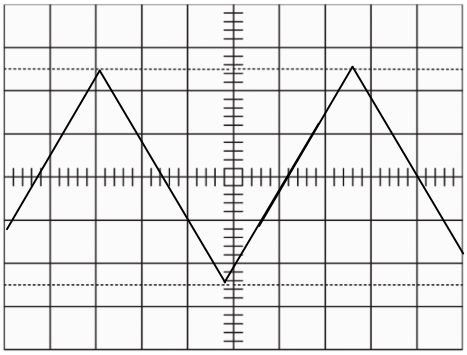
PHY2250 - Electronics & Circuit Theory Practice Test 2

Show all work
Turn off (OFF) all cell phones
Answer on separate paper. Hand in this sheet separately.
Answers on this sheet will not be considered.
100 points total

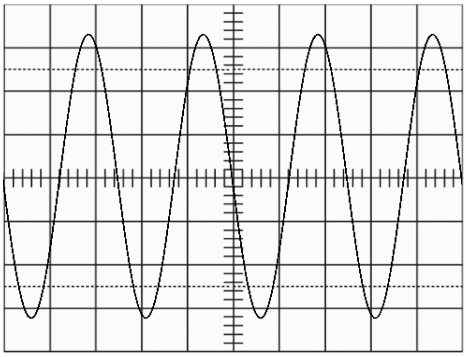
Questions 1 and 2 refer to the following oscilloscope traces:

#1



Volts/div: 0.5V
Time/div: 20μs

#2



Volts/div: 0.1 mV
Time/div: 2μs

1. (12 points) Identify each of these characteristics/values for the signal above on the left.
   a) Type of signal (i.e., the "name" of the "wave shape") **Answer: Triangle wave**
   b) Amplitude **Answer: V_{pp} = (5div)*(0.5V/div) = 2.5V. A = V_{pp}/2 = 1.25V**
   c) Frequency **Answer: T= (5.5div)*(20μs/div) = 110μs, *f* = 1/T = 9.1kHz**

2. (12 points) Identify each of these characteristics/values for the signal above on the right.
   a) Type of signal (i.e., the "name" of the "wave shape") **Answer: Sine wave**
   b) RMS voltage V_{RMS} **Answer: (0.32mV)*(0.707) = 0.23 mV**
   c) Period **Answer: T = 5.0 μs**

Multiple Choice: In the following problems, choose the "best" answer.

3. (5 points) What is the capacitance of a capacitor if it can store 6.0 mC of charge when 78 V is applied across the plates?
   a) 470 mF (b) 77 μF
   c) 4.7 F d) 82 mF e) None of the above

4. (5 points) An AC current with amplitude 1mA is sent into a "step up" transformer with a turns ratio of 100. The current in the secondary is therefore (ideally)
   a) 100 mA b) 10 mA
   c) 0.1 mA (d) 10 μA e) None of the above

5. (5 points) The ratio of the charge on a capacitor to its capacitance is equal to the
   a) current through the capacitor (b) voltage across the capacitor
   c) impedance of the capacitor d) None of the above

6. (5 points) A 50Ω resistor, 10nF capacitor and a 300mH inductor are connected in series and driven with a sine wave at 1kHz. Which component has the greatest impedance?

a) the resistor (b) the capacitor
c) the inductor d) the source e) Impossible to determine

7. (5 points) Direct current through a wire produces…

a) no magnetic field. b) an alternating magnetic field.
(c) a constant magnetic field. d) Both (b) and (c).

8. (5 points) In an LR circuit, measuring output voltage across the resistor results in a ____ filter.

(a) low pass b) high pass
c) bandpass d) short pass

9. (5 points) The region of a PN junction consisting of charged ions is called the…

a) no-current region. b) reverse breakdown region.
c) barrier region. (d) depletion region.

10. (5 points) The forward voltage drop across a typical LED is around…

a) 0.7 V. b) 0.3 V.
c) 10 V. (d) 2 V.

11. (5 points) A typical semiconductor has ___ valence electrons.

a) zero b) two
(c) four d) eight

Short Answer: In the following problems, remember to **show your work** and/or ***explain your answer*** in completing the calculations. **An answer by itself will not receive credit.**

12. (10 points) The last stage of a power supply for some piece of electronic gear uses a DC source of 8V to charge a capacitor of 11nF in series with a resistor of 2500Ω. How long does it take for the capacitor to reach 63% of the source voltage?

$$V_C = V_{\max}\left(1 - e^{-\frac{t}{RC}}\right)$$

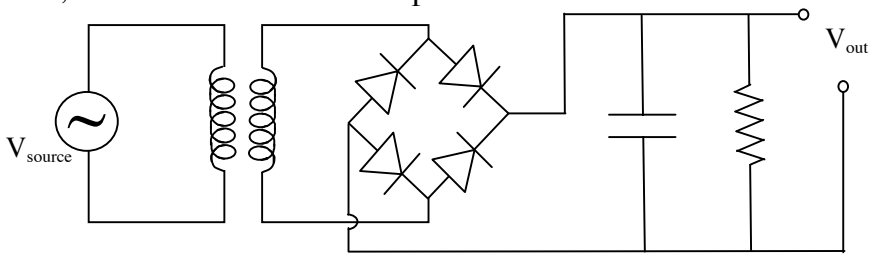
$$\frac{V_C}{V_{\max}} - 1 = -e^{-\frac{t}{RC}}$$

$$\ln\left(1 - \frac{V_C}{V_{\max}}\right) = -\frac{t}{RC}$$

$$t = -RC\ln\left(1 - \frac{V_C}{V_{\max}}\right) = -(2500\Omega)(11\times10^{-9}\text{F})\ln(1-0.63)$$

$$t = 27\mu\text{s}$$

13. (11 points) Draw a schematic for a DC power supply, consisting of a transformer, bridge rectifier, resistor and capacitor, and indicate where the output is measured from.



14. (10 points) The capacitors, C_1=20μF, C_2=15μF, and C_3=10μF, are connected in parallel.
a) If this parallel combination is connected to a 10V DC power supply and allowed to fully charge, what is the charge on *each* capacitor?
b) If this parallel capacitor combination is connected in series with a 20Ω resistor to a 100Hz AC source, find the total impedance.

Answer:

a)
$$\boldsymbol{Q_1 = VC_1 = (10V)(20\mu F) = 200\mu C}$$
$$\boldsymbol{Q_2 = VC_2 = (10V)(15\mu F) = 150\mu C}$$
$$\boldsymbol{Q_3 = VC_3 = (10V)(10\mu F) = 100\mu C}$$

b)
$$\boldsymbol{C_T = C_1 + C_2 + C_3 = 45\mu F}$$
$$X_C = \frac{1}{2\pi f C_T} = \frac{1}{2\pi(100)(45\times10^{-6})} = 35.4\Omega$$
$$Z = \sqrt{R^2 + X_C^2} = \sqrt{20^2 + 35.4^2} = 40.7\Omega$$

Extra Credit:
(5 points) The capacitor in a certain condenser microphone has a variable plate separation. The voltage across the capacitor is kept at a constant 48V by phantom power. If the capacitor in its "default" seperation has a capacitance of 30μF and then the plate separation *decreases* by a factor of 2 in 2ms, find the current that flows.

$$I = \frac{\Delta Q}{\Delta t} = \frac{\Delta(CV)}{\Delta t} = V\frac{\Delta C}{\Delta t}$$
$$\Delta C = (C_f - C_i), \text{ and } C \propto \frac{1}{d}, \text{ so } C_f = 2C_i = 60\mu F$$
$$I = 48V\frac{(60\mu F - 30\mu F)}{2ms} = 0.72A$$