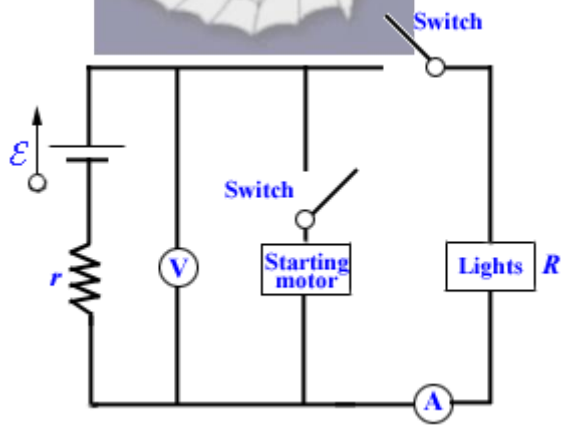
412.

Problem 33.34 (RHK)

When the lights of an automobile are switched on, an ammeter in series with them reads 10.0 A *and a voltmeter connected across them reads* 12 V (*see figure*). *When the electric starting motor is switched on, the ammeter reading drops to* 8.00 A *and the light dims somewhat. If the internal resistance of the battery is* 50.0 mΩ *and that of the ammeter is negligible, we have to find* (a) *the emf of the battery and* (b) *the current through the starting motor when the lights are on.*



Solution:

(a)

Let us consider the circuit shown above in the situation when the lights have been switched on. It is given that

the ammeter reading is 10.0 A and the voltmeter reading is 12.0 V. Applying Ohm's law, we note that the resistance of the light bulbs is

$$R = \frac{12\ \text{V}}{10\ \text{A}} = 1.2\ \Omega.$$

We next calculate the emf of the battery. As 10.0 A of current flows through the internal resistance of the battery,

$$r = 50.0 \times 10^{-3}\ \Omega = 0.05\ \Omega,$$

we have

$$-0.05 \times 10\ \text{V} + \text{E} = 12.0\ \text{V},$$

$$\text{E} \cong 12.5\ \text{V}.$$

(b)

When the motor is switched on and the lights are also on, the ammeter reading is 8.0 A. Let the current drawn by the motor be i_m A. In this situation the total current flowing through the battery will be

$$i = \left(8.0 + i_m\right)\ \text{A}.$$

Applying Kirchoff's law to the loop that includes the battery and the lights but excludes the motor, we have

$$-1.2 \times 8\ \left(\Omega\ \text{A}\right) - \left(8.0 + i_m\right) \times 0.05\ \left(\text{A}\ \Omega\ \right) + 12.5\ \text{V} = 0.$$

Solving this equation, we find that the current drawn by the motor when the lights are also switched on will be $i_m = 50.0$ A.