Physics 4B Winter 2018 Test 2

Name: _____

Feb 15, 2018

Please show your work! Answer as many questions as you can, in any order. Calculators are allowed. Books, notes, and internet connected devices are not allowed. Use any blank space to answer questions, but please make sure it is clear which question your answer refers to.

When asked for an expression, give your answer only in terms of the variables given in the question and fundamental constants such as g, k, e, and so on.
DO NOT OPEN TEST BOOKLET UNTIL TOLD TO DO SO.

$g = 9.8\ \text{ms}^{-2}$
$k = 8.99 \times 10^9\ \text{Nm}^2\text{C}^{-2} = \frac{1}{4\pi\epsilon_0}$
$\epsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\text{N}^{-1}\text{m}^{-2}$
$e = 1.60 \times 10^{-19}\ \text{C}$
$m_e = 9.11 \times 10^{-31}\ \text{kg}$
$m_p = 1.67 \times 10^{-27}\ \text{kg}$

$C = 2\pi\epsilon_0 \frac{L}{\ln(b/a)}$
$C = 4\pi\epsilon_0 \frac{ab}{b-a}$
$\rho - \rho_0 = \alpha\rho_0(T - T_0)$

Trigonometric Identities

$\sin^2\theta + \cos^2\theta = 1$
$\sin(2\theta) = 2\sin(\theta)\cos(\theta)$
$\cos(2\theta) = \cos^2\theta - \sin^2\theta$
$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$
$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$
$\cos\alpha\cos\beta = \frac{1}{2}[\cos(\alpha-\beta) + \cos(\alpha+\beta)]$
$\sin\alpha\sin\beta = \frac{1}{2}[\cos(\alpha-\beta) - \cos(\alpha+\beta)]$
$\sin\alpha\cos\beta = \frac{1}{2}[\sin(\alpha+\beta) + \sin(\alpha-\beta)]$

$\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$
$\cos\left(\theta + \frac{\pi}{2}\right) = -\sin\theta$
$\sec\theta := \frac{1}{\cos\theta}$
$\csc\theta := \frac{1}{\sin\theta}$
$\cot\theta := \frac{1}{\tan\theta}$

1. A certain copper wire has a resistance of 6.00 Ω at 20.0°C.

   (a) What resistance will it have at 35.0°C? [4 pts]

   (b) Suppose the wire connects the terminals of an ideal emf source, and as current passes through it, it heats from 20.0°C to 35.0°C. What is the ratio of the power dissipated as heat in the wire at 35.0°C to the power dissipated at 20.0°C? [3 pts]

   (At 20.0°C, copper has a resistivity of $1.70 \times 10^{-8}\ \Omega\,\mathrm{m}$ and a temperature coefficient of resistivity of $3.90 \times 10^{-3}\ (^\circ\mathrm{C})^{-1}$.)

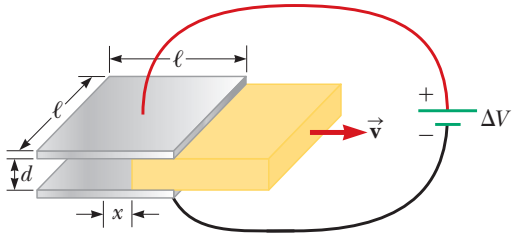
2. A parallel-plate capacitor consists of square plates of edge length ℓ, that are separated by a distance d, where $d \ll \ell$. A potential difference ΔV is maintained between the plates. A material of dielectric constant κ fills half the space between the plates. The dielectric slab is withdrawn from the capacitor as shown.

   (a) What is the charge on the capacitor after the dielectric is completely withdrawn? [2 pts]

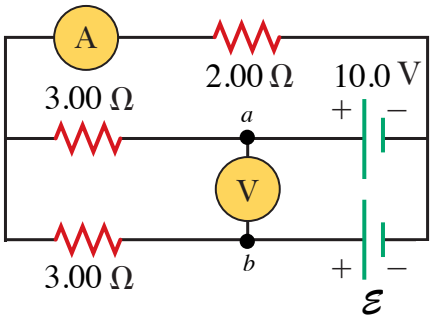
   (b) What is the charge on the capacitor initially, when the dielectric fills half the space between the plates? [4 pts]

   (c) Find the capacitance when the left edge of the dielectric is at a distance x from the center of the capacitor. [3 pts]

   (d) If the dielectric is removed at a constant speed v, what is the current in the circuit as the dielectric is being withdrawn? Which way is the current flowing? [4 pts]



3. In the circuit shown, the reading on the ideal voltmeter is 6.00 V, with point a being the high potential side and point b being the low potential side.



(a) Find $\mathcal{E}$, the value of the ideal emf source. [3 pts]

(b) What is the expected reading on the ideal ammeter? [7 pts]

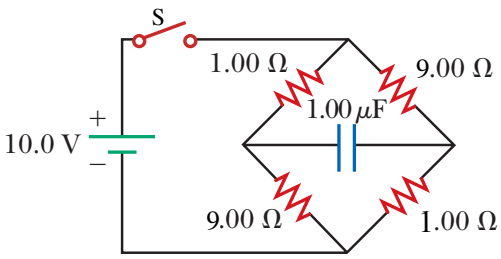
4. Consider the resistance-capacitance circuit shown. It includes an ideal 10 V battery. Initially the switch is open and the capacitor is uncharged.

   (a) What is the effective resistance of this arrangement just at the moment the switch is closed? [5 pts]

   (b) What is the effective resistance of this arrangement after the switch has been closed for a long time? [4 pts]

   (c) What is the potential difference across the capacitor when the switch has been closed for a long time? [5 pts]

   (d) After the switch has been closed a long time, it is opened again. Sketch a graph of the potential difference across the capacitor against time after the switch is opened, labelling the axes with the appropriate initial value. [3 pts]



–Extra Workspace–