EECE 210 – Quiz 1

October 22, 2011

1. The figure shows the assigned voltage drop across a given circuit element, the current being carried by electrons flowing through the circuit element in the direction shown. Which of the following statements is, or are, true? (Note: if a false statement is marked true, the answer to this Question 1 is considered incorrect).

1. The circuit element delivers power.
2. The electric potential energy of electrons is higher at terminal a than at terminal b.
3. If the flow of electrons is 3.2×1019/s, and the charge per electron is -1.6×10-19 C, the magnitude of the current is 2×1038 A.
4. The difference between the electric potential energies of electrons at terminals a and b is independent of which of these terminals is grounded.
5. If the element is a resistor and power is absorbed by the element, then if the rate of flow of electrons in particles per second is doubled, the power absorbed by the element will be doubled.

**Answers:** A. The direction of conventional current flow is opposite that of electron flow, because electrons are negatively charged. The current is in the direction of a voltage drop and power is absorbed by the element.

B. Because of their negative charge, electrons will have a higher electric potential energy at the more negatively charged terminal, b.

 C. The magnitude of the current is 3.2×1019×1.6×10-19 = 5.12 A.

 D. The difference in electric potential energy is independent of where the arbitrary zero of this potential energy is taken.

E. When the rate of flow is doubled, the current is doubled, the voltage drop is doubled, and the power absorbed is quadrupled.

 Only statement D is true.

**2.** Which of the following statements is, or are, true of the circuit shown? (Note: if a false statement is marked true, the answer to this Question 2 is considered incorrect).

1. It is impossible to tell whether or not the source connections are valid.
2. The connections of voltage sources and current sources are valid.
3. The connection of voltage sources is not valid.
4. The connection of current sources is not valid.
5. The source connections become valid if the 5 Ω resistor is removed.

**Solution:** From KCL, the currents in the voltage sources are the same as those of the current sources, and the current at node b is 1 A in the direction shown. The voltage across the 5 Ω resistor is 5 V in the polarity shown. From KVL, the voltage across the 2 A source is zero, and the voltage across the 1 A source is 5 V in the polarity shown. KVL and KCL are satisfied throughout the circuit, so the circuit is valid,

**3.** In the circuit shown, the values of two resistors are expressed in terms of the resistance *R*, and the values of two resistors are expressed in terms of the conductance *G*. Determine the resistance between terminals a and b, assuming  Ω.

1. 4.5 Ω
2. 3 Ω
3. 3/2 Ω
4. 7.5 Ω
5. 6 Ω

**Solution:** The resistance of a resistor whose conductance is 2*G* is , and the

resistance of a resistor whose conductance is *G* is . It follows that the resistance of the two paralleled resistors is *R*/2, and the total resistance between terminals ab is *Reqs* = 3*R*/2.

**Version 1:** *R* = 1 Ω, *Reqs* = 3*R*/2 = 3/2 Ω

**Version 2:** *R* = 2 Ω, *Reqs* = 3*R*/2 = 3 Ω

**Version 3:** *R* = 3 Ω, *Reqs* = 3*R*/2 = 4.5 Ω

**Version 4:** *R* = 4 Ω, *Reqs* = 3*R*/2 = 6 Ω

**Version 5:** *R* = 5 Ω, *Reqs* = 3*R*/2 = 7.5 Ω.

**4.** When the switch is closed, a current *i* flows that begins charging the capacitor. After a sufficiently long time, the capacitor is fully charged. Determine the energy stored in the capacitor when it is fully charged, assuming *VB* = 2 V.

1. 4 µJ
2. 16 µJ
3. 36 µJ
4. 25 µJ
5. 9 µJ

**Solution:** When the capacitor is fully charged, *i* = 0, and the voltage across the capacitor is *VB*, and the energy stored in the capacitor is .

**Version 1:** *VB* = 2 V, = 4 µJ

**Version 2:** *VB* = 3 V, = 9 µJ

**Version 3:** *VB* = 4 V, = 16 µJ

**Version 4:** *VB* = 5 V, = 25 µJ

**Version 5:** *VB* = 6 V, = 36 µJ.

**5.** Determine the total energy delivered by the battery in the preceding problem when the capacitor is fully charged.

1. 32 µJ
2. 72 µJ
3. 18 µJ
4. 50 µJ
5. 8 µJ

**Solution:** The instantaneous power delivered by the battery is *p* = *VBi*. The total energy delivered by the battery is , assuming that charging begins at *t* = 0. But  is the total charge delivered to the capacitor, which is *CVB*. It follows that .

**Version 1:** *VB* = 2 V, = 8 µJ

**Version 2:** *VB* = 3 V, = 18 µJ

**Version 3:** *VB* = 4 V, = 32 µJ

**Version 4:** *VB* = 5 V, = 50 µJ

**Version 5:** *VB* = 6 V, = 72 µJ.

**6.** Determine *I*  assuming *ρ* = 0.9 Ω.

1. 30 A
2. 12 A
3. 60 A
4. 15 A
5. 20 A

**Solution:** From KCL at node a: *I* = *I*1 + *I*2; from KVL in the outer loop, 6 = 1×*I*1; from KVL in the RHS mesh, *ρI* = 1×*I*2; hence, *I* = 6 + *ρI*, or A.

**Version 1:** *ρ* = 0.9 Ω, *I* = 6/(1 – *ρ*) = 6/0.1 = 60 A

**Version 2:** *ρ* = 0.8 Ω, *I* = 6/(1 – *ρ*) = 6/0.2 = 30 A

**Version 3:** *ρ* = 0.7 Ω, *I* = 6/(1 – *ρ*) = 6/0.3 = 20 A

**Version 4:** *ρ* = 0.6 Ω, *I* = 6/(1 – *ρ*) = 6/0.4 = 15 A

**Version 5:** *ρ* = 0.5 Ω, *I* = 6/(1 – *ρ*) = 6/0.5 = 12 A.

**7.** A nonideal voltage source has an open-circuit voltage *VSRC*. When connected to a load resistor that draws a current of *IL* = 1 A, the power dissipated in the load is four times the power dissipated in the source resistance. Determine the short-circuit current of the equivalent nonideal current source.

1. 12.5 A
2. 5 A
3. 7.5 A
4. 15 A

1. 10 A

**Solution:** Since the power dissipated in the load is four times the power dissipated in the source resistance, the load resistance is 4*Rsrc*. The short-circuit current of the nonideal current source is . From KVL, *VSRC* = 5*RsrcIL*. It follows that .

**Version 1:** *IL* = 1 A, *ISRC* = 5*IL* = 5 A

**Version 2:** *IL* = 1.5 A, *ISRC* = 5*IL* = 7.5 A

**Version 3:** *IL* = 2 A, *ISRC* = 5*IL* = 10 A

**Version 4:** *IL* = 2.5 A, *ISRC* = 5*IL* = 12.5 A

**Version 5:** *IL* = 3 A, *ISRC* = 5*IL* = 15 A.

**8.** Determine the energy stored in the inductor if *L* = 1 H assuming dc conditions, after all voltages and currents have assumed constant values.

1. 0.75 J
2. 1 J
3. 1.5 J
4. 2 J
5. 0.5 J

**Solution:** Under dc conditions, the current through the capacitors is zero, and the voltage across the inductor is zero. From KVL, a current equal to 1A passes through the

upper 5 Ω resistor and through *L*. The energy stored in the inductor is = *L*/2 J.

**Version 1:** *L* = 1 H, *W = L/*2 *=* 0.5 J

**Version 2:** *L* = 1.5 H, *W = L/*2 *=* 0.75 J

**Version 3:** *L* = 2 H, *W = L/*2 *=* 1 J

**Version 4:** *L* = 3 H, *W = L/*2 *=* 1.5 J

**Version 5:** *L* = 4 H, *W = L/*2 *=* 2 J.

**9.** Determine *VX*, assuming *VSRC* = 2.5 V.

1. 1 V
2. 5 V
3. 3 V
4. 2 V
5. 4 V

**Solution:** From KVL, *VSRC* = 3*I* + *Vx* = 5*I*; *I* = *VSRC*/5, and *VX* = 2*VSRC*/5 = 0.4*VSRC*.

**Version 1:** *VSRC* = 2.5 V, *VX =* 0.4*VSRC =* 1 V

**Version 2:** *VSRC* = 5 V, *VX =* 0.4*VSRC =* 2 V

**Version 3:** *VSRC* = 7.5 V, *VX =* 0.4*VSRC =* 3 V

**Version 4:** *VSRC* = 10 V, *VX =* 0.4*VSRC =* 4 V

**Version 5:** *VSRC* = 12.5 V, *VX =* 0.4*VSRC =* 5 V.

1. The figure shows the variation with time of the charge across a capacitor of 0.1 µF. Determine the average voltage across the capacitor.
2. V
3. 2.5 V
4. 2 V
5. 10 V
6. 5 V

**Solution:** The net area is  μC-min. The average charge is 6/6 = 1μC and the average voltage is *V* = (1μC)/(*C* μF) = 1/*C* V.

**Version 1:** *C* = 0.1 μF, *V =* 1/*C* = 10 V

**Version 2:** *C* = 0.2 μF, *V =* 1/*C* = 5 V

**Version 3:** *C* = 0.4 μF, *V =* 1/*C* = 2.5 V

**Version 4:** *C* = 0.5 μF, *V =* 1/*C* = 2 V

**Version 5:** *C* = 0.8 μF, *V =* 1/*C* = 1.25 V.

**11**. Determine *R*, so that no power is delivered or absorbed by the 1 A current source, assuming *VSRC* = -6 V.

**Solution:** The solution proceeds in the following steps:

1. Since 1 A passes in branch ad, the voltage drop across the 2 Ω resistor is 2 V in the polarity shown.
2. Since no power is delivered or absorbed by the 1 A source, the voltage across this source is zero. From KVL around mesh abd, the voltage across *R* is also 2 V.
3. From KVL around mesh bcd, the voltage across branch cd is (2 + *VSRC*) V, since by going clockwise around this mesh, (2 + *VSRC*) – 2 – *VSRC* = 0.

1. From Ohm’s law, the current in the branch bc is (1 + *VSRC*/2) A directed towards node b.
2. From KCL at node b, the current flowing away from node b is: (2 + *VSRC*/2) A.
3. From Ohm’s law applied to *R*, *R*(2 + *VSRC*/2) = -2.

It follows that *R* = .

**Version 1:** *VSRC* = -6 V,  Ω

**Version 2:** *VSRC* = -8 V,  Ω

**Version 3:** *VSRC* = -10 V,  Ω

**Version 4:** *VSRC* = -12 V,  Ω

**Version 5:** *VSRC* = -14 V,  Ω.

**12**. Determine the power delivered by *ISRC =* 1 A.

**Solution:** The 1 Ω and the 2 Ω resistors on the extreme RHS can be combined into a 3 Ω resistor. This gives a set of 3 Ω resistors connected in Δ, these being connected in parallel with three 1 Ω resistors connected in Y. The three Δ-connected resistors can be transformed to three 1 Ω resistors connected in Y. When these are paralleled with the existing 1 Ω resistors connected in Y, the result is three 0.5 Ω resistors connected in Y, as shown. The two 0.5 Ω resistors in series, paralleled with the give a 0.5 Ω resistor. When this is added to the 0.5 Ω and 2.5 Ω resistors, the resistors on the RHS of the source reduce to a 3 Ω resistor. Alternatively, the three 1 Ω resistors connected in Y can be transformed to three 3 Ω resistors connected in Δ. These are paralleled with the three 3 Ω Δ-connected resistors to give three 1.5 Ω resistors connected in Δ. These resistors can then be combined with the 1 Ω resistor to give a 0.5 Ω as before. The two 3 Ω resistors in parallel with *ISRC* give a 1.5 Ω resistor. The power delivered by the source is .

**Version 1:** *ISRC* = 1 A,= 1.5 W

**Version 2:** *ISRC* = 2 A,= 6 W

**Version 3:** *ISRC* = 3 A,= 13.5 W

**Version 4:** *ISRC* = 4 A,= 24 W

**Version 5:** *ISRC* = 5 A,= 37.5 W.

**13.** Determine the power dissipated in the 5 Ω resistor, assuming *ISRC* = 1 A.

**Solution:** The two current sources in parallel with their associated resistors can be transformed to voltage sources as shown. From KVL around the circuit: 3*ISRC* = 2*VX* + 5*I*, where *VX* = 5*I*. Substituting for *VX*, 3*ISRC* = 15*I,* and *I =* 0.2*ISRC*. The power dissipated in the 5 Ω resistor is *P* = W

**Version 1:** *ISRC* = 1 A,= 0.2 W

**Version 2:** *ISRC* = 2 A,= 0.8 W

**Version 3:** *ISRC* = 3 A,= 1.8 W

**Version 4:** *ISRC* = 4 A,= 3.2 W

**Version 5:** *ISRC* = 5 A,= 5 W.