Department of Mechanical Engineering
Indian Institute of Technology Kanpur
ME 352: Theory of Mechanisms and Machines (2018-19 I)

**Mid-Semester Examination**

Sep 23, 2018

Time: 1.5 hours F.M.: 50

**For the first four questions, the following link data are used for the mechanism under analysis.** The choice of the *method* — analytical or graphical — is completely up to you.

| Link number | Identification and Link-length | Role |
|---|---|---|
| 1 | $O_2O_4 = 10$ cm | frame |
| 2 | $O_2A = 5$ cm | input |
| 3 | $AB = 12$ cm | coupler |
| 4 | $O_4B = 8$ cm | follower |
| 5 | $BP = 5$ cm | transmission link |
| 6 | slider at P moving along a line at a distance of 6 cm above the horizontal line $O_2O_4$ | output |

1. Find out the position of the slider corresponding to the input link at $105^o$ from $O_2O_4$. (9)
2. At this configuration, what is the velocity of the slider if the input link is turning at the rate of 2 rad/sec counter-clockwise? (9)
3. Further, if the slider is required to move with this *constant* velocity through this configuration, then what would be the needed angular acceleration of the input link? (9)
4. Find out the angle/angles of the input link corresponding to the configuration(s) in which the transmission link (BP) is aligned with the line of the motion of the slider. (9)

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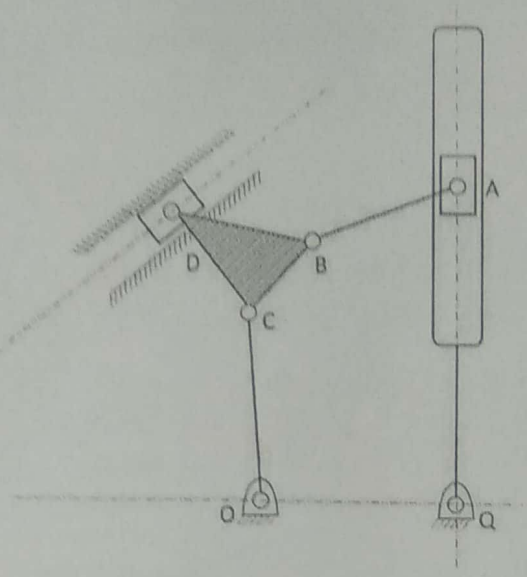
5. Suppose you are the group leader of an engineering team. The task given to your group is to simulate a control law on the mechanism shown in the figure. More precisely, your team needs to *predict* the positions and velocities for the mechanism as functions of time for a given period, when the input force(s)/moment(s) is/are given to you as function(s) of time.
   Work with the understanding that you already have an ODE solver programme that can do the computation-intensive integrations for you, if the team can provide the expressions for all *accelerations* in terms of time, initial positions, initial velocities, and (of course) the mechanism parameters which are constant.

   Your task in this present exercise is to explain clearly (to your team) which are the acceleration terms for which such expressions are needed and how to get those expressions. (14)




(a) First, copy the figure on your answerbook. Enumerate the mechanism parameters and annotate the figure showing them.

(b) Next, enumerate the links (annotating the figure further) and pairs, and work out the number of degrees of freedom ($F$).

(c) Accordingly, show input force(s)/moment(s) on the figure. Explain the basis of your choice.

(d) Choose suitable position coordinates from which all positions can be **uniquely** evaluated through explicit expressions. Show these also in the figure.

(e) Clearly spell out the kinematic considerations and the process to establish the relationships among these position coordinates and, possibly other relevant ones, mentioning the number of equations and what the solution/elimination would involve.
[*Detailed equations not required, their forms and nature will be enough.*]

(f) Spell out how the relevant velocities are to be found, and the numbers of equations and unknown velocity quantities involved in them.

(g) Enuemerate the dynamic parameters of the mechanism.

(h) Next, mention the steps involved in acceleration analysis, accounting for the number of equations and unknowns.

(i) Enumerate the dynamics consideartions, the resulting (scalar) equations and their nature, with the involved unknowns. [*The detailed complete equations not needed.*]

(j) Finally, mention how to determine the second derivatives of the position coordinates identified in step (d), to be supplied to the ODE solver with the initial conditions.

GOOD LUCK.