Course and Section_____ Names _____

Date_____ _____

ROTATIONAL DYNAMICS SIMULATION

Introduction:

In this simulation you will learn about the fundamental aspects of moment of inertia, angular velocity, centripetal force, torque and angular momentum.

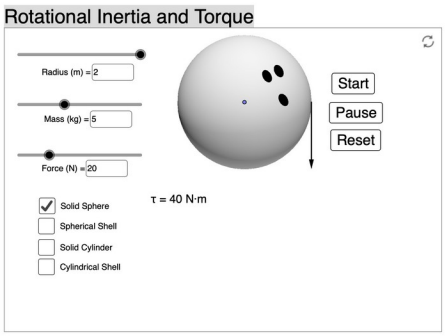
Submit your answers using Blackboard.

1 – Preliminary Questions

1. With the torque being constant, how is the moment of inertia related to the angular acceleration?
2. If the angular momentum stays constant, how is the moment of inertia related to the angular velocity?
3. Take a solid cylinder and a solid sphere both with same radii and mass. If you let them roll down an incline from the same position, which one will reach the bottom last?

2 – Moment of Inertia and Torque

Run the simulation (https://ophysics.com/r4.html)



The four circular objects in the simulation have moment of inertia which can be written as $I = \beta MR^2$ where β is constant with a different value for each one of the objects.
Start the simulation.
4. In which direction is the solid ball spinning?

Repeat using the Spherical Shell, the Solid cylinder and the cylindrical shell.
5. Which object has the greatest acceleration?
6. Which object has the least acceleration?
7. Which object has the greatest moment of inertia?
8. Which object has the least moment of inertia?

9. If you half the radius, what happens to the torque?
10. If you half the force, what happens to the torque?

Choose the solid sphere, radius = 1 m, mass = 10 kg, force = 40 N.
11. What is the angular acceleration of the solid sphere?
12. Use the relation $\tau = I\alpha$ to calculate the moment of inertia of solid sphere.
13. What is β for the solid sphere?
14. What is the angular velocity after 5 seconds?

Choose the solid cylinder, radius = 0.5 m, mass = 10 kg, force = 40 N.
15. What is the angular acceleration of solid cylinder?
16. Use the relation $\tau = I\alpha$ to calculate the moment of inertia of solid cylinder.
17. What is β for the solid cylinder?
18. What is the angular velocity after 5 seconds?

Suppose you want a solid cylinder with mass 10 kg to reach the same acceleration the sphere has in question 11 when applying the same force of 40 N in both cases.
19. To which value does the radius of the cylinder need to be changed?

3 – Newton's Second Law

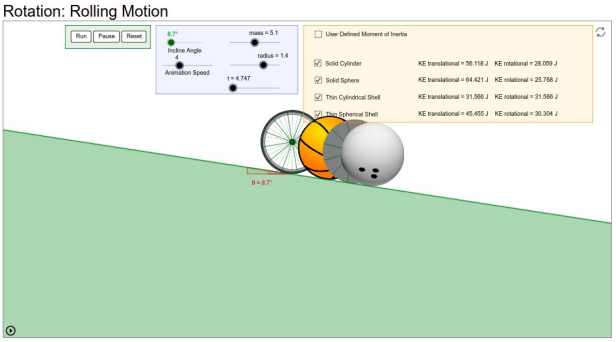
Different torques τ are applied to a solid object of moment of inertia I. The following table contains the data about the torque applied and the relative angular acceleration α of the solid object.

Torque (N m)	3.35	6.96	9.33	15.03	20.56	19.79	22.42	30.70
Alpha (rad/sec^2)	1	2	3	4	5	6	7	8

Plot the torque τ vs α.
20. Is the graph linear?
21. What is the numerical value of the slope?
22. What are the units of the slope?
23. What physical quantity does the slope represent?

4 – Rolling down the Incline

Open the simulation (https://ophysics.com/r2.html)



Uncheck the *User Defined* solid object and select all the other four boxes. Set the angle to about 6 degree and run the simulation

24. Which solid object gets to the bottom first?

Run the simulation again and then *Pause* it when the objects are about halfway the ramp

25. Which object has the greater translational KE?
26. Which object has the greater rotational KE?
27. Which object has the greater total KE?
28. Which object has the greater total PE?

Select the Solid sphere only. You can change its mass and radius before and as it rolls down.

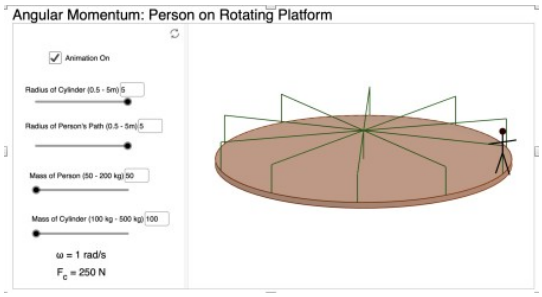
29. How does increasing the mass affect the time it takes to reach the bottom?
30. How does increasing the radius affect the time it takes to reach the bottom?

Select the *User Defined* solid object. Set two different values of its moment of inertia

31. For which value does the solid object reach the bottom first?

5 – Conservation of Angular Momentum

Open the simulation (https://ophysics.com/r9.html)



Situation A
Keep the radius of cylinder 5 m, radius of the person's path 2.05 m, mass of the person 100 kg and the mass of cylinder 100 kg. Check the box '*Animation On'*.
32. What is the angular velocity?
33. What is the centripetal force acting on the person?

Consider the system: cylinder + the person. As you move the person toward the center of the cylinder,
34. What happens to angular velocity?
35. What happens to moment of inertia?
36. If the moment of inertia increases, what happens to the angular velocity?

Situation B
Change the radius of the cylinder to 2.5 m, the mass of the person to 50 kg and the radius of the person 2.5 m, note the angular velocity. Now increase the both the radius of the cylinder and the radius of the persons path to 5m.
37. What happens to angular velocity?
38. What happens to moment of inertia of the system?

Situation C
Increase the mass of the person to 200 kg and the cylinder to 400 kg, note the value of the angular velocity. Keep the radius and position of the person at 5 m. Now decrease the mass of the person to 50 kg and the mass of the cylinder to 100 kg,
39. How does the angular velocity change?
40. How does the centripetal force change?
41. How does the moment of inertia change?
42. How does the product of moment of inertia and angular velocity change?