Physics 202 Midterm Exam 1
Oct 5, 2011

Name: _______________________________    Student ID: ____________

Section: _______________________________

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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, where you should fill in your student ID number under Identification number and your three digit section number starting with 3 under special codes).

2. Answer all multiple 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: Permittivity of free space (epsilon_0) = 8.85x10^-12 C^2/Nm^2,

k_e = 8.99 x 10^9 Nm^2/C^2,
g=9.81m/s^2
1. Which of the following statements about conductors and insulators is NOT correct?
   A) Charges can move freely in conductors.
   B) Charges can move freely in insulators.
   C) In conductors, one or more of the outer electrons from an atom is no longer bounded to the atom.
   D) In insulators, all the electrons from an atom are bounded to the atom.
   E) Charges in both conductors and insulators can become polarized, i.e., one end has charges of one sign and the other end has charges of opposite sign.

2. Two small spheres, each with mass $m = 5.0 \text{ g}$ and charge $q$, are suspended from a point by threads of length $L = 0.30 \text{ m}$. What is the charge on each sphere if the threads make an angle $\theta = 20.0^\circ$ with the vertical?

![Diagram of two small spheres suspended by threads making an angle $\theta$ with the vertical.]

A) $7.9 \times 10^{-7} \text{ C}$
B) $2.9 \times 10^{-7} \text{ C}$
C) $7.5 \times 10^{-2} \text{ C}$
D) $6.3 \times 10^{-13} \text{ C}$
E) $1.8 \times 10^{-7} \text{ C}$
3. Three charges, each of \( Q = 3.2 \times 10^{-19} \text{ C} \), are arranged at three of the corners of a 20.0 nm square as shown. The magnitude of the electric field at D, the fourth corner of the square, is approximately

\[
|E| \approx 1.4 \times 10^7 \text{ N/C}
\]

A) \( 1.4 \times 10^7 \text{ N/C} \)
B) \( 1.0 \times 10^{11} \text{ N/C} \)
C) \( 3.6 \times 10^{10} \text{ N/C} \)
D) 30 N/C
E) \( 1.8 \times 10^7 \text{ N/C} \)

4. The point P is on the axis of a ring of charge, and all vectors shown lie in the \( yz \) plane. The negatively charged ring lies in the \( xz \) plane. The vector that correctly represents the direction of the electric field at this point is

\[
\vec{E}_\text{correct} = \vec{3}
\]

A) \( \vec{1} \)
B) \( \vec{2} \)
C) \( \vec{3} \)
D) \( \vec{4} \)
E) \( \vec{5} \)
5. In the diagram, $Q_1 = 9.0 \, \mu C$ and $Q_2 = -9.0 \, \mu C$. If $Q_2$ has a mass of 3.0 g, a uniform electric field of 1.8 kN/C imposed in the positive $y$ direction would give this particle an acceleration in the $y$ direction of magnitude approximately

\[ 1.8 \, \text{kN/C} 	imes 3.0 \, \text{g} = 5.4 \, \text{m/s}^2 \]

A) zero
B) 5.4 m/s$^2$
C) 6.8 cm/s$^2$
D) 4.5 m/s$^2$
E) 7.5 cm/s$^2$

6. A uniform circular ring has charge $Q$ and radius $r$. The magnitude of the electric field at a distance of $r$ along the axis of the ring is $E_0$. If the radius were to double, then calculate the new electric field at a distance of $r$ along the axis of the ring in terms of $E_0$.

A) 0.40 $E_0$
B) 0.25 $E_0$
C) 0.50 $E_0$
D) 0.20 $E_0$
E) 0.089 $E_0$

7. Consider a uniform electric field $\vec{E} = (5.0 \, \text{kN/C}) \hat{i}$. What is the flux of this field through a square of side 20.0 cm if the normal to its plane makes a 45° angle with the $x$ axis?

A) 71 N $\cdot$ m$^2$/C
B) 0.14 kN $\cdot$ m$^2$/C
C) 0.28 kN $\cdot$ m$^2$/C
D) 0.35 kN $\cdot$ m$^2$/C
E) 0.19 kN $\cdot$ m$^2$/C
8. The electric field for an infinite plane of charge is discontinuous by the amount _____ at a point where there is a surface charge density $\sigma$.
   A) $\varepsilon_0/\sigma$
   B) $\sigma/\varepsilon_0$
   C) $\varepsilon_0/\sigma^2$
   D) $\varepsilon_0^2/\sigma^2$
   E) $\sigma^2/\varepsilon_0$

9. A non-conducting pipe has a uniform charge density of 50.0 C/m$^3$. The inner radius of the pipe is 25 cm, while the outer radius is 35 cm. Calculate the magnitude of the electric field at $r = 40.0$ cm.
   A) $6.8 \times 10^{11}$ N/C
   B) $8.5 \times 10^{11}$ N/C
   C) $4.2 \times 10^{11}$ N/C
   D) $1.3 \times 10^{11}$ N/C
   E) $8.7 \times 10^{10}$ N/C

10. A large, flat conducting plate has a surface charge density $\sigma = 8.0 \times 10^{-9}$ C/m$^2$ on one of its surfaces. What is the magnitude of the electric field 10.0 µm from this plate?
    A) 72 N/C
    B) 0.23 kN/C
    C) 0.90 kN/C
    D) 90 MN/C
    E) 9.0 $\times 10^{12}$ N/C

11. The electric field in a region is given by $\vec{E} = 2x^2 \hat{i} + 3y \hat{j}$ where the units are in V/m. What is the potential from the origin to $(x, y) = (2, 0)$ m?
    A) 8 V
    B) $-8$ V
    C) $-16/3$ V
    D) $-24/3$ V
    E) 11 V
12. Charges +Q and –Q are arranged at the corners of a square as shown. When the electric field \( \vec{E} \) and the electric potential \( V \) (with the convention that \( V = 0 \) at spatial infinity) are determined at P, the center of the square, we find that

A) \( E \neq 0 \) and \( V > 0 \)
B) \( E = 0 \) and \( V = 0 \)
C) \( E = 0 \) and \( V > 0 \)
D) \( E \neq 0 \) and \( V < 0 \)
E) None of these is correct.

13. The electric potential in a region of space is given by

\[ V(x, y, z) = (10 \text{ V/m}) x + (20 \text{ V/m}) y + (30 \text{ V/m}) z \]

The x-component of the electric field in this region is

A) \( (10 \text{ V/m}) \hat{i} \)
B) \( -(10 \text{ V/m}) \hat{i} \)
C) \( (20 \text{ V/m}) \hat{j} \)
D) \( -(20 \text{ V/m}) \hat{j} \)
E) \( -(30 \text{ V/m}) \hat{k} \)

14. A charge of 100 nC resides on the surface of a spherical shell of radius 20 cm. The electric potential at a distance of 15 cm from the center of the spherical shell is

A) 20 V
B) 200 V
C) 2000 V
D) 20,000 V
E) None of these is correct.
15. Calculate the work done to bring a charge, \( Q = 1 \text{ mC} \), from infinity and place it at a distance \( R = 10 \text{ cm} \) along the axis of a thin uniformly charged ring with linear charge density \( \lambda = 10 \text{ \( \mu \)C/m} \) and radius \( R \).

A) 600 J  
B) 300 J  
C) 100 J  
D) 400 J  
E) zero

16. If the area of the plates of a parallel plate capacitor is halved and the separation between the plates tripled, then by what factor does the capacitance change?

A) 6  
B) 2/3  
C) 1/6  
D) 3/2  
E) 1/2

17. If the potential difference of a capacitor is reduced by one-half, the energy stored in that capacitor is

A) reduced to one-half.  
B) reduced to one-quarter.  
C) increased by a factor of 2.  
D) increased by a factor of 4.  
E) not changed.
18. A cardiac defibrillator can be used to help an erratic heartbeat in a regular fashion. A defibrillator contains a capacitor charged to a voltage of 6.00 kV with an energy storage of 200.0 J. Calculate the capacitance of the capacitor.

A) $6.67 \times 10^{-2}$ F  
B) $1.11 \times 10^{-5}$ F  
C) $5.56 \times 10^{-6}$ F  
D) $2.22 \times 10^{-5}$ F  
E) 13.3 F

Use the following to answer question 19.

![Diagram of three capacitors connected in series]

19. You connect three capacitors as shown in the diagram below. The effective capacitance of this combination when $C_1 = 5.0 \mu F$, $C_2 = 4.0 \mu F$, and $C_3 = 3.0 \mu F$ is approximately

A) $0.44 \mu F$  
B) $2.3 \mu F$  
C) $3.5 \mu F$  
D) $5.2 \mu F$  
E) $12 \mu F$

20. Two identical capacitors $A$ and $B$ are connected across a battery, as shown. If mica ($\kappa = 5.4$) is inserted in $B$,

![Diagram of capacitors with mica inserted]

A) both capacitors will retain the same charge.  
B) $B$ will have the larger charge.  
C) $A$ will have the larger charge.  
D) the potential difference across $B$ will increase.  
E) the potential difference across $A$ will increase.
Answer Key - Midterm1

1. B
2. B
3. A
4. A
5. B
6. B
7. B
8. B
9. C
10. C
11. C
12. B
13. B
14. E
15. D
16. C
17. B
18. B
19. B
20. B