(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY SEPCIAL/SUPPLEMENTARY EXAMINATIONS 2021/2022 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL AND STRUCTURAL ENGINEERING

COURSE CODE: CSE 412

COURSE TITLE: STRUCTURAL DYNAMICS

DATE: THURSDAY 6TH OCTOBER 2022 **TIME: 9:00 – 11:00AM**

INSTRUCTIONS:

1. This paper contains **FIVE** questions
2. Answer **QUESTION ONE** and any other **TWO** Questions
3. Marks for each question are indicated in the parenthesis.
4. Examination duration is **2 Hours**

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 3 Printed Pages. Please Turn Over.

QUESTION ONE (*30 MARKS*)

a) Describe any FOUR (4) civil engineering fields where knowledge of dynamic analysis can be applied positively. **(4Mks)**

b) Differentiate between deterministic and random vibrations. In each case, give two practical examples. **(4Mks)**

c) Given a spring-mass-damper system, show that the response of an underdamped system is given by:

$$x(t) = e^{-\zeta\omega_n t}\left\{x_0 \cos\omega_d t + \frac{\dot{x}_0+\zeta\omega_n x_0}{\omega_d}\sin\omega_d t\right\}$$ **(10Mks)**

d) A structure, modelled as a spring-mass-damper system, is subjected to a harmonic force, $f(t) = 100\cos 10\,t$. If the mass, $m = 1000$kg, spring constant, $k = 400$kN/m and damping constant, $c = 200$Ns/m, determine the total response of the system after an initial displacement of 0.1m. **(12Mks)**

QUESTION TWO (*20 Marks*)

A one-storey building constructed in reinforced concrete shown in Figure Q2 is to be analysed for dynamic response when subjected to an initial displacement of 1m at the top. The floor weighs 500kN, the cross-section of each column is 0.4x0.4 m and the Young's Modulus is E = 28.5GPa. Each column is fixed at the floor level and the building has a damping ratio of 0.05. Carry out the following:

a) Model the building as SDF. **(3Mks)**

b) Determine the response of the system. **(10Mks)**

c) From the response of the system, determine the maximum displacement of the building. **(2Mks)**

d) Calculate whether the building will survive if the maximum allowable bending stress in the column is 500 N/mm^2. **(5Mks)**

QUESTION THREE (*20 Marks*)

A viscously damped system with mass m = 10 kg, damping constant c = 200 N-s/m and spring constant k = 1000 N/m is to be analyzed for dynamic response. If the system is excited by a harmonic force, $F(t) = F_0\cos(\omega t)$ with $F_0 = 100N$ and $\omega = 10$ rad/s;

a) Determine the steady-state response of the system using initial proposed solution of the form: $x_p(t) = X\cos(\omega t - \theta)$. **(14Mks)**

b) Determine the magnification factor in the system. **(6Mks)**

QUESTION FOUR (*20 Marks*)

A steel cantilever beam having a cross-section 0.4m x 0.4m and length 5m carries a mass of 1000kg at the free tip. If the Young's Modulus of the steel is taken as E = 2.0 x 10^{11} N/m^2, carryout the following:

a) From first principle, show that the natural frequency of a cantilever beam of mass m and carrying a mass M at the tip is given by: $\sqrt{\frac{k}{M+{}^{33}/_{140}m}}$. **(10Mks)**

b) Find the response of the system due to the boundary conditions given by: $x_0 = 0.01$m and $\dot{x}_0 = 0.5$m/s. **(10Mks)**

QUESTION FIVE (*20 Marks*)

a) A fixed-fixed beam of square cross-section 5mm x 5mm and length 1m, carrying a mass of 2.3kg at the middle is found to have a natural frequency of transverse vibration of 30rads/s. Determine the Young's modulus of elasticity of the beam. Assume the mass of the beam is negligible. **(10Mks)**

b) The magnification factor of a system is given by:

$$X/\delta_{st} = \frac{1}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

Discuss any Five (5) characteristics of the magnification factor shown above. **(10mks)**

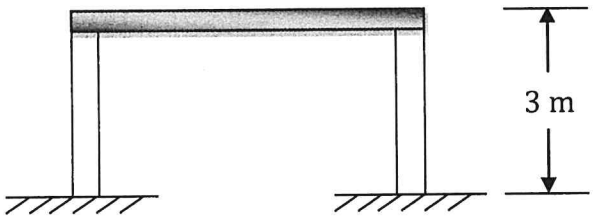

Figure Q2: One-storey building

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