EECS 210
Homework #3 Solutions

2. 1.8

$$i = \frac{dq}{dt} = 24\cos 4000t$$

$$q = \int i \ dt = \frac{24}{4000}\sin 4000t$$

$$q(t) = 0.006\sin 4000t$$

3. 1.10

a) $p = iv = (5A)(120V) = 600$ W Power flows A $\rightarrow$ B

b) $p = iv = (-8A)(250V) = -2$ kW Power flows B $\rightarrow$ A

c) $p = iv = (16A)(-150V) = -2.4$ kW Power flows B $\rightarrow$ A

d) $p = iv = (-10A)(-480V) = 4.8$ W Power flows A $\rightarrow$ B

4. 1.11

a) $p = iv = (-10A)(40V) = -400$ W delivered by the element

b) Convention: Negative charge (electrons) flows against reference arrow. Negative current value reverses this. Therefore, electrons flow with reference arrow, and enter terminal 2 in Fig. 1.6(d).

c) Since power is delivered by the element, the electrons gain energy.

5. 1.13

a) Consider car A:
Since a positive current is flowing in the direction of the reference voltage drop, positive power is being delivered to car A, which must be the dead battery.

b)

$$\frac{dw}{dt} = p = vi$$

$$w = \int p\,dt = \int_0^{60\,sec} vi\,dt = 12V(30A)t\Big|_0^{60} = 21.6\,kJ$$

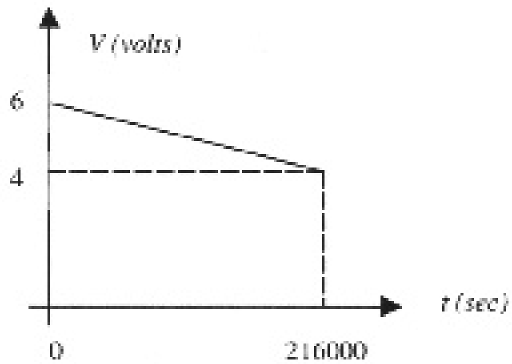
OR

Since the is 12 V DC:

$p = iv = (12V)(30A) = 360$ J/s

$$w = \frac{360\text{ J}}{1\text{sec}}\frac{60\text{sec}}{1\text{min}} = 21.6\text{ kJ}$$

6 1.14



$$v = -\frac{2}{216000}t + 6$$

$$w = \int p\,dt = \int vi\,dt = \int_0^{216000\,sec} \left(-\frac{2}{216000}t + 6\right) i\,dt$$

$$= \int_0^{216000\,sec} \left(-\frac{1}{108000}t\right) i\,dt + \int_0^{216000\,sec} 6i\,dt$$

$$= \left[-\frac{i}{108000}\frac{t^2}{2} + 6i \cdot t\right]_0^{216000}$$

$$= -216000i + 1296000zai = 16.2\text{ kJ}$$

OR

Realize voltage drop is linear, with average of $V_{ave} = 5$ V.

$$w = \text{Average power} \cdot \text{time} = (V_{ave} \cdot i) \cdot t$$
$$= (5V)(0.015A)(216000\,\text{sec}) = 16.2\text{ kJ}$$

7. 1.27

Element	Voltage (V)	Current (A)	Power (W)
A	48	-12	-576
B	18	-4	-72
C	30	-10	300
D	36	16	576
E	36	8	-288
F	-54	14	756
G	84	22	-1848

Total = -1152 W

Thus, conservation of energy is not satisfied and the circuit interconnections are inconsistent. By checking KCL at the node connecting elements a, b, d, e, a:

$$-12 - 4 - 16 + 8 = -24\text{ A} \neq 0$$

it is shown that there must be a 24 A current source is omitted from the circuit.

8. 2.2

a) 9
b) 7
c) 4
d) V_a, R_a;
   V_b R_b,
   V_a, R_c
e) 3,
   For example, verify that branch currents i_a, i_d, i_e through resistors R_a, R_d, R_e specify all other branch currents via application of KCL to the three essential nodes connecting R_a, R_d, R_f; R_d, R_b, R_c; R_c, R_e, R_f respectively.

9. 2.3

Source	Power delivered to:
8 A	$p = v \cdot i = (60\ V)(8\ A) = 480\ W$
60 V	$p = (60\ V)(12\text{-}8\ A) = 240\ W$
12 A	$p = v_{12A}(12\ A) = (-40\ V)(12\ A) = -480\ W$
20 V	$p = (-20\ V)(12\ A) = -240\ W$

Where v_{12A} is the voltage drop across the 12 A source found by using KVL around the right loop:

$$v_{12A} - 20\ V + 60\ V = 0$$
$$v_{12A} = -40\ V$$

Power supplied by the left two sources:

$p_{left} = 480\ W + 240\ W = 720\ W$

is delivered to the right two sources:

$p_{right} = -480\ W - 240\ W = -720\ W$

⇒ Energy is conserved

10.

Resistance values (from Table 6.2)

RH_A = 3 to 6 kΩ
RH_B = 10 t0 30 kΩ
RI = 200 to 1000 Ω
RF = 100 to 300 Ω

$R_{total\ A,\ max} = 6 + 1 + 0.3 = 7.3\ k\Omega$
$R_{total\ A,\ min} = 3 + 0.2 + 0.1 = 3.3\ k\Omega$
$R_{total\ B,\ max} = 30 + 1 + 0.3 = 31.3\ k\Omega$
$R_{total\ B,\ min} = 10 + 0.2 + 0.1 = 10.3\ k\Omega$

1) Currents
   $I_{A,\ max} = 120\sqrt{2} / 3.3 = 51.4$ mA
   $I_{A,\ min} = 120\sqrt{2} / 7.3 = 23.2$ mA
   $I_{B,\ max} = 120\sqrt{2} / 10.3 = 16.5$ mA
   $I_{B,\ min} = 120\sqrt{2} / 31.3 = 5.4$ mA

Effects (from Figure 6.8)

Let-Go current: 8 mA and more
Respiratory paralysis: 15 mA and more
Ventricular fibrillation: 50 mA and more

Conclusions:

2) For both students, the currents may exceed the Let-Go limit.

3) For both students, the currents may cause respiratory paralysis, fatigue, and pain. For student A, the currents may cause ventricular fibrillation.

4) **To reduce danger, DO NOT touch electrical wires when your feet are immersed in water.** According to Table 6.2 of the Additional Course Notes, RF was the lowest resistance in the series. If your feet are dry and well insulated (by wearing good shoes, standing on an insulating mat), the current will not flow through your heart even if you touch a live wire with one hand.