AP Physics 1
California Crosspoint High School
Mr. Darrell Yee
Rolling Race Lab

Hypothesis

1. If the small wood disk and the plastic hoop were to race, which would win and why? Explain without doing any calculations.

   I personally think the small wood disk. The hoop will have a higher moment of inertia, causing it to be harder to turn. Because of this, it will probably acceleration slower, causing it to

2. If the small wood disk and the large wood disk were to race, which would win and why? Explain without using any calculations.

   I personally think of the small wooden disk because it is lighter. The lighter the object, the easier it would be to accelerate. The two objects probably have the same density.

Experiment

What were the results of the race?

1. Small wood disk vs. plastic hoop
   Result: Small wood disk
2. Small wood disk vs. large wood disk
   Result: Equal

Calculations

1. Calculate the moments of inertia $\left(kg\ m^2\right)$ of all three objects.

   Small Disk: S
   Hoop: H
   Large Disk: L

   $I_S = \frac{1}{2}mr^2 = 426.657g \times cm^2 = 0.000042kg \times m^2$
   $I_H = mr^2 = 778.799g \times cm^2 = 0.000078kg \times m^2$
   $I_L = \frac{1}{2}mr^2 = 1664.2g \times cm^2 = 0.000166kg \times m^2$

2. If two objects start from rest and travel the same distance, the one with a greater final velocity must have had a greater linear acceleration and traveled that distance in a shorter amount of time. Determine a formula for the final velocity of each of the three objects.

   $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$
   $\omega = \frac{v}{r}$
   $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I(\frac{v^2}{r^2})$

   Velocity for any object (In terms of I)
   $v = \sqrt{\frac{2ghmr^2}{mr^2+I}}$

   Velocity for objects (Using the coefficient of moment of inertia k)
   $v = \sqrt{\frac{2ghmr^2}{mr^2+kmr^2}} = \sqrt{\frac{2gh}{1+k}}$

Discussion

1. The large wood disk has a larger moment of inertia than the small wood disk.
   a. How does that affect its rolling compared to the small wood disk?

      It does not affect the velocity at all. This is because mr^2 is canceled out. They will also both have the same coefficient for moment of inertia.

   b. Knowing the answer to part 1a, how could the large wood disk, with a larger moment of inertia than the small wood disk, still have the same linear acceleration as the small wood disk?

      This is because mr^2 is canceled out. They will also both have the same coefficient for moment of inertia. Because the change in linear velocity is the same, so will it's linear acceleration.

2. Given two random objects that roll, how could you predict which would win in a rolling race down the ramp? Explain without using equations.

   Whichever one has a greater moment of inertia (or greater moment of inertia coefficient). You can tell by seeing which one is harder to move.
3. How would a block do in the race compared to the other three, assuming that the block slides down the ramp with negligible friction? (What place would it come in?) Explain without using equations.

   The block would come first. This is because all the potential energy would transfer to linear kinetic energy, however for the other three, they roll. Rolling takes up some kinetic energy, which means that linear kinetic energy must be a little less to compensate for it.