LadyBug Rotational Kinematics

Go to the following website: http://phet.colorado.edu/en/simulations/category/physics/motion . Once there, click on the ***Ladybug Revolution Applet***. If you get directed to a different page and this applet is not visible, select the "physics" category on the left side of the screen. Once the applet opens up, you will want to switch to the tab labeled "rotation". Since radians are the units we must use when using the rotational version of the Big 4 equations, be sure to switch units from degrees to radians (there is a box on the lower portion of the screen you need to check).

Spend a couple of minutes becoming familiar with the various controls. Notice that the number and types of things you have control over changes as you click on different graph options on the left. For instance, if you wish to give the ladybug a rotational acceleration (α), then you must have this graph displaying at the time. Also, you can use the ruler and your mouse to position your ladybug in any location on the turntable.

Questions:

1. When the ladybug revolves with a constant angular velocity, in what direction is the ladybug's acceleration at any given instant? What is the magnitude of this acceleration as expressed in terms of the ladybug's velocity and position (I'm just looking for an equation here)?

2. When the ladybug is given an angular acceleration, what happens to the value of the ladybug's total linear acceleration (a)? Fully explain how the size and magnitude of this acceleration changes, and explain why it changes.

Complete the following example problems. Verify your answers using the applet. You may need to replay the motion in order to check values at certain times. Also, you may need to convert from angular quantities to linear quantities to check some of your answers. (In case you can't get your answer verified, answers are attached at the end; there are also solutions to each problem in the Solutions Book in the classroom. But realize that much of the purpose behind this activity is to try and get you to make the simulation do what you want).

3. When the ladybug is 2 meters from the center of the turntable and rotating with a constant angular velocity of 3 rad/sec,
   a) What is the ladybug's linear speed?
   b) What is the ladybug's acceleration?
   c) How far around the turntable (i.e what linear distance) has the ladybug travelled after 15.5 seconds?
   d) What is the ladybug's angular displacement after 15.5 seconds of rotation (in radians)? For some reason, to check this you will want to look at "the platform's" information rather than the ladybug's on the graph).
   e) What is the ladybug's angular displacement after 15.5 seconds of rotation (in degrees)?

4. If the ladybug (again 2 meters from the center) is initially moving at 4.3 rad/sec and decelerates at 1.2 rad/sec^2 for 2.0 seconds, predict its
   a) Final linear speed.
   b) Final linear acceleration in a radial direction.
   c) Final linear acceleration in a direction tangent to its instantaneous motion.
   d) Final net linear acceleration.

5. After travelling on the rotating turntable for a distance of 48 meters, what was the ladybug's initial angular velocity if it ends up rotating @ 13 rad/sec? Assume it experienced uniform acceleration of 2.5 rad/sec^2. The ladybug is still at a distance of 2 meters from the center.

6. How much time is required for the ladybug, now standing 3.0 meters from the center, to rotate through 751^o if she starts with an initial angular velocity of 1.5 rad/sec and accelerates at a rate of .76 rad/sec^2?

7. The ladybug wishes to really get a thrill. She travels to the very edge of the turntable (4 meters from the center). If she wishes to travel a total of 17.4 meters in 5 seconds, what must her angular acceleration be if she starts from rest?

8. For problem #7, what is the ladybug's total linear acceleration at 3 seconds?

9. Use the applet to determine the coefficient of friction acting between the ladybug and the turntable. Describe what you do to determine this and show all of your calculations.

ANSWERS:

1. It is the centripetal acceleration, it is directed inward, and it must equal v^2/r.
2. The total acceleration increases for two reasons. First, as the angular velocity increases, the centripetal acceleration increases (v is getting bigger). Secondly, with an angular acceleration, the ladybug now experiences an acceleration directed tangent to its path of travel. The bug's total acceleration is the vector sum of these two accelerations.

3a: 6 m/sec
3b: 18 m/sec^2 inward
3c: 93 m
3d: 46.5 radians
3e: 2664.25^o
4a: 3.8 m/sec
4b: 7.22 m/sec^2
4c: -2.4 m/sec^2
4d: 7.61 m/sec^2 at 18.39^o as shown in the diagram on the solution sheet
5: 7 rad/sec
6: 4.22 sec
7: .348 rad/sec^2
8: 4.577 m/sec^2 at 17.710^o as shown in the diagram on the solution sheet
9: 398.7 (yes, very very large)