

# Midterm 1

⚠ This is a preview of the published version of the quiz

Started: Oct 15 at 11:20pm

## Quiz Instructions

Midterm 1 is open book. You are allowed to use any lecture/course notes, homeworks, discussions, or websites (except those for collaborative documents or forums). In addition to this, we will allow the use of a calculator and a Python File or Notebook. You may not access or post on any collaborative documents (e.g. Google Docs) or forums (e.g. Chegg). **Collaboration with other students is prohibited.**

Assuming you do not have an approved time extension, you will have 1 hour (60 minutes) to complete the Midterm and you may begin the Midterm at any point during the window of 7:10-8:30 pm. However, the Midterm will close at 8:30 pm, meaning that you must start by 7:30 pm to have the full 1 hour. **We are not Zoom proctoring.**

We will not clarify anything during the exam so please do your best with the information provided. If you have an issue during your exam please email us at [eeecs16b-fa20@berkeley.edu](mailto:eeecs16b-fa20@berkeley.edu) (<mailto:eeecs16b-fa20@berkeley.edu>) and CC the professors ([seth.sanders@berkeley.edu](mailto:seth.sanders@berkeley.edu) (<mailto:seth.sanders@berkeley.edu>) and [mlustig@eeecs.berkeley.edu](mailto:mlustig@eeecs.berkeley.edu) (<mailto:mlustig@eeecs.berkeley.edu>)).

Good luck!

### Question 1

1 pts

Consider the following first-order differential equation

$$\frac{d}{dt}x(t) = 4x(t) \quad x(0) = 0;$$

What is the solution  $x(t)$  to this differential equation?

$e^{4t}$

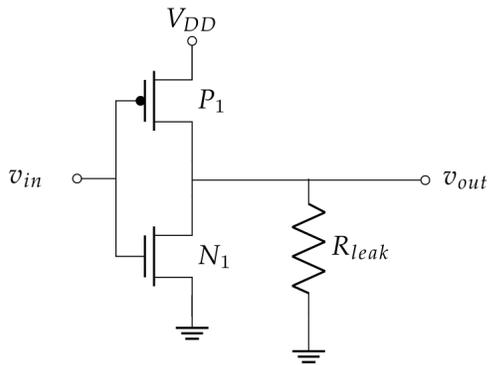
$1 - e^{4t}$

$0$

$e^{-4t}$

## Question 2

3 pts



A leaky inverter.

In the circuit shown, we have accidentally introduced a leakage resistance at the output of the inverter. **Use the resistor-switch model** to analyze the operation of this circuit, **ignore all capacitances**.

For the transistors, assume that  $R_{ON,N} = R_{ON,P} = R_{leak}$  (transistors  $N_1$  and  $P_1$  have the same on resistance). The threshold voltages for the NMOS and PMOS transistors are  $V_{tn} = 0.8V$  and  $V_{tp} = -0.6V$  respectively. We

are using  $V_{DD} = 1.5V$ .

Which of the following statements are **correct** for the operation of the inverter.

[ Select ]

False



When  $v_{in} < 0.5V$ , transistor  $N_1$  is ON (switch closed).

[ Select ]

True



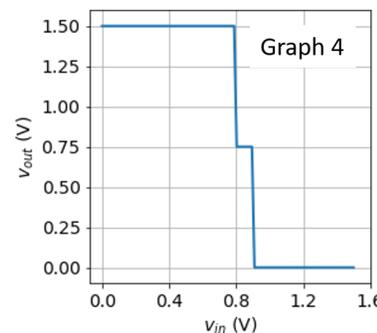
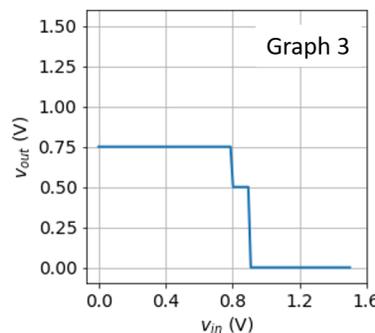
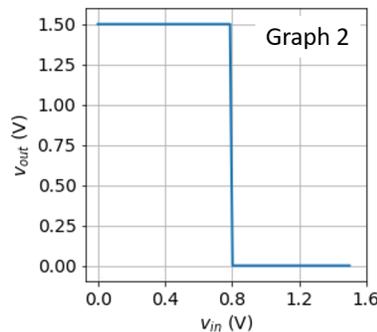
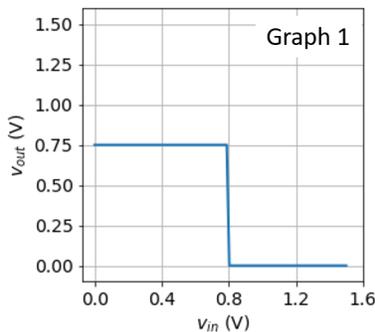
When  $v_{in} > 1V$ , transistor  $P_1$  is OFF (switch open).

[ Select ]

Graph 3



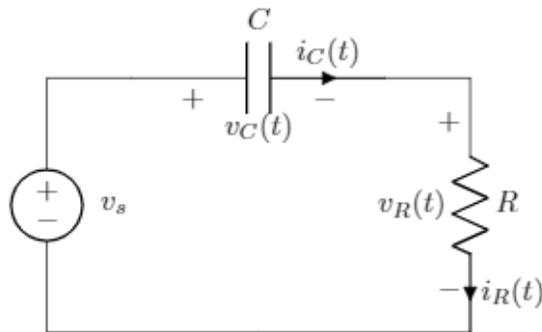
Pick the correct relationship between  $v_{in}$  and  $v_{out}$ .



## Question 3

1 pts

Consider the following circuit with a capacitor that is initially charged with  $v_C(t = 0) = 10\text{V}$ .



Let  $v_s = 20\text{V}$ ,  $C = 10\mu\text{F}$ ,  $R = 20\text{k}\Omega$ . What is the current passing through the capacitor after 1 second has passed?

$$i_C(t = 1) =$$

- $1.993 \cdot 10^6 \text{ A}$
- $9.97 \cdot 10^{-4} \text{ A}$
- $0.135 \text{ A}$
- $19.93 \text{ A}$
- $3.37 \cdot 10^{-6} \text{ A}$

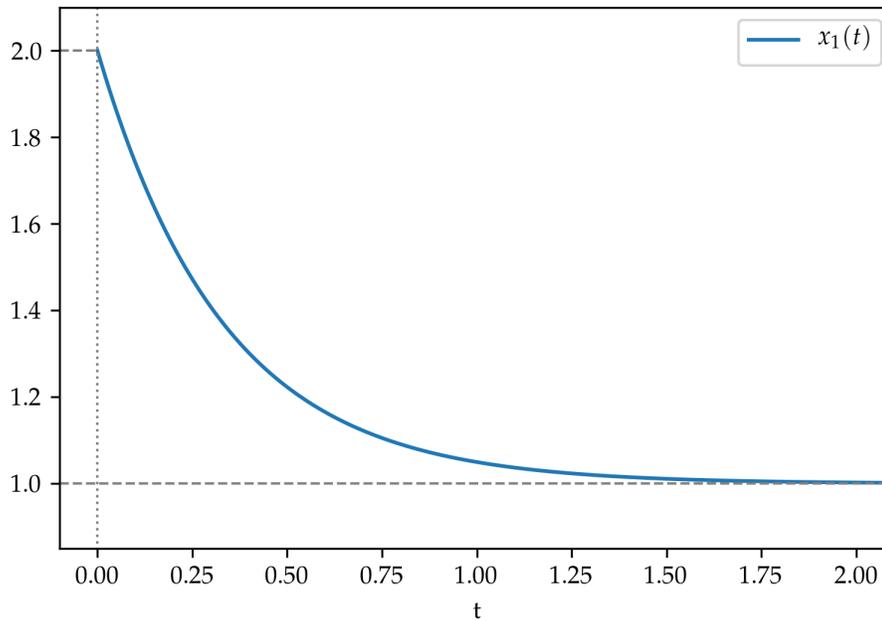
## Question 4

1 pts

Suppose we have the vector differential equation

$$\frac{d}{dt} \vec{x}(t) = A \vec{x}(t), \text{ where } A = \begin{bmatrix} -4 & 2 \\ -2 & 1 \end{bmatrix}.$$

Suppose the plot of  $x_1(t)$  is given below with  $\lim_{t \rightarrow \infty} x_1(t) = 1$ , what is  $x_2(t)$  when you take the limit as  $t \rightarrow \infty$ ?



*Hint: Think carefully about eigenvalue-eigenvector pairs.*

- Not enough information is given to find  $\lim_{t \rightarrow \infty} x_2(t)$
- 1/2
- 1
- 2

### Question 5

1 pts

What is the polar form of the following complex number?

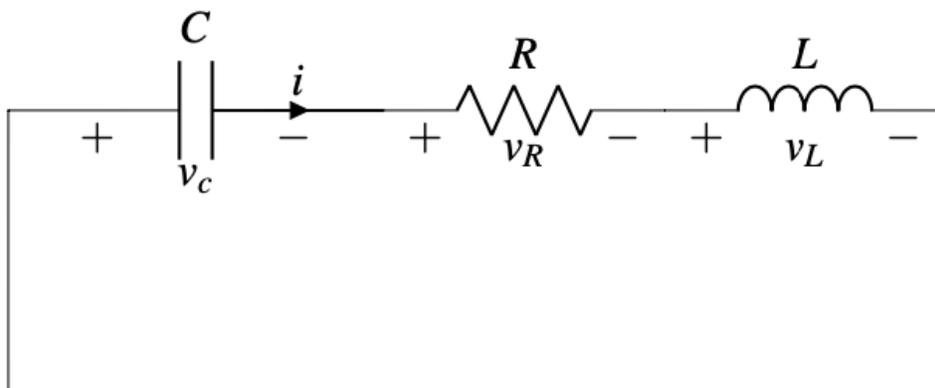
$$z = -\sqrt{3} - \frac{1}{j}$$

- $2e^{j\frac{5\pi}{6}}$
- $4e^{j\frac{2\pi}{3}}$
- $4e^{j\frac{5\pi}{6}}$
- $2e^{j\frac{2\pi}{3}}$

## Question 6

2 pts

Consider the following RLC circuit with unknown values of  $R, L, C > 0$  and unknown initial conditions.

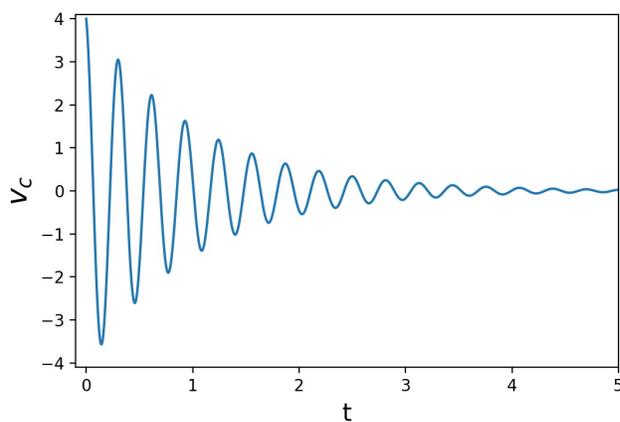


Mark all of the following plots of  $v_c(t)$  that are **possible**.

Plot 1:

[ Select ]

Possible

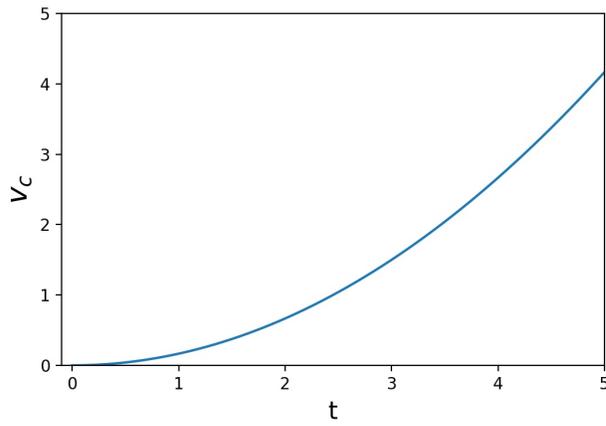


Plot 2:

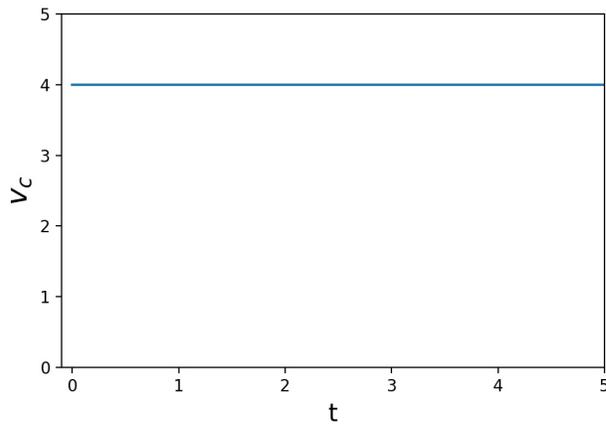
[ Select ]

Impossible

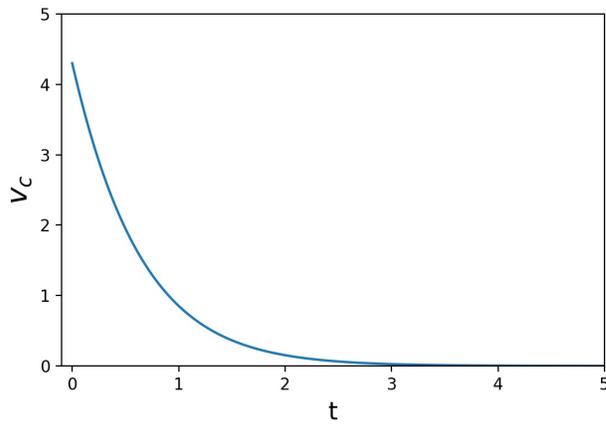




Plot 3: [ Select ] **Impossible** ▾



Plot 4: [ Select ] **Possible** ▾



## Question 7

1 pts

What is the phasor for the following time wave form?

$$i(t) = 2 \sin\left(\omega t - \frac{\pi}{6}\right)$$

$2e^{-j\frac{5\pi}{6}}$

$2e^{j\frac{\pi}{6}}$

$2e^{j\frac{2\pi}{3}}$

$2e^{-j\frac{\pi}{6}}$

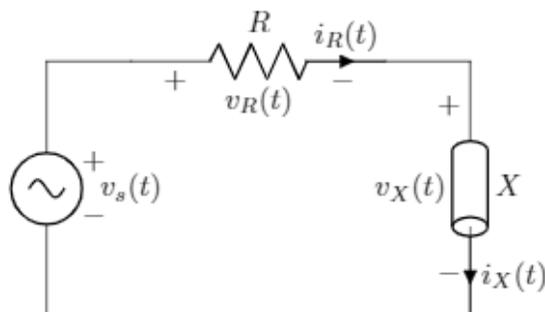
$2e^{-j\frac{2\pi}{3}}$

## Question 8

1 pts

Consider the below circuit which incorporates a novel circuit device  $X$  whose impedance

is of the form  $Z_X = -\frac{1}{\omega^3 X}$ :



Where  $v_s(t) = 4 \cos\left(10t + \frac{\pi}{4}\right)$ ,  $R = 10\mu\Omega$ ,  $X = 200$  with units appropriate to fit the above equation. What is the steady state output voltage of  $v_X(t)$ ?

$v_X(t) = 2 \cos\left(100t + \frac{\pi}{4}\right)$

$$v_X(t) = 2 \cos\left(10t - \frac{\pi}{4}\right)$$

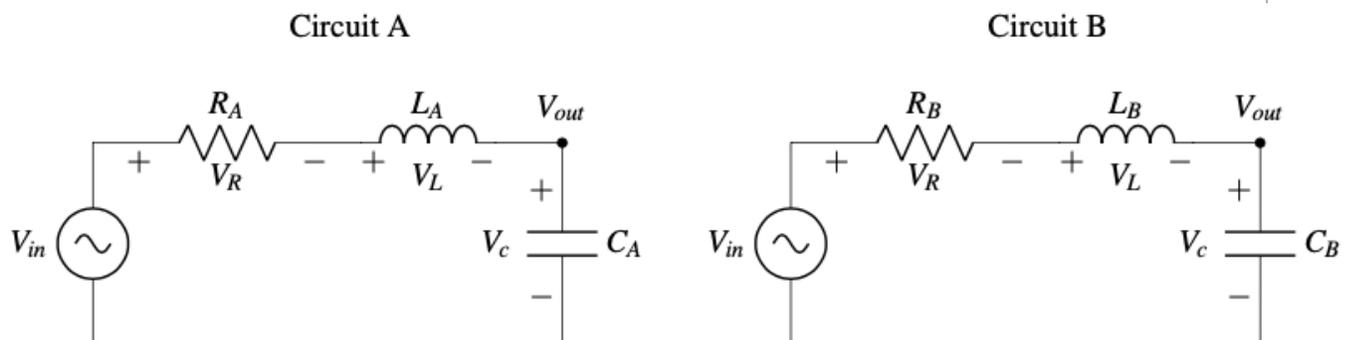
$$v_X(t) = -4 \cos\left(10t + \frac{\pi}{4}\right)$$

$$v_X(t) = 8 \cos\left(10t - \frac{\pi}{4}\right)$$

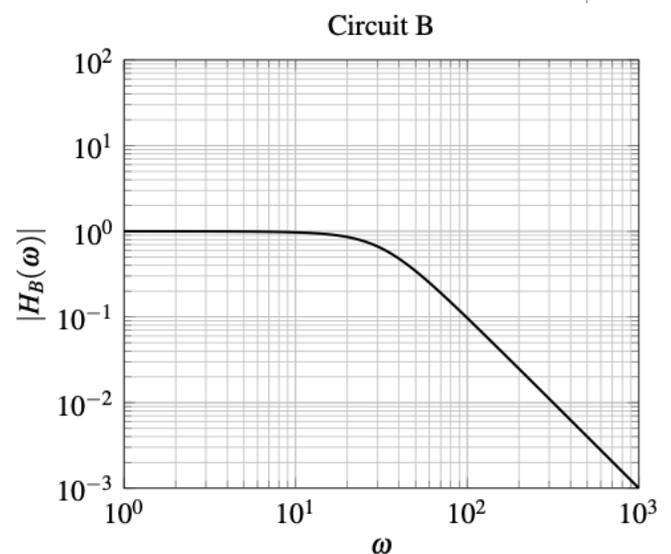
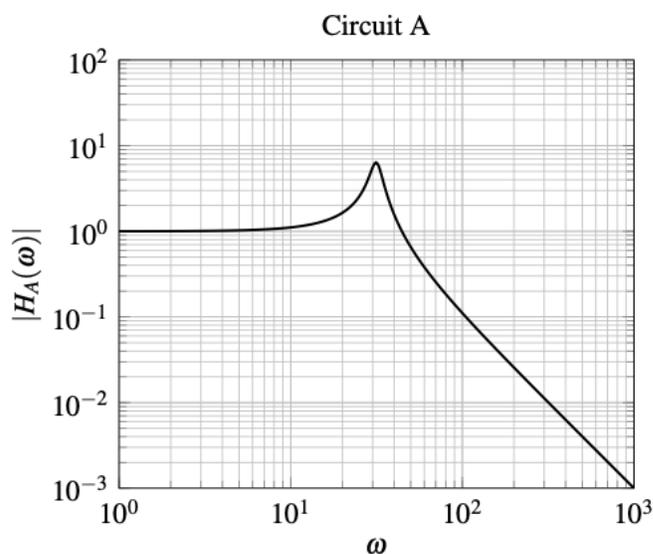
### Question 9

2 pts

Consider two RLC circuits A and B with sinusoidal inputs that have different R, L, and C values.



Defining the transfer function  $H(\omega) = \frac{V_{out}}{V_{in}}$ , the magnitude Bode plots of both circuits' transfer functions are shown below.



Mark all of the following statements that are **true**.

i. Circuit A has a lower quality factor  $Q$  than Circuit B.

[ Select ]

False

ii. Increasing  $R_A$  in circuit A will increase its quality factor  $Q$ .

[ Select ]

False

iii. Decreasing  $R_B$  in circuit B may cause a resonant peak to occur.

[ Select ]

True

iv. Increasing  $C$  in either circuit will decrease its respective quality factor  $Q$ .

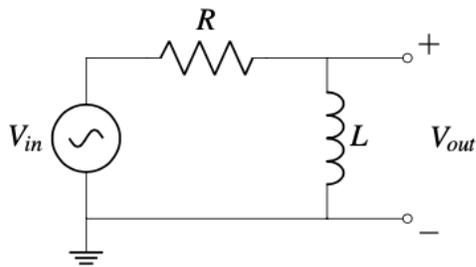
[ Select ]

True

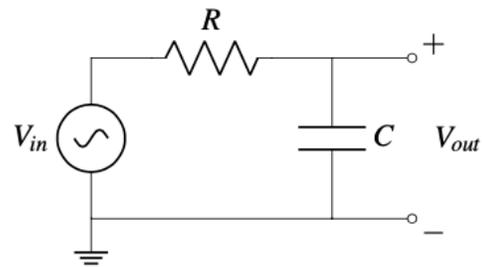
### Question 10

1 pts

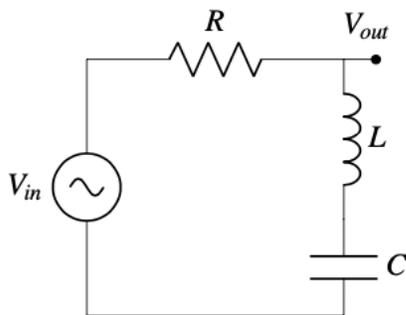
Given the following tasks, pick the circuit best suited for each task. Each task will have **exactly one** circuit that matches it the best.



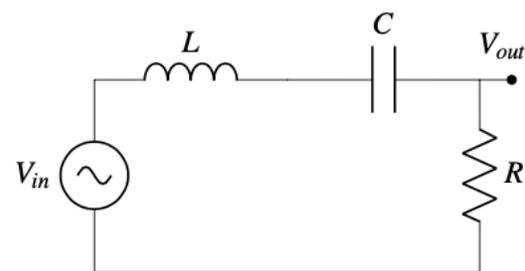
RL Circuit



RC Circuit



RLC Circuit



LCR Circuit

Filtering out noise with frequency larger than 20 kHz.



RC

Receiving a transmitted signal in between 2.3GHz and 2.7GHz.



LCR

Decreasing the amount of bass (lower frequencies) in your sound system.



RL

Blocking out the 60 Hz frequency from your wall-power while letting all other frequencies through.



RLC

### Question 11

2 pts

$$H(\omega) = 100 \frac{(1+j\frac{\omega}{100})(1+j\omega \cdot 10)}{(1000+j\omega)(1+j\omega)}$$

Below, we have some statements about the magnitude and phase of the transfer function given above. For (i), (ii) and (iii) state if the statements are True/False. For (iv), pick the correct graph.

False



As  $\omega \rightarrow 0$ , the magnitude  $|H(\omega)| \rightarrow 100$ .

False



As  $\omega \rightarrow \infty$ , the magnitude  $|H(\omega)| \rightarrow \infty$ .

False

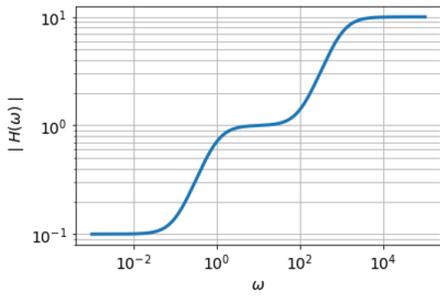


At  $\omega = 1$ ,  $\angle H(\omega) \approx -\frac{\pi}{4}$

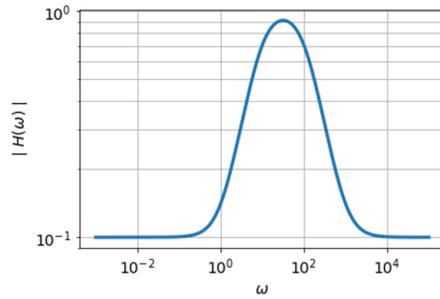
Graph 1



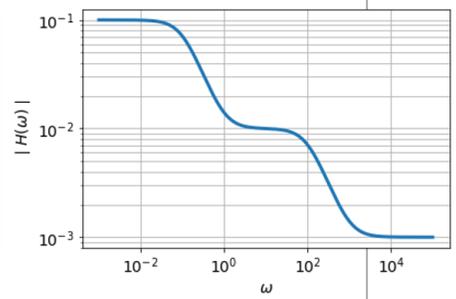
Pick the correct graph for the magnitude response  $|H(\omega)|$



Graph 1



Graph 2



Graph 3

Not saved

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