*The following are a few practice problems. There is no guarantee the practice problems will match the material on the test.*

**Midterm I Concepts**

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**Coulomb’s Law**

The next two questions pertain to the situation described below.

Three point-charges \(Q_1 = 10\mu C\), \(Q_2 = -20 \mu C\), and \(Q_3 = 10\mu C\) are placed a distance \(L = 1.5\) meter apart on the x-axis at points \((-L,0)\), \((0,0)\), and \((L,0)\) as shown in the figure. A fourth charge \(Q_4 = -20\mu C\) is placed at a position \((0,h)\) where \(h = 2.5\) m.

1) What is the x-component of the force on \(Q_4\) due to the charges \(Q_1\), \(Q_2\), and \(Q_3\)?
2) What is the y-component of the force on \(Q_4\) due to the charges \(Q_1\), \(Q_2\), and \(Q_3\)?

**Flux**

For the next 2 problems, a negative point charge \(-q\) is inside a cylinder of length \(L\) and radius \(R\), closer to one end of the cylinder (side A) than the other (side B).
1) What is the net electric flux integrated over the entire surface of the cylinder?

2) What is the sign of the flux through surface A, the end closest to the charge?

**Electric Fields**

Two point charges $q_1 = 6 \times 10^{-6}$ C and $q_2 = 11 \times 10^{-6}$ C are fixed on the x axis. $q_1$ is located at the origin and $q_2$ is a distance $d = 0.7$ m to the right as shown in the figure.

Plot the representation of the x component of the net electric field $E(x)$ along the x axis due to the two charges? $E(x)$ is defined to be positive when pointing to the right, and negative when pointing to the left.

**Capacitance**

A parallel plate capacitor is constructed from two plates each with area $0.025 \text{ m}^2$, separated by a distance of $0.004$ m. A charge of $Q=+0.38 \mu$C is moved from the bottom plate to the top plate.

1) What is the voltage across the plates, when the space between the plates is empty?

2) A dielectric is now placed between the plates. The bottom half has a dielectric constant $\kappa_1$, and the top half has dielectric constant $\kappa_2$. Let $C_0$ represent the capacitance of the plates before the dielectric is inserted. What is the capacitance of the system with the dielectric completely filling the region between the plates?

**Simple Circuits**
Six capacitors are connected to a battery as shown in the circuit diagram. The battery supplies E = 12 V.
C1 = 10 μF C2 = 15 μF C3 = 50 μF C4 = 9 μF C5 = 20 μF C6 = 35 μF

What is the equivalent capacitance for the combination of the six capacitors?

Kirchoff’s Laws

Find the current in V1 and V2

RC Circuit

Consider the RC Circuit in the figure. A battery with voltage V = 6 Volts is connected to two resistors of resistance \( R_1 = 60 \, \Omega \) and \( R_2 = 30 \, \Omega \), and a capacitor with capacitance \( C = 15 \mu F \).
Assume that the switch has been open for a very long time, so that the initial charge Q on the capacitor is 0.

1) What is the value of the current I immediately after the switch is closed?
2) After the switch was been closed for a long time, what is the charge Q on the capacitor?
3) The energy expended by the battery in charging the capacitor is (greater than, equal to, less than) the final value of the energy stored in the capacitor.
4) After the switch has been closed for a very long time, it is then re-opened. If the value of the charge on the capacitor at the instant the switch is reopened is $Q_0$, what is the charge on the capacitor after a time $t=60\mu s$?

Gauss’s Law

An insulating sphere of radius $R$ carries a charge density per unit volume $\rho$ as shown in the figure.

1) What is the magnitude of the electric field at a distance $r > R$ from the center of the sphere?

2) What is the magnitude of the electric field at a distance $r < R$ from the center of the sphere?

Electric Potential
As seen in figure 1, two charged, infinite plates have charge densities of \( \sigma_1 = 4 \frac{\mu C}{m^2} \) and \( \sigma_2 = 6 \frac{\mu C}{m^2} \) and are placed at \( x=0 \) cm and \( x=20 \) cm respectively.

1) What is the potential difference between point Q, \((q \text{ cm, } 0 \text{ cm})\) and point P, \((p \text{ cm, } 0 \text{ cm})\)? Let \( q=16.7 \) cm and \( p=1 \text{ cm} \).

2) A slab of metal with no net charge (shaded region; left edge at \( x=9 \) cm, right edge at \( x=11 \) cm) is now placed between the two charged, infinite plates. What are the surface charge densities for the left side of the slab (given by \( \sigma_L \)) and the right side of the slab (given by \( \sigma_R \))?

3) With the addition of the metal slab, what is the potential difference between point Q and point P?