Chapter 1 – Preliminary Considerations

PE1.1 Let the current due to the negative charges moving in the negative *x*-direction be I_{nx^-}. The current that neutralizes this current is that due to positive charges moving in the negative *x*-direction at a rate of 0.5 C/s, which is -0.5 A. Hence, I_{nx^-} + (-0.5) = 0, or, I_{nx^-} = 0.5 A\

PE1.2 For $0 \leq t \leq 0.5$ ms: rate of increase of charge is 15 mC/0.5 ms = 30 C/s = 30 A. For $0.5 \leq t \leq 2$ ms: rate of decrease of charge is 15 mC/1.5 ms = 10 C/s, equivalent to a current of -10 A.

PE1.3 In Figure 1.8, *q* = (1 A)×(1 s) – (1 A)×(0.25 s) = 0.75 C.

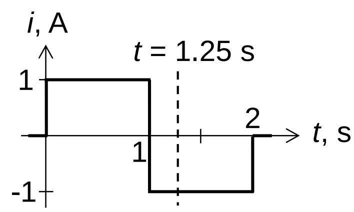

Figure 1.8

E1.4 From Equation 1.5,

$$I = Aneu = \frac{\pi}{4}\left(10^{-3}\right)^2 \times \left(8.4 \times 10^{28}\right) \times \left(-1.6 \times 10^{-19}\right) \times \left(0.02 \times 10^{-2}\right) = \text{-2.11 A}$$

The negative sign indicates that the current flows in the negative *x*-direction.

PE1.5 (a) A voltage drop is from terminal ‘b’ to terminal ‘a’; (b) a voltage rise is from terminal ‘a’ to terminal ‘b’.

PE1.6
(a) The electric potential energy of the particle increases by (0.1 C)×(3 V) = 0.3 J.
(b) The electric potential energy of the particle changes by (-0.2) ×(5 V) = -1 J, which represents a decrease of 1 J.
(c) Work must be done on the positive charge to move it up a voltage difference of 3 V. A negatively-charged particle loses potential energy when it moves up a voltage difference, that is, when it moves from a location of higher potential energy to a location of lower potential energy. This represents the motion of an unconstrained particle.

PE1.7
(a) The current that flows from terminal ‘a’ to terminal ‘b’ through the battery, or from terminal ‘b′’ to terminal ‘a′’ through the lamp, is in the direction opposite that of *I*. This current is therefore -0.25 A.
(b) If the voltage rise from terminal ‘b’ to terminal ‘a’ is 3 V, then the voltage drop from terminal ‘b’ to terminal ‘a’ is -3 V. Similarly, if the voltage drop from terminal ‘a’’ to terminal ‘b’’ is 3 V, then the voltage rise from terminal ‘a’’ to terminal ‘b’’ is -3V.

(c) Power delivered by the lamp = (current through the lamp)×(voltage rise across the lamp in the direction of current) = (0.25 A)×(-3 V) = -0.75 W = the negative of the power absorbed by the lamp.

Power absorbed by the battery = (current through the battery)×(voltage drop across the battery in the direction of current) = (0.25 A)×(-3 V) = -0.75 W = the negative of the power delivered by the battery.

PE1.8 In Figure 1.19, the area from 0 to 5 s is (1 W)×(5 s)/2 = 2.5 J, P_{av} = 2.5/5 = 0.5 W.

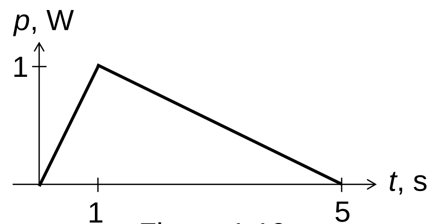

Figure 1.19

PE1.9 In Figure PE1.9,

(a) 0 < t < 1 s: power absorbed = (2 V)×(3 mA) = 6 mW; 1 < t < 2 s: power delivered = (2 V)×(3 mA) = 6 mW;

(b) 0 < t < 1 s: energy absorbed = (6 mW)×(1 s) = 6 mJ; 1 < t < 2 s: power delivered = (6 mW)×(1 s) = 6 mJ; over the interval 0 to 2 s, 6 mJ are absorbed and 6 mJ are delivered; hence no net energy is absorbed or delivered.

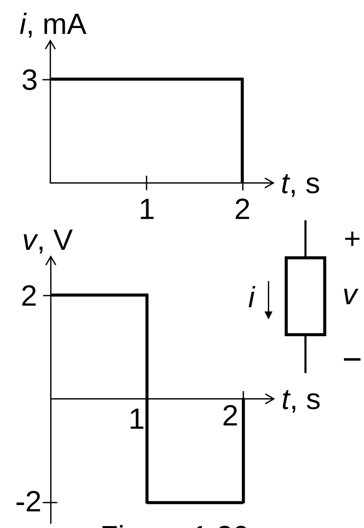

Figure 1.20

P1.1 The charge carried by a 10 m length of the belt is 4×0.75×10 = 30 μC. This charge passes a reference location in 1 s. The current is therefore 30 μA.

P1.2 $|u| = \dfrac{1\,\text{A}}{10^{-6} \times 8.4 \times 10^{28} \times 1.6 \times 10^{-19}} = 7.44 \times 10^{-5}$ m/s; $t = \dfrac{2\,\text{m}}{7.44 \times 10^{-5}} \cong 26880$ s ≡ 7 hrs, 28 min.

P1.3 (a) The current is equivalent to 0.5×10^{-6} C/s; since each alpha particle has a charge of 3.2×10^{-19} C, then the number of alpha particles striking the surface per second is $0.5\times10^{-6}/3.2\times10^{-19} = 1.563\times10^{12}$ particles.

(b) The number of particles per meter is the (concentration, n)×(cross section, A). If this is multiplied by the velocity in m/s, the product is the number of particles striking the surface per second. That is, $nAu = 1.563\times10^{12}$. Hence, n =

$$\frac{1.563\times10^{12}}{Au} = \frac{1.563\times10^{12}}{2\times10^{-4}\times1.5\times10^{7}} = 5.21\times10^{8}\ \text{particles/m}^3.$$

P1.4 (a) Disregarding signs to begin with, 1 A = rate of flow of charge in C/s = (rate of flow of electrons in electrons/s)×(magnitude of charge per electron in C). Hence, rate of flow of electrons = 1/(1.6×10^{-19}) = 6.25×10^{18} electrons/s. Because of the negative charge on electrons, the current is in the direction opposite that of electron flow.

(b) The fuse blows because of the melting of the fuse wire due to the heat generated by the current. Since this heat is proportional to the square of the current value, it is independent of the sign of this current and hence of the direction of current.

(c) From Equation 1.5, rate of flow of electrons = $6.25\times10^{18} = \frac{I}{e} = An|u|$ =

(0.0025×10^{-6} m^2)×(10^{28}/m^3)×$|u|$. This gives $|u| = \frac{6.25\times10^{18}}{2.5\times10^{-9}\times10^{28}} = 0.25$ m/s.

P1.5 (a) The current due to positive charges moving in the positive x-direction adds to the current due to negative charges moving in the negative x-direction. The total current is: $\frac{5\times10^{18}\times1.6\times10^{-19}}{60} + \frac{-2.5\times10^{18}\times(-1.6\times10^{-19})}{60} = 0.02$ A $\equiv$ 20 mA.

(b) The sign of the current is reversed to -20 mA.

(c) The currents due to holes and electrons are in opposition. The total current is:

$\frac{5\times10^{18}\times1.6\times10^{-19}}{60} + \frac{2.5\times10^{18}\times(-1.6\times10^{-19})}{60} = \frac{0.4}{60}$ A $\equiv \frac{20}{3}$ mA in the direction of movement.

P1.6 (a) The number of deposited silver atoms is $\frac{10\times3600}{1.6\times10^{-19}} = 22.5\times10^{22}$ silver atoms.

(b) The mass of a silver atom is $\frac{0.1079}{6.025\times10^{23}}$ kg; mass of deposited atoms is:

$\frac{0.1079}{6.025\times10^{23}}\times22.5\times10^{22} = 0.0403$ kg $\equiv$ 40.3 g.

P1.7 It follows from Figure P1.7 that i = $\frac{dq}{dt} = \pi\cos(\pi t/2)$ A, $0 \le t \le 1$ s; i = 0, $1 \le t \le 2$ s; for $2 \le t \le 4$ s; i is the slope of the line, which is -2 C/s = -2 A; similarly,

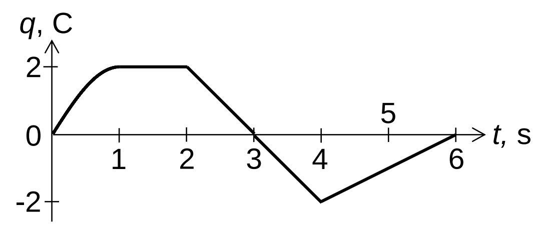

Figure P1.7

for $4 \le t \le 6$ s, the slope is 2 C/2s = 1 A. The time variation is as shown in Figure P1.7A. Note that q starts and ends at zero, so that the total area under the i-t should be zero. This area is

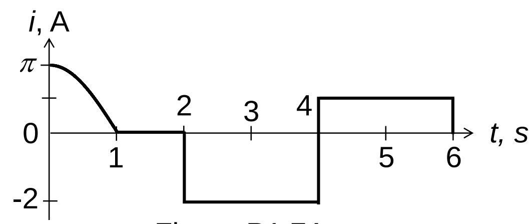

Figure P1.7A

$$\int_0^1 \pi \cos(\pi t/2)dt \; - 4 + 2 =$$

$$[2\sin(\pi t/2)]_0^1 = 2 - 4 + 2 = 0.$$

P1.8 From Figure P1.8A,

$0 \le t \le 1$ s: $i = 2\sin(\pi t/2)$ A,

$$q = \int_0^t 2\sin\left(\frac{\pi}{2}t\right)dt = \frac{4}{\pi}\left[-\cos\left(\frac{\pi}{2}\right)t\right]_0^t$$

$$q = \frac{4}{\pi}\left(1 - \cos\left(\frac{\pi t}{2}\right)\right) = \frac{4}{\pi} \text{ at } t = 1 \text{ s.}$$

$1 \le t \le 2$ s: $i = 2$ A; $q = \int_1^t 2dt + q\big|_{t=1}$,

$q = 2t - 2 + \frac{4}{\pi} = 2 + \frac{4}{\pi}$ at $t = 2$ s. The area added is that of the rectangle, which is 2 C.

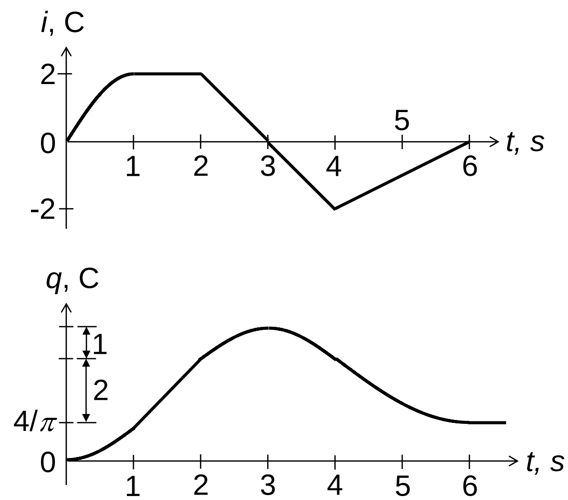

Figure P1.8A

$2 \le t \le 4$ s: $i = 2(3 - t)$ A; $q = \int_2^t 2(3-t)dt + q\big|_{t=2} = \left[6t - t^2\right]_2^t + 2 + \frac{4}{\pi} =$

$-t^2 + 6t - 6 + \frac{4}{\pi} = 3 + \frac{4}{\pi}$ at $t = 3$ s, and $2 + \frac{4}{\pi}$ at $t = 4$ s. At $t = 3$ s, the area that is added to that at $t = 2$ s is 1, the area of the triangle, and this same area is subtracted at $t = 4$.

$4 \le t \le 6$ s: $i = t - 6$ A; $q = \int_4^t (t-6)dt + q\big|_{t=4} = \left[\frac{t^2}{2} - 6t\right]_4^t + 2 + \frac{4}{\pi} =$

$\frac{t^2}{2} - 6t + 18 + \frac{4}{\pi} = \frac{4}{\pi}$ at $t = 6$ s, which is the value at $t = 4$ s minus 2, the area of the triangle. q remains at this value for $t > 6$ s. Note that the area of the rectangle plus that of the triangle above the time axis is equal to the area of the triangle below the time axis, so that the net positive area at $t = 6$ s is the same as at $t = 1$s.

P1.9 (a) From basic electrostatics, $F = q\xi$, in the direction of the electric field (Figure P1.9), where in SI units, q is in coulombs, ξ is in volts/meter, and F is in newtons.

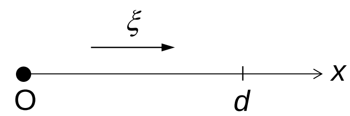

Figure P1.9

(b) Since F is independent of x, work done by F is $W = Fd$.

(c) $V_d = \int_0^d -\xi dx = -\xi d$ V, the minus sign indicating that v decreases in the x-direction.

(d) The loss in electric PE is $qV_d = q\xi d$, which is equal to Fd.

(e) The acceleration is $a = F/m = q\xi/m$ m/s^2, which is constant. Hence, velocity is $u = \int_0^t adt = at$. The distance travelled during the interval t is $d = \int_0^t udt = \int_0^t atdt = \frac{1}{2}at^2 = \frac{1}{2}a\frac{u^2}{a^2} = \frac{1}{2}\frac{u^2}{a}$. This gives: $u^2 = 2ad$. The KE is $\frac{1}{2}mu^2 = mad = m\frac{q\xi}{m}d = q\xi d$, which is the loss in electric PE.

P1.10 The KE is $\frac{1}{2}mu^2 = \frac{1}{2}(9.1\times10^{-31})(1.33\times10^6)^2 = 8.05\times10^{-19}$ J. The electron comes to rest when it loses potential energy that is equal to this K.E. The voltage drop for the electron to come to rest is $-8.05\times10^{-19}/-1.6\times10^{-19} = 5.03$ V. The distance along the x-axis is 5.03/(200) = 0.0252 m ≡ 2.52 cm.

P1.11 (a) Since electrons move to a more positive voltage, they lose potential energy. Energy loss per electron = $qV = 1.6\times10^{-19}\times10 = 1.6\times10^{-18}$ J.

(b) It is converted to K.E.

(c) $\frac{1}{2}mv^2 = 1.6\times10^{-18}$ J; $v = \sqrt{\frac{3.2\times10^{-18}}{9.1\times10^{-31}}} = 1.88\times10^6$ m/s.

P1.12 (a) $6.25\times10^{14}\times1.6\times10^{-18} = 10\times10^{-4}$ J ≡ 1 mJ.

(b) Current magnitude is: $6.25\times10^{14}\times1.6\times10^{-19} = 10\times10^{-5}$ A ≡ 100 μA in the direction of a voltage rise through the battery.

(c) The kinetic energy is converted to heat.

(d) $P = V\times I = 10\times10^{-4}$ W ≡ 1 mW.

(e) From (a), K.E. given up per second = 1 mW.

P1.13 (a) In moving a charge q through a voltage rise V_{AB}, the increase in electric PE is qV_{AB}, which is equal to the work done in moving the charge.

(b) Since $W = qV_{AB}$, with V_{AB} constant, the graph of W vs. q is straight line of slope V_{AB} passing through the origin (Figure 1.13A).

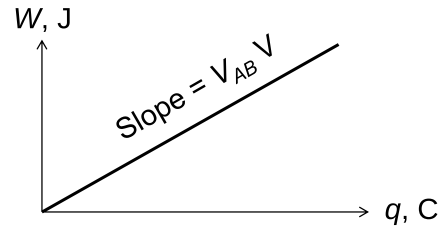

Figure P1.13A

P1.14 (a) The work done in moving dq through a voltage rise v is $dw = vdq$.

(b) Substituting $v = Kq$, $dw = Kqdq$, and $w = \int_0^{q_F} Kqdq = \frac{1}{2}Kq_F^2$ J.

(c) Substituting $q_F = V_{AB}/K$, $w = \frac{1}{2}K\left(\frac{V_{AB}}{K}\right)^2 = \frac{1}{2}\frac{V_{AB}^2}{K}$.

(d) The graph of W vs. q is parabola centered at the origin.

P1.15 $i = \frac{dq}{dt} = \omega q_m \cos\omega t$ A; $v = Kq = Kq_m \sin\omega t$; from the preceding problem,

$w(t) = \frac{1}{2}Kq^2 = \frac{1}{2}Kq_m^2 \sin^2\omega t = \frac{K}{4}q_m^2(1-\cos 2\omega t)$ J, or $w(t) = \int_0^t vidt =$

$\int_0^t \omega Kq_m^2 \sin\omega t \cos\omega t dt = \frac{\omega K}{2}q_m^2\int_0^t \sin 2\omega t = \frac{K}{4}q_m^2\left[-\cos 2\omega t\right]_0^t = \frac{K}{4}q_m^2\left(1-\cos 2\omega t\right)$ J.

P1.16 100×3600 = 360,000 J, or 360 kJ.

P1.17 During the interval $0 < t < 2$ s, i in Figure P1.17 is in the direction of a voltage drop v. Hence, 'A' absorbs power equal to (5 V)×(2 A) = 10 W. During the interval $2 < t < 4$ s, i reverses sign and becomes a current in the direction of a voltage rise v. Hence, 'A' delivers power equal to (5 V)×(2 A) = 10 W. The charge is the area under the i vs. t graph. This charge is 4 C in one direction during the first 2 s and 4 C in the opposite direction during the next 2 s. The total charge though 'A' is therefore zero at $t = 4$ s. Hence, zero net power is delivered or absorbed by the device at $t = 4$ s.

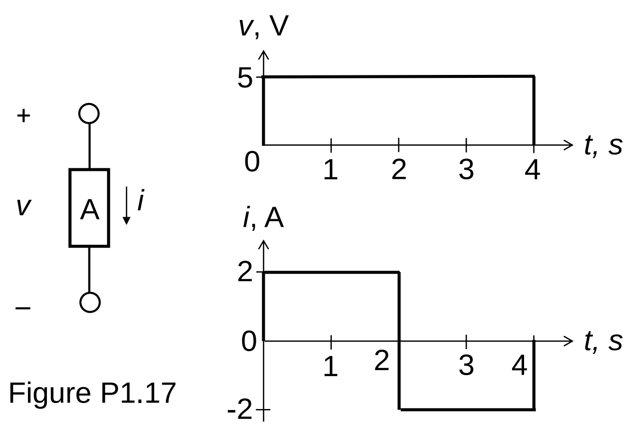

Figure P1.17

P1.18 (a) Power is absorbed during quarter cycles having the same sign and is delivered during quarter cycles of opposite sign (Figure P1.18A). Thus, power is absorbed during the intervals $0 \le t \le 1$ and $2 \le t \le 3$, and power is delivered during the intervals $1 \le t \le 2$ and $3 \le t \le 4$.

(b) $p = vi = \sin \pi t/2 \cos \pi t/2$ W $= 0.5 \sin \pi t$ W; $p > 0$ is power absorbed, $p < 0$ is power delivered; the maximum magnitude of the instantaneous power is 0.5 W, the amplitude of $0.5\sin \pi t$, and the average over a 4 s period is zero (Figure P1.18B).

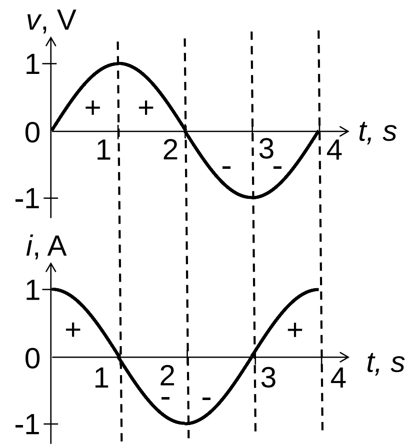

Figure P1.18A

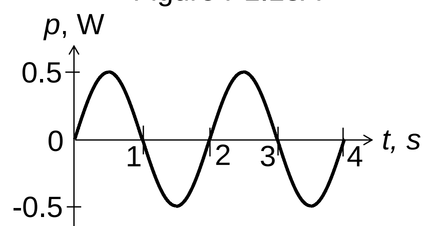

Figure P1.18B

P1.19 (a) From Figure P1.19, the battery delivers $0.1 \times 20 = 2$ Ah during the first 20 hours, During the next 10 hours, the current drops linearly with time. The average current during this interval is 90 mA, or 0.09 A. The battery delivers during this interval $0.09 \times 10 = 0.9$ Ah. The battery therefore delivers 2.9 Ah during the 30 hours of operation.

(b) To determine the energy delivered by the battery, we again have to consider the first 20 hours and the following 10 hours separately. During the first 20 hours, the battery voltage is constant at 1.5 V and the current is constant at 0.1 A. The battery delivers a constant power of $1.5 \times 0.1 = 0.15$ W. The energy delivered up to a time t hours is $0.15 \times 3600 \times t = 540t$ J. By the end of this period, the energy delivered is $540 \times 20 = 10{,}800$ J, or 10.8 kJ.

During the interval $20 \le t \le 30$ h, $v = 2 - 0.025t$ V, and $i = 0.14 - 2\times 10^{-3} t$ A. The instantaneous power p is: $p = vi = (2 - 0.025t)\times(0.14 - 2\times 10^{-3}t) = 0.28 - 0.0075t + 5\times 10^{-5}t^2$ W, where t is in hours. The energy delivered is: $w = \int_{20}^{30} p dt = \left[0.28t - \frac{0.0075}{2}t^2 + \frac{5\times 10^{-5}}{3}t^3\right]_{20}^{30} = 1.24$ W-hr

To convert to joules, this has to be multiplied by 3,600 s/hr, which gives 4.46 kJ. The total energy delivered by the battery is therefore 10.8 + 4.47 = 15.26 kJ.

P1.20 (a) In Figure P1.20,

$0 < t < 1$: $q = \int_0^1 i dt = \int_0^1 0 dt = 0$;

$t = 2$: $q = \int_1^2 i dt = \int_1^2 (1+t) dt = \left[t + \frac{t^2}{2}\right]_1^2 = 2.5$ mC, which is the area under the trapezoid;

$t = 3$: $q = 2.5 + \int_2^3 i dt = 2.5 + \int_2^3 3 dt = 5.5$ mC;

$t = 4$: $q = 5.5 + \int_3^4 i dt = 5.5 + \int_3^4 3 dt = 8.5$ mC;

$t = 5$: $q = 8.5 + \int_4^5 i dt = 8.5 + \int_4^5 (-t+7) dt = 8.5 + \left[-\frac{t^2}{2} + 7t\right]_4^5 = 11$ mC;

$t = 6$: $q = 11 + \int_5^6 i dt = \int_5^6 0 dt = 11$ mC.

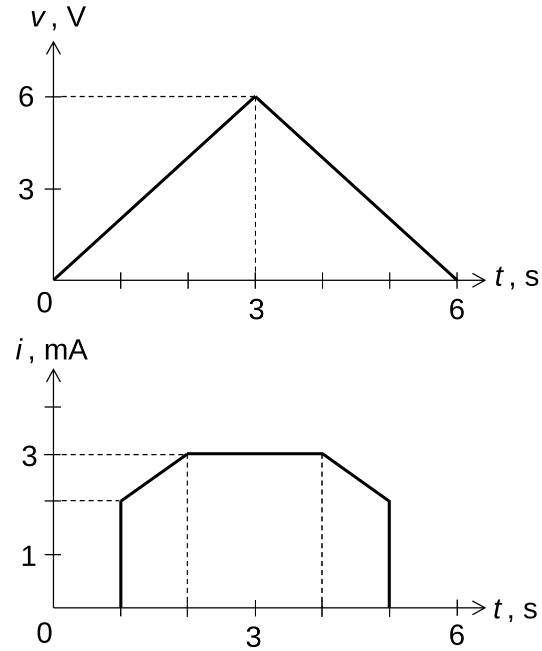

Figure P1.20

(b) $0 \le t \le 1: p = 0$;

$1 \le t \le 2: p = 2t(t+1) = 2t^2 + 2t$ mW;

$2 \le t \le 3: p = 2t \times 3 = 6t$ mW;

$3 \le t \le 4: p = (-2t + 12) \times 3 = -6t + 36$ mW;

$4 \le t \le 5: p = (-2t + 12)(-t + 7) = 2t^2 - 26t + 84$ mW;

$5 \le t \le 6: p = 0$.

(c) $w(t) = \int_0^6 pdt = \int_0^1 0dt + \int_1^2 (2t^2 + 2t)dt + \int_2^3 6tdt + \int_3^4 (-6t + 36)dt +$

$\int_4^5 (2t^2 - 26t + 84)dt + \int_5^6 0dt = \left[\frac{2t^3}{3} + t^2\right]_1^2 + \left[3t^2\right]_2^3 + \left[-3t^2 + 36t\right]_3^4 +$

$\left[\frac{2t^3}{3} - 13t^2 + 84t\right]_4^5 = 136/3 = 45.3$ mJ.

P1.21 In Figure P1.21A,

$p = vi = (2t + 1)(4 - 2t) = -4t^2 + 6t + 4$.

(a) $\frac{dp}{dt} = -8t + 6$; $\frac{dp}{dt} = 0$; p is maximum at $t = 0.75$ sand equals 6.25 mW.

(b) $p = -4t^2 + 6t + 4 = 0$ at $t = 2$ s, and $p = 0$ when either v or i is zero.

(c) At $t = 2$ s: $w = \int_0^2 pdt = \int_0^2 (-4t^2 + 6t + 4)dt =$

$\left[-\frac{4}{3}t^3 + 3t^2 + 4t\right]_0^2 =$ 9.3 mJ.

At $t = 4$s: $w =$

$\int_0^4 pdt = \int_0^4 (-4t^2 + 6t + 4)dt =$

$\left[-\frac{4}{3}t^3 + 3t^2 + 4t\right]_0^4 = -21.3$ mJ.

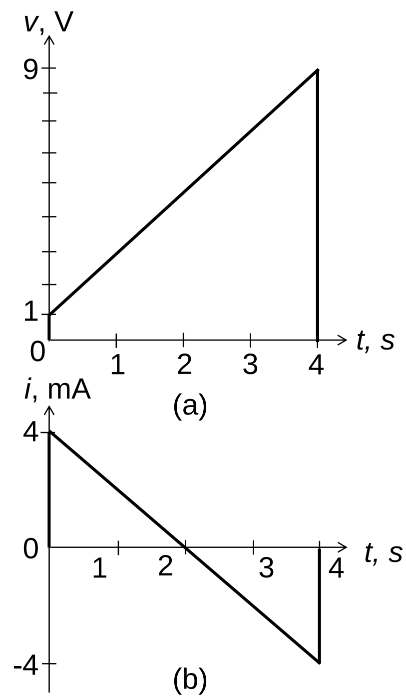

Figure P1.21A

(d) Power is absorbed by device for $t < 2$ s, and is delivered by device for $2 < t < 4$ s.

P1.22 (a) $0 \le v \le 2$; $p = vi = v(8 - 2v^2) = -2v^3 + 8v$, and $p = 0$, for $v \le 0$ and $v \ge 2$.

At $v = 1$ V; $p = 6$ W; at $v = 2$ V, $p = 0$.

(b) $\frac{dp}{dv} = -6v^2 + 8$, $0 \le v \le 2$; $\frac{dp}{dv} = 0$ when $v = \frac{2\sqrt{3}}{3}$ V; to show that this is a maximum, $\frac{d^2p}{dv^2} = -12v$, which is negative when $v = \frac{2\sqrt{3}}{3}$ V.

(c) $v(t) = 2e^{-t} \Rightarrow i = 8 - 8e^{-2t}$; $q = \int_0^2 idt = \int_0^2 \left(8 - 8e^{-2t}\right)dt = \left[8t + 4e^{-2t}\right]_0^2 = 12.07$ C.

P1.23 i is constant at -1 A in Figure P1.23, which means that energy is delivered for $0 < t < 2$ s and is absorbed for $2 < t < 3$ s. The delivered energy increases with time during the interval 0 to 2 s, then decreases when v goes negative. The largest magnitude of energy delivered therefore occurs at $t = 2$ s, and is $w(2) = (1/2)(1\times2)(11) = 1$ J.

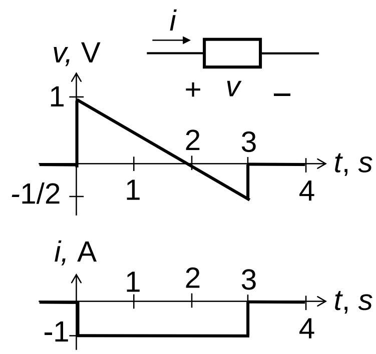

Figure P1.23

P1.24 (a) From the areas of the i plot in figure P1.24, $q = 0.5\times3\times1.5 - 0.5\times0.5\times1 = 2$ C;

(b) $i(t) = 1 - 2t$, $v(t) = 2t$, $p(t) = 2t - 4t^2$ W; the plot of p(t) is shown in Figure P1.24A. It is seen that power is absorbed for $0 \leq t \leq 0.5$ s, and is delivered for -1 s $\leq t \leq 0$ and 0.5 s $\leq t \leq 1$ s;

(c) $w(t) = \int_{-1}^{1}(2t - 4t^2)dt =$

$$\left[t^2 - \frac{4}{3}t^3\right]_{-1}^{1} = -\frac{8}{3}\text{ J}$$

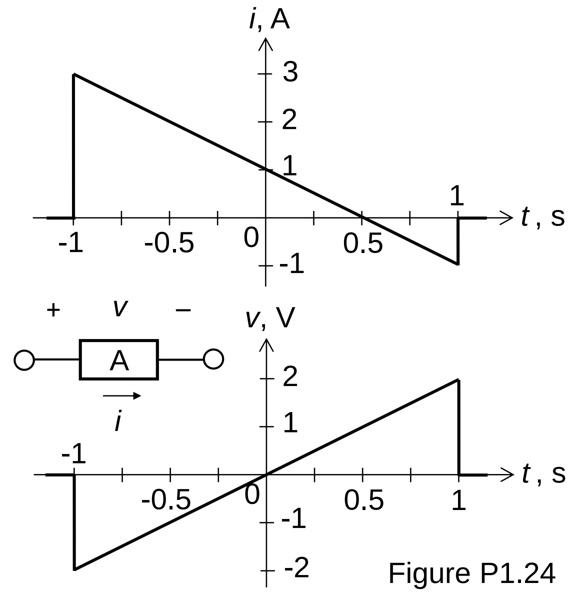

Figure P1.24

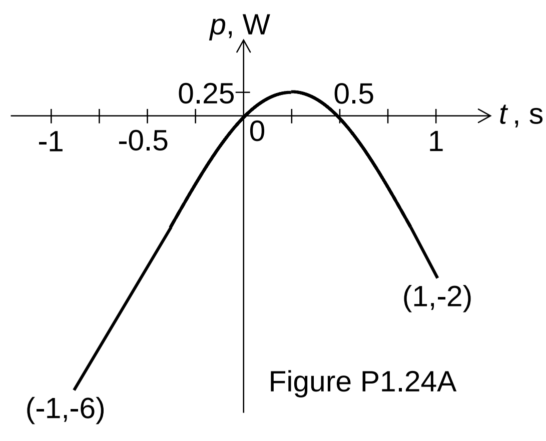

Figure P1.24A

Chapter 2 – Fundamentals of Resistive Circuits

PE2.1 $R = \dfrac{24}{3} = 8\ \Omega$, $G = \dfrac{1}{R} = \dfrac{3}{24} = 0.125\ \text{S}$, $P = 24\times3 = 72$ W.

PE2.2 $I = \sqrt{\dfrac{180}{5}} = 6\ \text{A}$, $V = \dfrac{180}{6} = 30\ \text{V}$. $W = \dfrac{(30)^2}{5} = 180\ \text{W}$; G = 1/5 = 0.2 S;

$W = (30)^2 \times 0.2 = 180\ \text{W}$.

PE2.3 (a) Power dissipated in the interval t = 0 to t = 3 s is $(2)^2\times5$ = 20 W (Figure 2.3); energy dissipated is 20×3 = 60 J; power dissipated in the interval t = 3 s to t = 5 s is $(1)^2\times5$ = 5 W; energy dissipated is 5×2 = 10 J; total energy dissipated is 60 + 10 = 70 J.

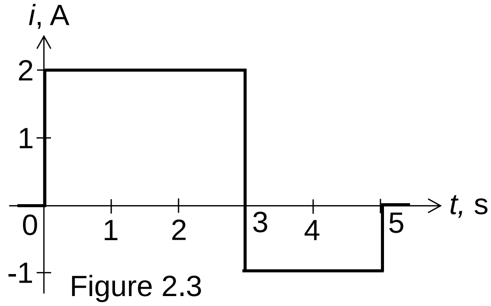

Figure 2.3

(b) Average power dissipated is 70/5 = 14 W.

PE2.4 (a) $p = 0\times I = 0$; (b) $p = V\times0 = 0$.

PE2.5 To have the largest voltage across terminals ‘ab’ in Figure 2.6, there should be no voltage drop across the 2 Ω resistor, which means no current in this resistor. This will be the case when terminals ‘ab’ are open circuited.

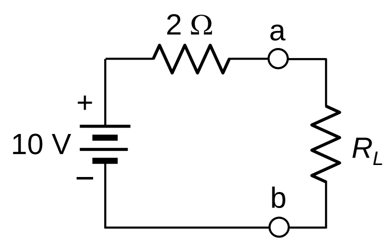

Figure 2.6

PE2.6 In accordance with the passive sign convention and its physical interpretation, the ideal voltage source delivers (12 V)×(2 A) = 24 W in (a), when the source current is in the direction of a voltage rise across the source, and absorbs 24 W in (b), when the source current is in the direction of a voltage drop across the source.

PE2.7 As illustrated in Figure 2.8c, the 5 A current is in the direction of a voltage drop across the battery and in the direction of a voltage rise through the charging circuit. According to the passive sign convention, a power of (24 V)×(5 A) = 120 W is absorbed by the battery (a) and delivered by the charging circuit (b). Equivalently, a power of -120 W is delivered by the battery (c) and absorbed by the charging circuit (d).

PE2.8 (a) The current source forces 0.1 A through the battery, directed from the + terminal to the – terminal of the battery in Figure 2.12.

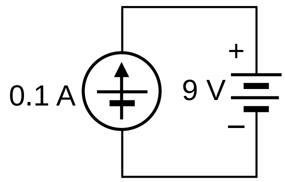

Figure 2.12

(b) The battery impresses 9 V across the current source, the voltage being of the same polarity as the battery.

(c) Current flows through the current source in the direction of a voltage rise, so that this source delivers (9 V)×(0.1 A) = 0.9 W.

(d) Current flows through the battery in the direction of a voltage drop, so that the battery absorbs (9 V)×(0.1 A) = 0.9 W.

(a′) The current source forces 0.1 A through the battery, directed from the – terminal to the + terminal of the battery.

(b′) The battery impresses 9 V across the current source, the voltage being of the same polarity as the battery.

(c′) Current flows through the current source in the direction of a voltage drop, so that this source absorbs (9 V)×(0.1 A) = 0.9 W.

(d′) Current flows through the battery in the direction of a voltage rise, so that the battery delivers (9 V)×(0.1 A) = 0.9 W.

PE2.9 (a) At the positive peaks of the sinusoid, the current through the source is in the direction of a voltage rise. Hence, $p_{max(del)}$ = 10×(4) = 40 W. These peaks occur at $t = \pi/2$ s plus an integer multiple of 2π.

(b) At the negative peaks of the sinusoid, the power delivered is p = 10×(-4) = -40 W. $p_{max(abs)}$ = 40 W, since the current through the source is in the direction of a voltage drop. The negative peaks occur at $t = 3\pi/2$ s plus an integer multiple of 2π.

(c) The average power over a cycle is $\int_0^{2\pi} 40 \sin t dt = -40[\cos \omega t]_0^{2\pi} = -40[1-1] = 0$.

PE2.10 In Figure 2.13A, the voltage of the VCVS is $2V_X = 2\times1.8 = 3.6$ V. The voltage of the CCVS is $3I_Y = 3\times2.4 = 7.2$ V.

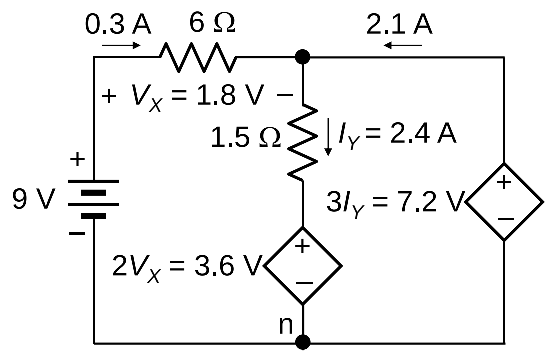

Figure 2.13A

(a) From Ohm's law, the current through the 6 Ω resistor is 1.8/6 = 0.3 A in the direction of the voltage drop V_X.

(b) From Ohm's law, the voltage across the 1.5 Ω resistor is $1.5\times2.4 = 3.6$ V and is a voltage drop in the direction of the current.

(c) The 0.3 A is in the direction of a voltage rise across the 9 V source. Hence, this source delivers $9\times0.3 = 2.7$ W. The 2.4 A current through the VCVS is in the direction of a voltage drop across the source. Hence, this source absorbs $3.6\times2.4 = 8.64$ W.

(d) The power dissipated in the resistors is $1.8\times0.3 + 3.6\times2.4 = 9.18$ W.

(e) Power absorbed by the VCVS and the resistors is 8.64 + 9.18 = 17.82 W. Power delivered by the independent source is 2.7 W. From conservation of power, the CCVS must deliver 17.82 – 2.7 = 15.12 W.

(f) The total voltage across the CCVS is 3.6 + 3.6 = 7.2 V. Current though the CCVS is 15.12/7.2 = 2.1 A. It is seen that charge is conserved at the upper and lower junctions. This is because in 1s, 2.1 C enter the upper junction and 2.1 C leave the junction.

PE2.11 (a) In Figure 2.14A, the current through the 1 Ω resistor is 3.6/1 = 3.6 A in the direction of the voltage drop V_X.

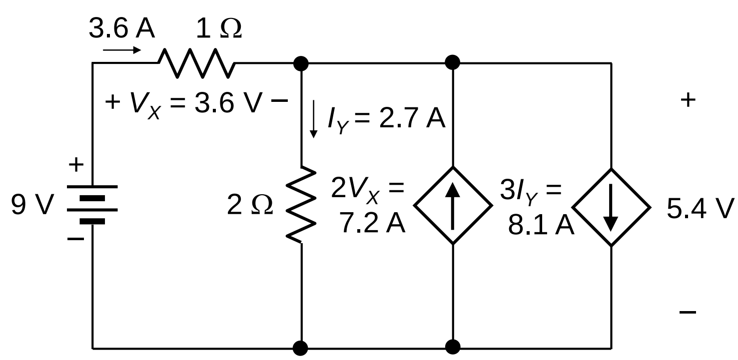

Figure 2.14A

(b) Voltage across the 2 Ω resistor is $2\times2.7 = 5.4$ V drop in the direction of I_Y.

(c) 3.6 A current is in the direction of a voltage rise across the battery.

Hence, battery delivers $9\times3.6 = 32.4$ W. The 7.2 A current through VCCS is in the direction of a voltage rise across the source. Hence, VCCS delivers 5.4×7.2 = 38.88 W. The 8.1 A current through CCCS is in the direction of a voltage drop across the source. Hence, CCCS absorbs 5.4×8.1 = 43.74 W.

(d) Power absorbed by 1 Ω resistor is 3.6×3.6 = 12.96 W. Power absorbed by 2 Ω resistor is 5.4×2.7 = 14.58 W.

(e) Total power delivered: 32.4 + 38.88 = 71.28 W. Total power absorbed: 43.74 + 12.96 + 14.58 = 71.28 W. Charge is conserved at the upper and lower junctions, because in 1 s, 3.6 + 7.2 = 10.8 C enter the upper junction and 2.7 + 8.1 = 10.8 A.

E2.12 If V_X is the voltage across the VCCS, the definition of an ideal current source is violated. In fact, such a source can be replaced by a resistor. If I_Y is the current through the CCCS, then $I_Y = 3I_Y$, so that $I_Y = 0$, and the CCCS is equivalent to an open circuit.

PE2.13 (a) 7 nodes, labelled 'a' to 'g' in Figure 2.17A.

(b) 4 essential nodes, labelled 'b', 'd', 'e', and 'f'.

(c) 9 branches, each element being a branch.

(d) 6 essential branches, 'bf', 'bd', 'be', 'de', 'ef', and 'df.

(e) 3 meshes, 'abfa', 'bcedb', and 'degfd'.

(f) 4 loops, 'bcgfb', 'abdegfa', 'acedfa', and 'acgfa'.

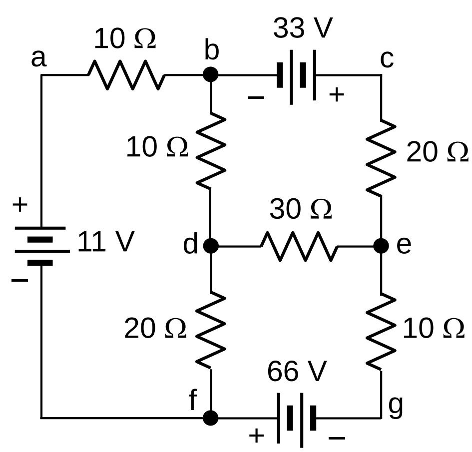

Figure 2.17A

PE2.14 $i_1 + i_2 + i_3 + i_4 = 0$ (Figure 2.18A); substituting given values: $1.5 - 2 + 1.25 + i_4 = 0$, or, $0.75 + i_4 = 0$, or, $i_4 = -0.75$ A.

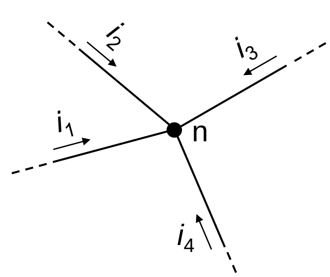

Figure 2.18A

PE2.15 In Figure P2.1A,

Node 'a': current entering = 1.5 A; current leaving = 0.5 + 1 = 1.5 A.

Node 'b': current entering = 1 + 2 = 3 A; current leaving = 3 A.

Node 'c': current entering = 2 A; current leaving = 1.5 + 1 = 2 A.

Node 'n': current entering 0.5 + 1.5 = 2 A; Current leaving = 2 A.

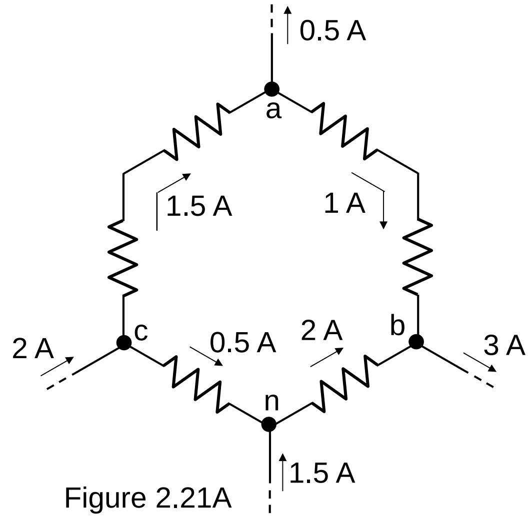

Figure 2.21A

PE2.16 The mesh with the voltages doubled is as shown in Figure P2.21B.

(a) Starting at node 'n' and going clockwise,

$+8 – 5 – 6 – 1 – 3 + 7 = 0$

KVL is satisfied.

(b) Starting at node 'n' and going counterclockwise,

$-7 + 3 + 1 + 6 + 5 – 8 = 0$

KVL is satisfied.

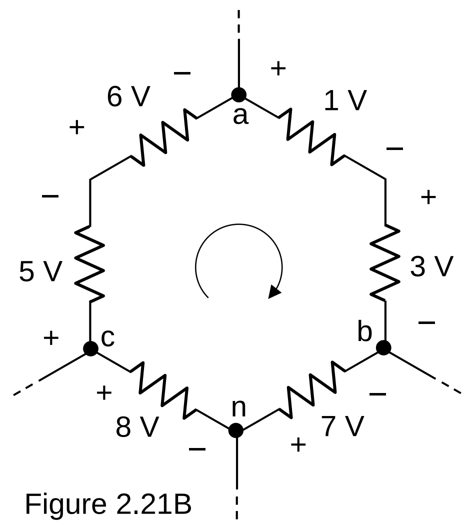

Figure 2.21B

PE2.17 (a) From KCL at the upper node, right-hand node in Figure 2.23 $I + 1 = 0$, or $I = -1$ A.

(b) From KVL around the mesh, starting from the bottom node and going clockwise, $12 – 2 + V_S = 0$, or $V_S = -10$ V.

(c) Power delivered by 12 V source is $12I = -12$ W, so that this source absorbs 12 W; power absorbed by 2 V source is $2I = -2$ W, so that this source delivers 2 W; power absorbed by current source is $V_S \times 1 = -10$ W, so that this source delivers 10 W.

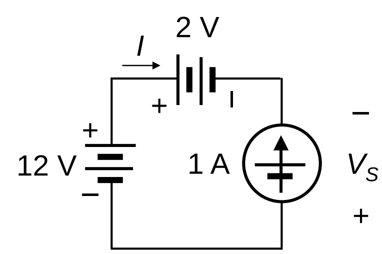

Figure 2.23

PE2.18 In Figure 2.17A,

(a) Number of independent KCL equations = Number of essential nodes – 1 = 4 – 1 = 3.

(b) Number of independent KVL equations = Number of meshes = 3.

(c) Number of essential branches = 6 = 3 + (4 – 1).

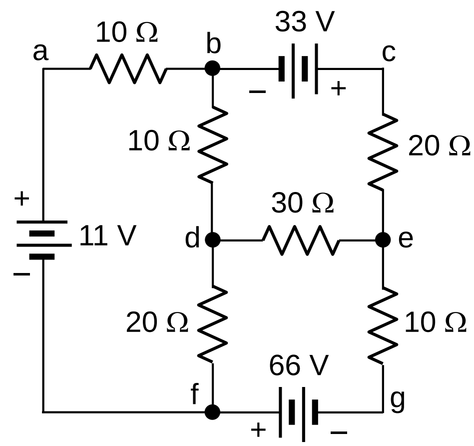

Figure 2.17A

PE2.19 In Figure 2.42, three wires are connected in parallel between common nodes. The three sets of three wires each are connected in series, since they carry the same total current (Figure 2.43).

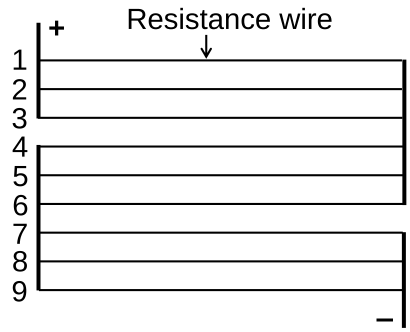

Figure 2.42

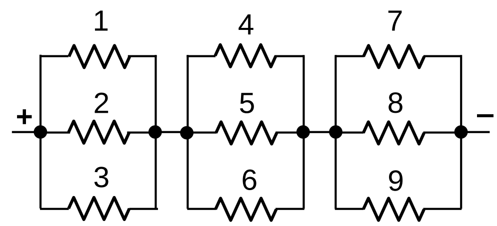

Figure 2.43

PE2.20 From KVL in Figure 2.44, $2.5 = 3I + V_X = 5I$; $I = 0.5$ A, and $V_X = 2I = 1$V.

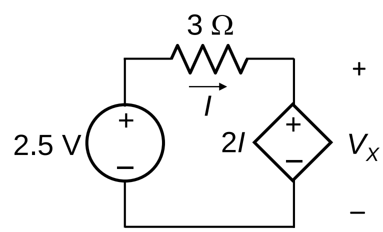

Figure 2.44

PE2.21 The current through 'A' in Figure 2.45A is (3 – 2) = 1 A; $V_A = 4/1 = 4$ V; the power absorbed by the 2 A source is $P_{2abs} = 4 \times 2 = 8$ W.

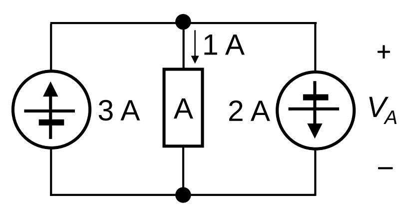

Figure 2.45A

PE2.22 Power dissipated in 6 Ω resistor in Figure 2.46A = $6(0.5)^2 = 1.5$ W. Current in 3 Ω resistor = 0.5 + 1.5 = 2 A. Power dissipated in 3 Ω resistor = $3(2)^2 = 12$ W. Total power dissipated = 13.5 W. Power delivered by 9 V source = $9 \times 0.5 = 4.5$ W. Voltage across current source = $3 \times 2 = 6$ V.

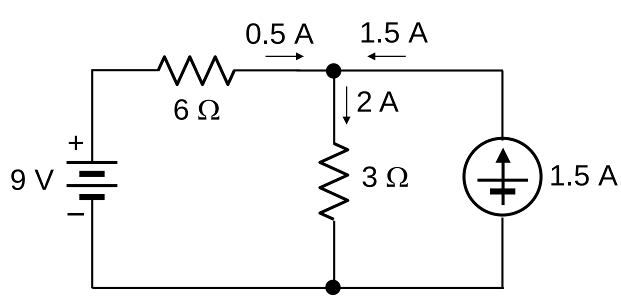

Figure 2.46A

Power delivered by 1.5 A source is 6×1.5 = 9 W. Total power delivered is 13.5 W.

PE2.23 Power dissipated in 10 Ω resistor in Figure 2.48A = $10(7)^2$ = 490 W. Current in 4 Ω resistor = 7 – 2 = 5 A. Power dissipated in 4 Ω resistor = $4(5)^2$ = 100 W. Power absorbed by 2 A source = 30×2 = 60 W. Power absorbed by 10 V source = 10×5 = 50 W. Total power absorbed = 490 + 100 + 60 + 50 = 700 W. Power delivered by dependent source = 100×7 = 700 W.

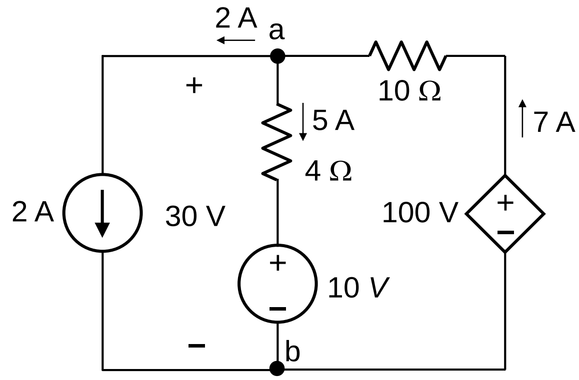

Figure 2.48A

P2.1 $P = \dfrac{V^2}{R}$, $V^2 = R \times P = 1.5 \times 10^6 \times 0.5 = 0.75 \times 10^6 = 75 \times 10^4$, $V = 500\sqrt{3}$ = 866.0 V.

P2.2 (a) At 120 V the current of a 60 W lamp is $\dfrac{60}{120} = 0.5$ A.

(b) Four lamps in parallel (Figure P2.2) draw 0.5×4 = 2 A from the supply, which is the current through *R*.

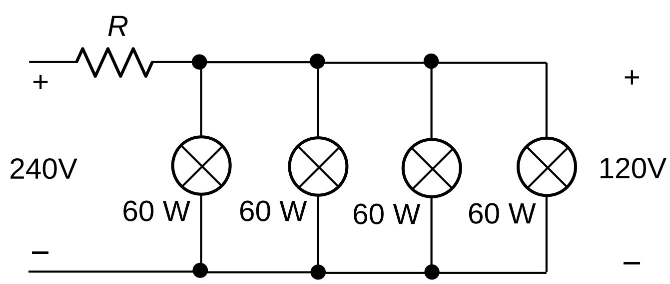

Figure P2.2

(c) The voltage across *R* is 120 V; $R = \dfrac{120}{2} = 60$ Ω.

(d) The power rating of the resistor is $60(2)^2$ = 240 W, the same as the total power rating of the lamps, since the voltage and current are the same.

P2.3 (a) $\dfrac{60\sin 100\pi t}{4\sin 100\pi t} = 15$ Ω.

(b) $p(t) = v(t)i(t) = 240\sin^2 100\pi t = 120(1 - \cos 200\pi t)$ W.

(c) $P = \dfrac{120}{\pi}\int_0^{\pi}(1 - \cos 2\omega t)d(\omega t) = \dfrac{120}{2\pi}\left[(\omega t) - \dfrac{1}{2}\sin 2(\omega t)\right]_0^{\pi}$ = 120 W.

(d) No. The average of the voltage and the current is zero, because they are alternately positive and negative in successive half cycles. But negative voltage multiplied by negative current gives a positive value of power, so that the power does not average to zero.

P2.4 $v\text{ (V)} = \begin{cases} t/12 & 0 \le t \le 60\text{ s} \\ 5 & 60 \le t < 180\text{ s} \\ 0 & t > 180\text{ s} \end{cases}$ (Figure P2.4)

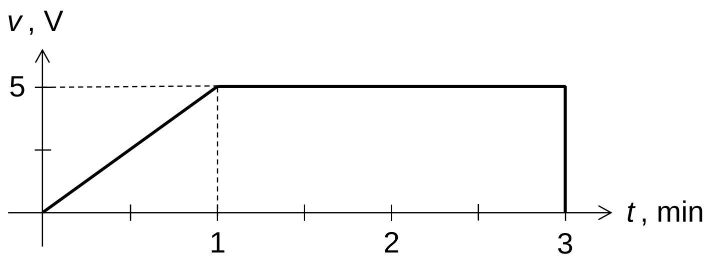

Figure P2.4

(a) $i = v/R$; $i = t/60$ A, $0 \le t \le 60$ s; $i = 1$ A, $60 \le t < 180$ s; $i = 0$, $t > 80$ s.

(b) $0 \le t \le 60$ s; $p(t) = \frac{v^2}{R} = \frac{1}{5}\left(\frac{t}{12}\right)^2 = \frac{t^2}{720}$ W, where t is in s.

(c) $w = \int_0^{180} pdt = \int_0^{60} \frac{t^2}{720} dt + \int_{60}^{180} \frac{25}{5} dt = 700$ J.

P2.5 $v(t) = 10\cos 100\pi t = 10\cos\omega t$, where $\omega = 100\pi$ rad/s, so that the supply frequency is $\frac{100\pi}{2\pi} = 50$ Hz, and the supply period is $\frac{1}{50} \equiv 20$ ms.

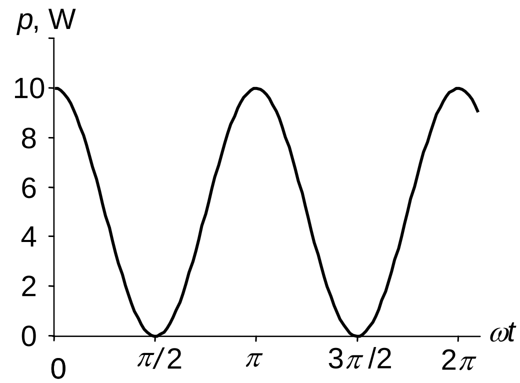

Figure P2.5A

(a) $p = \frac{v^2}{R} = \frac{(10\cos 100\pi t)^2}{10}$

$= 10\cos^2 100\pi t = 5(1 + \cos 2\omega t)$ W, as shown in Figure P2.5A

(b) $P = \frac{5}{\pi}\int_0^{\pi}(1 + \cos 2\omega t)d(\omega t) = \frac{5}{\pi} \times \pi = 5$ W.

$$w = \int_0^{0.01} pdt = \int_0^{0.01} 10\cos^2 100\pi t dt = 5\int_0^{0.01}(1 + \cos 200\pi t)dt = 5\left[t + \frac{\sin 200\pi t}{200\pi}\right]_0^{0.01} = 0.05 \text{ J.}$$

Since the average power dissipated is 5 W, the energy dissipated during one half cycle is 5(W)×0.01(s) = 0.05 J. Note that the average power, that is, average energy per unit time, is independent of the time scale, but the energy is the integral of instantaneous power with respect to time.

P2.6 In Figure P2.6, $v = 10t$ V, $0 \le t \le 1$ min; $v = -10t + 20$ V, $1 \le t \le 3$ min; $v = 10t - 40$ V, $3 \le t \le 4$ min.

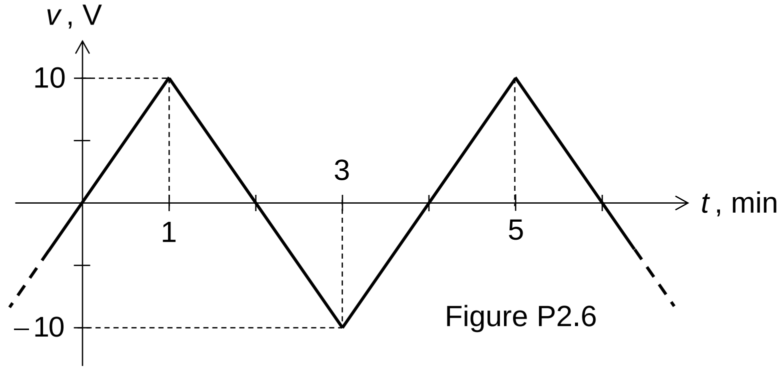

Figure P2.6

(a) $i = \dfrac{v}{100} = 0.1t$ A, $0 \le t \le 1$ min;
$i = -0.1t + 0.2$ A, $1 \le t \le 3$ min;
$i = 0.1t - 0.4$ A, $3 \le t \le 4$ min.

(b) $p(t) = \dfrac{v^2}{R} = t^2$ W, $0 \le t \le 1$ min, $p(t) = \dfrac{(-10t+20)^2}{100}$ W, $1 \le t \le 3$ min,

$p(t) = \dfrac{(10t-40)^2}{100}$ W, $3 \le t \le 4$ min.

(c) $P = \dfrac{1}{T}\int_0^T p dt = \dfrac{1}{4}\left[\int_0^1 t^2 dt + \int_1^3 (t^2 - 4t + 4)dt + \int_3^4 (t^2 - 8t + 16)dt\right]$

$= \dfrac{1}{4}\left\{\left[\dfrac{t^3}{3}\right]_0^1 + \left[\dfrac{t^3}{3} - 2t^2 + 4t\right]_1^3 + \left[\dfrac{t^3}{3} - 4t^2 + 16t\right]_3^4\right\} = \dfrac{1}{3}$ W. Note that it is simpler to work with t in minutes and not convert to seconds.

P2.7 $R_2 = R_1[1 + \alpha_m(T_2 - T_1)]$; $70 = 60[1 + 0.0039(T_2 - 20)]$; $T_2 = 62.7°$ C.

P2.8 $i = 10^{-9}(e^{20v} - 1)$ A.

(a) $v = 0.7$ V $\Rightarrow i = 10^{-9}(e^{20\times0.7} - 1) \cong 10^{-9} \times e^{20\times0.7} \equiv 1.20$ mA.

(b) $v = -0.7$ V $\Rightarrow i = 10^{-9}(e^{20\times(-0.7)} - 1) \cong -10^{-9} \equiv -1$nA.

P2.9 The instantaneous power delivered by i_{SRC} in Figure P2.9 is $1\times i_{SRC}$. The average power delivered is:

$P = \dfrac{1}{T}\int_0^T (2 + 2\cos 100\pi t)dt = \dfrac{1}{T}\left[2t + \dfrac{2}{100\pi}\sin 100\pi t\right]_0^T =$

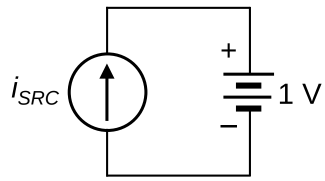

Figure P2.9

$$\frac{1}{T}\left[2T + \frac{2}{100\pi}\sin 2\pi - 0\right] = 2$$ W. Note that one can work with T, which is $2\pi/100\pi$ = 1/50 s, without having to substitute its numerical value.

P2.10 From KCL at the upper node in Figure P2.10A: 10 = I_x + 5, so I_x = 5 A. From KVL around the outer loop, starting at the lower node and going CW: 40 – V_y – 25 = 0, so V_y = 15 V. The voltage across the 5A current source is 40 V, and the current through the 25 V voltage source is 10 A.

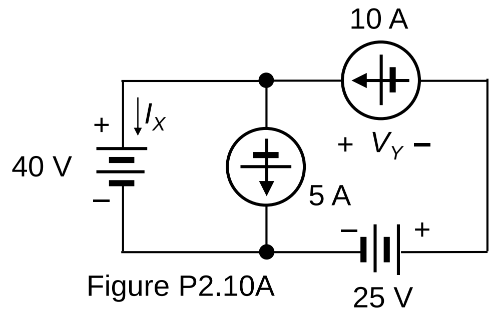

Figure P2.10A

P2.11 I_{SRC} = 5 A in Figure P2.11; from KVL, starting at the lower node and going CW: 50 – $2I_{SRC}$ –V_X = 0. Substituting for I_{SRC}, V_X = 40 V; power delivered by 50 V source is 50×5 = 250 W; power absorbed by dependent source is $2I_{SRC}\times I_{SRC}$ = 50 W; power absorbed by 5 A source is 40×5 = 200 W. Total power delivered =250 W = total power absorbed.

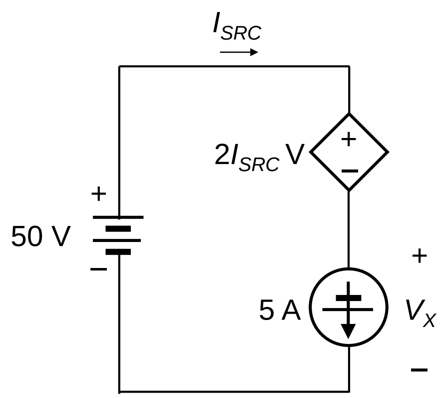

Figure P2.11

P2.12 From KVL in Figure P2.12, V_Y = 20 + (-10) = 10 V. The current of the dependent source is therefore 0.5×10 = 5 A. From KCL 10 = 5 + I_X, so that I_X = 5 A. The 10 A source delivers 100 W. The dependent source absorbs 50 W. The 10 a source absorbs 5(-10) = -50 W, so it actually delivers 50 W. The 20 V source absorbs 5×20 = 100 W. The total power delivered is 100 + 50 = 150 W, and the total power absorbed is 50 + 100 = 150 W.

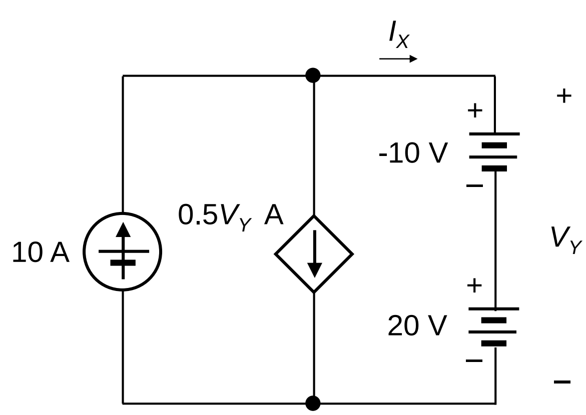

Figure P2.12

P2.13 From Figure P2.13A, $I_\Delta = -5$ A. From KCL at the upper node: $I_X = 10 + I_\Delta = 5$ A; $V_X = -10I_\Delta = 50$ V; from KVL around the outer loop: $V_\Delta + 5 - V_X = 0$, so $V_\Delta = 45$ V. From KVL around the mesh on the RHS: $-10 + V_Y - V_X = 0$, $V_Y = 60$ V. The 5 V source absorbs 25 W; the 5 A source absorbs 5×45 = 225 W; the 10 A source delivers 600 W; the 10 V source absorbs 100 W; the dependent source absorbs 250 W. Total power delivered = 600 W = total power absorbed.

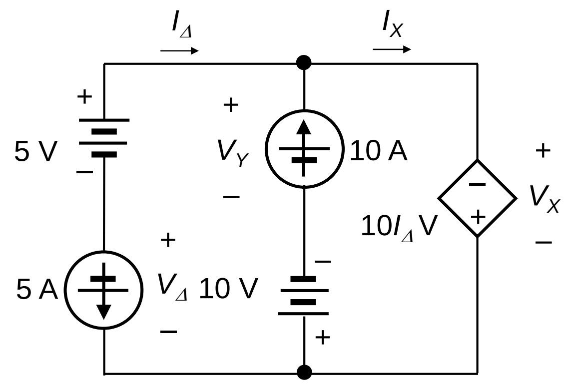

Figure P2.13A

P2.14 $V_{ab} = 20$ V in Figure P2.14A, $I_X = 0.8V_{ab} = 16$ A. From KCL at node 'a', net current flowing away from this node is 16 – 10 = 6 A. Hence, 6A must flow into node 'a' from the 20 V source.

Voltage drop across the CCVS = $0.5I_x = 8$ V; let the voltage drop across the VCCS be V_X. From KVL the voltage drop V_{ab} is the same whether going through the 20 V source or the two dependent sources. Hence $20 = V_X + 8$, which gives $V_X = 12$ V.

The 20 V source delivers 20×6 = 120 W; the 10 A source delivers 20×10 = 200 W; VCCS absorbs 12×16 = 192 W; and CCVS absorbs 8×16 = 128 W. Total power delivered = 320 W = total power absorbed.

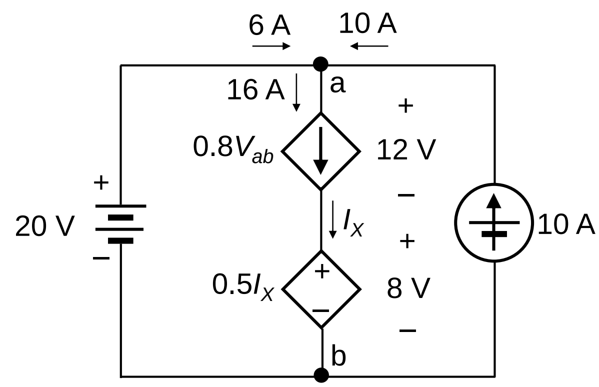

Figure P2.14A

P2.15 The current leaving node 'a' through V_1 in Figure P2.15A is $I_2 + I_3 = 1 + 1 = 2$ A. The source V_1 absorbs 1×2 = 2 W.

The current leaving node 'b' through V_2 is $I_1 - I_3 = 2 - 1 = 1$ A. The source V_2 delivers 1×1 = 1 W.

The current entering node 'c' through V_3 is $I_1 + I_2 = 3$ A. V_3 absorbs 1×3 = 3 W.

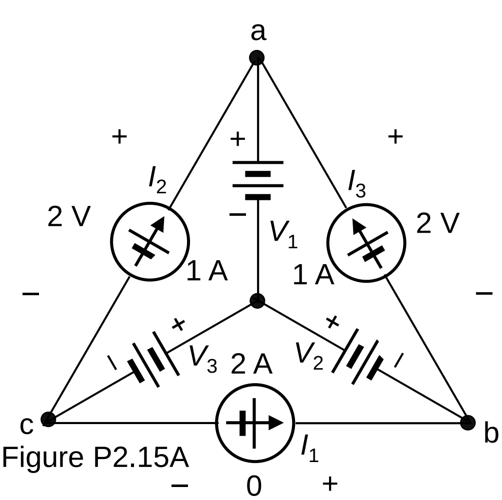

Figure P2.15A

From KVL, V_{ab} = 2 V, V_{ac} = 2 V, and V_{bc} = 0. The source I_1 neither absorbs nor delivers power; the source I_2 delivers 2 W; the source I_3 delivers 2 W.

Total power delivered = 5 W = total power absorbed.

P2.16 From KCL at node 'd' in Figure P2.16A : 10 = 5 + I_Δ, so I_Δ = 5 A. From KCL at node 'b': I_Y = 10 + 3 = 13 A. From KCL at node 'a': 3 + 5 = 8 A = I_X. As a check, KCL at node 'c' is: 13 = 8 + 5 A.

From KVL around the outer loop: -V_{cd} + 10 = 0, so that V_{cd} = 10 V. From KVL around the mesh on the RHS: 10 – V_{ba} = 0, so that V_{ba} = 10 V. From KVL around the mesh 'abda': -V_{ba} – 10 + V_{bd} = 0, so that V_{bd} = 20 V. As a check, KVL around the mesh 'bcdb' gives: -10 – V_{cd} + V_{bd} = -10 – 10 + 20 = 0. Upper 10 V source delivers 50 W; lower 10 V source delivers 130 W; 5 A source delivers 50 W; 10 A source absorbs 200 W; 3 A source absorbs 30 W. Total power delivered = 230 W = total power absorbed.

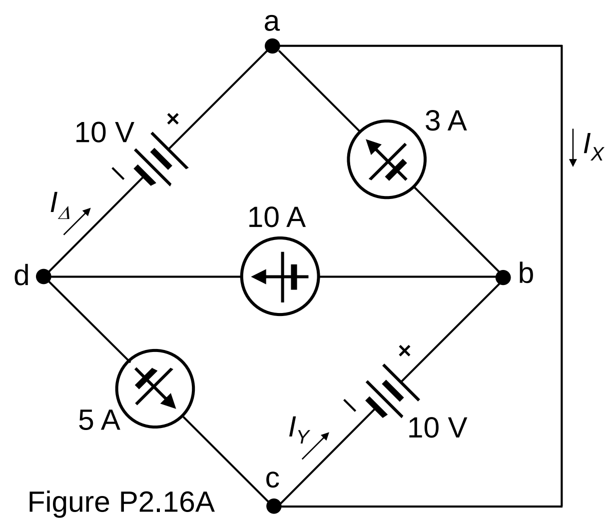

Figure P2.16A

P2.17 The resistance seen by the source in Figure P2.17 is 5||5 = 2.5 Ω; V_O = 2.5×0.2 = 0.5 V. The grounding does not affect V_O.

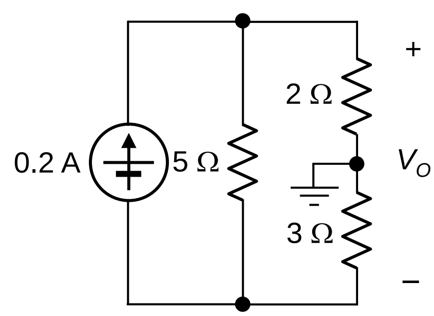

Figure P2.17

P2.18 When I_S = 0 in Figure P2.18, I_{SRC} flows through the 6 kΩ resistor, producing a voltage of 6I_{SRC} across this resistor. To have I_S = 0, this voltage must equal 3 V, which gives: I_{SRC} = 3/6 = 0.5 mA.

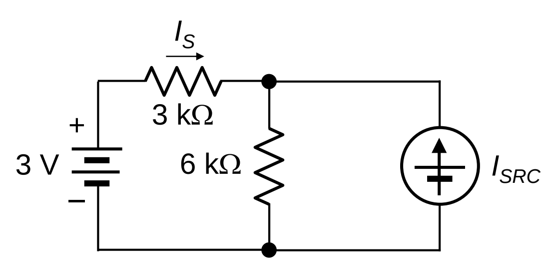

Figure P2.18

P2.19 The voltage across the 10 Ω resistor in Figure P2.19A is 20 V, as set by the voltage source. The current through this resistor is therefore 2 A. From KCL at the upper node, the current through the voltage source is 3 A downwards. Since the 5 A current of the current source is in the direction of a 20 V voltage rise across the source, this source delivers 20×5 = 100 W. The 3 A current of the voltage source is in the direction of a 20 V voltage drop across the source. This source absorbs 20×3 = 60 W. As a check, the resistor absorbs 20×2 = 40 W, so that the power delivered = 100 W = the total power absorbed.

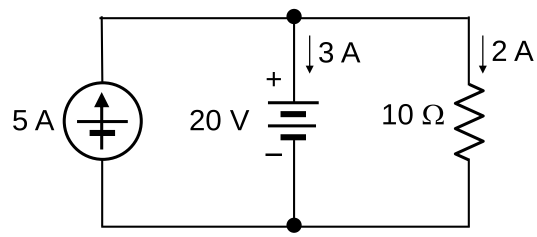

Figure P2.19A

P2.20 The current in the mesh in Figure P2.20A is the 6 A of the current source. The voltage drop across the resistor is 30 V. From KVL, starting at the lower node and going clockwise: $-V_S + 50 - 30 = 0$, which gives $V_S = 20$ V. Since the 6A current of the current source is in the direction of a 20 V voltage drop across the source, this source absorbs 20×6 = 120 W. The 6 A current of the voltage source is in the direction of a 50 V voltage rise across the source. This source delivers 50×6 = 300 W. As a check, the resistor absorbs 30×6 = 180 W, so that the power delivered = 300 W = the total power absorbed.

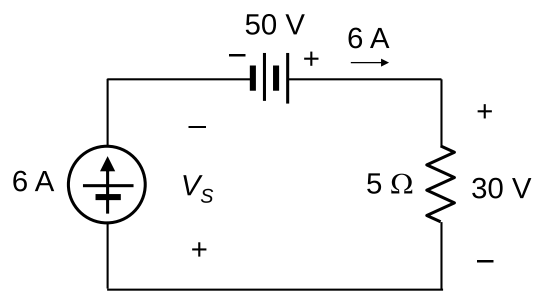

Figure P2.20A

P2.21 From Ohm's law, the current in the 1 Ω resistor in series with the 6 V source in Figure P2.21A is 6 A. From Ohm's law, the current in the 1 Ω resistor in series with the dependent source is $0.9I_X$ A. From KCL, $I_X = 6 + 0.9I_X$, which gives $I_X = 6/0.1 = 60$ A.

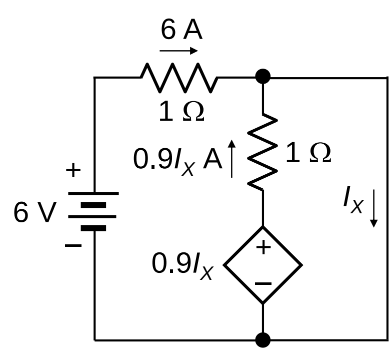

Figure P2.21A

P2.22 The 6 V source in Figure P2.22A appears across the two 2 Ω resistors in series. The current in these resistors is therefore 6/4 = 1.5 A in the direction shown. As a two-essential node circuit, KCL at node 'b' gives, $\frac{12+6}{6}+1.5=I_X$, or, I_X = 3 + 1.5 = 4.5 A.

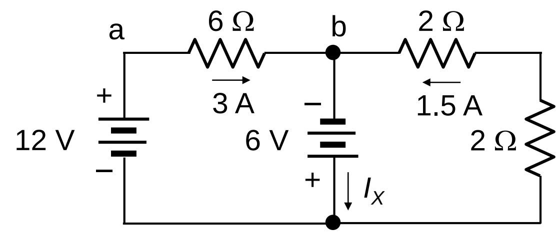

Figure P2.22A

P2.23 **Initialize.** The circuit is already marked with the given values and the required V_X. The nodes may be labelled 'a' and 'b' as in Figure P2.2.3A.

Simplify. The circuit is in a simple enough form.

Deduce. From KCL: 7 A enter node 'a' from R_2. From Ohm's law: voltage drop across the 3 Ω resistor is 45 V in the direction of 15 A; voltage drop across the 2 Ω resistor is 12 V in the direction of 6 A. From KVL around the outer loop, starting at node 'b' and going CW: -12 + 37 + V_X – 45 = 0, which gives V_X = 20 V. Note that this 20 V is a voltage rise across R_2 in the direction of 7A. This means that R_2 = -20/7 Ω and does not obey Ohm's law because it is a negative resistance.

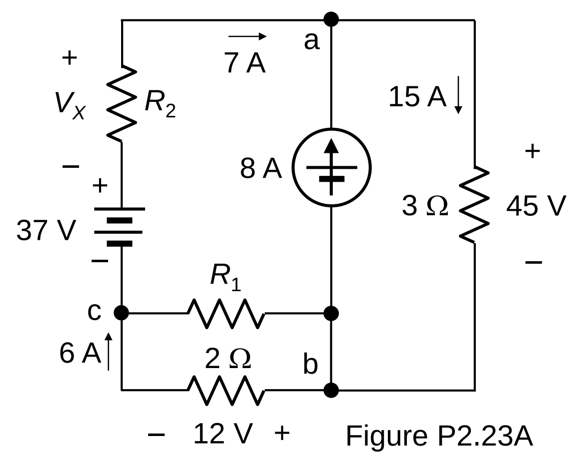

Figure P2.23A

P2.24 From current division in figure P2.24A, $I\times\frac{25}{25+75}=1$, which gives: I = 4 A. From KVL around the outer loop, 100 = R×4 + 75×1, or R = 25/4 = 6.25 Ω.

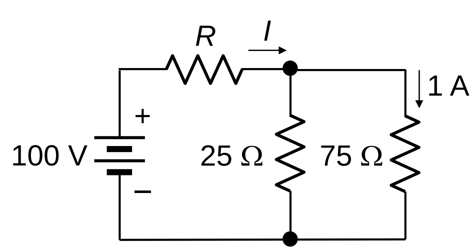

Figure P2.24A

P2.25 Since the voltage source in Figure P2.25A does not deliver or absorb power, $I = 0$. The voltage across R is 6 V, and the current through R and the 3 Ω resistor is 1 A. It follows that there is a voltage rise of 9 V across the current source in the direction of current. The source therefore delivers 9 W.

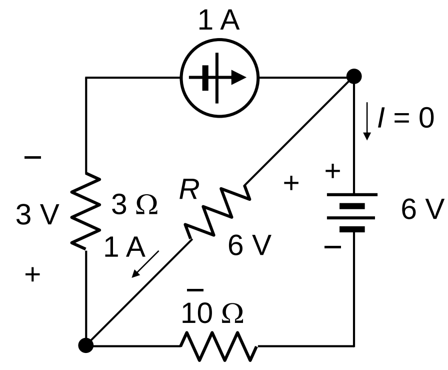

Figure P2.25A

P2.26 Since the current source in Figure P2.26A does not deliver or absorb power, the voltage across it is zero. The voltage across R is 3 V, the same as across the 3 Ω resistor, and the voltage across the 10 Ω resistor is 9 V. The current through the voltage source is 0.9 A in the direction of a voltage rise through the source. This source therefore delivers 0.9×6 = 5.4 W.

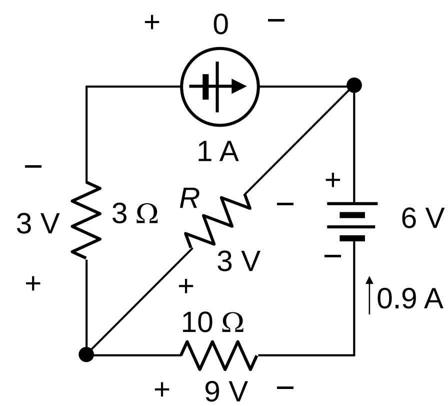

Figure P2.26A

P2.27 The voltage across the 20 Ω resistor in Figure P2.27A is V_{SRC} = 100 V, so the current through it is 5 A. The current of the dependent source is $0.2V_{SRC}$ = 20 A. From KCL at the upper node, the current flowing into the voltage source is 20 – 5 = 15 A. The voltage drop across the 2 Ω source is 40 V. From KVL, the voltage across the dependent source is 100 + 40 = 140 V. It follows that this source delivers 140×20 = 2,800 W, and the voltage source absorbs 100×15 = 1,500 W. The power absorbed in the 2 Ω resistor is 40×20 = 800 W, and the power absorbed in the 20 Ω resistor is 100×5 = 500 W. Total power delivered = 2,800 W = total power absorbed.

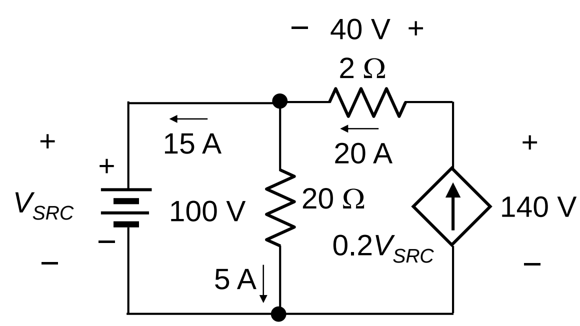

Figure P2.27A