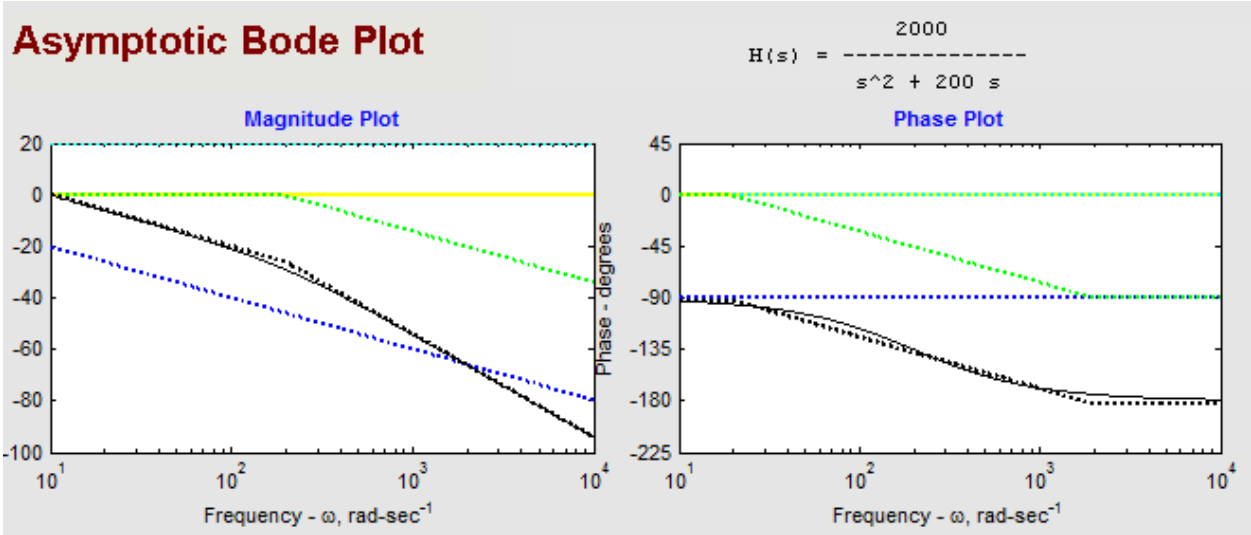
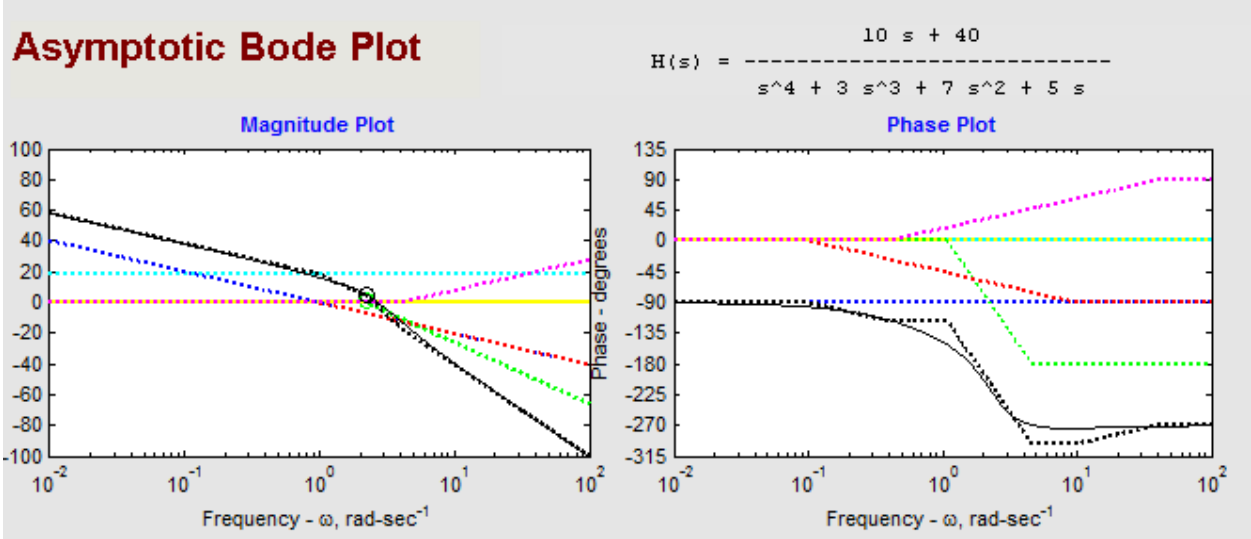
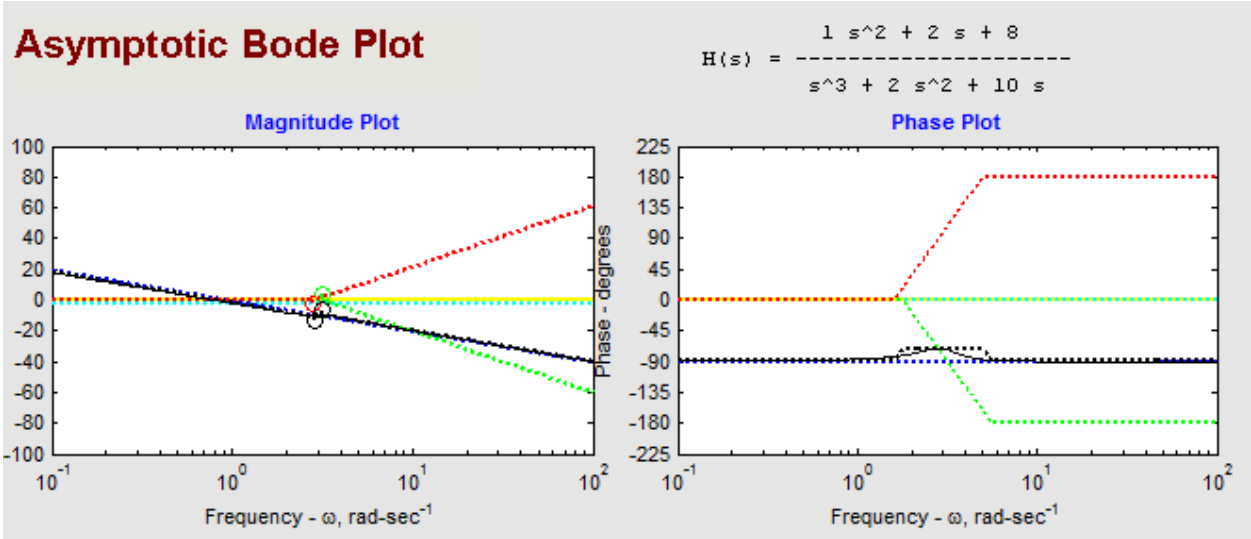
1) a)


Asymptotic Bode Plot
2000
H(s) = ----------
s^2 + 200 s
Magnitude Plot
Phase Plot
Phase - degrees
Frequency - ω, rad-sec-1
Frequency - ω, rad-sec-1

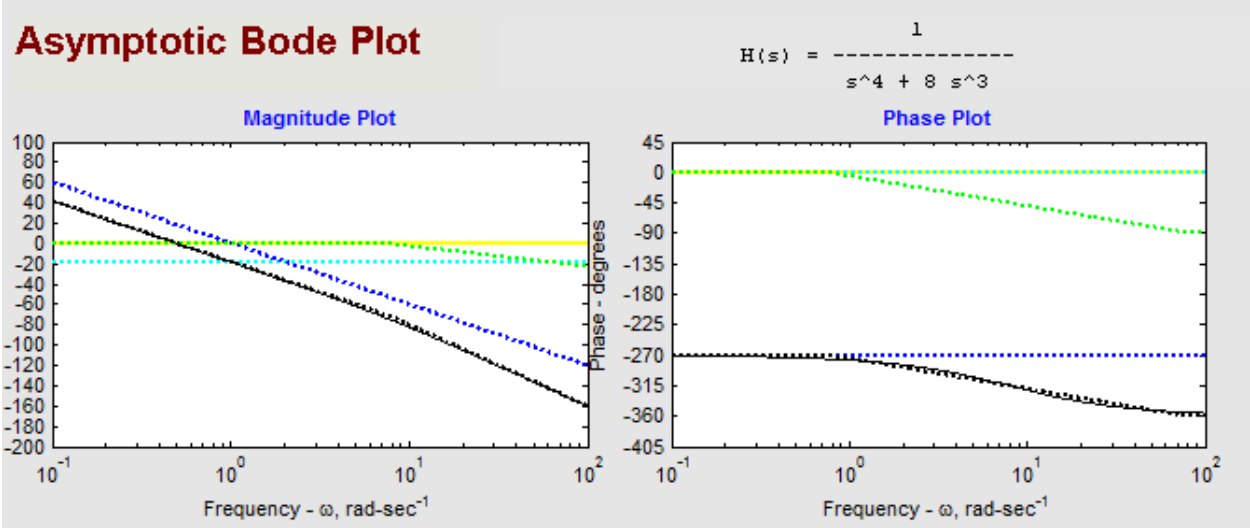
b)


Asymptotic Bode Plot
10 s + 40
H(s) = ----------
s^4 + 3 s^3 + 7 s^2 + 5 s
Magnitude Plot
Phase Plot
Phase - degrees
Frequency - ω, rad-sec-1
Frequency - ω, rad-sec-1

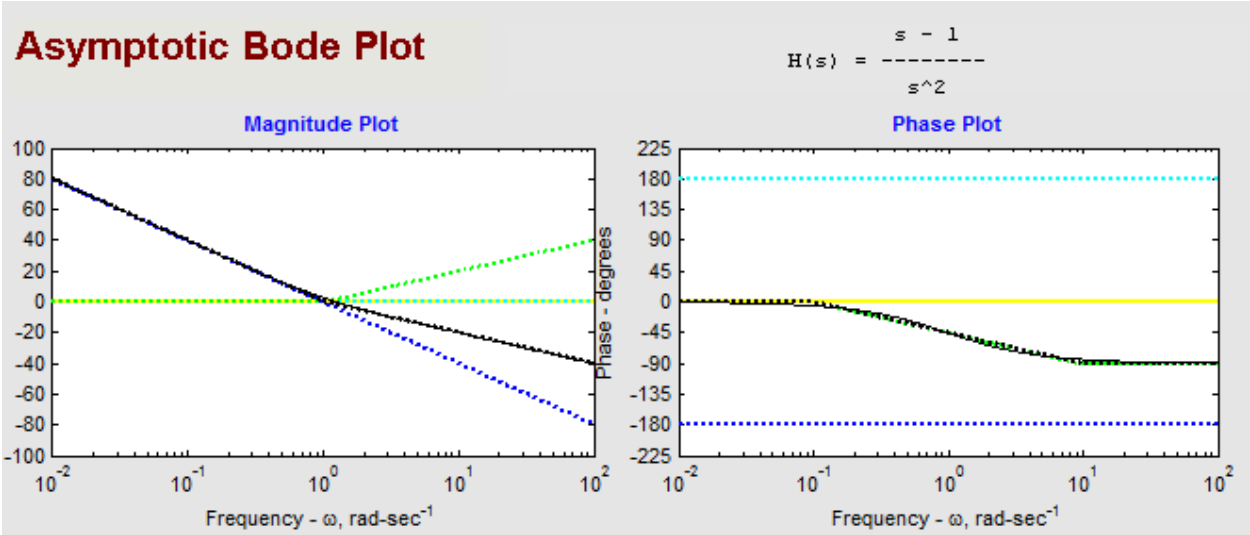
c)


Asymptotic Bode Plot
H(s) = 1 s^2 + 2 s + 8 / s^3 + 2 s^2 + 10 s
Magnitude Plot
Phase Plot
Phase - degrees
Frequency - ω, rad-sec-1
Frequency - ω, rad-sec-1

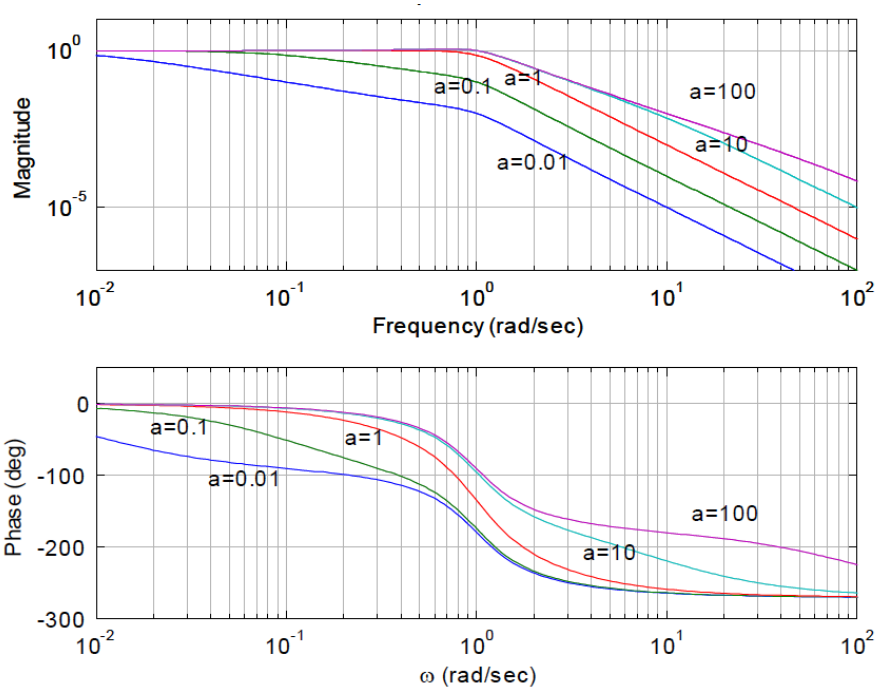
d)


Asymptotic Bode Plot
H(s) = 1 / s^4 + 8 s^3
Magnitude Plot
Phase Plot
Phase - degrees
Frequency - ω, rad-sec-1
Frequency - ω, rad-sec-1

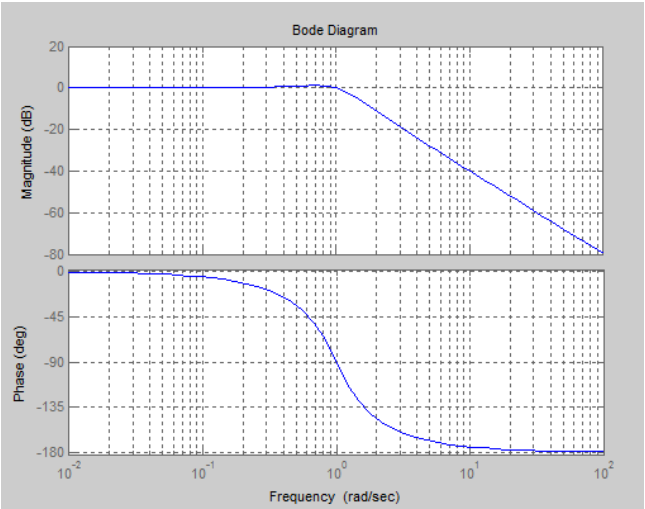
e)


Asymptotic Bode Plot
s - 1
H(s) = --------
s^2
Magnitude Plot
Phase Plot
Phase - degrees
Frequency - ω, rad-sec-1
Frequency - ω, rad-sec-1

Problem 2)



Without extra pole:



Conclusion – Bandwidth increases as the value of p increases and goes more close to the one without the pole being there. Thus the effect of the extra pole on the bandwidth is seen when it is close to the origin.

Problem 3

a) EOM: $I\ddot{\theta} + b\dot{\theta} + k\theta = T = K_m V$

▸ Since the problem says the pointer is damped a dumping coefficient b is introduced

$$\frac{\theta(s)}{V(s)} = \frac{K_m}{Is^2 + bs + k} = \frac{K_m/I}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$\omega_n = \sqrt{\frac{k}{I}} = \sqrt{\frac{4e\text{-}6}{40e6}} = 0.316$$

b) $M_p = 0.1$ → Given

$$M_p = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}$$

$$\ln 0.1 = \frac{-\pi\zeta}{\sqrt{1-\zeta^2}}$$

$$\zeta = 0.591$$

$$\omega_d = \omega_n\sqrt{1-\zeta^2} = 0.255$$

c) See Plot

$$\frac{\theta(j\omega)}{V(j\omega)} = \frac{K_m/I}{(j\omega)^2 + 2\zeta\omega_n(j\omega) + \omega_n^2}$$

$$\left|\frac{\theta(j\omega)}{V(j\omega)}\right| = \frac{K_m/I}{\sqrt{(\omega_n^2 - \omega^2)^2 + (2\zeta\omega_n\omega)^2}}$$

Maximize by setting the derivative of the magnitude with respect to ω to zero

$$\frac{d\left|\frac{\theta(j\omega)}{V(j\omega)}\right|}{d\omega} = \left(\frac{K_m}{I}\right)\frac{2\omega(\omega_n^2 - \omega^2 - 2\zeta^2\omega_n^2)}{((\omega_n^2-\omega^2)^2 + (2\zeta\omega_n\omega)^2)^{3/2}} = 0$$

$(\omega_n^2 - \omega_{max}^2 - 2\zeta^2\omega_n^2) = 0$

$\omega_{max} = \sqrt{(1-2\zeta^2)\omega_n^2} = 0.173$

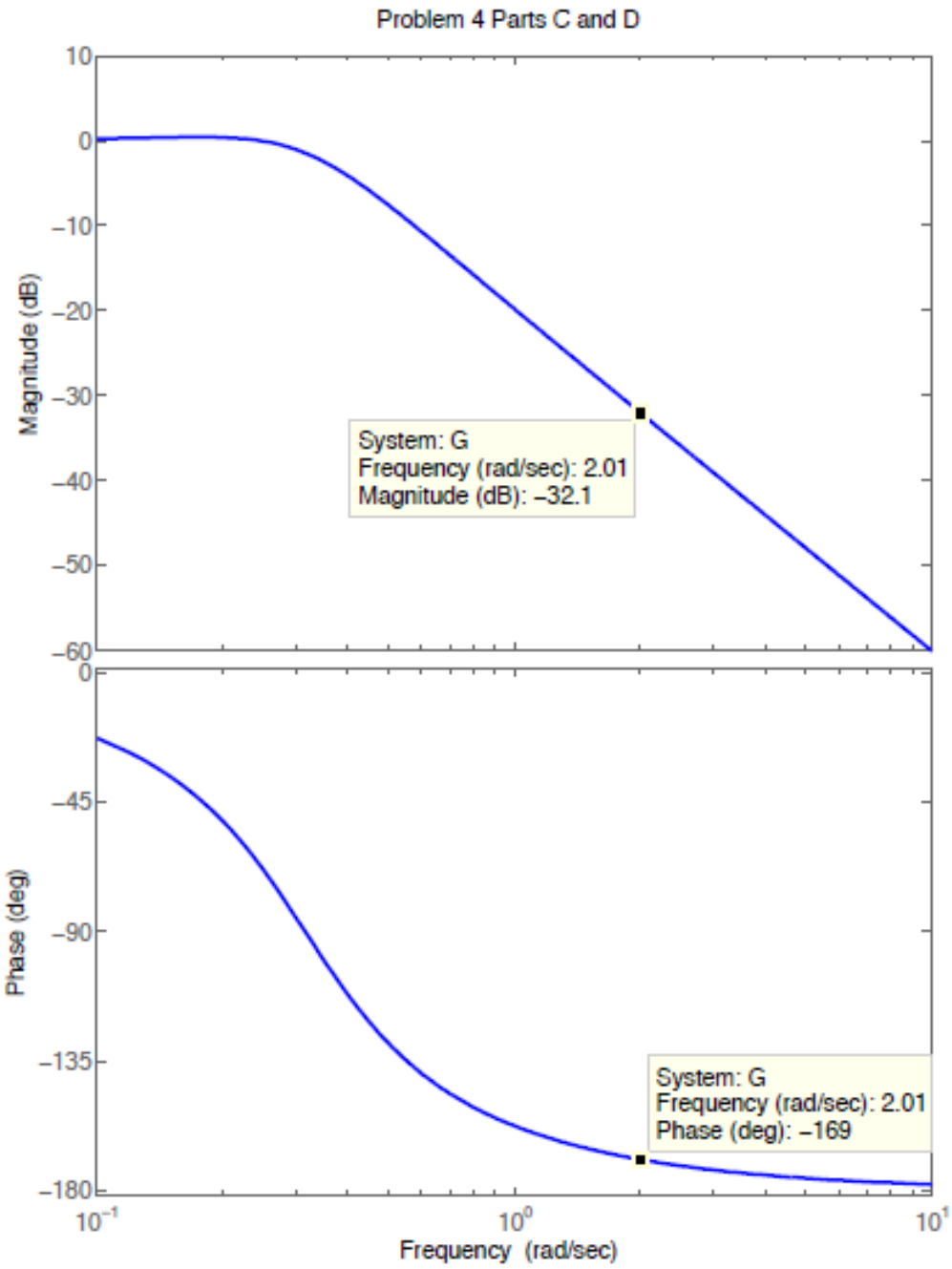
d) Using $K_m = 4 \times 10^{-6} \frac{Nm}{V}$

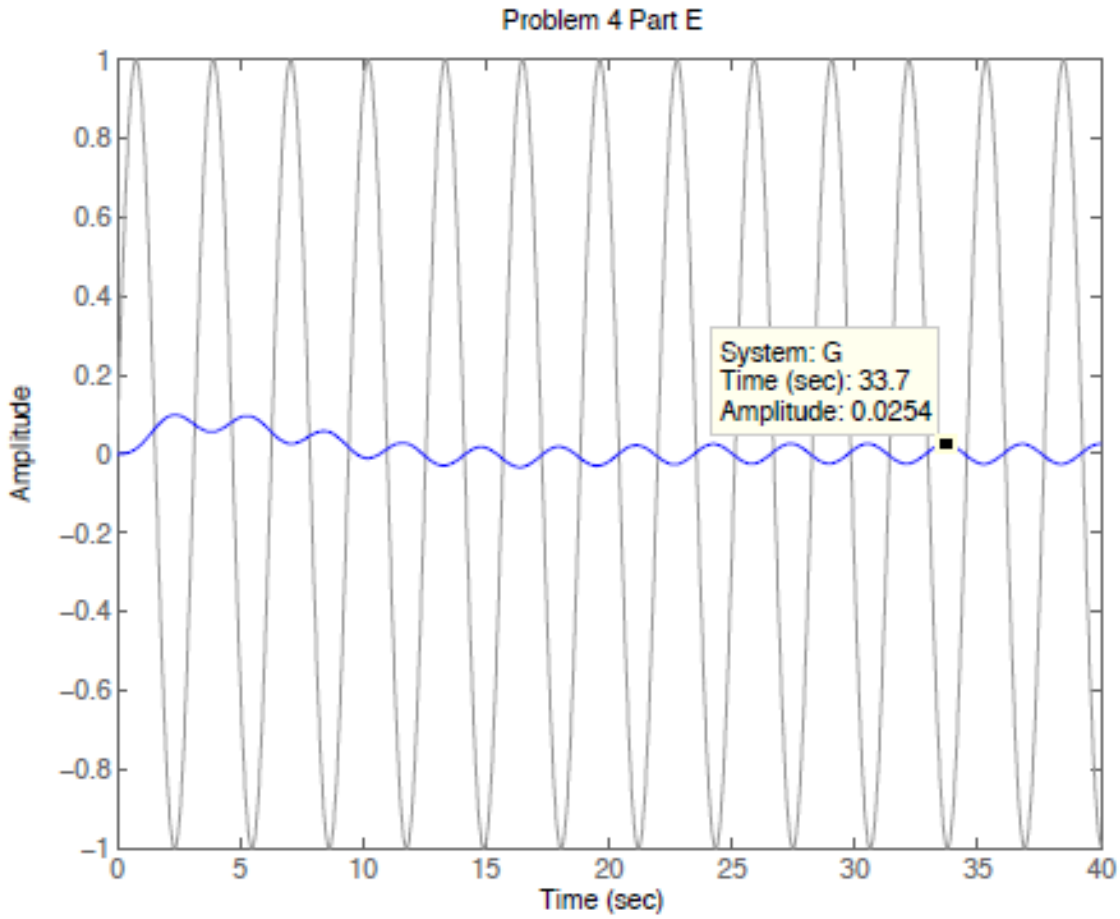
See Plot

i) Amplitude = $-32.1\,dB = 0.025$

ii) Phase = $-169°$

e) See Plot


Problem 4 Parts C and D
Magnitude (dB)
System: G
Frequency (rad/sec): 2.01
Magnitude (dB): –32.1
Phase (deg)
System: G
Frequency (rad/sec): 2.01
Phase (deg): –169
Frequency (rad/sec)



MATLAB code

```
zh = 0.591; wn = 0.316; Km = 4e-6; I = 40e-6;

G = (Km/I)/(s^2+2*zh*wn*s+wn^2);

bode(G)

t = 0:0.01:40;   u = sin(2*t);   lsim(G,u,t);
```