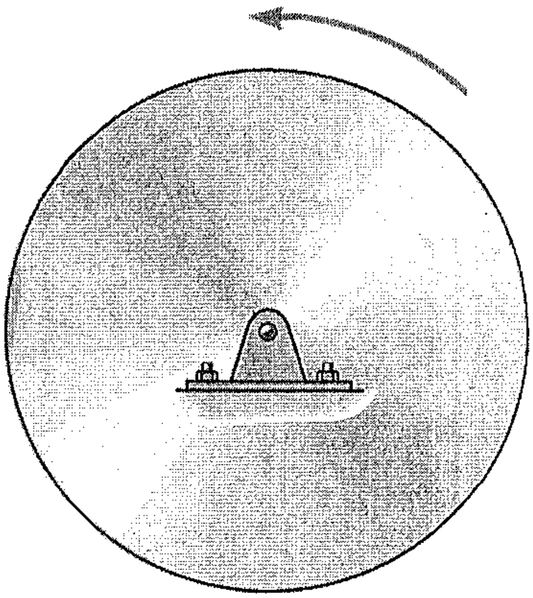
Green

1. A grindstone is rotating in the counter-clockwise sense as shown. If its speed is increasing, what direction is its angular acceleration?



(a) $\otimes$
$\boxed{\text{(b) } \odot}$
(c) *up*
(d) *Down*

By RHR, $\vec{\omega} = \odot$

INCREASING Speed So $\vec{\alpha}$ IN SAME DIRECTION AS $\vec{\omega}$

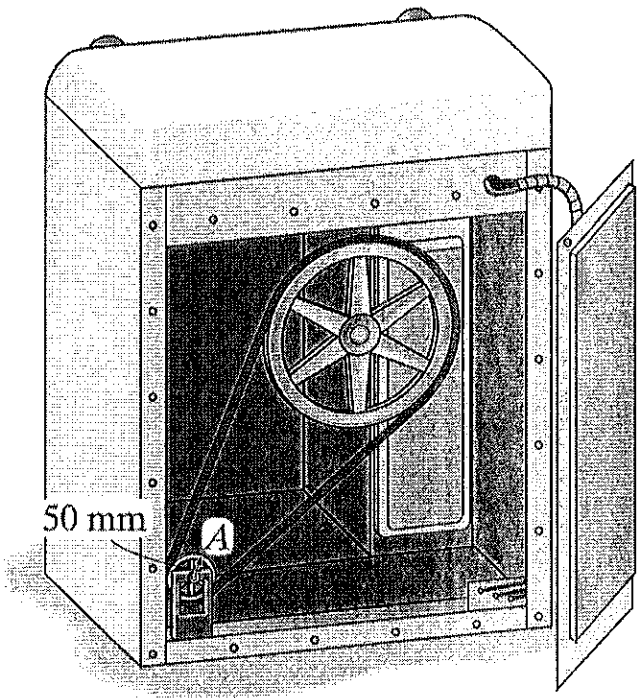
2. Water molecules in food absorb energy from a microwave oven and begin to rotate about their center at $4\,rev/s$. If a singe molecule of water has an angular momentum of $7.5 \times 10^{-46}\ kg \cdot m^2/s$, what is the moment of inertia for water rotated about its center?

(a) $1.88 \times 10^{-46}\ kg \cdot m^2$	(b) $5.97 \times 10^{-47}\ kg \cdot m^2$
(c) $9.5 \times 10^{-48}\ kg \cdot m^2$	$\boxed{\text{(d) } 2.98 \times 10^{-47}\ kg \cdot m^2}$

$L = I\omega$, $\omega = \frac{4\,rev}{s} \times \frac{2\pi\,rad}{rev} = 8\pi\,rad/s$

$$\underline{I} = \frac{L}{\omega} = \frac{7.5\times10^{-46}\ kg\cdot m^2/s}{8\pi\ rad/s} = 2.98\times10^{-47}\ kg\cdot m^2$$

3. The 50-mm radius motor at A of a clothes dryer rotates at $20\,rad/s$ and causes the larger gear (and therefore your clothes) to rotate at $4\,rad/s$. Assuming no slipping of the connecting belt, what is the radius of the larger gear?



(a) $250\,mm$
(b) $10\,mm$
(c) $50\,mm$
(d) $1000\,mm$

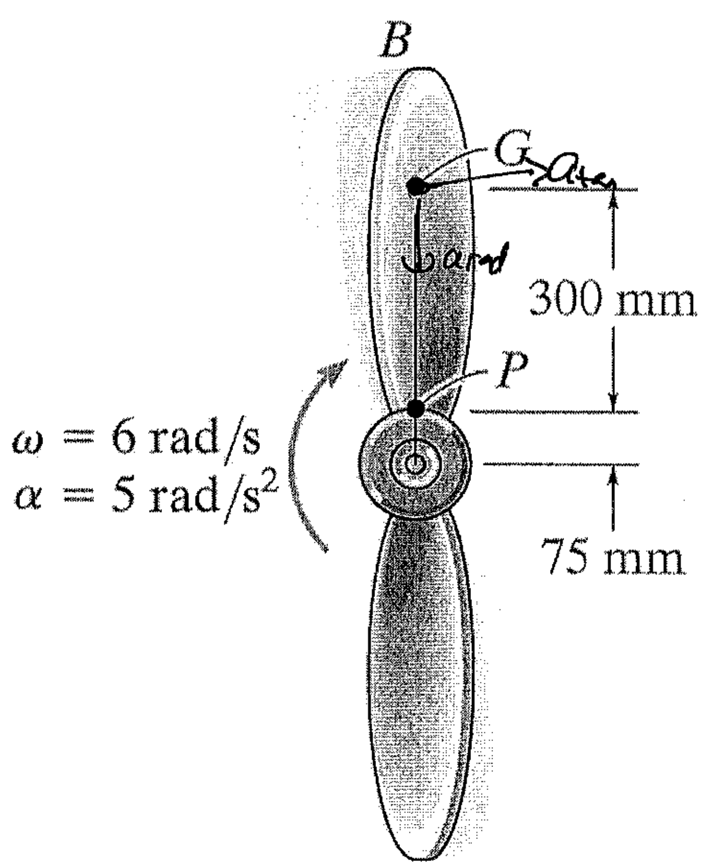
TWO CONNECTED, ROTATING OBJECTS

$\Rightarrow$ SAME LINEAR VELOCITY

$\therefore\ \omega_A r_A = \omega_B r_B \Rightarrow (20\,rad/s)(50\,mm) = (4\,rad/s)\,r_B$

$$\Rightarrow r_B = \frac{(20\,rad/s)(50\,mm)}{4\,rad/s} = 250\,mm$$

4. If the instant shown, the propeller has angular speeds and accelerations both in the clockwise sense and magnitudes given in the figure, what is the magnitude and direction of the *linear* acceleration at the point G? Assume the propeller is rotating about its center.



(a) $9.64\, m/s^2$ at $-76.5°$,

(b) $13.63\, m/s^2$ at $-82°$,

(c) $13.63\, m/s^2$ into the page, $\otimes$

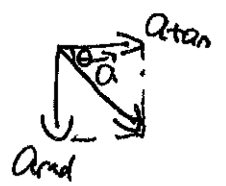
(d) $13.63\, m/s^2$ at $262°$,

$a_{tan} = \alpha r, \quad a_{rad} = \omega^2 r$ FOR BOTH $r = 375\text{mm} \times \frac{1\text{m}}{1000\text{mm}}$

$= .375\text{m}$

$a_{tan} = (5\text{rad/s}^2)(.375\text{m}) = 1.875\text{m/s}^2$

$a_{rad} = (6\text{rad/s})^2(.375\text{m}) = 13.5\text{m/s}^2 \quad a = \sqrt{a_{tan}^2 + a_{rad}^2} = 13.63\text{m/s}^2$



$\theta = \tan^{-1}\left(\frac{a_{rad}}{a_{tan}}\right) = 82°$ θ $\vec{a}$

5. A hollow sphere rotated about its center has moment of Inertia, $I = \frac{2}{3}MR^2$. Which of the following expressions is the correct one for the kinetic energy of a hollow sphere that is rolling without slipping?

(a) $\frac{1}{2}Mv^2$	(b) $\frac{5}{3}Mv^2$	$\boxed{\text{(c) } \frac{5}{6}Mv^2}$	(d) There is not enough information to determine.

Rolling: $K = \frac{1}{2}Mv^2\left(1 + \frac{I}{MR^2}\right) = \frac{1}{2}Mv^2\left(1 + \frac{2}{3}\right) = \frac{1}{2}Mv^2\left(\frac{5}{3}\right)$

$\Rightarrow K = \frac{5}{6}Mv^2$

6. A wheel, starting from rest, rotates through $2.0\,rev$ in $5.0\,s$. What is its constant angular acceleration?

$\boxed{\text{(a) } 1.0\,rad/s^2}$	(b) $0.16\,rad/s^2$	(c) $0.40\,rad/s^2$	(d) $2.51\,rad/s^2$

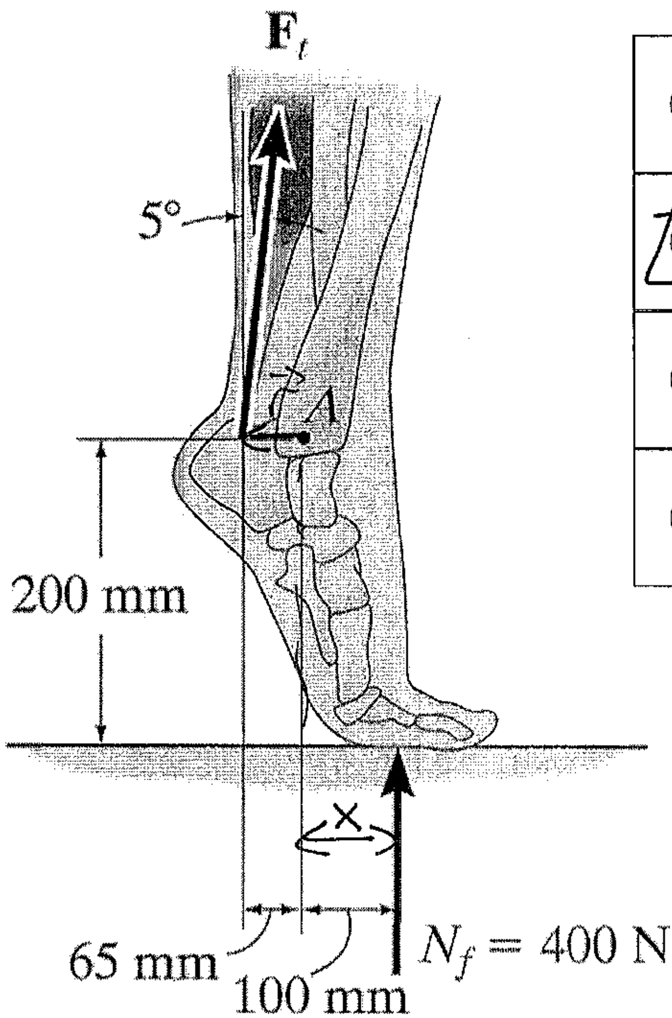
$\theta - \theta_0 = 2\,rev \times \frac{2\pi\,rad}{rev} = 4\pi\,rad$

FROM REST $\Rightarrow \omega_0 = 0$, $t = 5s$, $\alpha = ?$

$\theta - \theta_0 = \cancel{\omega_0 t} + \frac{1}{2}\alpha t^2 \Rightarrow 4\pi\,rad = \frac{1}{2}\alpha(5s)^2$

$\Rightarrow \alpha = \frac{2(4\pi\,rad)}{(5s)^2} = 1.0\,rad/s^2$

7. When a person stands on their "tip-toes", their tendons have to apply a force to prevent the foot from rotating. For the schematic foot shown below, find the magnitude of the tendon force $\vec{F}_t$ applied at 5° from the vertical necessary to make the sum of the torques about the point A zero. Ignore all other forces that would exist in reality besides the $N_f = 400\,N$ normal force. (Which is why these forces won't sum to zero.)



(a) 400 N

$\boxed{\text{(b) 618 } N}$

(c) 7060 N

(d) 15800 N

$$\sum \vec{\tau} = 0$$

$$\Rightarrow \vec{\tau}_N + \vec{\tau}_{F_t} = 0$$

About A, $\vec{N}_F$ causes counter-clockwise

$\vec{F}_t$ cause clockwise

$$\Rightarrow \tau_N - \tau_{F_t} = 0$$

$$\Rightarrow \tau_{F_t} = \tau_N$$

Normal is vertical force $\Rightarrow \tau_N = X N_F$

$X = 100\text{mm} = .1\text{m}$

For $\vec{F}_t$

$$\Rightarrow \tau_{F_t} = r F_t \sin 95^\circ$$

$r = 65\text{mm} = .065\text{m}$

$$\therefore (.065\text{m}) F_t \sin 95^\circ = (.1\text{m})(400\text{N})$$

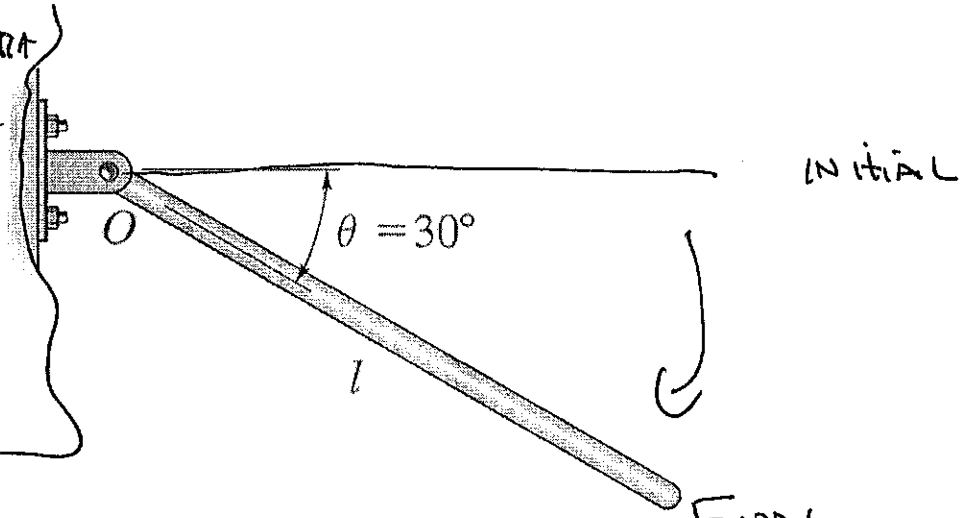
$$\Rightarrow F_t = \frac{(.1\text{m})(400\text{N})}{(.065)\sin 95^\circ} = 617.7\text{N}$$

8. A uniform thin rod of length $l = 2.00\,m$, free to rotate about one end, is started horizontally (at $\theta = 0°$) from rest. If friction can be ignored, what angular *velocity* (both speed and direction) will the rod have when it reaches the $\theta = 30°$ angle shown below? The moment of inertia for a thin rod rotated about one end is $I = \frac{1}{3}Ml^2$.

MOMENT OF INERTIA

$I = \frac{1}{3}M\ell^2 = \frac{1}{3}M(2m)^2$

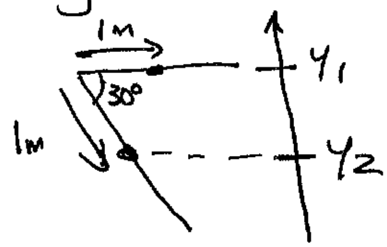
$\Rightarrow I = M\left(\frac{4m^2}{3}\right)$



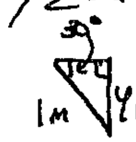
GRAVITY ONLY FORCE DOING WORK, ROD IS ROTATING

$\Rightarrow \frac{1}{2}I\omega_1^2 + Mgy_1 = \frac{1}{2}I\omega_2^2 + Mgy_2$. $\omega_1 = 0$, $\omega_2 = ?$

y_1, y_2 = CENTER OF MASS HEIGHT. UNIFORM ROD $\Rightarrow$ CENTER OF MASS AT $\ell/2 = 1m$ $\Rightarrow$



Let $y_2 = 0$ THEN



$\therefore Mgy_1 = \frac{1}{2}I\omega_2^2$

$y_1 = 1m \sin 30° = .5m$

$\Rightarrow M(9.8m/s^2)(.5m) = \frac{1}{2}\left[M \cdot \left(\frac{4m^2}{3}\right)\right]\omega_2^2 \Rightarrow \omega_2 = \sqrt{\frac{(9.8m/s^2)(.5m)3}{2m^2}}$

$\Rightarrow \omega_2 = 2.71\,rad/s$. ROD IS ROTATING clockwise. RHR $\Rightarrow \vec{\omega} = (\times)$

$\therefore \boxed{\vec{\omega}_2 = 2.71\,rad/s\,(\times)}$