Problem 1.

Charges $Q_1 = +11 \mu C$ and $Q_2 = -11 \mu C$ are at distance $R = 1m$ from each other. The mass of charge $Q_1$ is $m = 1kg$.

What is the magnitude and the direction of the force which acts on the charge $Q_1$? 
________ (show direction on the figure)

What is velocity the charge $Q_1$ must have in order to stay in orbit of radius $R$? 
________

How should the velocity be changed in order for the orbit to have radius $4R$? 
________
Problem 2.

Four charges Q1, Q2, Q3, and Q4 are positioned in the corners of a rhombus with sides measures $a=0.5\text{m}$ and angle $\theta=60^\circ$. $Q_1=+2.0\text{mC}$, $Q_4=+2.0\text{mC}$, and $Q_2=+1.0\text{mC}$ is positive.

What is the magnitude and direction of the force with which charge Q1 acts on charge Q2?______ (show direction on the figure)

What is the magnitude and direction of the force with which charge Q4 acts on charge Q2?______ (show direction on the figure)

If Q3 is zero what is the magnitude and direction of the total force which acts on charge Q2?______ (show direction on the figure)

What does Q3 have to be so that the total force on Q2 to be zero?______

What will be the total force acting on Q2 if we double Q3?______
Problem 3.

Three charges $Q_1$, $Q_2$, and $Q_3$ are positioned in the corners of a triangle whose side measures $a=0.5m$ and angle $	heta=60^\circ$. $Q_1=Q_2=+2.0\text{mC}$ and $Q_3=+1.0\text{mC}$.

What is the magnitude and direction of the force with which charge $Q_1$ acts on charge $Q_3$? _______ (show direction on the figure)

What is the magnitude and direction of the force with which charge $Q_2$ acts on charge $Q_3$? _______ (show direction on the figure)

What is the magnitude and direction of the total force which acts on charge $Q_3$? _______ (show direction on the figure)

What would be the magnitude and direction of the total force which acted on charge $Q_3$, if charge $Q_2=-2.0\text{mC}$? _______ (show direction on the figure)
Problem 4.

A solid, conducting sphere of radius \( a = 4.0 \text{cm} \) carries an excess charge of \( Q = +8 \mu \text{C} \). This sphere is located at the center of a hollow, conducting sphere with an inner radius of \( b = 12.0 \text{cm} \) and an outer radius of \( c = 14.0 \text{cm} \) as shown. The hollow sphere carries a total excess charge of \( q = -6 \mu \text{C} \).

What is the magnitude and direction of the electric field at a distance 3.8cm from the center?___________

What is the magnitude and direction of the electric field at a distance 5cm from the center?___________

What is the magnitude and direction of the electric field at a distance 13cm from the center?___________

What is the magnitude and direction of the electric field at a distance 15cm from the center?___________

What is the total charge at the outer surface of the hollow sphere?______
Problem 5.
Four protons are initially at rest in the corners of a square of side $a = 0.8\text{nm}$. All four are released simultaneously.

What is the maximum speed each will ever reach? _____________

When (at what distance) does this speed occur? ________________

What is the maximum acceleration each will achieve? ____________

When (at what distance) does this acceleration occur? ______________
**Problem 6.**

Three charges $Q_1$, $Q_2$, and $Q_3$ are positioned in the corners of a triangle whose side measures $a=0.5\text{m}$ and angle $\theta=60^\circ$. $Q_1=Q_2=+2.0\text{mC}$ and $Q_3=+1.0\text{mC}$. The mass of charge $Q_3$ is $M=10\text{g}$. At initial time the charge $Q_3$ is released.

What is initial acceleration of the charge $Q_3$?_____

What is the velocity of the charge $Q_3$ at infinity?_____

What would the velocity at infinity be if charge $Q_3$ started from midpoint between charges $Q_1$ and $Q_2$?______
Problem 7.
The plates of the parallel-plate capacitor are $d=1\text{mm}$ apart, and each carries a charge of magnitude $Q=8.0\mu\text{C}$. The capacitor is connected to the $V=1000\text{Volts}$ battery

What is the magnitude of the electric field between the plates? 

What is the magnitude of the electric field outside? 

What is the area of each plate? 

What is the capacitance? 

What is the energy stored in the capacitor? 

What will be the charge on the plates if we double the distance between the plates? 

**Problem 8.** (spherical capacitor)

A solid, conducting sphere of radius $a = 3.5\text{ cm}$ is located at the center of a hollow, conducting sphere with an inner radius of $b = 10.0\text{ cm}$ and an outer radius of $c = 12.0\text{ cm}$ as shown. The charge of the solid sphere is $Q = -6 \mu C$. The hollow sphere carries a total excess charge of $q = +6 \mu C$.

What is the potential difference between the solid and the hollow spheres?________

What is the capacitance of this system of conductors?_______

How the capacitance changes if we double the radius $c$?______________
Problem 9.

A parallel plate capacitor with the length of the plates $L=10\text{cm}$ is set up horizontally and has a distance between plates $d=1\text{cm}$ and the potential difference between the plates $V=1000\text{Volts}$. A small object of charge $Q=2\mu\text{C}$ and mass $m=1\text{g}$ enters the capacitor with horizontal velocity $v=20\text{m/s}$. Neglect the gravitational force.

What is the magnitude and the direction of the electric field in between the plates? 

What electrostatic force is acting on the object?

What is the magnitude of the object's velocity when it leaves the capacitor?

What is the direction of the object's velocity when it leaves the capacitor?
Problem 10.

An insulating sphere of radius \( R \) is uniformly charged throughout its volume. The total charge of the sphere is \( Q \). Find the electric field at distance \( r \) from the center of the sphere. (Volume of a sphere of radius \( a \) is \( \frac{4}{3} \pi a^3 \))

If \( r > R \) _________

if \( r < R \) ___________