1)

a) $G_c(s) = k$

$$G_p(s) = \frac{1}{(s+2)(s+5)(s+10)}$$

$H(s) = 10$

T.F. $$\frac{C(s)}{R(s)} = \frac{G_c(s) \cdot G_p(s)}{1 + G_c(s) \cdot G_p(s) \cdot H(s)}$$

$$= \frac{k/(s+2)(s+5)\cdot(s+10)}{1 + \dfrac{10k}{(s+2)(s+5)(s+10)}}$$

$$\boxed{T(s) = \frac{C(s)}{R(s)} = \frac{k}{(s+2)\cdot(s+5)\cdot(s+10) + 10k}}$$

$$\frac{C(s)}{R(s)} = \frac{k}{(s^2+7s+10)\cdot(s+10) + 10k}$$

$$= \frac{k}{s^3+10s^2+7s^2+70s+10s+100+10k}$$

$$\frac{C(s)}{R(s)} = \frac{k}{s^3 + 17s^2 + 80s + 100 + 10k}$$

for stability

take R.H. criterion

The characteristic equation (C.E.) $= 1 + G_c(s) \cdot G_p(s) \cdot H(s) = 0$

$= \text{Denominator of } \dfrac{C(s)}{R(s)} = T(s) = \text{T.F.}$

$s^3 + 17s^2 + 80s + 100 + 10k = 0$

s^3	1	80
s^2	17	$10k+100$
s^1	$\dfrac{1360-10k-100}{17} > 0 \rightarrow 1260 - 10k > 0$	
s^0	$10k + 100 > 0 \rightarrow k > -10$	

$k < 126$

for stability the range of k is; $\boxed{-10 < k < 126}$

b) for marginally (damped oscillation)

The k value is $\boxed{k = 126}$

c) frequency of oscillations.

Get the Auxillary equation from R-H criteria

$$A(s) = 0$$

$$A(s) = 17s^2 + 10k + 100 = 0$$

put $k = 126$

$$17s^2 + 1260 + 100 = 0$$

$$17s^2 = -1360$$

$$s = \dot{j}\sqrt{\frac{1360}{17}}$$

$$j\omega = \dot{j} \cdot 8.94 \quad (s = j\omega)$$

$$\omega = 8.94 \text{ radyon/sec.}$$

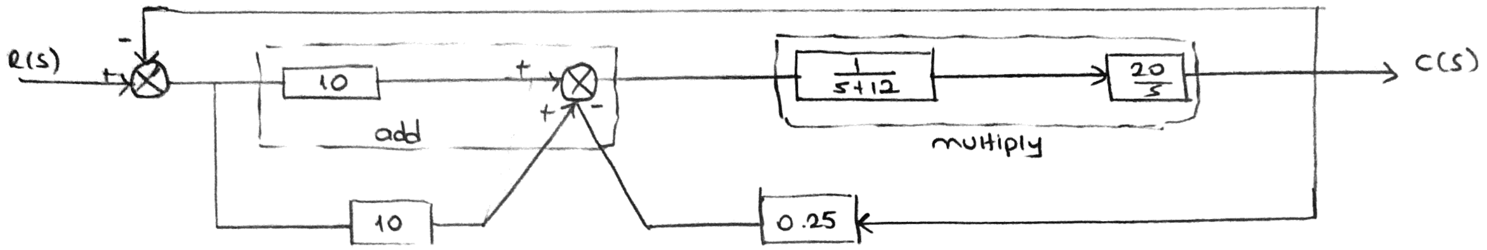
$$2\pi f = 8.36$$

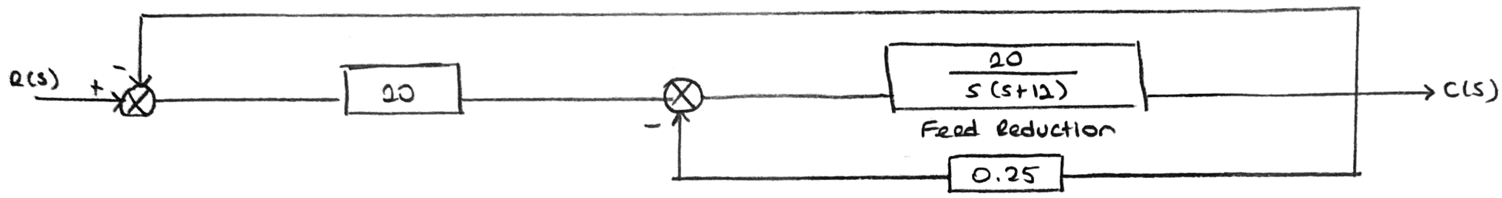
$$f = \frac{8.36}{2\pi}$$

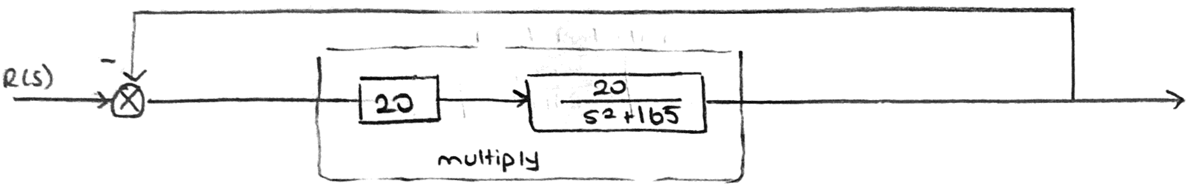
$$\boxed{f = 1.42 \text{ Hz}}$$

Damped oscillation with frequency $f = 1.42$ Hz where k is 126.

2)



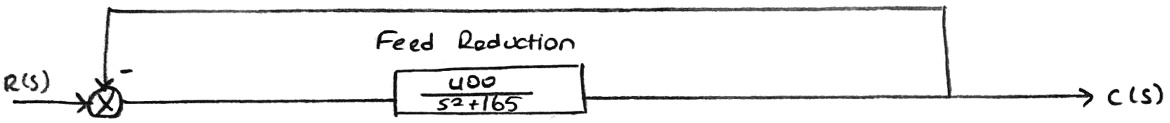




$$C(s) = \frac{\frac{20}{s(s+12)}}{1+\frac{20\times0.25}{s(s+12)}}$$

$$= \frac{20}{s(s+12)+45}$$

$$= \frac{20}{s^2+16s}$$



$$\boxed{T(s) = \frac{C(s)}{R(s)} = \frac{\frac{400}{s^2+16s}}{1+\frac{400}{s^2+16s}} = \frac{400}{s^2+16s+400}}$$

Characteristic equation; $s^2+16s+400$

Standard eq. $s^2+2\delta w_n s+w_n^2=0$

$2\delta w_n = 16$ $\quad w_n^2 = 400$

$\delta = \frac{16}{2w_n} = \frac{16}{40}$ $\quad \boxed{w_n = \sqrt{400} = 20 \text{ rad/s}}$

$$\boxed{\delta = 0.4}$$

$$\boxed{\text{Settling Time } (T_s) = \frac{4}{\delta w_n} = \frac{4}{(0.4\times20)} = 0.5 \text{ sec.}}$$