



EXAMINATIONS 2014 / 2015

AHOLIADAU 2014 / 2015

Semester 1

FACULTY OF: Applied Design & Engineering

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

YEAR OR LEVEL: Year 3 (PART TIME – RESIT)

NAME OF MODULE/UNIT/EXAM PAPER: Advanced Stress Analysis

MODULE NO:

DATE OF EXAMINATION: ??

EXAMINATION TIMES:

START TIME: ?? pm

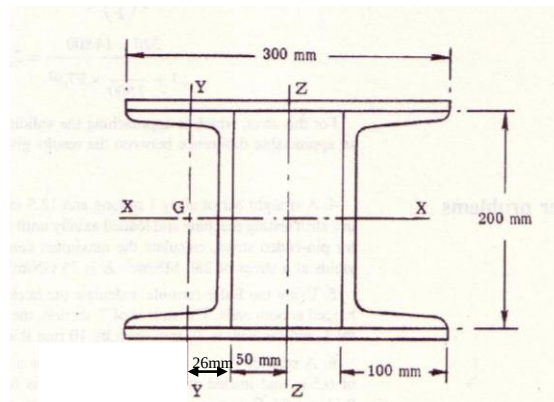
FINISH TIME: ?? pm

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer 3 from 4 questions.

1. A mild steel strut, 8m long, is fabricated from flat plates 300mm wide by 10mm thick and two channel sections 100mm wide by 200mm deep as shown below;



Properties of ONE channel;

$$I_{XX} = 26.2 \times 10^6 \text{ mm}^4$$

$$I_{YY} = 1.57 \times 10^6 \text{ mm}^4$$

$$A = 4400 \text{ mm}^2$$

Assuming pinned ends, determine the following:

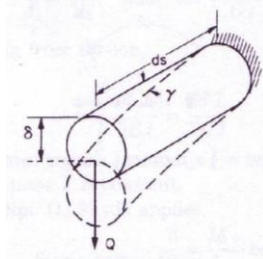
($E=200\text{GPa}$ for the plates and channel, $a = \frac{1}{7500}$, $\sigma_c = 320\text{MPa}$)

- Which axis will the strut buckle about?
[5 Marks]
- What is the radius of gyration about this axis?
[2 Marks]
- What is the slenderness ratio of this strut?
[2 Marks]
- According to Euler theory, what load will this strut buckle at?
[3 Marks]
- According to Rankine-Gordon theory, what load will this strut buckle at?
[3 Marks]
- Comment on the results of (d) and (e), and with the use of a diagram explain the difference between experimental results and buckling loads according to Euler theory.
[5 Marks]

2.

a)

- (i) Consider the below bar subjected to shear, prove from first principles that the shear strain γ , due to the load is given by; $\gamma = \frac{Q}{AG}$, where Q is the shear load, ds is the length of the bar, A is the cross sectional area and G is the Shear Modulus.



[2 Marks]

- (ii) Hence prove that the strain energy, U, for a bar in Shear is given by;

$$U = \frac{Q^2 L}{2AG} \quad [4 \text{ Marks}]$$

- (iii) What is meant by the term Resilience? Hence from prove from the standard relationship for a bar in tension, $U = \frac{P^2 L}{2AE}$, where P is the load and E is the Youngs Modulus, that resilience may be defined as

$$\text{Resilience} = \frac{\sigma^2}{2E}$$

[4 Marks]

- b) (i) A steel rod has a square cross section 15mm x 15mm and a length of 1m. Calculate the strain energy when a stress of 300MPa is produced by stretching it. (E=200GPa)

[3 Marks]

- (ii) The rod then has a metal collar fitted at the lower end, and a mass, m, is dropped onto the collar. Show, by considering the energy transferred from the falling weight to the rod, that the height, h, is related to the stress, σ , by the following relationship;

$$h = \frac{\sigma^2 V}{2Emg} - \frac{\sigma L}{E}$$

Where V is the volume of the bar, and L is the length. Assume that the extension of the bar is significant in the energy transfer.

[4 Marks]

- (iii) If the stress must not exceed 75MPa, from what height could 200kg fall onto the collar, without exceeding this?

[3 Marks]

FORMULA SHEET

$$U = \frac{P^2 L}{2AE} \quad \text{Strain energy in tension}$$

$$U = \frac{Q^2 L}{2AG} \quad \text{Strain energy in shear}$$

$$U = \frac{M^2 L}{2EI} \quad \text{Strain energy in bending}$$

$$U = \frac{T^2 L}{2GJ} \quad \text{Strain energy in torsion}$$

$$I_{NA} = \frac{BD^3}{12} \quad \text{Second moment of area of a rectangle}$$

$$I_{NA} = I_G + Ah^2 \quad \text{Parallel axis theorem}$$

$$\text{P.E.} = mgh \quad \text{Potential energy}$$

$$\text{K.E.} = \frac{1}{2} mv^2 \quad \text{Kinetic energy}$$

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R} \quad \text{The simple theory of elastic bending}$$

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L} \quad \text{The simple theory of elastic torsion}$$

$$J = \frac{2\pi R^4}{4} = \frac{\pi D^4}{32} \quad \text{Polar second moment of area for a solid circular shaft}$$

$$\text{slenderness ratio} = \frac{L}{k}$$

$$k = \sqrt{\frac{I}{A}} \quad \text{Radius of gyration}$$

$$P_e = \frac{\pi^2 EI}{L^2} \quad \text{Buckling: pinned-pinned}$$

$$P_e = \frac{\pi^2 EI}{4L^2} \quad \text{Buckling: fixed-free}$$

$$P_e = \frac{4\pi^2 EI}{L^2} \quad \text{Buckling: fixed-fixed}$$

$$P_e = \frac{2\pi^2 EI}{L^2} \quad \text{Buckling: fixed-pinned}$$

$$P_R = \frac{\sigma_y A}{1 + a(L/k)^2} \quad \text{Rankine Load}$$