Written Comprehensive (Closed-book) Examination for
Mr. Majid Hameed Koul (2009MEZ8526)
March 28, 2011(Monday)

Duration: 3 hours

Marks: 100

Part A (Marks 60)

1. (a) What is QR decomposition of a matrix? What are the methods to find it?
   (b) Showing the steps find the QR decomposition of the following matrix:
   A = 035035254025 [Hint: Multiply the resultants to see that you got matrix **A**]
   [4+8]
2. (a) What are the major differences in the methods of Euler, Runga-Kutta, and Adams-Bashforth to find the solution of a differential equation?
   (b) Using any of the above methods find y (t=0.4) for the following differential equation:
   $y' = 1 - t + 4y$ with $y(0) = 1$ and step size $h = 0.1$
   [4+8]
3. (a) Using the Grubler-Kutzbach formula find out the degree-of-freedom (dof) of a Revolute-Spherical-Spherical-Revolute (RSSR) spatial mechanism? Using a sketch clearly mention which are the motions corresponding to its dof.
   (b) Using three precision points, synthesize a planar four-bar linkage to generate the function $y = sin(x)$ for $0 \leq x \leq 90^o$. The input range of input angles is chosen arbitrarily to be $\Delta\phi = 120^o$ and the output range is similarly chosen to be $\Delta\psi = 60^o$. Find out the link lengths.
   [4+8]
4. (a) State different static theories of failure.
   (b) Draw the SN diagram of iron alloys. What are different failure criteria for the fatigue design of a iron-based component? How to find factor of safety in fatigue.
   [4+8]

   (a) Using sketched, define holonomic and non-holonomic constraints of a mechanical system. What is the relationship between the constraints and the degrees of freedom of a system?
   (b) Find out the equations of motion of the manipulator shown in Fig. 1 using the DeNOC matrices.
   [4+8]

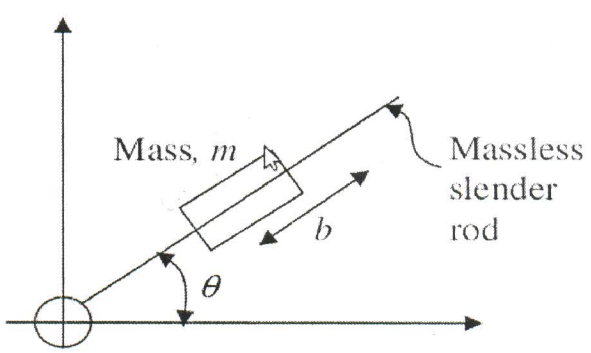


Fig. 1 Mass sliding on a massless rod

Part B (Marks 40)

Take-home Comprehensive Examination for Mr. Majid Hameed Koul (2009MEZ8526)

March 28-30, 2011 (Monday to Wednesday)

Submission: March 30 (Wed), 9am **Marks: 100**

[To be handed over after the end of written comprehensive on Mar. 28, 2011]

Part A (Marks 50)

1. For the questions in 1(b) and 2(b) of Part A of your written comprehensive, verify the results using MATLAB functions. [10]
2. For the manipulator in Fig. 1 of your written comprehensive, derive the equations of motion considering the slender rod has some mass and the manipulator is placed vertically (i.e., consider the gravity in the equations of motion). Write a MATLAB code to perform the inverse and forward dynamics of the manipulator. Get its manipulability evaluated also. Plot necessary graphs for some numerical values of the link lengths, angles, etc. and time. Show how the results will change if the assumptions in 5(b) of your written comprehensive are considered. [40]

Submit the above details as hand-written report only. Email your MATLAB codes for checking their correctness.

Part B (Marks 50)

1. Show how acceletation could be avoided in simulating dynamics of virtual objects in an impedance control system. [25]
2. Write down all the requirements of a haptic device from the human factors point of view. [25]

Written Comprehensive (closed-book) Exam. for Mr. Vinay Gupta (2009ME28138)

July 04, 2011 (Monday)

Duration: 2 hours Marks: 100

1. a) What is the physical interpretation of $|\vec{a} \times \vec{b}|$? Note that $\vec{a}$ and $\vec{b}$ are two non-collinear cartesian vectors. Use a sketch.

   b) State different static theories of failure. Which one would you use for a component design made of Cast Iron?

   c) Write Newton-Euler and Euler-Lagrange equations of motion. What is the basic difference in the two sets of equations?

   d) What are different numerical methods to solve non-linear differential equations? Classify them as implicit or explicit method.

   e) Define degree of freedom of a mechanism. How can you calculate it?

   [5x5 = 25]

2. Solve the following system of linear equations using a suitable decomposition technique, say, LU or LL^T, etc.

$$\begin{bmatrix} \frac{52}{3} & -3 & -2 \\ -3 & \frac{20}{3} & -6 \\ -2 & -6 & \frac{40}{3} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 3 \\ 4 \\ 1 \end{bmatrix}$$

   [25]

3. Consider a dynamic system whose equation of motion is given by

$$m\ddot{x} + b\dot{x} + kx = f$$

   where $m = 1$, $b = 4$, and $k = 3$.

   (a) Solve for x when $f = \sin 2t$.

   (b) Propose a PD control law so that the system is critically damped (give the relationship between the gains).

   [25]

4. Find the singular configurations of a 2-link 2-revolute jointed manipulator. [Hint: Derive Jacobian matrix and its determinant]. Indicate in a sketch. [25]

— End —

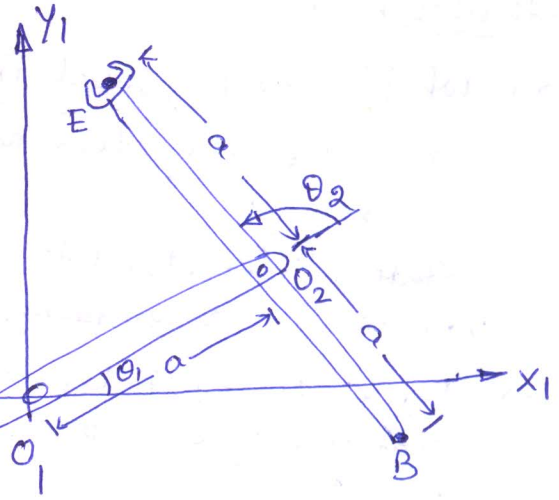
(P.T.O)

(For Take Home Exam.)

Take Home Examination

Duration: 04.07.11 to 06.07.2011 (12 noon) Marks: 100

For the 2-link 2-revolute jointed manipulator shown



I. Derive the dynamic equations of motion using the concept of equimomental systems.

II. Write a MATLAB program to obtain the inverse dynamics results (i.e., the joint torques) for a set of specified trajectories (you decide)

III. Perform forward dynamics and simulation for the following initial conditions:

$$\theta_1 = \theta_2 = 0\ ;\ \dot{\theta}_1 = \dot{\theta}_2 = 0$$

IV Compare the above results with those for a manipulator with $O_2B = 0$.

Submit a hand-written report explaining the formulations and the plot prints by 12 noon on 06/07/2011.

— End —