UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 106-4 / LeClair Fall 2008

# Solutions to Sample Exam 1 Questions

**1.** A charge of $100\,\mu$C is at the center of a cube of side $0.8$ m. What is the flux through one face of the cube?

- ■ $1.9 \times 10^6\,\mathrm{N \cdot m^2/C}$
- □ $3.7 \times 10^4\,\mathrm{N \cdot m^2/C}$
- □ $2.5 \times 10^12\,\mathrm{N \cdot m^2/C}$
- □ $0$

**2.** Suppose three positively charged particles are constrained to move on a fixed circular track. If all the charges were equal, an equilibrium arrangement would obviously be a symmetrical one with the particles spaced $120°$ apart around the circle. Suppose two of the charges have equal charge $q$, and the equilibrium arrangement is such that these two charges are $90°$ apart rather than $120°$. What is the *relative* magnitude and sign of the third charge?

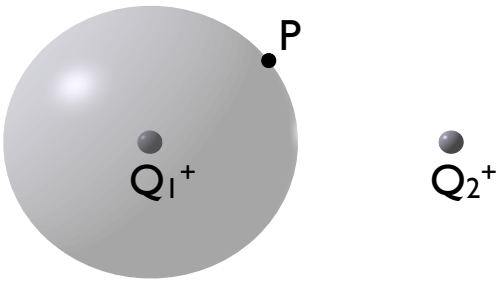
- ■ larger than either $q_1$ or $q_2$ and positive
- □ smaller than either $q_1$ or $q_2$ and positive
- □ larger than either $q_1$ or $q_2$ and negative
- □ smaller than either $q_1$ or $q_2$ and negative

**3.** A positive charge of $q$ and a negative charge of $-9q$ are placed a distance $d$ apart. For reference, let us say the charges are along a horizontal line, with the positive charge on the right and the negative charge on the left. Determine one point (other than infinity) at which the total electric field is zero.

- □ $d/4$ to the right of the negative charge
- □ $d/4$ to the right of the positive charge
- □ $d/2$ to the right of the negative charge
- ■ $d/2$ to the left of the negative charge

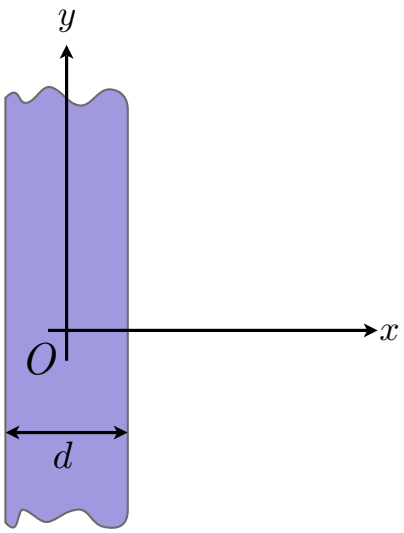
**4.** If the net flux through a closed surface is *zero*, the following four statements *could be true.* Which of the statements *must be true?*

- □ There are no charges inside the surface
- ■ The net charge inside the surface is zero
- □ The electric field is zero everywhere on the surface
- ■ The number of electric field lines entering the surface equals the number leaving the surface




**5.** In the figure above, a point charge $1Q^+$ is at the center of an imaginary spherical Gaussian surface and another point charge $2Q^+$ is outside of the Gaussian surface. Point $P$ is on the surface of the sphere. Which one of the following statements is true?

□ Both contribute to the net electric flux through the sphere but only $1Q^+$ contributes to the electric field at point $P$.
□ Both charges contribute to the net electric flux through the sphere but only $2Q^+$ contributes to the electric field at point $P$.
■ Only $1Q^+$ contributes to the net electric flux through the sphere but both charges contribute to the electric field at point $P$.
□ Only $2Q^+$ contributes to the net electric flux through the sphere but both charges contribute to the electric field at point $P$.
□ Only $1Q^+$ contributes to the net electric flux through the sphere and to the electric field at point $P$ on the sphere.
□ Only $2Q^+$ contributes to the net electric flux through the sphere and to the electric field at point $P$ on the sphere.
□ I don't know (this answer is worth 1/10 of full credit)




**6.** A slab of insulating material, infinite in two of its three dimensions, has a uniform positive charge density $\rho$, shown at left. Suppose an electron of charge $-e$ and mass $m_e$ can more freely within the slab, and is released from rest at a distance $x$ from the center. The electron will subsequently undergo simple harmonic motion; which expression gives the correct variation of frequency with $\rho$, $e$, and $m_e$?

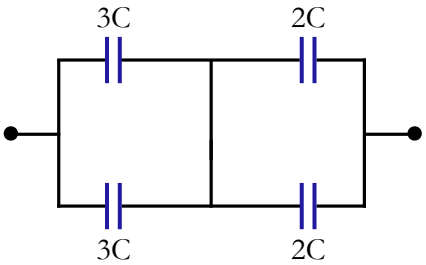
■ $f \propto \sqrt{\rho e/m_e}$
□ $f \propto \sqrt{\rho m_e/e}$
□ $f \propto \rho m_e/e$
□ $f \propto \rho e/m_e$
□ $f \propto \sqrt{\rho e m_e}$

**7.** A sphere the size of a basketball is charged to a potential of $-1000\,\text{V}$. About how many extra electrons are on it, per $\text{cm}^2$ of surface?

□ $4 \times 10^3$
■ $5 \times 10^7$
□ $8 \times 10^{10}$
□ $9 \times 10^{21}$

**8.** A spherical balloon contains a positively charged object at its center. As the balloon is inflated to a greater volume while the charged object remains at the center, does the electric **flux** at the surface of the balloon:

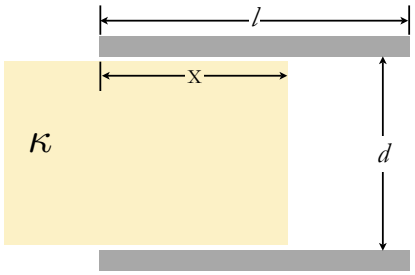
□ increase
□ decrease
■ remain the same




**9.** Find the equivalent capacitance for the combination of capacitors shown at left.

□ $10C$
□ $1.2C$
■ $2.4C$
□ $C$

**10.** A capacitor is constructed from two square plates of sides $l$ and separation $d$. A dielectric is inserted a distance $x$ into the capacitor, as shown at right. In what direction is the force on the dielectric?



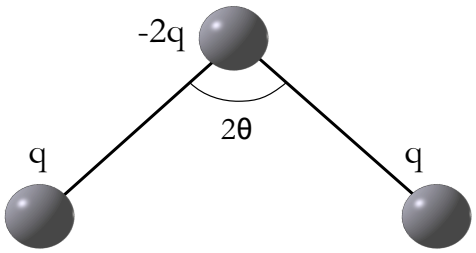

- □ up
- ■ to the right
- □ to the left
- □ down
- □ there is no net force

**11.** Referring to the figure above, in what direction would the force be if the inserted section were a *conductor* instead of a dielectric?

- □ up
- □ to the right
- ■ to the left
- □ down
- □ there is no net force

**12.** An electron (of charge $-e$ and mass $m_e$) enters a region of uniform electric field $\vec{\mathbf{E}} = 800\,\hat{\mathbf{x}}$ [N/C] with velocity $\vec{\mathbf{v}}_i = 1.5 \times 10^5\,\hat{\mathbf{x}}$ [m/s]. What is magnitude the acceleration $|\vec{\mathbf{a}}|$ of the electron due to the electric field?

- ■ $-3.5 \times 10^{13}\ \left[\text{m/s}^2\right]$
- □ $4.6 \times 10^{8}\ \left[\text{m/s}^2\right]$
- □ $-1.4 \times 10^{14}\ \left[\text{m/s}^2\right]$
- □ $6.8 \times 10^{12}\ \left[\text{m/s}^2\right]$




**13.** In the figure at left, three point charges are connected by unbreakable strings of length $d$. What is the equilibrium angle $2\theta$?[a]

- □ 90°
- ■ 180°
- □ 135°
- □ 90°

[a] Note that $\frac{d}{dx}\frac{1}{\sin x} = -\frac{\cos x}{\sin^2 x}$ and $\frac{d}{dx}\frac{1}{\cos x} = \frac{\sin x}{\cos^2 x}$.