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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	:	2016/17
Date	:	12th November 2017
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.
3. **Question No. 01 is Compulsory.**
4. Answer any 5 questions.

Question No.01: Compulsory (40 Marks)

a. Explain the terms "Vibrations" & "Vibration Isolation" in a mechanical engineering design perspective.

b. State Newton's second law & third law and explain how these theories are associated in determining Free Body Diagram of a given mechanical system.

c. Explain using examples how "Lumped Parameter Modelling" is associated with mechanical vibrational system analysis.

d. State five specification parameters of sensors & explain the significance of each parameter in vibration instrumentation.

e. Derive the equal stiffness of serial & parallel spring configurations shown in Fig.1.1 and Fig.1.2. Assume any parameter that is not given in figures.

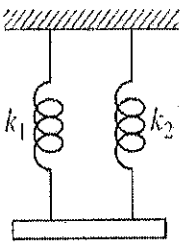


Fig. 1.1

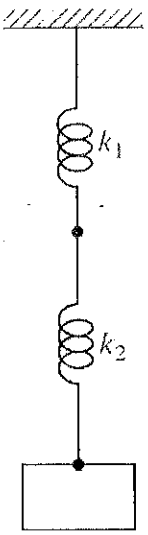


Fig. 1.2

Question No.02: (15 Marks)

a. Using D'Alembert principle, determine the frequency equation of the system shown in Fig. 2, in terms of given notations.

b. Considering the system shown in Fig. 2, if $m_1 = 1$ kg, $m_2 = 2$ kg and spring stiffness $k_1 = k_2 = k_3 = 1$N/m, determine the equations of motion and the natural frequencies.

c. Determine the principal modes of vibration for the system shown in Fig.2.

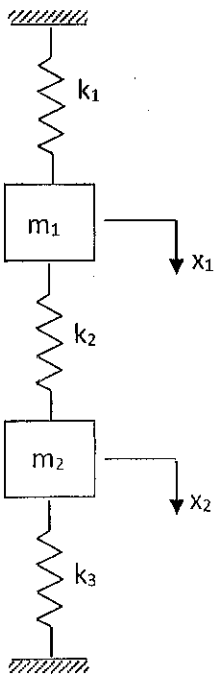


Fig. 2

Question No.03: (15 Marks)

Fig. 3 shows a system of three rotors where the moments of inertia of which are given as $I_1 = 100$ kgm^2, $I_2 = 150$ kgm^2 and $I_3 = 1000$ kgm^2. The shaft between $\mathbf{I_1}$ and $\mathbf{I_2}$ is 1m long and 100 mm diameter, and that between $\mathbf{I_2}$ and $\mathbf{I_3}$ is 0.6 m long and 50 mm diameter. The modulus of rigidity of the material of the shaft is 82 kN/mm^2.

I. Determine the natural frequencies of torsional vibrations and the positions of the nodes in each case.

II. Draw the mode shapes for two cases.

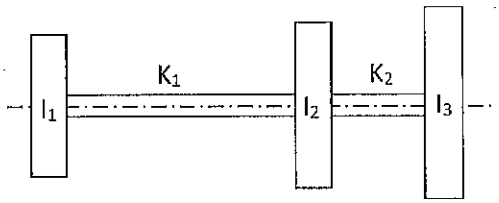


Fig. 3

Question No.04: (15 Marks)

a. Explain the importance of natural frequencies and mode shapes in Vibration & Fault Diagnosis.

b. If the equations of motion of a mechanical system can be written in matrix form as

$$\begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} \ddot{y}_1 \\ \ddot{y}_2 \end{bmatrix} + \begin{bmatrix} 2 & -\sqrt{2} \\ -\sqrt{2} & 4 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} f_1(t) \\ f_2(t) \end{bmatrix},$$

obtain the natural frequencies and mode shapes of the system.

Question No.05: (15 Marks)

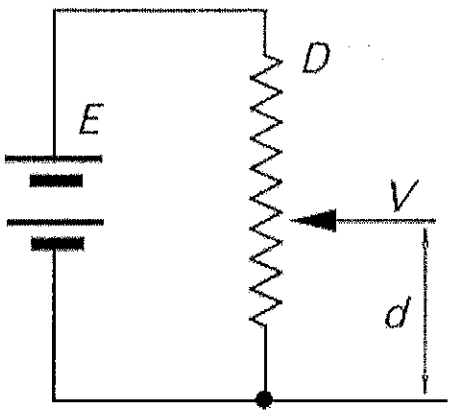


Fig. 5.1

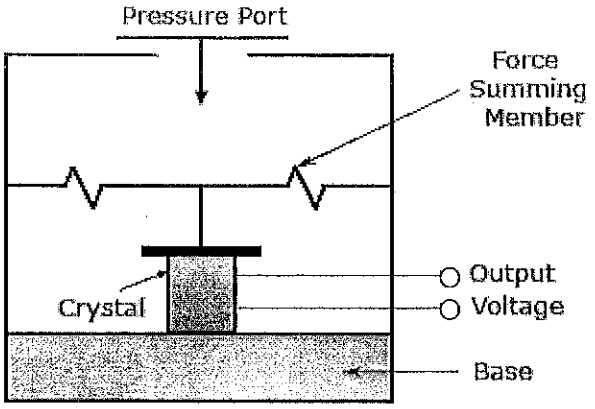


Fig. 5.2

A potentiometer displacement sensor and a piezo-electric sensor are shown in Fig. 5.*1* and Fig. 5.2.

I. Explain, the main characteristics of a sensor/transducer that you will consider when selecting a sensor for a practical application.

II. Explain the mechanism of potentiometer displacement sensor shown in Fig. 5.1 & piezo-electric sensor shown in Fig. 5.2.
What are the main applications of these two sensors?

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

IV. State main drawbacks of each sensor and suggest possible modifications to eliminate the drawbacks of each sensor in the context of vibration & fault diagnosis.

Question No.06: (15 Marks)

a. Explain the statement *"Unbalance & Misalignment are important to vibrations & fault diagnosis."*

b. Rubber parts manufacturer uses a conventional process of steam-cured moulding of natural latex. The moulded rubber parts are first cooled and buffed (polished), and then sent for inspection and packing. A simple version of a rubber buffing machine is shown in Fig. 6.

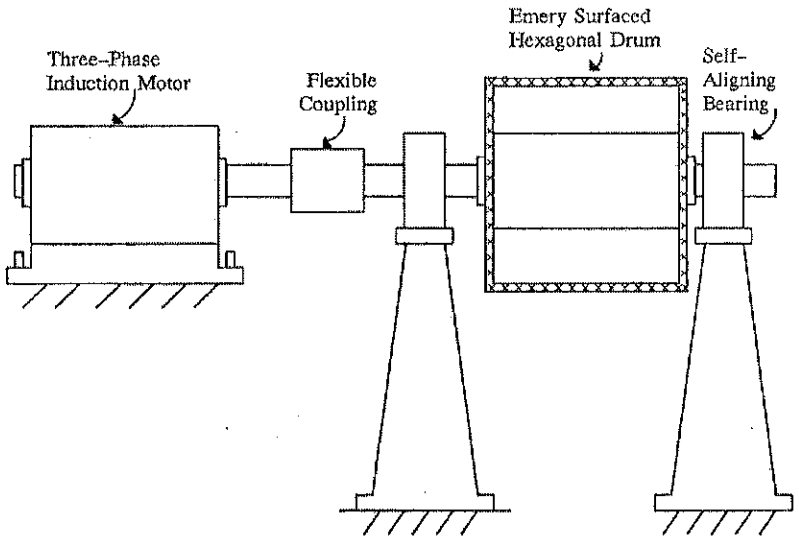


Fig. 6

The buffing unit has a Three Phase Induction Motor connected to emery surfaced hexagonal drum using a flexible coupling mechanism. Study the above system & ***Briefly Answer*** the following questions.

I. Imagine you are going to design the rubber buffing machine shown in Fig. 6. Explain the procedure that you are going to follow for Validation, Verification & Qualification of the system in the vibration & fault diagnosis point of view.

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

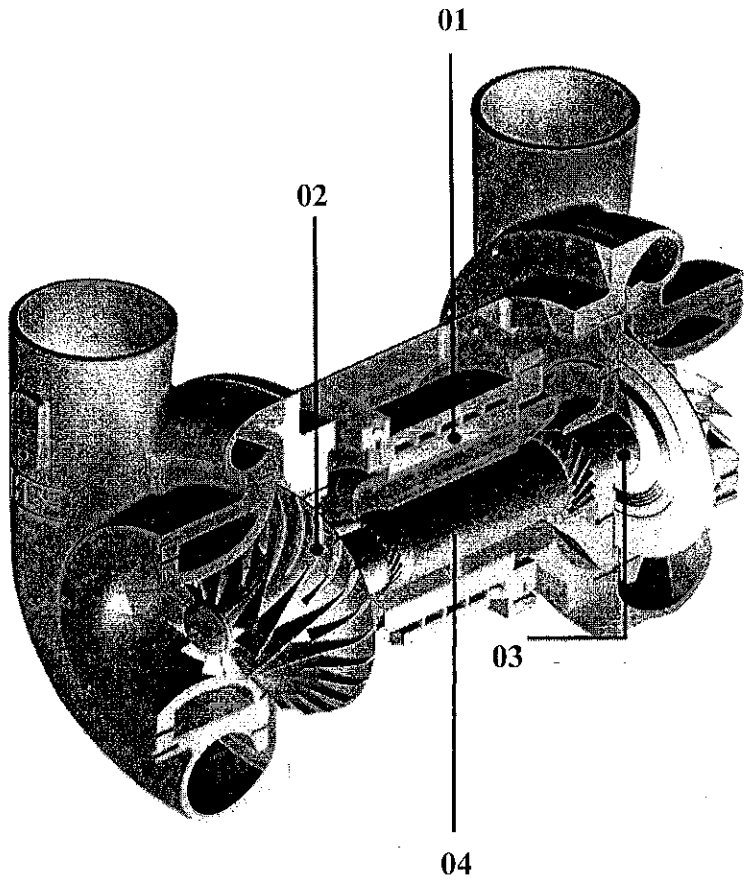
III. Draw a block diagram of the rubber buffing machine shown in Fig.6 and explain possible vibrations generated by each component with the reasons. Also explain the significance of the "Self Aligning Bearing" of the System.

IV. If you are asked to design a vibration monitoring system for the designed rubber buffing machine, draw a ***Block Diagram*** & explain the function of each component you suggested in your design.

Question No.07: (15 Marks)

a. Explain, the statement *"Continues machine condition monitoring is important in decision making of a continues production process".*

b.



01	Motor
02	Impeller
03	Bearing
04	Shaft

Fig.7

Fig.7, shows a special type of high speed turbo blower used in the industry. The system consists of a high efficient high speed motor designed for high temperature environment with air/liquid cooling. Air Bearings were used to support the shaft. Therefore when the shaft rotates at high speed, an air film is formed between the shaft and the bearings which achieves friction free floating without the use of lubricant. Impellers were at both ends of the common shaft which counterbalance thrust load in the axial direction.

Assume you are the maintenance engineer in a factory which use high speed turbo blowers as explained above,

i. Briefly explain how you are going to troubleshoot the following problems,
   1. Excessive Vibration/ Noise
   2. High Flow Rate (High CFM, Cubic Feet Per Minute)
   3. Low Flow Rate

ii. Explain the strategies that you will be using to continuously run these machines with faults mentioned in section 7.b.i.
Hint: Maintenance strategy should be use to run the machine.

iii. Prepare a Preventive Maintenance check list for the system.

Question No.08: (15 Marks)

Explain the following statements.

1. Harmful effects of vibrations & possible strategies to mitigate damages.

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

3. Establishing a proper maintenance procedure which will reduce the rate of Machine Failure.

4. Natural Vibrational Phenomenon (Eg. Earthquakes, Tsunamis .. etc.)

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