Written Comprehensive Examination (Closed-book) for

Mr. Vishnu Sukumar (2016MEZ8550)

May 10, 2018 (Thursday)

Duration: 3.5 hours **Marks: 120**

SK Saha

1. Decide whether the vectors in each sub-set of $\Re^3$ are linearly dependent or independent. Justify answers.

(a) $\begin{bmatrix}1\\-3\\5\end{bmatrix}, \begin{bmatrix}2\\2\\4\end{bmatrix}, \begin{bmatrix}4\\-4\\14\end{bmatrix}$; (b) $\begin{bmatrix}1\\7\\7\end{bmatrix}, \begin{bmatrix}2\\7\\7\end{bmatrix}, \begin{bmatrix}3\\7\\7\end{bmatrix}$; (c) $\begin{bmatrix}9\\9\\0\end{bmatrix}, \begin{bmatrix}2\\0\\1\end{bmatrix}, \begin{bmatrix}3\\5\\-4\end{bmatrix}, \begin{bmatrix}12\\12\\1\end{bmatrix}$ [3×5 = 15]

2. Find the Cholesky decomposition of the following matrix:

$$\mathbf{B} = \begin{bmatrix}4 & 10 & 14\\10 & 41 & 59\\14 & 59 & 94\end{bmatrix}$$ [15]

3. Explain briefly the following terms as related to a dynamic controlled vibration system.

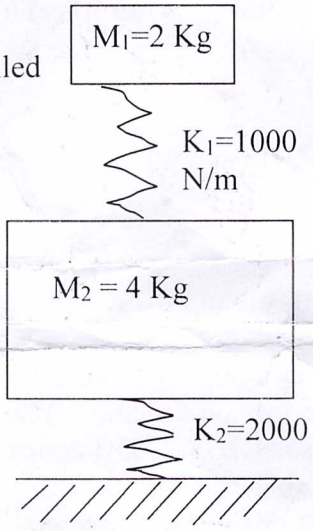
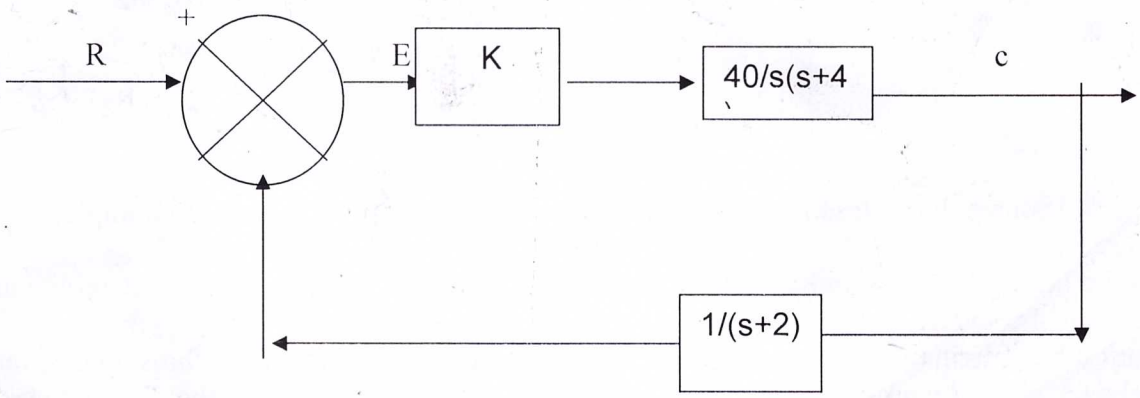


Fig. Q3

(i) Guyan Reduction Scheme
(ii) Isoparametric elements in Finite Element method.
(iii) Application of Feed-forward vs Feedback controller
(iv) State Space model of 2dof system of Fig Q.No.3
(v) Discrete Fourier Transform of a signal

5x4=20

4. For the system shown below draw Bode diagram (for K=1) and check whether the system is stable. Find the range of values of K beyond which the system will not be stable. (10)



5. (a) With regards to finite element formulation, what is the significance of Jacobian matrix? What are Gauss points. (5)

(b) Illustrate with appropriate expression the influence of axial compressive force on the natural frequency of a bar in longitudinal vibrations. (5)

6. For the 2-DOF system shown in Fig Q3 find the natural frequencies and the normal modes. Set up the modal equations of motion. (10)

7. A rotor machine of mass 650 kg. Operating at a constant speed of 1500 rpm has an unbalance of 0.12 kg. If the damping in the isolators is given by damping ratio of ξ=0.08, determine the stiffness of the isolators so that the transmissibility at the operating speed is less than or equal to 0.15. Also determine the magnitude of the force transmitted. (10)

8. A uniform beam, simply supported at both ends is found to vibrate in its first mode with an amplitude of 10 mm at its centre. If cross sectional area=120mm^2, I= 1000 mm^4, E=20.5x1010N/m^2, density of 7830 kg/m^3, and length of 1 m, determine the maximum bending moment in the beam. (10)

9. What is the difference between consistent mass matrix and lumped mass matrix. Derive the consistent mass matrix for the torsional analysis of a circular shaft. (10)

10. Define with examples, holonomic and non-holonomic constraints. Describe How will you model the rail wheel interacations and include them to evaluate the dynamics of the bogie.(10)

Take-home Comprehensive Examination

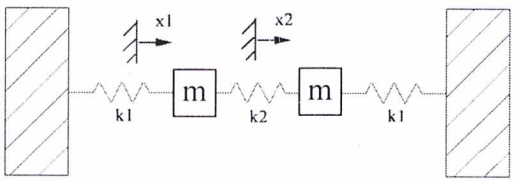
Mr. Vishnu Sukumar (2016MEZ8550)

May 10, 2018 (Thursday)

Submission: May 11, 2018 (Friday) ~~Marks: 100~~

1. Develop a dynamic model of a four-bar mechanism using the concept of DeNOC matrices and the cut-joint method. Write a MATLAB program to obtain the forward dynamics and simulation results. [Hint: "Dynamics and Balancing of Multibody Systems" by H. Chaudhary and S.K. Saha, Springer, 2008] [60]

2. Consider the system shown below with 2 masses and 3 springs. The masses are constrained to move only in the horizontal direction (they can't move up and down):



$m_1 = 2$

$m_2 = 2$

$k_1 = k_2 = k_3 = 2$

[Source: http://lpsa.swarthmore.edu/MtrxVibe/EigApp/EigVib.html#Example]

Write the equations of motion of the above 2-DOF system. Write a MATLAB programme to study its behavior. [40]

Submit a hand-written report with the block diagrams of the relevant algorithms, and printout of the plots. Upload the programmes/plots/videos (if any) to link, and mention that link in the report.

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