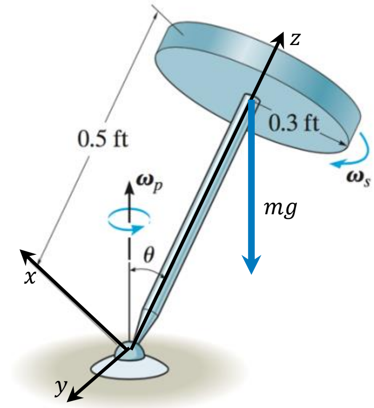
Quiz 20: Chapter 21 Due: Tuesday 15 Apr 25

Examine the solved problem below. Four errors! Your task is to locate and identify any mistakes, then correct them and calculate the proper result. If the same error occurs more than once, only count it as a single error, even if you have to correct it in more than one instance.

Each correctly identified error is worth 4 points, and the re-calculated results are worth 4 points as well. You must save your work in pdf format and submit via the Quiz 20 Assignment in the Chapter 21 folder in the Quizzes folder of the Online Classroom in Blackboard. Please do not use any other file format than pdf.

The top consists of a thin disk that has a weight $W = 8\text{lb}$ and a radius $r = 0.3\text{ft}$. The rod has a negligible mass and a length $l = 0.5\text{ft}$. If the top is spinning with an angular velocity $\omega_s = 300\frac{\text{rad}}{\text{s}}$, determine the steady-state precessional angular velocity ω_p of the rod when $\theta = 40°$.

Hint: Equation 21-30. Quadratic has two solutions. Careful with moments of inertia for the disk.



Steady-state means we can apply equation 21.30:

$$M_x = -(mg)(l\sin\theta) = -I\dot{\phi}^2\sin\theta\cos\theta + I_z\dot{\phi}\sin\theta\left(\dot{\phi}\cos\theta + \dot{\psi}\right)$$

$$-(mg)(l\sin\theta) = -I{\omega_p}^2\sin\theta\cos\theta + I_z\omega_p\sin\theta\left(\omega_p\cos\theta + \omega_s\right)$$

$$-(mg)(l\sin\theta) = -\left(\frac{1}{2}mr^2 + ml^2\right){\omega_p}^2\sin\theta\cos\theta + \left(\frac{1}{2}mr^2\right)\omega_p\sin\theta\left(\omega_p\cos\theta + \omega_s\right)$$

$$-g(l\sin\theta) = -\left(\frac{1}{2}r^2 + l^2\right){\omega_p}^2\sin\theta\cos\theta + \left(\frac{1}{2}r^2\right)\omega_p\sin\theta\left(\omega_p\cos\theta + \omega_s\right)$$

$$g(l\sin\theta) - \left(\frac{1}{2}r^2 + l^2\right){\omega_p}^2\sin\theta\cos\theta + \left(\frac{1}{2}r^2\right)\omega_p\sin\theta\left(\omega_p\cos\theta + \omega_s\right) = 0$$

$$(9.8)(0.5)\sin(40°) - \left(\frac{1}{2}(0.3)^2 + (0.5)^2\right){\omega_p}^2\sin(40°)\cos(40°)$$
$$+ \left(\frac{1}{2}(0.5)^2\right)\omega_p\sin(40°)\left(\omega_p\cos(40°) + 300\right) = 0$$

$$3.1497 - 0.1453{\omega_p}^2 + 0.0616{\omega_p}^2 + 24.105\omega_p = 0$$

$$3.1487 + 24.105\omega_p - 0.0837{\omega_p}^2 = 0$$

$$\omega_p = -0.1306\frac{\text{rad}}{\text{s}}$$

$$\omega_p = 288\frac{\text{rad}}{\text{s}}$$