HW Assignment Solution for EML 4806 CH 8

Problem 4:

Let $K_{0.2}$ be stiffness of the 0.2 cm diameter shaft, and $k_{0.3}$ be that of the 0.3 cm shaft. Then, using (8.14) and (8.19):

$$\frac{1}{K_{\text{total}}} = \frac{1}{K_{0.2}n^2} + \frac{1}{K_{0.3}} \quad \text{where } n = 8$$

From (8.15):

$$K_{0.2} = \frac{(7.5 \times 10^{10})(\pi)(0.002)^4}{(32)(0.30)} = 0.393 \text{ ntm/rad}$$

$$K_{0.3} = \frac{(7.5 \times 10^{10})(\pi)(0.003)^4}{(32)(0.30)} = 1.988 \text{ ntm/rad}$$

$$\frac{1}{K_{\text{total}}} = \frac{1}{(.393)8^2} + \frac{1}{1.988}$$

$$= \frac{1}{25.152} + \frac{1}{1.988} = 0.5427$$

$$\therefore \quad \boxed{K_{\text{total}} = 1.8426 \text{ ntm/rad}}$$

Problem 9:

Stiffness of input drive as seen at gear #1:

$$\frac{1}{K_{\text{gear 1}}} = \underbrace{\frac{1}{100}}_{\text{coupling \#1}} + \underbrace{\frac{1}{400}}_{\text{shaft}} + \underbrace{\frac{1}{100}}_{\text{coupling \#2}} = 0.0225; \quad K_{\text{gear 1}} = 44.44$$

Assume that shaft from gear 2 to gear 3 is rigid.. . .

$$\frac{1}{K_{\text{gear 3}}} = \frac{1}{2000} + \frac{1}{6^2(K_{\text{gear 1}})} = 1.125 \times 10^{-3}; \quad K_{\text{gear 3}} = 888.88$$

$$\frac{1}{K_{\text{gear 4}}} = \frac{1}{2000} + \frac{1}{6^2(K_{\text{gear 3}})} = 5.3125 \times 10^{-4};$$

$$\boxed{K_{\text{gear 4}} = 1882.35 \text{ ntm/rad}}$$

Problem 17:

From (8.12) $n = r_2/r_1 = 12/2 = \boxed{6}$

Problem 20:

In Grüblers formula:

$N = 6$ (3 ball-in-socket, 3 universal)

$L = 5$ (ground, object, 3 links)

$\sum_{i=1}^{N} f_i = 3 \times 3 + 3 \times 2 = 15$

so, $F = 6(5 - 6 - 1) + 15 = -12 + 15 = \boxed{3}$

Problem 29:

From (8.14):

$$\frac{1}{k_{\text{total}}} = \frac{1}{1500} + \frac{1}{100} = 0.0107$$

$$\therefore \quad k_{\text{total}} = 93.8 \text{ Nt} \cdot \text{m/rad}$$

Problem 31:

From (8.15):

$$k = \frac{G\pi d^4}{32L} = \frac{(0.33 \times 7.5 \times 10^10)(\pi)(0.01^4)}{(32)(0.30)}$$
$$= 81.8 \ \text{Nt} \cdot \text{m/rad}$$