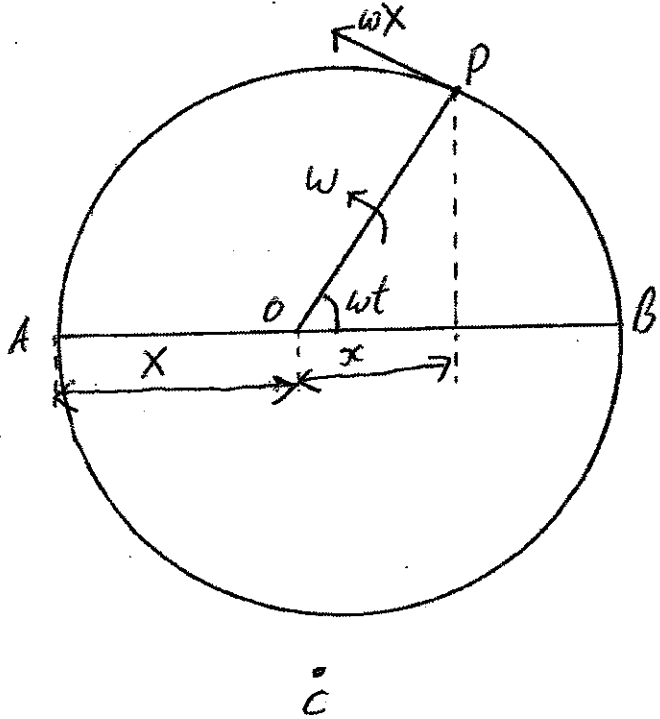




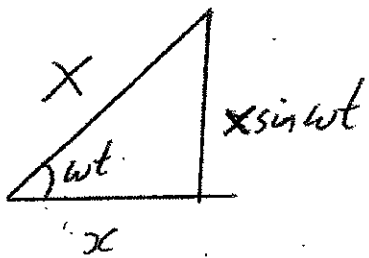
EXAMINATION SOLUTIONS: SESSION 2001/2

School:	LOGISTICS & MANUFACTURING ENGINEERING		
Programme:		Year:	
Module/Unit:	STRESS ANALYSIS & DYNAMICS		
Author:	KELVIN LAKE	Page:	1 of 16

Question No	Question	Marks
①	 DISTANCE x: $x = X \cos \omega t$ $\therefore$ <u>VELOCITY $v = \omega X \sin \omega t$</u> ①	1½

Continuation Sheet

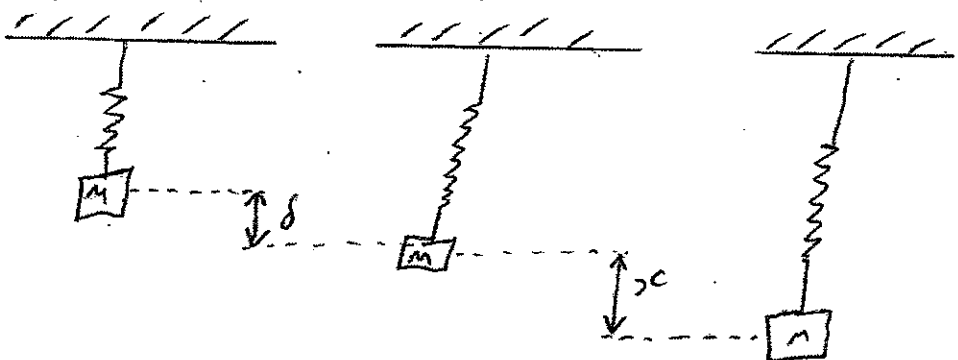
Module/unit	STRESS ANALYSIS & DYNAMICS	Page:	2 of 16
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Question No	Question	Marks
	 $(x \sin \omega t)^2 + x^2 = X^2$ $x \sin \omega t = \sqrt{X^2 - x^2} \quad (2)$ COMBINING (1) & (2) $v = \omega X \sin \omega t$ $\underline{\underline{v = \omega \sqrt{X^2 - x^2}}}$ v IS MAX WHEN $x=0$, i.e. WHEN p PASSES O.	$1\frac{1}{2}$ 2

Continuation Sheet

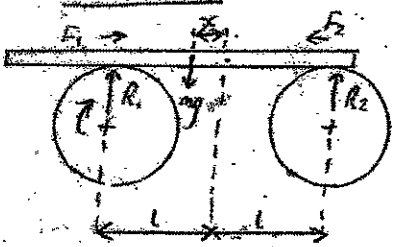
Module/Unit: STRBS ANALYSIS & DYNAMICS

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Question No	Question	Marks
16	 - IN EQUILIBRIUM $mg = K\delta$ - WHEN OSCILLATING RESTORING FORCE $F = Kx$ - NEWTON'S 2ND LAW $F = ma$ $Kx = ma$ $\underline{\underline{\frac{a}{x} = \frac{K}{m}}}$	

Continuation Sheet

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Question No.	Question	Marks
	<u>Also</u> $f = \frac{1}{T} = \frac{1}{2\pi} \omega$ <u>Also</u> $a = \omega^2 x \therefore \omega = \sqrt{\frac{a}{x}}$ $\therefore f = \frac{1}{2\pi} \sqrt{\frac{a}{x}}$ <u>From</u> $\star f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$  <u>Take moments about R_2</u> $mg(l+x) = R_1 \times 2l$ $\therefore R_1 = \frac{mg}{2l} (l+x)$ <u>Take moments about R_1</u> $mg(l-x) = R_2 \times 2l$ $\therefore R_2 = \frac{mg}{2l} (l-x)$	① ① ② ②

Continuation Sheet

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Question No.	Question	Marks
	$F_1 = \mu R_1$ AND $F_2 = \mu R_2$ $= \frac{\mu mg}{2L} (1+x)$ $= \frac{\mu mg}{2L} (1-x)$ (2) RESULTANT FORCE $F = F_1 - F_2$ $= \frac{\mu mg}{2L} (1+x) - \frac{\mu mg}{2L} (1-x)$ $= \frac{\mu mg}{2L} (1+x - (1-x))$ $F = \frac{\mu mgx}{L}$ FROM $\therefore a = \frac{F}{m} = \frac{\mu g x}{L}$ (2) NOW $T = \frac{1}{f} = \frac{2\pi}{\omega} = 2\pi \times \frac{1}{\omega}$ SINCE $a = \omega^2 x$, $\omega = \sqrt{\frac{a}{x}}$ $T = 2\pi \sqrt{\frac{\text{PERIOD}}{\text{ACCELERATION}}}$ $= 2\pi \sqrt{\frac{2L}{\mu g x}}$ $T = 2\pi \sqrt{\frac{L}{\mu g}}$ (2)	

Continuation Sheet

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Question No.	Question	Marks
	SEE DIAGRAM ON PREVIOUS PAGE CONSTRUCTION IS (2)	
2a	AS FOLLOWS: ~~CONSTRUCTION~~ (DESCRIPTION NOT NEEDED)	
①	VELOCITY OF A RELATIVE TO O $V_{A/O} = OA \times \omega_B$ $= 60 \times 10^{-3} \times 120 \times 2\pi$ $= 0.754 \text{ m/s}$	
	HENCE $\vec{OA}$ DRAWN $0.754 \text{ m} = 7.54 \text{ cm}$ LONG AT 75° FROM HORIZONTAL.	
② SLIDER B	• SLIDER B CONSTRAINED TO MOVE ALONG AXIS 30° TO O $\therefore \vec{OB}$ DRAWN WITH INDETERMINATE LENGTH.	1
	• V_{BA} (TANGENTIAL OF B RELATIVE TO A) : ANGLE OF TANGENT A MEASURED FROM HORIZONTAL = 19.5°	
	$\therefore \vec{ab}$ DRAWN 19.5° FROM HORIZONTAL, WITH INTERSECTION WITH $\vec{OB}$ FIXING b.	1
③ PINJOINT C	• IS POSITIONED SUCH THAT $\frac{ac}{ab} = \frac{AC}{AB} = \frac{80}{210} = 0.38$ $\therefore ac = 0.38 ab$	
	BY MEASUREMENT $ab = 82 \text{ mm} \therefore ac = 31.2 \text{ mm}$	1

Continuation Sheet

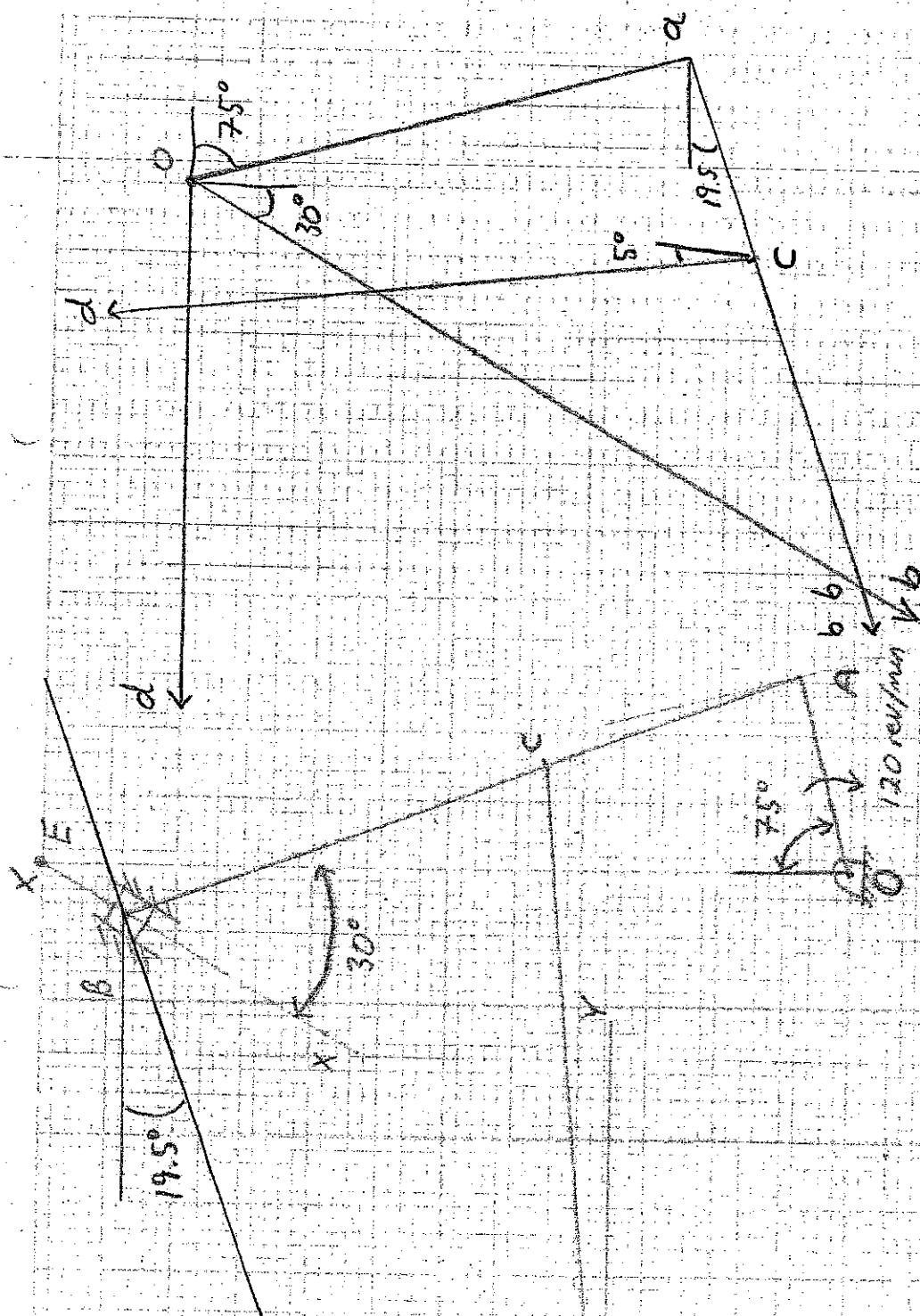
Module/Unit:

STRESS ANALYSIS & DYNAMICS

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Question No.	Question	Marks
Q. 2	SLIDER D	
	• SLIDER D CONSTRAINED TO MOVE ALONG HORIZONTAL AXIS ~~at~~ TO O $\therefore \vec{od}$ DRAWN WITH INDEFINITE LENGTH.	1
	• V_{AC} (TANGENTIAL OF D RELATIVE TO A): ANGLE OF TANGENT FROM VERTICAL MEASURED FROM DIAGRAM = 5° $\therefore \vec{cd}$ DRAWN 5° FROM VERTICAL, WITH INTERSECTION WITH <u>$\vec{od}$ FINISHED</u>	1
	VELOCITY DIAGRAM COMPLETE!	
	• SLIDER B: $\vec{ob}$ (MEASURED) = 11.7 cm $\therefore V_{ob} = 11.7 \times 0.1$ $= 1.17 \text{ m/s}$	1
	30° 'DOWNWARD AND LEFT' IN SENSE $O \rightarrow b$	
	• SLIDER D: $\vec{od}$ (MEASURED) = 1.9 cm $\therefore V_{od} = 1.9 \times 0.1$ $= 0.19 \text{ m/s}$	1
	TO 'LEFT' IN SENSE $O \rightarrow d$	

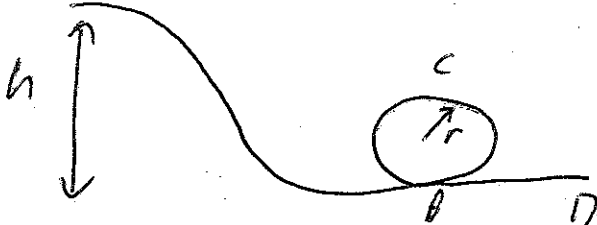


[10 MARKS TOTAL]

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Question No	Question	Marks
26	 A → C LOSS OF P.E. = GAIN IN K.E. $mg(h-2r) = \frac{1}{2}mv^2$ $v^2 = 2g(h-2r) \quad *$ FOR THE CAR TO REMAIN IN CONTACT THE UPWARD (CENTRIFUGAL) FORCE MUST BE $\geq$ WEIGHT $\frac{mv^2}{r} \geq mg$ ∴ FROM * $\frac{2mg(h-2r)}{r} \geq mg$ $2(h-2r) \geq r$ $2h - 4r \geq r$ $2h \geq 5r$ $\therefore \underline{h \geq 2.5r}$	(5)

Continuation Sheet

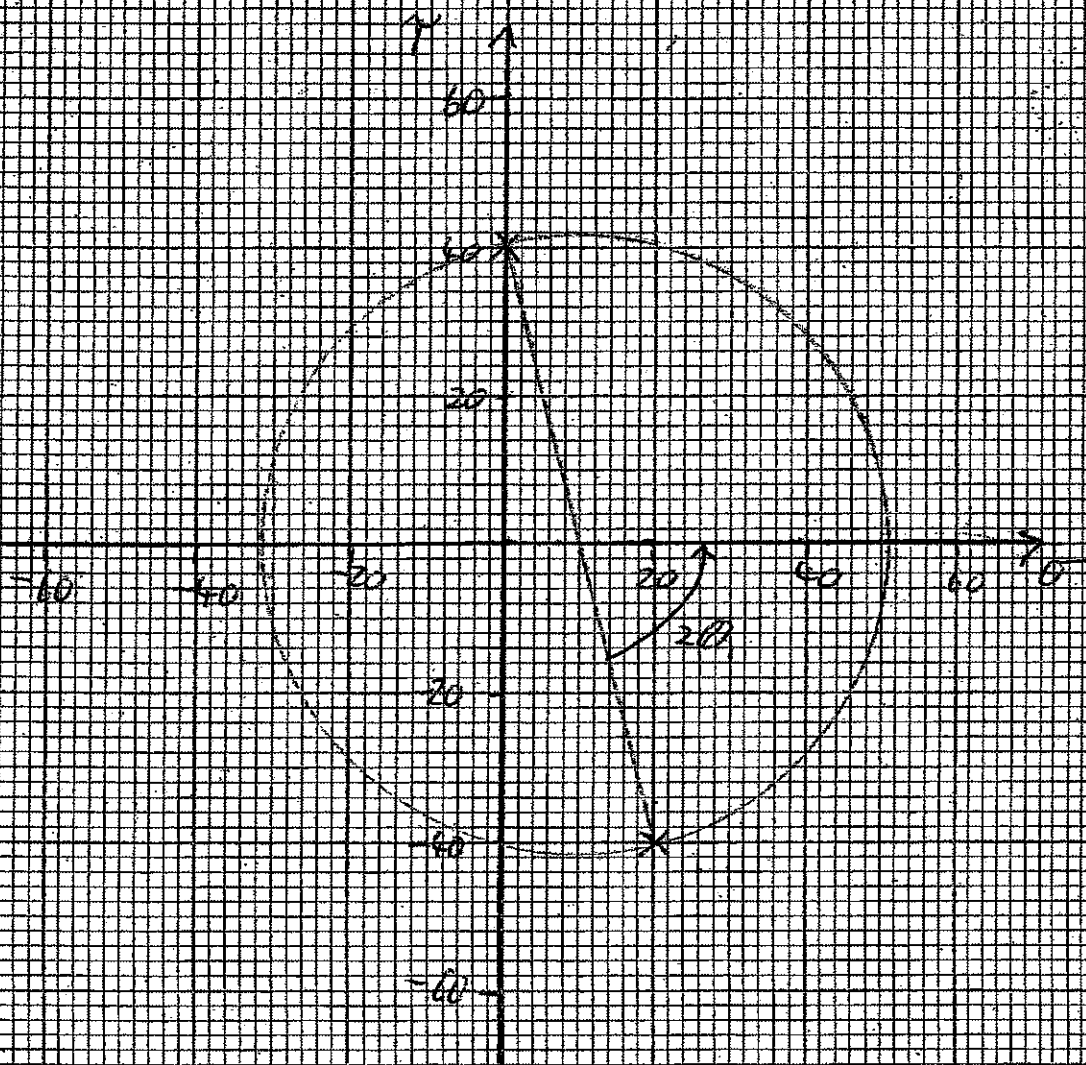
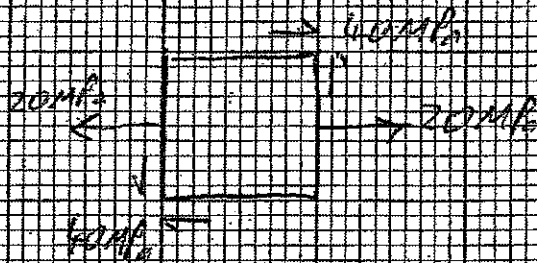
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Question No	Question	Marks
(ii)	ASSUMPTIONS - ALL P.E. IS CONVERTED TO K.E. - NEGLECTING - ROLLING RESISTANCE - DRAG - NOISE - DEFORMATION OF WHEELS/TRACKS - FRICTION - HEIGHT OF C.O.G. FROM TRACK - NOT ACCOUNTED FOR	5

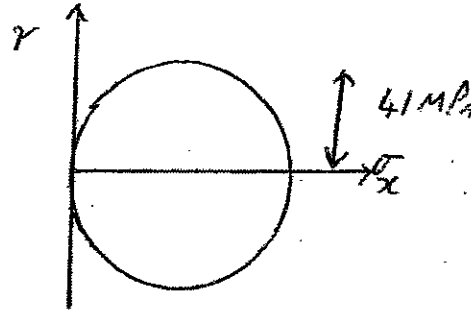
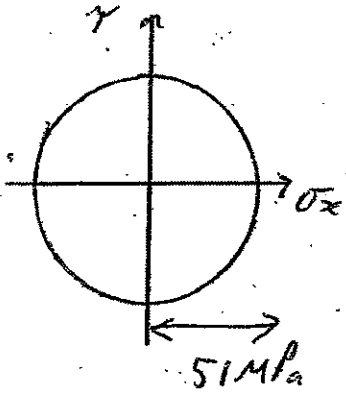
Continuation Sheet

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Question No	Question	Marks
(3) (a)	A PRINCIPAL STRESS IS THE <u>MAX</u> OR <u>MIN</u> VALUE OF STRESS THAT A LOADED SECTION WILL SEE. THESE OCCUR ON PRINCIPAL PLANES	(3)
(b) (i)	SEE MOHR'S CIRCLE ON NEXT PAGE BY MEASUREMENT $\sigma_1 \approx 51 \text{ MPa}$ (TENSILE) $\sigma_2 \approx -32 \text{ MPa}$ (COMPRESSIVE)	(5) (1) (1)
(ii)	$2\theta_1 \approx 76^\circ$ $\therefore \theta_1 = 38^\circ$: MAX PRINCIPAL STRESS	(1)
	$\therefore \theta_2 = 38 + 90$ $= 128^\circ$ MIN PRINCIPAL STRESS	(1)
(iii)	$\tau_{\max} \approx 42 \text{ MPa}$ $\theta = 38^\circ + 45$ $= 83^\circ$	(1) (1)



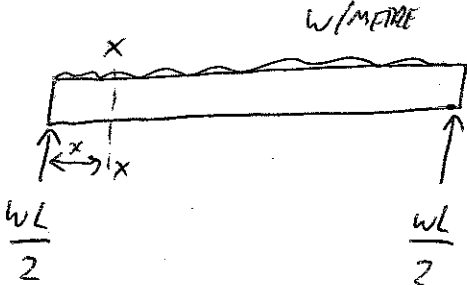
Continuation Sheet

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Question No	Question	Marks
(16)	σ_x ONLY $\therefore \sigma_y = 0$ $\tau_{xy} = 0$ $\tau_{max} = 41 \text{ MPa}$ RADIUS OF CIRCLE IS $41 \text{ MPa} \therefore \sigma_1 = \underline{\underline{82 \text{ MPa}}}$ 	(3)
(17)	$\sigma_x = 0$ $\sigma_y = 0$ $\sigma_1 = 51 \text{ MPa}$ RADIUS OF CIRCLE IS $51 \text{ MPa} \therefore \tau_{xy} = \underline{\underline{51 \text{ MPa}}}$ 	(3) / 20

Continuation Sheet

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Question No	Question	Marks
4	 $M_{xx} = \frac{wLx}{2} - wx \cdot \frac{x}{2}$ $= \frac{wLx}{2} - \frac{wx^2}{2}$ $\frac{wLx}{2} - \frac{wx^2}{2} = EI \frac{d^2y}{dx^2}$ INTEGRATING ONCE $EI \frac{dy}{dx} = \frac{wLx^2}{4} - \frac{wx^3}{6} + A \quad (1)$ INTEGRATING TWICE $EI y = \frac{wLx^3}{12} - \frac{wx^4}{24} + Ax + B \quad (2)$	(1) (1) (1½) (1½)

Continuation Sheet

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Question No	Question	Marks
	BOUNDARY CONDITIONS: WHEN $x=0$, $y=0$ $\therefore$ FROM (2) : <u>$B=0$</u> WHEN $x=L$, $y=0$ $\therefore$ FROM (2) $0 = \frac{wL^4}{12} - \frac{wL^4}{24} + AL$ $\therefore AL = -\frac{wL^4}{24}$ $\therefore A = -\frac{wL^3}{24}$ $\therefore$ FROM (2) $EI y = \frac{wLx^3}{12} - \frac{wx^4}{24} - \frac{wL^3x}{24}$ (6) $EI = \frac{1}{4} \left[\frac{wLx^3}{12} - \frac{wx^4}{24} - \frac{wL^3x}{24} \right]$ $= \frac{1}{2 \times 10^3} \left[\frac{200 \times 5 \times 2.5^3}{12} - \frac{200 \times 2.5^4}{24} - \frac{200 \times 5^3 \times 2.5}{24} \right]$ $= \frac{1}{2 \times 10^3} [1302.0 - 20833.3 - 2604.2]$ <u><u>$= 69.87 \times 10^6 \text{ Pa m}^4$</u></u>	(1) (1) (2) (1) (5)

Continuation Sheet

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Question No	Question	Marks
(i)	$EI = 69870000$ $\therefore I = \frac{69870000}{69 \times 10^9}$ $= \underline{1.01 \times 10^{-3} \text{ m}^4}$	(1)
(ii)	$I = 1.01 \times 10^{-3} \text{ m}^4$ $= (1.01 \times 10^{-3}) \times 10^8$ $= \underline{101273 \text{ cm}^4}$ $\therefore \text{LIGHTEST BEAM} = D \times B = 617.5 \times 307.0$ $I_{xx} = 151,631 \text{ cm}^4$ $\therefore \text{WEIGHT} = 113 \text{ kg/m}$ $\therefore \text{WEIGHT OF BEAM} = 113 \times 5 = \underline{565 \text{ kg}}$	(4) 20