



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 – PART TIME

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:

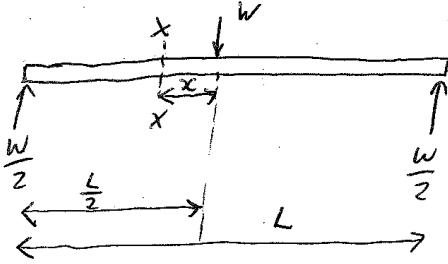
Answer 3 from 4 questions.

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 (PT)	Page:	of
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Question No	Question	Marks
(1a)	 $M_{xx} = \frac{W}{2} \left(\frac{L}{2} - x \right) = \frac{WL}{4} - \frac{Wx}{2}$ $\therefore EI \frac{d^2 y}{dx^2} = \frac{WL}{4} - \frac{Wx}{2}$ $\therefore \frac{EI dy}{dx} = \frac{WLx}{4} - \frac{Wx^2}{4} + A \quad *$ $\therefore EI y = \frac{WLx^2}{8} - \frac{Wx^3}{12} + Ax + B \quad **$ BOUNDARY CONDITIONS: WHEN $x=0 \quad \frac{dy}{dx} = 0 \quad \therefore A=0 \quad (\text{FROM } *)$ WHEN $x=\frac{L}{2} \quad y=0 \quad \therefore 0 = \frac{WL}{8} \left(\frac{L}{2} \right)^2 - \frac{W}{12} \left(\frac{L}{2} \right)^3 + B \quad (\text{FROM } **)$ $\therefore B = \frac{WL^3}{96} - \frac{WL^3}{32}$ $= \frac{-WL^3}{48}$ $\therefore \text{FROM } ** \quad y = \frac{1}{EI} \left[\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right] \quad \text{QED}$	(1) (1) (1) (2) (3) (1) <u>10</u>

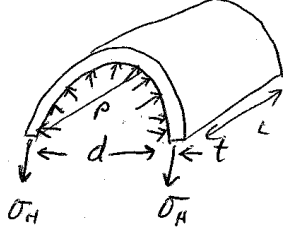
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Question No	Question	Marks
(6) (i)	$EI_y = \frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48}$ $\therefore EI = \frac{1}{y} \left[\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right]$ $= \frac{1}{2 \times 10^{-3}} \left[\frac{10,000 \times 5 \times 0^2}{8} - \frac{10,000 \times 0^3}{12} - \frac{10,000 \times 5^3}{48} \right]$ $= \frac{1}{2 \times 10^{-3}} [0 - 0 - 26041.7]$ $= 13020833$ $= \underline{\underline{13.0 \text{ MP}_m^4}}$	(5)
(ii)	$EI = 13020833$ $\therefore I = \frac{13020833}{200 \times 10^9} = \underline{\underline{6.51 \times 10^{-5} \text{ m}^4}}$	(1)
(iii)	$= \underline{\underline{6510 \text{ cm}^4}}$ $\therefore \text{LIGHTEST BEAM} = D \times B = 310.7 \times 166.8$ $= 54 \text{ Kg/m}$ $= 54 \times 5 = \underline{\underline{270 \text{ Kg}}}$	(4)

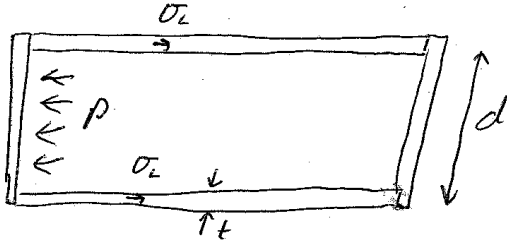
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Module/Unit:	STRESS ANALYSIS & DYNAMICS (PT)	Page:	of
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Question No	Question	Marks
2a. (i)	 RESOLVE VERTICALLY: FORCE ON HALF OF CYLINDER = $p \times \text{PROJECTION AREA}$ $= p \times dL$ TOTAL RESISTIVE FORCE = $2\sigma_H \times Lt$ $\therefore F\uparrow = F\downarrow$ $p dL = 2\sigma_H \times Lt$ $\therefore \sigma_H = \frac{pd}{2t}$ <u> </u>	(4)

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Question No	Question	Marks
(ii)	 TOTAL FORCE ON END OF CYLINDER = PRESSURE × AREA $= p \pi r^2$ $= \frac{p \pi d^2}{4}$ AREA OF METAL RESISTING THIS = CIRCUMFERENCE × t $= 2 \pi r t$ $= \pi d t$ ∴ STRESS = $\frac{\text{FORCE}}{\text{AREA}} = \frac{\frac{p \pi d^2}{4}}{\pi d t}$ $\sigma_L = \frac{p d}{4 t}$	(4)
(iii)	LONGITUDINAL STRESS IS ALWAYS HALF OF THE CIRCUMFERENTIAL STRESS	(2)

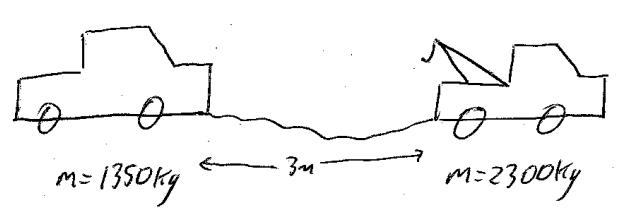
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Question No	Question	Marks
(b i)	HOOP STRESS = 2 × LONGITUDINAL STRESS ∴ HOOP STRESS IS LIMITING FACTOR $\sigma_H = \frac{Pd}{2t}$ $\therefore P = \frac{2t\sigma_H}{d}$ $= \frac{2 \times 10 \times 10^{-3} \times 150 \times 10^6}{5}$ $= \underline{\underline{0.6 \text{ MPa}}}$	(4)
(ii)	IF PRESSURE INSIDE SUB IS $1 \times 10^5 \text{ Pa}$ MAX PRESSURE OUTSIDE SUB = $1 \times 10^5 + 0.6 \times 10^6$ = $\underline{\underline{0.7 \text{ MPa}}}$ $P = \rho gh$ $\therefore h = \frac{P}{\rho g} = \frac{0.7 \times 10^6}{1000 \times 9.81} = \underline{\underline{71.4 \text{ m}}}$	(4)
(iii)	ASSUMPTIONS: THIN CYLINDER, NO JOINTS, NO MATERIAL INCONSISTANCES, NO TOLERANCES ON THICKNESS ETC.	(2)

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Question No	Question	Marks
3(a) i	 $m = 1350 \text{ kg}$ $M = 2300 \text{ kg}$ $\text{ROPE} = 3 \text{ m}$ $F = 2.25 \text{ kN}$ JUST BEFORE ROPE BREAKS $F = m a$ $\therefore a = \frac{F}{M}$ $= \frac{2.25 \times 10^3}{2300}$ $= 0.978 \text{ ms}^{-2}$ $\therefore v^2 = u^2 + 2as$ $\therefore v = \sqrt{u^2 + 2as}$ $= \sqrt{0^2 + 2 \times 0.978 \times 1.5}$ $= 1.713 \text{ ms}^{-1}$ $= \frac{1.713}{1000} \times 60 \times 60$ $= \underline{\underline{6.17 \text{ km/h}}}$	

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Question No	Question	Marks	
(ii)	FINAL VELOCITY MOMENTUM BEFORE = MOMENTUM AFTER ROPE STRETCHES ROPE STRETCHES $m_B V_B = m_A V_A$ $2300 \times 1.713 = (2300 + 1350) V_A$ $\therefore V_A = 1.079 \text{ ms}^{-1}$ $= \frac{1.079}{1000} \times 60 \times 60$ $= \underline{\underline{3.9 \text{ km/h}}}$		
(iii)	ASSUMPTIONS INCLUDE LINEAR ACCELERATION, PERFECT ENERGY TRANSFER, I.E. NO LOSSES DUE TO HEAT, NOISE, PLASTIC DEFORMATION OF ROPE, TOWNL HOOKS ETC.		

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Question No	Question	Marks	
③ i	$\alpha = 15 \text{ rad s}^{-1}$ $t = 3 \text{ s}$ $\omega_2 = 3500 \text{ rev/min} = \frac{3000 \times 2\pi}{60} = \underline{\underline{366.5 \text{ rad s}^{-1}}}$ $\omega_1 = ?$ $\omega_2 = \omega_1 + \alpha t$ $\therefore \omega_1 = 366.5 - 15 \times 3$ $= \underline{\underline{321.5 \text{ rad s}^{-1}}}$ $= \frac{321.5 \times 60}{2\pi} = 3070 \text{ rev/min}$ ii $T = I\alpha$ $= 0.5 \times 15$ $= \underline{\underline{7.5 \text{ Nm}}}$	④ ②	

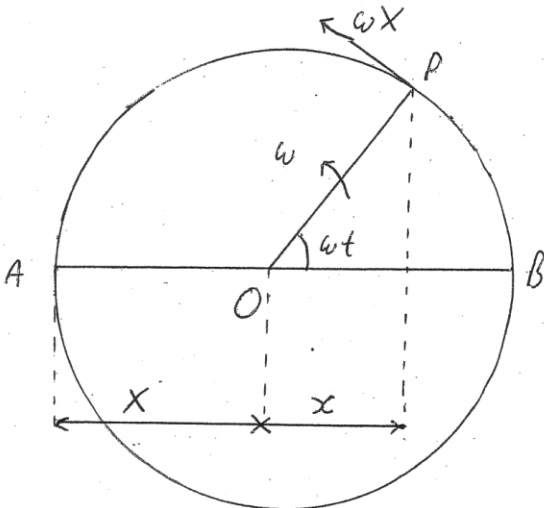
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Module/Unit:		Page:	of
Question No	Question	Marks	
(iii)	FOR A SOLID DISC RADIUS OF GYRATION $K = \frac{R}{\sqrt{2}}$ $= \frac{0.15}{\sqrt{2}}$ $= \underline{\underline{0.106m}}$ $I = mK^2$ MASS, $m = \rho \times V$ $= 7800 \times \pi \times 0.15^2 \times 0.02$ $= 11.0 \text{ Kg}$ $\therefore I = 11.0 \times 0.106^2$ $= \underline{\underline{0.12 \text{ Kg m}^2}}$ $\therefore \text{FLY WHEEL CONTRIBUTION} = \frac{0.12}{0.5} = 6\%$	(2)	
(v)	OTHER CONTRIBUTIONS TO THE ENGINE INERTIA ARE ANY ROTATING MASSES, eg. CON RODS, PISTONS, CRANK SHAFT ETC.	(2)	

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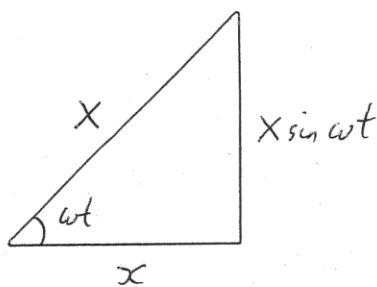
Module/Unit: *STRESS ANALYSIS & DYNAMICS*

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Question No	Question	Marks
4a	 • DISTANCE x $x = X \cos \omega t$ • <u>VELOCITY $v = \omega X \sin \omega t$ (2)</u>	 <i>1 1/2</i>

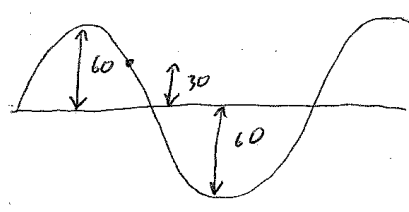
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Question No	Question	Marks
4a COM.	NOW  $\therefore (X \sin \omega t)^2 + x^2 = X^2$ $\therefore X \sin \omega t = \sqrt{X^2 - x^2} \quad (2)$ COMBINE (2) & (3) $\therefore v = \omega \sqrt{X^2 - x^2}$ V IS A MAX WHEN $x=0$ i.e. WHEN P PASSES O	(1½) ~~(2)~~ (2) ~~(2)~~

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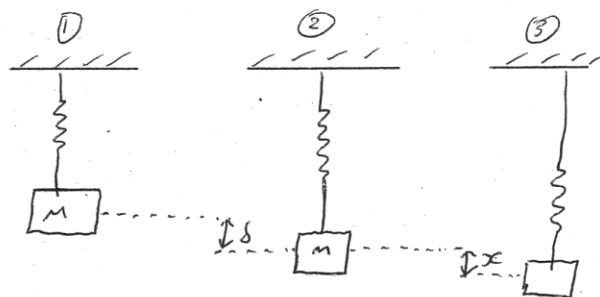
Question No	Question	Marks
4aii	$f = 3\text{Hz}$ $x = 60\text{mm}$ $v = ?$ $a = ?$ $x = 30\text{mm}$  $f = \frac{1}{T} = \frac{\omega}{2\pi}$ $3 = \frac{\omega}{2\pi} \therefore \omega = 3 \times 2\pi$ $\quad \quad \quad = 18.85 \text{ rads}^{-1}$ $v = \omega \sqrt{(x^2 - x^2)} = 18.85 \sqrt{(0.06^2 - 0.03^2)}$ $\quad \quad \quad = 0.98 \text{ ms}^{-1}$ $a = \omega^2 x = 18.85^2 \times 0.03$ $\quad \quad \quad = 10.66 \text{ ms}^{-2}$	① ① ①½ ①½ 5

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Question No	Question	Marks
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4b



② IN EQUILIBRIUM $mg = k\delta$

③ WHEN OSCILLATING RESTORING FORCE $F = kx$

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

③

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Module/Unit:	STATICS ANALYSIS & DYNAMICS	Page:	15 of 16
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Question No	Question	Marks
4b cont	$\overset{\text{now}}{f} = \frac{1}{T} = \frac{1}{2\pi} \omega$ $\underline{\text{ALSO}} \quad a = \omega^2 x \quad \therefore \quad \omega = \sqrt{\frac{a}{x}}$ $\therefore f = \frac{1}{2\pi} \sqrt{\frac{a}{x}}$ $\therefore \text{FROM } * \quad \underline{\underline{f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}}}$	① ①

Continuation Sheet

Module/Unit:	Page:	of
Question No	Question	Marks
4bii	$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ $F = kx \quad \therefore k = \frac{F}{x} = \frac{100 \times 10^{-3} \times 9.81}{5 \times 10^{-3}}$ $= \underline{\underline{196.2 \text{ N/m}}}$ $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ $= \frac{1}{2\pi} \sqrt{\frac{196.2}{250 \times 10^{-3}}}$ $= \underline{\underline{4.46 \text{ Hz}}}$ $T = \frac{1}{f} = \frac{1}{4.46}$ $= \underline{\underline{0.22 \text{ s}}}$	(2) (2) (1) 5