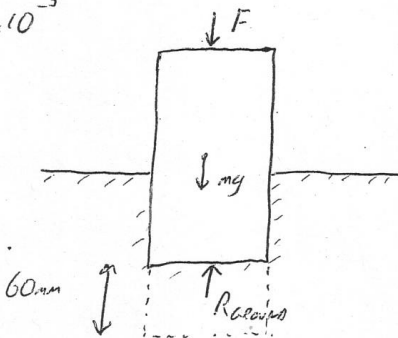


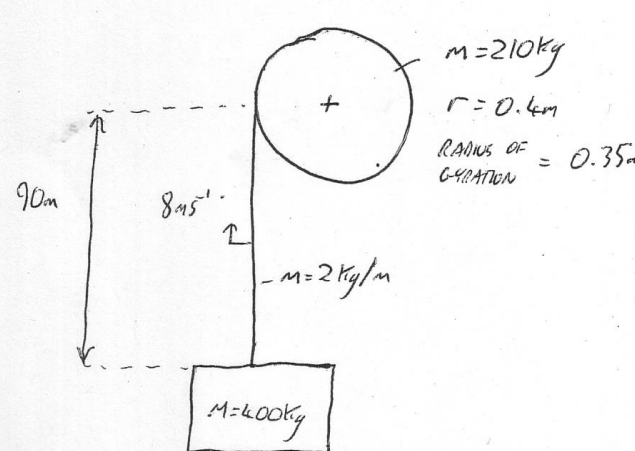
Continuation Sheet

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Question No	Question	Marks
1a ii	BEFORE IMPACT : $K.E. = \frac{1}{2} M_D V^2$ $= \frac{1}{2} \times 800 \times 2.25^2$ $= 1962.5 \text{ J}$ AFTER IMPACT : $K.E. = K.E._{DRIVER} + K.E._{PILE}$ $= \frac{1}{2} M_D u^2 + \frac{1}{2} M_P u^2$ $= \frac{1}{2} \times 800 \times 1.266^2 + \frac{1}{2} \times 600 \times 1.266^2$ $= 641.1 + 480.8$ $= 1121.9 \text{ J}$ $\therefore \Delta K.E. = 1962.5 - 1121.9 = 840.6 \text{ J}$ LOSS DUE TO HEAT, NOISE, DISTORTION IF REACTION IS CONSTANT THEN ACCELERATION MUST BE CONSTANT SINCE $F = ma$ $v^2 = u^2 + 2as$ $0 = 1.266^2 + 2a \times 60 \times 10^{-3}$ $\therefore a = -13.36 \text{ m/s}^2$ 	① ① ① ②

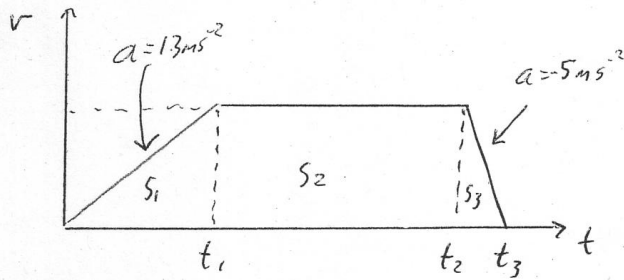
Continuation Sheet

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Question No	Question	Marks
	now $R = F + mg$ $= (M_0 + M_P) a + (M_0 + M_P) g$ $= (800 + 600) \times 13.36 + (800 + 600) \times 9.81$ $= 1400 \times 13.36 + 1400 \times 9.81$ $= 18704 + 13734$ $= \underline{\underline{32438 \text{ N}}}$ RESISTANCE, R, IS LIKELY TO CHANGE AS THE GROUND IS COMPACTED. (16)  $m = 210 \text{ kg}$ $r = 0.4 \text{ m}$ RADIUS OF GYRATION = 0.35 m $m = 2 \text{ kg/m}$ $M = 400 \text{ kg}$ 90 m 8.15 m ACCELERATES AT 1.3 ms^{-2} ACCELERATES AT 5 ms^{-2}	(2)

Continuation Sheet

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Question No	Question	Marks
(16) 1	 $s_{TOTAL} = 90m$ <u>DURING ACCELERATION</u> $u = 0, v = 8, a = 1.3, t = ?, s = ?$ $v = u + at$ $\therefore t_1 = \frac{v - u}{a}$ $= \frac{8 - 0}{1.3}$ $= \underline{\underline{6.15s}}$ $v^2 = u^2 + 2as$ $\therefore s = \frac{v^2 - u^2}{2a}$ $= \frac{8^2 - 0^2}{2 \times 1.3}$ $= \underline{\underline{24m}}$ <u>DURING DECELERATION</u> $u = 8, v = 0, a = -5, t = ?, s = ?$ $t = \frac{v - u}{a}$ $= \frac{0 - 8}{-5}$ $= \underline{\underline{1.6s}}$ $s = \frac{v^2 - u^2}{2a}$ $= \frac{0^2 - 8^2}{2 \times -5}$ $= \underline{\underline{6.4m}}$	(1) (1) (1)

Continuation Sheet

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Question No	Question	Marks
(16) i	$S_{TOTAL} = S_1 + S_2 + S_3$ $90 = 24 + S_2 + 6.4$ $\therefore S_2 = \underline{59.6m}$ CONSTANT VELOCITY $v = \frac{d}{t} \quad \therefore t = \frac{d}{v} = \frac{59.6}{8} = \underline{7.45s}$ $\therefore TOTAL TIME = 6.15 + 1.6 + 7.45 = \underline{15.2s}$	(2)
(16) ii	ROPE TENSION AT DRUM = $M_{TOT} \times a_{TOT}$ $= (M_{CAGE} + M_{ROPE}) \times (a + g)$ $= (1000 + 90 \times 2) \times (1.3 + 9.81)$ $= \underline{6443.8N}$ $\therefore$ TORQUE TO ACCELERATE CAGE + DRUM = 6443.8×0.4 $= \underline{2577.5Nm}$ HOWEVER TORQUE IS ALSO NEEDED TO ROTATE DRUM ITSELF $= MASS MOMENT OF INERTIA \times ACCELERATION$ $T_{DRUM} = I_{DRUM} \times \alpha_{DRUM}$ NOW $\alpha_{DRUM} = \frac{a}{r} = \frac{1.3}{0.4} = \underline{3.25 rad s^{-2}}$	(2)

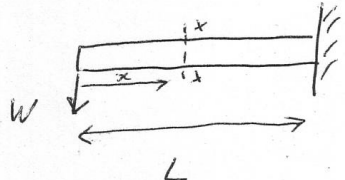
Continuation Sheet

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Question No	Question	Marks
(16) ii CONT	$I_{\text{new}} = \text{MASS} \times \text{RADIUS OF GYRATION}^2$ $= 210 \times 0.35^2$ $= 25.7 \text{ kgm}^2$ $\therefore T_{\text{new}} = 25.7 \times 325 = \underline{\underline{83.5 \text{ Nm}}}$ $\therefore \text{TOTAL TORQUE} = 2577.5 + 83.5 = \underline{\underline{2661 \text{ Nm}}}$	(2) (1)

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Module/Unit:	STRESS ANALYSIS & MECHANICS	Page:	7 of 16
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Question No	Question	Marks
(2a)	 $M_{xx} = -Wx$ $EI \frac{d^2 y}{dx^2} = -Wx$ $EI \frac{dy}{dx} = -\frac{Wx^2}{2} + A$ (1) $EI y = -\frac{Wx^3}{6} + Ax + B$ (2) FROM BOUNDARY CONDITION : WHEN $x=L$ $\frac{dy}{dx} = 0$ ∴ FROM (1) ~~0~~ $0 = -\frac{WL^2}{2} + A$ $A = \frac{WL^2}{2}$ 2nd BOUNDARY CONDITION : WHEN $x=L$, $y=0$ FROM (2) $0 = -\frac{WL^3}{6} + \frac{WL^2 L}{2} + B$ $\therefore B = \frac{WL^3}{6} - \frac{WL^3}{2} = -\frac{WL^3}{3}$	(1) (1) (1) (1) (1) (1) (2)

Continuation Sheet

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Question No	Question	Marks
	$\therefore$ FROM (2) $EIy = \frac{-wx^3}{6} + \frac{wL^2x}{2} - \frac{wL^3}{3}$ $\therefore y = \frac{1}{EI} \left[\frac{-wx^3}{6} + \frac{wL^2x}{2} - \frac{wL^3}{3} \right] \quad (2)$	
(b) (i)	$EIy = \frac{-wx^3}{6} + \frac{wL^2x}{2} - \frac{wL^3}{3}$ $\therefore EI = \frac{1}{y} \left[\frac{-wx^3}{6} + \frac{wL^2x}{2} - \frac{wL^3}{3} \right]$ $= \frac{1}{-2 \times 10^{-3}} \left[\frac{-2000 \times 2^3}{6} + \frac{2000 \times 2^2 \times 2}{2} - \frac{2000 \times 4^3}{3} \right]$ $= \frac{1}{-2 \times 10^{-3}} \left[-2666.7 + 32000 - 42666.7 \right]$ $= 6666700$ $= \underline{\underline{6.67 \text{ MPa}}}$	(5)

Continuation Sheet

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Question No	Question	Marks
(ii)	$EI = 666700$ $\therefore I = \frac{666700}{210 \times 10^9}$ $= \underline{\underline{3.175 \times 10^{-5} \text{ m}^4}}$	(1)
(iii)	$I = 3.175 \times 10^{-5} \text{ m}^4$ $= (3.175 \times 10^{-5}) \times 10^8$ $= \underline{\underline{3174 \text{ cm}^4}}$ LIGHTEST BEAM IS $D \times B = 312.7 \times 102.4$ $I_{xx} = 6487$ $WEIGHT = 33 \text{ kg/m}$ $\therefore \text{WEIGHT OF BEAM IS } 4 \times 33$ $= \underline{\underline{132 \text{ kg}}}$	(4) 20

Continuation Sheet

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Question No	Question	Marks
(3 a)	$\theta = 90 - 40 = 50^\circ$ $\sigma_x = 20 \text{ MPa}$ $\sigma_y = -40 \text{ MPa}$ $\tau_{xy} = -20 \text{ MPa}$	1
	$\therefore \sigma_\theta = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y) \cos 2\theta + \tau_{xy} \sin 2\theta$ $= \frac{1}{2}(20 - 40) + \frac{1}{2}(20 + 40) \cos 100 - 20 \sin 100$ $= -34.9 \text{ MPa}$	2
	$\tau_\theta = \frac{1}{2}(\sigma_x - \sigma_y) \sin 2\theta - \tau_{xy} \cos 2\theta$ $= \frac{1}{2}(20 + 40) \sin 100 + 20 \cos 100$ $= 26.1 \text{ MPa}$	2
(b)	$\sigma_1 = \frac{1}{2}[(\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}]$ $= \frac{1}{2}[(20 - 40) + \sqrt{(20 + 40)^2 + 4(-20)^2}]$ $= \frac{1}{2}(-20 + \sqrt{3600 + 1600})$	2

$$= 26.06 \text{ MPa}$$

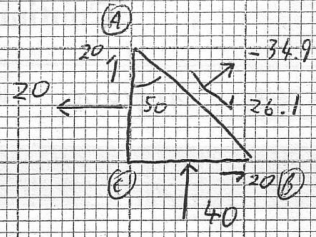
Continuation Sheet

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Question No	Question	Marks
(2)	$\tau_{max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$ $= \frac{1}{2} \sqrt{(20 + 40)^2 + 4(-20)^2}$ $= \underline{\underline{36.06 \text{ MPa}}}$	2
(d)	SEE MOHR'S CIRCLE OVER PAGE. TAKING MEASUREMENTS : $\sigma_0 \approx \underline{\underline{-34.5 \text{ MPa}}}$ $\tau_0 \approx \underline{\underline{26 \text{ MPa}}}$ $\sigma_1 \approx \underline{\underline{26 \text{ MPa}}}$ $\tau_{max} \approx \underline{\underline{36 \text{ MPa}}}$	(4)
(e)	BY MEASUREMENT $2\theta_1 \approx 146^\circ$ $\therefore \theta_1 \approx \underline{\underline{73^\circ}}$	2
(f)	(d) IS APPROXIMATE AS THEY ARE MEASURED.	1
		20

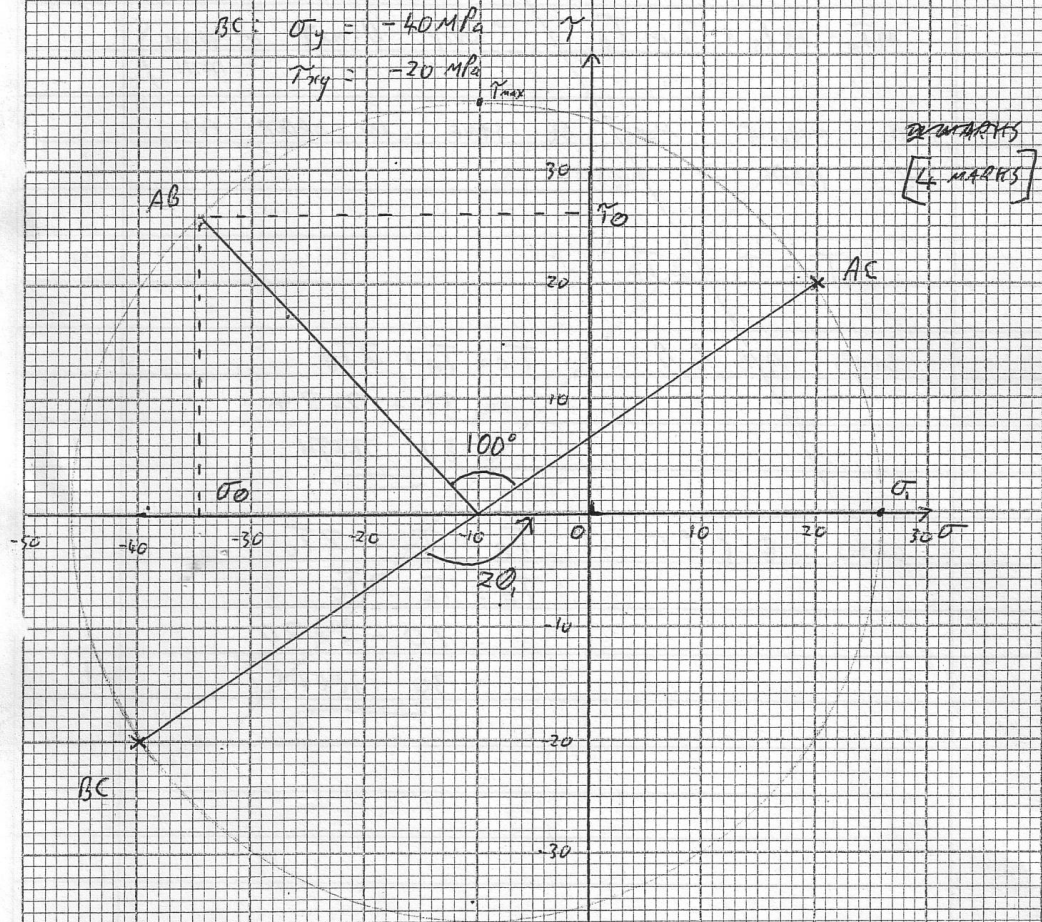
STRESS ANALYSIS & STRAIN ANALYSIS

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Plot: AC: $\sigma_x = 20 \text{ MPa}$
 $\tau_{xy} = 20 \text{ MPa}$

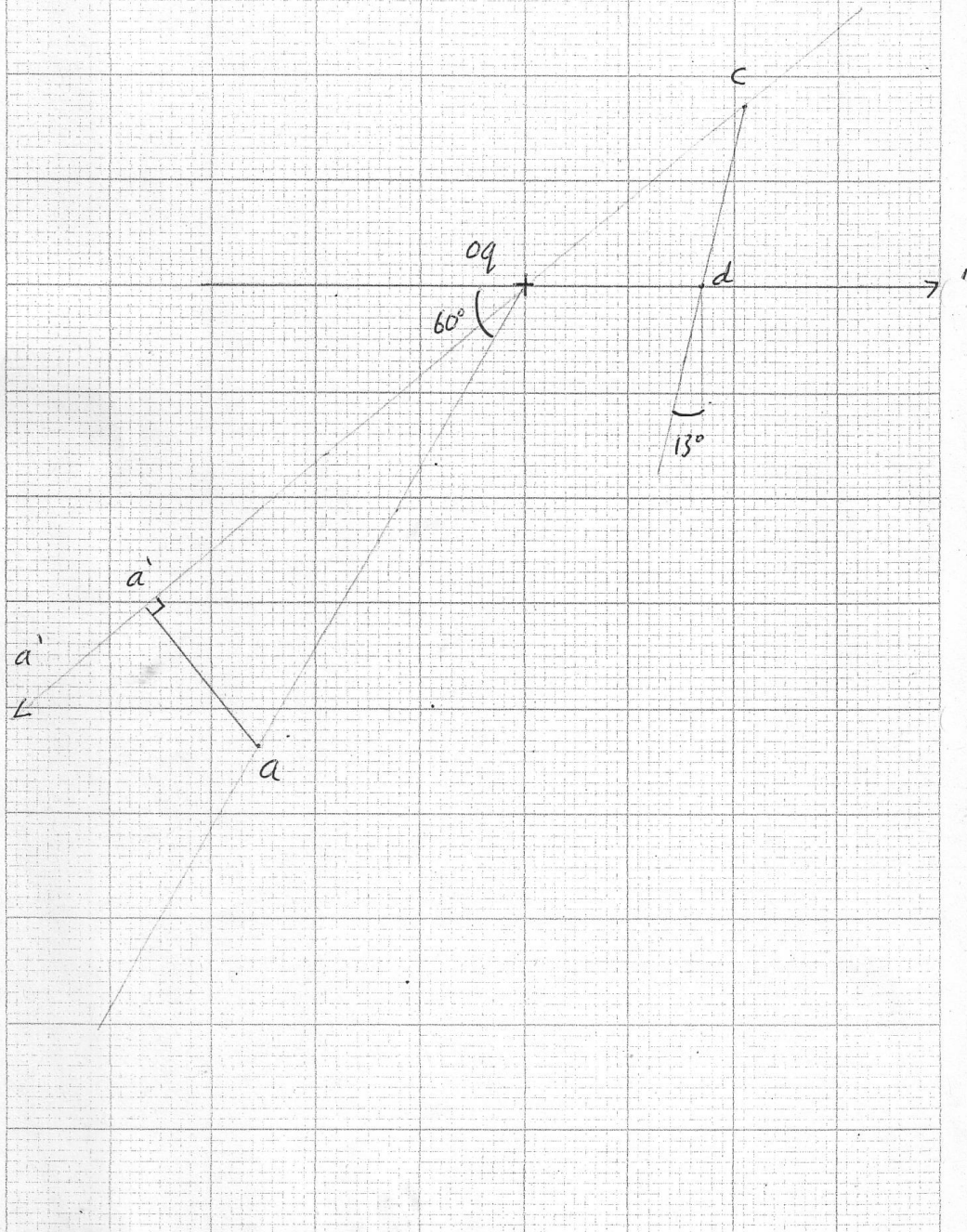
BC: $\sigma_y = -40 \text{ MPa}$
 $\tau_{xy} = -20 \text{ MPa}$



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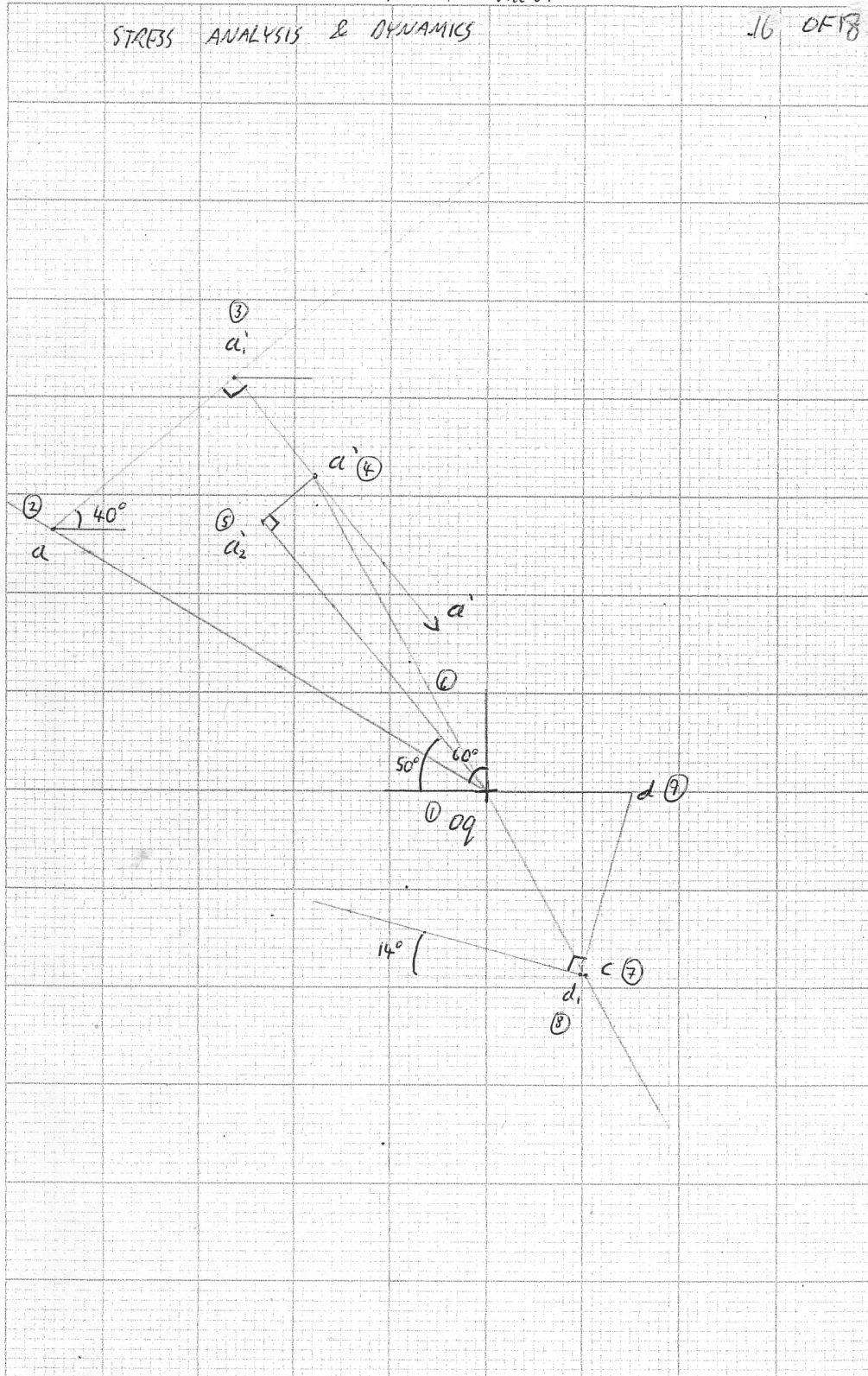
Question No	Question	Marks
④ a	O & Q DO NOT MOVE RELATIVE TO EACH OTHER VELOCITY OF A RELATIVE TO O: $V_a = \omega OA$ $= 120 \times \frac{2\pi}{60} \times 0.2$ $= \underline{\underline{2.515 \text{ m/s}}}$ VELOCITY OF A, V_a, IS $\perp$ TO OA i.e. 60° TO THE HORIZ, HENCE $\vec{oa}$ IS DRAWN $(2.515 \times 4 = 10.06 \text{ cm})$ RELATIVE TO Q, D HAS TO SLIDE HORIZONTALLY, HENCE $\vec{qd}$ IS DRAWN WITH INDETERMINATE LENGTH VELOCITY OF A', $V_{a'}$, IS $\perp$ TO QA' i.e. 40° TO THE HORIZ MEASURED FROM THE DIAGRAM. HENCE $\vec{qa'}$ IS DRAWN WITH INDETERMINATE LENGTH VELOCITY OF A IS PARALLEL TO QA i.e. $\perp$ TO $\vec{qa}$, HENCE $\vec{a'a}$ CAN BE DRAWN, FIXING a' NOW $\frac{V_{a'q}}{V_{qc}} = \frac{A'Q}{QC}$ FROM DIAGRAM $V_{a'q} = 2.35 \text{ m/s}$ $A'Q = 264 \text{ mm}$ $QC = 150 \text{ mm}$ $\therefore \frac{2.35}{V_{qc}} = \frac{264}{150}$ $\therefore V_{qc} = 1.34 \text{ ms}^{-1} (= 5.36 \text{ cm})$ HENCE $\vec{qa'}$ IS EXTENDED TO qc	① ① ① ① ① ① ①



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Question No	Question	Marks
	• VELOCITY OF D RELATIVE TO C, V_{dc}, IS 13° FROM VERTICAL (MEASURED FROM DIAGRAM) HENCE $\vec{cd}$ CAN BE DRAWN, FIXING d. BY MEASUREMENT $V_{dc} = \underline{0.8 \text{ ms}^{-1}}$	① ①
⑥	① THE CENTRIPETAL ACCELERATION OF A RELATIVE TO O IS GIVEN BY: $a = \omega^2 OA$ $= \left(\frac{120 \times 2\pi}{60} \right)^2 \times 0.2$ $= \underline{31.6 \text{ ms}^{-2}}$ ② THIS ACTS TOWARDS O, HENCE $\vec{oa}$ CAN BE DRAWN. SINCE THE CRANK IS CONSTANT VELOCITY THERE IS NO TANGENTIAL COMPONENT ($\alpha = 0$) • THE ACCELERATION OF A' RELATIVE TO A HAS TWO COMPONENTS • TANGENTIAL COMPONENT $= \alpha r + 2v\omega$ $= 0 + 2 \times V_{a'a} \times \frac{V_{a'q}}{AQ}$ FROM VELOCITY DIAGRAM $V_{a'a} = 0.8$ $V_{a'q} = 2.37$ $AQ = 0.26$ TANGENTIAL COMPONENT $= 2 \times 0.8 \times \frac{2.37}{0.26}$ $= \underline{14.6 \text{ ms}^{-2}}$	① ①



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Question No	Question	Marks
	③ THIS IS $\perp$ TO AXIS QB, FROM THE DIAGRAM THIS IS 40° FROM THE HORIZ., HENCE $\vec{a}_1$ IS DRAWN ④ THE RADIAL ACCELERATION OF A RELATIVE TO A IS PARALLEL TO QB ($\perp$ TO TANGENTIAL COMPONENT) BUT OF UNKNOWN LENGTH, THEREFORE $\vec{a}_1 \vec{a}'$ IS DRAWN OF INDETERMINATE LENGTH • THE ACCELERATION OF A' RELATIVE TO Q ALSO HAS TWO COMPONENTS: ⑤ THE CENTRIPETA COMPONENT = $\frac{v_{A'Q}^2}{A'Q}$ $= \frac{2.37}{0.26}$ FROM VELOCITY DIAGRAM $= \underline{\underline{21.6 \text{ ms}^{-2}}}$ THIS THIS IS DIRECTED TOWARDS Q ALONG THE AXIS A'Q FROM THE DIAGRAM, THIS IS 50° TO THE HORIZONTAL $\therefore$ VECTOR $\vec{qa}_2$ CAN BE DRAWN. • THE TANGENTIAL COMPONENT IS $\perp$ TO THE CENTRIPETA COMPONENT, AND PASSES THROUGH $\vec{a}_2$, WHERE THIS CROSSES $\vec{a}_1 \vec{a}'$ FINDS POINT $\vec{a}'$ ⑥ $\vec{a}' \vec{o}$ CAN THEN BE DRAWN	① ① ① ① ① ①

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Question No	Question	Marks
	• $\vec{a'q}$ IS EXTENDED TO FIND C, SUCH THAT $\frac{a'q}{qc} = \frac{A'Q}{QC}$ FROM ACCELERATION DIAGRAM $\rightarrow \frac{22.2}{qc} = \frac{0.26}{0.15}$ $\therefore qc = \underline{\underline{12.8 \text{ ms}^{-2}}}$ ⑦ • THE CENTRIPETAL ACCELERATION OF D RELATIVE TO C IS GIVEN BY $\frac{v_{dc}^2}{DC} = \frac{0.9^2}{0.5}$ ← FROM A VELOCITY DIAGRAM $\therefore = \underline{\underline{1.62 \text{ ms}^{-2}}}$ ⑧ THIS IS DIRECTED TOWARDS C i.e. 14° FROM THE HORIZONTAL $\therefore cd$ IS DRAWN ⑨ THE TANGENTIAL ACCELERATION OF D RELATIVE TO C IS $\perp$ TO CD, AND IS REPRESENTED BY $\vec{a'd}$ • D HAS TO MOVE HORIZONTALLY RELATIVE TO q, THUS FIXING d. THE ACCELERATION OF D RELATIVE TO O IS THEN MEASURED OFF OF THE DIAGRAM $a_d = o_d = \underline{\underline{10 \text{ ms}^{-2}}}$	① ① ① ①

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