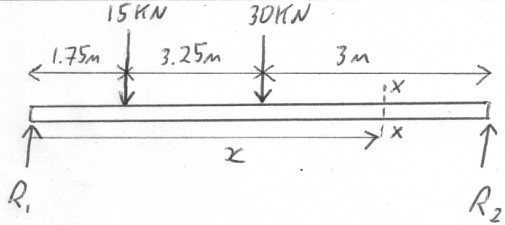




EXAMINATION SOLUTIONS: SESSION 2015/2016

School:	LOGISTICS & MANUFACTURING ENGINEERING		
Programme:	BENG MANUFACTURING SYSTEMS ENG.	Year:	2
Module/Unit:	CAE and Stress Analysis		
Author:	Kelvin lake/Rob Goodson	Page:	1 of 16

Question No	Question	Marks
① a	 $\sum M_{R_2} = 0$ $8R_1 = 15 \times 6.25 + 30 \times 3$ $8R_1 = 183.75$ $R_1 = 22.97 \text{ kN}$ $EI \frac{d^2 y}{dx^2} = M$ $= 22970x - 15000(x-1.75) - 30000(x-5)$ $\therefore EI \frac{dy}{dx} = \frac{22970x^2}{2} - \frac{15,000(x-1.75)^2}{2} - \frac{30,000(x-5)^2}{2} + A$ $\therefore EI y = \frac{22970x^3}{6} - \frac{15,000(x-1.75)^3}{6} - \frac{30,000(x-5)^3}{6} + Ax + B$	② ① ① ① ①

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	2 of 16
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Question No	Question	Marks
①a CONT	BOUNDARY CONDITIONS WHEN $x=0, y=0 \therefore$ FROM ** $B=0$ WHEN $x=8, y=0$ $\therefore$ FROM ** $0 = \frac{22970x^3}{6} - \frac{15,000(x-1.75)^3}{6} - \frac{30,000(x-5)^3}{6} + Ax$ $0 = \frac{22970 \times 8^3}{6} - \frac{15,000(6.25)^3}{6} - \frac{30,000 \times 3^3}{6} + 8A$ $0 = 1960106.7 - 610351.6 - 135,000 + 8A$ $\therefore 8A = -1214755$ $\therefore A = \underline{\underline{-151,844}}$ FROM ** $EIy = \frac{22970x^3}{6} - \frac{15,000(x-1.75)^3}{6} - \frac{30,000(x-5)^3}{6} - 151,844x$ AT MIDPOINT $x=4$ $EIy = \frac{22970 \times 4^3}{6} - \frac{15,000 \times 2.25^3}{6} - 151,844 \times 4$ $= 245013 - 28477 - 607376$ $= -390,840$	① ① ② ①

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	3 of 16
Question No	Question	Marks	
	IF $y = -7.5 \text{ mm}$ $EI = \frac{-390,840}{-7.5 \times 10^{-3}}$ $= \underline{52.1 \text{ MPa}}$ (b) $EI = 52.1 \text{ MPa}$ $= 52.1 \times 10^6$ $\therefore I = \frac{52.1 \times 10^6}{200 \times 10^9}$ $= \underline{2.605 \times 10^{-4} \text{ m}^4}$ (c) $I = 2.605 \times 10^{-4} \text{ m}^4$ $= (2.605 \times 10^{-4}) \times 10^8$ $= \underline{26,050 \text{ cm}^4}$ LIGHTEST BEAM IS $D \times B = 457.2 \times 151.9$ $I_{xx} = 28,577 \text{ cm}^4$ WEIGHT = 67 kg/m $\therefore \text{WEIGHT OF BEAM IS } 8 \times 67 = \underline{536 \text{ kg}}$	(3) (2) (1) (1) (1)	

Continuation Sheet

Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	10 of 18
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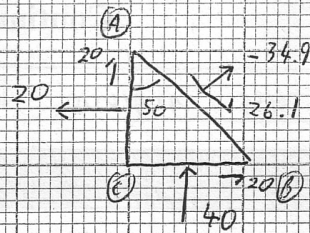
Question No	Question	Marks
2 a	$\theta = 90 - 40 = 50^\circ$ $\sigma_x = 20 \text{ MPa}$ $\sigma_y = -40 \text{ MPa}$ $\tau_{xy} = -20 \text{ MPa}$	1
	$\therefore \sigma_\theta = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y) \cos 2\theta + \tau_{xy} \sin 2\theta$ $= \frac{1}{2}(20 - 40) + \frac{1}{2}(20 + 40) \cos 100 - 20 \sin 100$ $= -34.9 \text{ MPa}$	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)	$\sigma_1 = \frac{1}{2} \left[(\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right]$ $= \frac{1}{2} \left[(20 - 40) + \sqrt{(20 + 40)^2 + 4(-20)^2} \right]$ $= \frac{1}{2} (-20 + \sqrt{3600 + 1600})$	2

$$= 26.06 \text{ MPa}$$

Continuation Sheet

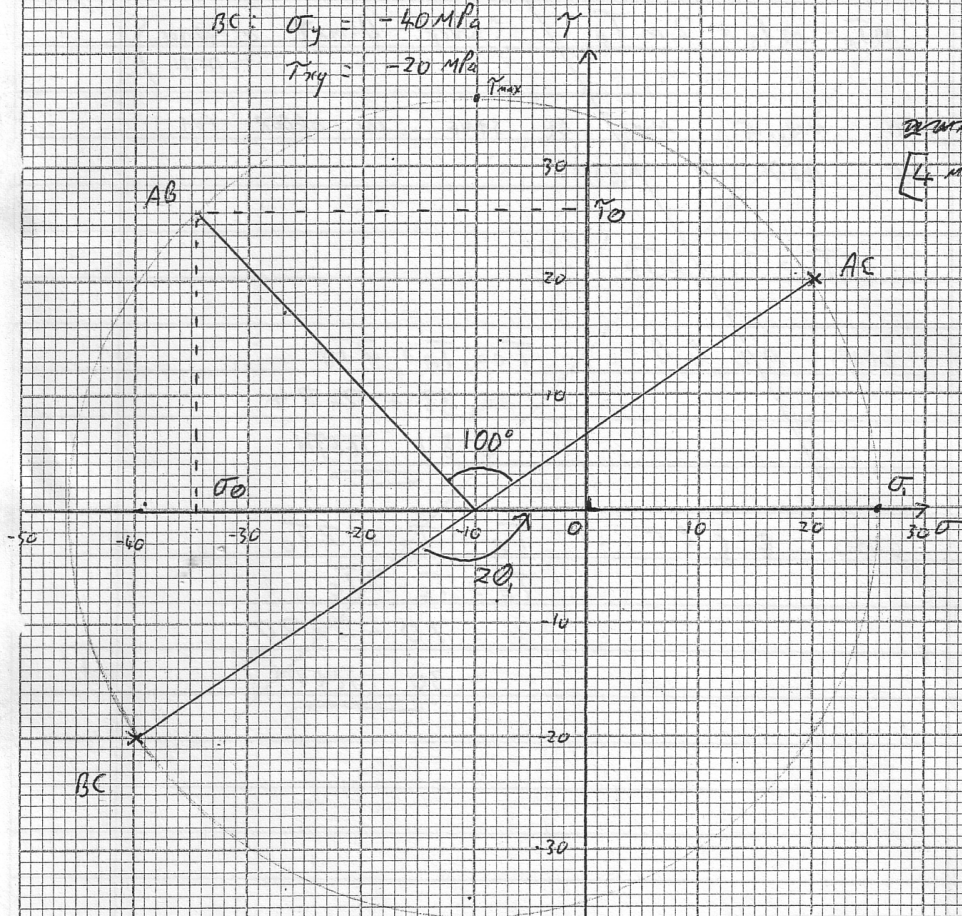
Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	11 of 18
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Question No	Question	Marks
(20)	$\tau_{max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$ $= \frac{1}{2} \sqrt{(20 + 40)^2 + 4(-20)^2}$ $= \underline{\underline{36.06 \text{ MPa}}}$	2
(d)	SEE MOHR'S CIRCLE OVER PAGE.	(4)
	TANGENT MEASUREMENTS : $\sigma_0 \approx \underline{\underline{-34.5 \text{ MPa}}}$	1
	$\tau_0 \approx \underline{\underline{26 \text{ MPa}}}$	1
	$\sigma_1 \approx \underline{\underline{26 \text{ MPa}}}$	1
	$\tau_{max} \approx \underline{\underline{36 \text{ MPa}}}$	1
(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



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

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



2 MARKS
 [4 MARKS]