

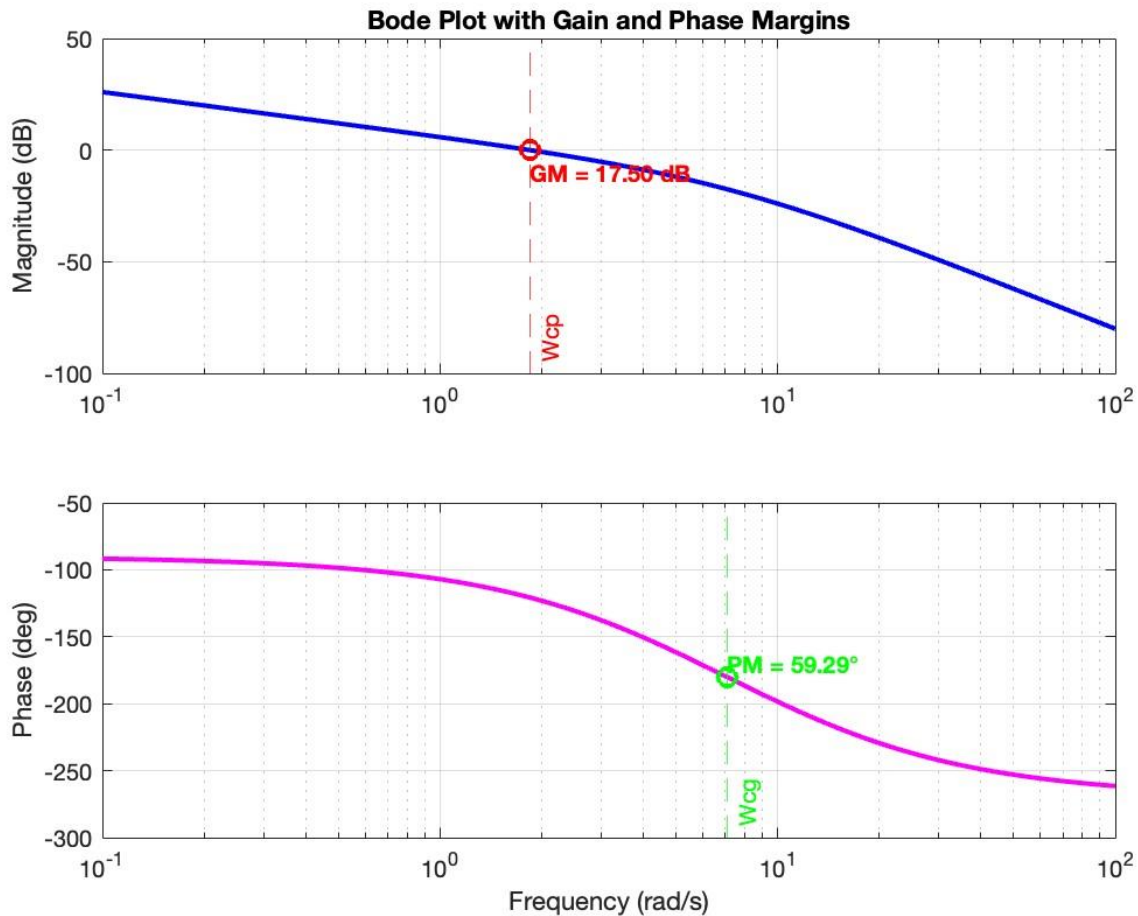
Question 2:

Using MATLAB, plot the Bode plot (both magnitude and phase) of the following transfer function and determine the system's gain margin, phase margin, gain crossover frequency, and phase crossover frequency:

$$G(s) = \frac{100}{s(s+5)(s+10)}$$

Instructions:

- Use MATLAB's `bode`, `margin`, or `bodeplot` functions to generate the plots.
- Label the critical frequencies and margins on the plot.
- Comment on the stability of the system based on the phase and gain margins.



Comments:

1. Gain Margin: 17.50 dB at 1.85 rad/s
2. Phase Margin: 59.29° at 7.07 rad/s
3. The system is stable.

Code:

```
clc;
clear;
close all;

% Define transfer function  $G(s) = 100 / [s(s+5)(s+10)]$ 
num = 100;
den = conv([1 0], conv([1 5], [1 10]));
G = tf(num, den);

% Compute gain & phase margins and crossover frequencies
[GM, PM, Wcg, Wcp] = margin(G);
GM_dB = 20*log10(GM);

% setting frequency range
w = logspace(-1, 2, 1000); % 0.1 to 100 rad/s
[mag, phase, wout] = bode(G, w);
mag = squeeze(mag); phase = squeeze(phase);

% Plot Bode diagram
figure('Color', 'w');
subplot(2,1,1);
semilogx(wout, 20*log10(mag), 'b', 'LineWidth', 2); hold on;
ylabel('Magnitude (dB)'); grid on;
title('Bode Plot with Gain and Phase Margins');

% Mark phase crossover (Wcp) for Gain Margin
if ~isnan(Wcp)
    mag_Wcp = interp1(wout, 20*log10(mag), Wcp);
    plot(Wcp, mag_Wcp, 'ro', 'MarkerSize', 8, 'LineWidth', 2);
    xline(Wcp, 'r--', 'Wcp', 'LabelVerticalAlignment', 'bottom');
    text(Wcp, mag_Wcp-10, sprintf('GM = %.2f dB', GM_dB), 'Color', 'r', 'FontWeight', 'bold');
end

subplot(2,1,2);
semilogx(wout, phase, 'm', 'LineWidth', 2); hold on;
```

```
ylabel('Phase (deg)'); xlabel('Frequency (rad/s)'); grid on;
```

```
% Mark gain crossover (Wcg) for Phase Margin
```

```
if ~isnan(Wcg)
```

```
    phase_Wcg = interp1(wout, phase, Wcg);
```

```
    plot(Wcg, phase_Wcg, 'go', 'MarkerSize', 8, 'LineWidth', 2);
```

```
    xline(Wcg, 'g--', 'Wcg', 'LabelVerticalAlignment', 'bottom');
```

```
    text(Wcg, phase_Wcg+10, sprintf('PM = %.2f°', PM), 'Color', 'g', 'FontWeight', 'bold');
```

```
end
```