1. $y = Gx$

$x = v - Dd$

$v = C(u + Fr)$

$u = Be$

$e = r - Hy$

$$y = G(v - Dd)$$
$$y = G(C(u + Fr) - Dd)$$
$$y = G(C(Be + Fr) - Dd)$$
$$y = G(C((B(r - Hy)) + Fr) - Dd)$$
$$y = GCBr - GCBHy + GCFr - GDd$$
$$(1 + GCBH)y = (GCB + GCF)r - GDd$$
$$y = \underbrace{\frac{(GCB + GCF)}{(1 + GCBH)}}_{G_{yr}} r - \underbrace{\frac{GD}{(1 + GCBH)}}_{G_{yd}} d$$

2. $y = G(-d + K(r - y))$

$$y = -Gd + KGr - GKy$$
$$y = \frac{-Gd + KGr}{(1 + GK)}$$
$$e = r - y$$
$$= \frac{(1 + GK)r + Gd - KGr}{(1 + GK)}$$
$$\cancel{e(s) = \frac{(1 - 2GK)r(s) + Gd(s)}{(1 + GK)}}$$

$\cancel{e(s) =}$

$$e(s) = \frac{1}{(1+GK)} r(s) + \frac{G}{(1+GK)} d(s)$$

3. $r(t) = ft$

$R(s) = f/s^2$

$d(t) = d_0$

$d(s) = d_0/s$

$$e(s) = \frac{1}{\left(1 + \frac{KK_v}{s(a+s)}\right)}\left(\frac{f}{s^2}\right) + \frac{K_v/s(a+s)}{\left(1 + \frac{KK_v}{s(a+s)}\right)}\left(\frac{d_0}{s}\right)$$

$$= \frac{\cancel{s}(a+s)}{(s(a+s)+KK_v)}\left(\frac{f}{s^2}\right) + \frac{K_v}{s\cancel{(a+s)}}\left(\frac{s\cancel{(a+s)}}{s(a+s)+KK_v}\right)\left(\frac{d_0}{s}\right)$$

$$= \frac{f(a+s)+K_v d_0}{s(s(s+a)+KK_v)}$$

$$~~\text{lim}~~ \quad e_{ss}(s) = \lim_{s\to 0} s e(s) = \lim_{s\to 0}\left(\frac{f(a+s)+K_v d_0}{s(s+a)+KK_v}\right)\left(\frac{\cancel{s}}{\cancel{s}}\right)$$

$$= \frac{f(a+0)+K_v d_0}{0(0+a)+KK_v}$$

$$= \frac{fa+K_v d_0}{KK_v}$$

y-coords of points a
in table. Slope of
scale as I can sh

4. $r(t) = r_0$ $\qquad$ $d(t) = 0$

$r(s) = r_0/s$ $\qquad$ $d(s) = 0$

$$y = \frac{-Gd + KGr}{(1+GK)} \quad \text{[from Q2]}$$

$$y = \frac{KG}{1+KG} r = \frac{1}{\frac{1}{KG}+1} r$$

$$= \frac{1}{1+\frac{s(s+a)}{KK_v}} \left(\frac{r_0}{s}\right)$$

$$y(s) = \frac{KK_v r_0}{sKK_v + s^2(s+a)} = \frac{KK_v r_0}{s(s^2+as+KK_v)} = \frac{10(.9)10}{(s^2+10s+9)s}$$

$$y(t) = \mathcal{L}^{-1}\{y(s)\} = \mathcal{L}^{-1}\left\{\frac{90}{s(s+1)(s+9)}\right\}$$

$$= \mathcal{L}^{-1}\left\{\frac{A}{s} + \frac{B}{s+1} + \frac{C}{s+9}\right\}$$

$$90 = As^2 + A10s + 9A + Bs^2 + 9Bs + Cs^2 + 1Cs$$

$$90 = 9A \rightarrow A = 10$$

$$0 = A10s + 9Bs + Cs \rightarrow -100 = 9B + C \rightarrow B = -90/8$$

$$0 = As^2 + Bs^2 + Cs^2 \rightarrow -10 = B + C \rightarrow C = -10 + 90/8$$

$$y(t) = \mathcal{L}^{-1}\left\{\frac{10}{s} + \frac{-90/8}{s+1} + \frac{5/4}{s+9}\right\}$$

$$y(t) = 10 - 11.25e^{-t} + 1.25e^{-9t} \quad \text{for } t \geq 0$$

5. $G_{yr}(s) = Y(s)/R(s) = \dfrac{KK_r}{KK_r + s(s+a)}$ [from Q4)

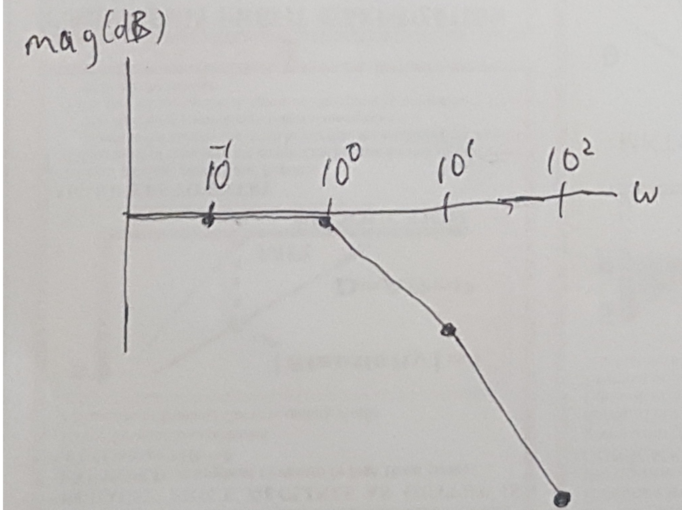
$$= \frac{9}{(s+1)(s+9)}$$

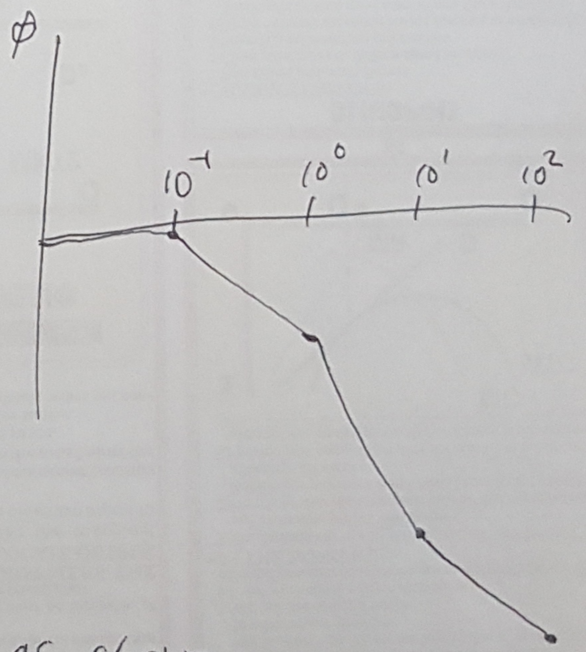
$$G_{yr}(j\omega) = \frac{9}{(-\omega^2+9)+10j\omega} = \left(\frac{9}{(-\omega^2+9)^2+(10\omega)^2}\right)\left((-\omega^2+9)-10j\omega\right)$$

$$|G_{yr}(j\omega)| = 20\log_{10}\left|\frac{9}{(-\omega^2+9)^2+(10\omega)^2}\left(\sqrt{(-\omega^2+9)^2+(10\omega)^2}\right)\right|$$

$$\phi = \tan^{-1}\left(\frac{-10\omega}{-\omega^2+9}\right)$$

ω	~~$\lvert G_{yr}(j\omega)\rvert$~~	~~ϕ (deg)~~	ϕ (rad)	$\lvert G_{yr}(j\omega)\rvert$	ϕ (deg)
0.1	~~18.222~~	~~-6.347~~	-.1108	-.04375	-6.347
1	~~16.128~~	~~[illegible]~~	-.8961	-3.064	-51.34
10	~~42.62~~	~~47.70~~	.8325	-23.54	-132.3
100		~~5.746~~	.09976	-60.85	-189.9





y-coords of points are as shown in table. Slope of line as best to scale as I can show (ie not very to scale).