Roller Derby

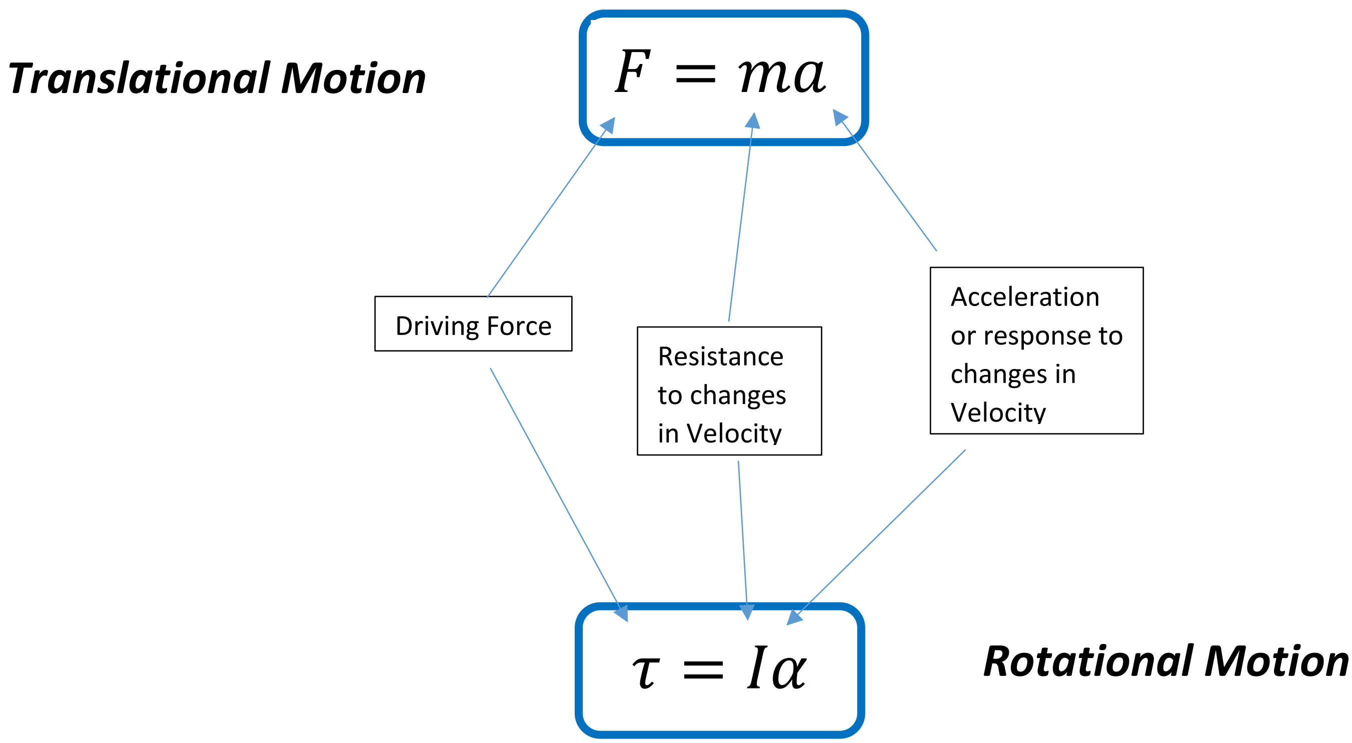
Prelab

1. Consider an object rolling down an incline having an angle θ. What parameters would you expect the acceleration of a rolling object to depend? Explain your reasoning.
2. Calculate the predicted acceleration for each of the 6 objects listed under the purpose of the experiment.
3. Completely derive the equation for acceleration on an incline.

Experiment

Purpose of Experiment

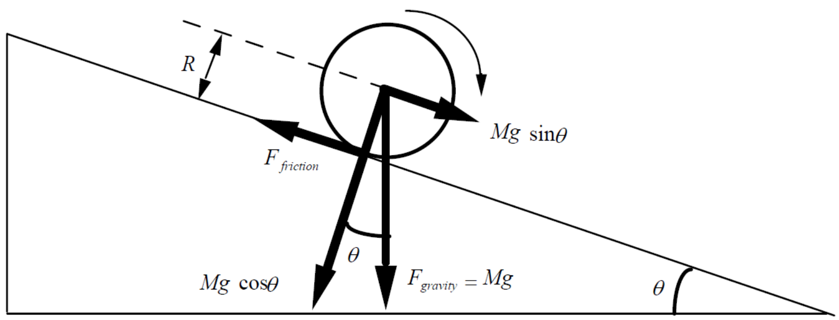
Mathematically, the moment of inertia I relates an applied torque τ to the resulting angular acceleration α through the equation, $\tau = I\alpha$. The moment of inertia of an object provides a measure of how hard it is to change that object's rotational velocity. Thus, the moment of inertia is to rotational motion what the mass of an object is to translational motion. This analogy is illustrated schematically



You will study how an object's moment of inertia affects an object's rotation. You will also study the motion of several simple objects with different moments of inertia.

Moments of inertia for spheres and cylinders (about the principal axes) can be written $I = \eta MR^2$, where η is a constant which is dependent upon the object's mass distribution, M is the object's mass and R is the object's radius.

Consider an object rolling down an incline of angle θ.



The sum of the forces yielding the object's translational acceleration a along the ramp is given by:

$$F = Mg\sin\theta - F_{friction} = Ma$$

The sum of the torques providing the objects rotational acceleration α about its center of mass can be written:

$$\sum \tau = F_{friction} R = I\alpha$$

Because the objects roll without slipping, one also has the following relationship between the translational and rotational acceleration:

$$a = R\alpha$$

Using the above equations, one can derive a relationship for the acceleration of the object down the incline in terms of θ and η.

$$a = \frac{g\sin\theta}{(1+\frac{I}{MR^2})} = \frac{g\sin\theta}{(1+\eta)}$$

We will use the following objects:

Object	**Diameter (cm)**	**Mass (g)**
Large Solid Sphere	10	810
Small Solid Sphere	5	110
Large Disk	10	370
Small Disk	5	70
Large Ring	10	230
Small Ring	5	90

Activity 1 ~ The Main Event

General Procedure

1. Set up the motion detector at the top of your ramp. Make sure the motion detector is firmly attached and can see the entire length of the ramp.
2. Connect to the software.
3. Determine the angle the ramp is set at.

Procedure

1. Test your predictions from the pre-lab by measuring the acceleration of each object.
2. Find the average acceleration of your object for each trial, use statistics from the software.
3. Conduct at least 5 trials for each object. Recording the mean acceleration for each trial.

Analysis

1. Develop a data collection table for your data in excel. Determine the measured acceleration for each object.
2. Determine the % difference between your measured and predicted accelerations.
3. Discuss and support your observations on how mass distribution affect the speed of rolling objects.

Activity 2 ~ Trial Runs

Procedure

1. Follow a similar procedure to compare three different sets of objects provided by the instructor.
2. Record the acceleration of each object.

Analysis

1. Create a data collection table in excel to compare the physical properties of each set of objects including the moment of inertia.
2. Determine the measured acceleration for each object.
3. Discuss which parameters matter in race performance.