Angular Kinematics Problems

1. A helicopter starts spinning its blades from rest. It reaches an angular speed of 400 rad/s in a time of 22 seconds. What is its angular acceleration?

2. A car approaches a stop sign and hits the brakes to stop. The wheels were initially turning at an angular speed of 2,500 rpm (rotations per minute). If the car's angular acceleration was -25 rad/s^2, how many complete revolutions did the wheels make?

3. A child blows on a pinwheel to make it spin faster. If it was already spinning at 1.9 rev/s and the child applies an angular acceleration of 3 rad/s^2 for 4 seconds, what is the maximum angular speed of the pinwheel (in rad/s)?

4. A penny spins around the edge of a record player. The record player is turning at a constant rate of 6 rad/s and has a diameter of 30 cm. What is the tangential speed of the penny?

5. Thread is pulled from a spool using an automatic sewing machine. The spool has a radius of 60 mm. The machine starts from rest and accelerates at a rate of 10 rad/s^2 for 6.5 seconds. What is the tangential velocity of the thread at this time?

6. A bird lands on the edge of a large rotating platform as it starts to slow down. Initially, the platform was rotating at 6 rad/s. As it slows down, it completes 32 revolutions in a time of 45 seconds. What is the angular velocity of the platform after 45 seconds? If the platform has an 8-meter diameter, what is the tangential acceleration of the bird?

7. A car speeds up as it makes a right turn at stop sign. Initially the car is at rest, and it reaches a final speed of 6.7 m/s. If the right turn is a full 90° turn with a turn radius of 5.3 meters, what is the tangential acceleration of the car? What is the total acceleration of the car at the end of the turn? (Hint: this requires centripetal acceleration as well)

1. $\omega_i = 0$ (from rest)

$\omega_f = 400 \text{ rad/s}$

$\alpha = ?$

$t = 22 \text{ s}$

$\Delta\theta$

$\omega_f = \omega_i + \alpha t$

$400 = 0 + \alpha(22)$

$\alpha = \frac{400}{22}$

$\alpha = 18.18 \text{ rad/s}^2$ ← angular acceleration

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2. $\omega_i = 2500 \frac{\text{rot}}{\text{min}}$

$\omega_f = 0$ (stopped)

$\alpha = -25 \text{ rad/s}^2$

t

$\Delta\theta = ?$

$2500 \frac{\text{rot}}{\text{min}} \left(\frac{2\pi \text{ rad}}{1 \text{ rot}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right) = 261.8 \frac{\text{rad}}{\text{s}}$

$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$

$0 = (261.8)^2 + 2(-25)\Delta\theta$

$0 = 68539 - 50\Delta\theta$

$50\Delta\theta = 68539$

$\Delta\theta = 1370.8 \text{ rad}$ (we want complete revolutions)

$1370.8 \text{ rad}\left(\frac{1 \text{ rev}}{2\pi \text{ rad}}\right) = 218.2 \text{ rev}$

218 complete revolutions

3. $\omega_i = 1.9 \frac{rev}{s}$ → $1.9 \frac{rev}{s}\left(\frac{2\pi\ rad}{1\ rev}\right) = 11.94 \frac{rad}{s}$

$\omega_f = ?$

$\alpha = 3$

$t = 4$

$\Delta\theta$

$\omega_f = \omega_i + \alpha t$

$= 11.94 + 3(4)$

$\omega_f = 23.94 \frac{rad}{s}$

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4. $V = \omega r$

$r = \frac{30\ cm}{2} = 15\ cm = .15\ m$

$V = 6(.15)$

$= .9 \frac{m}{s}$

(Tangential speed is the speed that would be detected by a speedometer)

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5. $\omega_i = 0$

$\omega_f = ?$

$\alpha = 10\ rad/s^2$

$t = 6.5$

$\Delta\theta$

angular velocity

$\omega_f = \omega_i + \alpha t$

$\omega_f = 0 + 10(6.5)$

$\omega_f = 65 \frac{rad}{s}$

$V = \omega r \qquad r = 60\ mm = .06\ m$

$V = 65(.06)$

$= 3.9 \frac{m}{s}$ ← Tangential Velocity

6. $\omega_i = 6 \frac{rad}{s}$

$\omega_f = ?$

$\alpha = ?$

$t = 45\ s$

$\Delta\theta = 32\ rev$

$32\ rev \left(\frac{2\pi\ rad}{1\ rev}\right) = 201.1\ rad$

Finding Angular velocity

$\Delta\theta = \frac{1}{2}(\omega_i + \omega_f)t$

$201.1 = \frac{1}{2}(6 + \omega_f)(45)$

Divide both sides by 45 and Multiply both sides by 2

$8.94 = 6 + \omega_f$

$-6 \quad -6$

Angular velocity → $2.94 = \omega_f$

Finding tangential acceleration

$\omega_f = \omega_i + \alpha t$

$2.94 = 6 + \alpha(45)$

$-3.06 = 45\alpha$

$\alpha = -.0681\ rad/s^2$

Tangential acceleration

$a = \alpha r$

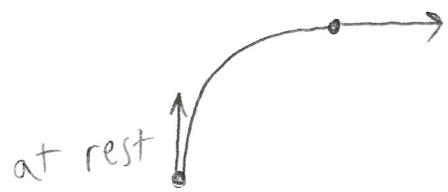
$r = \frac{8}{2} = 4$

$a = -.0681(4)$

$a = -.272\ m/s^2$

Tangential Acceleration

7.



$v_f = \omega_f r$

$6.7 = \omega_f (5.3)$

$\omega_f = 1.26 \frac{rad}{s}$

Finding tangential acceleration

$\omega_i = 0$

$\omega_f = 1.26$

$\alpha = ?$

t

$\Delta\theta = \frac{1}{4}$ rev

$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$

$1.26^2 = 0^2 + 2\alpha(1.57)$

$1.598 = 3.14\alpha$

$\alpha = .509 \ rad/s^2$ ← angular acceleration

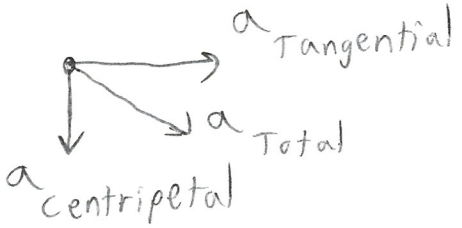
90° turn $= \frac{1}{4}$ rev

$\frac{1}{4}$ rev $\left(\frac{2\pi \ rad}{1 \ rev}\right) = 1.57$ rad

$a = \alpha r$ $\quad a = .509(5.3)$ $\quad a = 2.70 \ m/s^2$

Tangential acceleration

Total acceleration



$a_{Total}^2 = a_T^2 + a_c^2$

$a_{Total}^2 = (2.70)^2 + (8.47)^2$

$a_{Total}^2 = 79.0$

$a_{Total} = 8.89 \ m/s^2$

$a_c = \frac{v^2}{r} = \frac{6.7^2}{5.3} = 8.47 \ m/s^2$