8. The Bode diagram of a system, $G(s)$, is shown in Figure Q8-1.

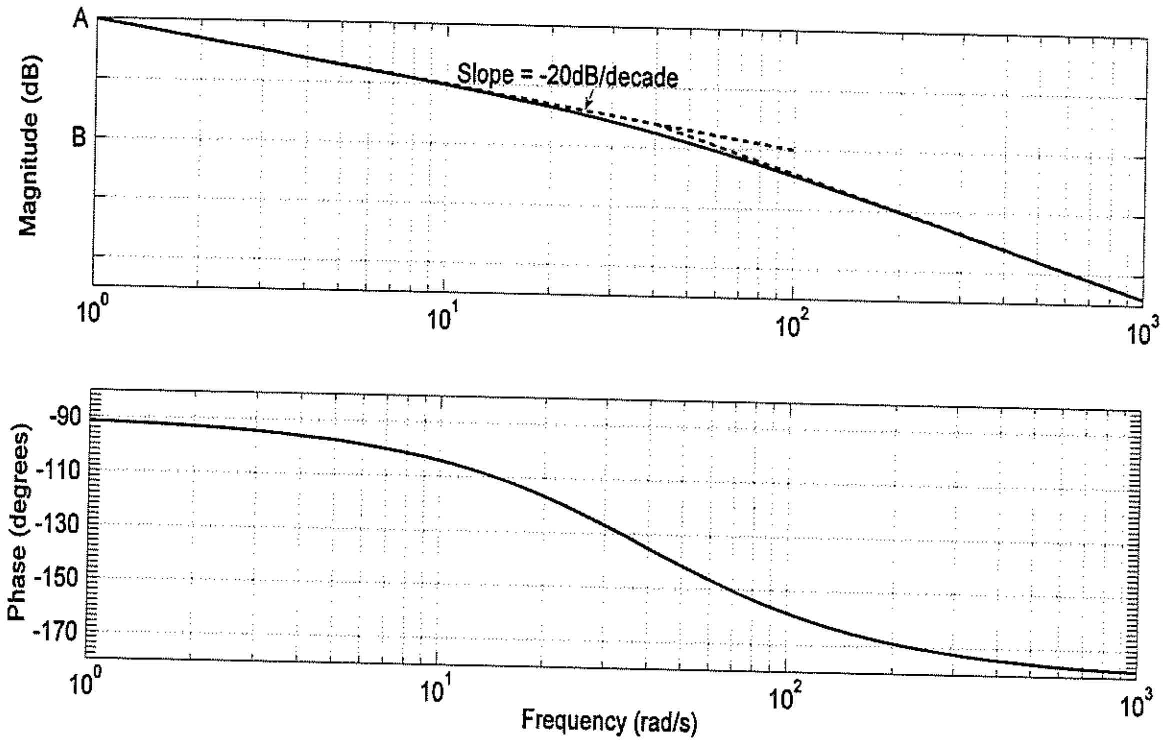

Figure Q8-1 : The Bode diagram of a system, $G(s)$.

The values on the y-axis of the Bode Magnitude diagram in Figure Q8-1 have not been marked, and needs to be deduced using the following information:

- The steady-state output signal for an input sinusoidal waveform, with an angular frequency **ω = 1 rad/s**, is also a sinusoidal waveform having the same frequency, but with an **amplitude 10 times** that of the input, and phase difference ϕ.

(a) What is the value of ϕ?

(2 marks)

(b) Determine the values of A and B on the y-axis of the Bode Magnitude diagram.

(4 marks)

(c) Identify the system transfer function, $G(s)$.

(6 marks)

(d) Suppose the input signal, $x(t)$, shown in Figure Q8-2 is applied to the system, $G(s)$.

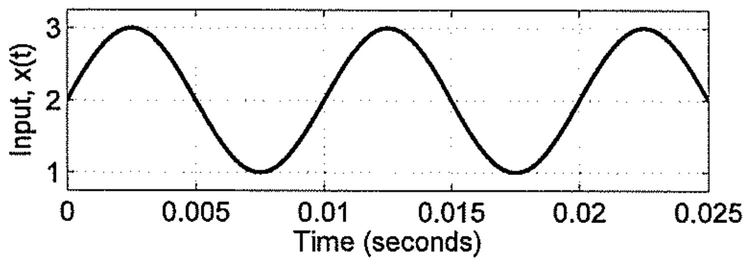

Figure Q8-2 : Input signal, $x(t)$

i. Derive the equation of the input signal, $x(t)$.

(3 marks)

ii. Explain why the output signal is essentially the step response of $G(s)$. Hence, or otherwise, sketch the output signal.

(5 marks)

END OF QUESTIONS

Q.7 (a) Consider a second order system with DC gain of K, unity damping ratio, undamped natural frequency of 3 rad/s and transportation delay of 0.1 seconds i.e.

$$G(s) = \frac{9Ke^{-0.1s}}{s^2 + 6s + 9}.$$

(i) Derive the steady state output signal of the second order system if the input signal is $7\cos(5t)$ and the DC gain, K, is 17.

(6 marks)

(ii) Suppose the desired amplitude of the steady state sinusoidal output signal is 36 when the input signal is $16\cos(5t + 15°)$. What should be the system DC gain?

(3 marks)

(b) Figure Q7 shows the Bode magnitude plot of a system with transfer function $H(s)$. Suppose the system is stable and does not have transportation delay.

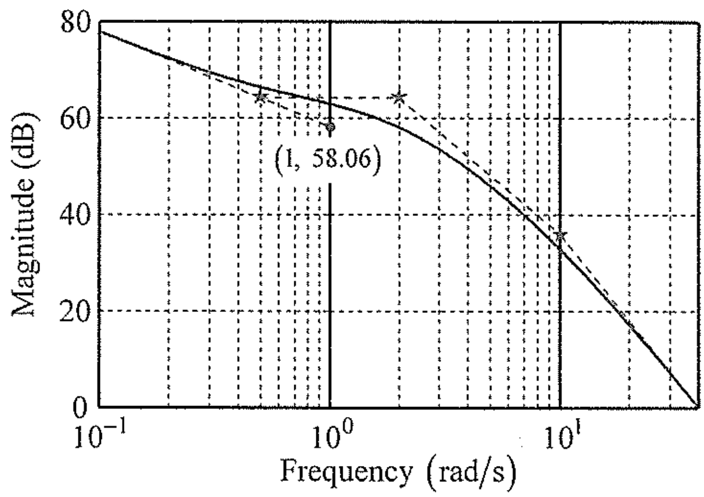

Figure Q7: Bode magnitude plot of $H(s)$

(i) Identify the transfer function, $H(s)$.

(7 marks)

(ii) Identify the error(s) in the following statement:

The low frequency asymptote of the Bode phase plot for $H(s)$ is a horizontal line at 90 degrees.

(2 marks)

(iii) Describe the high frequency asymptote of the Bode phase plot for $H(s)$.

(2 marks)

Q8. Figure Q8 shows the Bode magnitude plot of a machine with transfer function $G(s)$.

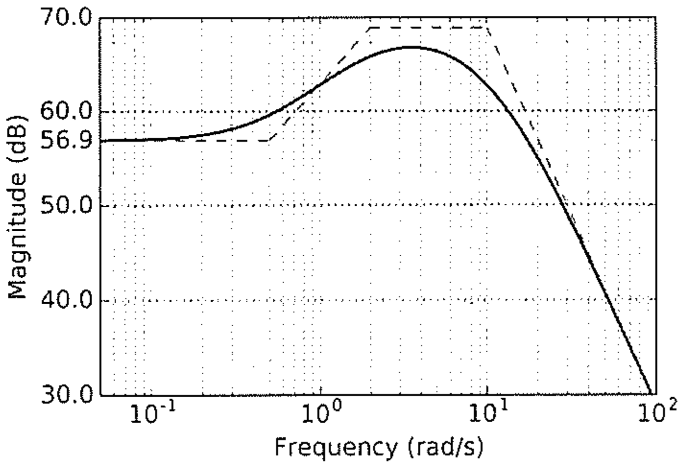

Figure Q8: Bode magnitude plot of $G(s)$.

(a) Suppose the machine is a stable system with no delay.

i. Identify the transfer function, $G(s)$.

(8 marks)

ii. Sketch the low frequency asymptote of the machine's Bode phase plot, clearly labelling the axes and important value(s).

(3 marks)

iii. Explain why $\measuredangle G(500j) = -270^o$ cannot be a valid point on the Bode phase plot for $G(s)$.

(3 marks)

(b) After extended use, the machine developed a delay. Experiments conducted revealed that $\measuredangle G(6j) = -151.4^o$. Assuming that the poles and zeros of the transfer function remain unchanged, determine the delay.

(6 marks)

END OF QUESTIONS

Q.8 Figure Q.8 shows the Bode magnitude plot of a system, whose transfer function is $G(s)$.

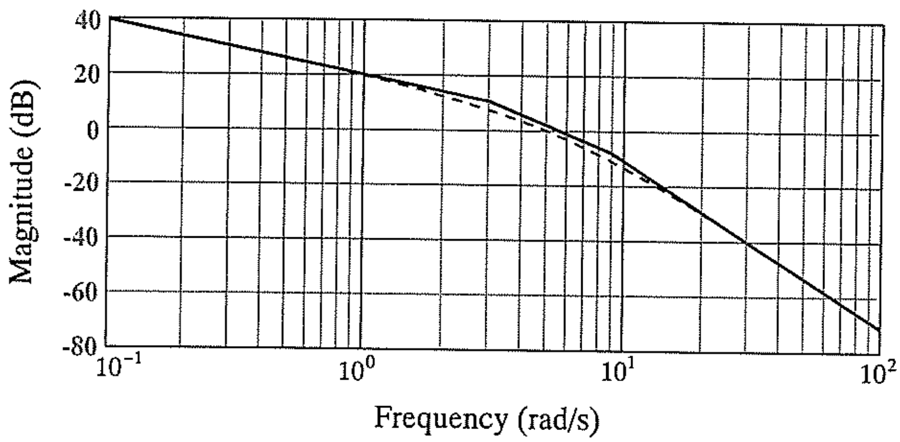

Figure Q.8: Bode magnitude plot of a system with transfer function $G(s)$

(a) Identify the transfer function, $G(s)$.

(6 marks)

(b) Describe the low frequency asymptote of the Bode phase plot for $G(s)$.

(2 marks)

(c) Determine the output signal of the system when the input signal $x(t) = 13\sin\left(0.8t + \frac{\pi}{4}\right)$ is applied.

(6 marks)

(d) Derive the impulse response of the system.

(6 marks)

END OF QUESTIONS