Duration: 3 hours

Marks: 100

1. Answer the following:
   (a) Define condition number of a matrix. What is its correlation with singularity?
   (b) Define degrees-of-freedom (DOF) of a mechanical system. Explain its relation with the number of coordinates used to represent its configuration with the constraints.
   (c) What are different types of errors occurred in numerical integration?
   (d) Define transfer function in a control theory. What are poles and zeros?
   (e) What are Rayleigh and Galerkin methods in Finite Element Method?

   [5×4 = 20]

3. (a) What is the pseudo-inverse of a matrix? Mention its two typical applications.
   (b) Using SVD decomposition of the following matrix, find its pseudo-inverse:

   $$A = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$$

   [5+10 = 15]

4. Find the Cholesky decomposition of the following matrix:

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

   [15]

5. (a) Using sketches, define holonomic and non-holonomic constraints of a mechanical system.
   (b) Find out the equations of motion of a prismatic and revolute jointed manipulator.

   [5+10 = 15]

6. Write the following system of equations in a state-space form. Determine its stability using any suitable method:

   $$\dot{x}_1 = -x_1 - 2x_2$$
   $$\dot{x}_2 = x_1 - 4x_2$$

   [13]

7. (a) Find the linear and quadratic approximation of the following function at x=2.

   $$f(x) = x^3 + 4x^2 + 3x + 8$$

   (b) For obtaining the minimum of the following function using Steepest Descent method, perform two iterations of the method starting from the initial design point (1,1).

   $$f(x_1, x_2) = x_1^2 + 2x_2^2 - 4x_1 - 2x_1 x_2$$

   [6+6=12]

8. (a) What is Adams-Bashforth method to solve a differential equation?
   (b) Using Runga-Kutta 4th order method, 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+8 = 10]

… END …

Take-home Comprehensive Examination
Mr. Suraj Bhat (2016MEZ8546)
May 10, 2018 (Thursday)

Submission: May 11, 2018 (Friday)

Marks: 100

1. Write a MATLAB program for the forward dynamics analyses of a slider-crank mechanism using DeNOC methodology and the cut-joint method. [50]
2. Formulate a static loading of a Cantilever beam as a finite-element problem. Write a MATLAB program to find its deflection at the tip for different length and loads. Verify the results using analytical formulas available in any text book on Design or Strength of Materials. [50]

Submit a hand-written report with relevant algorithms, and printout of the plots. Upload relevant programmes, videos, if any, to a portal and provide the link.

… END …