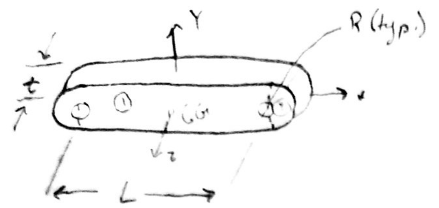
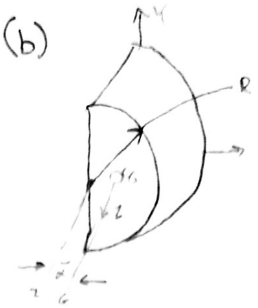
10-37 Row C

(a)



(b)



Row C

L	R	d	t	P	δ	Material
175	15	10	15	125	60	Aluminum

→ $\rho = 2700\ kg/m^3$

Main section

End pieces

$$m_2 = \frac{\pi R^2 \cdot t \cdot \rho}{2} = \frac{\pi (0.015)^2 \times 0.015 \cdot 2700}{2}$$

$$m_2 = 0.01431\ kg$$

$$I_2 = 2 \times \left[\frac{m_2 \times R^2}{2} + m_2 \left(\frac{L}{2}\right)^2\right]$$

$$= 2\left[\frac{0.0143 \times 15^2}{2} + 0.0143\left(\frac{175}{2}\right)^2\right]$$

$$= \underbrace{222.19\ kg \cdot mm^2}$$

(a) $$\text{mass} = L \cdot 2(15\,mm)\, t \cdot \rho \quad (2(15\,mm) = D)$$

$$= 0.175\,(.030)\,(.015)\,(2700)$$

$$m_1 = .21263\ Kg$$

$$I_1 = \frac{m}{12}(L^2 + D^2) = \frac{0.21263}{12}(175^2 + 30^2)$$

$$= \underbrace{558.9\ Kg \cdot mm^2}$$

Pin Holes

$$m_3 = \frac{\pi d^2 \cdot t \cdot \rho}{8} = \frac{\pi (.01)^2\, 0.015 \cdot 2700}{8} = .00159\ kg$$

(−) b/c not present

$$I_3 = 2\left[\frac{-.00159 \cdot 10^2}{8} - .00159\left(\frac{175^2}{4}\right)\right]$$

$$= \underbrace{24.389\ Kg \cdot mm^2}$$

MoI about Center of gravity

$$I_{CG} = I_1 + I_2 + I_3$$

$$= (558.9 + 229.19 - 24.389)\ kg \cdot mm^2$$

$$\boxed{I_{CG} = 763.7\ kg\ mm^2}$$

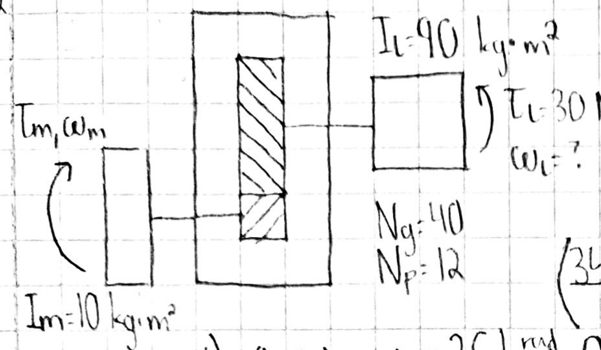
MoI about pivot hole (parallel axis theorem)

$$I_H = I_{CG} + \Sigma m \left(\frac{L}{2}\right)^2$$

$$= 763.7 + (.21422\,kg)\left(\frac{175^2}{4}\right)$$

$$\boxed{I_H = 2403.8\ kg \cdot mm^2}$$

2



a) $m_G = ?$ $m_G = \frac{N_G}{N_P} = \frac{40}{12}$ $\boxed{m_G = \frac{10}{3}}$

b) α of i) input, ii) output if motor goes from 0 to 3450 RPM in 0.5 s

$\left(\frac{3450\ rev}{min}\right)\left(\frac{1\ min}{60\ s}\right)\left(\frac{2\pi\ rad}{1\ rev}\right) = 361\ \frac{rad}{s}$

i) $\alpha_i = \frac{\omega_2 - \omega_1}{t} = \frac{361\ \frac{rad}{s} - 0\ \frac{rad}{s}}{0.5\ s}$ $\boxed{\alpha_i = 723\ \frac{rad}{s^2}}$ ii) $\alpha_o = \frac{\alpha_i}{m_G} = 723 \cdot \frac{3}{10}$ $\boxed{\alpha_o = 217\ \frac{rad}{s^2}}$

c) ω of load after startup. $\omega_o = \alpha_o t = (217\ \frac{rad}{s^2})(0.5\ s)$ $\boxed{\omega_o = 109\ \frac{rad}{s}}$

d) reflected inertia seen by motor resulting from load inertia=?

reflected inertia from load inertia $= \frac{I_L}{m_G^2} = (90\ kg \cdot m^2)\left(\frac{3}{10}\right)^2$ $\boxed{\text{reflected inertia} = 8.1\ kg \cdot m^2}$

e) torque on motor due to load torque (assuming constant over time)=?

torque on motor due to load torque: $T_m = \frac{T_L}{m_G} = 30\ N \cdot m \cdot \frac{3}{10}$ $\boxed{T_m = 9\ N \cdot m}$

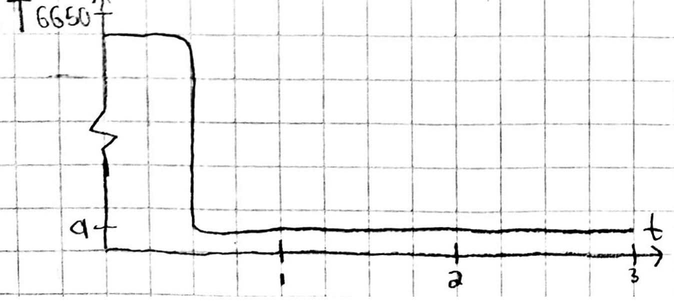
f) magnitude of total T_m to change ω_m from 0 to 1750 RPM in 0.5 s? assume T_L constant

Total $T_m = I_s \alpha_m + T_L$ $\left(\frac{1750\ rev}{min}\right)\left(\frac{1\ min}{60\ s}\right)\left(\frac{2\pi\ rad}{1\ rev}\right) = 183\ \frac{rad}{s}$ $\alpha_{in} = \frac{183\ rad/s}{0.5\ s} = 367\ \frac{rad}{s^2}$

$I_s = I_m + \frac{I_L}{m_G^2} = 10\ kg \cdot m^2 + 8.1\ kg \cdot m^2 = 18.1\ kg \cdot m^2$ $T_m = (18.1\ kg \cdot m^2)\left(367\ \frac{rad}{s^2}\right) + 9\ N \cdot m$

$\boxed{T_m = 6650\ N \cdot m}$

g)



plot motor torque vs time for t=0-3s; what value of torque to design system?

$\boxed{\text{use } T = 6650\ N \cdot m \text{ for system}}$

Reflected inertia seen by motor:

Reflected inertia of gear:

$$I_{Gear,\ reflected} = \frac{I_{Gear}}{m_G^2} = \frac{10\ kg\ m^2}{3.33^2} = 0.902\ kgm^2$$

$$I_{motor,\ total} = I_{motor} + I_{load,\ ref} + I_{gear,\ ref} + I_{pinion}$$

$$= (10\ kgm^2) + (8.12\ kgm^2) + (0.902\ kgm^2) + (1\ kgm^2)$$

$$\boxed{I_{motor,\ total} = 20.02\ kgm^2}$$

Override Mass Properties... | Recalculate

☑ Include hidden bodies/components

☐ Create Center of Mass feature

☐ Show weld bead mass

Report coordinate values relative to: -- default --

Mass properties of Part2
    Configuration: Default
    Coordinate system: -- default --

Density = 0.28 pounds per cubic inch

Mass = 10.08 pounds

Volume = 35.46 cubic inches

Surface area = 202.99 square inches

Center of mass: (inches)
    X = 0.00
    Y = 0.00
    Z = 0.25

Principal axes of inertia and principal moments of inertia: (pounds * square
Taken at the center of mass.

Ix = (0.00, 1.00, 0.00)	Px = 124.18
Iy = (-1.00, 0.00, 0.00)	Py = 124.18
Iz = (0.00, 0.00, 1.00)	Pz = 247.94

Moments of inertia: (pounds * square inches)
Taken at the center of mass and aligned with the output coordinate system.

Lxx = 124.18	Lxy = 0.00	Lxz = 0.00
Lyx = 0.00	Lyy = 124.18	Lyz = 0.00
Lzx = 0.00	Lzy = 0.00	Lzz = 247.94

Moments of inertia: (pounds * square inches)
Taken at the output coordinate system.

Ixx = 124.81	Ixy = 0.00	Ixz = 0.00
Iyx = 0.00	Iyy = 124.81	Iyz = 0.00
Izx = 0.00	Izy = 0.00	Izz = 247.94

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