Solutions to Sample Exam 1 Questions

1. A charge of 100 μC 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
- $2.5 \times 10^4$ 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° 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 $Q_1^+$ is at the center of an imaginary spherical Gaussian surface and another point charge $2Q_2^+$ 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 move 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 $-1000$ 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?

- \(-3.5 \times 10^{13} \text{ [m/s}^2]\)
- \(-1.4 \times 10^{14} \text{ [m/s}^2]\)
- \(6.8 \times 10^{12} \text{ [m/s}^2]\)

13. In the figure at left, three point charges are connected by unbreakable strings of length \(d\). What is the equilibrium angle \(2\theta\)?

- \(90^\circ\)
- \(180^\circ\)
- \(135^\circ\)
- \(90^\circ\)

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