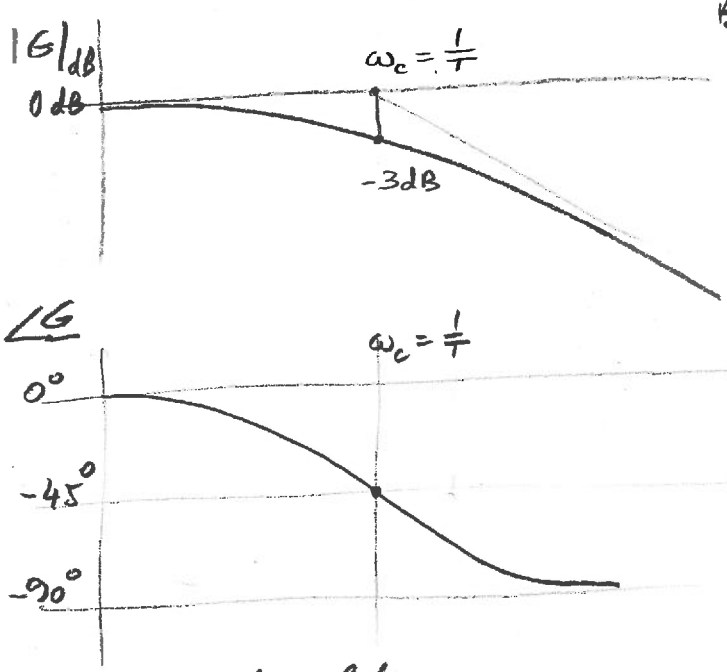
1st order sys ID in Freq Domain

$$G(i\omega) = \frac{1}{i\omega T + 1}$$

Bode plots



Given : Bode plots

Find : T

Sol^{n} : Read: -3dB point on $|G|_{dB}$ plot

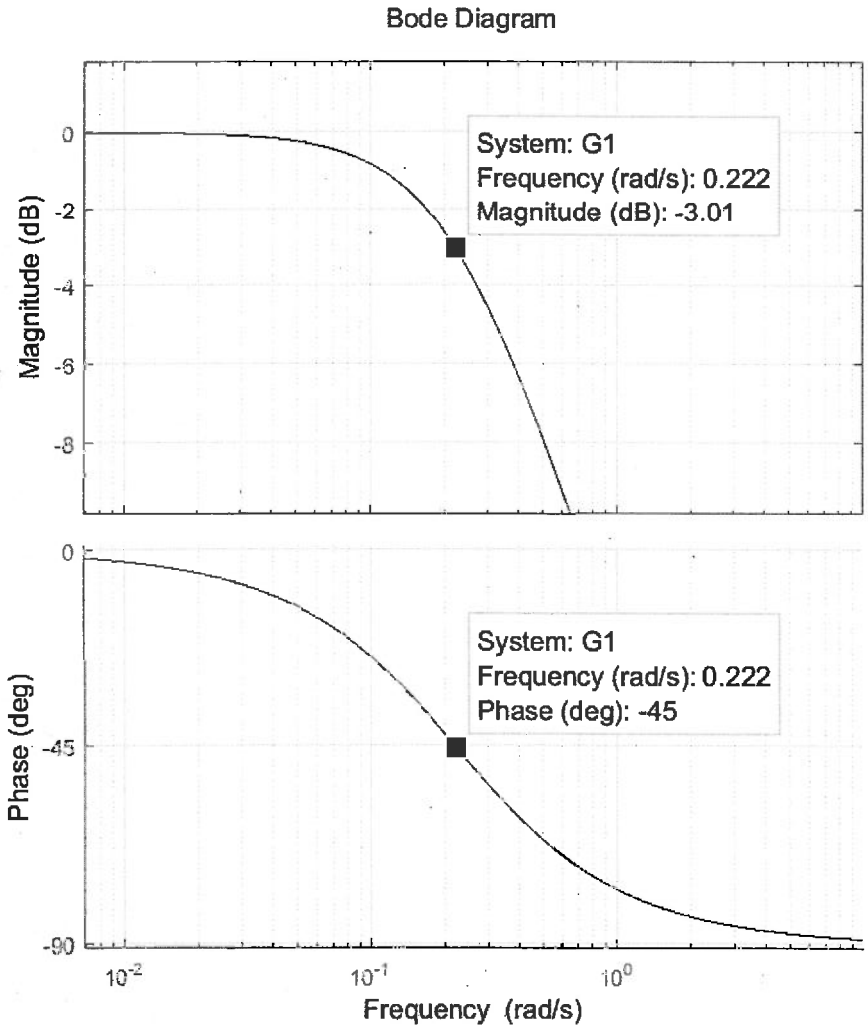
45° point on $\angle G$ plot

Estimate ω_c

Calculate $T = \frac{1}{\omega_c}$

2
1DF

Ex: ID 1st order sys. $G(s) = \frac{1}{4.5s+1}$



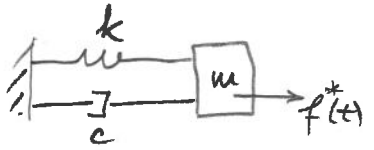
$\omega_c = 0.222$

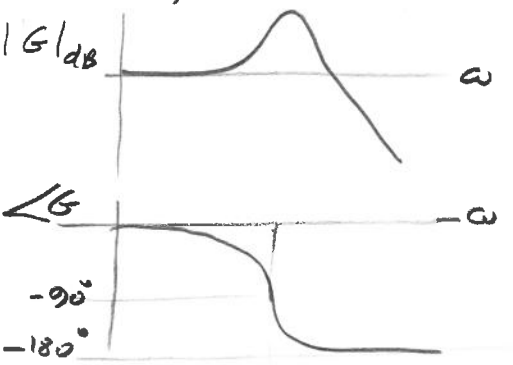
$T = \frac{1}{\omega_c} = 4.5045$

error : -0.1%

In practice, error may be larger due to noise.

3 IDF Ex: ID 2nd order sys





Given: Bode diagram FRF

Find: m, c, k.

Solution: recall FBD, EOM

$$m\ddot{x} + c\dot{x} + kx = f^*(t)$$

$$\mathcal{LT} \quad (ms^2 + cs + k)X(s) = F^*(s)$$

$$G(s) = \frac{X(s)}{F^*(s)} = \frac{1}{ms^2 + cs + k}$$

$$G(i\omega) = \frac{1}{-m\omega^2 + i\omega c + k} \; ; \; G(i0) = \frac{1}{k}$$

$$\omega_n^2 = k/m \qquad G(i\omega_n) = \frac{1}{i\omega_n c} \; ; \; |G(i\omega_n)| = \frac{1}{\omega_n c}$$

Numerical example: $m = 2\,kg$, $c = 4\,\frac{N}{m/s}$, $k = 20\,\frac{N}{m}$

Run MATLAB SYS_ID_2ndOrder_Ex11_1

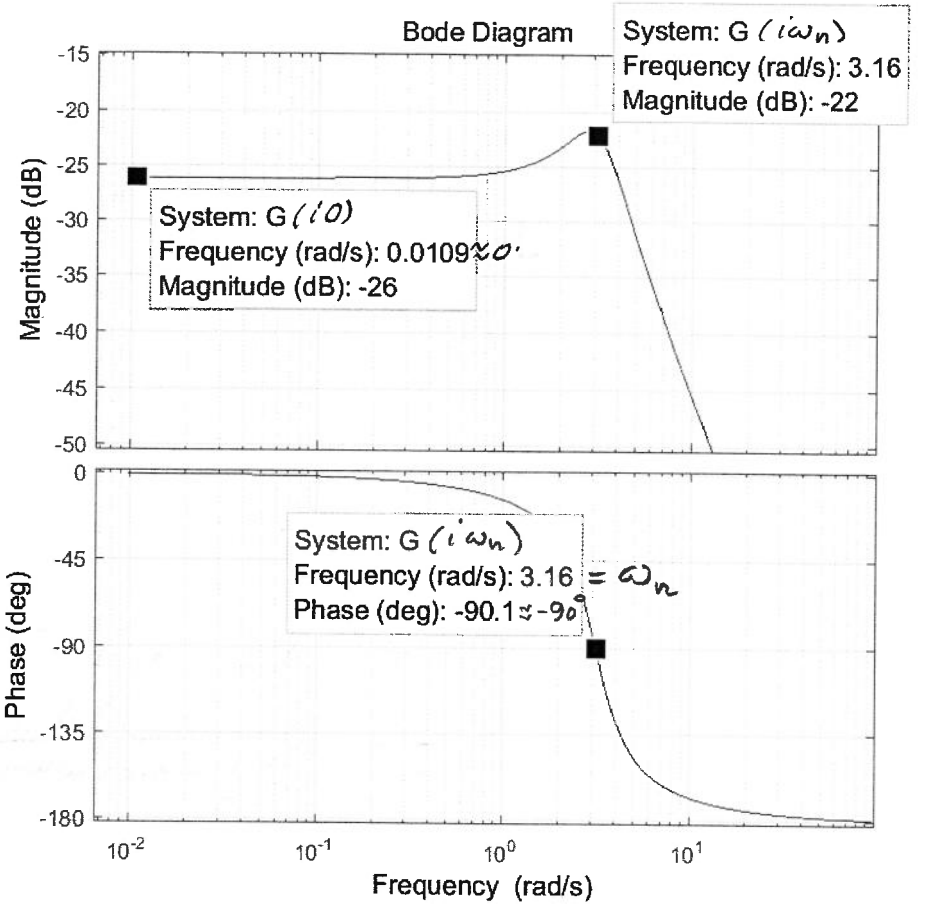
Read on Bode diagram:

$|G(i0)|_{dB} = -26\,dB$

$\omega_n = 3.16\,rad/sec$

$|G(i\omega_n)|_{dB} = -22\,dB$

4
1DF



$$\left(M_{p\omega}\right)_{dB} = \left|G(i\omega_n)\right|_{dB} - \left|G(i0)\right|_{dB}$$

$$= -22\,dB - (-26\,dB) = +4\,dB$$

5 1DF calculate k_1, ω_1, c_1

$$k_1 = \frac{1}{G(i0)} = 1/db2mag(G(i0)_{dB})$$

$$= 19.9526 \text{ N/m} \approx 20 \text{ N/m} \quad \checkmark$$

$\omega_n^2 = k/m$

$$m_1 = \frac{k_1}{\omega_n^2} = 1.9981 \text{ kg} \approx 2 \text{ kg} \quad \checkmark$$

$$c_1 = \frac{1}{\omega_n |G(i\omega_n)|} = 1/\omega_n/db2mag(G(i\omega_n)_{dB}) = 3.9839 \approx 4 \frac{N}{m/s}$$

or

$$(M_{p\omega})_{dB} = |G(i\omega_n)|_{dB} - |G(i0)|_{dB}$$

$$M_{p\omega} = db2mag(|G(i\omega_n)|_{dB} - |G(i0)|_{dB}|)$$

$$M_{p\omega} = \frac{1}{2\zeta} \rightarrow \zeta = \frac{1}{2M_{p\omega}}$$

$$c_2 = 2\zeta \omega_n m_1 = 3.9920 \frac{N}{m/s} \approx 4 \frac{N}{m/s} \quad \checkmark$$

All three parameters of the system, k, m, c have been recovered with quite acceptable error.