Problem 1

Solution:

Known quantities:

Schematic of the circuit shown in Figure P2.74; for part b: value of R_p and current displayed on the ammeter.

Find:

The current i; the internal resistance of the meter.

Assumptions:

$r_a << 50\ k\Omega$

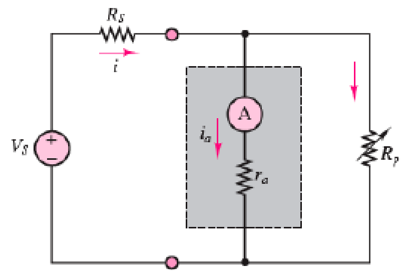


Figure P2.74

Analysis:

a) Assuming that $r_a << 50\ k\Omega$

$$i \approx \frac{V_s}{R_s} = \frac{12}{50000} = 240\ \mu A$$

b) With the same assumption as in part a)

$$i_{meter} = 150 \cdot (10)^{-6} = \frac{R_p}{r_a + R_p} i$$

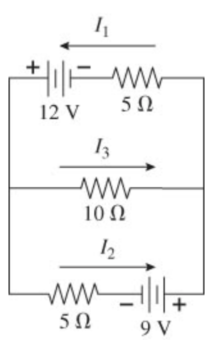
or:

$$150 \cdot (10)^{-6} = \frac{15}{r_a + 15} 240 \cdot 10^{-6}.$$

Therefore, $r_a = 9\ \Omega$.

Problem 2

Model: The wires and batteries are ideal.
Visualize:



Solve: Assign currents I_1, I_2, and I_3 as shown in the figure. If I_3 turns out to be negative, we'll know it really flows right to left.
Apply Kirchhoff's loop rule counterclockwise to the top loop from the top right corner:

$$-I_1(5\ \Omega) + 12\ \text{V} - I_3(10\ \Omega) = 0.$$

Apply the loop rule counterclockwise to the bottom loop starting at the lower left corner:

$$-I_2(5\ \Omega) + 9\ \text{V} + I_3(10\ \Omega) = 0.$$

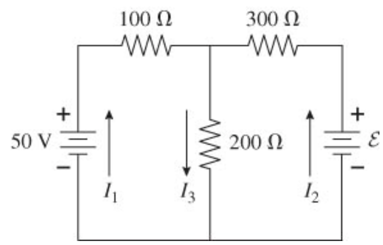
Note that since we went against the current direction through the $(10\ \Omega)$ resistor the potential increased. Apply the junction rule to the right middle:

$$I_1 = I_2 + I_3.$$

These three equations can be solved for the current I_3 by subtracting the second equation from the first then making the substitution $I_2 - I_1 = -I_3$ which was derived from the third equation. The result is $I_3 = \dfrac{3}{25}$ A = 0.12 A, left to right.

Problem 3

Model: The wires and batteries are ideal.
Visualize:



Solve: If no power is dissipated in the $200\ \Omega$ resistor, the current through it must be zero. To see if this is possible, set up Kirchhoff's rules for the circuit, then assume the current through the $200\ \Omega$ resistor is zero and see if there is a solution.

Assume the unknown battery is oriented with its positive terminal at the top and currents I_1, I_2, I_3 defined as shown in the figure above. Apply Kirchhoff's loop rule clockwise to the left loop:

$$50\text{ V} - I_1(100\ \Omega) - I_3(200\ \Omega) = 0$$

Again, counterclockwise to the right hand loop:

$$\mathcal{E} - I_2(300\ \Omega) - I_3(200\ \Omega) = 0$$

The junction rule yields

$$I_1 + I_2 = I_3.$$

Now assume $I_3 = 0$ and solve for $\mathcal{E}$. In that case, the first equation gives

$$I_1 = \frac{50\text{ V}}{100\ \Omega} = \frac{1}{2}\text{ A}.$$

From the third equation, $I_2 = -I_1$, so the second equation gives us

$$\mathcal{E} = I_2(300\ \Omega) = \left(-\frac{1}{2}\text{ A}\right)(300\ \Omega) = -150\text{ V}$$

Thus $\mathcal{E}$ = 150 V and it is oriented with negative terminal on top, opposite to our guess.