ME345 Modeling and Simulation, Spring 2019
Case Study 1
Assigned: Friday February 15
Due: Tuesday March 19 at 11:59 pm EST (upload on CANVAS)

__Note 1:__ Each of the Case Studies will be done in groups of 4-5 students. Each student is expected to contribute equally to the group work. No two students may sign up for the same group for more than one Case Study (as discussed in class). Students will complete an anonymous 360 Group Member evaluation after submitting the Case Study assignment.

__Note 2:__ There are three separate problems for Case Study 1. One report per group should be submitted through CANVAS by the deadline indicated above.

__Note 3:__ **All team members are responsible for all aspects of the project work.**

__Problem 1: Walking Beam Indexer with Pick and Place Mechanism [based on Norton Edition 3, Problems 4.19, 6.53, and 7.46] (40%):__

Shown in Figure 1 is a walking beam indexer with a pick and place mechanism. The mechanism can be considered as two fourbar linkages driven by a common crank. [Note: You may use the geometry and dimensions of a similar Walking Beam Indexer with slightly different geometry given in later editions of the Norton text.]

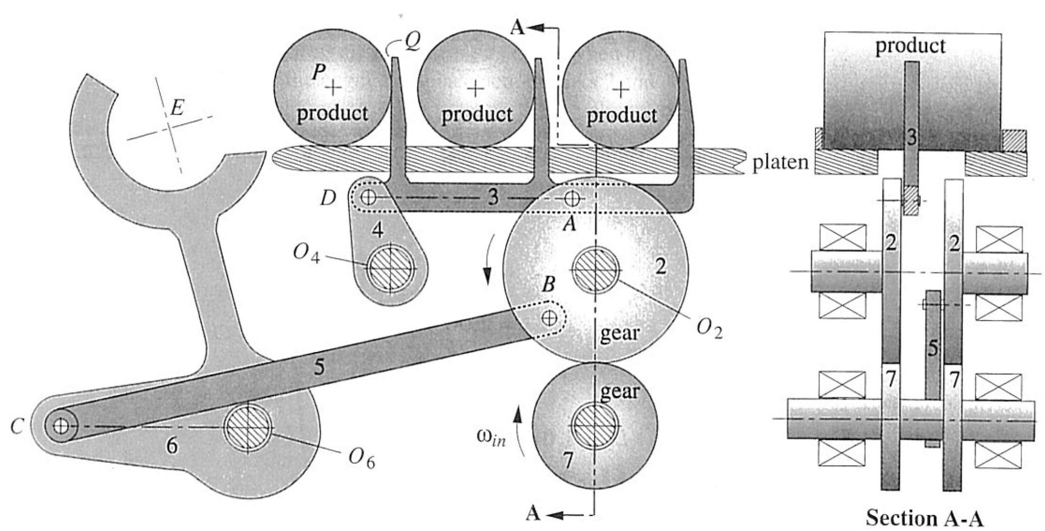

Figure 1. Walking Beam Indexer with Pick and Place Mechanism. From Norton, *Design of Machinery, 3rd Edition*, pg. 203. Note the following dimensions (in millimeters): O_2O_4 = 108,O_2A = 40, L_3 = 108, L_4 = 48 (you may wish to change this to 40), O_2O_6 = 200, O_2B = 32, L_5 = 260, and O_6C = 96.

To start, part A: Identify the two separate four bar mechanisms which comprise the mechanism shown in Figure 1. For each of the individual mechanisms, consider the motion of the smaller fourbar sub-mechanism as a function of the rotation of link 2.

To continue, part B: For one revolution of driving link 2, find the horizontal stroke of link 3 for the portion of their motion where their tips are above the top of the platen. Express the stroke as a percentage of the crank length O_2B. What portion of a revolution of link 2 does this stroke correspond to? Also, find the total angular displacement of link 6 over one revolution of link. The vertical distance from O_2 to the top of the platen is 64 mm. The vertical distance from O_2 to the top left corner of *Q* of the left-most finger is 73 mm (based on this you may wish to adjust the length of the fingers; feel free to do so). The horizontal distance from point *A* to *Q* is 95 mm.

Followup, part C (open-ended): Characterize the velocities and accelerations of different 'critical points' of the mechanism as a function of the input angular velocity ω_{in}. Explore how the behavior of the mechanism changes by altering the geometry.

Report:

Your group will need to submit an engineering report of your analysis to the company president (i.e. the professor). The report should be **well-organized, clear, and concise**, and *at minimum* address the points listed below. The report should also provide a justification of why the results that you have obtained are sensible. **NOTE: just submitting the software output without your analysis and discussion is NOT acceptable.**

While there will naturally be a delegation of responsibilities within the group, it is mandatory all work and progress is discussed with your colleagues (i.e. other members of your group). All group members are equally responsible for all aspects of the work including the written report.

- Discuss applications of how such a mechanism might be used.
- Describe briefly the specifics of the creation of your model and the setup of your analysis. In particular mention any aspects that you feel might be 'noteworthy' or unusual.
- Summarize briefly the motion of the TWO SEPARATE FOURBAR MECHANISMS YOU HAVE IDENTIFIED IN PART A for the given initial geometry given. Compare the behavior of EACH mechanism to a simplified analytical model and/or a model of the linkage system using another package.[1] Comment on the similarities and differences between the analytical model and the simulation results.
- Summarize the motion of the complete mechanism for the given initial geometry given. Address the specific questions given in Parts B and C of the problem statement. Discuss in detail how the results from the model are sensible, are compatible with your analyzes of the two separate fourbar mechanisms discussed in Part A, and reinforce your understanding of the behavior of the system.
- How does the motion of the mechanism change as a function of a change in one of the critical dimensions of the device? Is this change in mechanism behavior sensible? How might it be used from a design standpoint?
- Are their any recommendations to your supervisor regarding 'next steps' in analyzing this mechanism?

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[1] If you are not currently in ME358 and have not taken the class in the past, be sure that within your group is someone who is familiar with these programs when doing this analysis. Note that the use of even simpler analyzes (not requiring software from ME 358) would also be appropriate here.

Problem 2: Slider Mechanism (30%):

Consider the slider mechanism shown in Figure 2. Assume reasonable values for any physical dimensions not given.

1) Describe the location of points A, B, and C as a function of the angle of element 2 (where 0 degrees is aligned with the positive *x* direction)

2) For a constant clockwise angular velocity ω2 = 40 rad/min, describe the velocities and accelerations of points A, B, and C as a function of time (or angle).

3) How do the velocity and acceleration of C vary for different values of ω2?

4) How does the motion of the mechanism change as a function of a change in one of the critical dimensions of the device? Is this change in mechanism behavior sensible? How might it be used from a design standpoint?

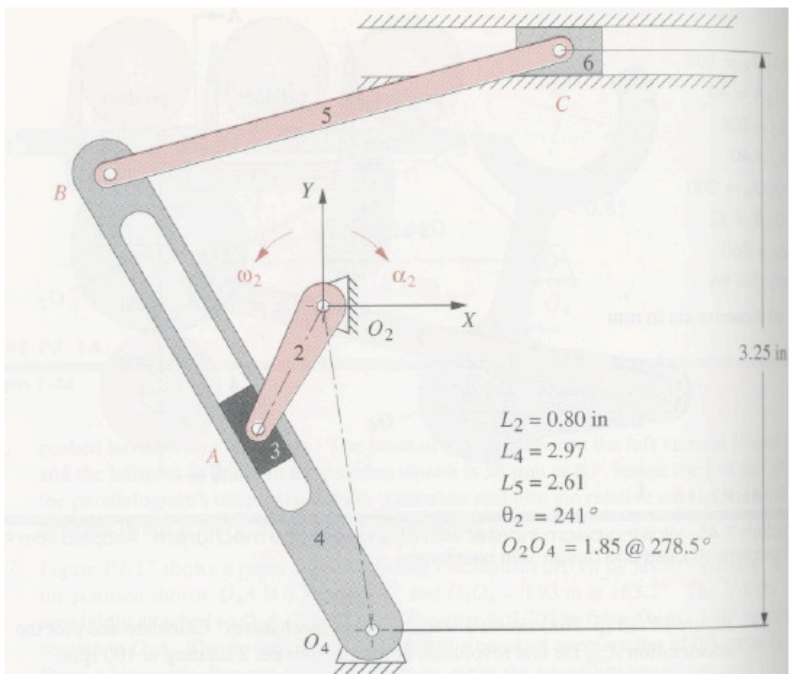

Figure 2. Slider Mechanism. (Norton, 3rd Edition, pg 368)

Report:

You will need to submit an engineering report of your analysis to the company president (i.e. the professor). The report should be **well-organized, clear, and concise**, and *at minimum* address the points listed below. The report should also provide a justification of why the results that you have obtained are sensible. **NOTE: just submitting the software output without your analysis and discussion is NOT acceptable.**

- Describe briefly the specifics of the creation of your model and the setup of your analysis. In particular mention any aspects that you feel might be 'noteworthy' or unusual.

- Compare the behavior of the mechanism to a simplified analytical model and/or a model of the linkage system using another package.[2] Comment on the similarities and differences between the analytical model and the simulation results.

- Discuss *in detail* how the results from the model are sensible and reinforce your understanding of the behavior of the system.

- Comment on any recommendations to your supervisor regarding 'next steps' in analyzing and/or improving your mechanism?

While there will naturally be a delegation of responsibilities within the group, it is mandatory all work and progress is discussed with your colleagues (i.e. other members of your group). All group members are equally responsible for all aspects of the work including the written report.

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[2] If you are not currently in ME358 and have not taken the class in the past, be sure that within your group is someone who is familiar with these programs when doing this analysis. Note that the use of even simpler analyzes (not requiring software from ME 358) would also be appropriate here.

Problem 3: Geneva Mechanism (30%):

The Geneva mechanism shown in Figure 3 is a mechanism for producing intermittent rotation. Pin P in the integral unit of wheel A and locking plate B engages the radial slots in wheel C thus turning wheel C one fourth of a revolution for each revolution of the pin. At the engagement position shown, $\theta = 45^{o}$.

1) For a constant clockwise angular velocity $\omega 1$ = 2 rad/s of wheel A, determine the corresponding counterclockwise angular velocity $\omega 2$ of wheel C for $\theta = 20^{o}$ (analytically)

2) Using appropriate CAE software, model this mechanism, and plot the angular velocity and the angular acceleration of a point at the end of the 'maltese cross' versus time. How do the maximum angular velocity and accelerations change for different constant values of $\omega 1$?

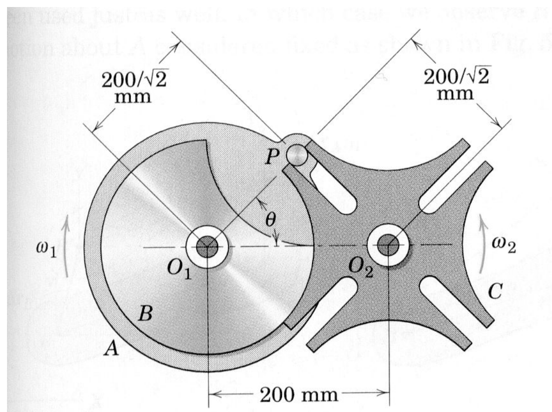

Figure 3. Geneva Mechanism

You are free to select any dimensions you wish to run the mechanism. Also note that a "Google" search will provide several websites that discuss Geneva mechanisms in detail. *Hint: you may wish to consider the use of a 'tangent mate' for your analysis.*

Report:

You will need to submit an engineering report of your analysis to the company president (i.e. the professor). The report should be **well-organized, clear, and concise**, and *at minimum* address the points listed below. The report should also provide a justification of why the results that you have obtained are sensible. **NOTE: just submitting the software output without your analysis and discussion is NOT acceptable.**

- Describe briefly the specifics of the creation of your model and the setup of your analysis. In particular mention any aspects that you feel might be 'noteworthy' or unusual.
- Compare the behavior of the mechanism to a simplified analytical model and/or a model of the linkage system using another package.[3] Comment on the similarities and differences between the analytical model and the simulation results.

[3] If you are not currently in ME358 and have not taken the class in the past, please be sure to work with a classmate in your group who is familiar with these programs when doing this analysis. Note that the use of even simpler analyzes (not requiring software from ME 358) would also be appropriate here.

- Discuss *in detail* how the results from the model are sensible and reinforce your understanding of the behavior of the system.
- Comment on any recommendations to your supervisor regarding 'next steps' in analyzing and/or improving your mechanism?

While it is natural to discuss your work and progress with your colleagues (i.e. classmates), **individual group analyzes and reports are required (this cannot be emphasized enough – work that fails to meet this requirement will not be given credit for the assignment)**. Your supervisor (i.e. the TA) is also available to answer thoughtful questions as you work on the project, but it would be unprofessional to overly rely on your supervisor to complete your assignment.