Lab-endsem-Report

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Answers-

Q1 and Q2-

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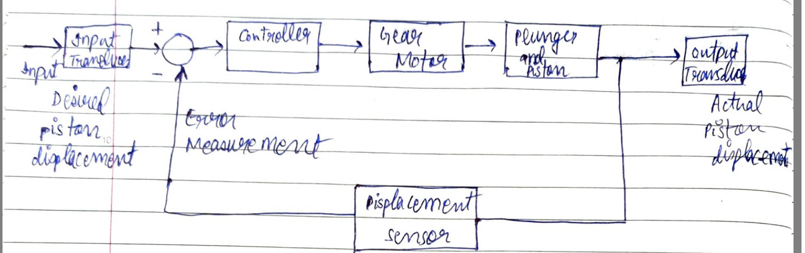
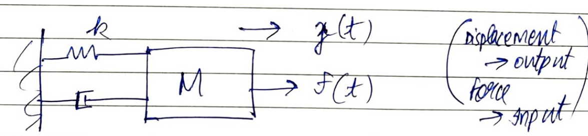
Q1.

1) Block Diagram (Feedback suspension system) -

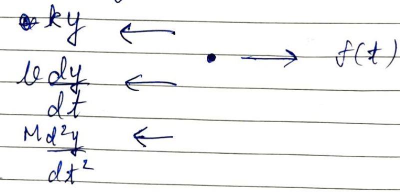


2) Assumption: spring − mass − damper system.

Given: $b = 10\ Ns/m$, $k = 2\ N/m$, $M = 30\ kg$



F.BD of M −



Balancing Forces -

$$\boxed{f(t) = ky + b\frac{dy}{dt} + M\frac{d^2y}{dt^2}}$$ Differential eqn of system

putting in values -

$$\boxed{f(t) = 2y + 10\frac{dy}{dt} + 30\frac{d^2y}{dt^2}} \quad \text{— ①}$$

for Transfer function -

Take Laplace transform of ① -

$$F(s) = 2Y(s) + 10sY(s) + 30s^2Y(s)$$

(taking initial cdns → 0)

$$\boxed{T(s) = \frac{Y(s)}{F(s)} = \frac{1}{2+10s+30s^2}}$$ Transfer function of system

Steady state gain → K

$$T(s)\big|_{s=0} = K$$

so

$$\boxed{T(s) = \frac{2K}{2+10s+30s^2}}$$

Here ⇒ $K = 2/k = 1$ $\quad (k = 2\,N/m)$

so

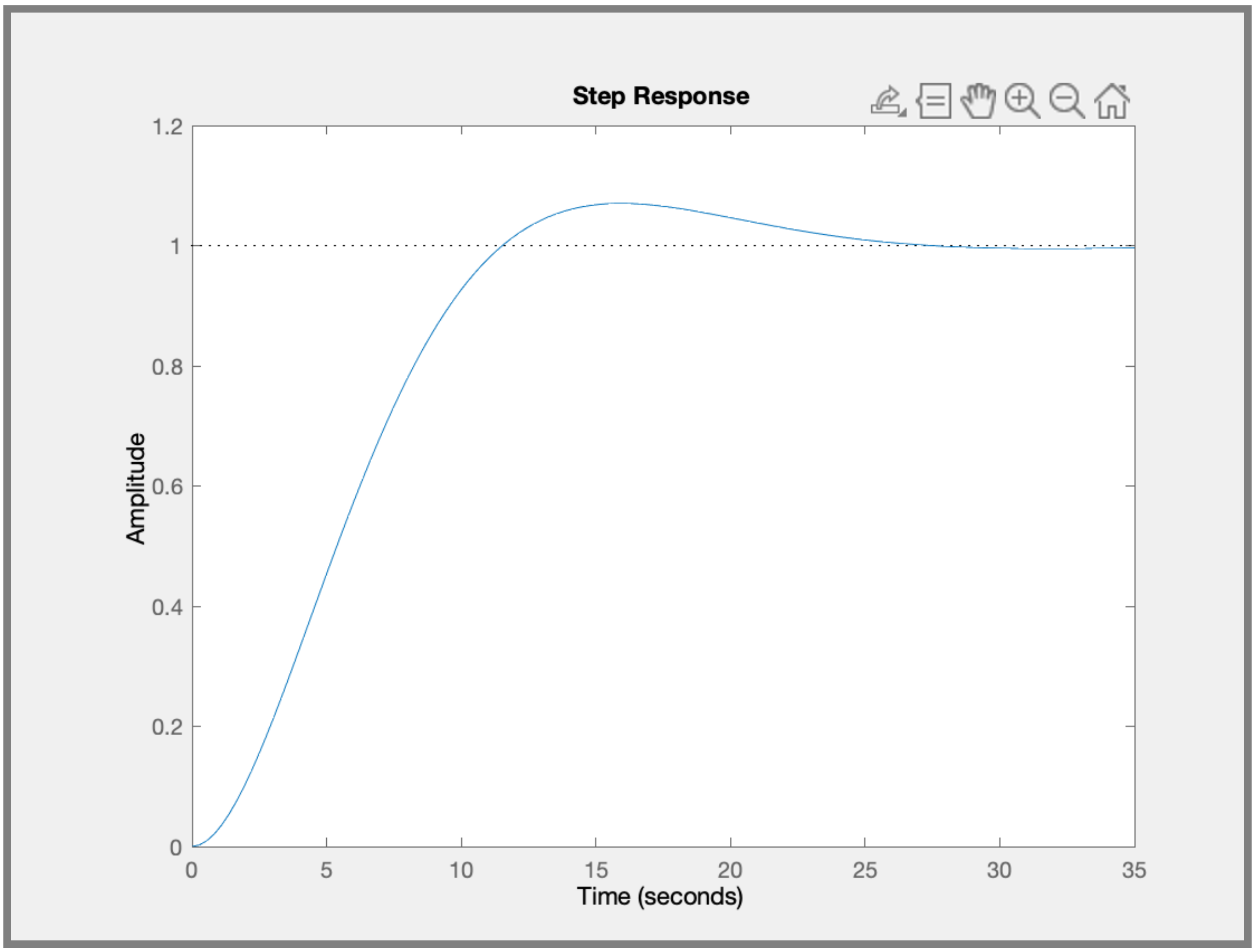
$$\boxed{T(s) = \frac{2}{2+10s+30s^2}}$$

Q3- Code-

```
%Q1
%Part-3
clear all;
close all;
sys = tf([2],[30,10,2]);

step(sys);
stepinfo(sys);
```

Plot-



Time Parameters-

Field	Value
RiseTime	7.6323
SettlingTime	23.2559
SettlingMin	0.9067
SettlingMax	1.0703
Overshoot	7.0269
Undershoot	0
Peak	1.0703
PeakTime	16.0260

Q4- Code-

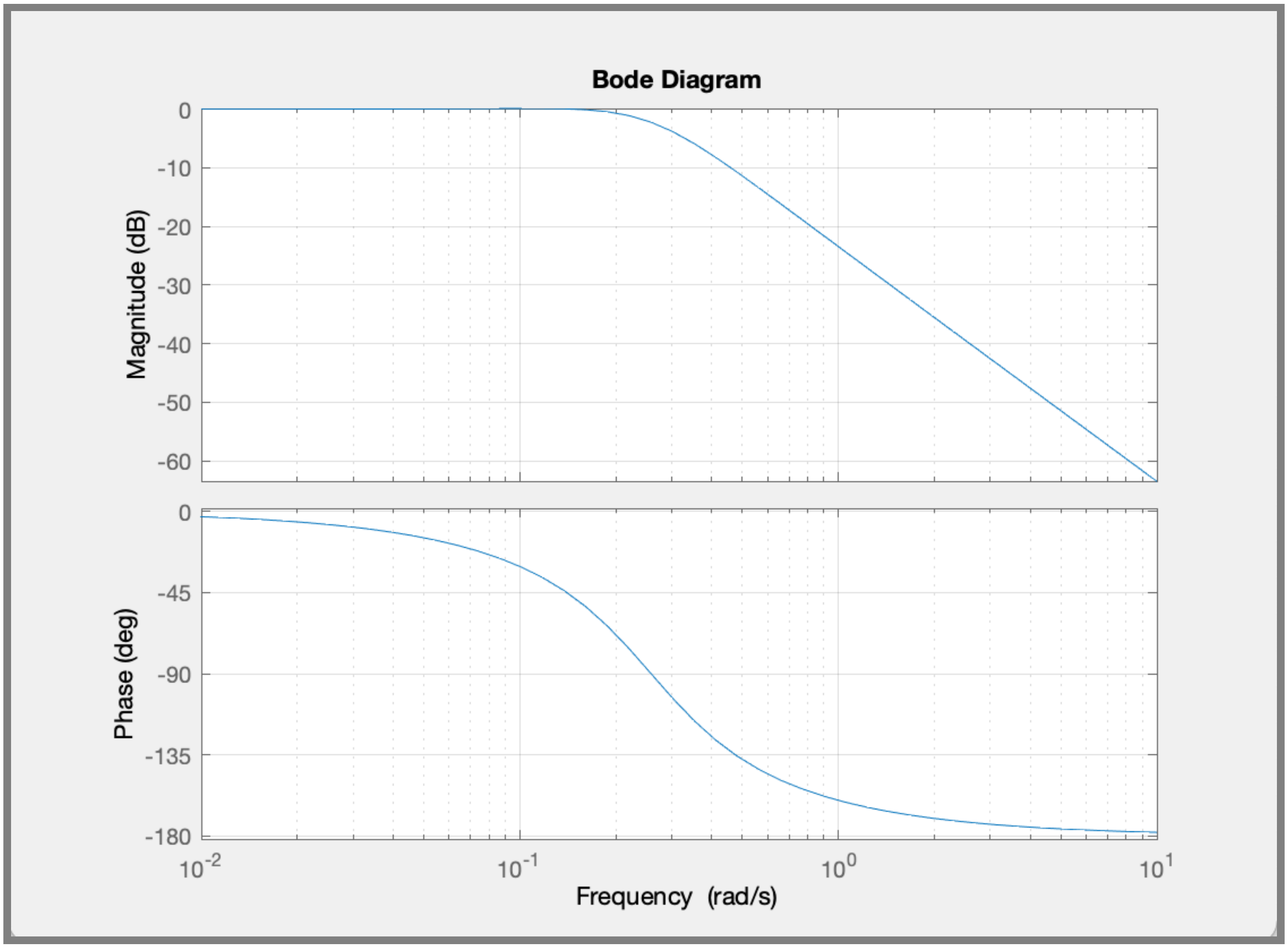
```
%Q1
%Part-4
clear all;
close all;

sys = tf([2],[30,10,2]);

bode(sys);
grid();

[Gm,Pm] = margin(sys);
```

Plot-



Q4- stability check-

Q4. From plot -

$\omega_{gc} = 0.149$

and

$PM = 180 +$ phase at ω_{gc}

$PM = 132^\circ$ (phase at $\omega_{gc} = -48^\circ$)

$\omega_{pc} \longrightarrow \infty$

so

$|GM| \rightarrow \dfrac{1}{\text{Gain(in dB)}} \longrightarrow +\infty$

and as below 0

so

as $GM, PM > 0$

so system is stable.

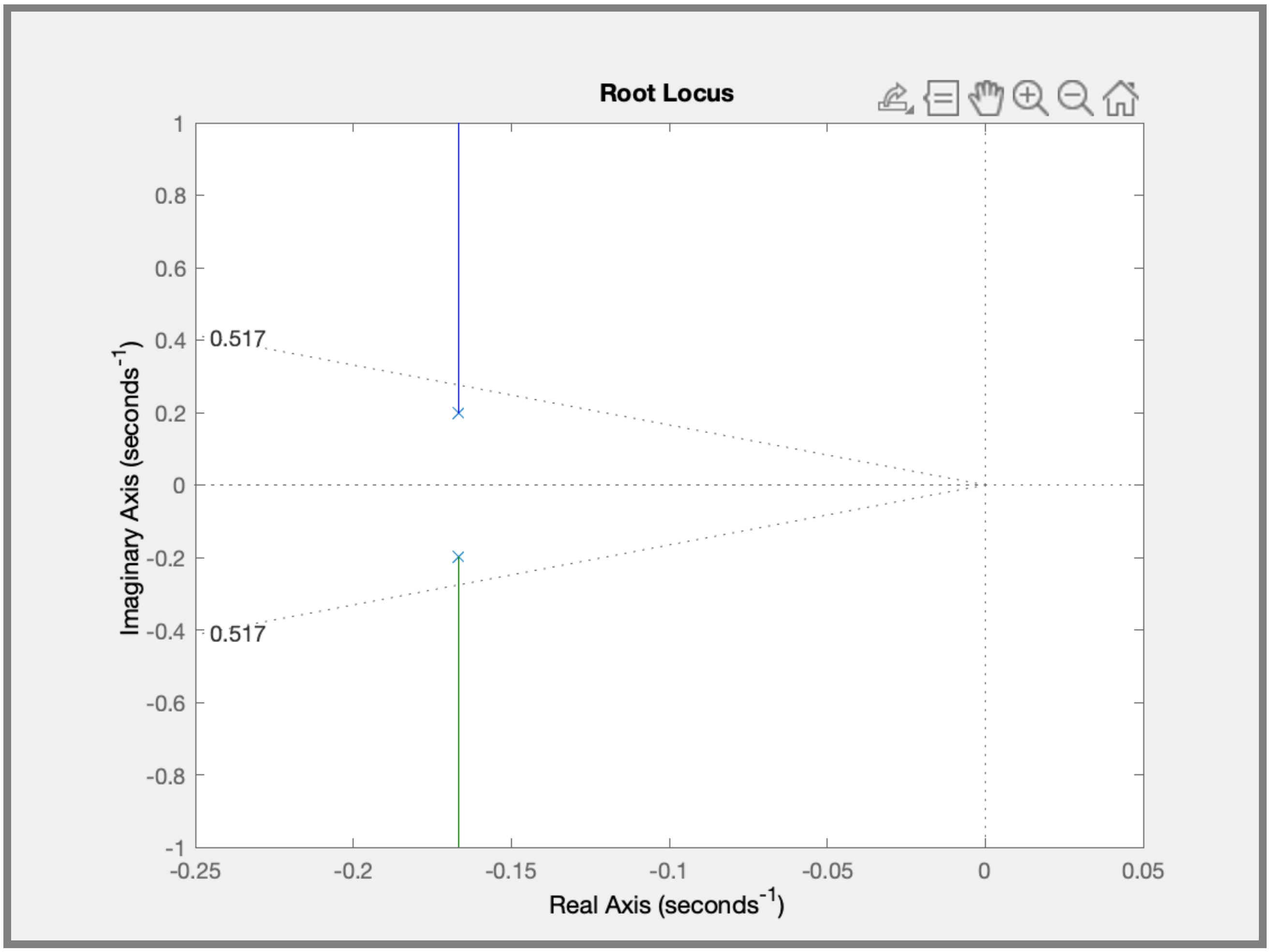
Q5- Code-(For Finding root locus)

```
%Q1
%Part5
clear all;
close all;

sys = tf([1],[30,10,2]);

hold on;
rlocus(sys);
sgrid(0.517,0);
hold off;
```

Plot-



Q5-

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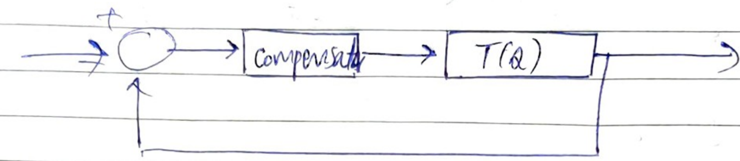
5) Given -

$\% OS = 15\%$ $\quad T_s \rightarrow T_s/2$

$z_c = -5$

Ans $\rightarrow$



$$\% OS = e^{-\pi \zeta/\sqrt{1-\zeta^2}}$$

$$0.15 = e^{-\pi \zeta/\sqrt{1-\zeta^2}}$$

$$\zeta \approx 0.517$$

From MATLAB -

Dominant Pole Pair -

$$-0.167 \pm 0.275 j$$

Freq. $\rightarrow$ 0.322

Gain $\rightarrow$ 0.546

settling time -

$$T_s = \frac{4}{\omega_n \zeta_n} = \frac{4}{0.167}$$

(as $\omega_n \zeta_n \rightarrow$ real part of dominant pole)

$$T_s = 23.95 \text{ s}$$

settling time reduced to half $\rightarrow T_s' = T_s/2 = 11.975$ s

so design point -

$\sigma_n = \zeta\omega_n \rightarrow$

$$\frac{4}{\zeta\omega_n} = (T_s)$$

$$\frac{4}{-\sigma_n} = 11.975$$

$$\sigma_n = -0.334$$

as $\zeta \approx 0.517$

$$\theta = \cos^{-1}(\zeta)$$

$$\theta = 58.86^\circ$$

so

for design pt $\rightarrow$ $\omega_n = 0.334 \times \tan(58.86^\circ)$

$$= \pm 0.553$$

so

design pts $\rightarrow$ $\sigma + \omega_n j$

$$\rightarrow -0.334 \pm 0.553 j$$

$Z_c \Rightarrow -5$ (given)

so for $P_c \rightarrow$

angle at design pt $\rightarrow$

$$-\theta_{P_c} + \theta_{Z_c} - \theta_1 - \theta_2 = -180^\circ$$

$$-\theta_{P_c} + 6.759 - 120.93 - 10[illegible].44 = -180$$

$$-\theta_{P_c} = -30.92$$

so

$$\theta_{P_c} = 30.92$$

so $\tan(30.92) = \dfrac{0.553 - 0}{P_c - 0.334}$

0.599

$= \dfrac{0.553}{P_c - 0.334}$

$0.376 = P_c - 0.334$

$P_c = 0.710$

so, ~~lead~~ lag compensator -

compensator $\rightarrow \boxed{0.546 \times \dfrac{(s + 5)}{(s + 0.710)}}$

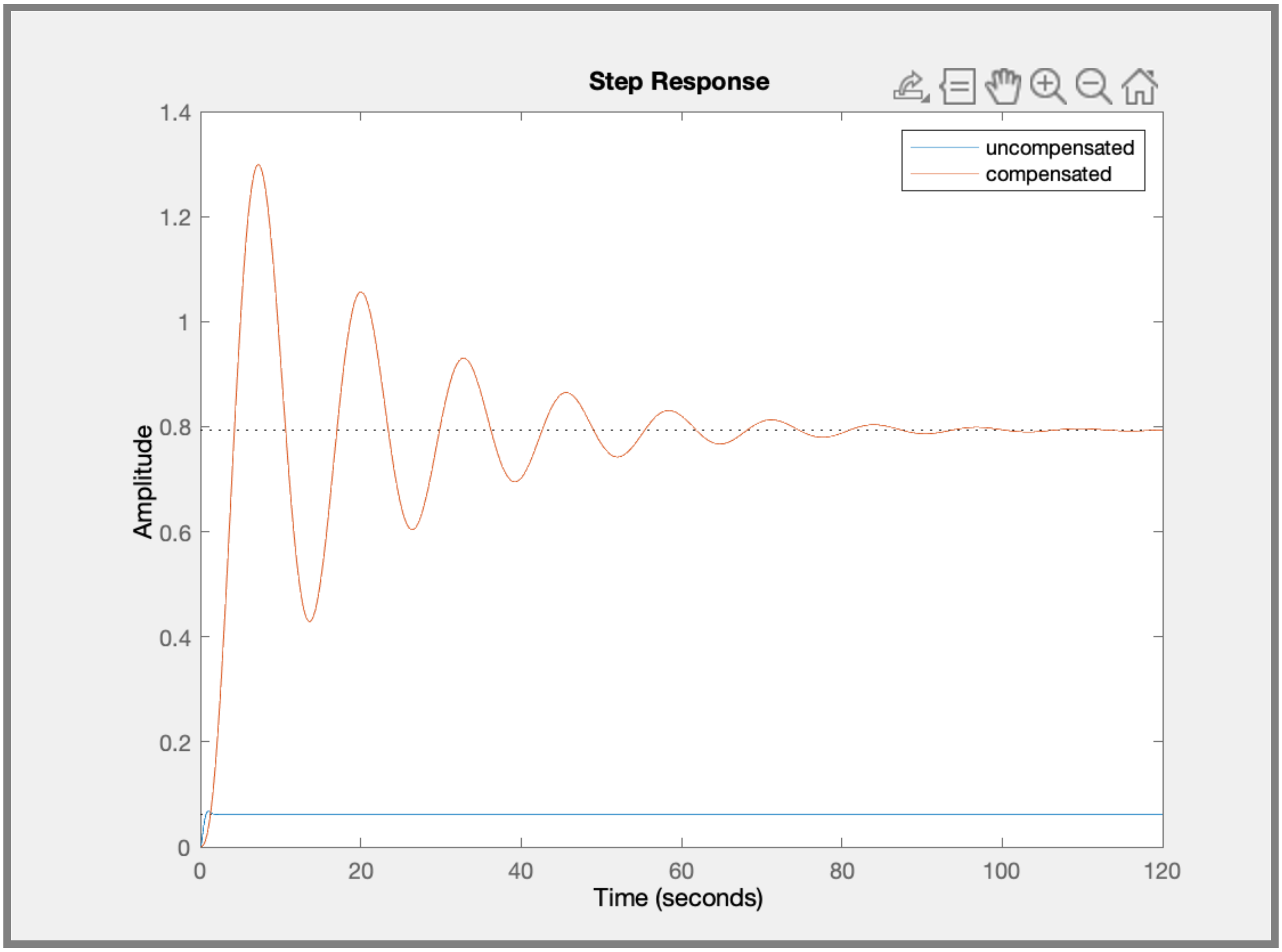
Q5- Code-(Uncompensated and Compensated)

```
%Q1
clear all;
close all;
%uncompensated system
sys = tf([2],[2,10,30]);
%compensated system
sys1 = tf([1.092,5.46],[30,31.3,9.1,1.42]);

hold on;
step(sys/(sys+1));
step(sys1/(sys1+1));
legend('uncompensated','compensated');
hold off;

stepinfo(sys1);
```

Plot-



Step Response
uncompensated
compensated
Amplitude
Time (seconds)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
20
40
60
80
100
120

THE END