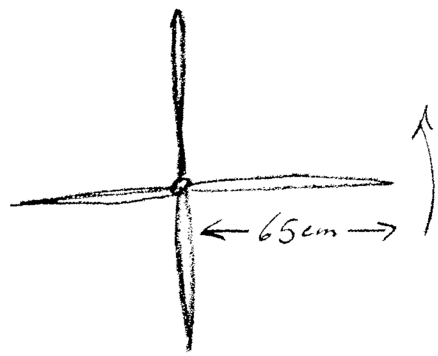
T312-01-03 A large ceiling fan has four blades each 60 cm in length. When switched on form rest, the fan requires 20 s to attain its final steady speed of 1.0 rev/s. Assume that the angular acceleration of the fan is constant. **(a)** What is the angular acceleration of the fan? **(b)** How many revolutions does the fan make in the first 20 s? **(c)** What is the distance traveled by the tip of a fan blade in the first 20 s? **(d)** What is the magnitude of the centripetal acceleration of a point on the tip of a fan blade at $t = 14$ s?



(a) Since α is constant, we can use the result

"$\omega = \omega_0 + \alpha(t - t_0)$" Set $t_0 = 0$

$\omega_0 = 0$ ← initially at rest

At $t = 20\,s$, $\omega = 1.0\,rev/s = 2\pi\,rad/s$

So

$$2\pi\,rad/s = \alpha(20\,s)$$

$$\alpha = \frac{2\pi\,rad/s}{20\,s} = \boxed{\frac{\pi}{10}\,rad/s^2 = \frac{1}{20}\,rev/s^2}$$

(b) Again, α is constant, so

$$\theta = \cancel{\theta_0} + \cancel{\omega_0}(t - \cancel{t_0}) + \frac{1}{2}\alpha(t - \cancel{t_0})^2$$

← initially at rest

Set $\theta_0 = 0$ Set $t_0 = 0$

$$\theta = \frac{1}{2}\alpha t^2$$

At $t = 20\,s$

$$\theta = \frac{1}{2}\left(\frac{1}{20}\,rev/s^2\right)(20\,s)^2 = \left(\frac{1}{2}\cdot\frac{1}{\cancel{20}}\cdot\cancel{20}\cdot 20\right)rev = \boxed{10\,rev}$$

(c) Use the linear-angular connection

$$S = R\theta \quad \{\theta \text{ in radians}\}$$

At the tip of a blade, $R = 0.6\,m$

So

$$S = (0.6\,m)(10\,rev)(2\pi\,rad/rev)$$

$$\boxed{S = 37.7\,m}$$

(d) We can use $a_c = \omega^2 R$. To do so we must compute ω [in rad/s] at $t = 14$ sec.

$$\omega = \cancel{\omega_0}^{\,0} + \alpha t = \alpha t$$

$$= \left(\frac{\pi}{10}\ \text{rad/s}^2\right)(14\ \text{s}) \approx 4.4\ \text{rad/s}$$

So

$$a_c = (4.4\ \text{rad/s})^2 (0.6\ \text{m}) \approx \boxed{11.6\ \text{m/s}^2}$$