Midterm 1 Review Questions

1. A negatively charge electroscope has separated leaves.
   a) Suppose you bring a negatively charged rod close to the top of the electroscope, but not touching. How will the leaves respond?
   b) Suppose you bring a positively charged rod close to the top of the electroscope, but not touching. How will the leaves respond?

2. Consider two identical metal spheres. Sphere A has on it 4 units of negative charge while Sphere B has on it 2 units of positive charge. If the two spheres are brought into contact, what will be the final charge state of each of them?

3. A positively charge rod is held near, but not touching, a neutral metal sphere.
   a) Add plusses and minuses to the figure to show the charge distribution on the sphere.
   b) Does the sphere experience a net force? If so, in which direction?

4. For each pair of charges, draw a force vector on each charge to show the electric force acting on that charge. The length of each vector should be proportional to the magnitude of the force.
5. For each group of charges, draw the individual forces acting on the shaded positive charge. Then draw the net force acting on that charge.

6. Consider the figure below.
   a) Draw a + anywhere a proton would experience zero force.
   b) Would an electron at the same location(s) experience a force to the left, right, or zero?

7. At each of the dots in the figure below, draw the electric field vectors from each of the individual point charges. Then draw the resultant field vector. The relative lengths of the vectors should indicate the strength of each electric field.
8. In the figure below, draw a vector representing the electric field at each dot. The length of the vector should indicate the strength of the field.

![Vector depiction](image)

9. The figure below shows some electric field lines. Draw representative field vectors at each of the 3 points. The length of the vector should represent the strength of the field.

![Field lines](image)

10. Draw a vector representing the electric field at the center of each semicircle below.

![Semicircles](image)

11. Rank the following diagrams in order of increasing surface charge density $\eta$.

![Charge densities](image)
12. A conducting sphere of radius \( R \) has charge \( Q \) uniformly distributed over it. What happens to the electric field strength at \( r=2R \) if
   a) the amount of charge is reduced to one half of \( Q \)?

   b) the radius of the sphere is reduced to one half \( R \)?

13. An isolated parallel plate capacitor has charge \( Q \) on one plate and \( -Q \) on the other. The plates have size \( L \times L \) and are a distance \( s \) apart. By what factors do the electric field strength \( E \) and the potential difference \( \Delta V \) between the plates change if
   a) the charge \( Q \) is doubled?

   b) the distance \( s \) between the plates is doubled?

   c) the dimension \( L \) of the plates is doubled?

14. A parallel plate capacitor is connected to a 12-volt battery. By what factors do the electric field strength \( E \) and the charge \( Q \) on the plates change if
   a) the distance \( s \) between the plates is doubled?

   b) the dimension \( L \) of the plates is doubled?

15. Positively and negatively charged objects, with equal masses and equal quantities of charge, enter the capacitor as indicated.
   a) Use solid lines to draw their trajectories on the figure if their initial velocities are fast.
   b) Use dotted lines to draw their trajectories on the figure if their initial velocities are slow.

16. A proton and an electron are released from rest in the center of a capacitor gap.
   a) Compare the forces on the two particles. Are they equal in magnitude, or is one larger? Explain.

   b) Compare the accelerations of the two particles. Are they equal in magnitude, or is one larger? Explain.
17. Does a charged particle always move in the direction of the electric field? If so, explain why. If not, give a counterexample.

18. If a positively charged particle is released from rest in the region of an electric field, it will follow a single field line until that line comes to an end. Explain your choice.
   a) TRUE
   b) FALSE

19. All wires in this figure are made of the same material and have the same diameter. Rank the 4 currents in order, from largest to smallest.

20. A light bulb is connected to a battery with 1-mm diameter wires. The bulb is glowing.
   a) Draw arrows at points 1, 2, and 3 to show the direction of the electric field at those points (the points are inside the wire).
   b) Rank in order from largest to smallest the field strengths at the 3 points. Explain.

21. Wires 1 and 2 are made from the same metal. Wire 1 has twice the diameter and half the electric field of wire 2. What is the ratio of currents in the two wires?

22. Metal 1 and metal 2 are each formed into 1-mm diameter wires. The electric field needed to cause a 1 A current in the wire of metal 1 is larger than the electric field needed to cause a 1 A current in the wire of metal 2. Which metal has the larger conductivity?
23. A wire consists of two segments of different diameters but made from the same metal. The current in segment 1 is $I_1$.
   
a) Compare the values of the currents in the two segments. Is $I_2$ greater than, less than, or equal to $I_1$? Explain.

b) Compare the values of the current densities $J_1$ and $J_2$.

c) Compare the strengths of the electric fields $E_1$ and $E_2$ in the two segments.

d) Compare the values of the electron drift speeds $v_{d1}$ and $v_{d2}$.

24. A wire consists of two equal-diameter segments. Their conductivities differ, with $\sigma_2 > \sigma_1$. The current in segment 1 is $I_1$.
   
a) Compare the values of the currents in the two segments. Is $I_2$ greater than, less than, or equal to $I_1$? Explain.

b) Compare the values of the current densities $J_1$ and $J_2$.

c) Compare the strengths of the electric fields $E_1$ and $E_2$ in the two segments.

d) Compare the values of the electron drift speeds $v_{d1}$ and $v_{d2}$. 