GRADES
100
99
94
91
80

PHYS 223 University Physics III
Exam 3

October 15, 2014

Name J.C. Daly

1. Derive an expression for the capacitance per unit length for the coaxial cable shown in Figure 1.

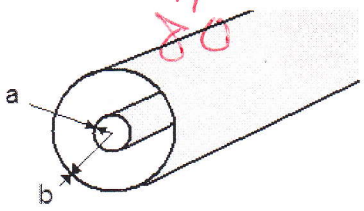

Figure 1 The inner radius is a meters. The outer radius is b meters. The material between the conductors is air.

Assume λ coul/m charge on the inner conductor.

By Gauss' Law

$$\oint \vec{E}\cdot d\vec{a} = E_r 2\pi r L = \lambda L/\epsilon_0$$

where L is the axial length of the Gaussian surface.

$$E_r = \frac{\lambda}{2\pi\epsilon_0 r}$$

$$V = V(a) - V(b) = -\int_{-b}^{a} \frac{\lambda\, dr}{2\pi\epsilon_0 r} = \frac{-\lambda}{2\pi\epsilon_0}\ln\left(\frac{a}{b}\right)$$

$$V = \frac{\lambda}{2\pi\epsilon_0}\ln(b/a)$$

$$\text{Capacitance per Length} = \frac{Q/V}{L} = \frac{\lambda}{V}$$

$$\boxed{C = \frac{2\pi\epsilon_0}{\ln(b/a)}}$$

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2. Determine the equivalent resistance between the points ***A*** and ***B*** for the group of resistors shown in Figure 2.

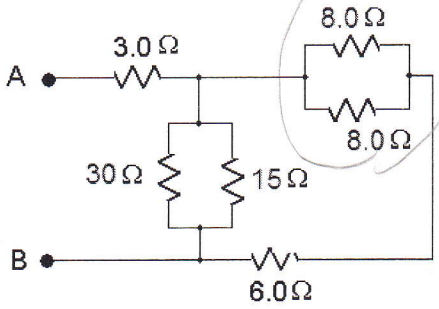
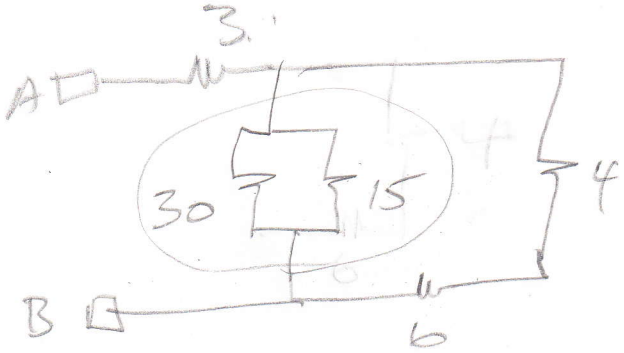
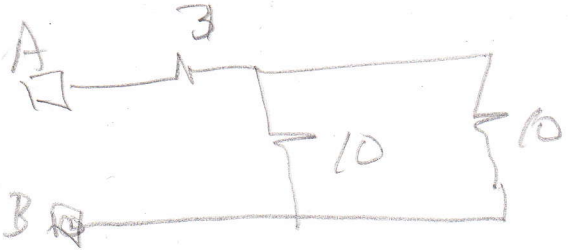
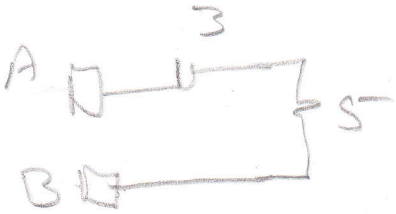
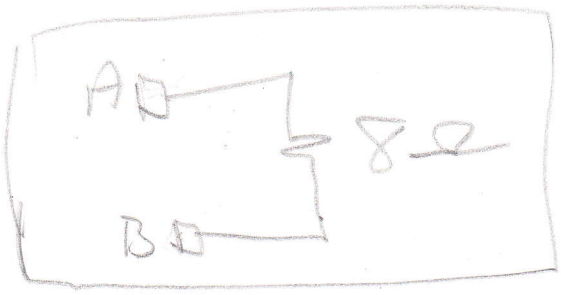


Figure 2









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3. A capacitor consists of two parallel plates area, A = 1.4 cm^2, separated by 0.88 mm. The plates are separated by an insulator with a dielectric constant, k = 8.3, Equal and opposite charges of 1.5 *uC* are distributed (uniformly) on the plates.

   Find

   a. the capacitance of the system, 11.7 pF
   b. the potential difference between the plates, 1.28×10^5 V
   c. the amount of stored electrostatic potential energy. 0.0962 J

$C = \frac{k\varepsilon_0 A}{d}$ $\quad A = 1.4\ cm^2 \times \frac{1\ m^2}{10^4\ cm^2} = 1.4 \times 10^{-4}\ m^2$

$C = \frac{8.3 * 8.854 \times 10^{-12} * 1.4 \times 10^{-4}}{0.88 \times 10^{-3}}$ $\quad d = 0.88\ mm = 0.88 \times 10^{-3}\ m$

a) $C = 1.169 \times 10^{-11}\ F = \boxed{11.7\ pF}$

b) $Q = CV$ $\quad V = \frac{Q}{C} = \frac{1.5 \times 10^{-6}}{1.169 \times 10^{-11}} = \boxed{1.28 \times 10^5\ V}$

c) $U = \frac{1}{2}CV^2 = \frac{1}{2} * 1.169 \times 10^{-11} * (1.28 \times 10^5)^2$

$\boxed{U = 0.0962\ J}$

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4. State Gauss' law in words.

The net electric flux through any closed surface is equal to the net electric charge enclosed within that closed surface divided by the permittivity of free space.

$$\oint_S \vec{E} \cdot d\vec{a} = \frac{\int \rho \, dv}{\epsilon_0}$$

where S is the surface of V