ASSIGNMENT 3

Due date: Sep 23, 2025 (4 PM)

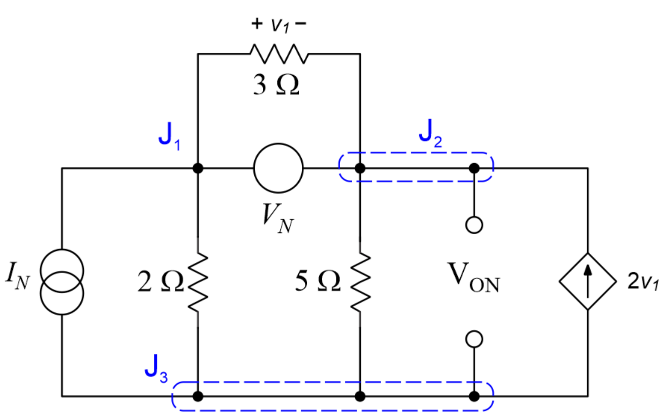
Relevant Class Notes	**Assessment Criteria**
Electronic Circuits (§ 15, 17, 18, 21, 23) Transfer Functions Bode Plots	Apply one or more procedure(s) to a problem. Write a MATLAB script to analyze a problem. Analyze a problem and obtain a correct result. Interpret observations / results. Provide short answers to questions.

Manage your time. Having problems with the assignment? Discuss them with the instructor!

Attachment03.zip accompanies this assignment and contains needed MATLAB files.

1. (2.6/10)

In the circuit shown below the independent sources are noise sources. (There is no ‘known’ deterministic input source to the system. This problem is just noise analysis.)



v_1 is a controlling variable and must be solved for. Note that it establishes the current direction through the 3Ω resistance.)

a) Using the circuit-solving technique shown in class, write down the network equations required to determine the output noise, V_{ON}. Do not solve the equations.

Tips:

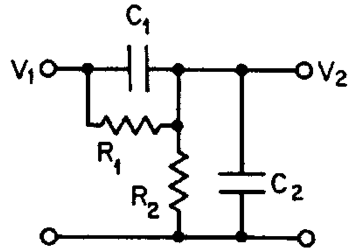
You may leave all sources on as symbols while determining the network equations. Superposition can be performed in MATLAB, when solving the equations, by only turning on one source at a time.

Junctions $J_{2\text{-}3}$ are ‘supernodes’. In each supernode, the constituent nodes may be thought of as creating one large node for the sake of KCL.

b) For the case where $V_N = 1V_{rms}$ and $I_N = 2A_{rms}$, solve the network equations using MATLAB and determine V_{ON}. Attach your code.

c) From the output noise level determined in (b) what is the peak-to-peak noise for this system?

2. (2/10)



a) Using the transform network technique, show that the transfer function, $V_2(s)/V_1(s)$, is:

$$\frac{V_2(s)}{V_1(s)} \propto \frac{1+\tau_1 s}{1+\tau_2 s}$$

where,

$$\tau_1 = R_1 C_1 \qquad\qquad \tau_2 = \frac{R_1 R_2}{R_1 + R_2}(C_1 + C_2)$$

Tip: Consider that $C_1||R_1$ is in series with $R_2||C_2$ and use the formulae of parallel impedances and the voltage divider rule to analyze the system. (Redrawing the circuit may help.)

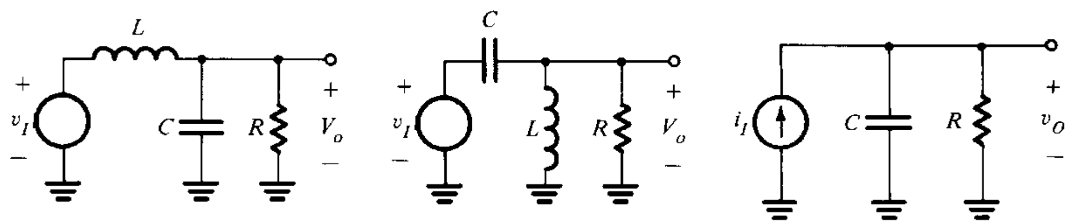
(b) Find the relationship between the components to make the system static (i.e., independent of frequency or 's').

(c) What is the static system gain?

3. (1.2/10)

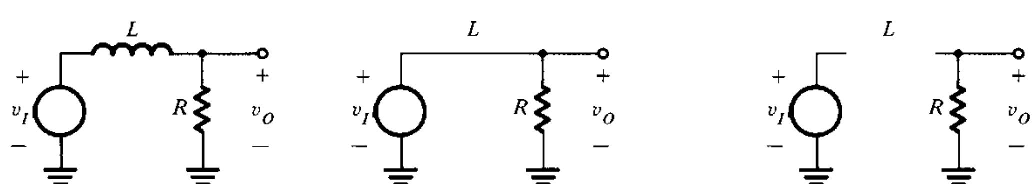
The intent of this question is to help you develop a feeling for the general frequency response of a system by examining how the reactance of components varies with frequency.

Use the general way that the reactance of a component varies with frequency to classify the following networks as either having a "high-pass" or a "low-pass" response with respect to their input variable, v_I or i_I, and output variable, v_O. Do not compute the system transfer functions. Test each network at low and high frequencies.



(a) (b) (c)

For example,



Hence, the system is low-pass.

Given this…

Low-frequency circuit: $v_O = v_I$.

High-frequency circuit: $v_O = 0$.

4. (1.2/10)

Load *Q4.mat*, in *Assignment03.zip*, into the MATLAB workspace.

The workspace now contains system transfer functions *H4a* and *H4b*. You may view each transfer function by typing its name at the command prompt.

For each transfer function:

i) Plot the system's pole-zero diagram.

ii) From the pole-zero diagram, determine whether the system is stable.

- If the system is unstable comment as to what specifically makes is unstable.
- If the system is stable determine the system time constant(s).

iii) Plot the system unit-step response.

- Where applicable plot the response over sufficient time to show the system steady state.

See the relevant MATLAB functions at the end of this assignment.

5. (2/10)

Load *Q5.mat*, in *Assignment03.zip*, into the MATLAB workspace.

The workspace now contains system transfer functions *H5a* and *H5b*. You may view each transfer function by typing its name at the command prompt.

For each system transfer functions $Y(s)/X(s) = H5i(s)$, where $i = a, b$, use the bode function in MATLAB to help you compute the sinusoidal steady-state output $y(t)$ for: $x(t) = 2\cos(3t - 45^\circ)$, where possible.

Note that you do not have to evaluate inverse Laplace transforms to answer this question.

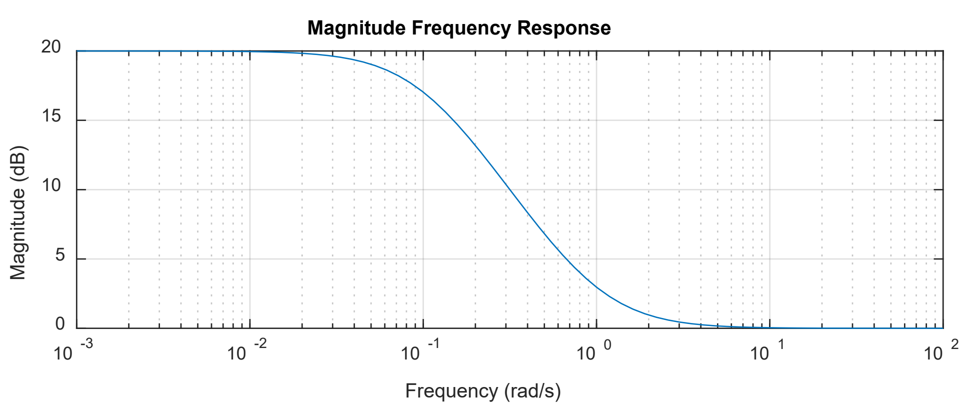
6. (1/10)

Based on Bode plotting techniques, which of the magnitude frequency responses shown below corresponds to the following transfer function?

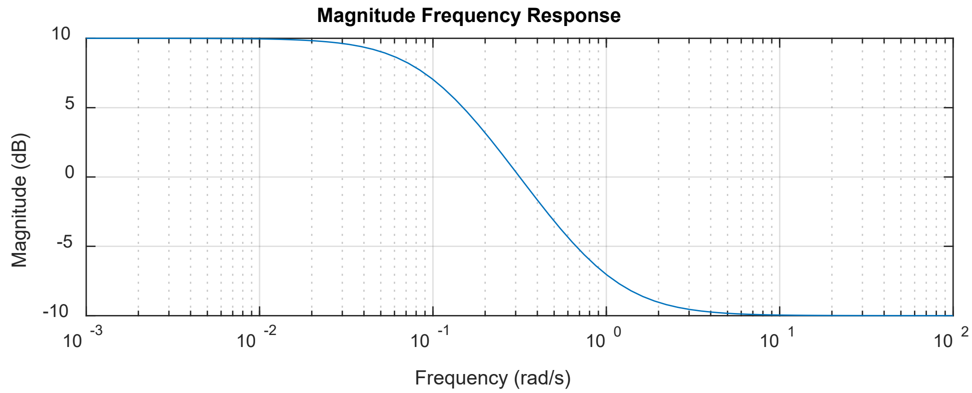
$$H(s) = 10\frac{s+1}{10s+1}$$

<u>Briefly</u> justify your answer.

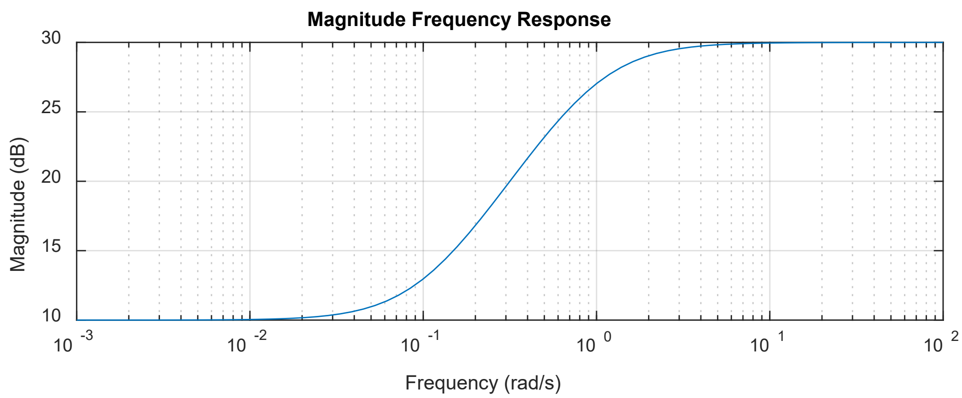
a)



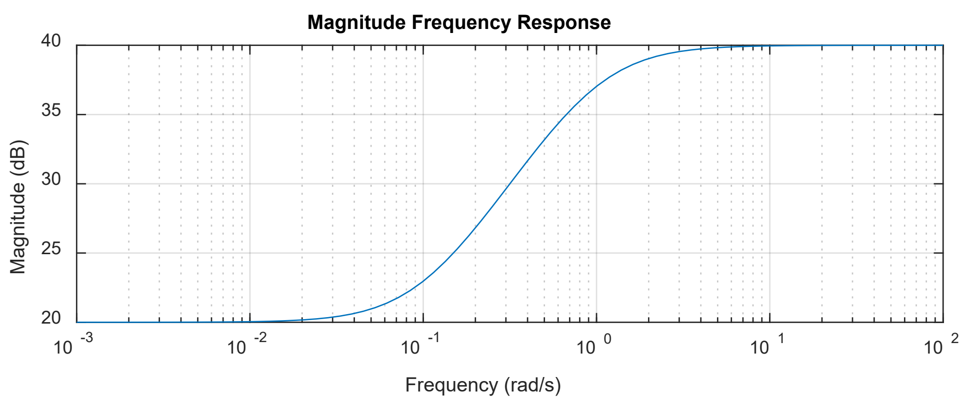
b)


Magnitude Frequency Response
10
5
0
-5
-10
Magnitude (dB)
10 -3
10 -2
10 -1
10 0
10 1
10 2
Frequency (rad/s)

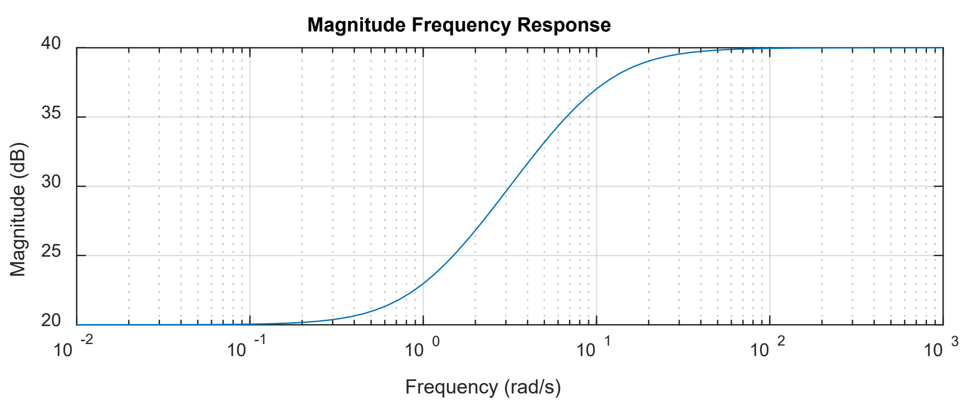
c)


Magnitude Frequency Response
30
25
20
15
10
Magnitude (dB)
10 -3
10 -2
10 -1
10 0
10 1
10 2
Frequency (rad/s)

d)


Magnitude Frequency Response
40
35
30
25
20
Magnitude (dB)
10 -3
10 -2
10 -1
10 0
10 1
10 2
Frequency (rad/s)

e)


Magnitude Frequency Response
40
35
30
25
20
Magnitude (dB)
10 -2
10 -1
10 0
10 1
10 2
10 3
Frequency (rad/s)

7.(0.5/10) Bonus

Report the amount of time spent on this assignment.

Relevant MATLAB function(s):

bode	Frequency response evaluation of dynamic systems (Use the form [MAG,PHASE] = bode(SYS,W) to get magnitude and phase at a specified frequency.)
pole/zero	Computes the poles or zeros of a transfer function object.
pzmap	Computes the poles and zeros of a dynamic system and plots them in the complex s-plane.
roots	Computes the roots of a polynomial.
step	Plots the unit-step response of a system.
tfdata	Returns the numerator and denominator of a transfer function object as polynomial coefficients. (Use form tfdata(SYS, 'v') to get the coefficients in vector form rather than in a cell array.)
\	Left matrix divide. x = A\y is the solution to the equation Ax = y computed by Gaussian elimination. See example below.

Functions from previous assignments may also be useful.

Example of solving a linear system of equations

You have the system of three equations shown to the right and wish to solve for the x_i for the two cases of the y vector (e.g., a superposition application).

	Case 1	Case 2
$2x_1 + x_2 + x_3 = y_1$ $x_1 - x_2 + 4x_3 = y_2$ $x_1 + 2x_2 - 2x_3 = y_3$	$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 3 \end{bmatrix}$	$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 3 \\ 6 \end{bmatrix}$

```
>> A = [2  1  1;
        1 -1  4;
        1  2 -2];

y = [1 0 3;
     2 3 6].';

x = A\y

x =

   -3   -10
    5    15
    2     7
```

The problem may be formulated in MATLAB as shown to the left. (The y matrix could also have been constructed as follows: y = [1 2; 0 3; 3 6].)

Type *help ops* at the MATLAB prompt to obtain help on operators.

Rather than solving the matrix equation twice, once for each case, the y column for each case is stacked into a 3x2 matrix allowing each case to be solved in one operation. As shown, the i^{th} column of x is the solution for the i^{th} case of y.

That is, for $(y_1, y_2, y_3) = (2, 3, 6)$ the solution is $(x_1, x_2, x_3) = (-10, 15, 7)$.