ME 263C, HW#1.

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1. a) consider the mechanical balances at the motor side and the load side:

$$C_m = I_m \dot{\omega}_m + F_m \omega_m + f r_m \qquad (1)$$

$$f r = I \dot{\omega} + F\omega + C_l \qquad (2)$$

$$\therefore \quad C_m = \left(I_m + \frac{I}{k_r^2}\right)\dot{\omega}_m + \left(F_m + \frac{F}{k_r^2}\right)\omega_m + \frac{C_l}{k_r}$$

let $I_{eq} = I_m + \frac{I}{k_r^2}$, $F_{eq} = F_m + \frac{F}{k_r^2}$, $C_l = mgl\sin\vartheta$

$\because$ The inertia of the pair of reduction gears and viscous friction is negligible

$F_m = 0$. [redacted]

$$\therefore \ C_m = \left(I_m + \frac{I_{load}}{k_r^2}\right)\dot{\omega}_m + \frac{C_l}{k_r}$$

$$I_{total} = I_m + \frac{I_{load}}{k_r^2}$$

i) If $k_r = 5$, $I_{total} = 0.03 + \frac{1}{25}\left(\frac{3\times0.5^2}{3} + 2\times0.5^2\right) = 0.06\ kg\cdot m^2$

$$\dot{\omega}_m = \left(C_m - \frac{mgl\sin\vartheta}{k_r}\right)\cdot\frac{1}{I_{total}}$$

$$= \left(C_m - \frac{g\sin\vartheta}{k_r}\left(m_1\cdot\frac{L}{2} + m_2\cdot L\right)\right)\frac{1}{I_{total}} = \frac{\left[12 - \frac{9.8\times\sin(270^\circ)}{5}\times\left(3\times\frac{0.5}{2}+2\times0.5\right)\right]}{0.06}$$

$$= 257.2\ rad/s^2$$

ii) If $k_r = 50$, $I_{total} = 0.03 \times \frac{1}{2500}\left(\frac{3\times0.5^2}{3} + 2\times0.5^2\right) = 0.0303\ kg\cdot m^2$

$$\dot{\omega}_m = \left[12 - \frac{9.8\times\sin(270^\circ)}{50}\times\left(3\times\frac{0.5}{2} + 2\times0.5\right)\right]\times\frac{1}{0.0303}$$

$$= 407.36\ rad/s^2$$

b) When $k_r = 5$, $I_{total} = 0.06\ kg\cdot m^2$, $\dot{w}_m = 257.2\ rad/s^2$.

When $k_r = 50$, $I_{total} = 0.0303\ kg\cdot m^2$, $\dot{w}_m = 407.36\ rad/s^2$

Higher the gear ratio, lower the impact from load side to the motor side.

2. ∵ Viscous friction in the system remains negligible

(a)

$$C_m = \left(I_m + I_{gm} + \frac{I_{load} + I_{gl}}{k_r^2}\right)\dot{w}_m + \frac{C_l}{k_r}$$

$$I_{total} = I_m + I_{gm} + \frac{I_{load} + I_{gl}}{k_r^2}$$

i) when $k_r = 5$,

$$I_{total} = 0.03 + 0.002 + \frac{1}{25}\left(\frac{3\times0.5^2}{3} + 2\times0.5^2 + 0.004\right) = 0.06216\ kg\cdot m^2$$

$$\dot{W}_m = \left[12 - \frac{9.8\times\sin(270^\circ)}{5}\times\left(3\times\frac{0.5}{2} + 2\times0.5\right)\right]\frac{1}{0.06216} = 248.26\ rad/s^2$$

ii) when $k_r = 50$

$$I_{total} = 0.03 + 0.002 + \frac{1}{2500}\left(\frac{3\times0.5^2}{3} + 2\times0.5^2 + 0.004\right) = 0.0323\ kg\cdot m^2$$

$$\dot{W}_m = \left[12 - \frac{9.8\times\sin 270^\circ}{50}\times\left(3\times\frac{0.5}{2} + 2\times0.5\right)\right]\cdot\frac{1}{0.0323} = 382.14\ rad/s^2$$

b) If we consider the inertias of gears, the I_{total} will increase. so the maximum angular acceleration values will decrease.

3. Consider the serial connection of two linear springs having stiffness coefficients k_1 and k_2.

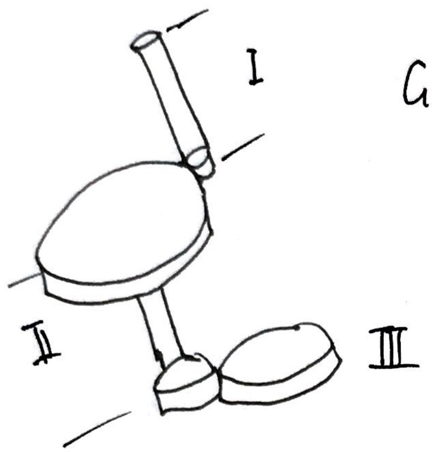
Give the system a torque T. $T = k_1\Delta\theta_1 = k_2\Delta\theta_2$, $\Delta\theta = \Delta\theta_1 + \Delta\theta_2$

$$K_{serial} = \frac{T}{\Delta\theta} = \frac{T}{\Delta\theta_1 + \Delta\theta_2} = \frac{T}{\frac{T}{k_1} + \frac{T}{k_2}} = \frac{1}{\frac{1}{k_1} + \frac{1}{k_2}}$$

$$\therefore \frac{1}{K_{serial}} = \frac{1}{k_1} + \frac{1}{k_2}$$

4. Consider the serial connection of #1 coupling, connecting rod and #2 Coupling. The serial stiffness $k_s = \frac{1}{\frac{1}{k_1}+\frac{1}{k_2}+\frac{1}{k_c}} = \frac{1}{\frac{1}{100}+\frac{1}{100}+\frac{1}{400}}$

$= 44.44\ N\cdot m/rad$



Give the system a torque T, $k_g = 2000\ N\cdot m/rad$

For I, $\frac{M}{k_s} = \Delta\theta_1$

For II, $\frac{M}{k_g} = \Delta\theta_2$

For III, $\frac{M}{k_g} = \Delta\theta_3$

$$\Delta\theta = \frac{\frac{\Delta\theta_1}{k_r^2}+\Delta\theta_2}{k_r^2} + \Delta\theta_3$$

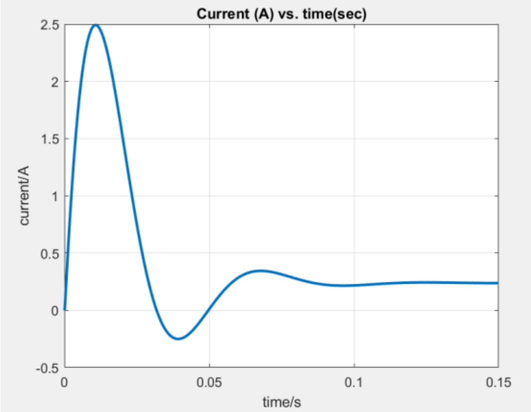
$$= \frac{\Delta\theta_1}{k_r^4} + \frac{\Delta\theta_2}{k_r^2} + \Delta\theta_3 \quad \text{where } k_r = 6.$$

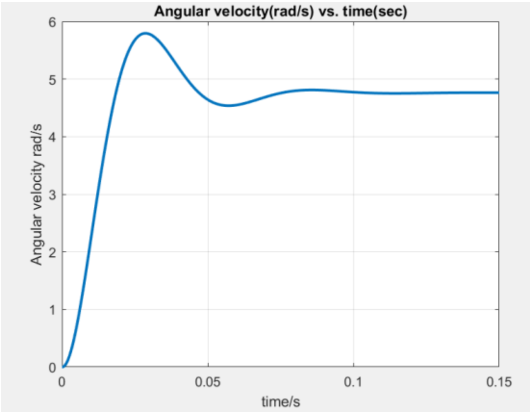
$$\therefore k_\phi = \frac{M}{\Delta\theta} = \frac{1}{\frac{1}{k_g}+\frac{1}{k_g k_r^2}+\frac{1}{k_s k_r^4}} = \frac{1}{\frac{1}{2000}+\frac{1}{2000\times6^2}+\frac{1}{44.44\times6^4}}$$

$= 1882.35\ N\cdot m/rad$

Prob5

(a) (b)



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%%% Zhaoxing Deng 005024802 %%%
clear all;
clc;
sim HW1

figure(1)
plot(tout,I_a,'linewidth',2);
grid on;
title('Current (A) vs. time(sec)');
xlabel('time/s');
ylabel('current/A');

figure(2)
plot(tout,omega,'linewidth',2);
grid on;
title('Angular velocity(rad/s) vs. time(sec)');
xlabel('time/s');
ylabel('Angular velocity rad/s');
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(c)