8.2 Newton's 2nd Law for Rotational Motion

1) Newton's 2nd Law for linear motion:

$$a = \frac{F_{net}}{m}$$

2) Change to rotational by:

$a = \alpha$ angular acceleration

$F_{net} = \tau_{net}$ Net of Torque

$m = I$ moment of Inertia

∴ Newton's 2nd law for Rotational Motion is

a) α - angular acceleration is directly proportional to net torque (τ_{net})

b) α - angular acceleration is inversely proportional to moment of Inertia (I)

3) Equation: $\alpha = \frac{\tau_{net}}{I}$

4) Challenge problem pg. 208 BOTTOM

b > c > d > a

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Example 1: A solid steel wheel has a mass of 15 kg and a diameter of 0.44 m. It starts at rest. You want to make it rotate at 8.0 rev/s in 15 s.

a) What torque must be applied to the wheel?

b) If you apply the torque by wrapping a strap around the outside of the wheel, how much force should you exert on the strap?

$r = 0.22\ m$

$m = 15\ kg$

$\omega_i = 0\ rad/s$

$\omega_f = 2\pi(8.0\ rev/s)$

$t_{time} = 15\ s$

$\alpha = 3.4\ rad/s^2$

$I = 0.36\ kg\ m^2$

$\tau = 1.2\ N \cdot m$

$F = 5.5\ N$

① $\alpha = \frac{\Delta\omega}{\Delta t} = \frac{2\pi(8) - 0}{15} = 3.4\ rad/s^2$

② $I = \frac{1}{2} m \cdot r^2 = \frac{1}{2} \cdot 15 \cdot (.22)^2 = 0.36\ kg\ m^2$

③ $\tau = \alpha \cdot I = 3.4(0.36) = 1.2\ N\ m$

④ $F = \frac{\tau}{r} = \frac{1.2}{.22} = 5.5\ N$

$\tau = f \cdot r$

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Example 2: Lawnmower starter

A solid wheel has a mass of 20 kg and a diameter of 0.50 m. When starting from rest you want to make it rotate at 10 rev/s in 17 s to get the lawnmower to start.

a) What torque must be applied to the wheel?

b) If you pull the rope that is wrapped around the wheel, how much force should you exert?

$\tau = 2.31\ N \cdot m$

$F = 9.24 N$

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Example 3: A solid wheel & a bicycle wheel

A solid wheel accelerates at 4.15 rad/s^2 when a force of 5 N exerts a torque on it. If the wheel is replaced by a bicycle wheel with all of its mass on the rim, the moment of inertial is given by $I = mr^2$. If the same angular velocity were desired, what force would have to be exerted on the strap?

10 N

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Example 4: A bicycle wheel

A bicycle wheel can be accelerated by pulling on the chain that is on the gear or by pulling on a string wrapped around the tire. The wheel's radius is 0.38 m, while the radius of the gear is 0.14 m. If you obtained the needed acceleration with a force of 15 N on the chain, what force would you need to exert on the string?

$r_w = 0.38\,m$

$r_g = 0.14\,m$

$F_g = 15\,N$

$T_g = r_g \cdot f_g$

$T_w = r_w \cdot f_w$

Net Torque = 0

$T_g = T_w$

$0.14 \cdot 15 = 0.38 \cdot f_w$

$\frac{0.14 \cdot 15}{0.38} = \frac{0.38 \cdot f_w}{0.38}$

$5.5\,N = f_w$

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Pg. 210 25-29 all

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