Mid-term Exam

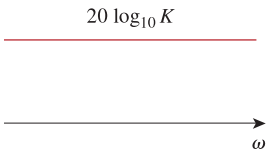
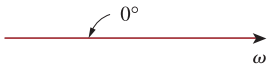
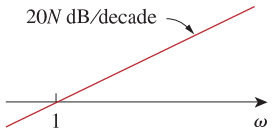
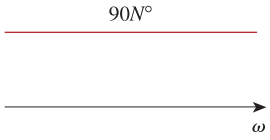
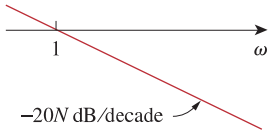
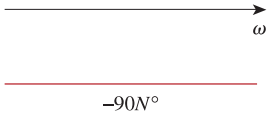
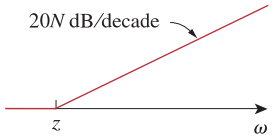
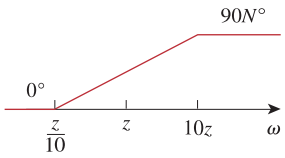
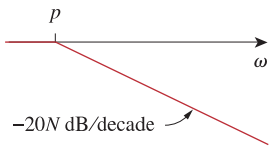
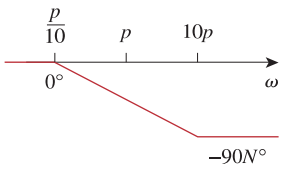
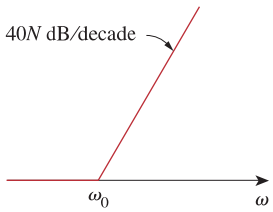
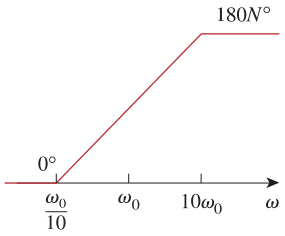
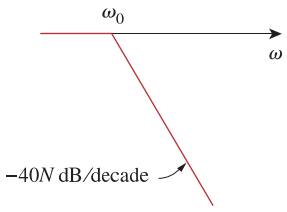
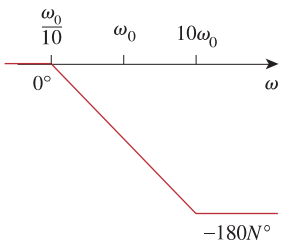
EE1C21 “Linear Circuits B”

Place:
Date:
Time:

- This exam consists of 4 exercises.
- Each exercise accounts for **10 points**; the total number of points to be obtained is **40**. The grade is obtained dividing the total number of points by 4, rescaling linearly the result to the 1-10 scale and rounding off to 1 decimal.
- **Each exercise must be solved on a separate double-sheet.** Writing more solutions on the same sheet may result in only one of the solutions being graded!
- Indicate your name and study number on **each** submitted sheet. **You must hand in (blank) signed sheets even for the exercises that you do not handle.**
- Students benefitting of the “Extra Time” (ET) rule are entitled to a 20 minutes extension of their exam provided they produce the relevant supporting document.
- Should any question not be completely clear, you are allowed to ask the instructors in the exam hall; the answer will be confined to rephrasing the text of the exercise such that to make it more intelligible.
- Should a part of an exercise depend on a previous result, mistakes made at a previous step will only be penalised once.
- Give your solution as completely as possible and never state numerical results without indicating how you derived them. **Simply stating numerical results will yield no points.**
- **Fill in the measure units for all calculated quantities.** This holds for intermediate results but definitely for the final ones.
- Write clearly; avoid messy solutions; should errors occur in your solution, cross the erratic part out and give clear indication on where the correct solution resumes.
- For this exam you are allowed to use:
    i. a simple calculator – programmable and graphing calculators are explicitly prohibited;
    ii. a handwritten, double-sided A4 sheet with formulas.
- This exam is provided only in English. Instructors will provide assistance with the Dutch translation of formulations that you may have difficulties to understand.

The Linear Circuits team wishes you a lot of success!

Summary of Bode straight-line magnitude and phase plots.

Factor	Magnitude	Phase
K		
$(j\omega)^N$		
$\frac{1}{(j\omega)^N}$		
$\left(1+\frac{j\omega}{z}\right)^N$		
$\frac{1}{(1+j\omega/p)^N}$		
$\left[1+\frac{2j\omega\zeta}{\omega_0}+\left(\frac{j\omega}{\omega_0}\right)^2\right]^N$		
$\frac{1}{[1+2j\omega\zeta/\omega_0+(j\omega/\omega_0)^2]^N}$		

- Take a new double-sheet -

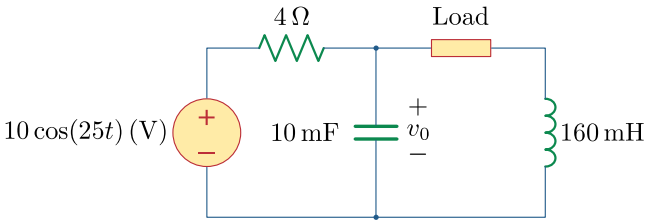
Exercise 1

a) By using the phasor-domain representation, determine the current $i(t)$ given by the expression:

$$9i + 14\int i\mathrm{d}t + 2\frac{\mathrm{d}i}{\mathrm{d}t} = 18\cos(7t + 45°)\ .$$

Give the final answer in the form $A\cos(\omega t + \varphi°)$. (4 points)

Now consider the following circuit, in which "load" is a *passive* circuit section:



b) By knowing that the phasor-domain correspondent of v_0 is $\boldsymbol{V}_0 = 5\angle 0°$, determine the complex impedance $\boldsymbol{Z}$ of the load. (6 points)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.

- Take a new double-sheet -

Exercise 2

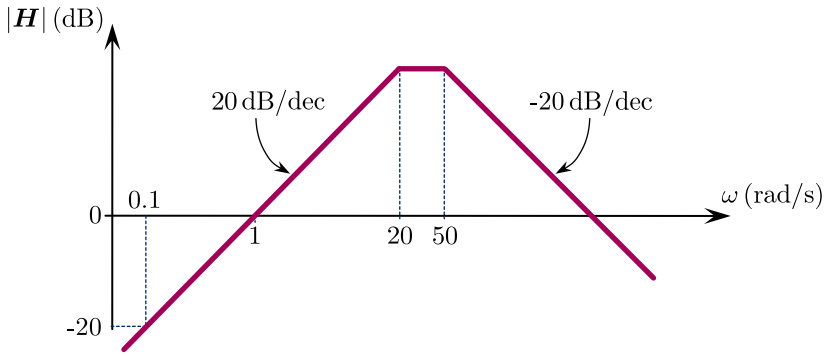
Consider the following transfer function:

$$H(s) = \frac{100 + 100s}{s(10s + 100)}, \quad s = \mathrm{j}\omega.$$

a) Construct the Bode magnitude plot $|H(s)|$. (4 points)

b) Construct the Bode phase plot $\angle H(s)$. (3 points)

Now consider the following Bode magnitude plot:



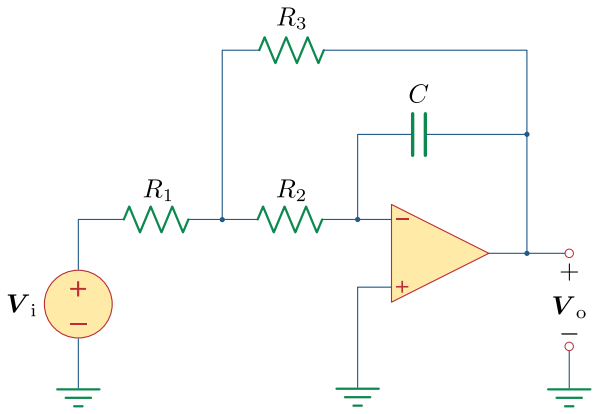
c) Determine the corresponding transfer function $H(s)$. (3 points)

Indicate the measure units for all calculated quantities (when applicable). Show all steps in your reasoning and never give numerical results without justification.

- Take a new double-sheet -

Exercise 3

Consider the circuit in the figure below, in which $R_1 = 2R$, $R_2 = R_3 = R = 1\,\mathrm{k\Omega}$ and $C = 100\,\mathrm{nF}$:



a) Determine the transfer function $\boldsymbol{H}(s) = \boldsymbol{V}_\mathrm{o}(s)/\boldsymbol{V}_\mathrm{i}(s)$ for $s = \mathrm{j}\omega$. (5 points)

b) Based on the obtained transfer function specify the type of the filter (low-pass, high-pass, band-pass or band-stop). (1 point)

c) Calculate the filter's corner frequency ω_0. (2 points)

d) Calculate the decibel magnitude of $\boldsymbol{H}(s)$ at that frequency. (1 point)

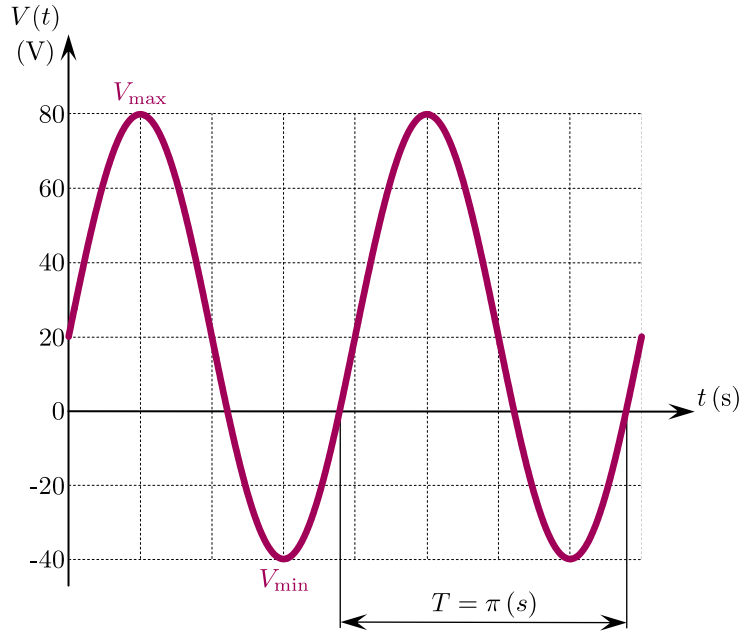
e) Calculate the phase (in degree) of $\boldsymbol{H}(s)$ at that frequency. (1 point)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.

- Take a new double-sheet -

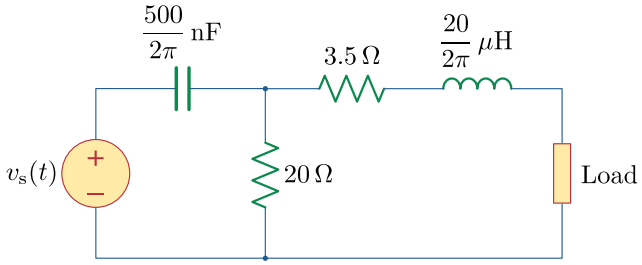
Exercise 4

Consider the *sinusoidal*, *periodic* signature in the figure below:



a) Calculate its *rms* value. (4 points)

Now consider the circuit in the figure below, in which $v_s(t) = 10\cos(\omega t)$(V), with the corresponding frequency being $f = 10^5$Hz:



b) Determine the *complex* load impedance $\boldsymbol{Z}_L$ that will receive the maximum power from the circuit. Calculate that maximum power P_{max} delivered to the load under this condition. (4 points)

c) Determine the value of the resistance R_L for maximum power dissipation if only *real* values are allowed for the load. (2 points)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.