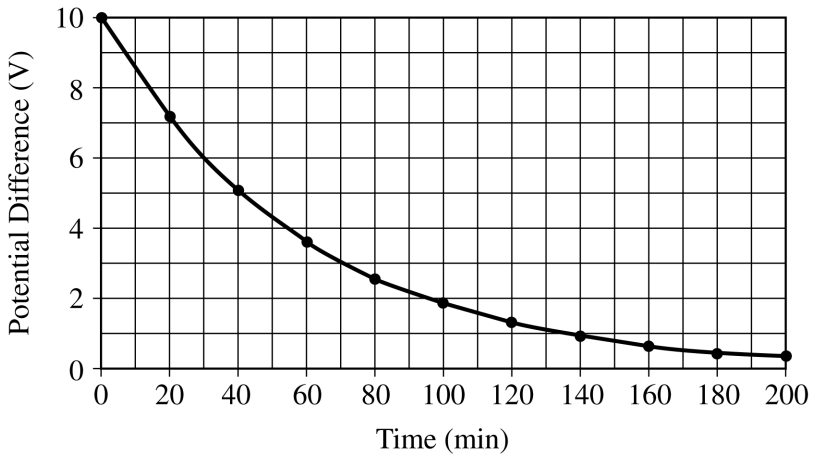


E & M 2.

You have been hired to determine the internal resistance of 8.0 μF capacitors for an electronic component manufacturer. (Ideal capacitors have an infinite internal resistance—that is, the material between their plates is a perfect insulator. In practice, however, the material has a very small, but nonzero, conductivity.) You cannot simply connect the capacitors to an ohmmeter, because their resistance is too large for an ohmmeter to measure. Therefore you charge the capacitor to a potential difference of 10 V with a battery, disconnect it from the battery and measure the potential difference across the capacitor every 20 minutes with an ideal voltmeter, obtaining the graph shown above.

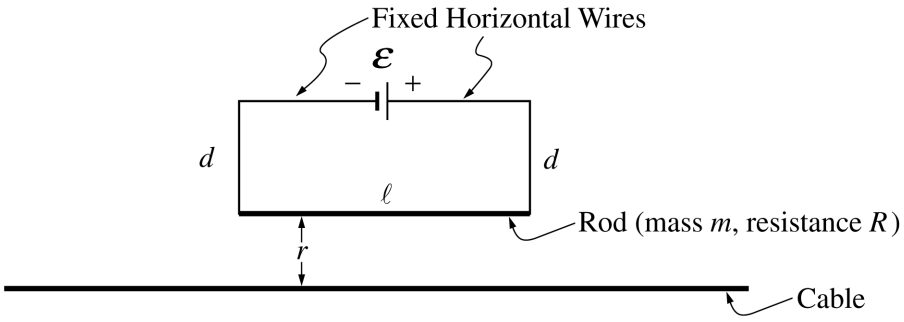
(a) Determine the internal resistance of the capacitor.

The capacitor can be approximated as a parallel-plate capacitor separated by a 0.10 mm thick dielectric with $\kappa = 5.6$.

(b) Determine the approximate surface area of one of the capacitor "plates."

(c) Determine the resistivity of the dielectric.

(d) Determine the magnitude of the charge leaving the positive plate of the capacitor in the first 100 min.



E&M 3.

The circuit shown above consists of a battery of emf $\mathcal{E}$ in series with a rod of length ℓ, mass m, and resistance R. The rod is suspended by vertical connecting wires of length d, and the horizontal wires that connect to the battery are fixed. All these wires have negligible mass and resistance. The rod is a distance r above a conducting cable. The cable is very long and is located directly below and parallel to the rod. Earth's gravitational pull is toward the bottom of the page. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) What is the magnitude and direction of the current I in the rod?

(b) In which direction must there be a current in the cable to exert an upward force on the rod? Justify your answer.

(c) With the proper current in the cable, the rod can be lifted up such that there is no tension in the connecting wires. Determine the minimum current I_c in the cable that satisfies this situation.

(d) Determine the magnitude of the magnetic flux through the circuit due to the minimum current I_c determined in part (c).

END OF SECTION II, ELECTRICITY AND MAGNETISM

Question 2

15 points total

2. (a) **4 points** **Distribution of Points**

There were three methods generally used to solve this problem.

Method 1.

For a correct method based on determining the time constant using values from the graph **2 points**

$\tau = RC \approx 60 \text{ min} = 3600 \text{ s}$

For correct substitution of values with proper units **1 point**

$$R = \frac{\tau}{C} = \frac{3600 \text{ s}}{8.0\times10^{-6} \text{ F}}$$

For answer consistent with values used **1 point**

$R = 4.5\times10^{8}\ \Omega$

Method 2.

$V = V_0 e^{-t/RC}$

For using the above equation with given value of C and values for V, V_0, and t from the graph with t correlating with V **2 points**

Example: $V_0 = 10$ V, and $V = 2$ V at $t = 100$ min

For correct substitution of values **1 point**

$$2 = 10e^{(-6000 \text{ s})/R(8\times10^{-6} \text{ F})}$$

$$\ln(2/10) = (6000)R\left(8\times10^{-6}\right)$$

For answer consistent with values used **1 point**

$R = 4.7\times10^{8}\ \Omega$

Method 3.

Find a correct relationship that depends on the slope of the graph:

Example: $R = \dfrac{V}{i} = \dfrac{V}{dQ/dt}$

But $dQ = CdV$

So $R = \dfrac{V}{C(dV/dt)}$

For estimating dV/dt by computing $\Delta V/\Delta t$ for a particular value of V **2 points**

For substituting values in equation above **1 point**

For answer consistent with values used **1 point**

Note: The value used for V must be that at the point where the slope is taken and clearly indicated.