14. The centripetal acceleration is

\[ a_c = R \omega^2 \], where \( R = \frac{d}{2} = \frac{1}{2}(5 \text{ mi}) = \frac{5}{2}(1609 \text{ m}) \)

\[ \therefore \text{ we want } a_c = g \]

\[
\omega = \sqrt{\frac{a_c}{R}} = \sqrt{\frac{2g}{d}} = \sqrt{\frac{9.8 \text{ m/s}^2 \times 2}{5(1609 \text{ m})}} = 0.05 \text{ rad/s}
\]

17. The angular velocity of the disk 3.0 s after starting from rest is:

\[ \omega = 78 \text{ rev/min} \left( \frac{2\pi \text{ rad}}{1 \text{ rev}} \right) \left( \frac{1 \text{ min}}{60 \text{ s}} \right) = 8.2 \text{ rad/s} \]

and the bug follows a circular path of radius

\[ r = 5.0 \text{ m} \left( \frac{1 \text{ m}}{3.1} \right) = 0.13 \text{ m} \]

(a) The constant angular acceleration of the disk is

\[ \alpha = \frac{\omega - \omega_0}{t} = \frac{8.2 \text{ rad/s} - 0}{3.05} = 2.7 \text{ rad/s}^2 \]

The tangential acceleration of the bug is \( a_t = ra \),

Thus \( a_t = (0.13 \text{ m}) (2.7 \text{ rad/s}^2) = 0.35 \text{ m/s}^2 \)

(b) When the disk is rotating at its final angular velocity, \( \omega = 8.2 \text{ rad/s} \), and

\[ v_t = rw = (0.13 \text{ m}) (8.2 \text{ rad/s}) = 1.0 \text{ m/s} \]

(c) Since both \( r \) and \( \alpha \) are constant, the tangential acceleration, \( a_t = ra \), is also constant. Thus at \( t = 1.05 \), \( a_t = 0.35 \text{ m/s}^2 \)

The tangential velocity of the bug is

\[ v_t = (v_t)_{t=0} + at = 0 + (0.35 \text{ m/s}^2)(1.05) = 0.35 \text{ m/s} \]

and the centripetal acceleration is
Since $F_c = m \frac{v_i^2}{r}$, the needed angular velocity is

$$\omega = \sqrt{\frac{F_c}{mr}} = \sqrt{\frac{4.0 \times 10^{-11} \text{ N}}{(3.0 \times 10^{-16} \text{ kg})(0.150 \text{ m})}}$$

$$= (9.4 \times 10^2 \text{ rad/s}) \left( \frac{1 \text{ rev}}{2 \pi \text{ rad}} \right) = 1.5 \times 10^2 \text{ rev/s}$$

$$\frac{a_c}{r} = \left( \frac{86.5 \text{ km}}{h} \frac{1 \text{ h}}{3600 \text{ s}} \frac{1000 \text{ m}}{1 \text{ km}} \right)^{-2} \frac{1 \text{ g}}{(9.80 \text{ m/s}^2)} = 0.966 \text{ g}$$

7.35 (a) The gravitational force must supply the required centripetal acceleration, so

$$\frac{G m_e m}{r^2} = m \left( \frac{v_i^2}{r} \right).$$

This reduces to $r = \frac{G m_e}{a_i}$, which gives

$$r = \left( 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2 \right) \left( \frac{5.98 \times 10^{24} \text{ kg}}{5000 \text{ m/s}^2} \right)^2 = 1.596 \times 10^7 \text{ m}.$$  

The altitude above the surface of the Earth is then

$$h = r - R_e = 1.596 \times 10^7 \text{ m} - 6.38 \times 10^6 \text{ m} = 9.58 \times 10^6 \text{ m}.$$  

(b) The time required to complete one orbit is

$$T = \frac{\text{circumference of orbit}}{\text{orbital speed}} = \frac{2\pi \left( 1.596 \times 10^7 \text{ m} \right)}{5000 \text{ m/s}} = 2.00 \times 10^4 \text{ s} = 5.57 \text{ h}.$$  

Kepler's third law gives

$$T^2 \propto \frac{4\pi^2}{G M_j} \frac{r^3}{T^2} = \frac{4 \left( \frac{3.14}{2} \right)^2}{6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2} \frac{(4.22 \times 10^5 \times 10^3 \text{ m})^3}{(1.77 \times 24 \times 3600 \text{ s})^2}$$

$$= 1.90 \times 10^{27} \text{ kg}$$
(a) \[ PE = - G \frac{M_{\text{mem}}}{r} \quad \text{where} \quad r = R + h \]

\[ PE = - G \frac{M_{\text{mem}}}{R + h} = - \frac{6.673 \times 10^{-11} \text{N} \cdot \text{m}^2/\text{kg}^2 \times 5.98 \times 10^2 \text{kg} (100 \text{kg})}{6.38 \times 10^6 \text{m}^2 + 2 \times 10^6 \text{m}^2} \]

\[ = -4.76 \times 10^8 \text{ J} \]

(b) \[ F = G \frac{M_{\text{mem}}}{r^2} = G \frac{M_{\text{mem}}}{(R + h)^2} \]

\[ = \frac{6.673 \times 10^{-11} \text{N} \cdot \text{m}^2/\text{kg}^2 \times 5.98 \times 10^2 \text{kg} (100 \text{kg})}{(6.38 \times 10^6 \text{m} + 2 \times 10^6 \text{m})^2} \]

\[ = 568 \text{ N} \quad \text{toward the Earth} \]

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**C4**

In order to conserve angular momentum, as the speed of the wheel increases, the nose of the bike must lift.

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**C6**

This question has 2 answers. The cat rotates to conserve angular momentum. The actual motion is slightly complicated and involves multiple states. See me (Ben) if you want a full explanation.
The magnitude of the torque $\tau$ of the force $\vec{F}$ is given by $\tau = rF\sin\theta$, where $r$ is the length of the position vector, $\theta$ the angle between $\vec{F}$ and $\vec{r}$.

Thus, when $\theta = \frac{\pi}{2}$, $F$ reaches its minimum value:

$$F_{\min} = \frac{\tau}{r \sin \theta} \bigg|_{\theta = \frac{\pi}{2}} = \frac{40.0 \text{ N} \cdot \text{m}}{(30.0 \text{ cm}) \times 1} = \frac{40.0 \text{ N} \cdot \text{m}}{0.30 \text{ m}} = 133 \text{ N}$$

(8.3)

a) Torque at C:

$$2.0 \text{ meters} \cdot 26 \text{ N} \cdot \cos(30^\circ)$$

Torque at end:

$$-10 \text{ N} \cdot 4 \text{ meters} \cdot \sin(20^\circ)$$

Total: 30 N m

b) Torque at D:

$$-30 \text{ N} \cdot -2 \text{ m} \cdot \sin 45$$

Torque at end:

$$2.0 \cdot -10 \text{ N} \cdot \sin 20^\circ$$

Total: 36 N
13) \[
\begin{align*}
\omega_i & = 3.0 \quad t = 3.0 \Rightarrow \\
\omega_p & = 98.0 \text{ rad/s} \\
\omega_p^2 & = \omega_i^2 + 2\alpha (\Delta \theta) \\
\omega_f & = \omega_i + \alpha t \\
\omega_i & = \omega_f - \alpha t \\
\omega_i^2 - \omega_f^2 & = 2\omega_f \alpha t + \alpha^2 t^2 + 2\alpha (\Delta \theta) \\
\alpha^2 t^2 + \alpha (\Delta \theta - 2\omega_f t) & = 0 \\
\alpha [\alpha t^2 + 2\Delta \theta - 2\omega_f t] & = 0
\end{align*}
\]

**Ten in Solution**: \[\alpha = 0\] (Units make sense.)

**Now solving**:
\[
\alpha = \frac{2 [\omega_f t - \Delta \theta]}{t^2} = \frac{2 [98 \text{ rad/s} \cdot 3.0 \text{ s} - 37.2 \pi \text{ rad}]}{3.0 \text{ s}^2} \\
= 137.7 \text{ rad/s}^2
\]
A: \[ a_c = \frac{1}{c} = \frac{\sqrt{3}}{c} \]

\[ \Gamma_{com} = 6378 \text{ Km} \]

\[ \omega = 2\pi \text{ radians} = 86400 \text{ s} \]

\[ V_{Earth} = \frac{2\pi R_c}{T} = 463 \text{ m/s} \]

\[ a_c = \frac{V^2}{\Gamma_a} = 3.5 \times 10^{-2} \frac{\text{m}}{\text{s}^2} \text{ inward.} \]

b.) At the north pole, \text{ THIS IS EAST.} 

\[ V = \frac{2\pi R_c}{T} = 0, \text{ so } a_c = 0. \]