Name: SOLUTION (please print)

Signature: ____________________

ECE 2300 – Quiz #1
June 11, 2015

Keep this quiz closed and face up until you are told to begin.

1. This quiz is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit.
3. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
4. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
5. Do not use red ink. Do not use red pencil.
6. You will have 30 minutes to work on this quiz.

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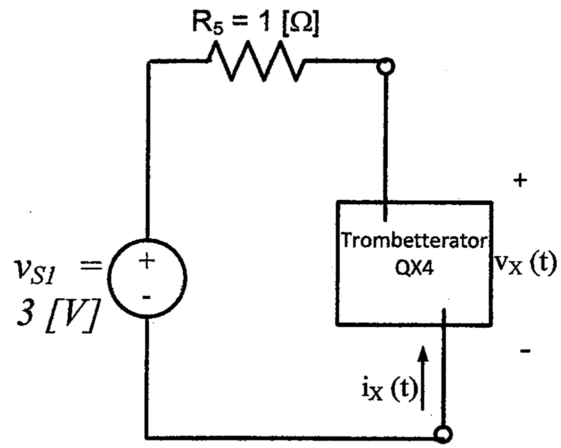
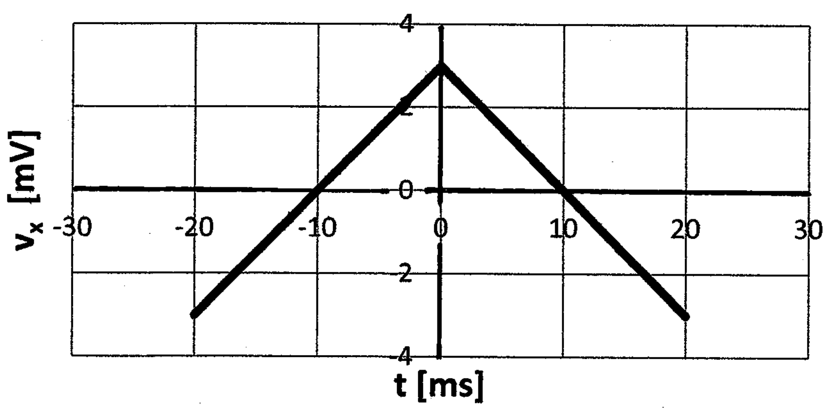
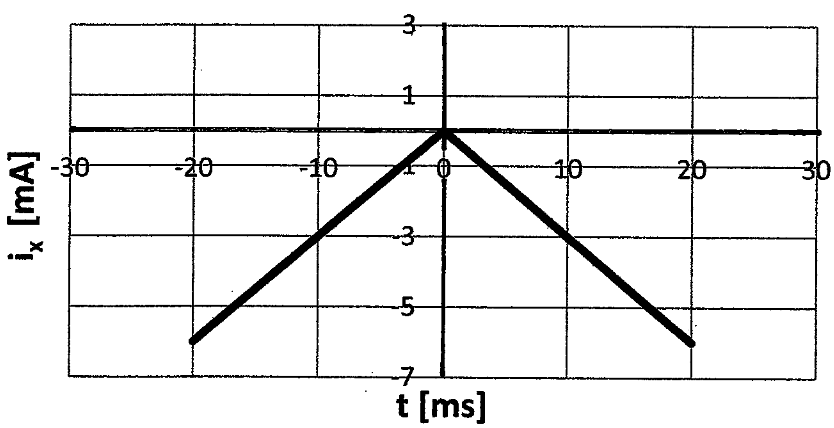
A revolutionary new device called the Trombetterator QX4 is connected to a voltage source and resistor as shown. The voltage $v_x(t)$ and current $i_x(t)$ are given in the accompanying graphs.



a) Find the energy delivered by the Trombetterator in the time range t = - 20 [ms] to 20 [ms].

b) State whether charge carriers are gaining or losing energy as they move through the Trombetterator at t = - 5 [ms].





Room for extra work $\quad Tr \equiv$ Trombetterator

UNITS: $mV \cdot mA = \mu W$

a) From the graphs we have...

$-20\,[ms] \le t \le 0$: $\quad v_x(t) = 3\,[mV] + 0.3\left[\frac{mV}{ms}\right]t$, $\quad i_x(t) = 0.3\left[\frac{mA}{ms}\right]t$

$$P_{abs\ by\ Tr} = -i_x(t)\cdot v_x(t) \Rightarrow P_{del\ by\ Tr} = i_x(t)\,v_x(t)$$

$$\Rightarrow P_{del\ by\ Tr} = 0.9\left[\frac{\mu W}{ms}\right] + 0.09\left[\frac{\mu W}{ms^2}\right]t^2$$

$0 \le t \le 20\,[ms]$: $\quad v_x(t) = 3\,[mV] - 0.3\left[\frac{mV}{ms}\right]t$, $\quad i_x(t) = -0.3\left[\frac{mA}{ms}\right]t$

$$\Rightarrow P_{del\ by\ Tr} = -0.9\left[\frac{\mu W}{ms}\right]t + 0.09\left[\frac{\mu W}{ms^2}\right]t^2$$

So $$W_{del\ by\ Tr} = \int_{-20[ms]}^{0}(0.9t + 0.09t^2)\,dt + \int_{0}^{20[ms]}(-0.9t + 0.09t^2)\,dt$$

Note: In effect, "dt" has units [ms] so each term in the integral has units $[\mu W]\cdot[ms] = [nJ]$

$$W_{del\ by\ Tr} = \frac{0.9}{2}t^2\Big|_{-20[ms]}^{0} + \frac{0.09}{3}t^3\Big|_{-20[ms]}^{0} + \left(\frac{-0.9}{2}\right)t^2\Big|_{0}^{20[ms]} + \frac{0.09}{3}t^3\Big|_{0}^{20[ms]}$$

$$= -0.45(-20)^2 - 0.03(-20)^3 - 0.45(20)^2 + 0.03((20))^3$$

UNITS: $\left[\frac{\mu W}{ms}\right]\ [ms]^2 \quad \left[\frac{\mu W}{ms^2}\right][ms]^3$

$= 120\,[nJ]$

b) At $t = -5\,[ms]$, i_x is negative and v_x is positive. Hence $P_{abs\ by\ Tr}$ is positive, so charge carriers are losing energy.