Mid-term

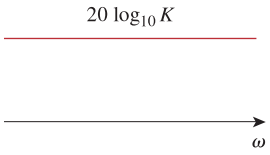
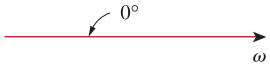
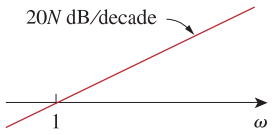
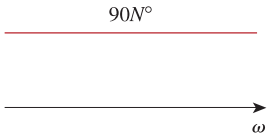
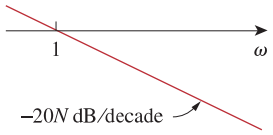
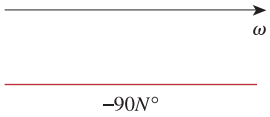
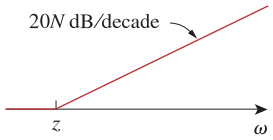
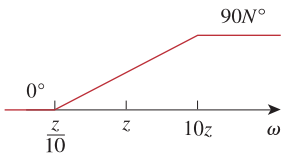
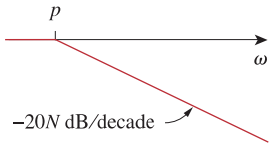
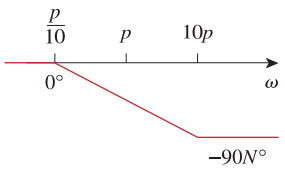
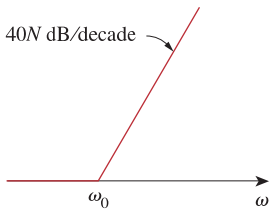
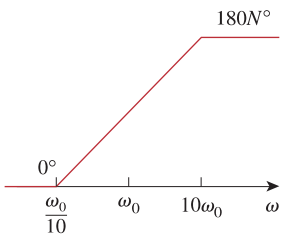
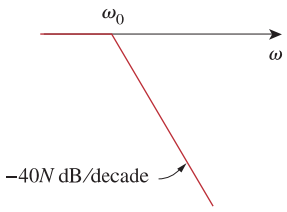
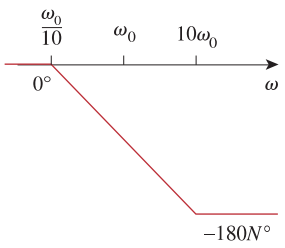
EE1C2 “Linear Circuits B”

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 exam grade is obtained by 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.**
- **When requested, fill in the measure units for all calculated quantities.** This holds for intermediate results but definitely for the final ones.
- Write clearly and avoid messy solutions. Should errors occur in your solution, cross the erroneous part out and give clear indications on where the correct solution resumes.
- For this exam you are allowed to use:
    i. a simple calculator – programmable and graphic calculators are explicitly prohibited;
    ii. a handwritten, double-sided A4 sheet with formulas.
- The text of this exam is offered only in English. Inasmuch as possible, instructors will assist you with the Dutch translation of formulations that you may have difficulties to understand.

The Linear Circuits team wishes you a lot of success!

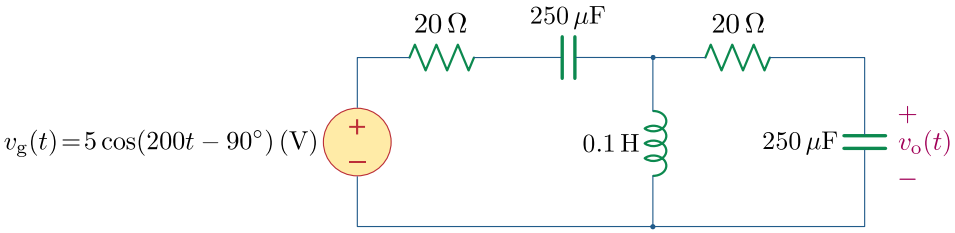
Summary of Bode straight-line magnitude and phase plots.

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 -

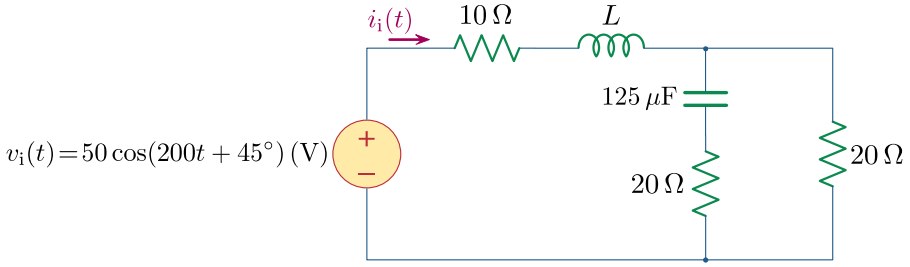
Exercise 1

Consider the circuit in the figure below:



a) Calculate the time-domain expression for the output voltage $v_o(t)$. (4 points)

Now consider the new circuit in the figure below:



b) Calculate the value of the inductance L such that to ensure that the phasor-domain input current $\boldsymbol{I}_i$ is in phase with the phasor-domain input voltage $\boldsymbol{V}_i$ (or, in time-domain, $i_i(t)$ does not lead or lag $v_i(t)$). (4 points)

c) Calculate the time-domain expression for the input current $i_i(t)$. (2 points)
Hint: Use $L = 0.15$H if you did not succeed in obtaining a value for L at subpoint (b) – this is not the solution of that exercise!

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 -

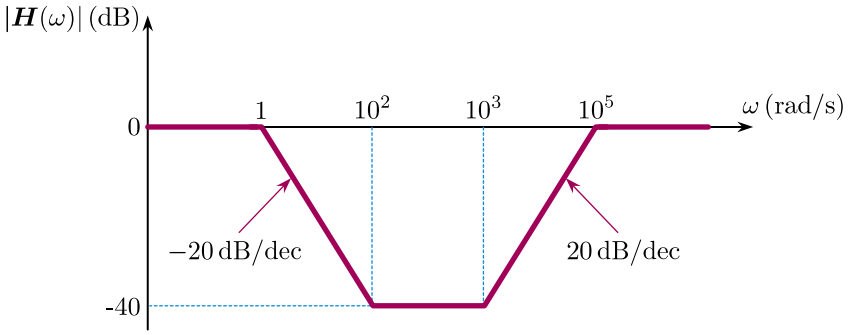
Exercise 2

Consider the following transfer function $\boldsymbol{H}(s)$:

$$\boldsymbol{H}(s) = \frac{100(s+10)}{(s+1)(s+100)}$$

a) Construct the **Bode magnitude plot** indicating for each slope the amount of dB per decade. (5 points)

Now consider the Bode magnitude plot in the figure below:



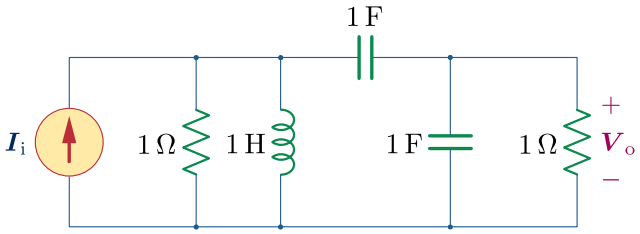
b) Find the corresponding transfer function $\boldsymbol{H}(\omega)$. (5 points)

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 3

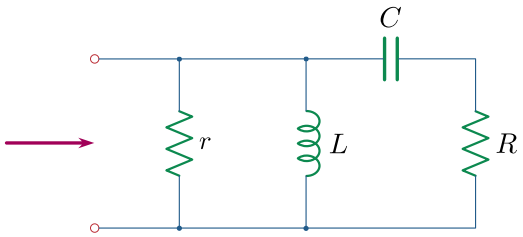
Consider the circuit in the figure below:



a) Find the transfer function $\boldsymbol{H}(\omega) = \dfrac{\boldsymbol{V}_o}{\boldsymbol{I}_i}$. (5 points)

b) Calculate the values of transfer function $\boldsymbol{H}(0)$ and $\boldsymbol{H}(\infty)$. (1 point)

Now consider the new circuit in the figure below:



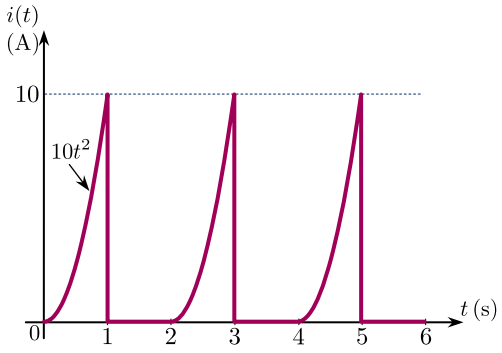
b) Calculate its resonant angular frequency ω_0. (4 points)

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 -

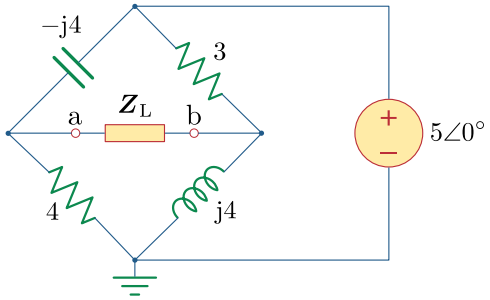
Exercise 4

Consider the waveform in the figure below:



a) Obtain the rms current I_{rms} of this current. (3 points)

Now consider the circuit in the figure below:



b) Calculate the Thévenin voltage $\boldsymbol{V}_{\text{Th}}$ at the terminals a – b. (3 points)
Hint: Redraw the circuit such that to make it easier to interpret.

c) Calculate the Thévenin impedance $\boldsymbol{Z}_{\text{Th}}$ at the terminals a – b. (2 points)
Hint: Redraw the circuit such that to make it easier to interpret.

d) Calculate the value of $\boldsymbol{Z}_{\text{L}}$ in the circuit in order for $\boldsymbol{Z}_{\text{L}}$ to receive maximum average power. (1 point)
Hint: If you were not able to solve the previous subpoints, adopt an own $\boldsymbol{V}_{\text{Th}}$ and $\boldsymbol{Z}_{\text{Th}}$ and continue with those values.

e) Calculate the maximum average power received by that $\boldsymbol{Z}_{\text{L}}$. (1 point)

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