Written Comprehensive (Open-book) Examination

Mr. Sandeep Kumar (2019MEZ8423)

December 28, 2020 (Monday), 3-6pm

Instruction: Submit answers in two separate .pdf files for Sections A and B.

Duration: 3 hours Marks: 100

Section A (Prof. S.K. Saha): 50 marks

1. Answer the following:
   (a) Define condition number of a matrix. How it is related to the eigenvalues of a matrix?
   (b) What is Cholesky decomposition? How is it found?
   (c) Define the assumptions of a Euler Beam
   (d) What is Newton-Raphson method? Where is it used?
   (e) Draw S-N diagram for steel in fatigue loading. How is it different from stress-strain diagram in static loading?

(5×3=15)

2. Answer the following:

(a) Find QR decomposition of the following matrix:

$$\mathbf{A} = \begin{bmatrix} 9 & -1 & 2 \\ -1 & 8 & 5 \\ 2 & 5 & 7 \end{bmatrix}$$

(b) Using Adams-Bashforth formula, find y (t=0.4) for the following differential equation:
$y' = 1 - t + 4y$ with y (0) = 1 and step size h = 0.1

(2×10=20)

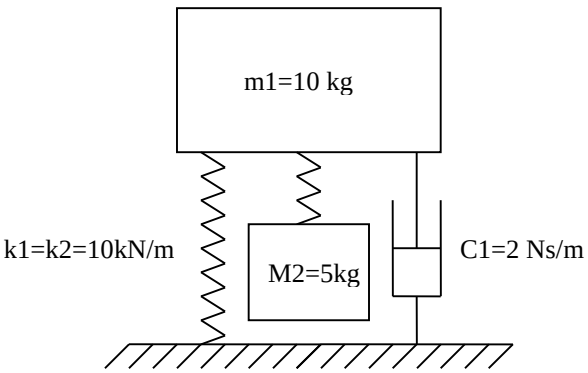
3. Derive the equations of motion of
   (a) A prismatic and revolute jointed manipulator using the DeNOC matrices.
   (b) A single flexible link using FE approach

(5+10=15)

Section B (Prof. S.P. Singh): 50 marks

1. For the 2-DOF system shown below find the natural frequencies and the normal modes. If the mass 'm1' is given a harmonic excitation on unit amplitude at a frequency midway between the two natural frequencies. Find the response amplitude at m2.

(10)



2. For a second order system with m=1 kg, k=2 N/m, c=0.1 Ns/m, derive the state equations. Using the state space formulation, find the response to an initial velocity of 1m/s.

(5)

3. Explain briefly the following terms as related to an actively controlled or uncontrolled vibration system. Do any 4 questions

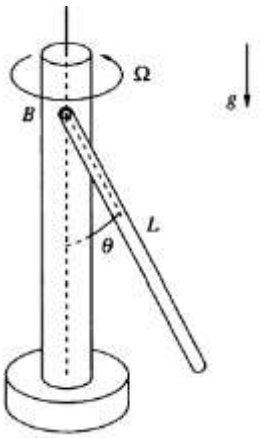
   (i) Controllability and observability
   (ii) Dynamic Boundary Condition in a robotic arm
   (iii) Application of Feed-forward vs Feedback controller
   (iv) Solution of MDOF response by modal analysis vs. direct integration
   (v) Discrete Fourier Transform of a signal
   (vi) Independent Modal space control and its limitations (5×4=20)

4. Do any two of the following
   (a) For a two link (R-R rigid links) the end effector has to follow a given trajectory [say y=cos(x) + x]. How will you approach this problem? Later, make a program to (use Pseudo Code Language) to decide and give control voltage to the both the dc motors.

   (b) What is the need of an observer in Active Vibration Control? Explain in detail any one observer?
   (c) Describe with a schematic diagram a complete active vibration control setup. Describe each of the element used in the setup.

   (5×2=10)

5. A slender bar of mass m and length L is attached to a vertical shaft, which is rotating with constant angular speed Ω as shown in figure below. Find the equations of motion of the bar. Assume any parameters needed. (5)



Take Home Comprehensive Examination for Mr. Sandeep Kumar

December 28, 2020

Duration: 48 hours (Submission: December 30, 9pm) Marks: 100

1. For a planar beam of 0.5m long with uniform cross-section, assume that it is initially straight, and its axis is parallel to the global X-axis. For an appropriately chosen displacement field defined in the body coordinate frame, write the components of the displacement vector at any arbitrary point along the beam using FEM. (30)

2. For the above beam, generate the plots for time, t=1, 2, …, 5 sec, using a computer program (may be using MATLAB or otherwise) for the following quantities:
   (a) Global position of the tip point P and the center of mass of the beam.
   (b) Absolute velocities and acceleration of the tip point P
   (c) Mass matrix of the beam
   (d) Generalized stiffness matrix
   (e) Generalized forces

   (5×10=50)

3. Generate numerical results for Question 1 of Section B using MATLAB or Octave. (20)

Submit a handwritten report in .pdf file describing the methodologies followed and the results obtained. Add the plots saved in .pdf as a part of the report.