CAMBRIDGE INTERNATIONAL AS & A LEVEL • PHYSICS 9702

Topical Questions

Unit 4: Moment of Force

Past Papers 2021 – 2025

MARK SCHEME 16 Questions

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Question 1 — Mark Scheme

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Question	Answer	Marks
3(a)	force × distance	M1
	perpendicular distance of (line of action of) force from the point	A1
3(b)(i)	distance moved by pointer = 123 – 86 (= 37 mm)	C1
	(extension =) 37 × (1.8 / 52.6) = 1.3 (mm) **or** sin or tan θ = 37 / 526 (so θ = 4.0° so extension =) sin or tan θ × 18 = 1.3 (mm)	A1
3(b)(ii)	moment = $0.472 \times 9.81 \times 6.2 \times 10^{-2}$	C1
	= 0.29 N m	A1
3(b)(iii)	$(\Delta)F \times 1.8 \times 10^{-2} = 0.29$	C1
	ΔF = 16 N	A1
3(b)(iv)	$k = F / x$	C1
	= $16 / (1.3 \times 10^{-3})$ = 1.2×10^{4} N m^{-1}	A1

Question 2 — Mark Scheme

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Question	Answer	Marks
2(a)	point where (all) the weight (of the object) is taken to act	**B1**
2(b)(i)	moments about P are: $(F \times 1.10)$, (44.0×0.60) and (3.0×2.90) *1 mark for any one correct moment and 2 marks for two correct moments*	**C2**
	$(F \times 1.10) = (44.0 \times 0.60) + (3.0 \times 2.90)$ $F = 32$ N	**A1**
2(b)(ii)	force = 32 + 44 + 3 = 79 N	**A1**
2(c)(i)	$(F = \rho g V)$ $V = 2.5 / (1100 \times 9.81)$ $(= 2.32 \times 10^{-4})$	**C1**
	$V = (4/3)\pi r^3$	**C1**
	$r = [(3 \times 2.32 \times 10^{-4}) / 4\pi]^{1/3}$ $r = 0.038$ m	**A1**
2(c)(ii)	resultant moment = 2.5×2.9 = 7.3 N m **or** resultant moment = $F \times 1.1 - (44 \times 0.6 + 0.5 \times 2.9)$ = 7.3 N m (allow 7.2 N m or 7.4 N m from rounded values of F)	**A1**
	direction: anticlockwise	**A1**

Question 3 — Mark Scheme

Question	Answer	Marks
4(a)	$E = \frac{1}{2}mv^2$	C1
	$= \frac{1}{2} \times 0.25 \times 2.3^2$ $= 0.66$ J	A1
4(b)	$E = \frac{1}{2}kx^2$ **or** $E = \frac{1}{2}Fx$ **and** $F = kx$	C1
	$x = [(2 \times 0.66) / 420]^{0.5}$ $= 0.056$ m	A1
	or	
	$E = \frac{1}{2}kx^2$	(C1)
	$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$ $x = (0.25 \times 2.3^2 / 420)^{0.5}$ $= 0.056$ m	(A1)
4(c)(i)	(p =) 0.25×2.3 **or** 0.25×1.5	C1
	change in momentum = $0.25 (2.3 + 1.5)$ $= 0.95$ N s	A1
4(c)(ii)	resultant force = $0.95 / 0.086$ or $0.25 \times (2.3 + 1.5) / 0.086$ $= 11$ N	A1
4(d)	curved line from the origin with an increasing gradient	B1

Question 4 — Mark Scheme

Question	Answer	Marks
3(a)	sum of CW moments = sum of ACW moments	**M1**
	about the same point for (an object in rotational) equilibrium	**A1**
3(b)	moment = $0.3(0) \times 0.29 \cos 40°$ **or** $0.3(0) \times 0.222$	**C1**
	= 0.067 N m	**A1**
3(c)(i)	$k = F / x$ **or** k = gradient	**C1**
	e.g. $k = 21 / 10 \times 10^{-3}$ $k = 2100\ \text{N m}^{-1}$	**A1**
3(c)(ii)	$V_{(\text{sphere})} = \frac{4}{3} \times \pi \times (0.0480)^3$	**C1**
	$F = \rho g V$ (upthrust =) $1000 \times 9.81 \times (\frac{4}{3} \times \pi \times (0.048)^3) \times 0.26(0) = 1.18$ (N)	**A1**
3(c)(iii)	1.18×0.29 **or** 0.30×0.29 **or** $F \times 0.017$	**C1**
	$(1.18 \times 0.29) = (0.30 \times 0.29) + (F \times 0.017)$ F = 15 N	**A1**

Question	Answer	Marks
3(c)(iv)	$E_{(P)} = \frac{1}{2}kx^2$ **or** $E_{(P)} = \frac{1}{2}Fx$	**C1**
	$x = F / k = 15 / 2100$ **or** x determined from graph for $F = 15.0$ N $E_P = \frac{1}{2} \times 2100 \times (15 / 2100)^2$ **or** $E_P = \frac{1}{2} \times 15 \times (15 / 2100)$ $E_P = 0.054$ J	**A1**
3(d)	the sphere has gained gravitational potential energy	**B1**

Question 5 — Mark Scheme

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Question	Answer	Marks
3(a)	resultant force (in any direction) is zero	**B1**
	resultant moment/torque (about any point) is zero	**B1**
3(b)	(component =) $17\sin 50^\circ = 13$ (N) **or** $17\cos 40^\circ = 13$ (N)	**A1**
3(c)	$(W \times 0.25)$ **or** (12×0.35) **or** (13×0.50)	**C1**
	$(W \times 0.25) + (12 \times 0.35) = (13 \times 0.50)$ $W = 9.2$ N	**A1**
3(d)	$F = 9.2 + 12 - 13$ $= 8$ N	**A1**
3(e)	decrease	**B1**

Question 6 — Mark Scheme

Question	Answer	Marks
2(a)(i)	(component =) 4.8 sin 30° = 2.4 (N)	**A1**
2(a)(ii)	(8.2 × 0.50) **or** (*W* × 0.60) **or** (0.30 × 0.80) **or** (2.4 × 1.2)	**C1**
	(8.2 × 0.50) = (*W* × 0.60) + (0.30 × 0.80) + (2.4 × 1.2)	**C1**
	W = 1.6 N	**A1**
2(a)(iii)	force = 4.8 cos 30° = 4.2 N	**A1**
2(b)	*E* = ½*Fx*	**C1**
	0.32 = ½ × 8.2 × *x* *x* = 0.078 m	**A1**

Question 7 — Mark Scheme

Question	Answer	Marks
2(a)	the point where (all) the weight (of the object) is taken to act	**B1**
2(b)(i)	(54 × 0.45) **or** (2.4 × 0.95) **or** (T sin 30° × 1.3)	**C1**
	(54 × 0.45) = (2.4 × 0.95) + (T sin 30° × 1.3)	**C1**
	T = 34 N	**A1**
2(b)(ii)	resultant moment = (54 × 0.45) – (2.4 × 0.95) **or** (34 sin 30° × 1.3) = 22 N m	**A1**
2(c)(i)	(Δ)E = mg(Δ)h **or** W(Δ)h	**C1**
	= 2.4 × 1.8 = 4.3 J	**A1**

Question 8 — Mark Scheme

3(b)	resultant force (in any direction) is zero	**B1**
	resultant moment / torque (about any point) is zero	**B1**
3(c)(i)	(moment =) $33 \times 0.65 / 2$ **or** $1.5 \times (0.65 - 0.12)$ **or** $T \sin 50° \times (0.65 / 2)$	**C1**
	sum of clockwise moments = sum of anticlockwise moments $33 \times (0.65 / 2) + 1.5 \times (0.65 - 0.12) = T \sin 50° \times (0.65 / 2)$	**C1**
	tension = 46 N	**A1**
3(c)(ii)	$\sigma = F / A$	**C1**
	$\pi r^2 = 46 / (1.5 \times 10^7)$ $r = 9.9 \times 10^{-4}$ m	**A1**

Question 9 — Mark Scheme

Question	Answer	Marks
3(a)	(for a system in equilibrium,) sum of clockwise moments (about a point) equals sum of anticlockwise moments (about the same point)	**B1**
3(b)(i)	2.6×0.40 **or** $F \times 0.40$ (any one moment)	**C1**
	$U = 4.0 - F$ $= 4.0 - (2.6 \times 0.40 / 0.40) = 1.4$ N	**A1**
	or	
	2.6×0.4 **or** $(4.0 - U) \times 0.4$	**(C1)**
	$2.6 \times 0.4 = (4.0 - U) \times 0.4$ hence $U = (4.0 - 2.6) = 1.4$ N	**(A1)**
3(b)(ii)	$U = \rho g V$ **and** $A = V / h$ **or** $p = h\rho g$ **and** $A = U / p$ **or** $A = U / h\rho g$	**C1**
	$A = 1.4 / (0.10 \times 1.0 \times 10^3 \times 9.81)$	**C1**
	$= 1.4 \times 10^{-3}$ m^2	**A1**
3(c)	line starting at (0.10, 0.40)	**B1**
	straight line with negative gradient	**B1**
	line ending at (0.29, 0)	**B1**

Question 10 — Mark Scheme

Question	Answer	Marks
2(a)	in (rotational) equilibrium	**B1**
	sum / total of CW moments about a point = sum / total of ACW moments about the (same) point.	**B1**
2(b)(i)	The magnitudes of the moments about A are: (1700 × 3.0) (660 *x*) (1300 × 5) Correct magnitude of any one moment about A.	**C1**
	Correct magnitudes of a second moment about A.	**C1**
	(1700 × 3.0) + (660 *x*) = (1300 × 5) *x* = 2.1 m	**A1**

Question	Answer	Marks
2(b)(ii)	(Upthrust =) 11 × 9.81 + 1300 = 1400 (N)	**A1**
2(b)(iii)	y = Upthrust / ρgA = 1400 / (990 × 9.81 × π × (0.78 / 2)^2)	**C1**
	= 0.30 m	**A1**
	OR [$P = F / A$ = 1400 / π × (0.78 / 2)^2 = 2930] y = $P / \rho g$ = 2930 / (990 × 9.81)	**(C1)**
	= 0.30 m	**(A1)**
2(b)(iv)	line with a non-zero value of depth at distance = 0	**B1**
	A line from distance = 0 to distance = 6.0 m with a gradient that is always positive	**B1**

Question 11 — Mark Scheme

Question	Answer	Marks
2(a)	in (rotational) equilibrium	B1
	sum / total of clockwise moments about a point = sum / total of anticlockwise moments about the (same) point.	B1
2(b)	$80 \times 9.81 \times 3$ **or** $60 \times 9.81 \times 3$ **or** $45 \times 9.81 \times x$	C1
	$80 \times 9.81 \times 3 = (60 \times 9.81 \times 3) + (45 \times 9.81 \times x)$	C1
	$x = 1.3$ m	A1
2(c)(i)	$k = F / x$	C1
	$x = 0.80 - 0.59$ $= 0.21$ m	C1
	$k = (60 \times 9.81) / 0.21$ $= 2800$ N m^{-1}	A1

Question	Answer	Marks
2(c)(ii)	$E = \frac{1}{2} kx^2$ **or** $E = \frac{1}{2} Fx$ **or** $E = \frac{1}{2} F^2/k$ $= \frac{1}{2} \times 2800 \times 0.21^2$ or $= \frac{1}{2} \times 60 \times 9.81 \times 0.21$ or $= \frac{1}{2} \times (60 \times 9.81)^2 / 2800$	C1
	$= 62$ J	A1

Question 12 — Mark Scheme

Question	Answer	Marks
2(a)	force × perpendicular distance (of line of action of force to / from the point)	B1
2(b)(i)	(moment due to weight =) 1.2 × 270 × 9.81	B1
	(moment due to post =) 1800 × (1.6 / cos θ)	B1
	1.2 × 270 × 9.81 = 1800 × (1.6 / cos θ) so θ = 25(°) or 1.2 × 270 × 9.81 – 1800 × (1.6 / cos θ) = 0 so θ = 25(°)	B1
2(b)(ii)	A closed tip-to-tail vector triangle	M1
	vector labelled *F* at an angle of 25° ± 3° anticlockwise from vertical **and** vector labelled *R* at an angle of 37° ± 3° clockwise from vertical	A1

Question	Answer	Marks
2(b)(iii)	$A = F / p$ $= 1800 / (150 \times 10^3)$	C1
	$= 0.012\ m^2$	A1

Question 13 — Mark Scheme

Question	Answer	Marks
2(a)	force × perpendicular distance (of line of action of force to / from the point)	**B1**
2(b)(i)	$150 \times 9.81 \times 4.5$ **or** $90 \times 9.81 \times 4.5$ **or** $3.0 \times 9.81 \times m$	**C1**
	$(150 \times 9.81 \times 4.5) = (90 \times 9.81 \times 4.5) + (3.0 \times 9.81 \times m)$	**C1**
	$m = 90$ kg	**A1**
2(b)(ii)	Young modulus = σ / ε **or** $F / A\varepsilon$ **or** FL / Ax	**C1**
	Area of wire = $\pi \times (1.8 \times 10^{-3} / 2)^2$ $= 2.5 \times 10^{-6}$	**C1**
	So Young modulus = $((90 \times 9.81) / \pi \times (9.0 \times 10^{-4})^2) / 1.2 \times 10^{-3}$ $= 2.9 \times 10^{11}$ Pa	**A1**
2(b)(iii)	Moment provided by B will decrease / moment due to wire will increase	**B1**
	So force acting on wire will increase (Young's modulus and area remain constant) and the strain will increase	**B1**

Question 14 — Mark Scheme

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Question	Answer	Marks
1(a)	force × perpendicular distance (of line of action of force to a point) **or** product of force and perpendicular distance (to a point)	**B1**
1(b)(i)	in (rotational) equilibrium	**B1**
	sum / total of CW moments about a point = sum / total of ACW moments about the (same) point.	**B1**
1(b)(ii)	component of weight = 75 × cos 42° = 56 N	**A1**
1(b)(iii)	F × 80 **or** 56 × 40 **or** *F* × 0.8 **or** 56 × 0.4 *F* × 80 = 56 × 40	**C1**
	F = 28 N	**A1**

Question 15 — Mark Scheme

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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	Answer	Marks
2(c)(ii)	$(\Delta)p = F(\Delta)t$	C1
	$m = Ft / (\Delta)v$ $(m =)\ 5500 \times 0.36 / 8.5 = 230$ (kg)	A1
	or	
	$F = ma$ **and** $a = (\Delta)v / (\Delta)t$	(C1)
	$(m =)\ 5500 / (8.5 / 0.36) = 230$ (kg)	(A1)
2(c)(iii)	$(\Delta p =)\ 5500 \times 0.36$ (= 1980 N s) **or** $(\Delta p =)\ 230 \times 8.5$ (= 1955 N s)	C1
	$1980 = (2.5 \times 10^3 - 230)\Delta v$ **or** $1955 = (2.5 \times 10^3 - 230)\Delta v$	C1
	$\Delta v = 0.87\ \text{m s}^{-1}$ **or** $0.86\ \text{m s}^{-1}$	A1
	or	
	$a = 5500 / (2.5 \times 10^3 - 230)$ $(= 2.42\ \text{m s}^{-2})$	(C1)
	$\Delta v = 2.42 \times 0.36$	(C1)
	$\Delta v = 0.87\ \text{m s}^{-1}$ **or** $0.86\ \text{m s}^{-1}$	(A1)

Question 16 — Mark Scheme

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Question	Answer	Marks
2(a)	product of force and distance	M1
	perpendicular distance between the (line of action of the two) forces	A1
2(b)	straight vertical line drawn from centre to bottom corner	B1
2(c)(i)	centre of gravity is to the right of the rod so torque is anticlockwise **or** moment of weight of sheet about rod is clockwise so torque is anticlockwise	B1
2(c)(ii)	(horizontal displacement) = $3.3 / (2.8 \times 9.81) = 0.12$ (m)	A1
2(d)	$\rho = m / V$	C1
	$V = 4.0 \times 10^{-3} \times (\text{side length})^2$	C1
	side length = $\sqrt{[2.8 / (3000 \times 0.0040)]} = 0.48\,\text{m}$	A1
2(e)	point lies on a straight line at 45° to the horizontal from the bottom-right corner to the edge of the rod	B1
	point lies on a vertical line half-way between rod and right-hand edge	B1

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