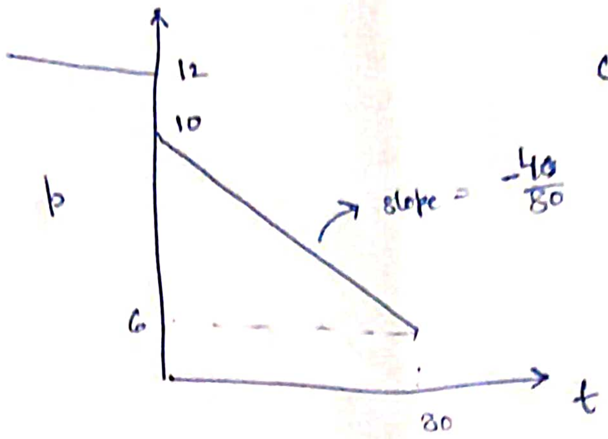
# # 801




Given step change = 3mA

$E(s) = 3/s$

for PI, $\frac{p^*(s)}{E(s)} = K_c\left(1 + \frac{1}{\tau_I s}\right)$

$E(s) = M/s$

$p'(s) = \frac{K_c M}{s} + \frac{K_c M}{\tau_I s^2}$

$p'(t) = K_c M + \frac{K_c M}{\tau_I} t$

At $t=0$, $p'(t) = -2$

$M = 3$

$K_c = -2/3$

slope $= -1/20 = \frac{K_c M}{\tau_I}$

$\tau_I = 40$ min

Q # 8.2

(a)

$$\frac{P'(s)}{E(s)} = \frac{K_1}{\tau_I s + 1} + K_2$$

$$= \frac{(K_1 + K_2) + s K_2 \tau_I}{\tau_I s + 1}$$

$$(K_1 + K_2)\left[\frac{1 + \frac{sK_2}{K_1+K_2}\tau_I s}{\tau_I s + 1}\right]$$

b) for PD, $\frac{P'(s)}{E(s)} = K_c\left[\frac{1 + \tau_D s}{\alpha \tau_D s + 1}\right]$

by comparing

$K_c = K_1 + K_2$

$\cancel{\tau_D = \frac{K_2}{K_1+K_2}\tau_1}$

$\cancel{\alpha = 1}$

$\alpha \tau_D = \tau_1$

$\tau_D = \frac{K_2 \tau_1}{K_1 + K_2}$

$\Rightarrow \alpha K_2 = K_1 + K_2$

$K_2 = \frac{K_c}{\alpha}$ & $K_1 = K_c\left[1 - \frac{1}{\alpha}\right]$

$\tau_D = \frac{\tau_1}{\alpha}$

Q 8.23

a) $\boxed{\text{Eq. 8.14}}$ $$\frac{P'(s)}{E(s)} = K_c^{\dagger}\left[1 + \frac{1}{\tau_I^{\dagger} s} + \tau_D^{\dagger} s\right]$$ parallel form

$\boxed{\text{Eq. 8.15}}$

$$\frac{P'(s)}{E(s)} = K_c\left(\frac{\tau_I s + 1}{\tau_I s}\right)\left(\frac{\tau_D s + 1}{\alpha \tau_D s + 1}\right)$$

Expanding #8.15 $$K_c\left[1 + \frac{\tau_D}{\tau_I} + \frac{1}{\tau_I s} + \tau_D s\right]$$

Comparing $s^0$ coeff

$$K_c^{\dagger} = K_c\left[1 + \frac{\tau_D}{\tau_I}\right]$$

Comparing $s'$ coeff

$$\frac{K_c^{\dagger}}{\tau_I^{\dagger}} = \frac{K_c}{\tau_I}$$

$$\tau_I^{\dagger} = \tau_I\left[1 + \frac{\tau_D}{\tau_I}\right]$$

$$K_c^{\dagger}\tau_D^{\dagger} = K_c \tau_D$$

$$\tau_D^{\dagger} = \frac{\tau_D}{1 + \frac{\tau_D}{\tau_I}}$$

(5 b) Since $\tau_D > 0$ & $\tau_I > 0$

$$\left(1 + \frac{\tau_D}{\tau_I}\right) \geq 1$$

$$K_c^{+} \geq K_c \quad , \quad \tau_I^{+} \geq \tau_I \quad , \quad \tau_D^{+} \leq \tau_D$$

c) $K_c = 4$ $\quad \tau_I = 10$ min $\quad \tau_D = 2$ min

$$K_c^{+}/_{4} \quad 1 + \frac{2}{10} = 1.2$$

$$K_c^{+} = 4.8$$

$$\tau_I^{+} = 10 \times 1.2 = 12 \text{ min}$$

$$\tau_D^{+} = \frac{2}{1.2} = 1.67 \text{ min}$$

Q 8.7 ~~Outp~~ Output = 12 mA

$y_{sp} = T_0$

$\check{y}_m = T_0$

$K_c = 2$

$\tau_I = 1.5$ min

$\tau_D = 0.5$ min

$e(t) = 0.5t$

$E(t) = \frac{0.5}{s^2}$

PID controller, $p(t)$ is given by

$$p(t) = \underbrace{\bar{p}(t)}_{12\,mA} + K_c\left[e(t) + \frac{1}{\tau_I}\int_0^t e(t^*)\,dt + \tau_D \frac{de(t)}{dt}\right]$$

$$p(t) = 12\,mA + K_c\left[0.5t + \frac{1}{1.5}\cdot\frac{0.5t^2}{2} + 0.5\times 0.5\right]$$

$$p(t) = 12\,mA + t + \frac{t^2}{3} + 0.5 \quad \text{for } t>0$$

$p(t) = 12$ mA for $t<0$

(b) for PI, $\tau_D = 0$

$\therefore p(t) = 12 + \cancel{0}\,t + \frac{t^2}{3}$

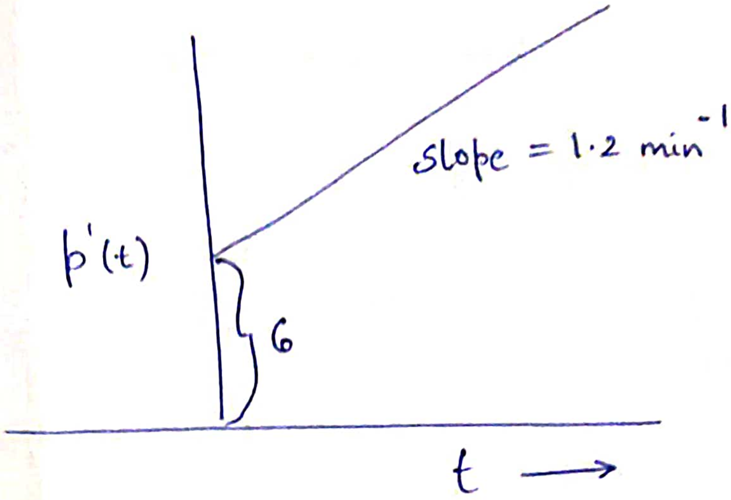
(C) plot done separately.

π

Q1 ✓

Q2

Q 8.6 $Y_m(s) = \frac{2}{s}$




$y_{sp} = 0$

$y_m(t) = 2$

$e(t) = y_{sp} - y_m = -2$

$= 0$

for PI controller,

$$p'(t) = K_c\left[e(t) + \frac{1}{\tau_I}\int_0^t e(t)\,dt\right]$$

$$= K_c\left[-2 + \frac{1}{\tau_I}\left[-2t\right]_0^t\right]$$

$$= -2K_c - \frac{2t\,K_c}{\tau_I}$$

at $t=0$,

$p'(t) = 6 = -2K_c$

$K_c = -3$

$\text{slope} = 1.2 = -\frac{2K_c}{\tau_I}$

$\tau_I = \frac{-2\times-3}{1.2} = 5$ min