Physics 202 Midterm Exam 1
Oct 2\textsuperscript{nd}, 2012

Name: ............Yibin Pan.......................... Student ID: ......................
Section: ..........................

TA (please circle):

James Buchanan  Diptaranjan Das  Ross Devol  Yutao Gong
Minho Kwon  Greg Lau  Andrew Loveridge
Tao Peng  Ben Stefanek  Gandhari Wattal

Instructions:

1. Don’t forget to write down your name, student ID#, and section number. You need to 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. You can also use empty space at the end of the test book.

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

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

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 oppositely charged particles, \( Q_1 \) and \( Q_2 \), are at a distance from each other. The magnitude of \( Q_2 \) is 3 times that of \( Q_1 \). Which of the followings is true?
   A. The magnitude of the electric force on \( q_1 \) is 3 times that on \( q_2 \).
   B. The magnitude of the electric force on \( q_1 \) is 1/3 of that on \( q_2 \).
   C. The magnitude of the electric force on \( q_1 \) is 9 times that on \( q_2 \).
   D. The magnitude of the electric force on \( q_1 \) is 1/9 of that on \( q_2 \).
   E. None of above \(|F_{12}| = |F_{21}| \), per Coulomb’s Law or Newton’s 3rd Law

3. Three point charges lie along a straight line as shown in the figure below, where \( q_1 = 5.82 \) \( \mu \)C, \( q_2 = 1.61 \) \( \mu \)C, and \( q_3 = -2.18 \) \( \mu \)C. The separation distances are \( d_1 = 3.00 \) cm and \( d_2 = 2.00 \) cm. What is the magnitude of net electric force on \( q_1 \)?

   \[ F_{31} = k_e \frac{q_3 q_1}{r_{13}^2} = 45.6 \text{N to right} \]
   \[ F_{21} = k_e \frac{q_2 q_1}{r_{12}^2} = 93.7 \text{N to left} \]
   \[ F_1 = 93.7 - 45.6 = 48 \text{N to the left.} \]
   Note: This was in your HW1

   A. 18.0N
   B. 28.0N
   C. 48.0N
   D. 56.0N
   E. None of above is within 0.5N from the correct answer.

4. A negative point charge \( Q = -q \) is put at the center of a spherical conductor shell of inner radius \( R \) and outer radius \( 2R \). It is known that the total charge on the conducting shell is \( +5q \). What is the charge on the outer surface of the shell?

   \[ Q_{\text{inner surface}} = +q \]
   \[ Q_{\text{outer surface}} = +5q - (+q) = +4q \]

   Note: This was shown as one of the lecture examples
5. The figure below shows the electric field lines for two charged particles separated by a small distance. What are the possible charges for \( q_1 \) and \( q_2 \)?

![Diagram of electric field lines showing two particles](image)

**Counting field lines**

\[ \frac{|q_1|}{q_2} = 0.333 \]

**Direction** \( q_1 < 0, \) and \( q_2 > 0 \)

Note: This was in HW1 also

A. \( q_1 = 0.6 \text{ mC} \) and \( q_2 = -0.2 \text{ mC} \)
B. \( q_1 = 2 \text{ mC} \) and \( q_2 = -25 \text{ mC} \)
C. \( q_1 = 0.3 \text{ mC} \) and \( q_2 = -0.9 \text{ mC} \)
D. \( q_1 = -0.4 \text{ mC} \) and \( q_2 = 1.2 \text{ mC} \)
E. None of above is possible

6. A thin spherical shell of radius \( r=0.5 \text{ m} \) is concentric with a cube of side length \( L=2.0 \text{ m} \). It is known that the total charge on the sphere shell is \( 1.0 \mu \text{C} \) and there is no other charge elsewhere. What is the total electric flux through the surface (i.e. 6 faces) of the cube?

A. 0
B. \( 1.1 \times 10^5 \text{ Nm}^2/\text{C} = \frac{Q}{\varepsilon_0} \)
C. 6547.0 Nm²/C
D. Can’t be determined, as the question does not specify whether the charge is uniformly distributed on the shell.
E. none of above

7. If the radius of the shell in previous problem is 2.0 m instead (i.e. the shell enclose the cube entirely), what is the total electric flux through the surface of the same cube?

A. 0 \( \text{(no charge inside the cube)} \)
B. \( 1.1 \times 10^5 \text{ Nm}^2/\text{C} \)
C. 6547.0 Nm²/C
D. Can’t be determined, as the question does not specify whether the charge is uniformly distributed on the shell.
E. none of above
8. A uniform electric field of magnitude 315 V/m is directed in the negative y direction as shown in the figure below. The coordinates of point A are \((x,y)=(-0.400, -0.850)\) m, and those of point B are \((0.850, 0.350)\) m. What is the electric potential difference \(V_B - V_A\) ?

\[ V_B - V_A = -E(y_A - y_B) = 378 \text{ V} \]

Note: This was in HW3

A. 436 V
B. -436 V
C. -378 V
D. 378 V
E. None of above.

9. A circular ring of radius \(R=2.0\) m has a charge \(Q=2.0\mu\text{C}\) uniformly distributed along it. A test charge \(q=1.0\mu\text{C}\) is being moved from infinity to the center of the ring. During the process, what is the work done by the electric field to the test charge?

\[ -9 \text{ mJ} = -\Delta U = -q\Delta V = -q \frac{k_e Q}{R} \]

Note: similar example was in lecture 8.

A. 0
B. 9 mJ
C. -9 mJ
D. 4.5 mJ
E. None of above

10. In the above setting, once this test charge of \(q=1.0\mu\text{C}\) is placed at the center of the ring, what is the magnitude of the electric force on it?

A. 0 per symmetry
B. 4.5 mN
C. 9.0 mN
D. 18 mN
E. None of above is within 1mN of the correct answer.
11. As shown, three concentric thin spherical shell have radius 1.0m, 2.0m, and 4.0m. Also, charges of 1.0C, -1.0C, and -2.0C are uniformly distributed, respectively, on each shell (from inner to outer ones).

What is the electric field at r=5.0m (measured from the center)?

A. 0.
B. $7.2 \times 10^8$ N/C, pointing towards the center (see above yellow box)
C. $14.4 \times 10^8$ N/C, pointing radially away from the center
D. $14.4 \times 10^8$ N/C, pointing towards the center
E. The above answers are either wrong in direction or off from true magnitude by more than 10%.

12. In the above setting, what is the electric field at r=3.5 m (from the center)?

A. 0. (again see above yellow box)
B. $7.2 \times 10^8$ N/C, pointing towards the center
C. $3.6 \times 10^8$ N/C, pointing radially away from the center
D. $14.4 \times 10^8$ N/C, pointing towards the center
E. The above answers are either wrong in direction or off from true magnitude by more than 10%.

13. Still in the above setting, what is the electric potential at r=3.5 m from the center?

(assuming V=0 at infinity)

A. 0.
B. $4.5 \times 10^9$ V
C. $-4.5 \times 10^9$ V
D. $-5.1 \times 10^9$ V
E. The above answers are either wrong in the sign or off from true value by more than 5%.
14. The figure above shows several equipotential lines each labeled by its potential in volts.
   Compare the magnitude of the field bigger at A or at B:
   A. $E_A > E_B$  \[\text{Use } E=\frac{\Delta V}{\text{distance}}\]
   B. $E_A = E_B$
   C. $E_A < E_B$

15. In the figure above, a test charge $q$ of 1.0$\mu$C is placed at point A. Which statement is true about the force on $q$? (ignore the effect of the test charge on the field).
   A. The force is upwards but its magnitude can not be determined. \[E \text{ to lower } V\]
   B. The force is downwards but its magnitude can not be determined.
   C. The force is 4$\mu$N upwards
   D. The force is 4$\mu$N downwards
   E. The force is upwards, its magnitude can be determined but the value in answer C or D above is not correct.

16. Still in the above setting, a test charge $q$ of charge -1.0$\mu$C is moved from point C to point B. Ignoring the effect of the test charge $q$ on the field, what is the work done to $q$ by the electric field in the process?
   A. 4.0 $\mu$J \[W=-\Delta U = -q\Delta V = - (1.0)(-1.0) = 4.0 \mu J\]
   B. - 4.0 $\mu$J
   C. - 3.0 $\mu$J
   D. + 3.0 $\mu$J
   E. none of above or con not be determined.
17. Three capacitors, $C_1=3.0\,\mu F$, $C_2=2.0\,\mu F$ and $C_3=10.0\,\mu F$ are connected to a battery with $\Delta V=20V$ as shown in fig A:

![Capacitor Diagram](image)

The combined capacitance of the capacitors in fig A is:

A. $15.0\,\mu F$
B. $6.2\,\mu F$
C. $3.3\,\mu F\quad C_{12}=C_1+C_2, \frac{1}{C_{123}}=\frac{1}{C_{12}}+\frac{1}{C_3}$
D. $5.0\,\mu F$
E. none of above is within $0.2\,\mu F$ from the correct answer.

18. In above setting (fig A), what is the charge on $C_3$?

A. $67\,\mu C\quad Q_3=Q=C_{123}\Delta V$
B. $124\,\mu C$
C. $300\,\mu C$
D. $100\,\mu C$
E. none of above is within $1\,\mu C$ from the correct answer.

19. Still in the above Fig A setting, what is the total energy stored in the three capacitors?

A. $1000\,\mu J$
B. $667\,\mu J\quad U=\frac{1}{2} C_{123}\Delta V^2$
C. $1450\,\mu J$
D. $496\,\mu J$
E. none of above is within $10\,\mu J$ from the correct answer.
20. Yet still in the above Fig A setting, what is the ratio of the energy stored in $C_1$ and $C_2$ to that in $C_3$? (ie. $(U_1+U_2):U_3$)

A. 1:2
B. 2:1 take $U=\frac{1}{2} Q^2/C$, $Q_{12}=Q_1+Q_2=Q=Q_3$ then $(U_{12}=U_1+U_2):U_3=C_3:C_{12}$
C. 1:1
D. 4:1
E. None of above

21. Now, some dielectric material is filled in between plates of capacitor $C_3$, as shown in fig B, while the battery is still connected. Which of the following statements is true? Compared to the setting in fig A, after insertion of the dielectrics,

A. the charge on $C_1$ and $C_2$ remain the same but the charge on $C_3$ increases.
B. the charge on $C_1$ and $C_2$ remain the same but the charge on $C_3$ decreases.
C. the charge on $C_1$ and $C_2$ both increase.

$\kappa>1 \Rightarrow C_3 \uparrow \Rightarrow C_{123} \uparrow \Rightarrow Q=Q_{12}=Q_3 \uparrow \Rightarrow \Delta V_{12}=\Delta V_1=\Delta V_2=Q_{12}/C_{12} \uparrow \Rightarrow Q_1,Q_2 \uparrow$
D. the charge on $C_1$ and $C_2$ both decrease.
E. None of above