Unit 2 – Rotational Motion
Post-Lecture

- A wheel rotates with a constant angular acceleration of 3.50 rad/s^2. If the angular speed of the wheel is 2.00 rad/s at t = 0, through what angle does the wheel rotate between t = 0 and t = 2.00s? (Give your answer in **(a)** radians and **(b)** revolutions). **(c)** What is the angular speed of the wheel at t = 2.00 s? **(d)** What angular displacement (in revolutions) results while the angular speed found in part (c) doubles?

$$\Delta\theta = \omega_i t + \tfrac{1}{2}\alpha t^2 = (2.00\ \text{rad/s})(2.00\ \text{s}) + \tfrac{1}{2}(3.50\ \text{rad/s}^2)(2.00\ \text{s})^2 = \boxed{11.0\ \text{rad}}$$

$$\Delta\theta = (11.0\ \text{rad})\left(\frac{1.00\ \text{rev}}{2\pi\ \text{rad}}\right) = \boxed{1.75\ \text{rev}}$$

$$\omega = \omega_i + \alpha t = (2.00\ \text{rad/s}) + (3.50\ \text{rad/s}^2)(2.00\ \text{s}) = \boxed{9.00\ \text{rad/s}}$$

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

$$\therefore\quad \Delta\theta = \frac{\omega_f^2 - \omega_i^2}{2\alpha} = \frac{(2 \text{ x } 9.00\ \text{rad/s})^2 - (9.00\ \text{rad/s})^2}{2(3.50\ \text{rad/s}^2)} = 34.7\ \text{rad}$$

$$\Delta\theta = (34.7\ \text{rad})\left(\frac{1.00\ \text{rev}}{2\pi\ \text{rad}}\right) = \boxed{5.52\ \text{rev}}$$

- A compact disc rotates from rest up to an angular speed of 31.4 rad/s in a time of 0.892 s. **(a)** What is the angular acceleration of the disc, assuming the angular acceleration is uniform? **(b)** Through what angle (in radians) does the disc turn while coming up to speed? **(c)** If the radius of the disc is 44.5 mm, find the tangential speed of a microbe riding on the rim of the disc when $t = 0.892$ s. **(d)** What is the magnitude of the tangential acceleration of the microbe at the given time?

$$\alpha = \frac{\omega}{t} = \frac{31.4 \text{ rad/s}}{0.892 \text{ s}} = \boxed{35.2 \text{ rad/s}^2}$$

$$\Delta\theta = \omega_i t + \tfrac{1}{2}\alpha t^2 = (0 \text{ rad/s})(0.892 \text{ s}) + \tfrac{1}{2}\left(35.2 \text{ rad/s}^2\right)(0.892 \text{ s})^2 = \boxed{14.0 \text{ rad}}$$

$$v_t = r\omega = \left(4.45 \text{ cm} \cdot \frac{1 \text{ m}}{100 \text{ cm}}\right)(31.4 \text{ rad/s}) = \boxed{1.40 \text{ m/s}}$$

$$a_t = r\alpha = \left(4.45 \text{ cm} \cdot \frac{1 \text{ m}}{100 \text{ cm}}\right)\left(35.2 \text{ rad/s}^2\right) = \boxed{1.57 \text{ m/s}^2}$$

- In a compact disc player, as the read head moves out from the center of the disc, the angular speed of the disc changes so that the linear speed at the position of the head remains at a constant value of about 1.3 m/s **(a)** Find the angular speed of a compact disc of radius 6.00 cm when the read head is at r = 2.00 cm and again **(b)** at r = 5.60 cm. An old-fashioned vinyl record player rotates at a constant angular speed, so the linear speed of the record groove moving under the detector (stylus-needle) changes. Find the linear speed of a 45.0-rpm record at points **(c)** 2.00 cm **(d)** and 5.60 cm from the records center. In both the CD and phonograph record, information is recorded in a continuous spiral track. **(e)** Calculate the total length of the track (in miles) for a CD designed to play for 60.0 minutes.

$$\omega = \frac{v_t}{r} = \frac{1.30\text{ m/s}}{0.0200\text{ m}} = \boxed{65.0\text{ rad/s}}$$

$$\omega = \frac{v_t}{r} = \frac{1.30\text{ m/s}}{0.0560\text{ m}} = \boxed{23.2\text{ rad/s}}$$

$$\left(\frac{45.0\ \cancel{\text{rev}}}{\cancel{\text{min}}}\right)\left(\frac{2\pi\text{ rad}}{\cancel{\text{rev}}}\right)\left(\frac{1\ \cancel{\text{min}}}{60\text{ s}}\right) = 4.71\text{ rad/s}$$

$$v_t = r\omega = (0.0200\text{ m})(4.71\text{ rad/s}) = \boxed{0.0942\text{ m/s}}$$

$$v_t = r\omega = (0.0560\text{ m})(4.71\text{ rad/s}) = \boxed{0.264\text{ m/s}}$$

$$d = v_t t = \left(\frac{1.30\ \cancel{\text{m}}}{\cancel{\text{s}}}\cdot\frac{1\text{ mi}}{1609\ \cancel{\text{m}}}\right)\left(60.0\ \cancel{\text{min}}\cdot\frac{60\ \cancel{\text{s}}}{1\ \cancel{\text{min}}}\right) = \boxed{2.91\text{ mi}}$$