Prob. #3

(a) $$H(s) = \frac{\Omega(s)}{V_s(s)} = \frac{50}{s^2+21s+20}$$

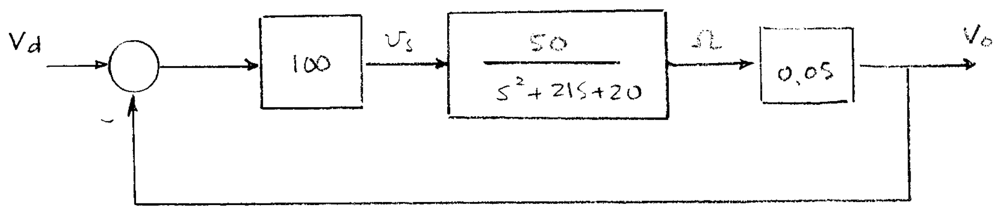
Hence

$$(s^2+21s+20)\,\Omega(s) = 50\,V_s(s)$$

OR

$$\frac{d^2\Omega}{dt^2} + 21\frac{d\Omega}{dt} + 20\,\Omega = 50\,V_s(t)$$

(b)



$$V_o = 0{,}05\,\Omega$$

$$V_s = 100\,(V_d - V_o) = 100\,(V_d - 0{,}05\,\Omega)$$

$$\Omega = \frac{50}{s^2+21s+20}\,V_s = \frac{50}{s^2+21s+20}\,(100)\,(V_d - 0{,}05\,\Omega)$$

$$\left(1 + \frac{250}{s^2+21s+20}\right)\Omega = \frac{5000}{s^2+21s+20}\,V_d$$

Hence

$$H_1(s) = \frac{\Omega}{V_d} = \frac{5000}{s^2+21s+270}$$

poles: $s^2 + 21s + 270 = 0$

$$s = \frac{1}{2}\left[-21 \pm \sqrt{(21)^2 - 4(270)}\right]$$

$$= \frac{1}{2}\left[-21 \pm 25.278j\right] = -10.5 \pm 12.64j$$

zeros: None

(c) For $v_d^{(1)}$ of 4 Hz, $s_1 = (4)(2\pi)j = 25.13j$

$$H_1(s) = \frac{5000}{(8\pi j)^2 + 21(8\pi j) + 270} = -4.417 - 6.447j$$

$$|H_1(s)| = 7.815$$

(d) For $v_d^{(2)}$ of 10 Hz, $s_2 = (10)(2\pi)j = 62.83j$

$$H_1(s) = \frac{5000}{(20\pi j)^2 + 21(20\pi j) + 270}$$

$$= -1.2 - 0.432j$$

$$|H_1(s)| = 1.280$$

Hence $v_d^{(1)}$ will have Larger output, because s_1 is closer to the poles.

(d) $V_o = 0.05\Omega$

$$V_s = 100(V_d - V_o) = 100(V_d - 0.05\Omega)$$

$$\Omega = \frac{50}{s^2+2s+20} V_s = \frac{50}{s^2+2s+20}(100)(V_d - 0.05\Omega)$$

$$\Omega\left(1+\frac{250}{s^2+2s+20}\right) = \frac{5000}{s^2+2s+20} V_d$$

Hence

$$H_2(s) = \frac{\Omega}{V_d} = \frac{5000}{s^2+2s+270}$$

Poles: $s^2+2s+270 = 0$

$$s = \frac{1}{2}\left[-2 \pm \sqrt{2^2 - 4(270)}\right]$$

$$= \frac{1}{2}(-2 \pm 32.80j) = -1 + 16.40j$$

Zeros: None

(e) The wear decreases damping of the motor; therefore, the real part of the poles are less negative

(f) The damping component