



EXAMINATIONS 2012 / 2013 **AHOLIADAU 2012 / 2013**

Semester 2

FACULTY OF: Applied Design & Engineering

NAME OF COURSE/PROGRAMME: BEng Manufacturing Systems Engineering
BEng Mechanical & Manufacturing Engineering

YEAR OR LEVEL: Year 2 – Resit

NAME OF MODULE/UNIT/EXAM PAPER: Stress Analysis and Dynamics

MODULE NO:

DATE OF EXAMINATION: ??

EXAMINATION TIMES:

START TIME: ?? pm

FINISH TIME: ?? pm

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer 3 from 4 questions.

Assume acceleration due to gravity, $g = 9.81 \text{ ms}^{-2}$

Attach any graph paper used to your answer booklet

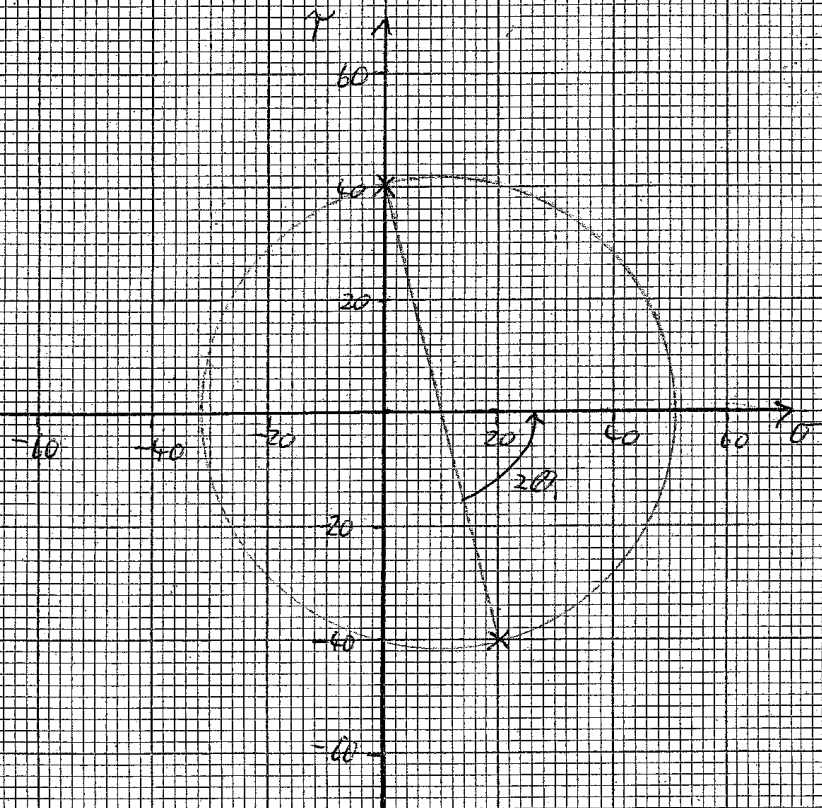
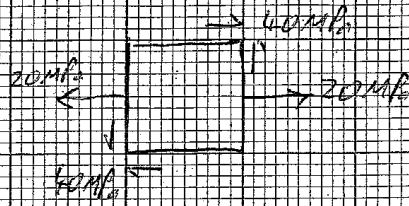
Continuation Sheet

Module/Unit: STRESS ANALYSIS & DYNAMICS	Page:
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Question No	Question	Marks
1a	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 (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) ii $2\theta_1 \approx 76^\circ$ $\therefore \theta_1 = 38^\circ$: MAX PRINCIPAL STRESS $\therefore \theta_2 = 38^\circ + 90^\circ$ $= 128^\circ$ MIN PRINCIPAL STRESS iii $\tau_{\max} \approx 42 \text{ MPa}$ $\theta = 38^\circ + 45^\circ$ $= 83^\circ$	(3) (5) (1) (1) (1) (1) (1) (1) (1)

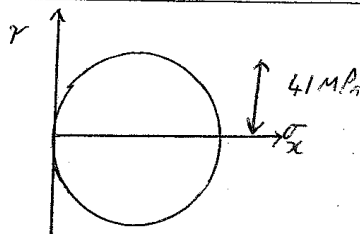
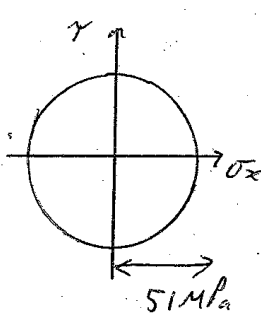
CONTINUATION SHEET

RTS ANALYSIS & DYNAMICS



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Module/Unit:	STATES ANALYSIS & DYNAMICS	Page:	
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Question No	Question	Marks
(iv)	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)
(v)	$\sigma_x = 0$ $\sigma_y = 0$ $\sigma_1 = 51 \text{ MPa}$  RADIUS OF CIRCLE IS $51 \text{ MPa} \therefore \tau_{xy} = \underline{\underline{51 \text{ MPa}}}$	(3)

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Continuation Sheet

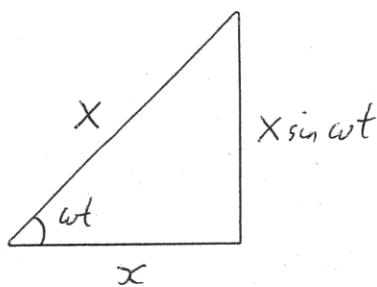
Module/Unit: *STRESS ANALYSIS & DYNAMICS*

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Question No	Question	Marks
(2a)	• DISTANCE x $x = X \cos \omega t$ • $\therefore$ <u>velocity $v = \omega X \sin \omega t$</u> (2)	~~1 1/2~~

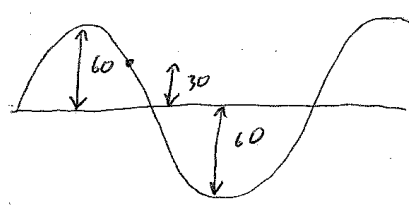
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Module/Unit:	STRESS ANALYSIS & DYNAMICS	Page:	
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Question No	Question	Marks
2a COM.	now  $\therefore (X \sin \omega t)^2 + x^2 = X^2$ $\therefore X \sin \omega t = \sqrt{X^2 - x^2} \quad (2)$ combine (2) & (3) $\therefore v = \omega \sqrt{X^2 - x^2}$	(1/2) ~~(2)~~ (2) ~~(2)~~

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Module/Unit:		Page:	
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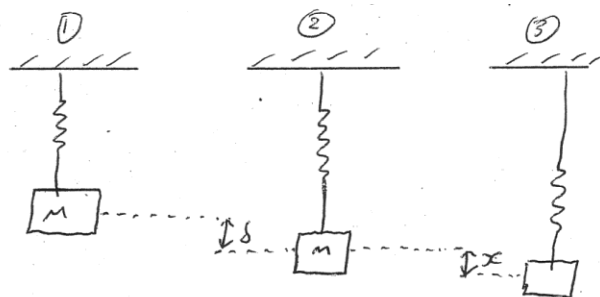
Question No	Question	Marks
2a ii	$f = 3\text{Hz}$ $X = 60\text{mm}$ $v = ?$ $a = ?$ $x = 30\text{mm}$  $f = \frac{1}{T} = \frac{\omega}{2\pi}$ $3 = \frac{\omega}{2\pi} \therefore \omega = 3 \times 2\pi$ $\quad \quad \quad = 18.85 \text{ rad s}^{-1}$ $v = \omega \sqrt{(X^2 - x^2)} = 18.85 \sqrt{(0.06^2 - 0.03^2)}$ $\quad \quad \quad = 0.98 \text{ m s}^{-1}$ $a = \omega^2 x = 18.85^2 \times 0.03$ $\quad \quad \quad = 10.66 \text{ m s}^{-2}$	① ① ①½ ①½ 5

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Module/Unit: STRESS ANALYSIS & DYNAMICS

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(2b)



(2) IN EQUILIBRIUM $mg = k\delta$

(3) WHEN OSCILLATING RESTORING FORCE $F = kx$

• NEWTON'S 2nd LAW $F = ma$ $\therefore ma = kx$ $\therefore \underline{\underline{\frac{a}{x} = \frac{k}{m}}}$ *

(3)

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Module/Unit:	STATS ANALYSIS & DYNAMICS	Page:	
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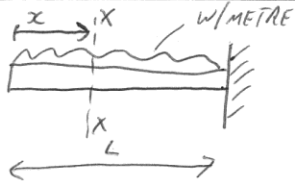
Question No	Question	Marks
26 cont	now $f = \frac{1}{T} = \frac{1}{2\pi} \omega$ ALSO $a = \omega^2 x \therefore \omega = \sqrt{\frac{a}{x}}$ $\therefore f = \frac{1}{2\pi} \sqrt{\frac{a}{x}}$ $\therefore$ FROM * $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$	① ①

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Module/Unit:	Page:
Question No 2b ii	Question $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ $F = kx \quad \therefore k = \frac{F}{x} = \frac{100 \times 10^{-3} \times 9.81}{5 \times 10^{-3}}$ $= \underline{\underline{196.2 \text{ N/m}}}$ $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ $= \frac{1}{2\pi} \sqrt{\frac{196.2}{250 \times 10^{-3}}}$ $= \underline{\underline{4.46 \text{ Hz}}}$ $T = \frac{1}{f} = \frac{1}{4.46}$ $= \underline{\underline{0.22 \text{ s}}}$ Marks (2) (2) (1) 5

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Question No	Question	Marks
3	 $M_{xx} = -wx \cdot \frac{x}{2}$ $= -\frac{wx^2}{2}$ $\therefore EI \frac{d^2 y}{dx^2} = -\frac{wx^2}{2}$ $\therefore EI \frac{dy}{dx} = -\frac{wx^3}{6} + A \quad (1)$ $\therefore EI y = -\frac{wx^4}{24} + Ax + B \quad (2)$ BOUNDARY CONDITIONS: WHEN $x=L$ $\frac{dy}{dx} = 0$ $\therefore \text{FROM } (1) \quad 0 = -\frac{wL^3}{6} + A$ $\therefore A = \frac{wL^3}{6}$ 2nd BOUNDARY CONDITION: WHEN $x=L, y=0$ $\therefore \text{FROM } (2) \quad 0 = -\frac{wL^4}{24} + \frac{wL^3}{6} L + B$ $\therefore B = \frac{wL^4}{24} - \frac{wL^4}{6} = -\frac{wL^4}{8}$	(1) (1) (1) (1) (1) (2)

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Question No	Question	Marks
(b i)	FROM (2) $EIy = -\frac{wx^4}{24} + \frac{wL^3x}{6} - \frac{wL^4}{8}$ $\therefore y = \frac{1}{EI} \left[-\frac{wx^4}{24} + \frac{wL^3x}{6} - \frac{wL^4}{8} \right]$ $EIy = -\frac{wx^4}{24} + \frac{wL^3x}{6} - \frac{wL^4}{8}$ $\therefore EI = \frac{1}{y} \left[-\frac{wx^4}{24} + \frac{wL^3x}{6} - \frac{wL^4}{8} \right]$ $= \frac{1}{-2 \times 10^{-3}} \left[-\frac{200 \times 2.5^4}{24} + \frac{200 \times 5^3 \times 2.5}{6} - \frac{200 \times 5^4}{8} \right]$ $= \frac{1}{-2 \times 10^{-3}} \left[-325.5 + 10416.7 - 15625 \right]$ $= \underline{\underline{2.77 \text{ MPam}^4}}$	(2) (5)

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Module/Unit:	STRIPS ANALYSIS & DYNAMICS	Page:	
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Question No	Question	Marks
(i)	$EI = 2766900$ $\therefore I = \frac{2766900}{69 \times 10^9}$ $= \underline{\underline{4.01 \times 10^{-5} \text{ m}^4}}$	(1)
(iii)	$I = 4.01 \times 10^{-5} \text{ m}^4$ $= (4.01 \times 10^{-5}) \times 10^8$ $= \underline{\underline{4010 \text{ cm}^4}}$ LIGHTEST BEAM IS $D \times B = 312.7 \times 102.4$ $I_{xx} = 6487 \text{ cm}^4$ WEIGHT = 33 kg/m $\therefore$ WEIGHT OF BEAM IS $5 \times 33 = \underline{\underline{165 \text{ kg}}}$	(4) <u>20</u>

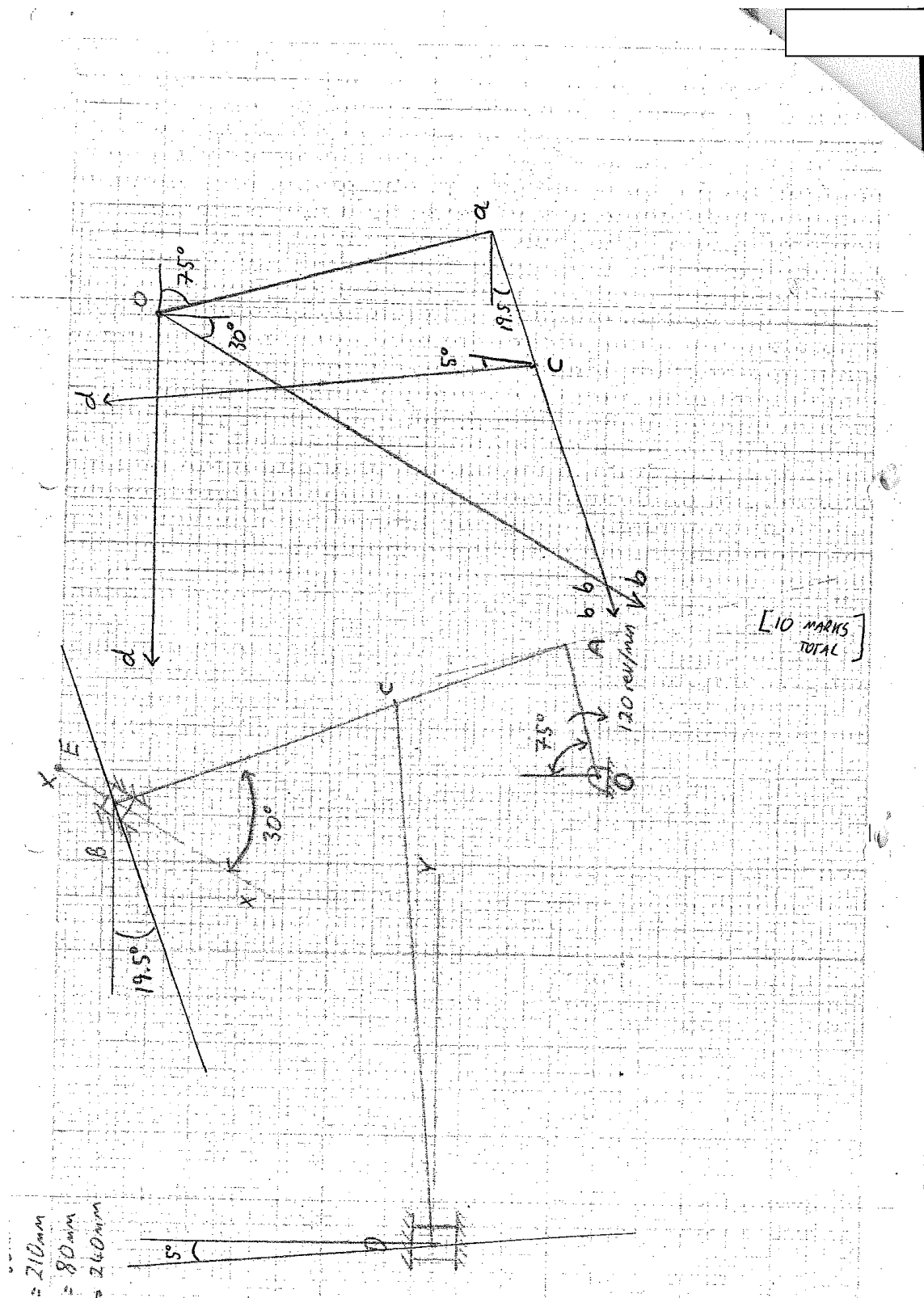
Continuation Sheet

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Question No	Question	Marks	
	SEE DIAGRAM ON NEXT PAGE CONSTRUCTION IS AS FOLLOWS: ~~CONSTRUCTION~~ (DESCRIPTION NOT NEEDED)	(2)	
4a	①		
	VELOCITY OF A RELATIVE TO O $V_{AO} = OA \times \omega_B$		
	$= 60 \times 10^{-3} \times 120 \times 2\pi$		
	60		
	$= 0.754 \text{ m/s}$		
	HENCE $\vec{OA}$ DRAWN $0.754 \approx 7.54 \text{ cm}$ 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.		
	• V_{BA} (TANGENTIAL OF B RELATIVE TO A): ANGLE OF TANGENT FROM HORIZ MEASURED FROM DIAGRAM $= 19.5^\circ$		
	$\therefore \vec{OB}$ DRAWN 19.5° FROM HORIZONTAL, WITH INTERSECTION WITH $\vec{OA}$ FIXING b.		
	③ PIN JOINT C		
	• IS POSITIONED SUCH THAT $\frac{ac}{ab} = \frac{AC}{AB} = \frac{80}{210} = 0.38$		
	$\therefore ac = 0.38 ab$		
	BY MEASUREMENT $ab = 82 \text{ mm} \therefore \underline{ac = 31.2 \text{ mm}}$		

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Question No	Question	Marks
26	SLIDER D • SLIDER D CONSTRAINED TO MOVE ALONG HORIZONTAL AXIS ~~AT~~ TO O $\therefore \vec{OD}$ DRAWN WITH INDETERMINATE LENGTH. • V_{DC} (TANGENTIAL OF D RELATIVE TO A) : ANGLE OF TANGENT FROM VERTICAL MEASURED FROM DIAGRAM = $5^\circ \therefore \vec{CD}$ DRAWN 5° FROM VERTICAL, WITH INTERSECTION WITH $\vec{OD}$ <u>FIXED</u> VELOCITY DIAGRAM COMPLETE! • SLIDER B : $\vec{OB}$ (MEASURED) = 11.7cm $\therefore V_{OB} = 11.7 \times 0.1$ $= 1.17 \text{ m/s}$ 30° 'DOWNWARD AND LEFT' IN SENSE $O \rightarrow b$ • SLIDER D : $\vec{OD}$ (MEASURED) = 1.9cm $\therefore V_{OD} = 1.9 \times 0.1$ $= 0.19 \text{ m/s}$ TO 'LEFT' IN SENSE $O \rightarrow d$	1



[10 MARKS TOTAL]

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Question No	Question	Marks
4b	 A → C LOSS OF P.E. = GAIN IN K.E. $mg(h-2r) = \frac{1}{2}mv^2$ $v^2 = 2g(h-2r) *$ 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

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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