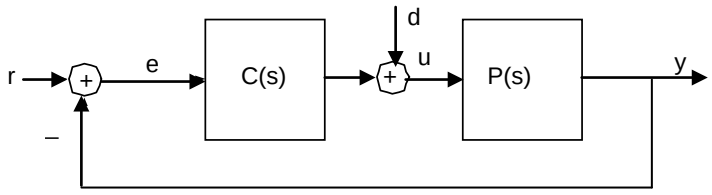
EEE 304, Test 5 **Name: _____**

Closed-book closed-notes, tables and calculators allowed, 30'

Problem 1:

For the feedback system shown below, compute the transfer functions from r to y (y/r) and from d to u (u/d).

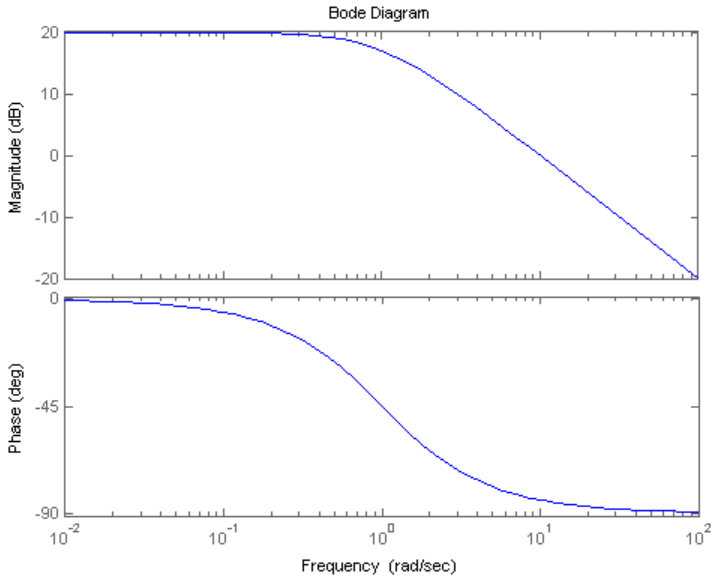


$$\frac{y}{r} = \frac{PC(s)}{1 + PC(s)}, \quad \frac{u}{d} = \frac{1}{1 + CP(s)}$$

Problem 2:

For the feedback system of Problem 1, suppose $P(s) = 10/(s+1)$ and $C(s) = K(s+a)/s$. Determine *K*,*a* so that the crossover frequency is 1rad/sec and the Phase Margin is at least 60^o.

(You may use the given Bode plot to compute the necessary quantities graphically.)



At crossover, the phase condition is

$$\angle\frac{1}{j\omega_c} + \angle K + \angle(j\omega_c + a) + \angle\frac{10}{j\omega_c + 1} = -90^\circ + 0^\circ + \tan^{-1}(\omega_c / a) - \tan^{-1}(\omega_c / 1) \geq -180^\circ + 60^\circ$$

$$\Rightarrow \tan^{-1}(1/a) \geq 15^o \Rightarrow a = 3.7$$

Using this value we get the gain condition

$$\left| K\frac{j\omega_c + 3.7}{j\omega_c}\frac{10}{j\omega_c + 1}\right\|_{\omega_c = 1} = K\frac{10\sqrt{1+3.7^2}}{1\sqrt{1+1}} = 1 \Rightarrow K = 0.037$$

Thus controller transfer function is

$$C(s) = \frac{\mathbf{0.037}\,\boldsymbol{s} + \mathbf{0.137}}{\boldsymbol{s}}$$