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?
   - $1.9 \times 10^6$ N·m²/C
   - $3.7 \times 10^4$ N·m²/C
   - $2.5 \times 10^1$ N·m²/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 $120^\circ$ apart around the circle. Suppose two of the charges have equal charge $q$, and the equilibrium arrangement is such that these two charges are $90^\circ$ apart rather than $120^\circ$. 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 $-5q$ 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.
   - to the right of the negative charge
   - to the right of the positive charge
   - to the right of the negative charge
   - 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 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 $\vec{E} = 800 \hat{x} \text{ [N/C]}$ with velocity $\vec{v}_i = 1.5 \times 10^5 \hat{x} \text{ [m/s]}$. What is magnitude the acceleration $|\vec{a}|$ of the electron due to the electric field?
   - $-3.5 \times 10^{13} \text{ [m/s}^2]\]
   - $4.6 \times 10^8 \text{ [m/s}^2]\]
   - $-1.4 \times 10^{14} \text{ [m/s}^2]\]
   - $6.8 \times 10^{12} \text{ [m/s}^2]\]

13. In the figure at left, three point charges are connected by unbreakable strings of length $d$. What is the equilibrium angle $\theta$?
   - $90^\circ$
   - $180^\circ$
   - $135^\circ$
   - $90^\circ$

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