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ECE461
EXAM FINAL

12/16/2020
Wednesday

1) Setting time $T_s \approx 1.5s$, DC gain = 11, $\omega_d \approx \dots$ $T_d = 0.28s \Rightarrow \approx 3.57Hz$

a) $T = T_s/4 \approx 0.375s \Rightarrow \sigma = -2.667$; $\omega_d \approx 22.4$ rad/s

Dom. Poles @ $-2.667 \pm j22.4$

↑ Hella underdamped

$$G(s) = k \frac{1}{(s+2.667 \pm j22.4)}$$

$G(0) = 11 \Rightarrow \boxed{k \approx 5597.6} \Rightarrow \boxed{G(s) = \frac{5597.6}{(s+2.667 \pm j22.4)}}$

↓

Checking on MATLAB...
(see attached)

b) Step Response of $Y = \frac{2000}{(s+7\pm j12)(s+40)} X$

$F(s)$

$$X(s) = \frac{1}{s} \Rightarrow Y = \frac{2000}{s(s+7\pm j12)(s+40)} = 2000\left(\frac{A}{s} + \frac{B}{s+40} + \frac{C}{s+7\pm j12} + \frac{C^*}{s+7-j12}\right)$$

$$A = F(s)(s)\Big|_{s=0} = \frac{1}{|7+j12|^2 40} \approx 0.12953 \times 10^{-3}$$

$$B = F(s)(s+40)\Big|_{s=-40} \approx -2.0276 \times 10^{-3}$$

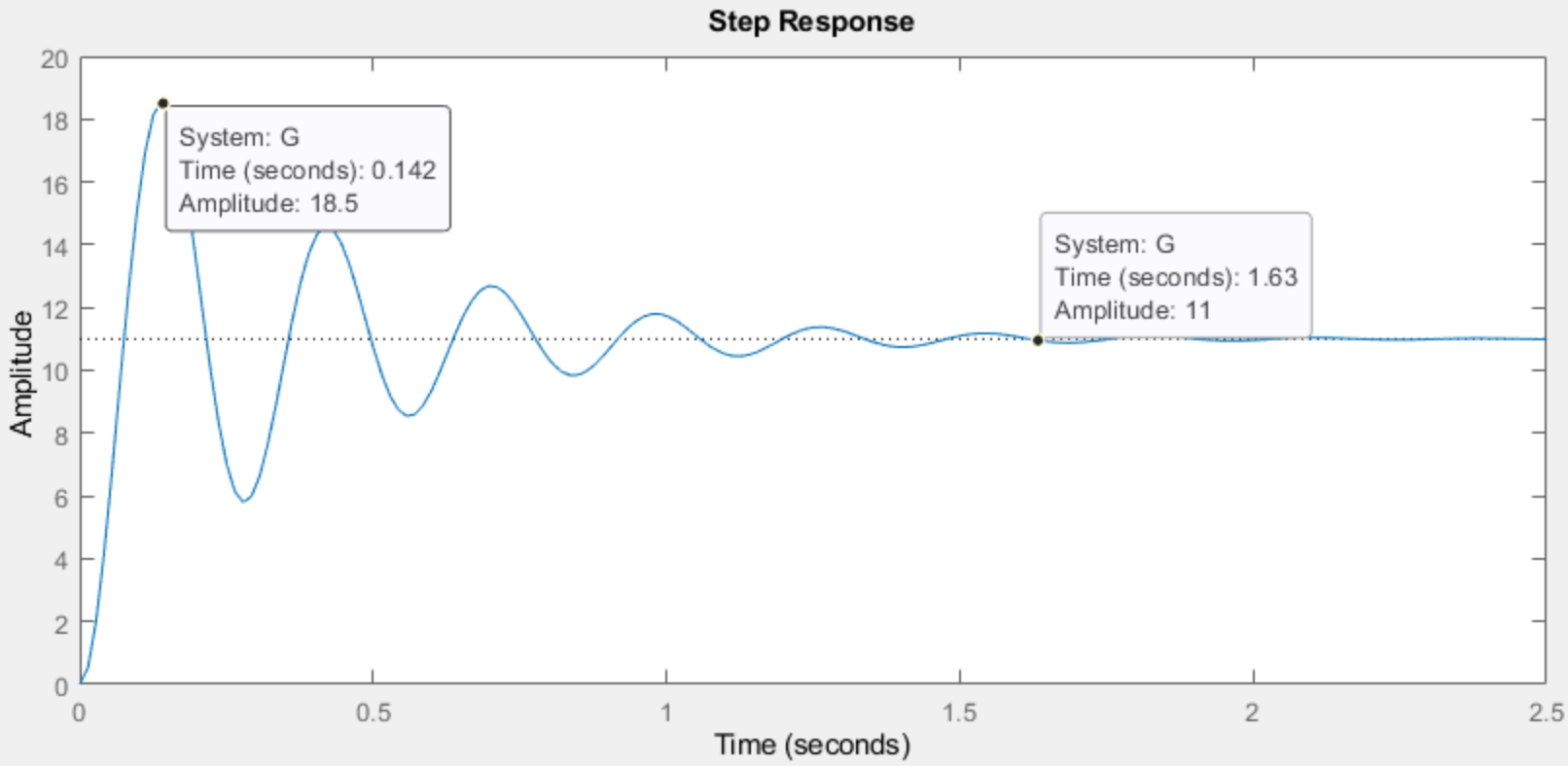
$$C = F(s)(s+7+j12)\Big|_{s=-7-j12} \approx (-0.0546 * -0.0656) * 10^{-3}$$

$$|C| \approx 0.1708 \qquad \angle C \approx -130°$$

hold on;
xli

Figure 1

File Edit View Insert Tools Desktop Window Help



Wind
ATLAB
1*a
=
5.59
G =

$$Y(s) = \frac{0.2590}{s} + -0.04055\,\frac{1}{s+40} + (-0.1093 + j0.1313)\,\frac{1}{s+7-j12} + \cdots$$

$$y(t) = 0.2590\,u(t) - 0.04055\,e^{-40t}u(t) + 2(0.1708)e^{-7t}\cos(12t + 130^\circ)$$

So DC gain: 0.2590

2% Settling: slowest is e^{-7t} term, $\tau = 1/7 \Rightarrow$ 2% $T_s = 4/7$ s $= 0.57$s

% OS: Angle of Dom. Pole $-7 \pm j12$ is ~~45°~~ -60° from − real axis
This corresponds to $\zeta = 0.5039$
$\Rightarrow OS = \exp\left(-\pi \frac{\zeta}{\sqrt{1-\zeta^2}}\right)$

OS ≈ 16%

Checking in MATLAB (2 step):

Command Window

New to MATLAB? See resources for Getting Started.

```
>> step(G)
>> stepinfo(G)

ans =

  struct with fields:

        RiseTime: 0.1277
    SettlingTime: 0.5984
     SettlingMin: 0.2340
     SettlingMax: 0.2976
       Overshoot: 14.8699
      Undershoot: 0
            Peak: 0.2976
        PeakTime: 0.2901
```