(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN MECHANICAL AND INDUSTRIAL

COURSE CODE: MIE 442

COURSE TITLE: MECHANICAL VIBRATIONS

SPECIAL/ SUPPLEMENTARY EXAMINATION

DATE: 6 – 10 - 2022 **TIME: 9:00 AM – 11:00 AM**

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **FOUR** questions
2. Answer Question **ONE (Compulsory)** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 3 Printed Pages. Please Turn Over

Question ONE (Compulsory)

a) A harmonic motion has an amplitude of 0.07 m and a frequency of 25 Hz. Find the time period, maximum velocity and maximum acceleration. (10 Marks)

b) A single cylinder vertical petrol engine of total mass *400 kg* is mounted upon a steel chassis and causes a vertical static deflection of *2 mm*. The reciprocating parts of the engine have a mass of *24 kg* and move through a vertical stroke of *150 mm* with simple harmonic motion. A shock absorber attached to the system offers a resistance of *490 N* at a velocity of *0.3 m/s*.

Determine ;

a. The speed of driving shaft at resonance (5 marks)
b. The amplitude of steady state vibration when the driving shaft of the engine rotates at *480 rpm.* (5 marks)

Let

$$X = \frac{\left(\frac{m_0 e}{m}\right)(\omega/\omega_n)^2}{\sqrt{\left(1-\frac{\omega^2}{\omega_n^2}\right)^2 + \left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$

c) A machine of mass 2000 kg is observed to have large vertical vibrations at a motor speed of 260 rpm. To overcome this effect it is proposed to add an undamped vibration absorber. Calculate the minimum absorber mass and relevant spring stiffness required if the resonance frequency is to lie outside the range corresponding to the motor speed of 200 to 300 rpm. Let

$$\omega_{n1} * \omega_{n2} = \omega^2$$

$$\left(\frac{\omega_{n1}}{\omega_2}\right)^2 + \left(\frac{\omega_{n2}}{\omega_2}\right)^2 = 2 + \mu \qquad (10\ marks)$$

Question TWO

An electric overhead travelling crane, consisting of a girder, trolley and wire rope as shown in figure 1. Make a mathematical model of the system and determine the natural frequencies. Let the span of girder be *40 m,* area moment of inertia I be $0.02\ m^4$, modulus of elasticity E be $206\ x\ 10^9\ N/m^2$, mass of trolley, $m_1 = 1000\ kg$, load be lifted $m_2 = 500\ kg$ and the stiffness of the wire rope to be $300\ kN/m$. (20 marks)

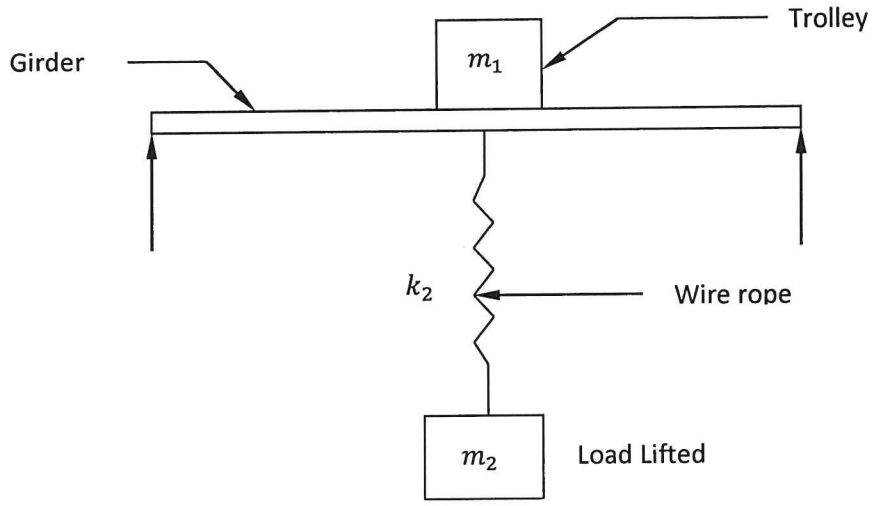

Figure 1: Electric overhead crane

Question THREE

(a) A shaft carrying a rotor of mass 50 kg and eccentricity of 3 mm rotates at 15000 rpm. Let the stiffness of the shaft $k = 60\ x\ 10^6\ N/m$ and damping ratio $\xi = 0.2$. Determine the steady state whirling amplitude and the maximum whiling amplitude during start up conditions of the system. (10 marks)

(b) A machine of *520 kg* produces a vertical disturbing force which oscillates sinusoidally at a frequency of *25 Hz.* The force transmitted to the floor is to have an amplitude, at this frequency, not more than 0.4 times that of the disturbing force in the machine, and the static deflection of the machine on its mounting is to be as small as possible consistent with this. For this purpose rubber mountings are to be used, which are available as units, each has a stiffness of *359 kN/m* and a dumping coefficient of *2410 Ns/m.* How many of the units are need.

Question FOUR

A steel shaft 1.2 m long is 65 mm in diameter for the first 0.4 m of its length, 50 mm in diameter in the next 0.5 m of the length and 40 mm in diameter for the remaining 0.3 m of its length. The shaft carries two flywheels at the two ends, the first having a mass of 900 kg and 0.75 m radius of gyration located at the 95 mm diameter and the second having a mass of 600 kg and 0.45 radius of gyration located at the other end. Determine the location of the node and the natural frequency of torsional vibration of the system. Let the modulus rigidity of the shaft material be 80 GN/m^2. (20 marks)