 4.0 \times \cos\theta) + (2.5 \times 4.8 \times \cos\theta) = (5.5 \times 3.7)$	**C1**
	$\theta = 32°$	**A1**
4(b)(ii)	(initial $E_K = \frac{1}{2} \times 3.0 \times 4.0^2 + \frac{1}{2} \times 2.5 \times 4.8^2$ =) 53 (J) **or** (final $E_K = \frac{1}{2} \times 5.5 \times 3.7^2$ =) 38 (J)	**C1**
	values of initial E_K and final E_K both correct **and** inelastic stated	**A1**

Question 12 — Mark Scheme

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Question	Answer	Marks
2(a)	(time =) displacement / velocity	**C1**
	(time =) 70.0 / 65.0 cos 4.30° = 1.08 (s)	**A1**
2(b)	$s = ut + \frac{1}{2}at^2$ $= (65 \times \sin 4.30° \times 1.08) - (0.5 \times 9.81 \times 1.08^2)$	**C1**
	$s = -0.46$ (m)	**C1**
	height above ground = 1.66 − 0.46 = 1.2 m	**A1**
2(c)	GPE has decreased	**M1**
	(total energy conserved so) KE has increased	**A1**

Question 13 — Mark Scheme

Question	Answer	Marks
3(a)	(velocity =) change in displacement / time	**B1**
3(b)(i)	a = 2400 / 1200 = 2.0 m s^{-2}	**A1**
3(b)(ii)	straight line from the origin with positive gradient (labelled A)	**M1**
	ending at (20, 40)	**A1**
3(c)(i)	line starting at origin (with the same gradient as A) and beneath A at all points	**B1**
	gradient decreasing to zero	**B1**
	straight horizontal line from t = 12 s and ending at t = 20 s (and labelled B)	**B1**
3(c)(ii)	the velocity/speed will increase	**B1**
	to a new terminal/constant/maximum velocity/speed	**B1**
	or	
	the car has an acceleration	**(B1)**
	to a new (higher) terminal/constant/maximum velocity/speed	**(B1)**

Question 14 — Mark Scheme

Question	Answer	Marks
2(a)(i)	$t = 1.8 / 4.9$ $= 0.37$ s	A1
2(a)(ii)	$v = u + at$ $= 9.81 \times 0.37$	C1
	$= 3.6$ m s^{-1}	A1
2(a)(iii)	$v^2 = 3.6^2 + 4.9^2$	C1
	$v = 6.1$ m s^{-1}	A1
	$\theta = \tan^{-1}(3.6 / 4.9)$ $= 36°$	A1
2(b)(i)	$\rho = m / V$	C1
	$V = \frac{4}{3}\pi r^3$	C1
	$\rho = 0.017 / [\frac{4}{3}\pi \times (0.016 / 2)^3]$ $= 7900$ kg m^{-3}	A1
2(b)(ii)	$(E =)$ ½mv^2	C1
	$(E =)$ ½ $\times$ 0.017 $\times$ 4.9^2 = 0.20 (J)	A1

Question	Answer	Marks
2(b)(iii)	$k = F / x$ **or** k = gradient	**C1**
	e.g. $k = 6.4 / 10 \times 10^{-2}$ $= 64\ \text{N m}^{-1}$ (*allow 63–65 N m^{-1}*)	**A1**
2(b)(iv)	$E = ½kx^2$ **or** $E = ½Fx$ **and** $F = kx$	**C1**
	$x_0 = [(2 \times 0.20) / 64]^{0.5}$ $= 0.079$ m or 0.080 m	**A1**
2(c)(i)	same elastic potential energy / same (initial) kinetic energy and (polystyrene ball has) smaller mass (so greater speed) **or** same (average) force and (polystyrene ball has) smaller mass, (so greater average acceleration so greater speed)	**B1**
2(c)(ii)	(for the polystyrene ball there is) less (average vertical) acceleration / smaller (average vertical component of) resultant force (so takes longer time to reach ground)	**B1**

Question 15 — Mark Scheme

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Question	Answer	Marks
2(a)	$F = \rho g V$ $0.071 = 1.2 \times 9.81 \times V$	C1
	$(V = 6.03 \times 10^{-3}\ m^3)$ $4/3 \times \pi \times r^3 = 6.03 \times 10^{-3}$ $r = 0.11$ m	A1
2(b)	$m = 0.053 / 9.81$ $(= 5.4 \times 10^{-3}$ kg)	C1
	$F = 0.071 - 0.053$ (= 0.018 N)	C1
	$a = (0.071 - 0.053) / (0.053 / 9.81)$ $= 3.3\ m\ s^{-2}$	A1
2(c)(i)	$v^2 = u^2 + 2as$ $3.6^2 = (-1.4)^2 + 2 \times 9.81 \times s$ **or** $3.6^2 = 1.4^2 + 2 \times 9.81 \times s$	C1
	$s = 0.56$ m	A1
2(c)(ii)	single straight line from any positive non-zero value of v at $t = 0$ to any negative non-zero value of v at $t = T$	B1
	line starting at (0, 1.4) and ending at (T, –3.6)	B1

Question 16 — Mark Scheme

Question	Answer	Marks
2(a)(i)	(e.g. a =) [16.5 – 0] / [0.30 – 0] = 55 (m s^{-2})	**A1**
2(a)(ii)	(F =) $T - W$	**A1**
2(a)(iii)	$ma = T - mg$ m = 16 / (55 + 9.81)	**C1**
	m = 0.25 kg	**A1**
2(b)(i)	$s = ut + \frac{1}{2}at^2$ **or** $v^2 = u^2 + 2as$ **or** $s = vt - \frac{1}{2}at^2$ **or** $s = \frac{1}{2}(u + v)t$ **or** s = area under graph $s = \frac{1}{2} \times 55 \times 0.30^2$ **or** $s = 16.5^2 / (2 \times 55)$ **or** $s = 16.5 \times 0.30 - \frac{1}{2} \times 55 \times 0.30^2$ **or** $s = \frac{1}{2} \times 16.5 \times 0.30$	**C1**
	s = 2.5 m	**A1**
2(b)(ii)	u = 16.5 (m s^{-1})	**C1**
	$v^2 = u^2 + 2as$ $v^2 = 16.5^2 + 2 \times 9.81 \times 2.5$	**C1**
	v = 18 m s^{-1}	**A1**

Question 17 — Mark Scheme

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Question	Answer	Marks
4(a)	$E = \frac{1}{2}mv^2$	**C1**
	$p = mv$	**C1**
	$m = 0.37^2 / (2 \times 0.30)$ **or** $0.37 / 1.6$ **or** $(0.30 \times 2) / 1.6^2$ $= 0.23$ kg	**A1**
4(b)	$0.37 - 0.65 = -0.13 - p$ $p = 0.15$ kg m s^{-1}	**A1**
4(c)	$7.7 = (0.13 + 0.37) / (\Delta)t$ **or** $7.7 = (0.65 - 0.15) / (\Delta)t$	**C1**
	time = 0.065 s	**A1**

Question 18 — Mark Scheme

Question	Answer	Marks
3(a)	(resultant) force (on an object) is proportional to / equal to the rate of change of momentum	**B1**
3(b)(i)	resultant force = e.g. 6.0 / 4.0 = 1.5 N	**A1**
3(b)(ii)	force X = 1.5 + 2.0 = 3.5 N	**A1**
3(c)	from t = 0 to t = 4.0 s: horizontal line at any non-zero value of X	**B1**
	from t = 0 to t = 4.0 s: horizontal line at X = 3.5 N	**B1**
	from t = 4.0 s to t = 6.0 s: horizontal line at X = 2.0 N	**B1**

Question 19 — Mark Scheme

Question	Answer	Marks
3(a)(i)	rate of change of momentum	**B1**
3(a)(ii)	change in momentum = (1.4 – 0.80) × 3.0	**C1**
	= 1.8 kg m s^{-1}	**A1**
3(b)(i)	resultant force (on block) is zero	**B1**
	(so) velocity is constant	**B1**
3(b)(ii)	$P = Fv$ **or** $P = Fs / t$	**C1**
	v = 2.0 / 0.80 (= 2.5 m s^{-1})	**C1**
	distance = 2.5 × 3.0 = 7.5 m	**A1**
	or	
	$P = W / t$ **or** $P = Fs / t$	**(C1)**
	W = 2.0 × 3.0 (= 6.0 J)	**(C1)**
	distance = 6.0 / 0.80 = 7.5 m	**(A1)**
3(c)	0 to 3.0 s: upward sloping straight line from the origin.	**B1**
	3.0 to 6.0 s: horizontal line at non-zero value of momentum with no 'step change' in momentum at 3.0 s	**B1**

Question 20 — Mark Scheme

Question	Answer	Marks
1(a)	$t = \sqrt{(2s / g)}$ $= \sqrt{[(2 \times 36) / 9.81]}$	**C1**
	$= 2.7$ s	**A1**
1(b)	• reaction time between hearing the splash and stopping the stop-watch • the sound (of the splash) takes time to reach the student **or** the stone hits the water at a different time to the sound being heard **or** the sound (of the splash) has to travel to the student • the student might not let go of the stone from ground level • the student might not let go of the stone and start the stop-watch at the same time • stop-watch may not be properly calibrated / has a zero error • (local value of) g is not (exactly) 9.81 (m s^{-2}) • stone given initial velocity / initial velocity not zero • stone does not fall (exactly) vertically / in a straight line *Any three points, 1 mark each*	**B3**
1(c)	precise: results are close together / have little scatter	**B1**
	not accurate: the values are not close to / 50% different / (very) different from the true value	**B1**

Question 21 — Mark Scheme

Question	Answer	Marks
2(a)	$F = 1050 \times 9.81 \times 0.21V$ **or** $W = \rho \times 9.81 \times V$	**C1**
	$0.21V \times 1050\ (\times 9.81) = V\ (\times 9.81) \times \rho$ $\rho = 220\ \text{kg m}^{-3}$	**A1**
2(b)(i)	$F = 1050 \times 9.81 \times V$ **or** $W = 220 \times 9.81 \times V$	**C1**
	$(V \times 1050 \times 9.81) - (V \times 220 \times 9.81) = (V \times 220) \times a$	**C1**
	$a = 37\ \text{m s}^{-2}$	**A1**
2(b)(ii)	the (downward) drag / viscous force increases (with speed)	**M1**
	resultant force decreases (as upthrust and weight remain the same)	**M1**
	acceleration decreases (as its velocity increases)	**A1**

Question 22 — Mark Scheme

Question	Answer	Marks
3(a)	sum / total momentum before = sum / total momentum after **or** sum / total momentum (of a system of objects) is constant	**M1**
	if no (resultant) external force / for an isolated system	**A1**
3(b)(i)	$3m \times 4 = m \times v \sin \theta$ ($v \sin \theta = 12$)	**C1**
	$2m \times 6 = m \times v \cos \theta$ ($v \cos \theta = 12$)	**C1**
	therefore $\sin \theta = \cos \theta$ **or** $\tan \theta = 1$ $\theta = 45°$	**A1**
3(b)(ii)	$mv \times \cos 45° = 12m$ **or** $mv \times \sin 45° = 12m$ **or** $(mv)^2 = (3m \times 4)^2 + (2m \times 6)^2$	**C1**
	$v = 17$ m s^{-1}	**A1**
3(c)(i)	(chemical energy) $= 0.0050 \times 700 = 3.5$ (J) **or** (chemical energy) $= 5.0 \times 0.700 = 3.5$ (J)	**A1**

Question	Answer	Marks
3(c)(ii)	$E = ½mv^2$	**C1**
	total $E = (0.5 \times 3m \times 4^2) + (0.5 \times 2m \times 6^2) + (0.5 \times m \times 17^2)$	**C1**
	$3.5 = 204m$ $m = 0.017$ kg	**A1**

Question 23 — Mark Scheme

Question	Answer	Mark
2(a)(i)	arrow upwards (↑) **and** labelled upthrust / U arrow downwards (↓) **and** labelled weight / W / mg arrow downwards (↓) **and** labelled tension / T *1 mark: One or two correctly labelled arrows* *2 marks: Three correctly labelled arrows*	**B2**
2(a)(ii)	$U = T + W$ **or** upthrust = tension + weight	**C1**
	$\rho Vg = T + W$ $V = [(4.00 \times 10^2) + (3.39 \times 10^4)] / (1.23 \times 9.81)$	**C1**
	$V = 2.84 \times 10^3\ m^3$	**A1**
2(a)(iii)	$m = W / g$ **or** $a = F / m$	**C1**
	$a = (4.00 \times 10^2) / [(3.39 \times 10^4) / 9.81)]$	**C1**
	$a = 0.12\ m\ s^{-2}$	**A1**
2(b)	there is air resistance (which increases with speed)	**B1**
	(average) resultant force is less (than weight)	**B1**
	(average) acceleration is less (than g / 9.81, so speed is less than 100 $m\ s^{-1}$)	**B1**
2(c)(i)	(extension =) $2.5 \times 2.4 \times 10^{-5} = 6.0 \times 10^{-5}$ (m)	**A1**

Question	Answer	Mark
2(c)(ii)	$E_{(P)} = \frac{1}{2} Fx$ **or** $E_{(P)} = \frac{1}{2} kx^2$ **and** $F = kx$	**C1**
	$E_{(P)} = \frac{1}{2} \times 4.00 \times 10^2 \times 6.0 \times 10^{-5}$ **or** $E_{(P)} = \frac{1}{2} \times 6.7 \times 10^6 \times (6.0 \times 10^{-5})^2$ $E_{(P)} = 0.012\ \text{J}$	**A1**
2(c)(iii)	longer extension **or** smaller spring constant	**M1**
	elastic potential energy is greater	**A1**

Question 24 — Mark Scheme

Question	Answer	Mark
3(a)	displacement	**A1**
3(b)(i)	a = gradient **or** $a = \Delta v / (\Delta)t$ **or** $a = (v - u) / t$	**C1**
	e.g. $a = (0.30 - 0.12) / (0.35 - 0.15)$ $a = 0.90$ m s^{-2}	**A1**
3(b)(ii)	$(0.25 \times 0.48) + (0.75 \times 0.12) = (0.25\ v) + (0.75 \times 0.30)$ **or** $(0.48 - 0.12) = (0.30 - v)$ **or** $(½ \times 0.25 \times 0.48^2) + (½ \times 0.75 \times 0.12^2) = (½ \times 0.25 \times v^2) + (½ \times 0.75 \times 0.30^2)$	**C1**
	$v = (-)0.060$ m s^{-1}	**A1**
	direction: to the left / from the right / opposite to (its) initial velocity / opposite to (initial / final) velocity of B	**B1**
3(c)	sketch: horizontal line from (0, 0.48) to (0.15, 0.48)	**B1**
	horizontal line from (0.35, –0.06) to (0.5, –0.06)	**B1**
	straight line between (0.15, 0.48) and (0.35, –0.06)	**B1**

Question 25 — Mark Scheme

Question	Answer	Marks
1(a)	only electric current **and** time underlined	**B1**
1(b)	initial speed / velocity is zero	**B1**
	(non-zero magnitude of) acceleration is constant / uniform (and in a straight line)	**B1**
1(c)(i)	• magnitude of acceleration at t = 8.0 s is less than that at t = 14.0 s	**B1**
	• direction of acceleration at t = 8.0 s is opposite to that at t = 14.0 s	**B1**
1(c)(ii)	a = gradient **or** $a = (v - u) / t$ **or** $a = \Delta v / (\Delta)t$	**C1**
	a = e.g. $(20 + 10) / 12$ **or** $(0 + 10) / 4$ **or** $(20 - 0) / (12 - 4)$ $a = 2.5\ \text{m s}^{-2}$	**A1**
1(c)(iii)	displacement = $[\frac{1}{2} \times (12 - 4) \times 20] - [\frac{1}{2} \times 4 \times 10]$ **or** displacement = $(-10 \times 12) + (\frac{1}{2} \times 2.5 \times 12^2)$ **or** displacement = $(20 \times 12) - (\frac{1}{2} \times 2.5 \times 12^2)$ **or** displacement = $\frac{1}{2} \times (20 - 10) \times 12$	**C1**
	displacement = 60 m	**A1**

Question 26 — Mark Scheme

Question	Answer	Marks
2(a)	$65 = \rho g V$ **or** $65 = mg$ **and** $m = \rho V$	**C1**
	$\rho = 65 / (9.81 \times 7.5)$ $= 0.88\ \text{kg m}^{-3}$	**A1**
2(b)(i)	acceleration = $9.8\ \text{m s}^{-2}$	**A1**
2(b)(ii)	air resistance (acting on sphere) increases	**B1**
	resultant force (on sphere) decreases	**B1**
	(magnitude of) acceleration decreases	**B1**
2(c)	$F = ma$ $= 4.0 \times 1.9$ (= 7.6 N)	**C1**
	resistive force = $(4.0 \times 9.81) - (4.0 \times 1.9)$ = 32 N	**A1**

Question 27 — Mark Scheme

Question	Answer	Marks
4(a)(i)	component of momentum = $0.25 \times 3.7 \times \sin 27°$	C1
	= 0.42 N s	A1
4(a)(ii)	$m_{(Z)} \times 5.5 \times \sin 44° = 0.42$ **or** $m_{(Z)} \times 5.5 \times \sin 44° = 0.25 \times 3.7 \times \sin 27°$ $m_Z = 0.11$ kg	A1
4(a)(iii)	magnitudes: equal	B1
	directions: opposite	B1
4(b)	$4 + 6 = 2 + v$ $v = 8$ m s^{-1}	A1

Question 28 — Mark Scheme

Question	Answer	Marks
2(a)(i)	(time / t =) 9(.0) / 9.5 = 0.95 (s)	**A1**
2(a)(ii)	(u_V) = 9.5 tan 38° **or** 9.5 / tan 52° **or** 9.5 = u cos 38° **and** u_V = u sin 38° **or** 9.5 = u cos 38° **and** $u_V = (u^2 - 9.5^2)^{½}$	**C1**
	u_V = 7.4 m s^{-1}	**A1**
2(a)(iii)	$s = ut + ½at^2$ (h =) 7.4 × 0.95 – ½ × 9.81 × 0.95^2	**C1**
	h = 2.6 m	**A1**
2(b)	(collision is) inelastic	**B1**

Question 29 — Mark Scheme

Question	Answer	Marks
3(a)	resultant force (in any direction) is zero	B1
	resultant moment / torque (about any point) is zero	B1
3(b)(i)	$F = \rho Vg$ $V = 93\,000 / (1.2 \times 9.81)$ $= 7900\ \text{m}^3$	A1
3(b)(ii)	weight = $93\,000 + 3(.0) \times 10^3$	C1
	$m = (93\,000 + 3.0 \times 10^3) / 9.81$ $= 9800\ \text{kg}$	A1
3(c)(i)	$(\Delta p) = F(\Delta)t$ **or** $F = \Delta p / (\Delta)t$ **or** F = rate of change of momentum **or** $F = m\,(v - u) / t$	C1
	$\Delta p = 2800 \times 0.50$ $= 1400\ \text{kg m s}^{-1}$	A1
3(c)(ii)	$(\Delta p =)\ mv$	C1
	$v = 1400 / 64$ $= 22\ \text{m s}^{-1}$	A1

Question	Answer	Marks
3(c)(iii)	$E_K = ½mv^2$	**C1**
	$= ½ \times 64 \times 22^2$ $= 15\,000$ J	**A1**
	or	
	$E_K = p^2 / 2m$	**(C1)**
	$= 1400^2 / (2 \times 64)$ $= 15\,000$ J	**(A1)**

Question 30 — Mark Scheme

9702/22 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** February/March 2024

Question	Answer	Marks
2(a)	rate of change of velocity	B1
2(b)	$\frac{1}{2} m(\Delta)v^2 = mg(\Delta)h$	C1
	$v^2 = 5.9^2 + 2 \times 9.81 \times 7.8$ $v^2 = 188$	C1
	$v = 14\ \text{m s}^{-1}$	A1
	or by resolving components Vertically: $v^2 = u^2 + 2as$ $v^2 = (5.9\sin 60)^2 + 2 \times -9.81 \times (1.2 - 9.0)$ $v_v = 13.4$	(C1)
	horizontally: $v_h = 5.9\cos 60$ $v_h = 2.95$	(C1)
	resultant velocity $= \sqrt{(13.4^2 + 2.95^2)}$ $= 14\ \text{m s}^{-1}$	(A1)
2(c)(i)	(As the diver moves down their) speed decreases	B1
	(So) viscous force / drag (force) decreases	B1
2(c)(ii)	$(F =)\ \rho g V$ $= 1000 \times 9.81 \times 7.5 \times 10^{-2} = 740$ (N)	A1

Question	Answer	Marks
2c(iii)	resultant force = 740 + 950 – (78 × 9.81) = 925	C1
	acceleration = F / m	C1
	= 925 / 78 = 12 m s^{-2}	A1
	(vertically) upwards	B1

Question 31 — Mark Scheme

9702/21 Cambridge International AS & A Level – Mark Scheme May/June 2024
PUBLISHED

Question	Answer	Marks
1(a)	units of F_D: kg m s^{-2}	**M1**
	units of ρ: kg m^{-3} **and** units of A: m^2 **and** units of v: m s^{-1} **or** units of v^2: m^2 s^{-2}	**M1**
	kg m s^{-2} = C kg m s^{-2} **and** comment '(so) C has no units' / unit terms cancelled **or** C = kg m s^{-2} / (kg m^{-3} m^2 m^2 s^{-2}) **and** comment '(so) C has no units' / unit terms cancelled	**A1**
1(b)	one arrow vertically downward labelled weight to within 10° of the vertical	**B1**
	one arrow vertically upwards labelled drag / drag force / F_D / air resistance / viscous force to within 10° of the vertical	**B1**
1(c)	(at terminal velocity) $F_D = mg$	**C1**
	$F_D = 0.049 \times 9.81$ $= 0.48$ N	**A1**
1(d)	area = $\pi \times (0.060 / 2)^2$	**C1**
	$0.48 = ½ \times C \times 1.2 \times \pi \times (0.060 / 2)^2 \times 25^2$	**C1**
	$C = 0.45$	**A1**

Question 32 — Mark Scheme

Question	Answer	Marks
2(a)	change in displacement / time (taken)	**B1**
2(b)(i)	horizontal velocity = $22 \times \cos 40°$	**C1**
	time taken = $36 / (22 \times \cos 40°)$ = 2.1 s	**A1**
2(b)(ii)	$u = 22 \times \sin 40°$ = 14 m s^{-1}	**A1**
2(b)(iii)	$s = ut + ½ at^2$ $= (14 \times 2.1) + (½ \times -9.81 \times 2.1^2)$	**C1**
	= 7.8 (m)	**C1**
	(therefore) height of wall = 7.8 + 1.2 = 9.0 m	**A1**

Question	Answer	Marks
2(b)(iii)	**or**	
	other methods possible e.g. time to maximum height = (0 – 14) / –9.81 (= 1.43 s) time from maximum height to wall = 2.1 – 1.43 (= 0.67 s) maximum height above release = (14 × 1.43) + (½ × −9.81 × 1.43^2) = 9.99 (m)	**(C1)**
	height from maximum to wall = 0.5 × 9.81 × 0.67^2 (= 2.2 m) height above release = 9.99 – 2.2 = 7.8 (m)	**(C1)**
	height of wall = 1.2 + 7.8 = 9.0 m	**(A1)**

Question 33 — Mark Scheme

Question	Answer	Marks
3(a)	sum / total momentum before (a collision) = sum / total momentum after (a collision) **or** sum / total momentum (of a system) is constant	**M1**
	if no (resultant) external force (acts) / for an isolated system	**A1**
3(b)	along direction of motion: $10m = 2mv \cos 30° + 3mw \cos 30°$	**C1**
	perpendicular to direction of motion: $2mv \cos 60° = 3mw \cos 60°$ $(v = 3w / 2)$	**C1**
	$v = 2.9\ \text{m s}^{-1}$	**A1**
	$w = 1.9\ \text{m s}^{-1}$	**A1**
3(c)	$E_K = ½ \times m \times v^2$ $(= ½ \times 4.2 \times 6.0^2)$ $(= 76\ \text{J})$	**C1**
	force = work done / distance	**C1**
	force = 76 / 0.050 = 1500 N	**A1**

Question	Answer	Marks
3(c)	**or**	
	$a = (-)u^2 / 2s$ $= (-)6.0^2 / (2 \times 0.050)$ $(= (-)360\ m\ s^{-2})$	**(C1)**
	$F = ma$	**(C1)**
	$F = 4.2 \times 360$ $= 1500\ N$	**(A1)**
	or	
	$a = (-)u^2 / 2s$ $= (-)6.0^2 / (2 \times 0.050)$ $(= (-)360\ m\ s^{-2})$	**(C1)**
	$t = -u / a$ $= -6.0 / -360\ (= 0.017\ s)$ $F = \Delta p / t$	**(C1)**
	$F = (0 - 4.2 \times 6) / 0.017$ $= 1500\ N$	**(A1)**

Question 34 — Mark Scheme

Question	Answer	Marks
2(a)(i)	39 m s^{-1}	**A1**
2(a)(ii)	tangent line to curve drawn on Fig. 2.1	**C1**
	a = gradient of tangent line = $\Delta v / \Delta t$ e.g. = (44 – 26) / (18 – 0) 0.9 ⩽ a ⩽ 1.1 m s^{-2}	**A1**
2(b)	$(\Sigma)F$ = 68 × 9.81 – 1800 (= –1133 N)	**C1**
	a = $(\Sigma)F / m$ = – 1133 / 68 = (–)17 m s^{-2}	**A1**
	upwards	**B1**
2c(i)	drag force decreases (as speed decreases)	**B1**
	(as speed decreases) resultant force decreases so (magnitude of) acceleration decreases (to zero)	**B1**
2(c)(ii)	$(\Delta)p$ = $m\Delta v$ **or** $(\Delta)p = m(v – u)$	**C1**
	= 68 × (5.7 – 39) = (–)2300 N s	**A1**

Question 35 — Mark Scheme

Question	Answer	Marks
3(a)	extension is proportional to (applied) force	**B1**
3(b)(i)	P at (60, 5.4)	**A1**
3(b)(ii)	E at (80, 5.9)	**A1**
3(c)(i)	$k = F / x$ **or** k = gradient of (straight line section of) graph	**C1**
	e.g. gradient = 5.4 / 0.060 $k = 90\ \text{N m}^{-1}$	**A1**
3(c)(ii)	Young modulus or $E = \sigma / \varepsilon$ **or** FL / Ax **or** kL / A	**C1**
	$E = (5.4 \times 3.2) / (4.0 \times 10^{-7} \times 0.06)$ **or** $90 \times 3.2 / (4.0 \times 10^{-7})$	**C1**
	$E = 7.2 \times 10^{8}$ Pa	**A1**
3(d)	work done = area under graph	**B1**
	= (1.0 ± 0.2) J	**A1**
3(e)	the extension will be smaller (for the same force on the thicker sample) **or** a greater force is required (to extend the thicker sample by the same amount) **or** spring constant is proportional to area	**M1**
	the spring constant (of the second sample) will be greater	**A1**

Question 36 — Mark Scheme

Question	Answer	Marks
2(a)	product of mass and velocity	**B1**
2(b)(i)	maximum speed = $7.2 \times 10^4 / 1800$ = 40 m s^{-1}	**A1**
2(b)(ii)	kinetic energy = $\frac{1}{2} mv^2$	**C1**
	= $\frac{1}{2} \times 1800 \times 40^2$ = 1.4×10^6 J	**A1**
2(b)(iii)	a = gradient of line / mass **or** $a = (v - u) / t$ **or** $a = \Delta v / t$	**C1**
	a = e.g. $(3.6 \times 10^4) / (4.0 \times 1800) = 5.0$ m s^{-2} **or** a = e.g. $20 (- 0) / 4 = 5.0$ m s^{-2} **or** F = e.g. $3.6 \times 10^4 / 4.0 = 9.0 \times 10^3$ **and** $a = 9.0 \times 10^3 / 1800 = 5.0$ m s^{-2}	**A1**
2(b)(iv)	distance = $\frac{1}{2} \times 40 \times (8 + 4)$ **or** distance = $\frac{1}{2} \times 72\,000 \times (8 + 4) / 1800$ **or** distance = $[40^2 / (2 \times 5)] + [40^2 / (2 \times 10)]$ **or** distance = $\frac{1}{2} \times 5 \times 8^2 + (40 \times 4 - \frac{1}{2} \times 10 \times 4^2)$	**C1**
	distance = 240 m	**A1**

Question	Answer	Marks
2(c)	stepped shape, showing one constant value up to 8.0 s then stepping to a different constant value from 8.0 s with no time delay	**B1**
	horizontal straight line from (0, 5.0) to (8.0, 5.0)	**B1**
	horizontal straight line from (8.0, –10.0) to (12.0, –10.0)	**B1**

Question 37 — Mark Scheme

Question	Answer	Marks
2(a)	product of mass and velocity	**B1**
2(b)	$F = m\Delta v / \Delta t$ $= 16 \times 0.60 / 1.1$	**C1**
	$= 8.7$ N	**A1**
2(c)	$x = ut + \frac{1}{2}at^2$ $x = 0.60 \times 3.7 + \frac{1}{2} \times 0.85 \times 3.7^2$	**C1**
	or	
	$v = 0.60 + 0.85 \times 3.7$ (= 3.75 m s^{-1}) $x = 3.75 \times 3.7 - 0.5 \times 0.85 \times 3.7^2$ **or** $x = \frac{1}{2} \times (0.60 + 3.75) \times 3.7$ **or** $x = (3.75^2 - 0.60^2) / (2 \times 0.85)$	**(C1)**
	$x = 8.0$ m	**A1**
2(d)(i)	$F = W / s$	**C1**
	$= 250 / 18$ $= 14$ N	**A1**
2(d)(ii)	any line starting at distance = 0 and a positive non-zero value of kinetic energy	**B1**
	a straight line from distance = 0 to distance = x with positive gradient	**B1**
	a straight horizontal line at a non-zero value of kinetic energy starting at distance = x and ending at distance = x + 18 m that is continuous with the previous line	**B1**

Question 38 — Mark Scheme

9702/23 Cambridge International AS & A Level – Mark Scheme October/November 2024
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Question	Answer	Marks
1(a)	rate of change of velocity	**B1**
1(b)(i)	curved path from aircraft to ground, starting horizontal at aircraft and then with increasing negative gradient as it moves towards the ground	**B1**
1(b)(ii)	$s = ut + \frac{1}{2}at^2$ $63 = \frac{1}{2} \times 9.81 \times t^2$	**C1**
	time = 3.6 s	**A1**
1(b)(iii)	$v^2 = 2 \times 9.81 \times 63$ **or** $v = 0 + (9.81 \times 3.6)$ **or** $63 = (v \times 3.6) - (\frac{1}{2} \times 9.81 \times 3.6^2)$ **or** $63 = \frac{1}{2} \times (0 + v) \times 3.6$ $v = 35\ \text{m s}^{-1}$	**A1**
1(b)(iv)	$\text{speed}^2 = 35^2 + 42^2$	**C1**
	speed = 55 m s^{-1}	**A1**

Question 39 — Mark Scheme

Question	Answer	Marks
2(a)	sum / total momentum (of a system of bodies) is constant **or** sum / total momentum before = sum / total momentum after	**M1**
	for an isolated system / no (resultant) external force	**A1**
2(b)(i)	$240 \times 16 = 480v$ and so $v = 8.0\ \text{m s}^{-1}$ **or** (initial momentum =) 240×16 (= 3840 g m s^{-1}) **and** $v = 3840 / 480 = 8.0\ \text{m s}^{-1}$	**A1**
2(b)(ii)	(E_K =) $\frac{1}{2} mv^2$	**C1**
	$\Delta E_K = \frac{1}{2} [(0.24 \times 16^2) - (0.48 \times 8.0^2)]$	**C1**
	= 15 J	**A1**
2(c)(i)	$F = (0.24 \times 16) / (2.0 \times 10^{-3})$ **or** $F = (0.48 \times 8) / (2.0 \times 10^{-3})$	**C1**
	= 1900 N	**A1**
	direction: to the left	**B1**
2(c)(ii)	equal (magnitude)	**B1**
	opposite (direction)	**B1**

Question 40 — Mark Scheme

Question	Answer	Marks
3(a)(i)	$a = (v^2 - u^2) / 2s$ $= (22^2 - 13^2) / (2 \times 180)$	C1
	$= 0.88\ \text{m s}^{-2}$	A1
	OR [$t = (180 \times 2) / (22 + 13) = 10.3$] $180 = 13 \times 10.3 + ½ a \times 10.3^2$ or $180 = 22 \times 10.3 - ½ a \times 10.3^2$ or $22 = 13 + a \times 10.3$	(C1)
	$a = 0.88\ \text{m s}^{-2}$	(A1)
3(a)(ii)	$(\Delta)E = ½m(\Delta)v^2$	C1
	gain in KE $= ½m(v^2 - u^2)$ $= ½ \times 9400 \times (22^2 - 13^2)$	C1
	$= 1.5 \times 10^6$ J	A1
	OR $W = Fs$ $= ma \times d$	(C1)
	gain in KE $= 9400 \times 0.88 \times 180$	(C1)
	$= 1.5 \times 10^6$ J	(A1)
3(b)(i)	rate of change of momentum	B1
3(b)(ii)	(Force =) $(2.5 \times 10^4 - 21 \times 10^4) / 15 = -1.2 \times 10^4$ (N)	A1

Question	Answer	Marks
3(b)(iii)	The change of momentum (for S and R to come to rest) is the same	**B1**
	(Average) force on R (to come to rest) is (–21 × 10^4 / 23 =) 0.91 × 10^4 N **or** (Average) force on R (to come to rest) is less than the force on S / less than *F*	**B1**
	(S will come to rest in) less time (than R).	**B1**
	OR The change of momentum (for S and R to come to rest) is the same	**(B1)**
	Time for S to come to rest is (–21 × 10^4 / 1.2 × 10^4 =) 17.5 s (and time for R to come to rest is 23 s)	**(B1)**
	(S comes to rest in) less time (than R).	**(B1)**

Question 41 — Mark Scheme

Question	Answer	Marks
1(a)	rate of change of velocity	**B1**
1(b)(i)	$s = ut + \frac{1}{2}at^2$ **and** $u = 0$ or $s = \frac{1}{2}at^2$ $t = \sqrt{(2 \times 14 / 9.81)}$	**C1**
	$t = 1.7$ s	**A1**
	OR $v = \sqrt{(0^2 + 2 \times 9.81 \times 14)}$ $v = 17$ (m s^{-1}) $17 = (0 + 9.81) \times t$ **or** $17 = 9.81 \times t$ or $14 = \frac{1}{2} \times (0 + 17) \times t$ **or** $14 = \frac{1}{2} \times 17 \times t$	**(C1)**
	$t = 1.7$ s	**(A1)**
1(b)(ii)	$s = ut + \frac{1}{2}at^2$ $u = (3.6 - \frac{1}{2} \times 9.81 \times 1.7^2) / 1.7$	**C1**
	$u = (-) 6.2$ m s^{-1}	**A1**
	OR $v = (3.6 + \frac{1}{2} \times 9.81 \times 1.7^2) / 1.7$ $v = 10$ (m s^{-1}) $10 = u + 9.81 \times 1.7$ or $10^2 = u^2 + (2 \times 9.81 \times 3.6)$ or $3.6 = \frac{1}{2} \times (u + 10) \times 1.7$	**(C1)**
	$u = (-) 6.2$ m s^{-1}	**(A1)**

Question	Answer	Marks
1(c)(i)	Less time (as it reaches a lower height)	**B1**
	(because) the initial vertical (component of the) velocity is smaller (than in part **(b)**)	**B1**
1(c)(ii)	The (total) initial energy is the same (as in part **(b)**)	**B1**
	change in gravitational potential energy is same, so speed is the same	**B1**

Question 42 — Mark Scheme

Question	Answer	Marks
4(a)	The (total) kinetic energy changes / decreases so (the collision is) inelastic	B1
	OR (relative) speed of approach not equal to / greater than (relative) speed of separation so (collision is) inelastic	(B1)
4(b)(i)	$p = mv$ **or** 0.25×3.6 **or** 0.25×5.2 $\Delta p = 0.25 \times (3.6 + 5.2)$	C1
	$= 2.2$ kg m s^{-1}	A1
4(b)(ii)	$F = \Delta p / (\Delta)t$ $= 2.2 / 0.18$	C1
	$= 12$ N	A1
	OR $F = ma$ **and** $a = (v–u) / t$ $= m\Delta v / t$ $= 0.25 \times (3.6 + 5.2) / 0.18$	(C1)
	$= 12$ N	(A1)

Question	Answer	Marks
4(c)	$\frac{1}{2} mv^2 = mg(\Delta)h$ $\frac{1}{2} \times 0.25 \times 5.2^2 = 0.25 \times g \times h_1$ $h_1 = 5.2^2 / 2g$ $h_1 = 1.38$	**C1**
	$\frac{1}{2} \times 0.25 \times 3.6^2 = 0.25 \times g \times h_2$ $h_2 = 3.6^2/2g$ $h_2 = 0.66$ $h_2 / h_1 = 0.66 / 1.38$	**C1**
	ratio = 0.48	**A1**

Question 43 — Mark Scheme

Question	Answer	Marks
2(a)	product of mass and velocity	**B1**
2(b)	change in momentum = (–1.4) – (+2.8) = (–) 4.2 kg m s^{-1}	**A1**
2(c)	$F = \Delta p / (\Delta)t$ **or** F = gradient = 4.2 / 12	**C1**
	= 0.35 N	**A1**
2(d)	constant / uniform (rate of) decrease (of speed to zero).	**B1**

Question	Answer	Marks
2(e)	• The (resultant) force is constant / does not decrease • air resistance would vary / decrease / not constant • the force is not zero when speed / velocity is zero / at 8 s Any two of the above 3 marking points (1 mark each, max 2)	**B2**
2(f)	line from origin with decreasing positive gradient	**B1**
	gradient changes from positive to negative at 8.0 s	**B1**
	after t = 8.0 s the line has a negative gradient of increasing magnitude and a positive value of d at t = 12 s	**B1**

Question 44 — Mark Scheme

Question	Answer	Marks
1(a)	rate of change of velocity	B1
1(b)(i)	acceleration = 320 / 20 = 16 m s^{-2}	A1
1(b)(ii)	$s = \frac{1}{2}((u) + v)t$ **or** distance = area under graph	C1
	(height) = $\frac{1}{2} \times 20 \times 320$ = 3200 m **or** 3.2 km	A1
1(c)(i)	$(\Delta E_P) = mg\Delta h$	C1
	= $2.9 \times 10^6 \times 9.81 \times 3200$ = 9.1×10^{10} J	A1
1(c)(ii)	$(\Delta E_K) = \frac{1}{2} m\Delta(v^2)$	C1
	= $\frac{1}{2} \times 2.9 \times 10^6 \times 320^2$ = 1.5×10^{11} J	A1
1(c)(iii)	(power =) work done / time	C1
	power = $((1.5 + 0.91) \times 10^{11}) / 20$ = 1.2×10^{10} W	A1

Question 45 — Mark Scheme

Question	Answer	Marks
2(a)(i)	60 × 1.6 (= 96 N m) **or** 220 × 0.40 (= 88 N m)	**C1**
	resultant moment = 96 – 88 = 8.0 N m	**A1**
2(a)(ii)	the resultant force (of A and C) is not zero **or** forces (from A and C) are not parallel **or** forces (from A and C) are not equal (magnitude) **or** forces (from A and C) are not opposite (direction) **or** forces (from A and C) act through the same point so (they are) not a couple	**B1**
2(b)	line with a positive gradient from (t_1, 0) to t_2	**B1**
	line with increasing positive gradient from t_1 to t_2	**B1**
2(c)(i)	sum / total momentum before = sum / total momentum after **or** sum / total momentum (of a system of objects) is constant	**M1**
	if no (resultant) external force / for an isolated system	**A1**

Question 46 — Mark Scheme

Question	Answer	Marks
1(a)	rate of change of velocity	B1
1(b)(i)	acceleration = 320 / 20	A1
	= 16 m s^{-2}	
1(b)(ii)	$s = \frac{1}{2}((u) + v)t$ **or** distance = area under graph	C1
	(height) = $\frac{1}{2} \times 20 \times 320$ = 3200 m **or** 3.2 km	A1
1(c)(i)	$(\Delta E_P) = mg\Delta h$	C1
	= $2.9 \times 10^6 \times 9.81 \times 3200$	A1
	= 9.1×10^{10} J	
1(c)(ii)	$(\Delta E_K) = \frac{1}{2} m\Delta(v^2)$	C1
	= $\frac{1}{2} \times 2.9 \times 10^6 \times 320^2$	A1
	= 1.5×10^{11} J	
1(c)(iii)	(power =) work done / time	C1
	power = $((1.5 + 0.91) \times 10^{11}) / 20$	A1
	= 1.2×10^{10} W	

End of Mark Scheme • Waseem Ahmad, A Level Physics Teacher • examspath.com