Acceleration HW Hints

I have assigned the same two problems as in the Chapter 3 HW II assignment, but this time finding some accelerations. Please use my "velocity" solution for these problems (posted online) to help you in the acceleration analysis.

Problem 3.15: Solve this problem both analytically and using ADAMS. You will have to use the "one point moving on a body expression" as well as the "two points on a body" expression. **NOTE:** the angular acceleration of link 2 ($\boldsymbol{\alpha}_2$) should be **ZERO**.

Find the angular acceleration of bodies 3 and 4 (they are the same) and the acceleration of point B. Also make ADAMS plots of these two quantities *vs* crank angle. Confirm your analytical results by making a notation on the ADAMS plot.

(a) Analytical Solution. The procedure for solving this problems is as follows:

1. Since you know the path of point A relative to link 4 (just like the velocity analysis), express the "1 point moving on a body equation" as

$$\mathbf{a}_A = \mathbf{a}_{A_4} + {}^4\mathbf{a}_A + 2\boldsymbol{\omega}_4 \times {}^4\mathbf{v}_A$$

2. Relate the acceleration of A and O_2 using the "2 points on a body" equation, the known angular velocity $\boldsymbol{\omega}_2$, and the known angular acceleration $\boldsymbol{\alpha}_2$ (it's zero, remember). So $\mathbf{a}_A$ will be known.
3. Relate the acceleration of A_4 and O_4 using the "2 points on a body" equation, the known angular velocity $\boldsymbol{\omega}_2$, and the *unknown* angular acceleration $\boldsymbol{\alpha}_4$ (unknown magnitude, but *known direction*). This will contribute one unknown: scalar magnitude α_4.
4. Just like the relative velocity, you know the *direction* of the relative acceleration term ${}^4\mathbf{a}_A$ (it's along line AB). Express this as an unknown magnitude times a known direction (just like equation (6) in my HW solution). This will contribute another unknown: scalar magnitude ${}^4a_A$.
5. The Coriolis term can be completely computed, since you known both $\boldsymbol{\omega}_4$ and ${}^4\mathbf{v}_A$ from the velocity analysis (consult my HW solution).
6. You should end up with two equations: an $\mathbf{i}$ and $\mathbf{j}$ equation in the two scalar unknowns.
7. Finally, you can relate the acceleration of B to that of A using $\boldsymbol{\alpha}_3$ and $\boldsymbol{\omega}_3$ (same as $\boldsymbol{\alpha}_4$ and $\boldsymbol{\omega}_4$) since both points are fixed to link 3.

Some of my intermediate (and final) results are:

$$\begin{aligned}
\mathbf{a}_A &= 233.8\,\mathbf{i} - 135\,\mathbf{j} \text{ m/s}^2 \\
{}^4\mathbf{v}_A &= -1.425\,\mathbf{i} + 0.281\,\mathbf{j} \text{ m/s}^2 \\
\alpha_4 &\approx \text{ between 100 and 150 rad/s}^2 \\
\mathbf{a}_B &= 53.2\,\mathbf{i} + ???\,\mathbf{j} \text{ m/s}^2
\end{aligned}$$

(b) ADAMS Model. You can use the same model as for the velocity analysis. Depending on the unit selection, you may have to scale the dimensions by 1000 to get meters instead of mm (and scale by `pi/180` to convert from degrees to radians for the angular acceleration). Also, I did create an "`Angle MEASURE`" for the angle of link 2, so I could plot acceleration *vs* "`Crank Angle`" instead of time. If time permits, I will again review how to create (and use) measures. This is also covered in my ADAMS Guide, Section 6.

I obtained the same results in ADAMS as analytically. Note that in the position given in the problem statement the velocities and accelerations are both quite low compared with other regions of the cycle of the mechanism.

Your ADAMS results should include plots of the angular velocity of link 3 (or 4) *vs* crank angle (deg), and the acceleration of point B (X and Y components) *vs* crank angle (deg).

Problem 3.23: Solve this problem both analytically and using ADAMS. You only need the "two points on a body" expression to solve this problem. Again, assume the angular acceleration of link 2 (α_2) is zero.

Just find the acceleration of point B and the angular acceleration of body 3. Make ADAMS plots of these two quantities *vs* crank angle. Confirm your analytical results by making a notation on the ADAMS plot.

(a) Analytical Solution. The procedure for solving this problems is much simpler:

1. Since both $\boldsymbol{\omega}_2$ and $\boldsymbol{\alpha}_2$ are known, relate the accelerations of A and O_2, and thereby find $\mathbf{a}_A$.
2. Relate the accelerations of B and A (since both points are fixed to link 3). Angular velocity $\boldsymbol{\omega}_3$ is known from the velocity analysis, and the *direction* of angular acceleration $\boldsymbol{\alpha}_3$ is known. So there will be one scalar unknown, magnitude α_3.
3. The *direction* of $\mathbf{a}_B$ is known (it's along BO_2), so $\mathbf{a}_B$ can be expressed as an unknown magnitude times a known direction (like equation (19) in my HW solution): this will contribute another scalar unknown, magnitude a_B.
4. With two equations (both $\mathbf{i}$ and $\mathbf{j}$ equations) in two unknowns, the problem is solvable.

Some partial results:

$$\mathbf{a}_A = -7311\,\mathbf{i}\ \text{ft/s}^2$$
$$\mathbf{a}_B = ???\,\mathbf{i} - 2113\,\mathbf{j}\ \text{ft/s}^2$$
$$\alpha_3 \approx \text{ between -10,000 and -20,000 rad/s}^2$$

(b) ADAMS Model. Again, use the same ADAMS model as for the velocity analysis. Again, I created an "`Angle MEASURE`" to explicitly obtain angle θ_2 for use in plotting. Since $\boldsymbol{\omega}_2$ was given in the CW direction, I created my `MEASURE` to be positive "downwards." That's simply determined by the order in which you select the three points (markers) which define the measure. Again, refer to Section 6 in the ADAMS Guide.

Create ADAMS plots of the acceleration of B (both X and Y components) *vs* crank angle, and of the angular acceleration of link 3 *vs* crank angle.