School of Electrical Engineering and Computing (SoEEC)

Electrical Power and Control Engineering Department (EPCE)

Fundamentals of Electrical Engineering (EPCE2101)

Worksheet on Chapter One

1. How many coulombs are represented by these amounts of electrons:

a. 6.482 x 1017 electrons

b. 2.460 x 1019 electrons

Solution

a. **qe** = 6.482 x 1017 * -1.602 x 10-19 C = **-0.10384 C**

b. **qe = 2.460 x 1019 * -1.602 x 10-19 C = -0.19865 C**

2. Determine the current flowing through an element if the charge flow is given by:

a. q(t) = (3t + 8) mC

b. $q(t)=(8t^2+4t-2)$ C

c. $q(t)=(10\sin 120\pi t)$ pC

Solution

a. i= dq/dt = 3mA

b. i = dq/dt = $(16t - 8t^{-3})$ A

c. i=dq/dt = 1200 π cos (120 πt) pA

3. Find the charge q(t) flowing through a device if the current is i(t)=(2t+5)mA, q(0)=0

Solution

$$(t) = \int (t)dt + q(0) = (t^2 + 5t)\ \text{mC}$$

4. Determine the total charge transferred over the time interval of $0 \leq t \leq 10s$ when $\boldsymbol{i(t) = ½\ t\ A}$

Solution

$$q = \int i * dt = \int_0^{10} \frac{1}{2} t * dt = \frac{t^2}{4}\ [0,10] = \mathbf{25\ C}$$

5. A current of 200 mA flows through a resistance of 750 Ω for a time of 5 minutes. Calculate

a. The potential difference developed

b. The energy dissipated.

Solution

I =200 mA = 0.2A; t = 5x60 =300s; R =750Ω

a. V= IR

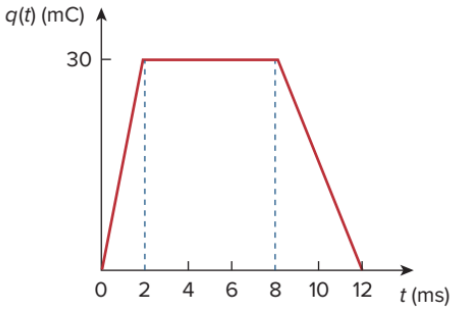
= 0.2X750Ω

= 150 V

b. $W= I^2Rt=0.04x750x300=9000J$

6. The charge entering a certain element is shown in the figure below, Find the current at:

a. t = 1 ms
b. t = 6 ms
c. t = 10 ms



Solution

a. At *t=1 ms*, $\frac{\Delta q}{\Delta t} = \frac{30}{2} = 15A$

b. At *t=6 ms*, $\frac{\Delta q}{\Delta t} = \frac{0}{6} = 0A$

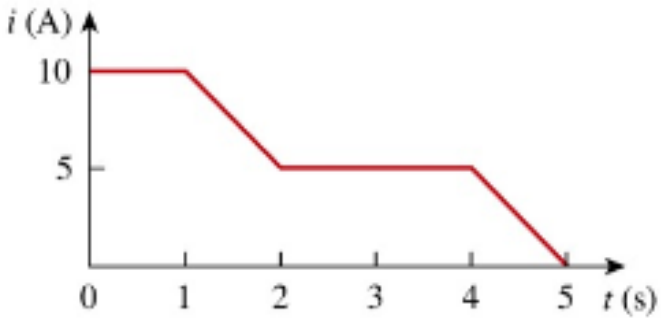
c. At *t=10 ms*, $\frac{\Delta q}{\Delta t} = \frac{-30}{4} = -7.5A$

7. The current of element is shown. Find the total charge that passed through element at:

a. t=1s

b. t=3s

c. t=5s



Solution

a. $q = \int idt = \int_0^1 10dt = 10C$

b. $q = \int_0^3 idt = 10x1 + (10 - \frac{5x1}{2}) + 5x1$

$= 15 + 7.5 + 5 = 22.5C$

c. $q = \int_0^5 idt = 10 + 10 + 10 = 30C$

8. A rechargeable flashlight battery is capable of delivering 90 mA for about 12 h. How much charge can it release at that rate? If its terminal voltage is 1.5 V, how much energy can the battery deliver?

Solution

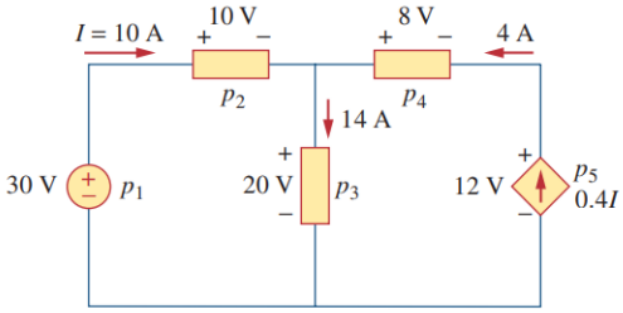
Multiply the current by the time to get the amount of charge delivered.

$$Q = (90mAx\frac{1A}{1000mA})x(12hx\frac{3600s}{1h}) = 3888A.s = 3888C$$

Note that terminal voltage is the amount of work it takes to move a unit of positive charge from one battery terminal to the other. Multiply the calculated charge by the terminal voltage to get the amount of energy the battery can deliver.

$$W = QV = (3888C)(1.5V) = 5832J$$

9. Find the power absorbed by each of the elements in Fig. shown below



Solution

The numerical value of the power for an element is obtained by multiplying the voltage and current through it. i.e. **P=V*i**

P_1 = -30V*10A = -300W(emitted)

P_2 = +10V*10A = +100W(absorbed)

P_3 = +20V*14A = +280W(absorbed)

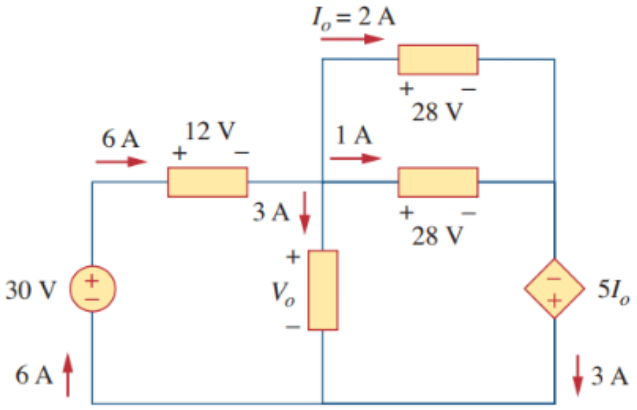
P_4 = -8V*4A = -32W(emitted)

P_5 = -12V*0.4*10A = -48W(emitted)

Observe that the sum of power in this circuit is zero, consistent with the law of conservation of energy.

$$\sum P = p_1 + p_2 + p_3 + p_4 + p_5 = (-300 + 100 + 280 - 32 - 48)\ \text{W} = 0$$

10. Find **Vo** in the circuit of Fig. shown below



Solution

To get the power for a circuit element, multiply the voltage and current through it. The current is negative if it flows out of the element through the positive end.

P Independent voltage source = (30 V) (−6 A) = −180 W

$$P_{left12V} = (12V)(6A) = 72W$$

$$P_{middleV_0} = (V_0)(3A) = 3V_0W$$

$$P_{right1A} = (28V)(1A) = 28W$$

$$P_{right2A} = (28V)(2A) = 56W$$

P Independent voltage source = (5x2V) (−3 A) = −30 W

Use the fact that the sum of power in this circuit is zero (law of conservation of energy) to solve for $\mathbf{V_0}$

$$\sum P = (-180 + 72 + 3V_0 + 28 + 56 - 30)W = (3V_0 - 54)W = 0$$

Therefore,

$$V_0 = 18$$

$$P_{middleV_0=3V_0} = 54W$$

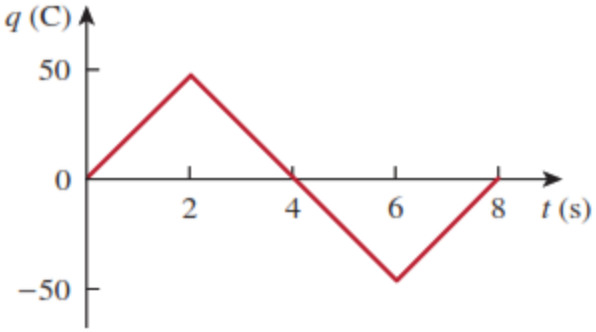
Exercise

1. If the current flowing through an element is given by

$$i(t) = \begin{cases} 3t\text{A}, & 0 \leqq t < 6\text{ s} \\ 18\text{A}, & 6 \leqq t < 10\text{ s} \\ -12\text{A}, & 10 \leqq t < 15\text{ s} \\ 0, & t \geqq 15\text{ s} \end{cases}$$

   Plot the charge stored in the element over **0< t < 20 s.**

2. The charge flowing in a wire is plotted in Fig. below. Sketch the corresponding current.



3. The charge entering the positive terminal of an element is

$$q = 10\sin 4\pi mC$$

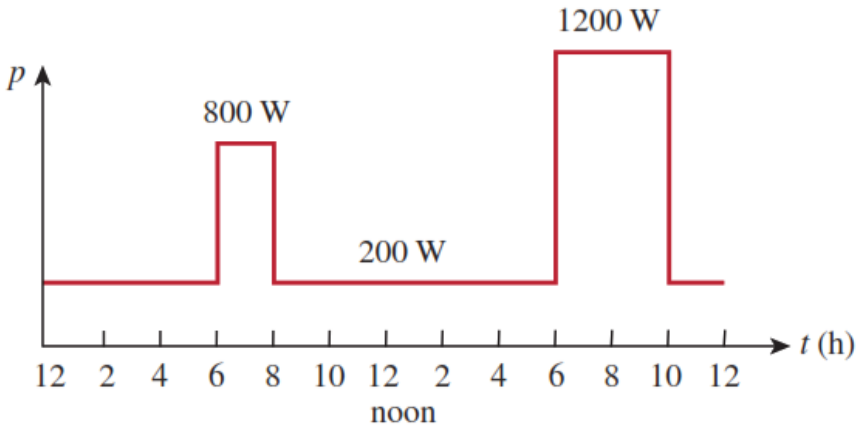
   while the voltage across the element (plus to minus) is

$$v = 2\cos 4\pi tV$$

   Find

   a. The power delivered to the element at **t= 0.3s**
   b. The energy delivered to the element between **0 and 0.6 s**.

4. Figure below shows the power consumption of a certain household in one day. Calculate:
   a. The total energy consumed in kWh,
   b. The average power per hour.



5. A 30-W incandescent lamp is connected to a 120-V source and is left burning continuously in an otherwise dark staircase. Determine:

a. The current through the lamp.

b. The cost of operating the light for one non-leap year if electricity costs 12 cents per kWh.

6. A 600-W TV receiver is turned on for 4 h with nobody watching it. If electricity costs 10 cents/kWh, how much money is wasted?

7. In a household, a 120-W personal computer is run for 4 h/day, while a 60-W bulb runs for 8 h/day. If the utility company charges $0.12/kWh, calculate how much the household pays per year on the PC and the bulb.