NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CIVIL AND WATER ENGINEERING

STRUCTURAL ANALYSIS II

TCW 3207

Examination Paper

April/May 2015

This examination paper consists of 6 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements:

Examiner's Name: Miss Diana Makweche

INSTRUCTIONS

1. Answer any four (4) questions
2. Each question carries 25 marks
3. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
5.	**25**
TOTAL	**100**

QUESTION 1

(a) Explain why the plastic design of structures is preferable to elastic design. [3]

(b) With the aid of clearly labeled diagrams, describe how the stress distribution at a cross-section change as load is gradually increased (consider four separate instances: $M < M_Y$, $M = M_Y$, $M_Y < M < M_P$, $M = M_P$) [12]

(c) Calculate the shape factor for the section in Figure 1 [10]

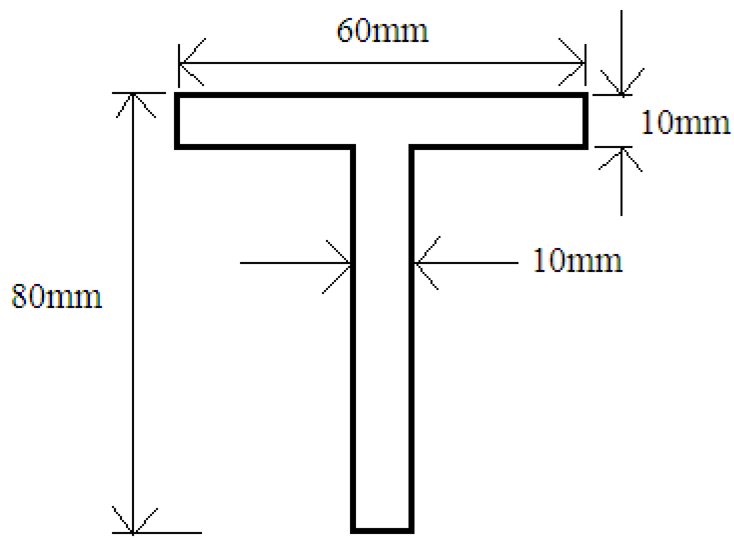

Figure 1

QUESTION 2

(a) Determine the required value of M_P to ensure a minimum load factor of $\lambda = 1.7$ for the beam in Figure 2a. [10]

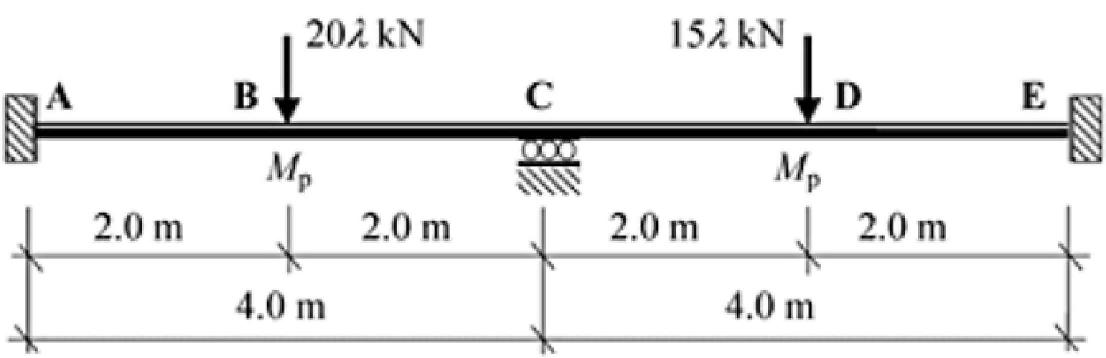

Figure 2a

(b) Sketch the possible collapse mechanisms for the frame in Figure 2b. Clearly indicate the positions of the plastic hinges. [6]

(c) Calculate the collapse load of the frame in Figure 2b. [9]

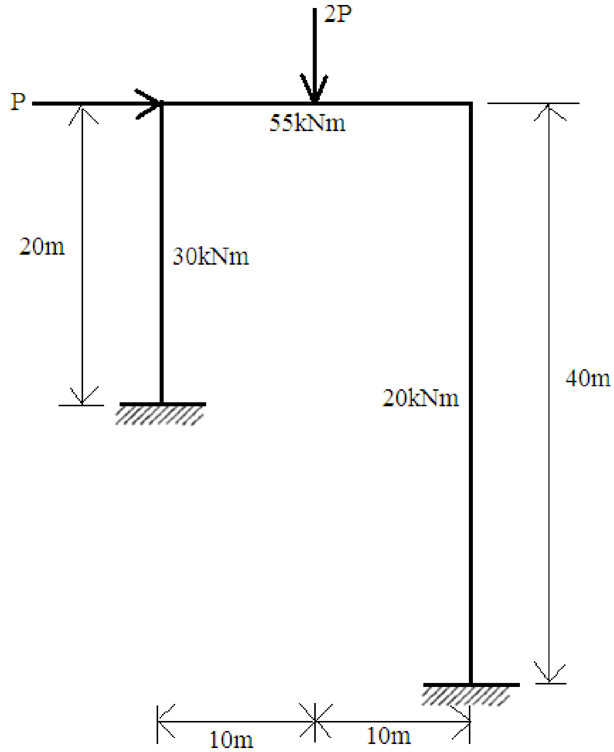

Figure 2b

QUESTION 3

(a) Define the term *yield line*. [2]

(b) Sketch one possible yield line pattern for the slabs in Figure 3a. [6]

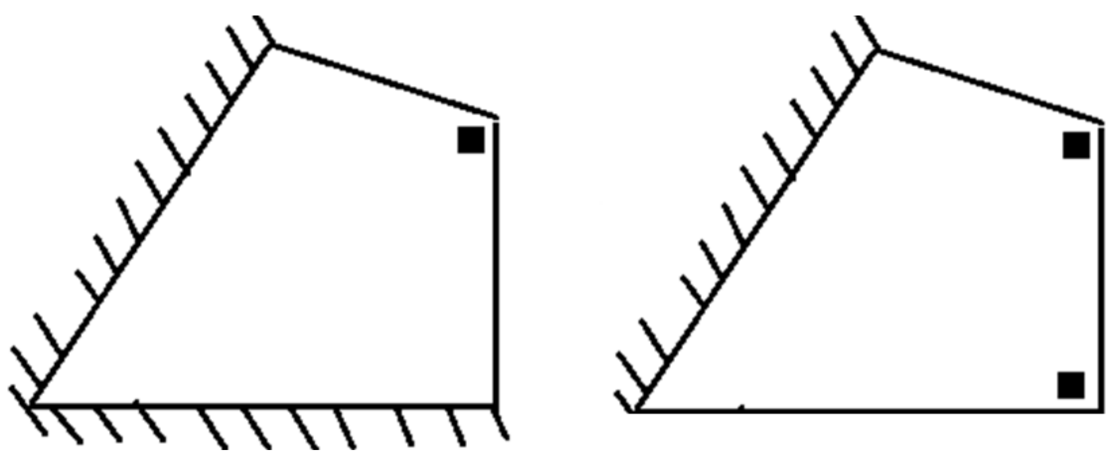

Figure 3a

(c) For the slab in Figure 3b calculate :

(i) The distance x.

(ii) the intensity of the UDL that would cause the reinforced concrete slab to collapse in the manner shown. [17]

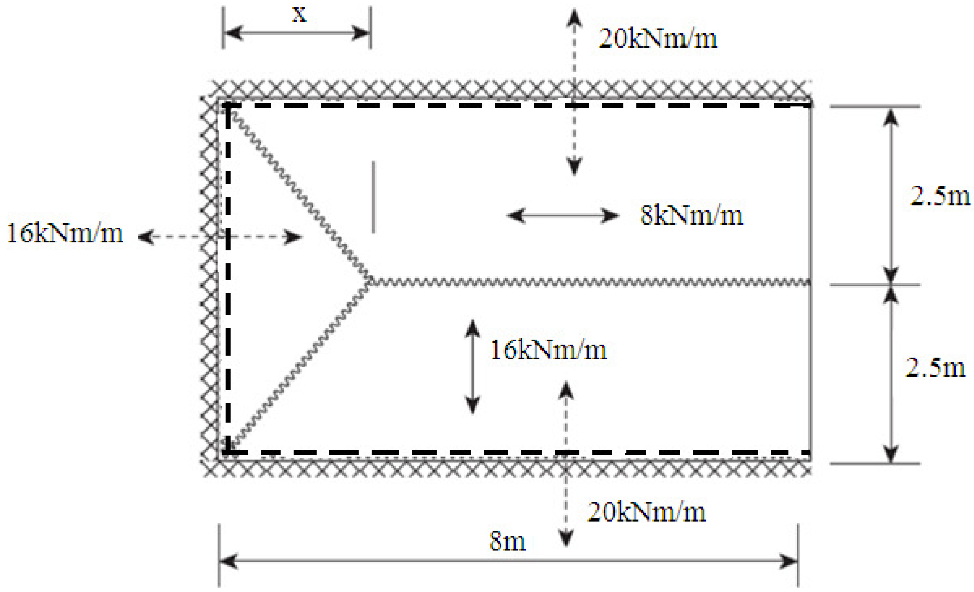

Figure 3b

QUESTION 4

(a) Figure 4 shows a 2-storey building. The floor slabs are very stiff compared to the columns. Find :

(i) the natural angular frequencies

(ii) the corresponding characteristic mode shapes. [25]

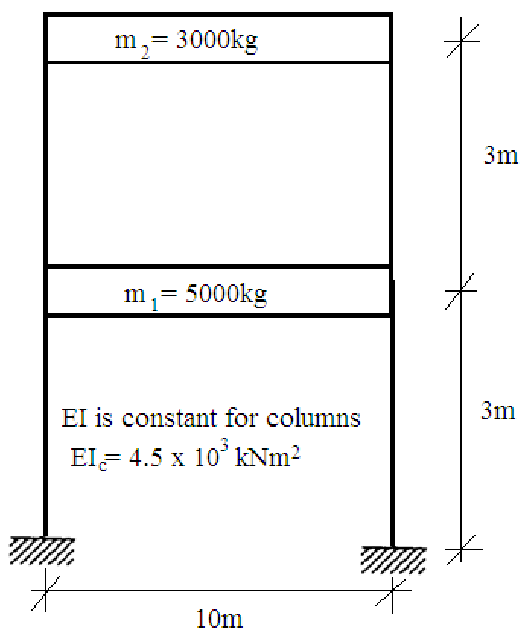

Figure 4

QUESTION 5

(a) Write the fundamental equation of free vibration, explaining each term. [5]

(b) (i) What is *damping*? [2]

(ii)On the graph of the undamped, free vibration response of a system in Figure 5 clearly indicate the following: amplitude, phase angle, period. [5]

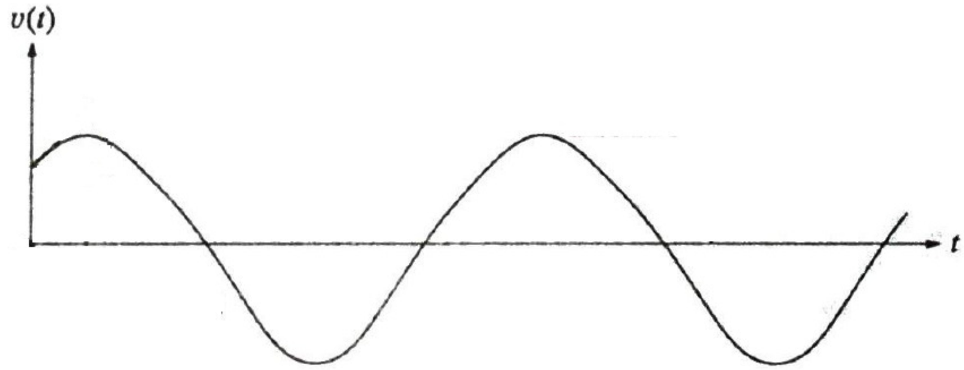

Figure 5

(iii) Sketch the response of an under-damped, a critically damped, and over-damped system. (Draw the three curves on one diagram) [6]

(c) A spring-mass single degree-of-freedom system has the following properties:

$mass, m = 20kg; spring\ stiffness, k = 350N/m;\ u_0 = 10mm;\ \dot{u}_0 = 100mm/s$

Determine the natural frequency, period, and amplitude of vibration of the system. [7]

FORMULAE

$$m\ddot{u}(t) + c\dot{u}(t) + ku(t) = F(t)$$

$$\omega^2 = \frac{k}{m} \qquad \xi = \frac{c}{c_{cr}}$$

$$\ddot{u}(t) + 2\xi\omega\dot{u}(t) + \omega^2 u(t) = 0$$

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

$$\omega_d = \omega\sqrt{1-\xi^2}$$

$$T_d = \frac{2\pi}{\omega_d};\ f_d = \frac{\omega_d}{2\pi}$$

$$c_{cr} = 2m\omega = 2\sqrt{km}$$

$$u(t) = \rho\cos(\omega t - \theta)$$

$$u(t) = \rho e^{-\xi\omega t}\cos(\omega_d t - \theta)$$

$$\rho = \sqrt{u_0^2 + \left(\frac{\dot{u}_0}{\omega}\right)^2};\ \tan\theta = \frac{\dot{u}_0}{u_0\omega}$$

$$\rho = \sqrt{u_0^2 + \left(\frac{\dot{u}_0 + \xi\omega u_0}{\omega_d}\right)^2};$$

$$2\xi\omega = \frac{c}{m}$$

$$\tan\theta = \frac{\dot{u}_0 + \xi\omega u_0}{u_0\omega_d}$$

$$\delta = \ln\frac{u_n}{u_{n+m}} = 2m\pi\xi\frac{\omega}{\omega_d}$$

$$u_p(t) = \rho\sin(\Omega t - \theta)$$

$$\rho = \frac{F_0}{k}\left[\left(1-\beta^2\right)^2 + \left(2\xi\beta\right)^2\right]^{-1/2}$$

$$\xi \cong \frac{0.11}{m} \text{ when } u_{n+m} = 0.5u_n$$

$$\tan\theta = \frac{2\xi\beta}{1-\beta^2}\quad \beta = \frac{\Omega}{\omega}$$

$$u_{n+p} = \left(\frac{u_{n+1}}{u_n}\right)^p u_n$$

$$\text{DAF} \equiv D = \left[\left(1-\beta^2\right)^2 + \left(2\xi\beta\right)^2\right]^{-1/2}$$

$$m\ddot{u}(t) + c\dot{u}(t) + ku(t) = F_0\sin\Omega t$$

$$\mathbf{M\ddot{u} + C\dot{u} + Ku = F}$$

$$\mathbf{M\ddot{u} + Ku = 0}$$

$$\mathbf{u} = \mathbf{a}\sin(\omega t + \phi)$$

$$\mathbf{\ddot{u}} = -\omega^2\mathbf{a}\sin(\omega t + \phi) = -\omega^2\mathbf{u}$$

$$\left[\mathbf{K} - \omega^2\mathbf{M}\right]\mathbf{a} = \mathbf{0}$$

$$\mathbf{E} = \left[\mathbf{K} - \omega^2\mathbf{M}\right]$$

$$\mathbf{Ea = 0}$$

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix}\begin{Bmatrix} \ddot{u}_1 \\ \ddot{u}_2 \end{Bmatrix} + \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

$$\left|\mathbf{K} - \omega^2\mathbf{M}\right| = \left[(k_2 + k_1) - \omega^2 m_1\right]\left[k_2 - \omega^2 m_2\right] - k_2^2 = 0$$