

Consider the following three objects all thrown with  $\omega_3 = 40$  rad/s but with a small off-axis spin such that  $\theta = 10^\circ$

- A. A Frisbee of mass  $M = 175$  g and radius  $R = 13.7$  cm (we ignore the height which is about 3.4 cm)
- B. A wooden dowel with  $M = 38$  g, radius  $R = .94$  cm and length  $\ell = 23$  cm
- C. A thin-walled cylinder with  $M = 16$  g, radius  $R = 2.4$  cm and length  $\ell = 8$  cm

For a disk:

$$I_A = \frac{1}{4}MR^2 \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{pmatrix}$$

for a solid cylinder:

$$I_B = \frac{1}{12}M \begin{pmatrix} 3R^2 + \ell^2 & 0 & 0 \\ 0 & 3R^2 + \ell^2 & 0 \\ 0 & 0 & 6R^2 \end{pmatrix}$$

for a thin-walled cylinder:

$$I_C = \frac{1}{12}M \begin{pmatrix} 6R^2 + \ell^2 & 0 & 0 \\ 0 & 6R^2 + \ell^2 & 0 \\ 0 & 0 & 12R^2 \end{pmatrix}$$

For each object report the wobble frequency in the body frame (and the direction of  $\omega_\perp$  motion: same as or reverse from  $\omega_3$ ) and the wobble frequency in the inertial frame.