All codes at:
https://github.com/MananMohnot/CL302/tree/master/Assignment%204

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Q1

$$q = C_v f(l) \sqrt{\frac{\Delta P_v}{g_s}} \rightarrow 1$$

$f(l) = l$, for linear

$$q = C_v\, l \sqrt{\Delta P_v}$$

a) for configuration 1, $\Delta P = \Delta P_{v_1} + \Delta P_{v_2} = 20$ psi

$$= \left(\frac{q}{100\, l_1}\right)^2 + \left(\frac{q}{100\, l_2}\right)^2 = 20$$

q in terms of l_2 can be given as

$$q^2 \left(\frac{10^2 l_2^2 + 100^2 l_1^2}{100^2 l_1^2 \cdot 10^2 l_2^2} \right) = 20$$

$$q = \sqrt{\frac{20 \cdot 100^2 l^2 \cdot 10^2 l_2^2}{10^2 l_2^2 + 100^2 l_1^2}}$$

b) for config 2,

$$\Delta P_{v_1} = \Delta P_{v_2} = 20$$

$$q = q_1 + q_2 \Rightarrow 100\, l_1 \sqrt{20} + 10\, l_2 \sqrt{20}$$

For series, since the flow rate is dependent on the resistance offered by both the valves, the increase in l, which leads to decrease in R_2, leads to increase in overall flow rate.

for large l_1, l_2 almost act as an independent linear valve while for lower l_1, influence can be seen on q v/s l_2.

In parallel configuration, ~~more flow rate will be through~~

The more ~~the~~ l_2 ~~of~~ open the valve is, the greater is the flow

$C_{v_1} > C_{v_2}$ ∴ ~~flow~~ Resistance of $V_1 < V_2$ and flow through $V_1 > V_2$, so the impact of l_2 on q is less, while change in l_1 is huge.

Also flow in parallel is more than in series.

mixture.

CL 302 HW-4

Q2 ~~Sp gr = 1.11~~

~~$q = 200$ gal/min = 45.42 m^3/h~~

~~$P_T = k$~~

~~$\Delta P_c = C_1 q^2 = 30$ psi = 206843 Pa~~

~~$C_1 = \frac{30}{(200)^2} \Rightarrow \boxed{7.5\times10^{-4}}$ gal psi $\frac{min^2}{gal^2}$~~

~~$C_1 q^2$~~

~~$\Delta P_v + \Delta P_c = \Delta P$~~

~~Take Max Flow rate at max position~~
~~Equal f(x) = 0.5~~

~~$\boxed{q = C_v f(x) \sqrt{\frac{\Delta P_v}{g_s}}}$~~

~~$P_c = C_1 q^2 \therefore C_1 = \frac{206843}{45.42 \times 45.42}$ kg/m s² · h²/(m³ m³) ⇒ 100.26 kg/m⁷~~

Sp gr = 1.11

$q = 200$ gal/min = 0.012618 m^3/s ⇒ 1.26×10^{-2} m^3/s

$\Delta P_c = 30$ psi = 2.07×10^{5} kg m^{-1} s^{-2}

$$C_1 = \frac{P_c}{q^2} = \frac{2.07\times10^{5}}{1.26\times10^{-2}\times1.26\times10^{-2}} \cdot \frac{kg}{m\,s^2}\cdot\frac{s\,s}{m^3\,m^3} = \frac{kg}{m^7}\ 1.3\times10^{9}$$

(a) = 5 psi = 3.44×10^{4} Pa

(b) = 30 psi = 2.07×10^{5} kg Pa

(c) = 90 psi = 6.2×10^{5} Pa

Azeotropes or constant boiling mixture.

CL 302 HW-4

$\frac{R \text{ kg m}^2}{s}$

Q2 $~~Sp\ gr = 1.11~~$

$~~q = 200 \text{ gal/min} = 45.42 \text{ m}^3/h~~$

$~~P_T = k~~$

$~~\Delta P_c = C_1 q^2 = 30 \text{ psi} = 206843 \text{ Pa}~~$

$~~C_1 = \frac{30}{(200)^2} \Rightarrow \boxed{7.5 \times 10^{-4}} \frac{\text{gal psi min}^2}{\text{gal}^2}~~$

To Do

Plot Flow Rate v/s stem position

linear

Equal %

$f(l) = 0.5$

$q = C_v f(l) \sqrt{\frac{\Delta P_v}{g_s}}$

$C_1 q^2$

$\Delta P_v + \Delta P_c = \Delta P$

$~~P_c = C_1 q^2 \therefore C_1 = \frac{206843}{45.42 \times 45.42} \frac{\text{kg/m}^3 \cdot h^2}{\text{m}^3 \cdot \text{m}^3} \Rightarrow 100.26 \frac{\text{kg h}^2}{\text{m}^9}~~$

$Sp\ gr = 1.11$

$q = 200 \text{ gal/min} = 0.012618 \text{ m}^3/s \Rightarrow 1.26 \times 10^{-2} \text{ m}^3/s$

$\Delta P_c = 30 \text{ psi} = 2.07 \times 10^5 \text{ kg m}^{-1} s^{-2}$

$C_1 = \frac{P_c}{q^2} = \frac{2.07 \times 10^5}{1.26 \times 10^{-2} \times 1.26 \times 10^{-2}} \cdot \frac{\text{kg} \cdot ss}{m s^2 \cdot m^3 \cdot m^3} = \frac{\text{kg}}{\text{m}^7}\ 1.3 \times 10^9$

(a) = 5 psi = 3.44×10^4 Pa

(b) = 30 psi = 2.07×10^5 kg Pa

(c) = 90 psi = 6.2×10^5 Pa

taking $R=10$

9.4 let the total pressure be k

$\Delta P_v + \Delta P_L = k$ $\quad \cancel{\Delta P_v = 1}$

$$q = C_v\, f(l) \sqrt{\frac{\Delta P_v}{g_s}} \quad \therefore \quad C_v = \frac{q}{f(l)} \sqrt{\frac{\Delta P_v\, g_s}{\Delta P_v}}$$

$$C_v = \frac{200}{0.5} \left(\frac{\Delta \bar{P}_v}{1.11} \right)^{-0.5} \Rightarrow$$

$$\Delta P_v = (\Delta \bar{P}_v + \Delta \bar{P}_c) - \Delta P_c = (30 + \bar{P}_v) - \frac{3}{4000} q^2$$

$$\cancel{q = 400 \left(\frac{\Delta \bar{P}_v}{1.11} \right)^{-0.5}}$$

$$q = \left[400 \sqrt{\left(\frac{1.11}{\Delta \bar{P}_v} \right)} \right] f(l) \sqrt{\frac{1.11}{30 + \Delta \bar{P}_v - 3/4000\, q^2}}$$

$f(l) = l$ for linear

&

$f(l) = R^{l-1}$

R can be assumed as nothing

a) $\Delta \bar{P}_v = 5$ and f_6

$$q = 400 \sqrt{\frac{1.11}{5}}\; l \sqrt{\frac{1.11}{30 + 5 - \frac{3}{4000} q^2}}$$

$$l = \frac{q}{188.5} \left(\frac{35 - 0.00075 q^2}{1.11} \right)^{-0.5}$$

for equal % ,

$$q = 400 \sqrt{\frac{1.11}{5}} \cdot 10^{l-1} \sqrt{\frac{1.11}{35 - 0.00075 q^2}}$$

9.4

$$l = 1 + \frac{\ln\left[\frac{q}{188.5}\left(\frac{35 - 0.00075 q^2}{1.11}\right)^{-1/2}\right]}{\ln 10}$$

b) taking inspiration from a) $p = 30$

for linear,

$$l = \frac{q}{76.94}\left(\frac{60 - 0.00075 q^2}{1.11}\right)^{-1/2}$$

for equal %

$$l = 1 + \frac{\ln\left|\frac{q}{76.94}\left(\frac{60 - 0.00075 q^2}{1.11}\right)^{-1/2}\right.}{\ln 10}$$

c) $p = 90$

for linear

$$l = \frac{q}{44.22}\left(\frac{120 - 0.00075 q^2}{1.11}\right)^{-0.5}$$

for equal %

$$l = 1 + \frac{\ln\left[\frac{q}{44.22}\left(\frac{120 - 0.00075 q^2}{1.11}\right)^{-0.5}\right]}{\ln 10}$$

Conclusions :

for a)
linear value is not linear,
Eql % is linear for small range

for b)
linear value is linear initially (for low l)
& eql %. ~~for~~ is ~~linear~~ more liner than a)

for c)
linear value is more linear for wider values and also equal %. is linear for $l > 0.5$

As $\Delta \bar{P}_v \uparrow$, it can handle flowrates above $\bar{q}$ more easily. and is higher for equal % than linear.

$\Delta \bar{P}_v \uparrow$, costs $\uparrow$

range of linearity ↑ around nominal flow rate as Δp ↑

Δp_v ↑ , cost ↑

Q3 # 9.9

$T\ ^\circ C$	Measurement, mA
0	4.0
100	8.1
200	11.9
300	16.1
400	20.0

$$\frac{T_m}{T} = \frac{K}{\tau s + 1}$$

$$K = \frac{20-4}{400-0} = 0.04 \frac{mA}{^\circ C}$$

from code, $\Delta\tau$ between thermometer & transmitter = $\boxed{1.262 \text{ min} \Rightarrow 75.72\ s}$

given τ_{thermo} = 20 s

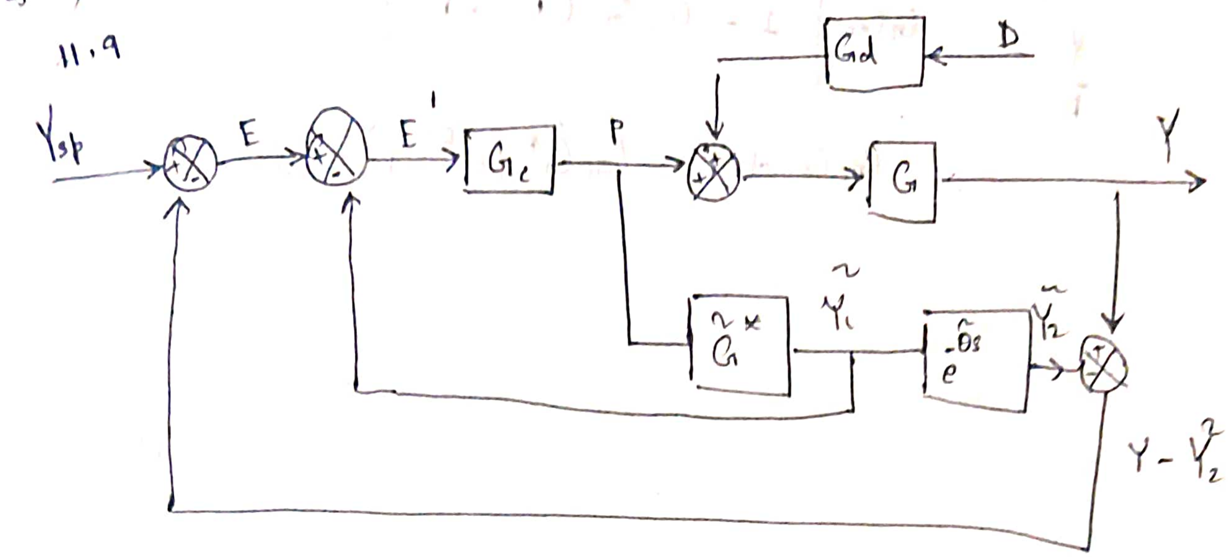
$\therefore \tau_{trans}$ = 75.72 + 20 = 95.72 s

range of linearity ↑ around nominal flow rate as Δp ↑

Δp_v ↑, cost ↑

Q4)

11.9



$$\tilde{Y}_2 = \tilde{Y}_1 e^{-\tilde{\theta} s} \quad \text{—— (V)}$$

$$Y_{sp} - (Y - \tilde{Y}_2) = E \quad \text{—— (IV)}$$

$$E - \tilde{Y}_1 = E' \quad \text{—— (III)}$$

$$P = G_c E' \quad \text{—— (II)}$$

$$(P + G_d D)\, G = Y \quad \text{—— (I)}$$

$$P \tilde{G}^* = \tilde{Y}_1 \quad \text{—— (VI)}$$

(IV) in (III)

$$\rightarrow Y_{sp} - Y + \tilde{Y}_2 - \tilde{Y}_1 = E'$$

(V) in

$$Y_{sp} - Y + \tilde{Y}_1 \left[e^{-\tilde{\theta} s} - 1\right] = E'$$

(VI) in

$$Y_{sp} - Y + P\tilde{G}^* \left[e^{-\tilde{\theta} s} - 1\right] = E'$$

$G_c E'$

$$Y_s - Y = E'\left[1 - G_c \tilde{G}^* \left[e^{-\tilde{\theta} s} - 1\right]\right]$$

II in I

$$(G_c E' + G_d D)\, G = Y$$

$$\frac{G_c G}{\left[1 - G_c G^* \left[e^{-\tilde{\theta} s} - 1\right]\right]} (Y_s - Y) - Y = -G\, G_d D \qquad \text{Assuming } Y_s = 0$$

$$Y \left[\frac{G_c G + 1 - G_c G^* \left[e^{-\tilde{\theta} s} - 1\right]}{1 - G_c G^* \left[e^{-\tilde{\theta} s} - 1\right]}\right] = G\, G_d D$$

$$\frac{Y}{D} = \frac{G G_D \left[1 - G_c \tilde{G}^* \left(e^{-\hat{\theta} s} - 1 \right) \right]}{G_c G + 1 - G_c \tilde{G}^* \left(e^{-\hat{\theta} s} - 1 \right)}$$

Q5)

11.10

$\tilde{Y}_{sp} = K_m Y_{sp}$

$\rightarrow E K_c = P$

$E = K_m Y_{sp} - Y K_m$

$Y_{sp} = 0$

$P = -Y K_m K_c$

Final Ans

$\boxed{K_c > 1}$

$(D + G_1 P) G_3 = Y_3$

$Y_3 + P G_2 = Y$

$\left(D + G_1(-Y K_m K_c)\right) G_3 + (-Y K_m K_c) G_2 = Y$

$D G_3 - Y K_m K_c G_1 G_3 - Y K_m K_c G_2 = Y$

$$\frac{Y(s)}{D(s)} = \cancel{1 + K_m K} \quad \frac{G_3}{1 + K_m K_c G_1 G_3 + K_m K_c G_2}$$

a)
$$= \frac{G_3}{1 + K_m K_c (G_1 G_3 + G_2)}$$

b) $G_1(s) = 5$ $\quad G_2(s) = \frac{4}{2s+1}$ $\quad K_m = 1$ $\quad G_3(s) = \frac{1}{s-1}$

$$\Rightarrow \frac{1/(s-1)}{1 + K_c\left[\frac{5}{s-1} + \frac{4}{2s+1}\right]} \Rightarrow \frac{1}{\cancel{(s-1)}\left[\frac{2s^2 - s - 1 + K_c(14s+1)}{\cancel{(s-1)}(2s+1)}\right]}$$

1	2	$K_c - 1$
2	$14K_c - 1$	
3	$K_c - 1$	

$$\frac{2s+1}{2s^2 + (14K_c - 1)s + (K_c - 1)}$$

for stable, the product of roots > 0 and sum < 0

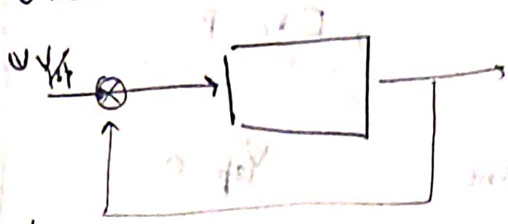
$\therefore -\frac{(14K_c - 1)}{2} < 0 \Rightarrow K_c > 1/14$ & $\frac{K_c - 1}{2} > 0 \Rightarrow K_c > 1$

$\therefore \boxed{K_c > 1}$

Q6

11.20

$G_{OL}(s) = 0.5 K_c e^{-3s}/(10s+1)$



$Y = (U - Y_{sp}) G$

$\Rightarrow Y(1+G) = UG$

$G' \quad \frac{Y}{U} = \frac{G}{1+G} = \frac{0.5K_c e^{-3s}}{(10s+1) + 0.5K_c e^{-s}}$

a) Pade approx $e^{-3s} \approx \frac{1-1.5s}{1+1.5s}$

$\therefore G' = \frac{0.5K_c\, e\left(\frac{1-1.5s}{1+1.5s}\right)}{(10s+1) + 0.5K_c\left(\frac{1-1.5s}{1+1.5s}\right)}$

for stability, real part of roots of $(10s+1)(1+1.5s) + 0.5K_c(1-1.5s) = 0$

should be < 0

$\Rightarrow 15s^2 + (11.5 - 0.75K_c)s + (1 + 0.5K_c) = 0$

for stability,

$11.5 - 0.75K_c > 0$

$\Rightarrow K_c < 15.33$

and $1 + 0.5K_c > 0$ or $K_c > -2$

therefore $-2 < K_c < 15.33$

b) $s = j\omega$, $e^{-3j\omega} = \cos(3\omega) - j\sin(3\omega)$,

focusing only on denominator part, as it only dictates stability,

$$(10j\omega + 1) + 0.5k_c\left[\cos(3\omega) - j\sin(3\omega)\right] = 0$$

for roots $1 + 0.5k_c\cos(3\omega) = 0$

and $10\omega - 0.5k_c\sin(3\omega) = 0$

$\Rightarrow \omega = 0$ ~~or~~ gives $k_c = -2$

$\therefore k_c > -2$

or $\tan(3\omega) = -10\omega$

$\omega =$ ~~-0.58~~ or 0.58 (through desmos)

$$1 + 0.5k_c\cos(3 \times 0.58) = 0$$

$$k_c = -\frac{1}{0.5\cos(1.74)} = 11.87$$

Stable $k_c < 11.87$ $\therefore 0 < k_c < 11.87$

~~-2~~

$$\cancel{-2}\ 0 < k_c < 11.87$$

c) $e^{-3s} \approx 1 - 3s$

real part roots < 0

$$(10s + 1) + 0.5k_c(1 - 3s) = 0$$

$$10s - 1.5sk_c + 0.5k_c = 0$$

$$s(10 - 1.5k_c) = -0.5k_c$$

$$s = \frac{-0.5k_c}{10 - 1.5k_c}$$

$\frac{0.5k_c}{10} < 0$

$1.5k_c - 10$

$$\boxed{10 < k_c < 6.67}$$

d) $e^{-8s} = \dfrac{1}{1+3s}$

$$(10s+1) + 0.5k_c\left(\frac{1}{1+3s}\right) = 0$$

$$(10s^2 + 13s + 1) + 0.5k_c = 0$$

$$10s^2 + 13s + 1 + 0.5k_c$$

for stability,

$$1 + 0.5k_c > 0$$

$$k_c > -2$$

e)

$$(10s+1)\left[1 + \frac{3}{2}s + \frac{3}{4}s^2\right] + 0.5k_c\left[1 - \frac{3}{2}s + \frac{3}{4}s^2\right] = 0$$

$$10s + 15s^2 + 7.5s^3 + 1 + 1.5s + 0.75s^2 + 0.5k_c - 0.75k_c s + 0.375k_c s^2 = 0$$

$$7.5s^3 + (15.75 + 0.375k_c)s^2 + (11.5 - 0.75k_c)s + 1 + 0.5k_c =$$

$$15.75 + 0.375k_c > 0$$

$$\underline{k_c > -42}$$

$$11.5 - 0.75k_c > 0$$

$$\underline{k_c < 15.33}$$

&

$$1 + 0.5k_c > 0$$

$$\underline{k_c > -2}$$

$$\therefore \quad -2 < k_c < 15.33$$

No, both gave the same bounds.

b and e gave the closest responses against b

Routh Array.

7.5 $\quad$ $11.5 - 0.75k_c$

$15.75 + 0.375k_c$ $\quad$ $1 + 0.5k_c$

$\cancel{b_1 = 1 + 0.5}$ $\quad$ $b_2 = 0$

$$b_1 = \frac{(15.75 + 0.375k_c)(11.5 - 0.75k_c) - 7.5(1 + 0.5k_c)}{15.75 + 0.375k_c}$$

$$b_1 = \frac{181.125 - 0.28125k_c^2 - 7.5k_c - 7.5 - 3.75k_c}{15.75 + 0.375k_c}$$

$C_1 = 1 + 0.5k_c$

$$b_1 > 0 \Rightarrow \frac{181.125 - 0.28125k_c^2 - 11.25k_c - 7.5}{15.75 + 0.375k_c} > 0$$

for $15.75 + 0.375k_c > 0$ ($\cancel{k_c > 0}$), $181.125 - 0.28125k_c^2 - 11.25k_c - 7.5 > 0$

$\Rightarrow k_c > -42$

$\Rightarrow k_c < 11.896$ or $k_c > -51.896$

$\Rightarrow$ $\cancel{11.8}$ $\underline{\underline{-42 < k_c < 11.896}}$

~~If k_c <~~

if $k_c < -42$

then $k_c < -51.896$ or $k_c > 11.896$

$\Rightarrow k_c < -51.896$

intersection of the cases, gives solution

e) $-2 < k_c < 11.896$

→ 2/2 Pade gives a better approximation as the upper limit is closer to actual answer.

→ 2/2 Pade gives the best approximation (e) against b

a) $k_c \in (-2, 15.33)$

b) $k_c \in (0, 11.67)$

c) $k_c \in (-2, 6.67)$

d) $k_c \in (-2, \infty)$

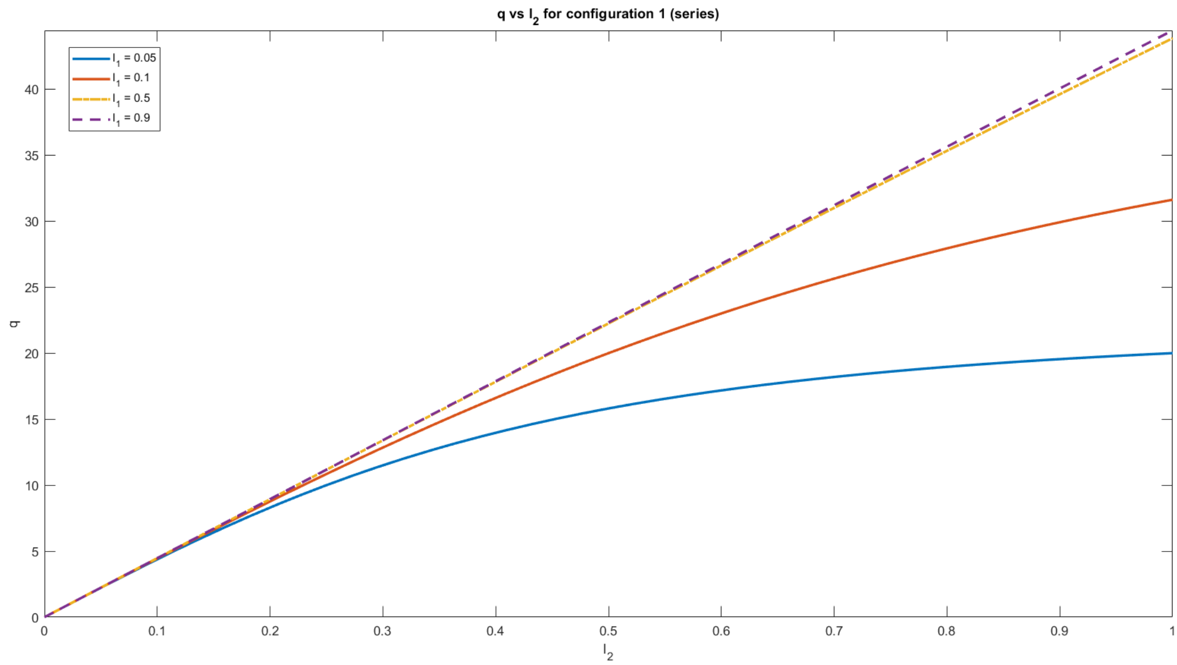
e) $k_c \in (-2, 11.896)$

Among a) c) & d)

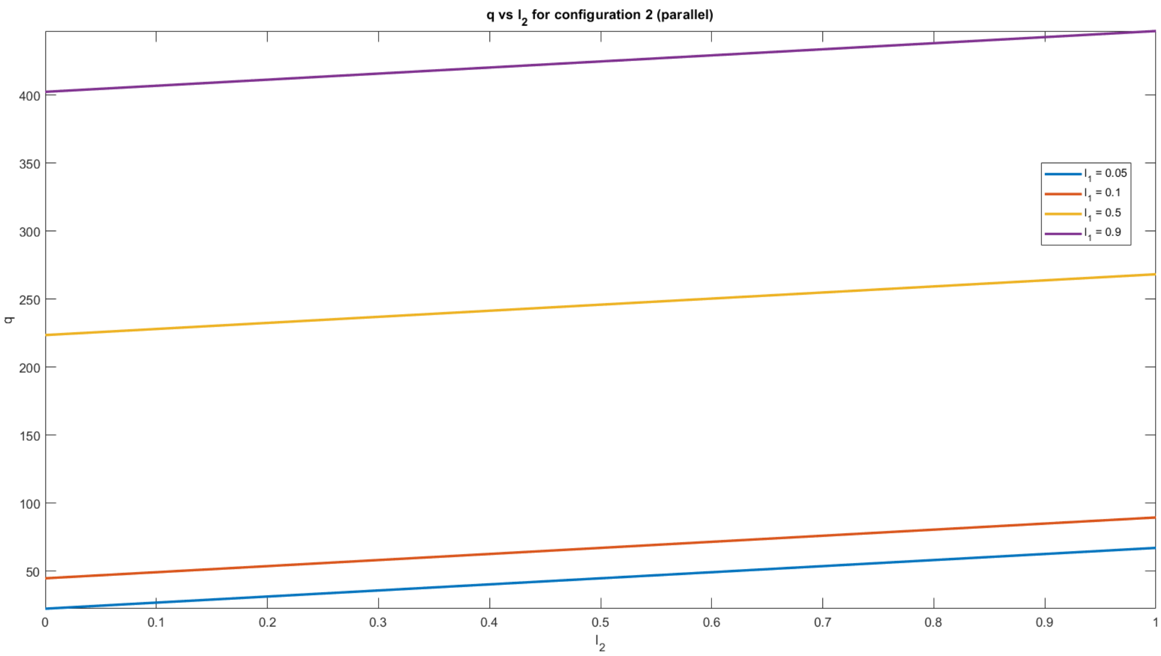
a) gives better

c) gives better amongst c & d (the two taylors)

Plots for Q1

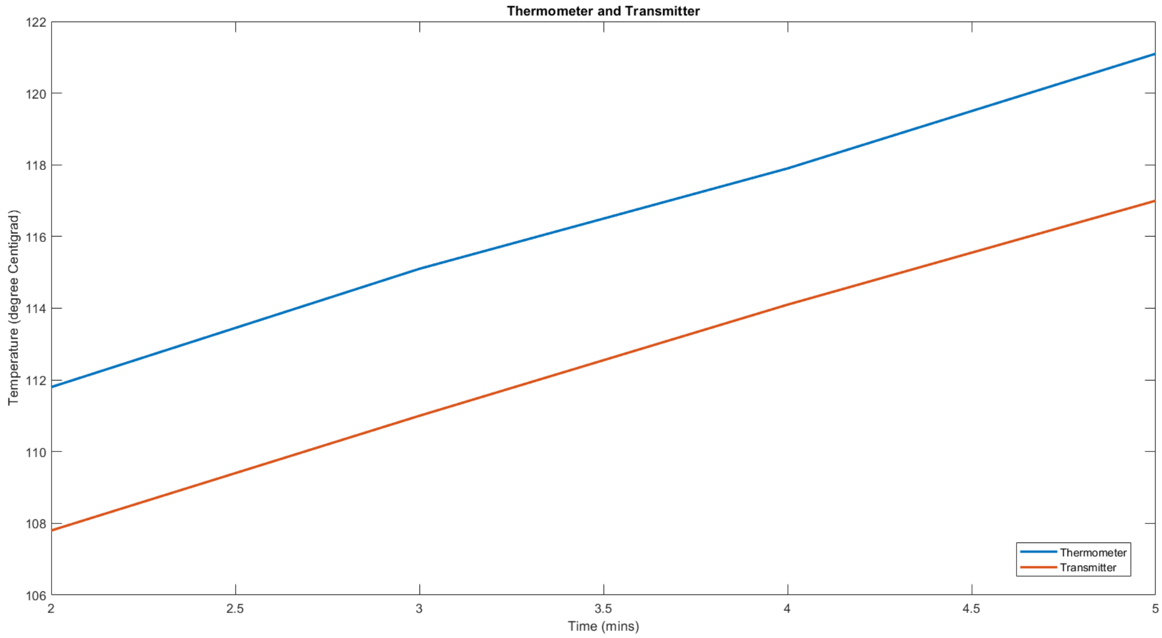


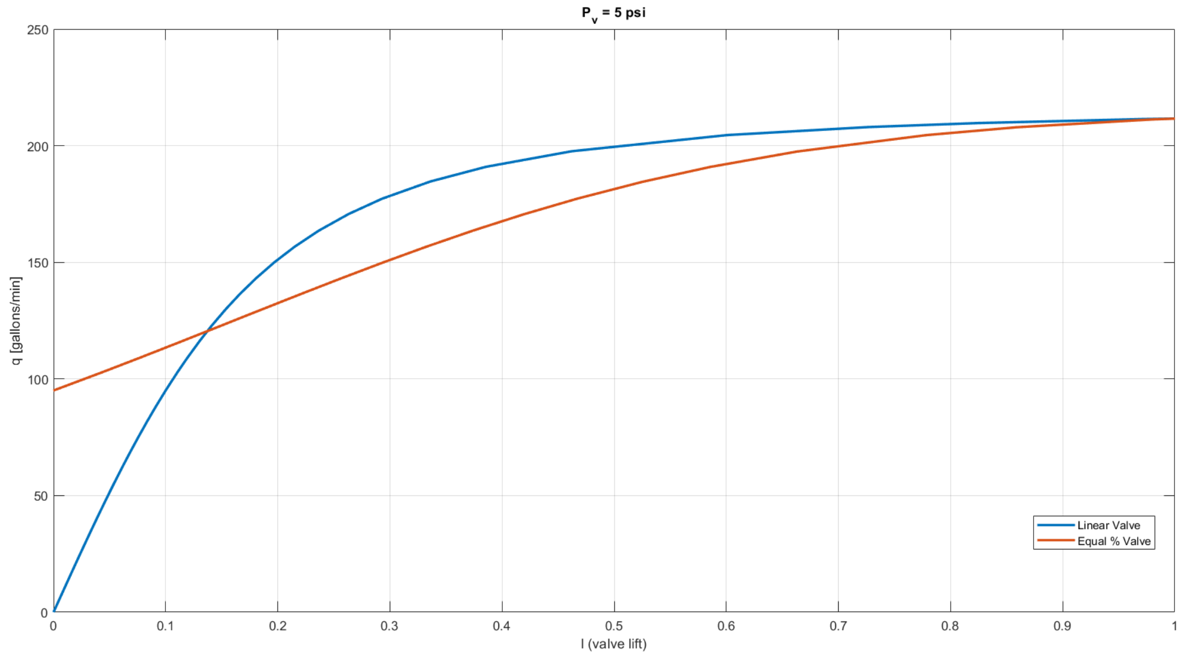
q vs l2 for configuration 1 (series)
l1 = 0.05
l1 = 0.1
l1 = 0.5
l1 = 0.9
q
l2

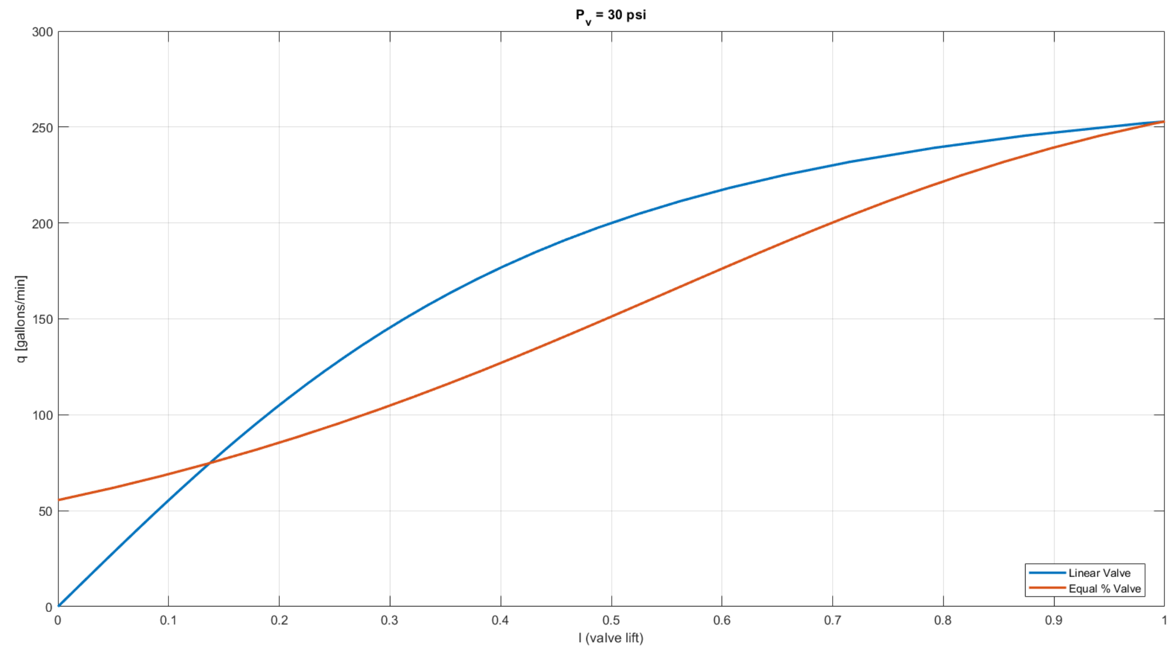


q vs l2 for configuration 2 (parallel)
l1 = 0.05
l1 = 0.1
l1 = 0.5
l1 = 0.9
q
l2

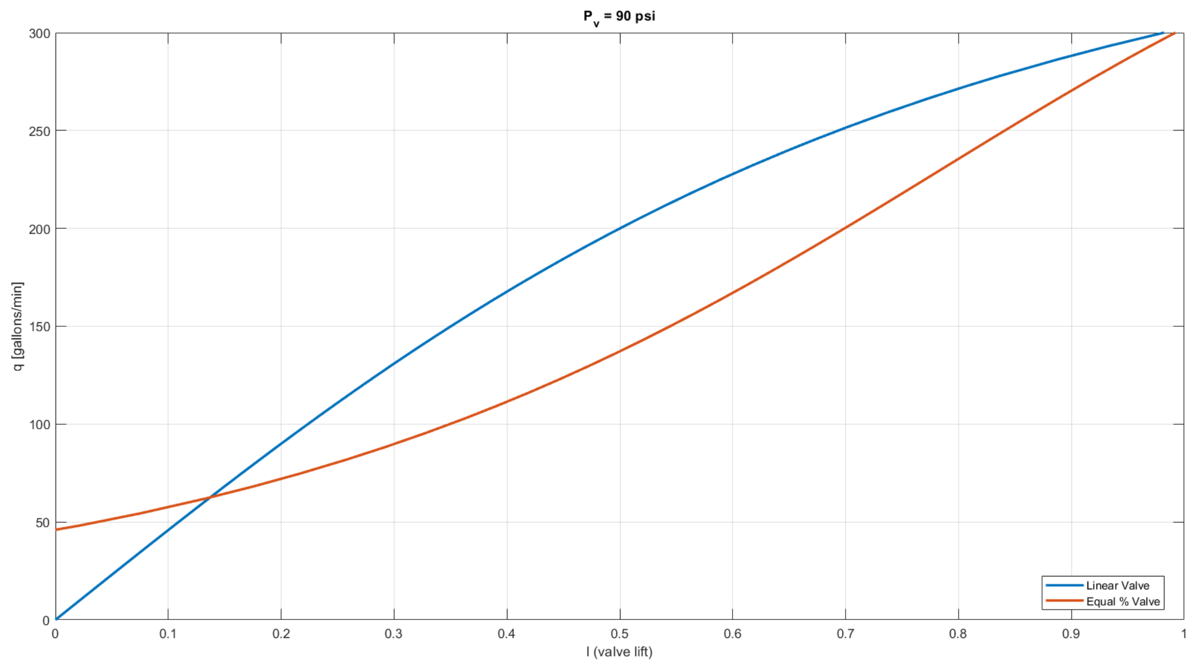
For Question 3







P_v = 30 psi
q [gallons/min]
l (valve lift)
Linear Valve
Equal % Valve



P_v = 90 psi
q [gallons/min]
l (valve lift)
Linear Valve
Equal % Valve

```
% Q1
clc
clear
l=[0.05 0.1 0.5 0.9];
```

```
l = 1×4
    0.0500    0.1000    0.5000    0.9000
```

```

% for config 1
l1=l(1)
```

```
l1 = 0.0500
```

```
q= @(l2) (((20*100*100*10*10*l1*l1*l2*l2)/(10*10*l2*l2 + 100*100*l1*l1)).^0.5);
fplot(q,[0 1],LineWidth=2);
```

```
Warning: Function behaves unexpectedly on array inputs. To improve performance, properly vectorize your
function to return an output with the same size and shape as the input arguments.
```

```
hold on
l1=l(2);
q= @(l2) (((20*100*100*10*10*l1*l1*l2*l2)/(10*10*l2*l2 + 100*100*l1*l1)).^0.5);
fplot(q,[0 1],LineWidth=2);
```

```
Warning: Function behaves unexpectedly on array inputs. To improve performance, properly vectorize your
function to return an output with the same size and shape as the input arguments.
```

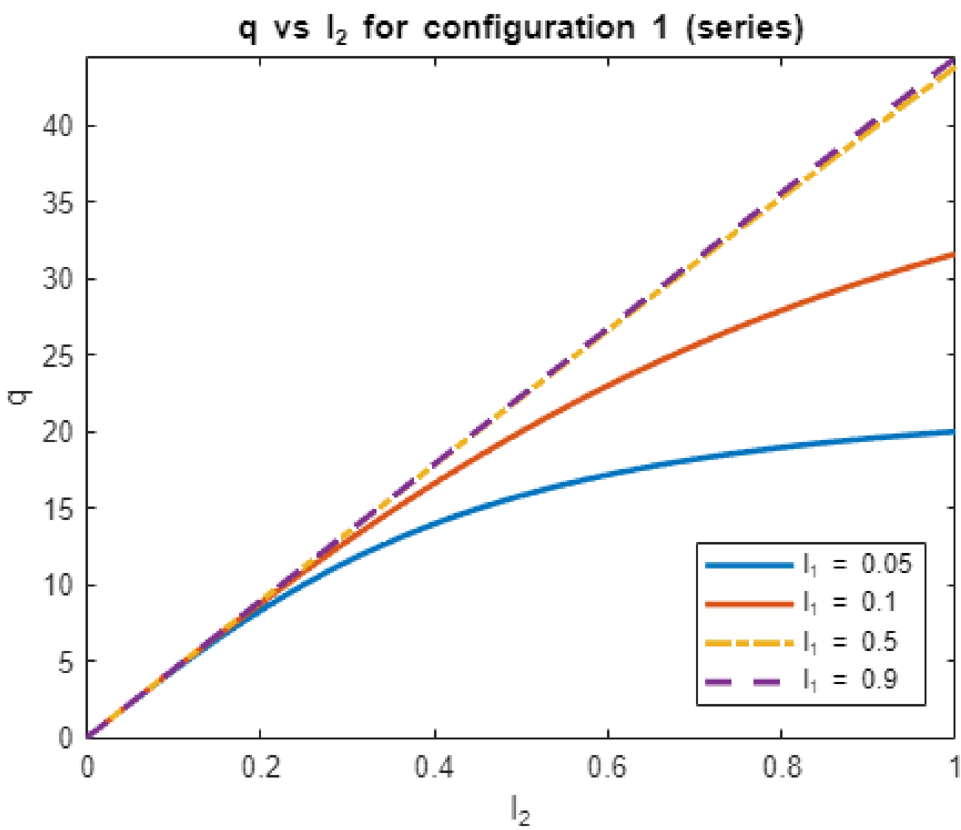
```
l1=l(3);
q= @(l2) (((20*100*100*10*10*l1*l1*l2*l2)/(10*10*l2*l2 + 100*100*l1*l1)).^0.5);
fplot(q,[0 1],'-.',LineWidth=2);
```

```
Warning: Function behaves unexpectedly on array inputs. To improve performance, properly vectorize your
function to return an output with the same size and shape as the input arguments.
```

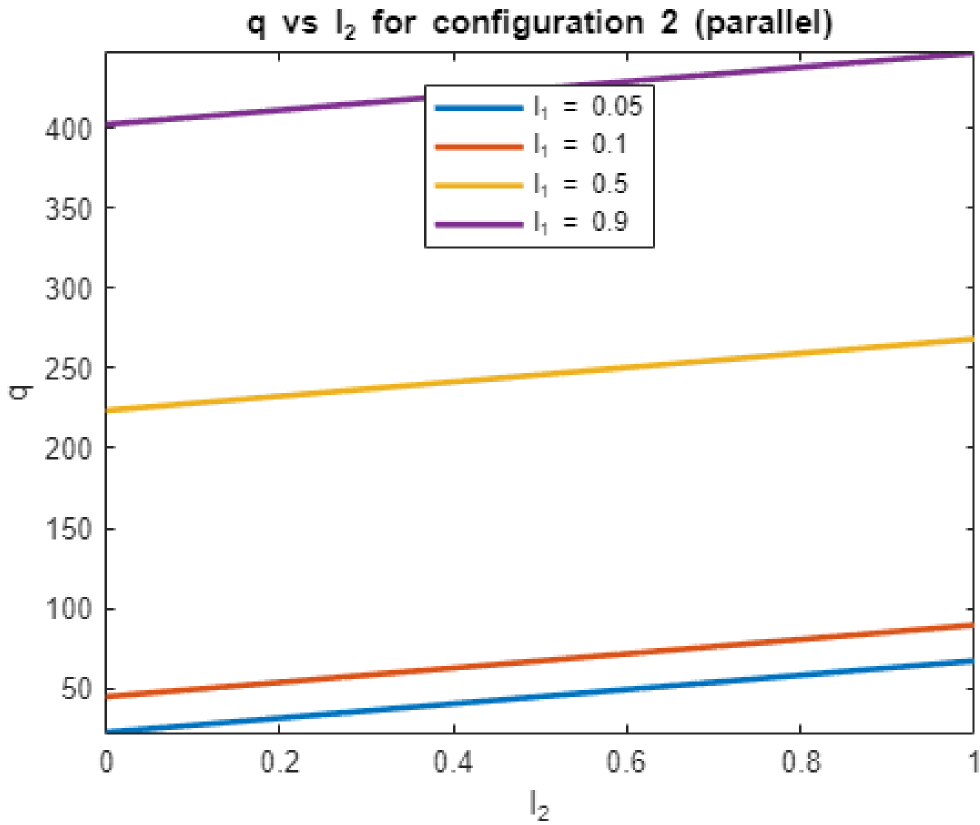
```
l1=l(4);
q= @(l2) (((20*100*100*10*10*l1*l1*l2*l2)/(10*10*l2*l2 + 100*100*l1*l1)).^0.5);
fplot(q,[0 1],'--',LineWidth=2);
```

```
Warning: Function behaves unexpectedly on array inputs. To improve performance, properly vectorize your
function to return an output with the same size and shape as the input arguments.
```

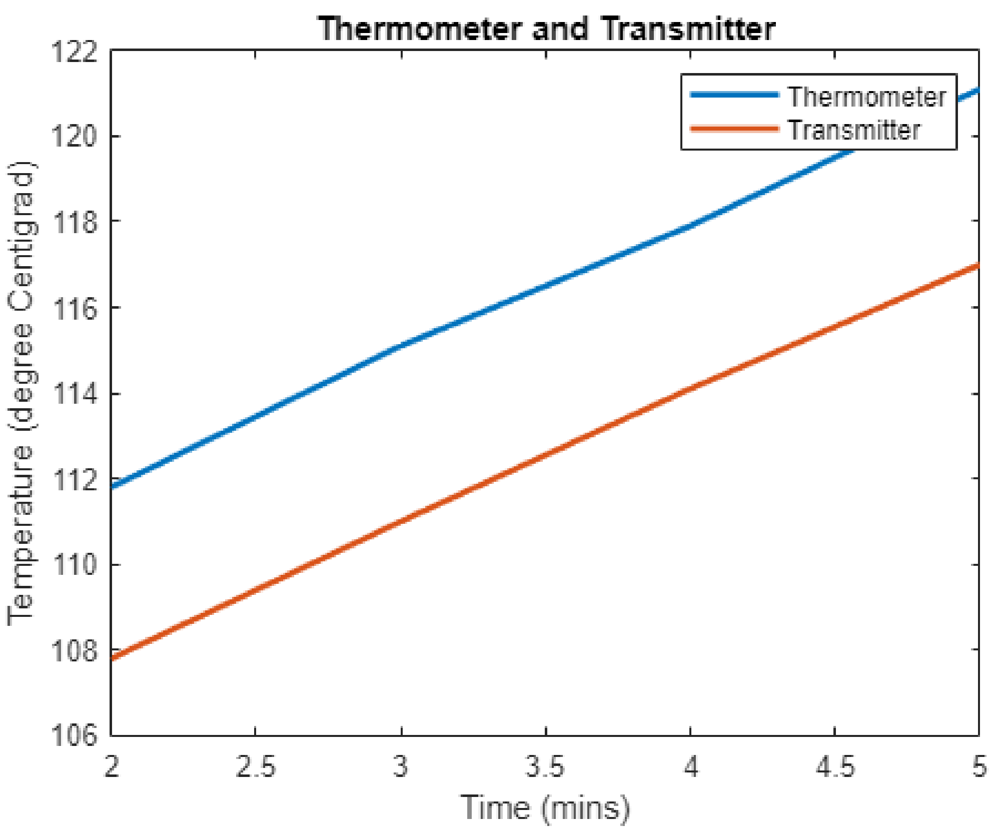
```
hold off

title('q vs l_2 for configuration 1 (series)')
xlabel('l_2')
ylabel('q')
legend('l_1 = 0.05','l_1 = 0.1','l_1 = 0.5','l_1 = 0.9',Location='best')
```




```
% for config 2
l1=l(1);
q=@(l2) (100*sqrt(20)*l1+10*sqrt(20)*l2);
fplot(q,[0 1],LineWidth=2);
hold on
l1=l(2);
q=@(l2) (100*sqrt(20)*l1+10*sqrt(20)*l2);
fplot(q,[0 1],LineWidth=2);
l1=l(3);
q=@(l2) (100*sqrt(20)*l1+10*sqrt(20)*l2);
fplot(q,[0 1],LineWidth=2);
l1=l(4);
q=@(l2) (100*sqrt(20)*l1+10*sqrt(20)*l2);
fplot(q,[0 1],LineWidth=2);
hold off

title('q vs l_2 for configuration 2 (parallel)')
xlabel('l_2')
ylabel('q')
legend('l_1 = 0.05','l_1 = 0.1','l_1 = 0.5','l_1 = 0.9',Location='best')
```


q vs l2 for configuration 2 (parallel)
l1 = 0.05
l1 = 0.1
l1 = 0.5
l1 = 0.9
400
350
300
250
200
150
100
50
q
0
0.2
0.4
0.6
0.8
1
l2

```
% Q3
clc
clear
T = [0 100 200 400];
T_m = [4 8.1 11.9 16.1 20];

t=[2 3 4 5];
Thermo = [111.8 115.1 117.9 121.1];
Trans = [107.8 111 114.1 117];

plot(t,Thermo,'LineWidth',2)
hold on
plot(t,Trans,'LineWidth',2)
hold off
title("Thermometer and Transmitter")
ylabel("Temperature (degree Centigrad)")
legend("Thermometer","Transmitter")
xlabel("Time (mins)")
```




```
x1 = interp1(Thermo,t,112)
```

```
x1 = 2.0606
```

```
x2 = interp1(Trans,t,112)
```

```
x2 = 3.3226
```

```
del_x = x2-x1
```

```
del_x = 1.2620
```

```
del_x*60
```

```
ans = 75.7185
```

```
% for linear valves
p=5
```

```
p = 5
```

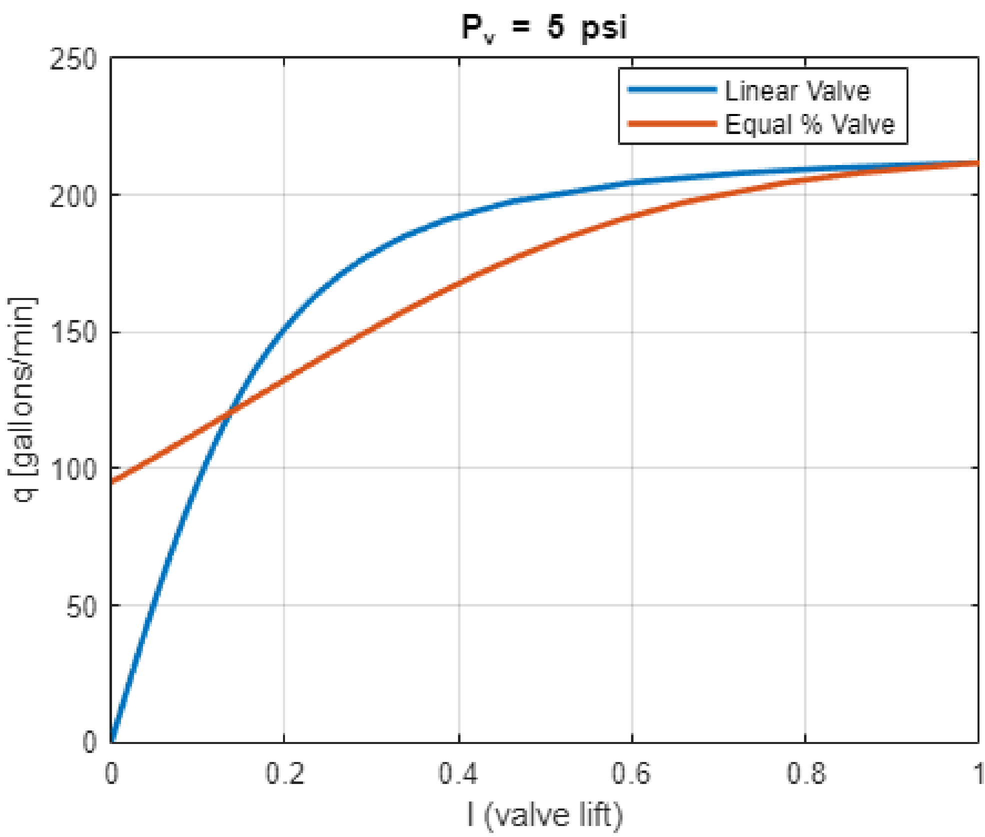
```
l = @(q) ((q/188.5).*((35-0.00075*q.*q)/1.11).^(-0.5));
[Y,X]=fplot(l,[0 300]);
```

```
Warning: Having two output arguments for fplot will be removed in a future release. Use the XData and YData
properties instead.
```

```
plot(X,Y,LineWidth=2)
xlim([0 1]);
grid on
hold on
% for equal %
l = @(q) ( 1 + (log((q/188.5).*((35-0.00075*q.*q)/1.11).^(-0.5)))/log(10));
[Y,X]=fplot(l,[0 300]);
```

```
Warning: Having two output arguments for fplot will be removed in a future release. Use the XData and YData
properties instead.
```

```
plot(X,Y,LineWidth=2)
xlim([0 1]);
legend('Linear Valve', 'Equal % Valve',Location='best')
title('P_v = 5 psi')
hold off
xlabel('l (valve lift)')
ylabel('q [gallons/min]')
```




```
% for linear valves
p=30
```

```
p = 30
```

```
l = @(q) ((q/76.94).*((60-0.00075*q.*q)/1.11).^(-0.5));
[Y,X]=fplot(l,[0 300]);
```

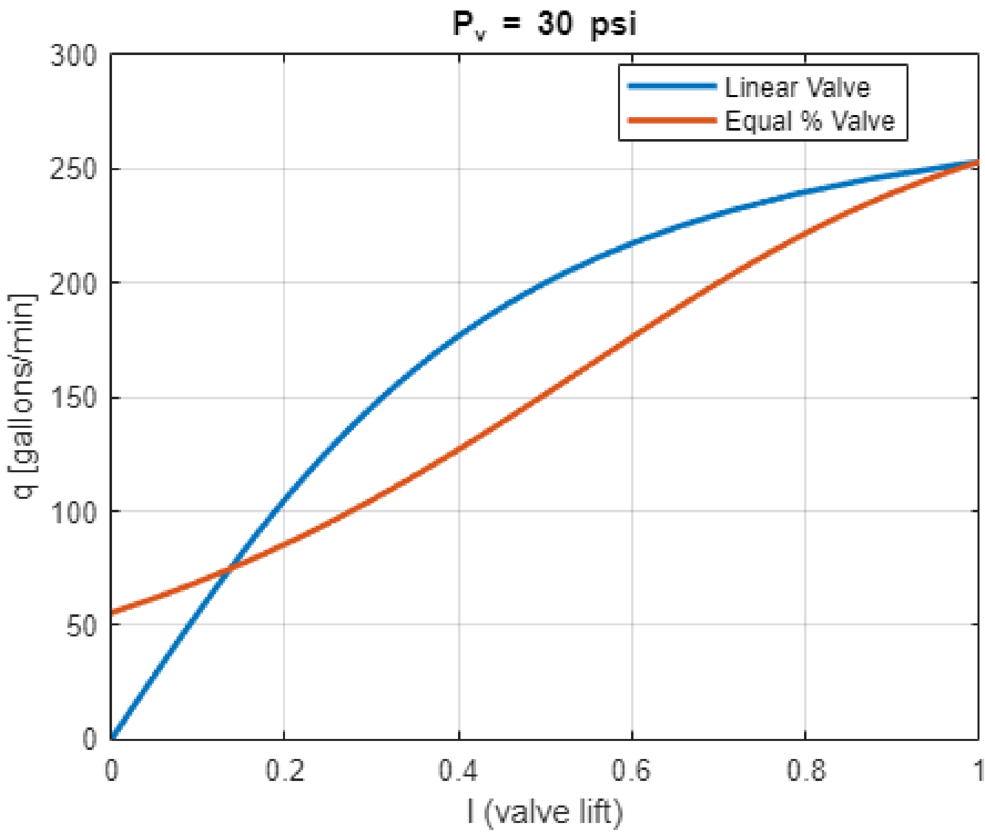
```
Warning: Having two output arguments for fplot will be removed in a future release. Use the XData and YData
properties instead.
```

```
plot(X,Y,LineWidth=2)
xlim([0 1]);
grid on
hold on
% for equal %
l = @(q) ( 1 + (log((q/76.94).*((60-0.00075*q.*q)/1.11).^(-0.5)))/log(10));
[Y,X]=fplot(l,[0 300]);
```

```
Warning: Having two output arguments for fplot will be removed in a future release. Use the XData and YData
properties instead.
```

```
plot(X,Y,LineWidth=2)
xlim([0 1]);
legend('Linear Valve', 'Equal % Valve',Location='best')
title('P_v = 30 psi')
hold off
xlabel('l (valve lift)')
```

```
ylabel('q [gallons/min]')
```




```
% for linear valves
p=90
```

```
p = 90
```

```
l = @(q) ((q/44.42).*((120-0.00075*q.*q)/1.11).^(-0.5));
[Y,X]=fplot(l,[0 300]);
```

```
Warning: Having two output arguments for fplot will be removed in a future release. Use the XData and YData
properties instead.
```

```
plot(X,Y,LineWidth=2)
xlim([0 1]);
grid on
hold on
% for equal %
l = @(q) ( 1 + (log((q/44.42).*((120-0.00075*q.*q)/1.11).^(-0.5)))/log(10));
[Y,X]=fplot(l,[0 300]);
```

```
Warning: Having two output arguments for fplot will be removed in a future release. Use the XData and YData
properties instead.
```

```
plot(X,Y,LineWidth=2)
xlim([0 1]);
legend('Linear Valve', 'Equal % Valve',Location='best')
title('P_v = 90 psi')
hold off
```

```
xlabel('l (valve lift)')
ylabel('q [gallons/min]')
```