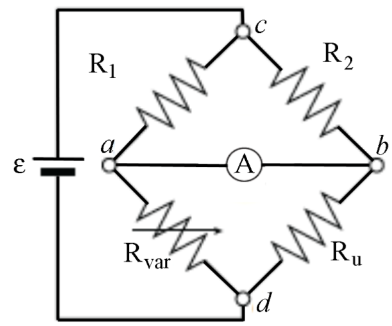
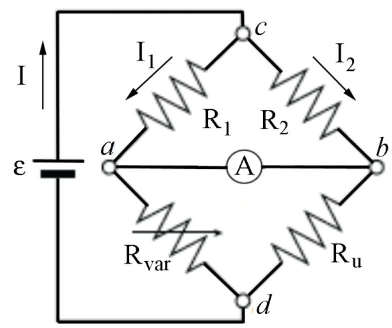
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics
8.02

Group Problem Solution: Wheatstone Bridge

A circuit consists of two resistors with resistances $R_1 = 6.0\ \Omega$ and $R_2 = 1.5\ \Omega$, a variable resistor, the resistance R_{var} of which can be adjusted, a resistor of unknown value R_u, and 9.0 volt battery connected as shown in the figure. When R_{var} is adjusted to 12 ohms, there is zero current through the ammeter. What is the unknown resistance R_u?



Solution: When there is no current flowing through the ammeter, the potential difference $V(b) - V(a) = 0$. Therefore $V(c) - V(a) = V(c) - V(b)$. If we assign currents as shown in the figure below then $V(c) - V(a) = I_1 R_1$ and $V(c) - V(b) = I_2 R_2$.



Thus when the ammeter measures zero current

$$I_1 R_1 = I_2 R_2 .$$

In a similar fashion, $V(a) - V(d) = V(b) - V(d)$ which implies that

$$I_1 R_{\text{var}} = I_2 R_u \Rightarrow R_u = \frac{I_1}{I_2} R_{\text{var}} .$$

Combining results yields

$$R_u = \frac{R_2 R_{\text{var}}}{R_1} = \frac{(1.5\ \Omega)(12\ \Omega)}{6.0\ \Omega} = 3.0\ \Omega$$