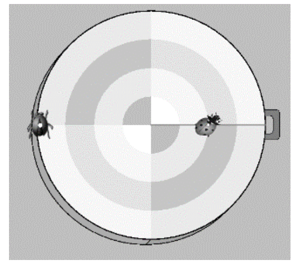
VIRTUAL LAB ROTATIONAL MOTION	Name_______________________________ Period ___________ Date: ___________
PreAP Physics	**Weight (Formative)**

DIRECTIONS: Go to the website below and familiarize yourself with the controls. Then do the activities following filling in the blanks with your answers. Show your work for partial credit, where applicable.(https://phet.colorado.edu/en/simulation/legacy/rotation). The PhET simulation is called Ladybug Revolution.

PART 1: Angular velocity vs linear velocity



STEP 1. See illustration at right.

In the control box at bottom left of your screen, turn on the ruler, acceleration vector, and velocity vectors if not done so already.

Measure the distance between the red ladybug and the center of the platform and the brown ladybug and the center. Record here:

Radius of red ladybug: ____________ **m** Radius of brown ladybug: ___________ **m**

The brown ladybug is ___________________ as far from the center as the red ladybug. Now move the angular velocity dial to 180 degrees per second.

MULTIPLE CHOICE. This amounts to ________________ turn(s) per second.

a. two b. one c. three-quarters of a d. half of a e. a quarter of a

What is your angular velocity, ω, in radians/sec? _______________________.

STEP 2. Let the wheel spin for a little while and hit the pause button.

Record the angular distance (angle), θ, travelled so far: __________________ in degrees.

Now find how long the platform has been spinning if it has moved the angular distance you recorded above (in degrees) and was moving the whole time at 180 degrees per second.

Record your answer here: _______________________ s.

Convert your angular distance, θ, to radians ________________________ rads.

Is there any difference between the angular velocity ω, in radians/sec, of the two ladybugs who are different distances from the center of the rotating platform? ☐ YES ☐ NO

Your answer above tells you that angular velocity **depends on/is independent of** (*cross out the one that is wrong*) the distance the object is from the center of rotation.

STEP 3: Now look at the velocity and acceleration vectors of the two bugs.

To explain what happens to the magnitude of the velocity and acceleration vectors of the brown ladybug vs. the red ladybug, **cross out the answers that are <u>wrong</u> in each bolded pair below in the speech cloud.**

Tangential velocity is the velocity of the ladybug measured in **meters per second/radians per second.** It is the amount of **circumference/angle** covered by the ladybugs per second. The tangential velocity, v_T, of the brown lady bug is **twice as big/the same size** as the tangential velocity, v_T, of the red ladybug. The centripetal acceleration, a_c, of the two ladybugs points **to the center/away from the center** of the circle. The centripetal acceleration, a_c, of the brown lady bug is **twice as big/the same size** as the centripetal acceleration, a_c, of the red ladybug.

Your results above suggest that tangential velocity, v_T, does **depend/doesn't depend** on how far the bug is from the center of the circle and that centripetal acceleration, a_c, **does depend/doesn't depend** on how far the bug is from the center of the circle.

The size difference of the arrow vectors showing the tangential velocity and centripetal acceleration suggests, in fact, that if the lady bug is **twice/four times** as far from the center of the circle, its tangential velocity and centripetal acceleration will be **twice/the same as** the tangential velocity and centripetal acceleration of the closer bug.

DIRECTIONS: Go to the website below and familiarize yourself with the controls. (https://phet.colorado.edu/en/simulation/legacy/torque). The PhET simulation is called Torque. Do the activities following filling in the blanks with your answers. Show your work for partial credit, where applicable.

PART 2: Torque

STEP 1. Click on the **Torque** TAB at the top left of the screen. Set the force (Applied Force) equal to 1 N. Click **Go!** Let the simulation run for 15 – 20 seconds

1. Look up the formula for torque on your formula sheet. Calculate the torque on the outer edge of the wheel (include direction, either clockwise or counter-clockwise)
Magnitude: ______________________ N·m Direction: _________________
Show work here:

2. Does your calculation pretty much match up with the torque (Applied Torque) given on screen? ☐ YES ☐ NO

3. What eventually happens to the lady bug? ______________________________

4. From Newton's Second Law, a **force** ***F*** applied to a **mass** *m* will cause the **mass** to undergo a linear _________________________ (in m/s^2)

5. When considering angular motion, a torque τ (which is like "angular" force) will cause **an object with rotational inertia** ***I*** (which is like "angular" mass) to undergo a(n) __________________ ___________________ (in rad/s^2).

6. ________ ***MULTIPLE CHOICE.*** A force keeps objects moving in horizontal and vertical circles. What is the generic name for this formula?
   A. Radial Force
   B. Resultant Force
   C. Centripetal Force
   D. Tangential Force
   E. Centrifugal force

7. ____________ ***MULTIPLE CHOICE.*** What causes the force from No. 6?
   A. Gravity
   B. Normal Force
   C. Friction
   D. Tension
   E. Spring (elastic) force

8. Why does the force you picked in No. 7 eventually fail to hold the lady bug on the wheel? In other words, what would have to be true of that force, in real life?
____
____

STEP 2. Reset all, and set the Applied Force back to 1 N. Hit **Go!**

9. Observe the acceleration vector as you start. Describe how it changes. _________
____

10. Look carefully at the acceleration vector. As a torque is being applied, does the acceleration vector ever point directly to the center? ☐ YES ☐ NO

11. Why/Why not? (STEPS 3, 4, & 8 above might help you answer this question)
____
____

STEP 3: Reset all. Set the Applied Force back to 1 N. Hit start, wait about 3 seconds, and set the brake force (Force of Brake) to 1 N. This is located below the platform area on the screen. Hit Go! and observe.

12. Describe the motion of the wheel. You may want to look at the graphs and values to understand what is happening since it is hard to see how quantities are changing just by looking at the spinning wheel: ____
____
____

13. What is the net force acting on the wheel? ΔF, the net force is the counterclockwise forces minus the clockwise forces ($F_{final} - F_{initial}$) __________ N.
Show your work here:

What is the direction of the net force (clockwise/counter-clockwise)? ___________________

14. Before the spinning disk comes to a halt, what does the screen say her net force is? __________ N.

15. Which way is the centripetal acceleration vector pointing now? _________________

16. Why can it point to the center of the circle now? _____________________________
____

17. What is the net torque, τ_{NET}, on the wheel? $\Delta\tau$, the net force is the counterclockwise torques minus the clockwise torques ($\tau_{final} - \tau_{initial}$)__________ N·m

STEP 4: Reset all. Set the Force back to 1 N. Hit Start. After a few seconds, set the brake force equal to 3N and hit enter.

18. Right after you set the brake force, calculate the net torque, magnitude and direction (use right hand rule for direction)
Show work here:

$\tau_{NET} = \Delta\tau = \tau_{final} - \tau_{initial} =$ __________ N·m Direction: ________________________

19. Does your calculation pretty much match up with the net torque, τ_{NET}, given on screen?

☐ YES ☐ NO

20. Eventually the disc stops and the net torque is zero. Once the disk stops spinning, does the braking torque reported on the screen change at this point?

☐ YES ☐ NO

21. **MULTIPLE CHOICE.** _________ The braking torque doesn't become zero even though the spinning disk is completely stopped because
    A. The wheel is going to start going clockwise pretty soon, spinning in the opposite direction to what it was going originally.
    B. There is still a torque (from a motor or something) that is still trying to turn the wheel counter-clockwise.
    C. Nonsense! The braking torque is zero, otherwise the wheel wouldn't have stopped.

22. The braking torque in the rotational "universe" has its twin in the linear universe that we studied before. What is this force called? ____________________.

PART 3: Moment of Inertia

a. Click the Moment of Inertia Tab at the top. Disregard any millimeter units. They should all be meters.
b. To best see the graphs, set the scale of the torque graph to show a range of 20 to –20.
c. Set the Moment of Inertia Graph to show a range of 2 kg m^2 to – 2 kg m^2
d. Set the angular acceleration graph to show 1,000 degrees/s^2 to –1000 degrees/s^2

1. Calculate the moment of Inertia for the disk with the given information.
   Show work here:

e. Hold the mouse over the disk so the mouse finger is pointing anywhere between the green and pink circles.
f. Hold down the left mouse button. Move your mouse to apply a force.
g. Look at the graph and try to apply a force that creates a torque of 10.

2. Use the ruler to determine the radius at any point between the green and pink circles. r = ____________m
3. Calculate what the applied force must have been.
   Show work here:
4. Calculate the angular acceleration of the disk. Work in SI units, and then convert to degrees/s^2. Compare to the graph to check your answer.
   Show work here:
5. Predict what will happen to the moment of inertia if you keep the mass of the platform the same, but you create a hole in the middle (increase inner radius).
   ____

h. Set the inner radius equal to 2.

6. Calculate the moment of inertia for this shape.
   Show work here:

i. Set the disk in motion and check your answer by looking at the moment of inertia graph. Is it roughly the same? ☐ YES ☐ NO

7. Even when the force on the platform changes, the moment of inertia graph remains constant. Why? ____
   ____
8. FILL IN THE BLANKS: When the mass of an object increases, the moment of inertia _________________. When the distance of the mass from the axis of rotation increases, the moment of inertia __________________________.

PART 4: Angular Momentum

a. Click the Angular Momentum tab at the top.
b. Set the scale of the moment of inertia and angular momentum graphs to show a range of 2 to –2.
c. Set the angular speed to be 45 degrees/s.

1. What is the SI unit for angular momentum? _______________________________

2. Calculate the angular momentum in SI units (you should have already calculated the moment of inertia in **PART 2**).
   Show work here:

d. While the disk is moving, change the inner radius to 2.
e. Observe the graphs.

3. Changing the inner radius automatically changes the angular velocity to 36 degrees/s. Why? (mention moment of inertia and angular momentum in your answer).
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   ____
   ____
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