Name:	ID:
Please answer the following questions. In your answers, please show your work (include the main formulas/principles, calculation steps and brief explanations if necessary).	

1. A metal sphere is insulated electrically and is given a charge. If 24 electrons are added to the sphere in giving a charge, how many Coulombs are added to the sphere? ($e = 1.6 \times 10^{-19}$ C)
(Use: $Q = Ne$).

2.1 Two identical small charged spheres are a certain distance apart, and each initially experiences an electrostatic force of magnitude F due to the other. With time, charge gradually diminishes on both spheres. When each of the spheres has lost half of its initial charge, by what factor the magnitude of the electrostatic force will be reduced?
(Use this formula $F = Kq_1q_2/r^2$ to draw the concept).

2.2 Two unequal point charges q1 and q2 are held in place separated from each other. A point charge Q is placed somewhere between them at a point where it remains stationary when released. From this observation, what can we say about the signs of the charges q1 and q2 (both positive, both negative, or one positive and other negative)?
(Use: draw the concepts from $F = Kq_1q_2/r^2$ for any two charges and $F = ma$).

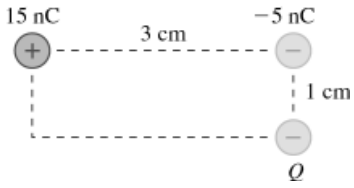
2.3 Is it possible for any object to have a charge of 7.5e?
(Use: the fact that a bigger charge is always an integer multiple of basic unit of charge e).

2.4 Do two protons slightly separated from one another form an electric dipole?
(Use: a dipole is defined to be made up of two opposite but equal charges separated by a small distance).

2.5 Can two neutral objects with no excess charge attract each other electrically?
(Use: the fact that even charge-neutral objects can contain polarized charges in presence of external electric field).

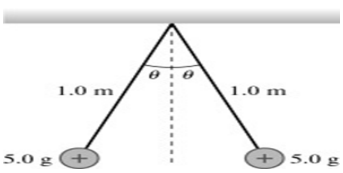
3. The charge in the bottom right corner of the figure is Q =- 10 nC. What is the force on Q?

(Draw the force vectors and calculate the vector sum $\mathbf{F} = \mathbf{F_1} + \mathbf{F_2}$ from the x- and y-components: $F_x = F_{1x} + F_{2x}$, $F_y = F_{1y} + F_{2y}$, $F = \text{sqrt}(F_x^2 + F_y^2)$, $\phi = \tan^{-1}(F_y/F_x)$)



4. The figure shows two 5.0 g spheres suspended from 1.0-m-long threads. The spheres repel each other after being charged to +91 nC. What is this small angle θ?

(Draw the tension T on the string and its x-component and y-component and F vectors, and use $T\cos\theta = mg$, $F = Kq_1q_2/(2r)^2$, $T\sin\theta = F$, $r = 2\sin\theta$ and, for small angle θ in radians, $\sin\theta \approx \theta$ and $\cos\theta \approx 1$).

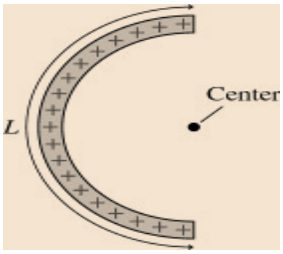


5. What force does a 5.0 N/C electric field exert on a 9.0 C charge? (Use: $\mathbf{F} = q\mathbf{E}$).

6. A spherical object with a 2.0 m radius has a charge spread throughout it with a uniform charge density, ρ. If the electric field strength 4.1 m from the center of the sphere is 2.0 x 1012 N/C, what is the charge density of the sphere? (Use: Q = charge-density and volume, volume of sphere = 4/3 pi*r^3).

7. An object with a 10.0 µC charge is accelerating at 0.0080 m/s^2. If the object has a mass of 5.0 mg, what is the magnitude of the electric field? (Use: F = ma, F = qE).

8. A spherical conductor with radius 4.0 mm carries a charge of 6.0 µC. What is the electrical field strength at 6.0 mm from the center of the conductor? (Use: $F = Kq_1q_2/r^2$)



9. A thin, flexible rod of length *L* = 10 cm carries charge *Q* = 91 nC uniformly along its length. The rod is then bent into a semicircle, as shown in the figure. What is the magnitude of the electric field at the center? (Use: for a small i^{th} segment with length ds on the rod, a charge dq = Q/L*ds = Q/L*R*dθ, $E = \int Kdq/R^2\cos\theta$ since y-component of $\mathbf{E}_i$ sums to be zero, θ = angle variable goes from -pi/2 to +pi/2).

10. Two 4.0 cm × 4.0 cm electrodes spaced 2.0 mm apart form a parallel-plate capacitor. Inside the capacitor the electric field strength is 2.5 × 106 N/C. What is the charge on each electrode? (Use: $E = Q/\in_0 A$).

11. A charge of 1.0 × 10-6 µC is located inside a sphere. What is the flux through the sphere? (Use: Electric flux, $\Phi_e = Q_{in}/\in_0$).

12. A 2.0 cm x 3.0 cm rectangle lies in the xy-plane. What is the magnitude of the electric flux through the rectangle if E = (100i – 200k) N/C? (Here, E is a vector, i and k are unit vectors).

(Use: Here, E is a vector, i and k are unit vectors. Area vector is directed normal to the plane that the surface lies in. A dot product of different unit vectors (e.g i and k) is zero and that of the same unit vectors (e.g. i and i) is 1.).