



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: 28/06/13

EXAMINATION TIMES:

START TIME: 1.30 pm

FINISH TIME: 3.30 pm

TIME ALLOWED: 2 hours

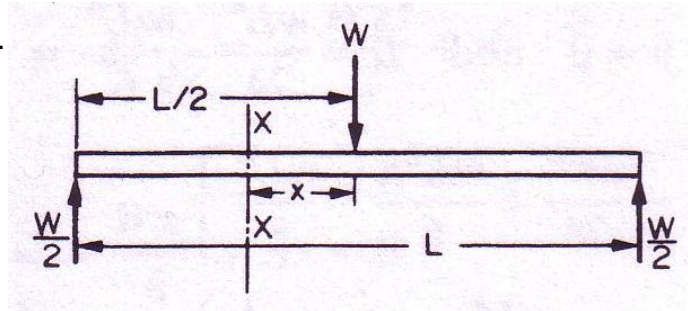
INSTRUCTIONS TO CANDIDATES:

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

Question 1



a) Given the above diagram, and using the relationship, $M = EI \frac{d^2y}{dx^2}$, show that the deflection, y , at any point on the beam is given by;

$$y = \frac{1}{EI} \left[\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right]$$

[10 marks]

b)

i)

A 5m long simply supported beam has a point load of 5kN applied to the centre of the beam. What is the minimum flexural stiffness required to limit the central deflection to 2mm neglecting the weight of the beam?

[5 marks]

ii)

If the beam were to be made out of steel ($E=200\text{GPa}$) what would the minimum second moment of area be?

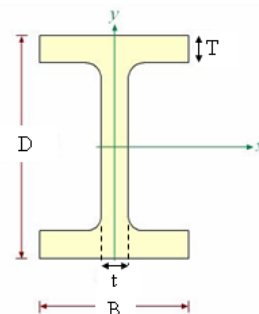
[1 mark]

iii)

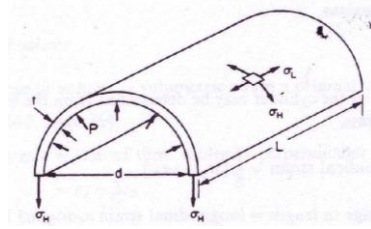
Hence choose the lightest suitable beam from the below table assuming the beam is loaded about the x axis. What would the weight of this beam be over the length required?

[4 marks]

Size D x B (mm)	Mass per metre (kg)	Thickness		I_{xx} (cm^4)	I_{yy} (cm^4)
		Web, t (mm)	Flange, T (mm)		
910.3 x 304.1	222	15.9	23.9	375924	11223
840.7 x 292.4	194	14.7	21.7	279450	9069
762 x 266.7	173	14.3	21.6	205177	6846
677.9 x 253.0	125	11.7	16.2	118003	4379
617.5 x 307.0	113	14.1	23.6	151631	11412
533.1 x 209.3	92	10.2	15.6	55353	2392
467.4 x 192.8	98	11.4	19.6	45717	2343
457.2 x 151.9	67	9.1	15	28577	878
402.3 x 142.4	46	6.9	11.2	15647	539
364 x 173.2	67	9.1	15.7	19522	1362
352.8 x 126.0	39	6.5	10.7	10087	357
310.9 x 166.8	54	7.7	13.7	11710	1061
312.7 x 102.4	33	6.6	10.8	6487	193
254 x 101.6	22	5.8	6.8	2867	120
203.2 x 133.4	25	5.8	7.8	2356	310



Question 2



a.

i.

Given the above structure which shows a freebody diagram of part of a thin cylinder subjected to internal pressure show that the hoop stress (σ_H) is given by the following relationship.

$$\sigma_H = \frac{Pd}{2t}$$

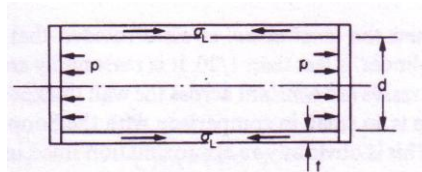
[4 marks]

ii.

Considering the same structure, pictured below, show the longitudinal stress (σ_L) is given by the following relationship.

$$\sigma_L = \frac{Pd}{4t}$$

[4 marks]



iii.

What observation can you draw from a(i) and a(ii)?

[2 marks]

b.

i.

A prototype submarine is 5m in diameter with a wall thickness of 10mm. Calculate the maximum pressure difference allowed between the inside and the outside of the vessel if the stress in the wall must not exceed 150MPa using the assumption of thin cylinder theory.

[4 marks]

ii.

Given that hydrostatic pressure, P , is given by $P = \rho gh$, where ρ is the density of water and can be taken at 1000kg/m^3 , and atmospheric pressure inside the submarine can be taken as $1\text{e}5\text{Pa}$, calculate the maximum depth, h , that this submarine can dive to.

[4 marks]

iii.

Discuss the limitations of your calculations in b(ii).

[2 marks]

Question 3

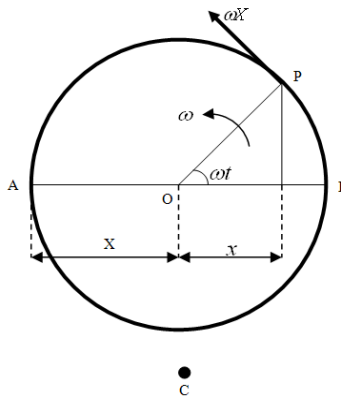
- a. A breakdown truck of mass 2300kg is attached to a car of mass 1350kg by a 4.5m long rope. The initial distance between the fixing points for the rope is 3m so that the truck can move 1.5m before the rope tightens and the truck is accelerated from rest under a tractive effort of 2.25kN. Determine the truck speed in km/h;
- i. Just before the rope starts to tighten [5 marks]
 - ii. At the instant when the rope ceases to stretch [3 marks]
 - iii. Discuss any assumptions in your calculations [2 marks]
- b. The flywheel of an internal combustion engine is accelerated uniformly at 15 rad/s^2 for 3 seconds, until the engine speed is 3500 rev/min.
- i. What is the initial rotational speed of the engine in rev/min [4 marks]
 - ii. If the rotating parts of the engine have a moment of inertia of 0.5 kgm^2 , determine the accelerating torque [2 marks]
 - iii. Given that the flywheel of the engine is of a solid circular steel construction (density 8100 kg/m^3) of diameter 30cm and thickness 2cm, calculate what percentage of the moment of inertia of the engine is due to the flywheel. [2 marks]
 - iv. Discuss what else contributes to the moment of inertia of the engine. [2 marks]

Question 4

a. i.

Consider point P rotating about point O at a constant angular velocity, ω , as shown in the below figure. When viewed from position C point P appears to move with simple harmonic motion. Prove that the velocity, v , of P, when viewed from C, is given by $v = \omega\sqrt{(X^2 - x^2)}$. When would P appear to have its greatest velocity when viewed from position C.

[5 Marks]



ii.

If the frequency of a body oscillating with simple harmonic motion is 3Hz and the amplitude of the motion is 60mm, determine the velocity and acceleration of the body when it is at a point midway between the maximum displacement and the mean position

[5 Marks]

b.

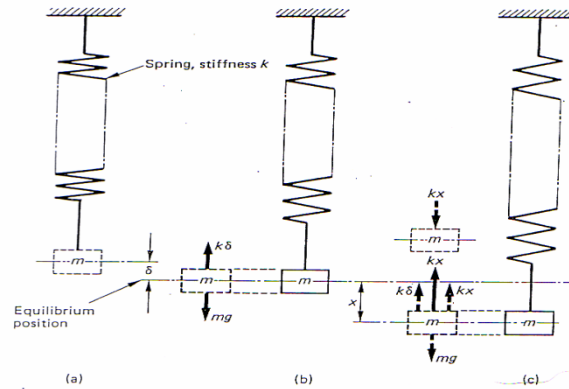
i.

Consider a mass on a spring as shown below, show that the natural frequency

is given by

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

[5 Marks]



ii.

A structure when loaded statically with a weight of 100g deflects 5mm. Determine the periodic time of this structure if this oscillates with simple harmonic motion due to a mass of 250g being hung from the structure.

[5 Marks]

Formula Sheet

Slope and deflection of beam theory;

$$EI \frac{d^2 y}{dx^2} = M \quad \text{Bending moment.}$$

$$Q = EI \frac{d^3 y}{dx^3} \quad \text{Shear Force}$$

$$w = EI \frac{d^4 y}{dx^4} \quad \text{Load}$$

Complex stress;

$$\sigma_{\theta} = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y)\cos 2\theta + \tau_{xy} \sin 2\theta \quad \text{Stress normal to a plane.}$$

$$\tau_{\theta} = \frac{1}{2}(\sigma_x - \sigma_y)\sin 2\theta - \tau_{xy} \cos 2\theta \quad \text{Shear stress on a plane.}$$

$$\sigma_{1,2} = \frac{1}{2} \left[(\sigma_x + \sigma_y) \pm \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right] \quad \text{Principal stresses}$$

$$\tau_{\max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \quad \text{Maximum shear stress}$$

Simple Harmonic Motion

$$a = \omega^2 x$$

$$T = \frac{2\pi}{\omega}$$

$$f = \frac{1}{T} = \frac{\omega}{2\pi}$$

Hydrostatic Pressure

$$P = \rho gh$$

Dynamics

$$v = u + at$$

$$s = ut + \frac{1}{2} at^2$$

$$v^2 = u^2 + 2as$$

$$\begin{aligned}\omega_1 &= \omega_2 + \alpha t \\ \theta &= \omega_1 t + \frac{1}{2} \alpha t^2 \\ \omega_2^2 &= \omega_1^2 + 2\alpha\theta\end{aligned}$$

$$F=ma$$

$$T=I\alpha$$

$$I = mk^2$$

$$\text{For a solid disc rotating } k = \frac{R}{\sqrt{2}} = 0.707R$$