PHYS 102 Midterm

Feb. 15, 2013

You have 50 minutes to complete this midterm. Attempt all questions. Write your name and student number on this page. Include 3 significant figures in all of your answers. Include units with all of your answers. Including this coversheet, which is unnumbered, there are a total of 7 pages.

The last page of the exam may be removed. This page contains a formula sheet which you may find helpful when solving some of the problems.

Name: ______________________________

Student #: ______________________________

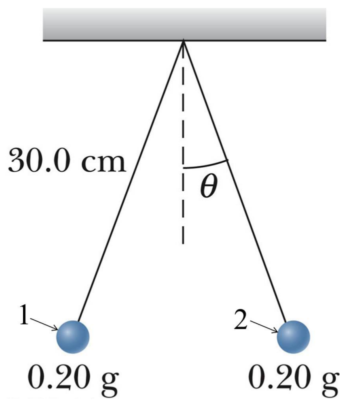
PHYSICS 102 Midterm Name: ____________________

Feb. 15, 2013 12:30-13:20 Student Number: ________________

Midterm (24 points)

Multiple Choice: Circle the best answer for each of the three multiple choice questions.

(2^{pts}) **1.** Two identical spheres (same radius and mass) are suspended from strings of equal length as shown in the figure. Initially, both spheres carry a charge of q and the electrostatic repulsion causes the string on the right to make an angle θ with respect to the vertical dashed line.



If the charge on sphere 1 is changed to $q/2$ and the charge on sphere 2 is changed to $2q$, what happens to θ?

(a) θ increases.

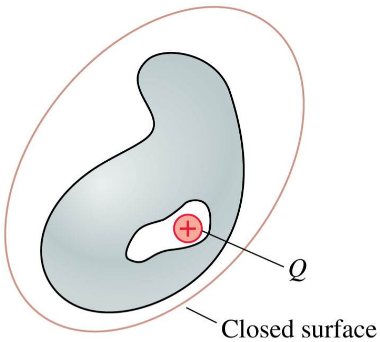
(b) θ decreases.

(c) θ stays the same.

(d) More information is needed.

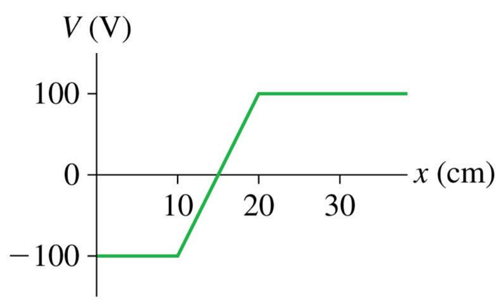
2 pts

(2pts) **2.** The figure shows a hollow cavity within a neutral conductor. Point charge Q is inside the cavity. What is the net electric flux through the closed surface that surrounds the conductor?



(a) $-2Q/\varepsilon_0$ (b) $-Q/\varepsilon_0$ (c) zero (d) Q/ε_0 (e) $2Q/\varepsilon_0$

(2pts) **3.** The electric potential along the x-axis of a coordinate system is given by the plot below. What is the electric field along the x-direction at the position $x = 15$ cm?

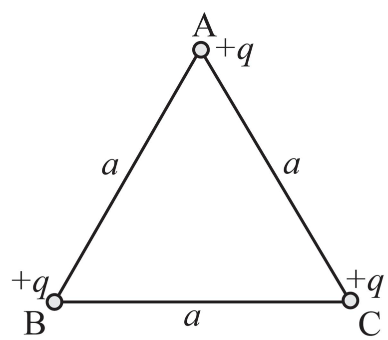


(a) $-2000\ \frac{\text{V}}{\text{m}}\ \hat{\imath}$ (b) $-20\ \frac{\text{V}}{\text{m}}\ \hat{\imath}$ (c) zero (d) $+20\ \frac{\text{V}}{\text{m}}\ \hat{\imath}$ (e) $+2000\ \frac{\text{V}}{\text{m}}\ \hat{\imath}$

4 pts

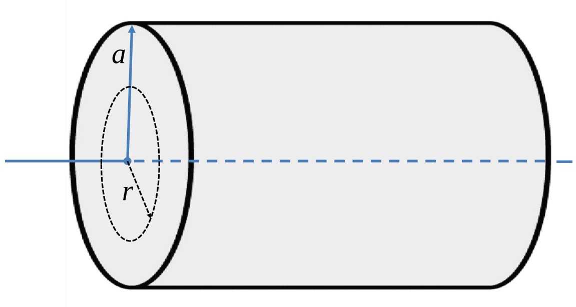
Free Response: Write out complete answers to the following questions. Show your work since it allows us to be generous with partial credit.

(6pts) **4.** Three identical charges of mass m and charge q are held in place at the corners of an equilateral triangle. The charges are then simultaneously released from rest. With what speed v_f do the charges move once they are very far apart? Find an expression for v_f in terms of q, m, a, and Coulomb's constant K.



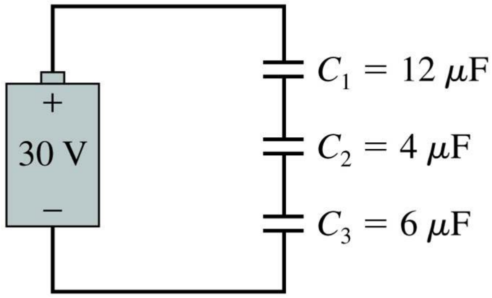
6 pts

(6pts) **5.** A section of a long cylinder of radius a is shown below. The cylinder has a *uniform* charge per unit volume ρ. Find an expression for the magnitude of the electric field E at point *inside* the cylinder that is a distance r from the cylinder axis.



6 pts

(6pts) **6.** What is the charge on capacitor C_3?



6 pts

Potentially Useful Formulae.
Detach this sheet and keep it.

$g = 9.81\ \mathrm{m/s^2}$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$K = 8.99 \times 10^9\ \mathrm{N\,m^2/C^2}$

$$\varepsilon_0 = \frac{1}{4\pi K} = 8.85 \times 10^{-12}\ \mathrm{C^2/N\,m^2}$$

Electron: $q_\mathrm{e} = -e = -1.60 \times 10^{-19}\ \mathrm{C}$

$m_\mathrm{e} = 9.11 \times 10^{-31}\ \mathrm{kg}$

$$v = v_\mathrm{i} + a_\mathrm{c}\Delta t$$

$$x = x_\mathrm{i} + v_\mathrm{i}\Delta t + \frac{1}{2}a_\mathrm{c}\,(\Delta t)^2$$

$$v^2 = v_\mathrm{i}^2 + 2a_\mathrm{c}\Delta x$$

$$\vec{A} \cdot \vec{B} = AB\cos\theta = A_x B_x + A_y B_y + A_z B_z$$

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$$

$$\vec{E} = \vec{F}/q \qquad \vec{E}_\mathrm{net} = \sum_i \vec{E}_i$$

$$\Phi_\mathrm{e} = \int_\mathrm{surface} \vec{E} \cdot d\vec{A}$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_\mathrm{in}}{\varepsilon_0}$$

$$U_\mathrm{elec} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

$$V = U_\mathrm{elec}/q \qquad V_\mathrm{net} = \sum_i V_i$$

$$\Delta V = V_\mathrm{f} - V_\mathrm{i} = -\int_\mathrm{i}^\mathrm{f} \vec{E} \cdot d\vec{s}$$

$$E_s = -\frac{dV}{ds}$$

$$C = \frac{Q}{\Delta V_\mathrm{C}}$$

parallel plate cap.: $C_0 = \varepsilon_0 \dfrac{A}{d}$

parallel: $C_\mathrm{eq} = \sum_i C_i$

series: $\dfrac{1}{C_\mathrm{eq}} = \sum_i \dfrac{1}{C_i}$