Take Home Exam (40% of Exam 1 Score)

(Based on Example 3.1.2, a slider-crank mechanism)

Due: Friday, March 13, 11:59 PM (no late submission accepted)

For the slider-crank in Example 3.1.2 (pp. 54), the length of the connecting rod is $l = 2$. All units used are SI. Use the same set of generalized coordinates as in the book (Cartesian generalized coordinates).

a) [30 points] Write a MATLAB code that will find the position configuration as a function of time for the slider-crank in Fig. 3.1.3, given the motion specified in Eq. 3.1.12. Assume $\omega = 4$ rad/s. To demonstrate the correctness of your answer, generate two separate plots that show $x_2(t)$ and $\phi_2(t)$. We are interested in the time evolution of the mechanism between $T_{start} = 0$ and $T_{end} = 2$ [s]. Output the position configuration on a time grid with time step $\Delta t = 0.05$ s; i.e., every other Δt seconds. NOTE: implement and use the Newton-Raphson method discussed in class for the solution of the nonlinear system that you have to solve at each time step $t_0, t_1, \ldots, t_{40}$.

b) [10 points] Does the tip of the connecting rod, that is point O_2, experience a sinusoidal motion? Explain your answer.

c) [15 points] Augment the MATLAB code you developed at a) above with functionality that allows you to compute at each $t_0, t_1, \ldots, t_{40}$ the velocity of each component of the slider-crank mechanism. To demonstrate the correctness of your results, plot $\dot{x}_2(t)$ and $\dot{\phi}_2(t)$. NOTE: You will have to solve a linear system to find both velocities and accelerations. If you want to solve a linear system $\mathbf{Ax} = \mathbf{b}$ in MATLAB once you have the **A** and **b** quantities, you can easily find the solution $\mathbf{x}$ by just typing "x = A\b".

d) [15 points] Augment the code you implemented at point c) above with functionality that allows you to compute at each $t_0, t_1, \ldots, t_{40}$ the acceleration of each component of the slider-crank mechanism. Plot $\ddot{x}_2(t)$ and $\ddot{\phi}_2(t)$ to prove the correctness of your results.

e) [30 points] Run a "what-if?" (design sensitivity) study to understand how the length of the connecting rod influences the velocity of the tip of the connecting rod $\dot{x}_2(t)$. For this, start with $l = 1.1:0.1:2.0$ and display in the same plot all the 10 responses that you get for $\dot{x}_2(t)$. What happens with the velocity of the tip as you increase the length of the connecting rod? Does it come in line with what you expect and why?

What should you turn in?

- On paper, turn in the plots that you obtained
- On paper, turn in the answer to any questions asked in a) through e) above
- In one zipped file, "takeHomeExamYourName.zip", turn in *all* the MATLAB files necessary to answer questions a) through d) above. Do not turn in the MATLAB code for e), a plot on paper will do for this. Make sure that there is a file called driverTakeHomeExam.m which can be called from the MATLAB command line and generates the output that you provide on paper for a) through d) above.

PLEASE NOTE: Keep all your files in a directory TakeHomeExamYourName. It is this directory that you should zip and email the grader (khude@wisc.edu). The grader will unzip the file, start MATLAB from the directory TakeHomeExamYourName, and type

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>> driverTakeHomeExam
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The TA will not debug your code if when issuing this command he does not get the expected plots. Email the TA or come to talk to me during office hours for MATLAB related questions. There is one big problem that you're assigned…