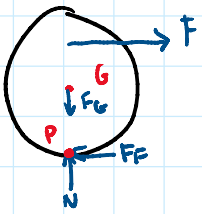
20-R-IM-DK-2

July 2, 2020 10:08 AM

Intermediate Principle of Impulse and Momentum

Inspiration: Hibbeler pg. 527

A ***200 g*** yo-yo is being pulled along the ground where it rolls without slipping. The string is wrapped around the central hub of the yo-yo and is subjected to a force ***F = (t^2 + 2) N***, where t is in seconds. If the yo-yo can be treated as two outer disks with a radius of ***r_2 = 4 cm*** and an inner disk (central hub) with a radius of ***r_1 = 3 cm***, each with the same mass, determine the yo-yo's angular velocity after ***5 seconds*** if it initially starts at rest. Assume the string has negligible mass.



3 disks with total mass of 200g, each with equal mass

$m_{disk} = \frac{200}{3} = 66.\overline{66}\ g = \frac{1}{15}\ kg$

$$I_G = \frac{1}{2}\left(\frac{1}{15}\right)\left(\frac{4}{100}\right)^2 \times 2 + \frac{1}{2}\left(\frac{1}{15}\right)\left(\frac{3}{100}\right)^2$$
$$= \frac{41}{300\,000}$$

F_F will be a variable force because it is rolling without slipping and it is an unknown. It creates a moment about G so to "ignore" it, take the moment about where the yoyo contacts the ground, point P

$$I_P\omega_1 + \sum \int M_P\, dt = I_P\omega_2 = (I_G + md^2)\omega_2$$
$$0 + \int_0^5 t^2 + 2\, dt\left(\frac{4}{100} + \frac{3}{100}\right) = \left[\frac{41}{300000} + \left(\frac{200}{1000}\right)\left(\frac{4}{100}\right)^2\right]\omega_2$$
$$\left[\frac{1}{3}t^3 + 2t\right]_0^5\left(\frac{7}{100}\right) = 0.00333\overline{666}\,\omega_2$$

$$\omega_2 = 1083.916084$$

very fast so should change force and time in code

$t = 0.1$