Name ________________________________

**(1 point)** Section 1 or 2: MR 12 noon to 1:50pm or MR 4:00 to 5:50 pm

**Part B (79 Points)**

1. (10 Pts) _________
2. (8 Pts) _________
3. (15 Pts) _________
4. (14 Pts) _________
5. (12 Pts) _________
6. (10 Pts) ________
7. (10 Pts) _________

Total __________________

If useful, draw circuit diagrams for problems were you make simplifications. It is useful for assigning partial credit.

Annotate plots to explain your solutions. It is useful for assigning partial credit.

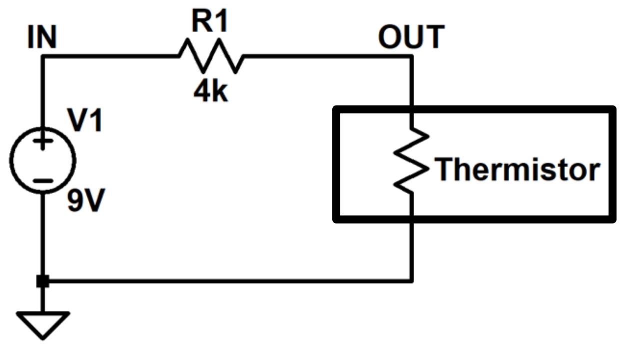
Show all of your work

Many problems can be solved using more than one method. Check your answers by using a second method.

At least skim through the entire quiz before you begin and then start with the problems you know best.

The proctor will only answer clarification questions where wording is unclear or where there may be errors/typos. No other questions will be responded to.

**Problem 1 (10 Pts) – Experimentally Determining an Input Impedance (Quiz 2 crib sheet)**




Nearly all loads can be characterized by some kind of simple input impedance. For example, the two analog input channels on the Analog Discovery board have an input resistance of 1MΩ and an input capacitance of 24pF. The circuit at the right is set up to determine the resistance of a Thermistor, thermally sensitive resistor, under two ambient temperatures. The thermistor used here has a negative temperature coefficient NTC (commonly used), i.e. its resistance decreases while the temperature increases.

The voltage across the Thermistor is measured using Analog Discovery at ambient temperatures of 25$^o$C and 35$^o$C. The data for these two measurements are given below.

| Trial | Temperature [$^o$C] | V(OUT) |
|---|---|---|
| **1** | **25** | **3.1935V** |
| **2** | **35** | **2.4545V** |

a. (5 Pts) Determine the unknown resistance of the Thermistor at 25$^o$C.

b. (5 Pts) Determine the unknown resistance of the Thermistor at 35$^o$C.

**Problem 2 (8 Points) – Complex numbers (Quiz 2 crib sheet)**

a. (2 Pts) A complex number is given as $z = 2+j2$. Determine the magnitude and phase of $z$.

Maginitude: Phase:

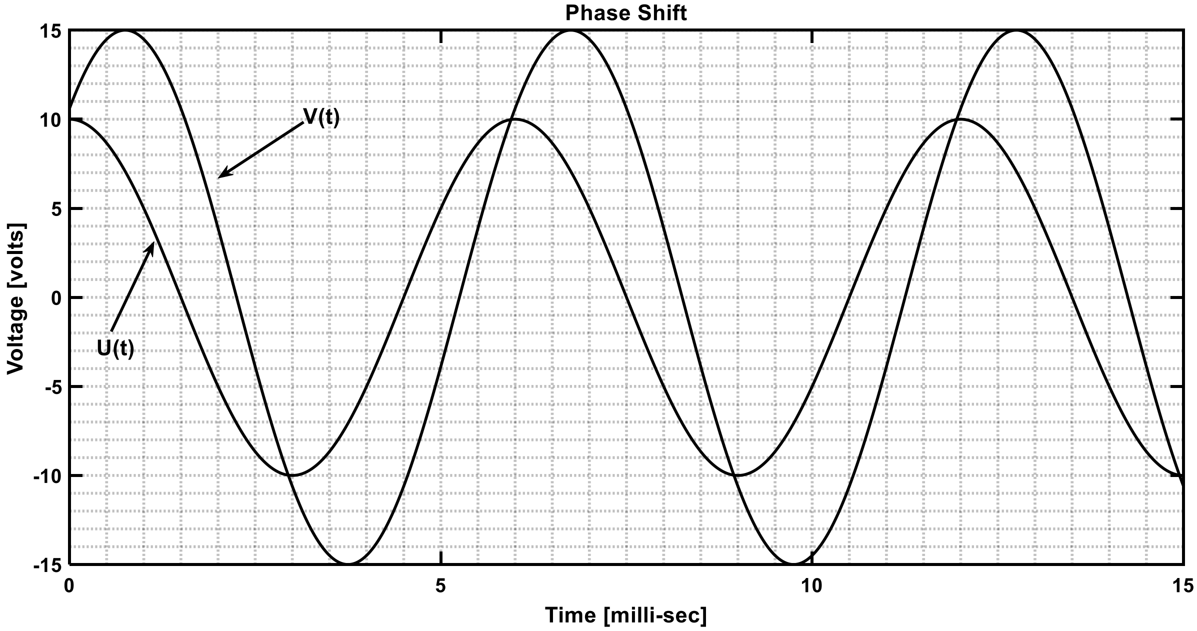
b. (2 Pts) Another complex number is given as $y = 3-j3$. Determine the magnitude and phase of $y$.

Maginitude: Phase:

c. (2 Pts) Multiply the two above complex numbers $w = yz$ and express your result in phasor notation, $Ae^{j\Theta}$, where $A$ is the magnitude of $w$ and $\Theta$ is the phase of $w$.

d. (2 pts) Divide the two above complex numbers $x = y/z$ and express your result in Cartesian notation, $B+jD$, where $B$ is the real part and $D$ is the imaginary part.

**Problem 3 (15 Points) – Phase (Quiz 2 crib sheet)**
In the Matlab generated plot below, two cosinusoidal voltages are shown vs time. $U(t)=U_o\cos(\omega t)$ and $V(t)=V_o\cos(\omega t+\theta)$. The magnitudes of the two voltages are not the same. The vertical scale is in volts and the time scale is in milli-seconds.




a. (2 Pts) Determine the frequency *f in Hertz* and radial frequency *ω in Radians.*

b. (1 Pt) What is the amplitude, $U_o$, of *U(t)* in Volts?

c. (2 Pts) Assuming *U(t)* has zero phase, write the voltage as a function of time using the expression $U(t)=U_o\cos(\omega t+\theta)$.

d. (1 Pt) What is the phasor form of *U(t)*, $\tilde{U}=?$

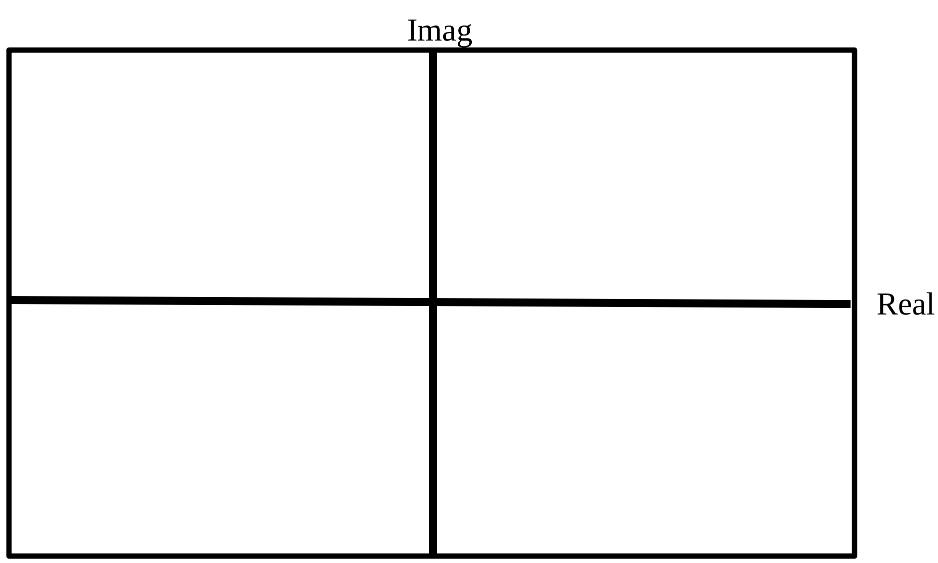
e. (2 Pts) Determine the phase of *V(t)* relative to *U(t)* in degrees. *Be sure to specify its sign and remember it can have any value from -360 degrees to +360 degrees.*

f. (1 Pt) What is the amplitude of *V(t)* in Volts?

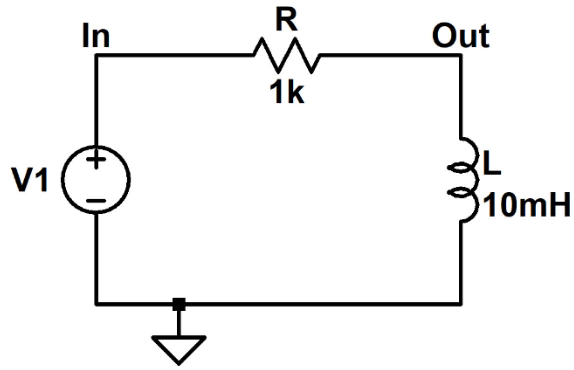
g. (2 Pts) Using your part e and f results, write the voltage, *V(t)*, as a function of time using the expression $V(t) = V_o \cos(\omega t + \theta)$

h. (2 Pts) What is the phasor form of *V(t)*, $\tilde{V} = ?$

i. (2 Pts) Plot the point for the phasor voltage $\tilde{V}$ on the complex plane. *Plot the point that represents its value as a complex number. Be sure to fully label the plot.*



**Problem 4 (14 Points) – Filters and Transfer Functions (Quiz 1 and Quiz 2 crib sheets)**
A simple filter is configured with a resistor and an inductor, as shown.
V(OUT) is voltage measured across the inductor.




a. (2 pts) When the output voltage is measured across the inductor, is this a high pass or a low pass filter?

b. (3 Pts) Derive an expression in terms of ω, R, and L for the transfer function of this filter, $H(j\omega) = \dfrac{\tilde{V}_{OUT}}{\tilde{V}_{IN}} = ?$ *Hint: Treat this as a voltage divider built with two general impedances, $Z_R$ and $Z_L$.*

c. (3 Pts) Using the values of R and L shown in circuit, determine the corner frequency in radians, $\omega_c$ (Quiz 1 crib sheet)?

d. (3 pts) Find the real and imaginary parts of the transfer function when the frequency is the corner frequency, $\omega = \omega_c$. (Consider the process in problem 2.)

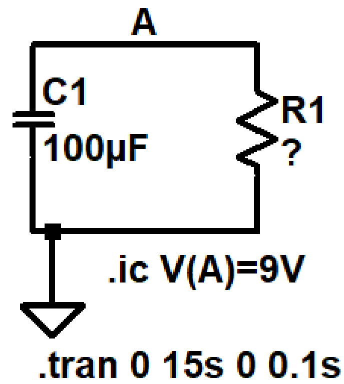
$\mathrm{Re}\{H(j\omega)\} = ?$ $\mathrm{Im}\{H(j\omega)\} = ?$

e. (3 Pts) Using your answers to part d, write the transfer function in polar form. That is find the magnitude and phase (in radians or degrees). *Hint: The phase should be near π/n where n is some integer from 1 to 12.*

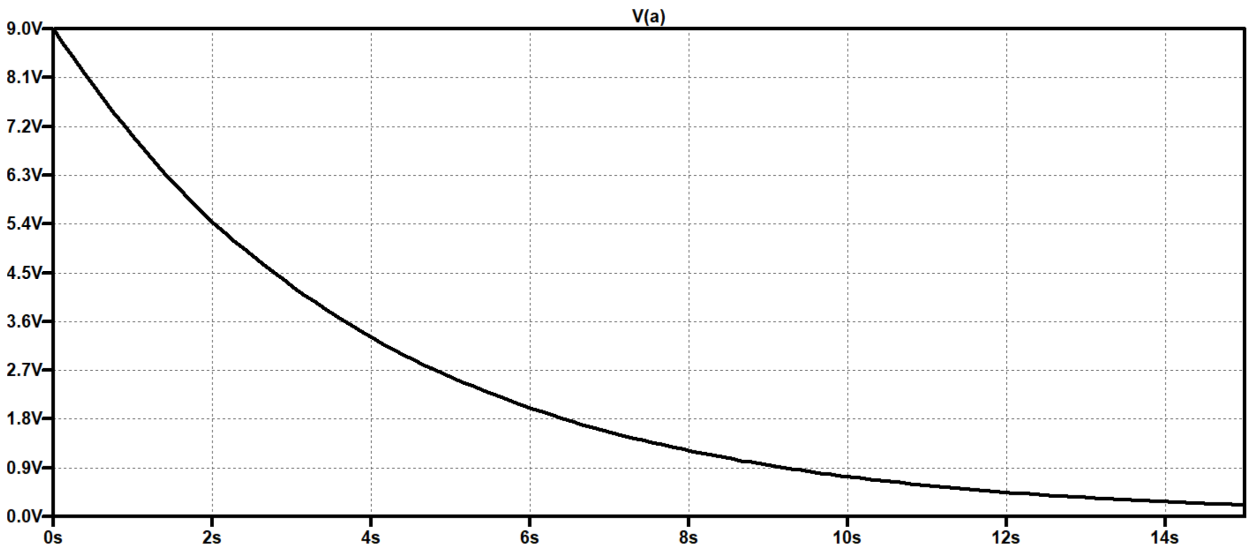
$$H(j\omega) = |H(j\omega)|e^{j\theta_H} = ?$$

**Problem 5 (12 Points) – Capacitor discharge (Quiz 2 crib sheet)**

A capacitor is charged using a battery and then allowed to discharge through a resistor for 15 seconds as shown in the circuit to the right. Capacitor C1 is known, C1 = 100uF. Initial voltage across capacitor is 9V. R1 is unknown.




You are also given a plot that shows how capacitor C1 discharges with time below.

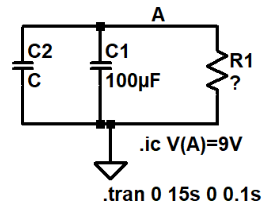



a. (3 pts) Determine the **decay constant τ** by using the plot and the general expression for capacitor discharge? (Quiz 2 crib sheet) Mark the data point you use on the plot.

b. (3 pts) Find the value of **R1** that results in the decay constant you found in part a?

**All rate of capacitor discharge comparisons in part c-e, should be made with respect to the original circuit with C1 and R1, shown on the previous page.**

c. (2 pts) If another capacitor C2 (non-zero value) were to be added to the circuit in parallel with C1, the rate of capacitor discharge would become (circle one)

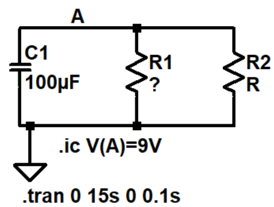



Faster

Slower

Remain the same

d. (2 pts) Now consider adding R2 (non-zero value) in parallel with R1 as shown below. The rate of capacitor discharge would become (circle one)

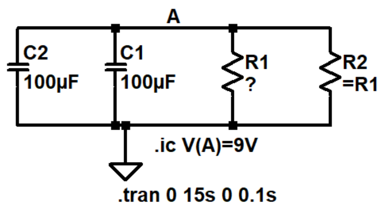



Faster

Slower

Remain the same

e. (2 pts) Now consider adding both C2 and R2 to the original circuit as shown to the right. C2=C1 and R2=R1. The rate of capacitor discharge would become (circle one)



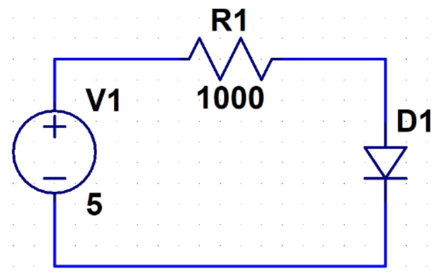

Faster

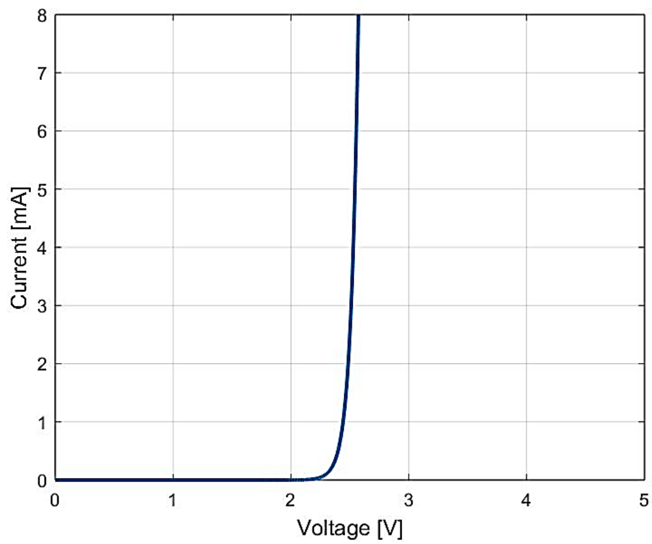
Slower

Remain the same

Cannot be determined

**Problem 6 (10 Pts) – Load Lines (Quiz 2 crib sheet)**
The I-V (current-voltage) characteristics of the diode in the circuit to the right are shown below. Note, the y-axis units are given in mA ($10^{-3}$ amps) and the x-axis units are given in V (Volts).




a. (3 Pts) Determine the expression for the load line, $I$ = ?

b. (3 Pts) Draw the load line on the diode I-V plot.

c. (2 Pts) Based on your part b graph, approximately determine the diode voltage and diode current for this circuit.

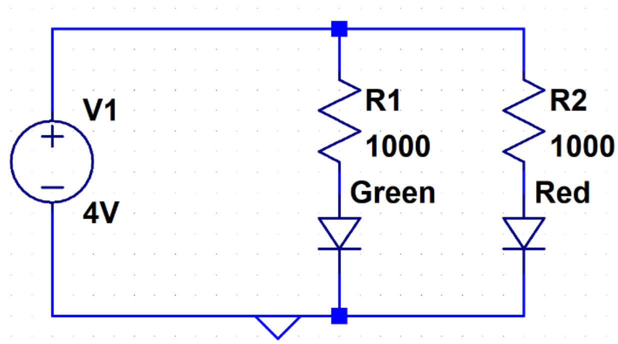
$V_D$ =  $I_D$ =

d. (2 Pts) If the resistance were to increase, the diode current, $I_D$, would (circle one)

increase  decrease

**Problem 7 (10 Pts) – Diodes, Current, (Quiz 1 crib sheet)**

In the circuit to the right, the green LED has an on voltage of 2.0V and the red LED has an on voltage of 1.5V.

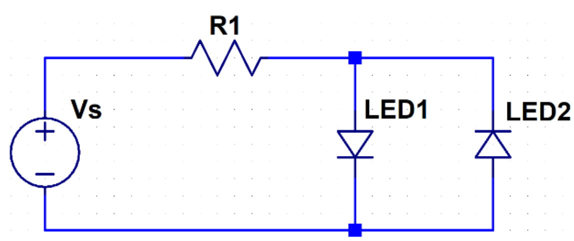



*a.* (2 Pt) What is the current through the **green** LED?

*b.* (2 pts) What is the current through the **red** LED?

*c.* (3 Pts) If the voltage source, V1, changed to 1.75V, what happens to the brightness of both LEDs? Be specific as possible.

*d.* (3 Pts) The LEDs in the circuit shown to the right are ideal with a zero turn on voltage (different LEDs). Complete the following table, indicating whether the LEDs are on for the indicated Vs. (Write ‘on’ or ‘off’ in the table boxes.)




| | LED1 | LED2 |
|---|---|---|
| Vs = 0V | | |
| Vs = 5V | | |
| Vs = -5V | | |