The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4272 –Vibration & Fault Diagnosis**
Academic Year	:	2015/16
Date	:	20th November 2016
Time	:	0930hrs – 1230hrs
Duration	:	3 hours

General instructions

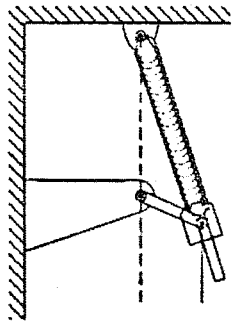
1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.

Question 01.

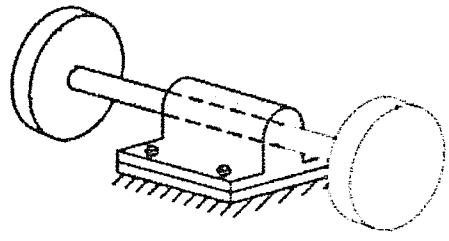
I. Explain three (03) sources of vibration which can be found in machines.

II. State Newton's Second Law of motion and D' Alembert Principle.

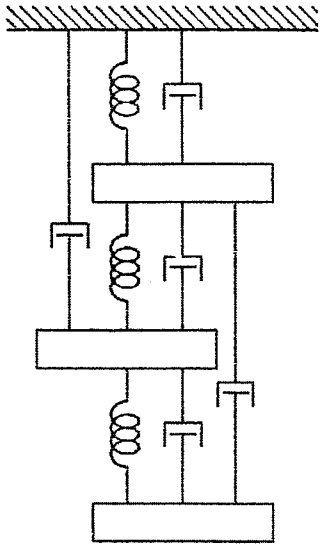
III. Find the Degree of Freedom (DOF) of the systems shown in Figure -1 a, b, c, d and illustrate your answer using necessary sketches.



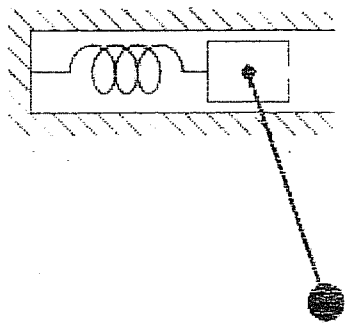
a



b



c



d

Figure - 1

IV. Write the equation of motion for the system shown in Figure-1.1 and derive the equivalent stiffness for springs K_1 and K_2. Hence determine the natural frequency of the system if damping constant is equal to zero.

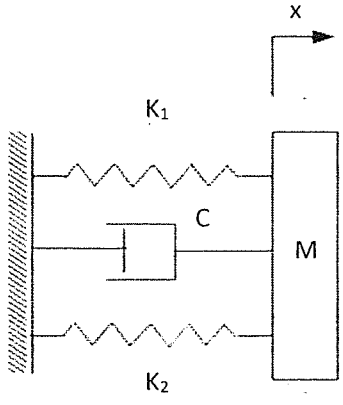


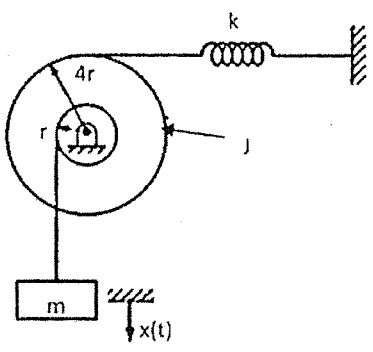
Figure-1.1

Question 02.

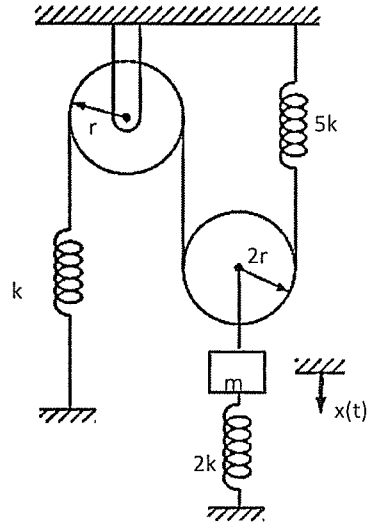
I. Draw the free body diagramme (FBD) for the systems shown in Figure- 2, *a* and b.

II. Derive the equations of motion for the two systems using D'Alembert principle and find the natural frequencies of each of the systems.

III. Verify the equation of motion derived in part II, using energy method.



a



b

Figure- 2

Question 03.

The vibratory system shown in Figure - 3, consists of two pulleys of moments of inertia ***I*** and ***2I.*** These pulleys can freely rotate about their polar axes through the centers. Two springs of stiffness ***k*** and ***2k*** and two masses ***m*** and ***2m*** are attached to the system.

I. Determine the equations of motion using Newton's laws and verify the result using Lagrange's equations.

II. Obtain the frequency equation assuming $I = mr^2$.

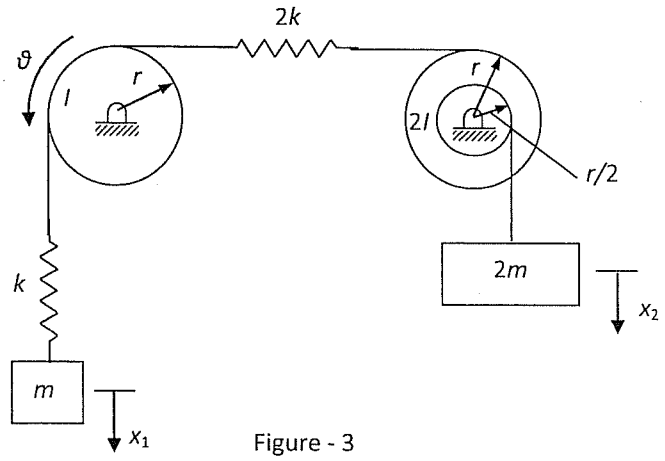


Figure - 3

Question 04.

Figure- 4, shows a system of three rotors which the moment of inertia of each is given as I_1 = 100 kgm^2, I_2 = 150 kgm^2 and I_3 = 1000 kgm^2. The shaft between I_1 and I_2 is 1m long and 100 mm in diameter, and that between I_2 and I_3 is 0.6 m long and 50 mm in diameter. The modulus of rigidity of the material of the shaft is 82 kN/mm^2.

Determine the natural frequencies of torsional vibrations and the positions of the nodes by drawing mode shapes.

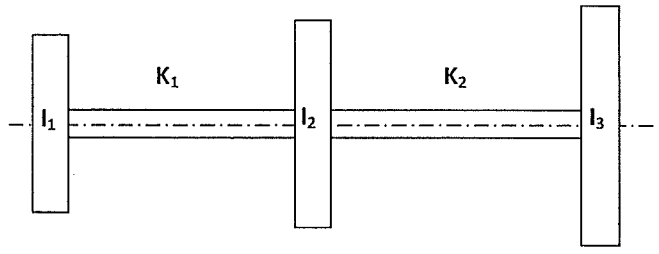


Figure- 4

Question 05.

Two masses m_1 and m_2 attached to three springs of stiffness k_1 , k_2 and k_3 as shown in Figure- 5. Determine,

I. the frequency equation for the system in terms of given notations using D'Alembert principle.

II. the natural frequencies, if $m_1 = 1$ kg, $m_2 = 2$ kg and $k_1 = k_2 = k_3 = 1$N/m.

III. the principal modes of vibration.

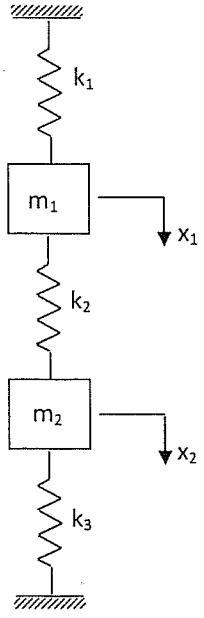


Figure - 5

Question 06.

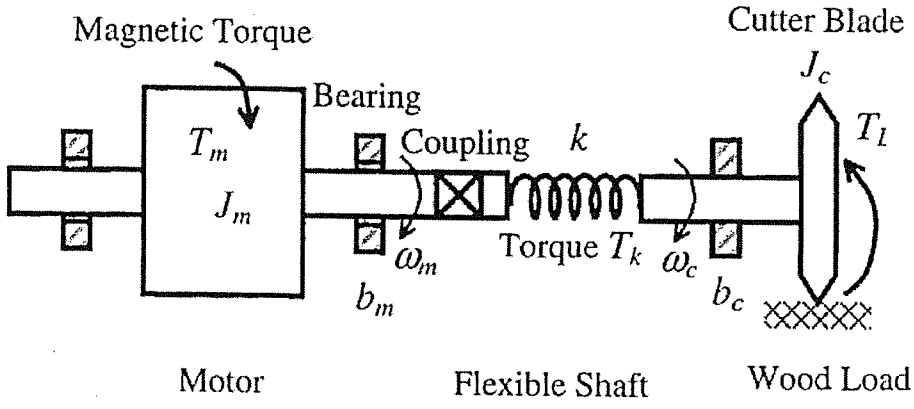


Figure -6

Figure - 6 shows a wood cutting machine. The cutting unit has an electric motor and a cutting blade, connected using a flexible shaft and coupling. The main intention of flexible shaft is to keep the cutting blade in a desirable configuration. This system has three main bearings, two for holding motor shaft and one for the cutting blade.

The main parameters and the variables for the given system are as follows,

J_m = axial moment of inertia of the motor rotor
b_m = equivalent viscous damping constant of the motor bearings
k = torsional stiffness of the flexible shaft
J_c = axial moment of inertia of the cutter blade
b_c = equivalent viscous damping constant of the cutter bearings
T_m = magnetic torque of the motor
ω_m= motor speed
T_k = torque transmitted through the flexible shaft
ω_c = cutter speed
T_L = load torque on the cutter from the work piece (wood)

Study the above system and answer the following.

I. Imagine you are going to design the wood cutting machine mentioned above. Explain the procedure that you are going to follow for Validation, Verification and Qualification of your system within the context of vibration and fault diagnosis.

II. Which maintenance procedure you would suggest to implement for the system? Justify your answer.

III. You are asked to do a MATAB Simulation for the system. Write an appropriate Algorithm in Pseudo Code for the proposed simulation.

IV. You are asked to design a vibration monitoring system for your wood cutting machine. Draw a Block Diagram and explain the function of each component suggested in the system.

Question 07.

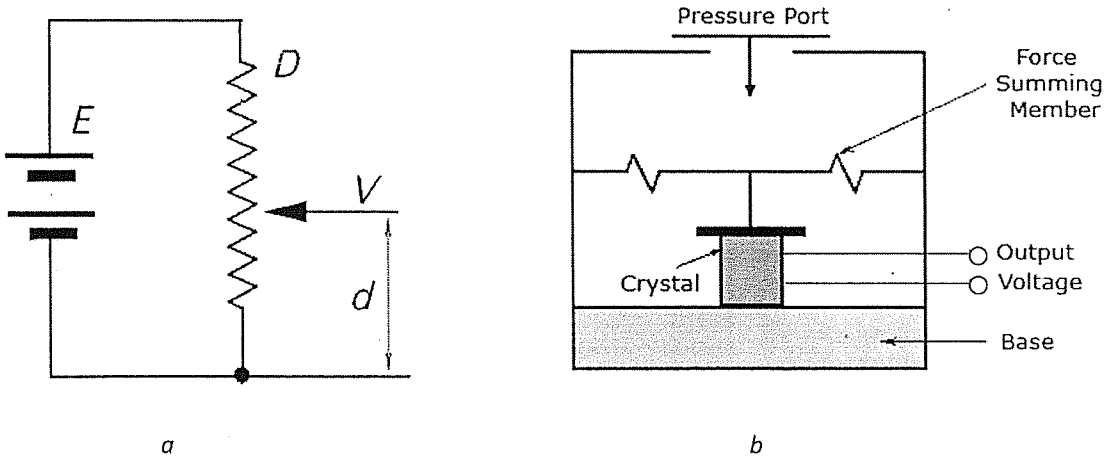


Figure -7

Figure - 7*a* shows a potentiometer displacement sensor and Figure - 7*b* shows a piezo-electric sensor.

I. Explain, the main characteristics of a sensor/transducer which should be considered when selecting a sensor/transducer for a practical application which involves vibration.

II. Explain the mechanism of potentiometer displacement sensor shown in Figure 7*a* & piezo-electric sensor shown in Figure 7*b*.
What are the main applications of these two sensors?

III. Which sensor out of the two sensors (potentiometer or piezo-electric) you would use for a high frequency application. Explain the reason for the selection.

IV. State main drawbacks of using each sensor in situations where vibration involves, and suggest possible modifications to address the stated drawbacks.

Question 08.

Explain the following statements within the context of Vibration and Fault Diagnosis.

I. "Importance of Mechanical Vibrations in Machine Design."

II. "Anecdotal and statistical data describing the frequency of failures can be summarized in Bath-tub curve."

III. "Establishing a proper maintenance procedure will reduce the rate of Machine Failure."

IV. "Unbalance and Misalignment are important in vibrations and fault diagnosis."

V. "Frequent monitoring of machine conditions such as vibrations, noise etc., is important in decision making related to machine maintenance and to have uninterrupted function of a continues production process."

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