UNIVERSITY
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IN DUBAI

Assignment Cover Sheet

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Subject code and name	ECTE202 – Circuits and Systems
Lab Instructor	Ms. Eva Barbulescu
Title of Assignment	Lab 5
Lab Number	5

Student declaration and acknowledgment

By submitting this assignment online, the submitting student declares on behalf of the team that:

1. All team members have read the subject outline for this subject, and this assessment item meets the requirements of the subject detailed therein.
2. This assessment is entirely our work, except where we have included fully documented references to the work of others. The material in this assessment item has yet to be submitted for assessment.
3. Acknowledgement of source information is by the guidelines or referencing style specified in the subject outline.
4. All team members know the late submission policy and penalty.
5. The submitting student undertakes to communicate all feedback with the other team members.

Lab 5

Task 1: Transfer Function of a First Order Circuit

RC Circuit

Calculations:

Applying Kirchhoff's Law,

$$V_{in} = V_C + V_R$$

For a capacitor,

$$i_c(t) = C\frac{dv(t)}{dt}$$

Taking the Laplace transform (assuming zero initial conditions):

$$I(s) = CsV_C(s)$$

Since $V_C = V_0$,

$$I(s) = CsV_0(s)$$

Substituting for the resistor,

$$V_R(t) = IR = CsV_0(s)R$$

Substituting,

$$V_{in} = V_0 + CsV_0R$$

$$V_{in} = V_0(1 + CsR)$$

$$H = \frac{V_0}{V_{in}} = \frac{1}{1 + CsR} = \frac{1}{1 + (5 \times 2)s} = \frac{1}{10s\ +\ 1}$$

```matlab
% Circuit Parameters
R = 5; % Resistance in ohms
C = 2; % Capacitance in Farads

% Transfer Function Coefficients
num = [1]; % Numerator Coefficients
den = [R*C 1]; % Denominator Coefficients = [10 1]

% Create Transfer Function
H = tf(num, den);

% Generate Bode Plot and get data
[mag, phase, w] = bode(H);
mag = squeeze(mag);
phase = squeeze(phase);
w = squeeze(w);
mag_dB = 20*log10(mag);

disp(table(w, mag_dB, phase, 'VariableNames', {'Frequency_rad_s',
'Magnitude_dB', 'Phase_deg'}));

% Generate Bode Plot
bode(H);
grid on;

% Display transfer function
disp(H);
```

Decline begins at 0.1000 rad/s with magnitude -3.0103 dB

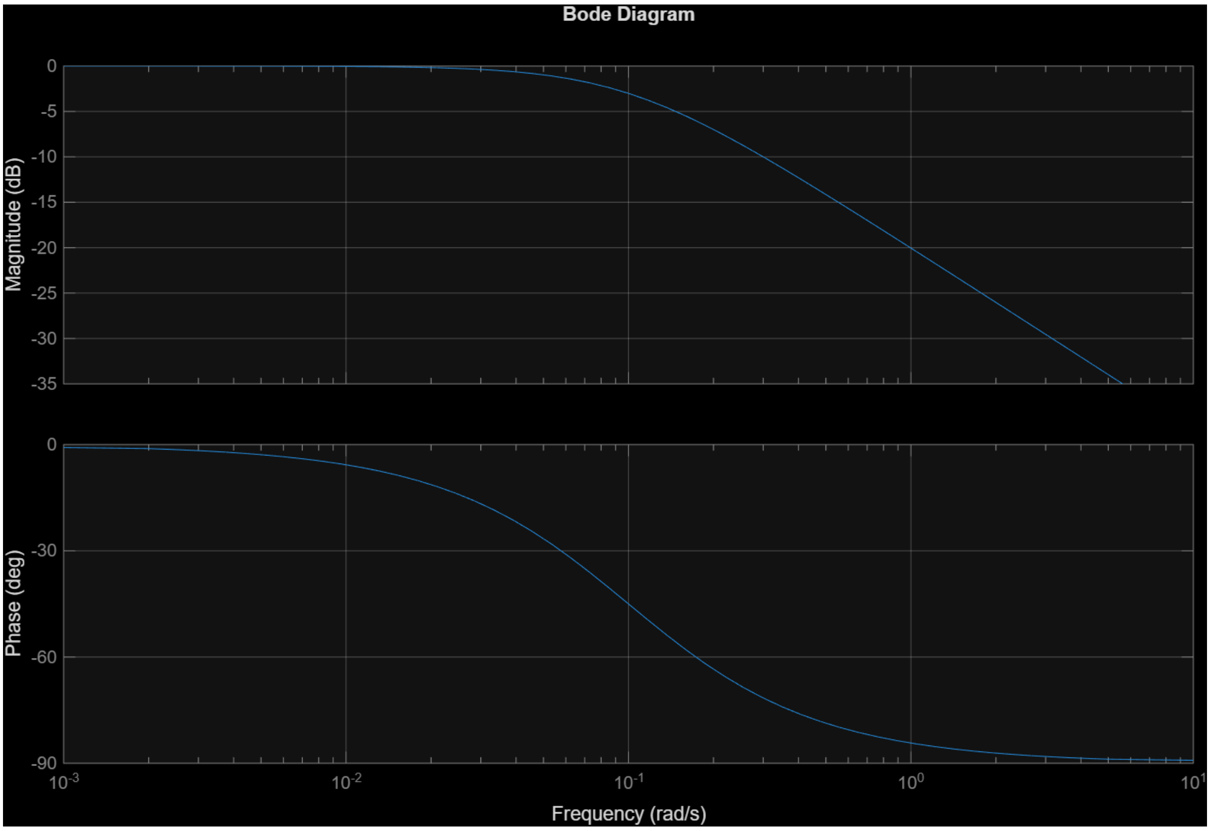
At -3 dB point: Frequency: 0.1000 rad/s

Filter type: This is a low-pass filter because the magnitude starts at 0 dB and declines.

Magnitude and phase values:

Frequency_rad_s	Magnitude_dB	Phase_deg
0.001	-0.00043427	-0.57294
0.002	-0.0017368	-1.1458
0.0023388	-0.0023749	-1.3398
0.0027349	-0.0032473	-1.5666
0.0031982	-0.0044399	-1.8318

0.0037399	-0.0060703	-2.1418
0.0043734	-0.0082988	-2.5042
0.0051143	-0.011344	-2.9277
0.0059806	-0.015506	-3.4225
0.0069936	-0.02119	-4.0005
	...	
1.4299	-23.127	-85.999
1.6721	-24.481	-86.577
1.9553	-25.836	-87.072
2.2865	-27.192	-87.496
2.6738	-28.549	-87.858
3.1268	-29.906	-88.168
3.6564	-31.264	-88.433
4.2757	-32.623	-88.66
5	-33.981	-88.854
10	-40	-89.427



RL Circuit

Calculations:

Applying Kirchhoff's Law,

$$V_{in} = V_L + V_R$$

For an inductor,

$$v_L = L\frac{di(t)}{dt}$$

Taking the Laplace transform (assuming zero initial conditions):

$$V_L(s) = sLI(s)$$

Substituting,

$$V_{in} = IR + sLI$$

$$V_{in} = I(R + sL)$$

$$I = \frac{V_{in}}{R + sL}$$

$$H = \frac{V_0}{V_{in}} = \frac{sLI}{V_{in}} = \frac{sLV_{in}}{V_{in}(R + sL)}$$

$$H = \frac{sL}{R + sL} = \frac{2s}{2s + 3}$$

```
% Circuit Parameters
R = 3; % Resistance in ohms
L = 2; % Inductance in Henries

% Transfer Function Coefficients
num = [L 0]; % Numerator Coefficients
den = [L R]; % Denominator Coefficients

% Create Transfer Function
H = tf(num, den);

% Generate Bode Plot and get data
[mag, phase, w] = bode(H);
mag = squeeze(mag);
phase = squeeze(phase);
w = squeeze(w);
mag_dB = 20*log10(mag);

disp(table(w, mag_dB, phase, 'VariableNames', {'Frequency_rad_s',
'Magnitude_dB', 'Phase_deg'}));

% Generate Bode Plot
bode(H);
grid on;

% Display transfer function
disp(H);
```

Incline begins at 0.1667 rad/s with magnitude -19.1 dB

At -3 dB point: Frequency: 1.5 rad/s

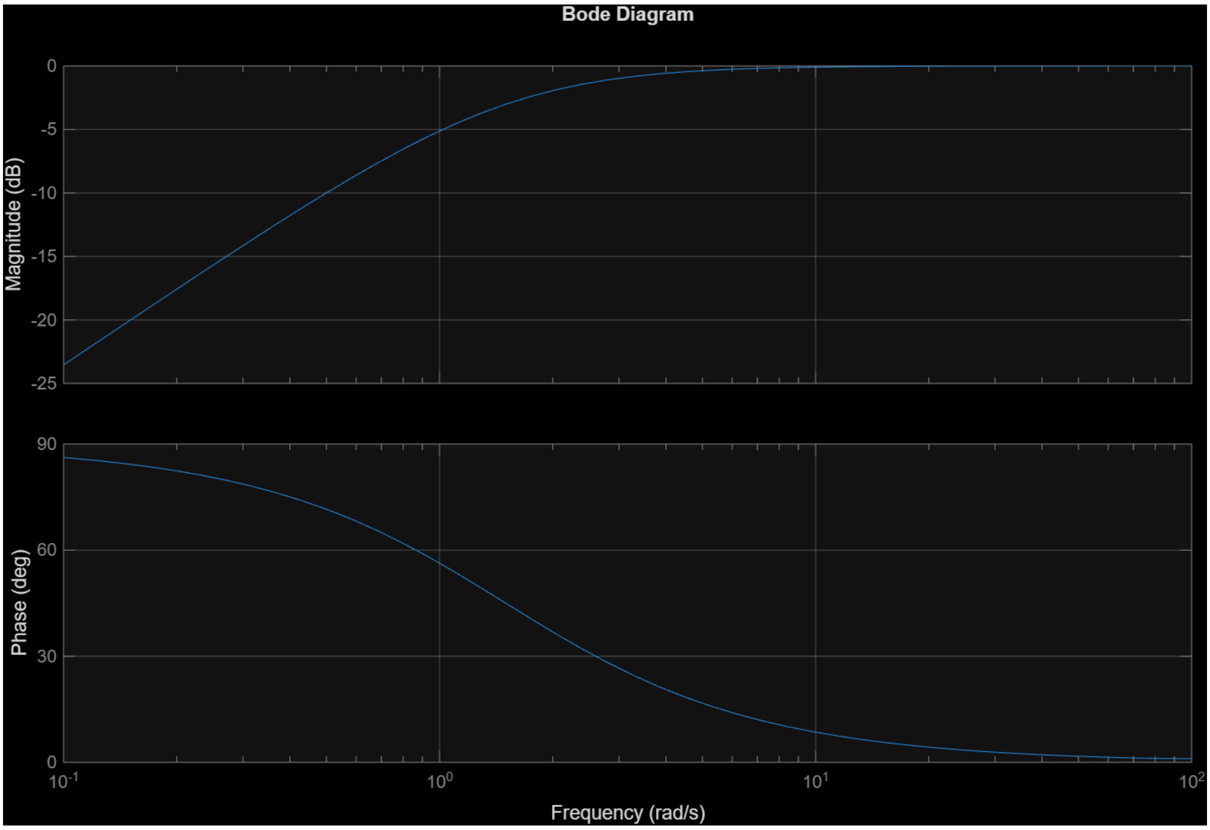
This is a high-pass filter because the magnitude increases.

Magnitude and phase values:

```
    Frequency_rad_s    Magnitude_dB    Phase_deg
    _______________    ____________    _________


           0.01           -43.522        89.618
           0.03           -33.981        88.854
       0.035082           -32.623         88.66
```

0.041024	-31.264	88.433
0.047973	-29.906	88.168
0.056099	-28.549	87.858
0.065602	-27.192	87.496
0.076714	-25.836	87.072
0.089708	-24.481	86.577
0.1	-23.541	86.186
0.1049	-23.127	85.999
0.12267	-21.776	85.325
0.14345	-20.427	84.537
	...	
46.901	-0.0044399	1.8318
54.846	-0.0032473	1.5666
64.136	-0.0023749	1.3398
75	-0.0017368	1.1458
100	-0.00097705	0.85937



Comparision between RC and RL Circuit:

- The RC circuit behaves as a **low-pass filter**, meaning it allows low-frequency signals to pass while attenuating higher frequencies.
- The RL circuit acts as a **high-pass filter**, meaning it blocks low-frequency signals and allows higher frequencies to pass.
- In the **Bode plot**, the RC circuit's magnitude **gradually declines**, while the RL circuit's magnitude **gradually increases** after a certain point.
- The -3dB cutoff frequency of the **RC circuit** is **0.1 rad/s**, whereas for the **RL circuit**, it is **1.5 rad/s**.

Task 2: RLC Parallel Circuit

Calculations:

Given Values

$$R_1 = 2\Omega, \quad R_2 = 4\Omega, \quad L = 1H, \quad C = 0.1F$$

Using Laplace Transformations:

$$\text{Inductor:} \quad sL = s \cdot 1 = s$$

$$\text{Capacitor:} \quad \frac{1}{sC} = \frac{1}{s \cdot 0.1} = \frac{10}{s}$$

Parallel Impedance

$$Z_p = \left(\frac{1}{R_2} + \frac{1}{Z_C}\right)^{-1} = \left(\frac{1}{4} + \frac{s}{10}\right)^{-1}$$

$$Z_p = \left(\frac{10 + 4s}{40}\right)^{-1} = \frac{40}{10 + 4s} = \frac{20}{5 + 2s}$$

Series Impedance

$$Z_s = R_1 + sL = 2 + s$$

Using Voltage Divider Rule

$$H = \frac{Z_p}{Z_s + Z_p} = \frac{\frac{20}{5 + 2s}}{(2 + s) + \frac{20}{5 + 2s}}$$

$$H = \frac{20}{(2 + s)(5 + 2s) + 20} = \frac{20}{2s^2 + 9s + 30}$$

$$H = \frac{10}{s^2 + 4.5s + 15}$$

```
% Circuit Parameters
R1 = 2;     % Ohms
L1 = 1;     % Henry
R2 = 4;     % Ohms
C1 = 0.1;   % Farad

% Transfer Function Coefficients
num = [10];           % Numerator: 10
den = [1 4.5 15];     % Denominator: s² + 4.5s + 15

% Create Transfer Function
H = tf(num, den);

% Generate Bode Plot and get data
[mag, phase, w] = bode(H);
mag = squeeze(mag);
phase = squeeze(phase);
w = squeeze(w);
mag_dB = 20*log10(mag);

disp(table(w, mag_dB, phase, 'VariableNames', {'Frequency_rad_s',
'Magnitude_dB', 'Phase_deg'}));

% Generate Bode Plot
bode(H);
grid on;

% Display transfer function
disp(H);
```

Decline begins at 3 rad/s with magnitude -3.44 dB

At -3 dB point: The line does not have any value at -3dB. The line starts at 0 rad/s with a magnitude of -3.52dB.

Filter type: This is a low-pass filter because the magnitude starts at 0 dB and declines.

The Bode magnitude plot declines because the system is a second-order low-pass filter with two poles and no zeros

Magnitude and phase values:

```
    Frequency_rad_s    Magnitude_dB    Phase_deg
    _______________    ____________    _________

          0.1            -3.5199        -1.7195
```

0.10592	-3.5197	-1.8214
0.12387	-3.5189	-2.1303
0.14485	-3.5179	-2.4917
	...	
18.52	-30.589	-165.74
21.657	-33.337	-167.89
25.325	-36.078	-169.69
29.615	-38.813	-171.21
34.631	-41.544	-172.5
40.497	-44.272	-173.6
47.357	-46.997	-174.54
55.379	-49.72	-175.33
64.76	-52.442	-176.01
75.729	-55.163	-176.59
88.557	-57.883	-177.09
100	-59.996	-177.42