## Spring 2002

2. Diodes ( 25 points)

In the figure below, each of the diodes turns on at between 0.7 volts and $R=2 k$.


1. Give the voltage at Vout for each of the following values of the input voltage, Vin (2 points each).
a. Vin $=5$ Volts
b. Vin $=2$ Volt
c. Vin $=1$ Volts
d. Vin $=0.4$ Volts
e. Vin $=0$ Volts
f. Vin $=-0.4$ Volts
g. Vin $=-1$ Volt
h. Vin $=-2$ Volt
2. Use the above data to plot Vout vs Vin for the range $-5<=$ Vin $<=+5$ (4 points)

Vout

3. Which of the plots below represents Vout for this circuit (5 points)?



## Spring 2002 solution

## 2. Diodes (25 points)

In the figure below, each of the diodes turns on at between 0.7 volts and $R=2 k$.


1. Give the voltage at Vout for each of the following values of the input voltage, Vin (2 points each).
a. Vin $=5$ Volts
Vout $=0.7 \mathrm{~V}$
b. Vin $=2$ Volt
Vout $=0.7 \mathrm{~V}$
c. Vin $=1$ Volts
Vout $=0.7 \mathrm{~V}$
d. Vin $=0.4$ Volts
Vout $=0.4 \mathrm{~V}$
e. Vin $=0$ Volts
Vout $=0 \mathrm{~V}$
f. Vin $=-0.4$ Volts $\quad$ Vout $=\mathbf{- 0 . 4 V}$
g. Vin $=-1$ Volt $\quad$ Vout $=\mathbf{- 1} \boldsymbol{V} \quad$ h. Vin $=-2$ Volt Vout $=-\mathbf{2} \boldsymbol{V}$
2. Use the above data to plot Vout vs Vin for the range $-5<=$ Vin $<=+5$ (4 points)

3. Which of the plots below represents Vout for this circuit (5 points)?



The one below is correct.


Questions about Zener Diodes
Fall 2004
Question 3 - Zener Diodes (18 points)
Below is a circuit built with a zener diode and a picture of the characteristic curve of the diode.


Here are the input and output, when a 10 Volt, 1 K Hertz signal is applied at the input.

a) Write the letter of the appropriate region on the zener diode characteristic curve next to each of the five descriptions below. (5 points)

Forward Bias Region
Zener Region

Reverse Bias Region
Zener Voltage ( $-\mathrm{V}_{\mathrm{Z}}$ )

Saturation Current
b) Identify the following areas on the plot of the input and output. (5 points)

1. The input signal
2. The output signal
3. An area on the output signal where the diode is forward biased.
4. An area on the output signal where the saturation current runs through the diode.
5. An area on the output signal where the voltage across the diode is the zener voltage.
c) Using the output plot, estimate the zener voltage and the forward bias cutoff voltage of the diode. (4 points)

$$
\mathrm{V}_{\mathrm{Z}}
$$

Von
d) If $\mathrm{R}=5 \mathrm{~K}$, what is the current through the load resistor when the input voltage is -10 V ? (2 points)
d) If $\mathrm{R}=5 \mathrm{~K}$, what is the current through the load resistor when the input voltage is +10 V ? (2 points)

## Fall 2004 Solution <br> Question 3 - Zener Diodes (18 points)

Below is a circuit built with a zener diode and a picture of the characteristic curve of the diode.


Here are the input and output, when a 10 Volt, 1 K Hertz signal is applied at the input.

a) Write the letter of the appropriate region on the zener diode characteristic curve next to each of the five descriptions below. (5 points)

| Forward Bias Region $B$ | Reverse Bias Region $A$ |
| :--- | :--- |
| Zener Region $E$ | Zener Voltage $\left(-\mathrm{V}_{\mathrm{Z}}\right) D$ |
| Saturation Current $C$ |  |

b) Identify the following areas on the plot of the input and output. (5 points)

1. The input signal
2. The output signal
3. An area on the output signal where the diode is forward biased.
4. An area on the output signal where the saturation current runs through the diode.
5. An area on the output signal where the voltage across the diode is the zener voltage.
c) Using the output plot, estimate the zener voltage and the forward bias cutoff voltage of the diode. (4 points)

$$
\begin{aligned}
& \mathrm{V}_{\mathrm{Z}}=4.7 \mathrm{~V} \text { (Vout is } 4.7 \text { volts less than Vin) } \\
& \text { Von }=0.7 \text { (Vout is } 0.7 \text { volts more than Vin) }
\end{aligned}
$$

A-d) If $\mathrm{R}=5 \mathrm{~K}$, what is the current through the load resistor when the input voltage is 10V? (2 points)
$I=(-10+0.7) / 5 K=-1.86 m A$

B-d) If $R=6 \mathrm{~K}$, what is the current through the load resistor when the input voltage is 10V? (2 points)
$I=(-10+0.7) / 6 K=-1.55 \mathrm{~mA}$

A-e) If $\mathrm{R}=5 \mathrm{~K}$, what is the current through the load resistor when the input voltage is +10 V ? (2 points)
$I=(10-4.7) / 5 K=1.06 m A$
$B-e)$ If $R=6 \mathrm{~K}$, what is the current through the load resistor when the input voltage is +10 V ? (2 points)
$I=(10-4.7) / 6 K=0.883 m A$

## 5) Circuit Functionality ( $\mathbf{2 0} \mathrm{pts}$ )



Below is a graph of the input and output, just to give you some reference of what the circuit will do. The source is 1 V at 10 KHz .


List the functionality of each block, A,B,C,D and E. (4 pt each

## Spring 2002 solution <br> 5) Circuit Functionality ( 20 pts )

List the functionality of each block, A,B,C,D and E. (4 pt each)
A = bypass capacitors (filter out high frequency noise from power supply)
$B=$ buffer or voltage follower
$C=$ inverting amplifier
$D=$ approximate integrator or low pass filter
(capacitor is open at low frequencies and short at high frequencies)
$E=$ high pass filter
(inductor is short at low frequencies and open at high frequencies)

Fall 2000
5. Circuit Functionality

Shown below is an audio amplifier circuit.


Indicate on the circuit diagram where each of the following sub-circuits is found. Also, answer any questions asked.

## Bypass Capacitors

Standard Amplifier (Is it an inverting or a non-inverting amplifier?)
Speaker

## Protection Diodes

High Pass Filter (Give an example of a frequency that is blocked and a frequency that is passed)

## Fall 2000 Solution

## 5. Circuit Functionality



Indicate on the circuit diagram where each of the following sub-circuits is found. Also, answer any questions asked.

## Bypass Capacitors

Standard Amplifier (Is it an inverting or a non-inverting amplifier?)
Speaker
Protection Diodes
High Pass Filter (Give an example of a frequency that is blocked and a frequency that is passed)
$R=47 K C=1 \mu F f c=(1 / 2 \pi R C)=1 /[(2)(\pi)(47 K)(1 \mu)]=3.4$ Hertz
Frequency blocked = 1Hz (anything less than about 2 Hertz)
Frequency passed $=1 \mathrm{~K} \mathrm{~Hz}$ (anything more than about 10 Hertz)

Fall 2003

## Question 5 -- Circuit functionality and transformers (20 points)

The following circuit was constructed to test two DC power supplies. One is a battery and one is a wall wart (connects to a normal 120 V outlet). The boxes surrounding each part of the circuit identify the functional blocks (each has a specific purpose). Each of the boxes is also shown expanded for clarity.


a. Identify the function of each of the nine blocks. (Draw a line to connect the letter of the block to its function). (9 points)

| A | 1. | Measure output voltage |
| :--- | :--- | :--- |
| B | 2. Rectify AC voltage |  |
| C | 3. Input signal voltage |  |
| D | 4. Block DC voltage while passing AC voltage |  |
| E | 5. Smooth ripples to improve DC output voltage |  |
| F | 6. Step AC voltage down from 120 V to 12 V |  |
| G | 7. Provide AC power for DC supply |  |
| H | 8. Amplify signal voltage |  |
| I | 9. | -12 V power supply |

b. On the next page are plotted six voltages measured at various points in the circuit. Identify each of the voltages by indicating the block for which this is the output voltage. Note that there are only six voltages but there are eight output points for the blocks. (6 points)
c. Based on the voltages you have just identified, what is the ratio of the input voltage to the output voltage of the transformer? Note that a real transformer is modeled here so that it has finite resistance in its windings. However, you can neglect these small resistances in the rest of this problem. (3 points)
d. If the primary winding of the transformer has 10000 turns, how many turns does the secondary winding have to produce this change in voltage? (2 points)


## Fall 2003 Solution

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$$
120 \mathrm{~V}: 12 \mathrm{~V}=10: \mathbf{1}
$$

d. If the primary winding of the transformer has 10000 turns, how many turns does the secondary winding have to produce this change in voltage? (2 points)

Test A: N2/10000 = 1/10 N2 = $\mathbf{1 0 0 0}$ turns

Test B: N2/20000 = 1/10 N2 = 2000 turns



