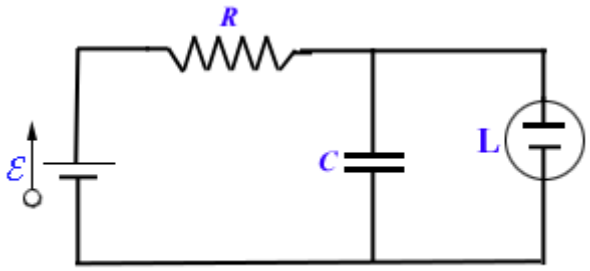
422.

Problem 33.53 (RHK)

In the figure a circuit has been shown of a flashing lamp of the type that is attached to barrels at highway construction sites. The fluorescent lamp **L** *is connected in parallel across the capacitor C of an RC circuit. Current passes through the lamp only when the potential across it reaches the breakdown voltage* V_L; *in this event the capacitor discharges through the lamp and it flashes for a very short time. Suppose that two flashes per second are needed. We have to calculate the resistance R of the resistor for a lamp with breakdown voltage* $V_L = 72$ V *which is used with a* 95-V battery, *and a* 0.15-μF *capacitor.*



Solution:

In the figure circuit has been drawn of a flashing lamp.

Capacitance of the capacitor in the circuit is

$C = 0.15\ \mu\text{F} = 0.15 \times 10^{-6}$ F.

EMF of the battery is

$\text{E} = 95.0$ V.

The breakdown voltage of the fluorescent lamp is

$V_{\text{L}} = 72.0$ V.

If two flashes per second are needed, the time for charging the 0.15-μF capacitor to 72 V using 95.0-V battery has to be 0.5 s. This requirement fixes the value of the resistance *R* in the circuit.

Equation for charging a capacitor of capacitance *C* in a *RC* circuit is

$$\frac{q(t)}{C} = \frac{q_0}{C}\left(1 - e^{-t/RC}\right),$$

or

$$V(t) = V_0\left(1 - e^{-t/RC}\right).$$

In our problem

$V_0 = 95.0$ V.

If the lamp has to flash in $t = 0.5$ s, voltage across the capacitor has to build from $V = 0$ V to $V = V_{\text{L}} = 72.0$ V in 0.5 s. This requirement will determine the resistance *R*. Therefore,

$$\frac{V_{\mathrm{L}}}{V_0}-1=-e^{-0.5/RC},$$

or

$$\frac{72}{95}-1=-e^{-0.5/RC},$$

or

$$\frac{23}{95}=e^{-0.5/RC},$$

or

$$R=\frac{(-0.5)}{C\times\ln\left(\frac{23}{95}\right)}\ \Omega=\frac{0.5}{0.15\times10^{-6}\times1.4184}\ \Omega=2.35\ \mathrm{M}\Omega.$$