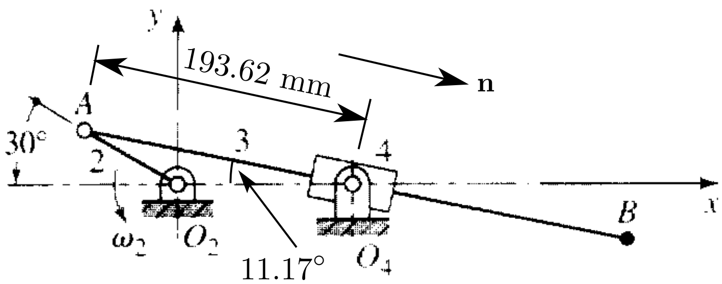
Chapter 3 HW II Hints (due ~~Friday~~ Monday, September ~~16~~ 19)

Problem 3.15: Solve this problem both analytically and using ADAMS. Here are some suggestions.

(a) Analytical Method. This problem can be a little challenging analytically... You need to find angle O_2AO_4 of link 3 and distance AO_4. I found the distance to be 193.62 mm, and the angle to be 11.17°. These are shown in the figure below.



Since there is sliding relative to a *rotating* body, this problem can't be solved using only "two points on a body," you must also use the "one point moving on a body" principle. The way I approached the problem was as follows:

- Consider the two bodies that are sliding, and identify the moving point of interest on one body **WHOSE PATH IS KNOWN** relative to the other body. For this problem these are bodies 3 and 4, and—this is one possibility—the path of A relative to 4 is known. So the "one point moving on a body" equation will be written using point A and body 4.
- Find the velocity of A using points O_2 and A and the "two points on a body" relationship and the fact that both A and O_2 are on link 2. Since $\boldsymbol{\omega}_2$ is given, $\mathbf{v}_A$ can be found numerically.
- Find the velocity of A using the "one point moving on a body" equation written as follows:

$$\mathbf{v}_A = \mathbf{v}_{A_4} + {}^4\mathbf{v}_A$$

  in which A_4 is point A fixed to body 4. The velocity of A_4 can be found using the "2 points" equation along with point O_4 and $\boldsymbol{\omega}_4$ (which is equal to $\boldsymbol{\omega}_3$). Also, the *direction* of ${}^4\mathbf{v}_A$ is known—invert the mechanism by fixing link 4, then visualize the path of A. So there will be two unknowns: ω_4 and ${}^4v_A$.
- Equate both expressions for $\mathbf{v}_A$ and solve for ω_4 and ${}^4v_A$.
- Relate the velocity of A and B using the "2 points" equation.

The answers in the text are correct.

(b) ADAMS Model. You'll need to construct link 4 as a block (at least that's what I used), and create a rotational joint between links 1 (ground) and 4. Then create link 3 as a reasonably thin rod, and place a translational joint between links 3 and 4. Make sure to specify the direction of translation along AB. Place a marker (frame) at point B so its velocity and path can be calculated.

(i) Plot the path of point B (you can use a screenshot; "crop out" the path if you want)

(ii) Plot the velocity of point B (both x and y components in m/s), and the angular velocity of links 3 and 4 (rad/s). Plot velocities and angular velocities *vs* crank angle θ_2 (deg). To change the plot dimensions, consult the ADAMS Guide.

Problem 3.23: If I had realized how difficult it was to solve for all the geometry, I don't think I would've assigned this problem...

FYI, I used to own a motorcycle with a 60° V-twin engine (Aprilia Mille, with Rotax V990 engine), although it didn't have a "master" connecting rod like this engine. The use of a "master" connecting rod (to which all other connecting rods are attached) is typical in multi-cylinder aircraft radial engines.

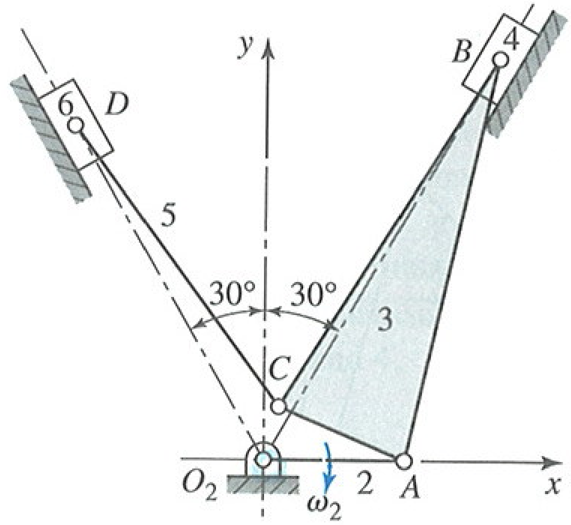
(a) Analytical Approach. Find the velocities the text states.

In addition to the geometry given, you need the following:

- $\angle AB$ from horizontal = 76.78°
- $\angle AC$ from horizontal = 22.82°
- $\angle CD$ from horizontal = 54°

Given these angles, since there are only pin joints and fixed (non-rotating) sliding joints, the problem can be completely solved using only the "2 points on a rigid body" equation. Some partial results are:

$$\mathbf{v}_B = (\ )\,\mathbf{i} - 30.7387\,\mathbf{j} \text{ ft/s}$$
$$\mathbf{v}_D = 15.7804\,\mathbf{i} - (\ )\,\mathbf{j} \text{ ft/s}$$



(b) ADAMS Model. You should create an ADAMS model for Problem 23: here are the steps that I followed:

1. Construct horizontal link 2 from O_2 to A, and rename marker "point_A"
2. Find the coordinates of points B (3.3723,5.8410), and D (-2.7826,4.8196), and construct links 4 and 6. Rename markers "point_B" and "point_D"
3. Create triangular plate link 3 between points A, B, C and back to A. When creating the plate, just click approximately where point C is, then after creating the plate go back and rename and modify the marker at C to have the correct coordinates. Link 3 will then have the correct shape.
4. Add link 5 (don't specify length, just connect points C and D).
5. Look at the TOP view to make sure all parts are in the same plane.
6. Add all joints, both revolute and translational.
7. Add angular speed to crank (rad/s); my expression was -2000*(2*pi/60). I first had this positive, and the mechanism would "seize up"...I changed the sign to the proper direction and then it worked successfully.
8. To obtain one revolution, set the time duration to 60/2000 seconds. I set the "number of steps" to 360, thereby getting one degree intervals.

(i) Plot the same velocities you found analytically, and verify your results. To change the dimensions on the plots, look at my ADAMS Guide.

(ii) Back in the early 60's, the old "hot-rodder's maxim" was that the maximum permissible piston speed was 2,500 fpm. What is the maximum "piston speed" of this engine (consider both cylinders) at 2,000 rpm?