Physics 122 Practice Midterm Exam 
Winter 2004 
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g = 9.8 m/s^2  
G = 6.7 x 10^{-11} Nm^2/kg^2 
k = 1/4\pi\varepsilon_0 = 9.0 x 10^9 Nm^2/C^2 
\varepsilon_0 = 8.85 x 10^{-12} C^2/Nm^2 
e = 1.6 x 10^{-19} C  
electron charge = -e  
proton charge = +e 
electron mass = 9.1 x 10^{-31} kg  
proton mass = 1.67 x 10^{-27} kg
A particle of mass, \( m_1 = 2.0 \text{ kg} \) with a charge, \( q_1 = -3.1 \times 10^{-10} \text{ C} \) is separated by 0.50 m from another particle of mass, \( m_2 = 2.3 \text{ kg} \), and a charge, \( q_2 = -2.1 \times 10^{-11} \text{ C} \).

1. Is the force between them attractive or repulsive?

2. What is the magnitude of the electric force between them?

3. What is the resulting acceleration of the mass, \( m_1 = 2.0 \text{ kg} \)?
Four charged particles are positioned at the corners of a square such that each charge is 2.0 m from the center, as shown above.

4. What is the direction of the electric field vector in the middle of the square? (choose one of the following:)
   +x
   -x
   +y
   -y

5. What is the magnitude of the electric field in the center of the square?

6. What is the electric potential at the center of the square due to the four charges?
A single infinite sheet with a uniform charge distribution produces a uniform electric field with a magnitude of 2000 N/C and directed vertically downward as shown.

7. What is the magnitude and the direction of the force that the electric field exerts on a test charge, $q_o = -1.0 \, \mu C$?

8. What is the surface charge density, $\sigma$, of the charge distribution on the sheet? (Be sure to include the sign).
A charge $q$ is distributed uniformly over the surface of a spherical shell. The resulting electric field points in toward the center of the sphere, and has a magnitude of 4.5 N/C at a distance of 2.0 m from the center of the sphere as shown.

9. What is the sign of the charge, $q$?

10. What is the magnitude of the charge, $q$?
An electron moving in an electric field undergoes a change in electrical potential energy of $\Delta U = -4.0 \times 10^{-18}$ Joules.

11. What is the change in the electrical potential, $\Delta V$, of the electron?

12. If the electron starts from rest, and experiences no other forces, how fast is it going after it undergoes the change in potential, $\Delta U$?
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Physics 122 Practice Midterm Exam Winter 2003 Solutions:

1. Repulsive

2. \( F = k|q_1||q_2|/r^2 = (9 \times 10^9)(3.1 \times 10^{-10})(2.1 \times 10^{-11})/(0.5)^2 = 2.34 \times 10^{-10} \) N

3. \( a = F/m = 2.34 \times 10^{-10} \text{ N/kg} = 1.17 \times 10^{-10} \text{ m/s}^2 \)

4. -x by symmetry

5. The fields from the two charges on top and bottom cancel leaving only the fields from the charges on the left and right which have the same magnitude and direction.
   So: \( E = 2kQ/r^2 = 2(9 \times 10^9)(2 \times 10^{-9})/2^2 = 9 \text{ N/C} \)

6. \( V = k(Q_1+Q_2+Q_3+Q_4)/r = (9 \times 10^9)(4 \times 10^{-9})/2 = 18 \text{ V} \)

7. \( F = |q_o|E = (10^{-6})(2000) = 2 \text{ mN} \), The direction of the force on a negative charge is opposite to the electric field so the direction is up.

8. \( E = |\sigma|/2\varepsilon_0 \), so \( |\sigma| = 2\varepsilon_0 E = 2(8.85 \times 10^{-12})(2000) = 35.4 \text{ nC/m}^2 \). Since the electric field points toward negative charge, the surface charge density must be negative. So \( \sigma = -34.4 \text{ nC/m}^2 \)

9. Electric fields point toward negative charges so the charge is negative.

10. \( E = k|q|/r^2 \) so \( |q| = r^2E/k = 2^2(4.5)/(9 \times 10^9) = 2 \text{nC} \)

11. \( \Delta V = \Delta U/q_o = -4.0 \times 10^{-18}/(-1.6 \times 10^{-19}) = 25 \text{ V} \)

12. \( (1/2)mv^2 = -\Delta U \) so \( v = (-2\Delta U/m)^{1/2} = (-2(-4.0 \times 10^{-18})/9.1 \times 10^{-31})^{1/2} = 2.97 \times 10^6 \text{ m/s} \)