Advanced Vibration and Modal Analysis – Final Examination (Graduate School) Upload deadline: 2026/06/25 24:00

1. **Determine the differential equation of motion of the two degree of freedom system shown in Fig. I. Obtain the characteristic equation and determine the natural frequencies of the system in the special case of equal masses and spring constants (ie. $m_1=m_2=m$. $k_1=k_2=k_3=k$) (20%)**

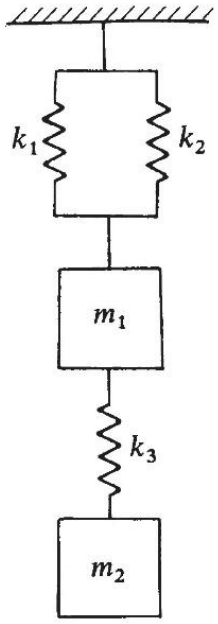


Fig. 1

2. **In Problem 1, if $m_1=m_2$=10kg and $k_1=k_2=k_3$=1000N/m, determine the system response to the initial conditions: x_{10}=0.02m, x_{20}=0m, $\dot{x}_{10}$=0m, $\dot{x}_{20}$=0m. (10%)**

3. **Please describe the internal structure of the transducers used for general vibration measurement and when they are used. (10%)**

4. **What types of spectrum analyzers are used for vibration measurement? Please explain their working principles, advantages, and disadvantages. (10%)**

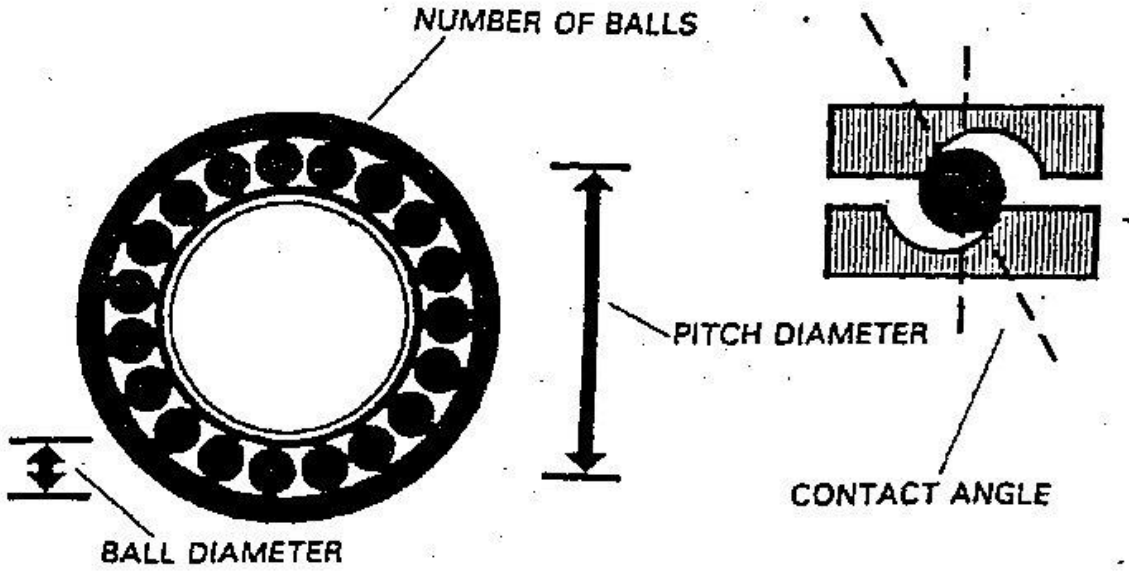
5. **What is aliasing in an FFT dynamic signal analyzer? Explain its causes and prevention methods. (10%)**

6. **The dynamic signal analyzer can perform many functions. Please write down at least ten signal processing functions. (10%)**

7. **What are the sources of the forces that cause various vibrations during machine operation? (10%)**

8. **In order to measure a machine with a maximum analysis frequency Fmax = 2000 Hz using an FFT dynamic signal analyzer with N=2048, please set its sampling frequency, period, sampling time, and the number of numerical points it can process in the frequency domain to avoid aliasing. Furthermore, if the analyzer instrument can process data in real-time with a period of 0.005 sec, what is the maximum frequency that the analyzer instrument can process in real-time? (20%)**

9. **When a ball bearing component in use has a defect, calculate the natural vibration frequency of its related component has a defect as shown in Fig. 2. Assume that the ball bearing has a rotational speed of 600 rpm, 19 balls, a pitch diameter of 2.5 cm, a ball diameter of 0.5 cm, and a contact angle of 30 degrees. (20%)**



$$\text{Defect on outer race (Ball pass frequency outer)} = \frac{n}{2}\frac{RPM}{60}\left(1 - \frac{Bd}{Pd}\cos\phi\right) \quad (1)$$

$$\text{Defect on inner race (Ball pass frequency inner)} = \frac{n}{2}\frac{RPM}{60}\left(1 + \frac{Bd}{Pd}\cos\phi\right) \quad (2)$$

$$\text{Ball defect (ball spin frequency)} = \frac{Pd}{2Bd}\frac{RPM}{60}\left[1 - \left(\frac{Bd}{Pd}\right)^2\cos^2\phi\right] \quad (3)$$

$$\text{Fundamental train frequency} = \frac{1}{2}\frac{RPM}{60}\left(1 - \frac{Bd}{Pd}\cos\phi\right) \quad (4)$$

Pd = Pitch diameter
Bd = Ball diameter
n = Number of balls
ϕ = Contact angle

Fig. 2

Final Examination Notice

1. **Please submit the solution of final examination before the deadline 2026/6/25.**
2. **Please upload your document file(*.docx) and insert hand-writing file（please scan to the image file save as JPG file）to the following website.**

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Please go to directory \Final-Examination, you can use your student ID to create a subdirectory. Finally, you should upload your files to your student ID subdirectory.