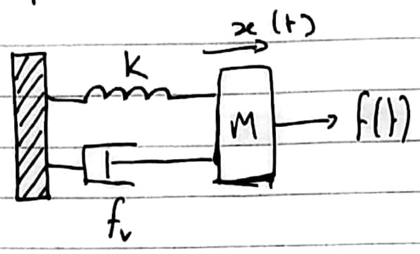
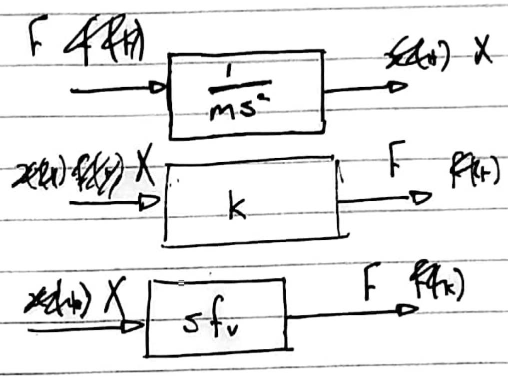
Ecen 315 Test 1 Joshua Benfell 300438229

1 input $f(t)$

output $x(t)$





in opposite Direction to applied.

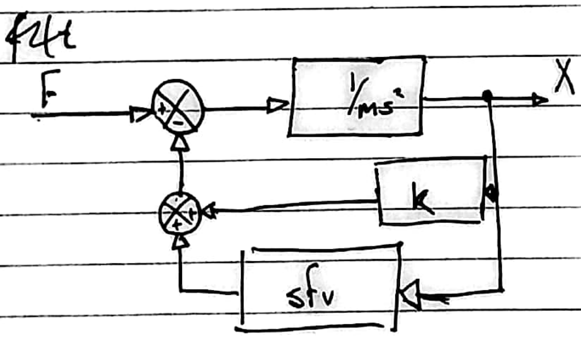
In opposite Direction to applied.

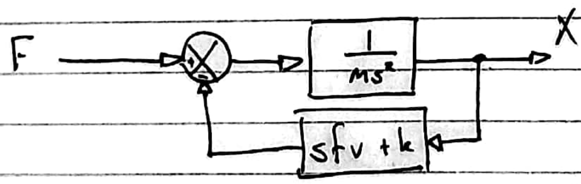
spring $F = kx$

damper $F = f_v v$

Mass $F = ma.$

combine blocks

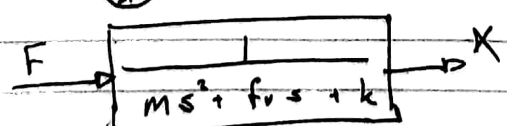




$$\frac{X}{F} = \frac{\text{forward}}{1-\text{loop}}$$

$$= \frac{\frac{1}{ms^2}}{1 - -\frac{sfv+k}{ms^2}}$$

$$= \frac{1}{ms^2 + sfv + k}$$



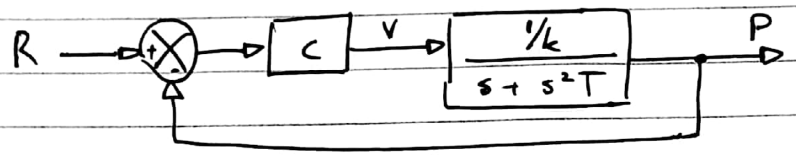
2

a

$$\frac{P}{V} = \frac{\frac{1}{k}}{s + s^2 T} \qquad k = 0.2 \ \frac{Nm}{A}$$

$$T = 0.8s$$

i



$$\frac{P}{R} = \frac{\text{forward}}{1 - \text{loop}}$$

$$= \frac{C \times P/V}{1 + C \times P/V}$$

$$= \frac{C \times P}{V + C \times P}$$

$$= \frac{C/k}{s^2 T + s + C/k} = \frac{\frac{C}{0.2 \times 0.8}}{s^2 + \frac{s}{0.8} + \frac{C}{0.2 \times 0.8}}$$

$$= \frac{6.25C}{s^2 + 1.25s + 6.25C}$$

~~iii~~

ii ~~$R(t) = u(t)$~~

~~$R(s) = \frac{1}{s}$~~

~~$\frac{P}{R} = \frac{6.25C}{s^2 \ldots}$~~

~~$s^2 + 1.25s + f$~~

~~discriminant $\Delta = 1.25^2 - 4 \times 1 \times 6.25C$~~

~~$= 1.5625 - 25C$~~

~~Underdamped when Δ~~

2ii

discriminant $\Delta = b^2 - 4ac$ ← coef

$= 1.25^2 - 4 \times 6.25\,c$ ← gain controller c

$= 1.5625 - 25c$

~~underdamped when $\Delta < 0$~~

critically damped when $\Delta = 0$

$0 = 1.5625 - 25c$

$25c = 1.5625$

$c = \frac{1.5625}{25}$

$= 0.0625$

underdamped when $\Delta < 0$

ie $\cancel{4ac > b^2}$ $0 > b^2 - 4ac$

$\cancel{25a}$ $4ac > b^2$

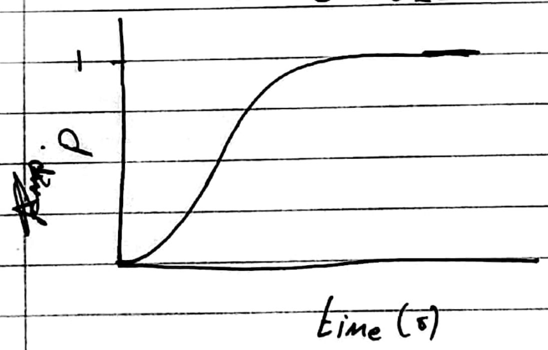
$c > 0.0625$

overdamped when $\Delta > 0$

$c < 0.0625$

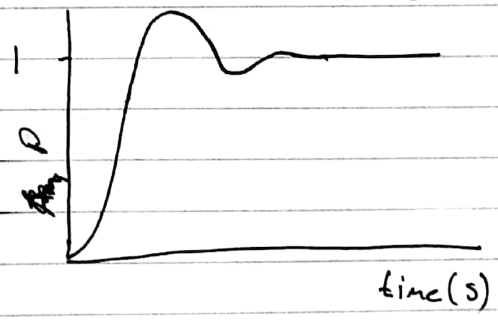
steady state gain for all systems is 1

$c = 0.0625$



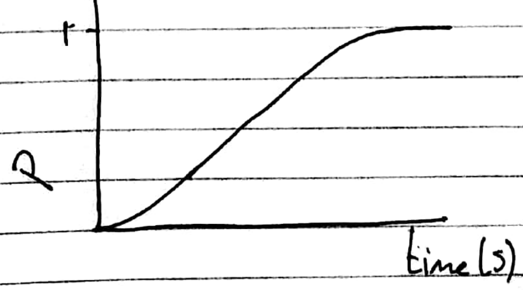
critically damped

$c > 0.0625$



under damped

$c < 0.0625$



Q3 $\quad G(s) = \dfrac{1}{(s+20)(s^2+5s+20)}$

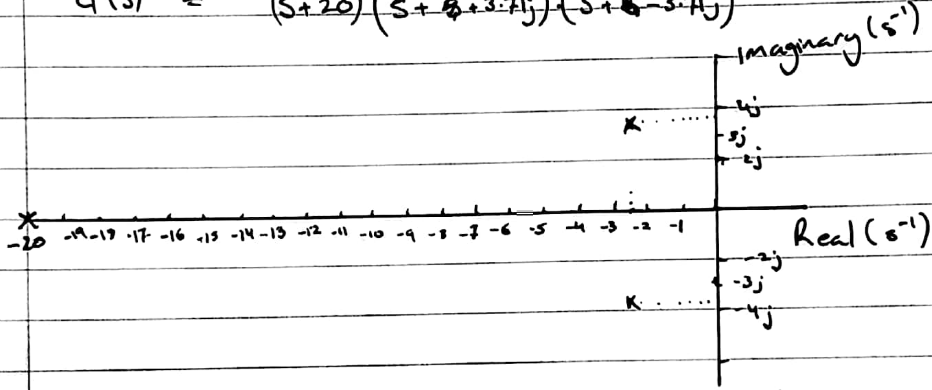
i roots of ~~eq~~ 2nd order component

$$s = \frac{-5 \pm \sqrt{25-80}}{2}$$

$$= -2.5 \pm \frac{\sqrt{-55}}{2}$$

$$= -2.5 \pm 3.71j$$

$$G(s) = \frac{1}{(s+20)(s+\cancel{5}^{\,2.5}+3.71j)(s+\cancel{5}^{\,2.5}-3.71j)}$$



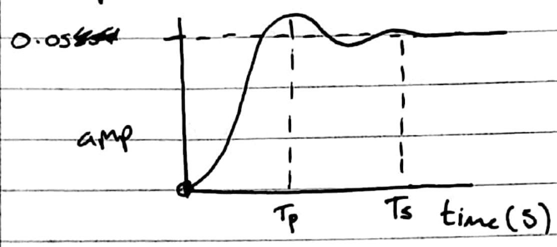
ii We can simplify this system to a second order system by ignoring the response caused by the pole at $s=-20$. We can do this because ~~that~~ pole the poles that Dominate the system response are the slower ~~form~~ poles which are defined by being closer to the real component origin. As $s=-20$ is much more negative than the real components of the other poles it provides a much quicker response that isn't ~~at~~ as dominant in the system.

Q3 iii Plot step response to $G(s) = \dfrac{1}{s^2+5s+20}$

~~and~~ input $= u(t)$

$\Rightarrow \frac{1}{s}$

expect it to look like.



Steady state gain $= \frac{1}{20}$

$= 0.05$

this is 20 times greater than it would have been had we not ignored the fast pole.

$$G(s) = k\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$\omega_n = \sqrt{20}$ $\qquad k = 1/20$

$= 2\sqrt{5}$

$2\zeta\omega_n = 5$

$\zeta\omega_n = 5/2$

$\zeta = \frac{5}{2} \times \frac{1}{2\sqrt{5}}$

$= \frac{\sqrt{5}}{4}$

$$\%OS = e^{-\left(\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)} \times 100$$

$$= e^{-\left(\frac{\frac{\sqrt{5}}{4}\pi}{\sqrt{1-\left(\frac{\sqrt{5}}{4}\right)^2}}\right)} \times 100$$

$\approx 12.03\ \%$

$$T_s = \frac{4}{\zeta\omega_n}$$

$$= \frac{16}{2\sqrt{5} \times \sqrt{5}}$$

$$= \frac{16}{2 \times 5}$$

$$= \frac{8}{5}$$

$= 1.6\ s$

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$$

$$= \frac{\pi}{2\sqrt{5}\sqrt{1-\left(\frac{\sqrt{5}}{4}\right)^2}}$$

$= 0.847\ s$

Q 4 i Negative Feedback when the output (or part of) is ~~fee~~ fed back into the system and subtracted from the input ~~so that~~ with the goal of reducing fluctuations and increasing stability.

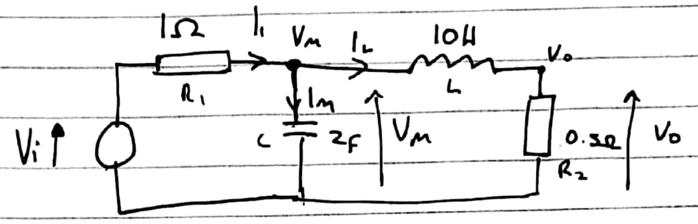
ii advantages
- Reduces effect of external disturbances
- Reduces effect of parameter changes
- improves ~~stabilitg~~ stability.

iii ~~- schmitt triggers, use positive feedback to create a region where nothing switches areah so that noise has less effect.~~

- schmitt trigger, use positive feedback to create a hysteresis region that ~~delays the~~ causes the trigger to not respond to small changes and reduce the effect of noise in a signal.

- Radio signals, greatly amplify the signal so that it can be transmitted further.

Q5



$$\frac{V_o}{V_i} = \frac{1}{40s^2 + 22s + 3}$$

$$V_i - V_m = I_1 R_1$$

$$I_1 = I_m + I_L$$

$$V_m = \frac{1}{C}\frac{dI_m}{dt}$$

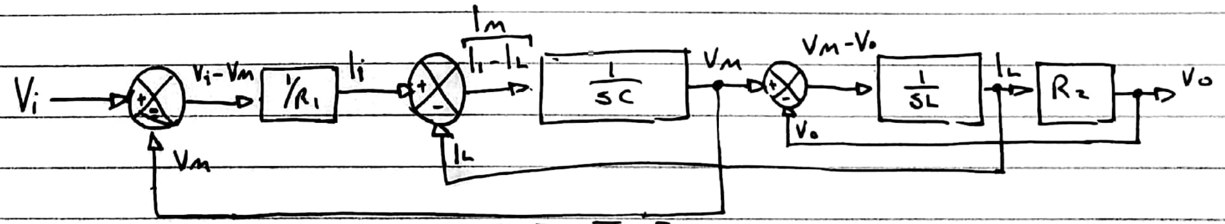
$$V_m = L\int I_L\,dt \cancel{+ I_L R_2} + V_o \qquad V_o = I_L R_2$$

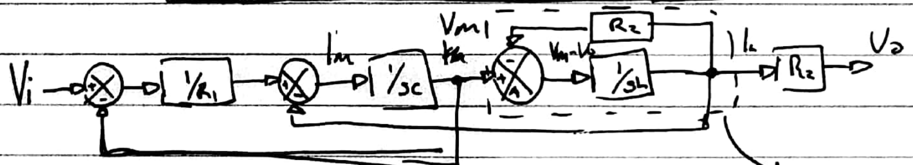
$I_1 \rightarrow \boxed{R_1} \rightarrow V_i - V_m$

$I_m \rightarrow \boxed{\frac{1}{sC}} \rightarrow V_m$

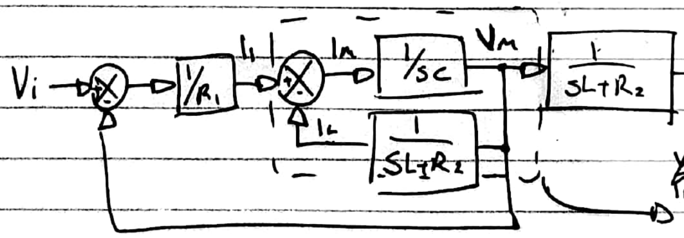
$I_L \rightarrow \boxed{sL} \rightarrow V_m - V_o$

$I_L \rightarrow \boxed{R_2} \rightarrow V_o$



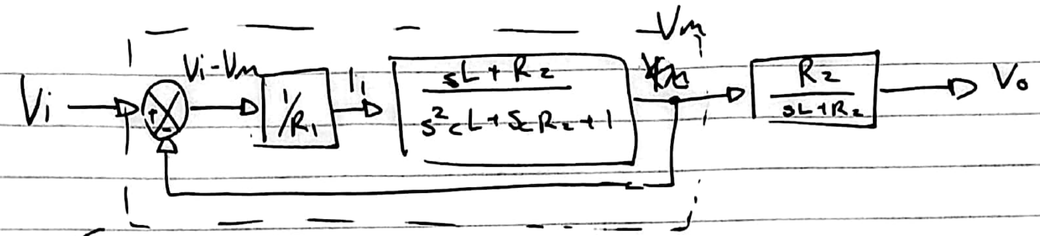


$$\frac{\frac{1}{sL}}{1 + \frac{R_2}{sL}} = \frac{I_L}{V_m}$$



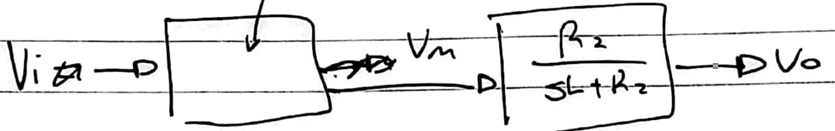
$$\frac{\frac{1}{sC}}{1 + \frac{1}{sC}\frac{1}{sL+R_2}} = \frac{sL + R_2}{s^2CL + sCR_2 + 1} = \frac{V_m}{I_1}$$

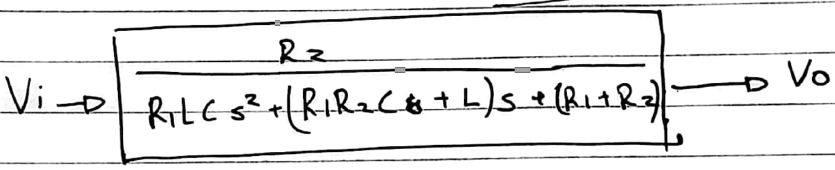
Q5 cont



$$\frac{V_m}{V_i} = \frac{\frac{1}{R_1}\,\frac{sL+R_2}{Lcs^2+R_2cs+1}}{1+\frac{1}{R_1}\,\frac{sL+R_2}{Lcs^2+R_2cs+1}}$$

$$= \frac{sL+R_2}{\cancel{R_1LCs^2+R_1R_2Cs+R_1+sL+R_2}}$$





To ~~change~~ make it underdamped without changing steady state gain, change the value of C or L

$\Delta = 22^2 - 4\times40\times3$ we want $b^2 < 4ac$.

$= 484 - 480$

one way to do this is lower L to something like $9\,H$

$b^2 = (1\times0.5\times2+9)^2$ $4ac = 4\times9\times2\times1\times(1+0.5)$

$= 10^2$ $= 108$

$= 100$

so $b^2 < 4ac$.

The other way is to increase C to something like $3F$

$b^2 = (1\times0.5\times3+10)^2$ $4ac = 4\times10\times3\times1\times(1+0.5)$

$= 11.5^2$ $= 180$

$= 132.25$

so $b^2 < 4ac$.