Physics 202 Midterm Exam 1  
September 27th, 2010

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Section:  .........................

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Instructions:
1. Don’t forget to write down your name, student ID#, and section number. You need do this on (this page of) your test book and on your Scantron sheet as well.

2. Answer all multiple choice questions in this test book by indicating the best answer among choices. You must do this both on your test book and on your Scantron sheet. Follow instructions on the Scantron sheet on how to mark valid answers.

3. When you finish, you need to turn in both this test book and the Scantron sheet.

4: Use the blank side of question pages as additional draft spaces. An extra blank sheet is provided at the end of the test book.

5: Only one answer is allowed per problem/question. All problems have equal weight.

Constants:  \( k_e = 9 \times 10^9 \text{ Nm}^2/\text{C}^2 = 1/(4\pi\varepsilon_0) \),  \( \varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{Nm}^2) \)

Please be very careful with the first question even though the answer will not count towards your grade:

1. ENTER THE ID CODE ABOVE IN THE UPPER RIGHT CORNER
   A. ID Code A
   B. ID Code B
   C. ID Code C
   D. ID Code D
   E. ID Code E
2. Two charged particles, \( Q_1 \) and \( Q_2 \), are a distance \( r \) apart with \( Q_2 = 5Q_1 \). Compare the forces they exert on one another when \( F_{21} \) is the force \( Q_2 \) exerts on \( Q_1 \) and \( F_{12} \) is the force \( Q_1 \) exerts on \( Q_2 \).

A. \( 5F_{21} = -F_{12} \)
B. \( F_{21} = -5F_{12} \)
C. \( F_{21} = 5F_{12} \)
D. \( F_{21} = -F_{12} \)

Per Newton’s 3rd Law.
(Coulomb’s Law also reflects this)

3. A point charge \( Q \) is placed on the \( x \) axis at the origin. An identical point charge is placed on the \( x \) axis at \( x = -1.0 \) m and another at \( x = +1.0 \) m. If \( Q = 40 \) \( \mu \)C, what is the magnitude of the electrostatic force on the charge at \( x = +1.0 \) m?

A. 29N  
B. 18N  
C. 11N  
D. 7.0N

\[
F_1 = k \frac{Q^2}{1^2} \text{ to the right} \\
F_2 = k \frac{Q^2}{2^2} \text{ to the right} \\
F = F_1 + F_2 = k \frac{Q^2}{1+1/4} = 18N
\]

4. A cube of 1.0 m in side length has a charge of 40\( \mu \)C at its center. What is the total electric flux through its six faces?

A. \( 3.2 \times 10^6 \) Nm\(^2\)/C  
B. \( 4.5 \times 10^6 \) Nm\(^2\)/C  
C. \( 7.0 \times 10^6 \) Nm\(^2\)/C  
D. \( 9.8 \times 10^6 \) Nm\(^2\)/C

Per Gauss’s Law
\[
\Phi_E = \frac{q_{in}}{\epsilon_0} = 4.5 \times 10^6 \text{ Nm}^2/\text{C}
\]

5. If the above point charge of \( Q = 40 \) \( \mu \)C is now moved to a new position which is 0.4m from the center of the same cube, what is the total electric flux through faces of the cube?

A. same as before  
B. twice as much  
C. half as much  
D. can not determine as the question does not specify in which direction the charge is moving away from the center.

Electric flux is independent of position of charges inside Gaussian surface.
6. A point charge of $Q = 50 \mu C$ is moving in a region where electrostatic force is the only force on it. As the point charge moves 25 cm from point A to point B, it’s kinetic energy increases by 1.5 mJ. What is the potential difference between point A and B, $V_B - V_A$?

A. 300 V  
B. -300 V  
C. 30 V  
D. can not determine as the electric field strength is not given.

\[
\Delta KE = -(U_f - U_i) = -(U_B - U_A) = -Q(V_B - V_A) \Rightarrow V_B - V_A = -\Delta KE/Q = -30V
\]

7. Four identical point charge of $Q = 6 \times 10^{-9} C$ is placed at the corners of a rectangle which measures 6.0m x 8.0m. Taking infinity as $V=0$, what is the electric potential at the center of the rectangle?

A. 25V  
B. 38V  
C. 43V  
D. 57V

The distance between center and corner $r = \sqrt{4^2 + 3^2} = 5$ 
$V = 4k_\varepsilon Q/r = 43.2V$

8. A large, flat, horizontal sheet of charge has a charge per unit area of $7.10 \mu C/m^2$. Find the electric field just above the middle of the sheet.

A. 401 kN/C upward  
B. 542 kN/C downward  
C. 283 kN/C upward  
D. 283 kN/C downward

\[E = \sigma/(2\varepsilon_0) = 401 \text{ kN/C}\]  
(If you forgot the formula, you can use Gauss’s Law to derive it).  
This was in you HW 1, by the way.

9. At a certain distance of a point charge, the magnitude of the electric field is 514 V/m and the electric potential is -2.80 kV (taking infinity be at zero potential). What is that distance?

A. 2.8 m  
B. 5.4 m  
C. 7.2 m  
D. 9.7 m

For point charge 
$E = k_\varepsilon Q/r^2$  
$V = k_\varepsilon Q/r$  
$r = V/E = 5.44m$  
(This was in your HW2)
10. In figure above, the surface charge at point A, which is on the surface of the conductor at +10 V, is
A. positive  
B. negative  
C. zero  
D. can not be determined

Field lines always point towards lower potential. In this setting they point towards Point A. And field lines point towards negative charge…

11. In the figure above, the potential at point B, which is inside an empty cavity inside the conductor +10V, is
A. higher than 10V  
B. exactly 10V  
C. lower than 10V but higher than 9V  
D. lower than 9V

Electrostatic field is always zero inside empty cavity in a conductor. So the potential anywhere inside such cavity shall be the same as that of the conductor.

12. In the figure above, a test charge q of charge 1.0\mu C is placed at point C, the magnitude of the electric force on q is
A. +1.0\mu N  
B. - 1.0\mu N  
C. zero  
D. can not be determined

Without distance information, Electric field strength can not be determined by potential alone.

13. In the above figure, a test charge q of charge 1.0\mu C is moved from point A to point C, what is the work done to q by the electric field in the process?
A. 2.0 \mu J  
B. - 2.0 \mu J  
C. zero  
D. none of above or can not be determined

\[ W_{\text{electric field}} = -(U_f - U_i) = -q(V_f - V_i) = -2\mu J \]
Review Phy201 if in question of the – sign.
14. As shown in figure above, a conducting spherical shell, of inner radius R and outer radius 2R, carries a total charge +2Q (Q>0). A point charge +Q is placed at the center of the shell. Concentric to the conducting shell is an insulating spherical shell of radius 3R with negligible thickness. A charge of +2Q is uniformly distributed on this insulating shell. What is the magnitude of electric force on the charge at the center?

A. \( \frac{kQ^2}{R^2} + \frac{kQ^2}{(3R)^2} \)
B. \( \frac{kQ^2}{(1.5R)^2} + \frac{kQ^2}{(3R)^2} \)
C. \( \frac{kQ^2}{(2R)^2} + \frac{kQ^2}{(3R)^2} \)
D. zero

15. In the same setting as above, what is the total charge on the outer surface of the conducting shell?

A. zero
B. Q
C. 2Q
D. 3Q

16. Still in the same setting, what is the magnitude of electric field at \( r=0.5R \).

A. \( \frac{kQ}{(0.5R)^2} \)
B. \( \frac{kQ}{(0.5R)^2} \)
C. \( \frac{kQ}{(0.5R)^2} \)
D. zero

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**The figure below applies to the next three questions.**

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**Apply Gauss’s Law, one can get \( E=\frac{kQ}{r^2} \) for \( r \) between 0 to R.**
17. A circular ring of radius $R$ has a charge $2Q$ uniformly distributed along it. A test charge $+Q$ is placed at the center of the ring. What is the magnitude of the force on the test charge?

A. $2k_eQ^2/R^2$
B. zero
C. $-2k_eQ^2/R^2$
D. none of above or can not be determined

18. A circular ring of radius $R$ has a charge $2Q$ uniformly distributed along it. What is the energy required to move a test charge of $+Q$ from infinity to the center of the ring?

A. $2k_eQ^2/R$
B. $-2k_eQ^2/R$
C. zero
D. none of the above or can not be determined

19. The electric potential distribution of an electric field is described by expression $V=2y^2+5xy-7xyz$. What is the magnitude of the force on a test charge of $1.0 \mu C$ at location $(x,y,z) = (1.0, 1.0,1.0)$? (SI units implied).

A. $7.5 \mu N$
B. $14.0 \mu N$
C. $11.9 \mu N$
D. $17.6 \mu N$

20. The electric potential distribution of an electric field is described by expression $V=2y^2+5xy-7xyz$. A test charge of $1.0 \mu C$ is moved from $(x,y,z) = (1.0, 1.0,1.0)$ to $(1.0,2.0,1.0)$. What is the total work done by the field to the test charge in the whole process? (SI units implied).

A. $4.0 \mu J$
B. $-4.0 \mu J$
C. $7.5 \mu J$
D. $-7.5 \mu J$

21. The electric potential distribution of an electric field is described by expression $V=2y^2+5xy-7xyz$. A test charge of $1.0 \mu C$ is moved from $(x,y,z) = (1.0, 1.0,1.0)$ to $(1.0,2.0,1.0)$, then to $(1.0,2.0,3.0)$, and then to $(2.0, 2.0,3.0)$ and finally to $(2.0,1.0,2.0)$. What is the total work done by the field to the test charge in the whole process? (SI units implied).

A. $-10 \mu J$
B. $13 \mu J$
C. $16 \mu J$
D. $23 \mu J$

note the path independent feature. No need to spend time on intermediate stops.