Be sure to fill in your **student number and FORM letter (A, B, C)** on your answer sheet. If you forget to include this information, your Exam will not be counted towards your grade.

Each question may have one answer which is more correct than the others. Be sure to read all five answers so than you will not miss the best one. The last page has a list of equations you may find useful and may be detached for use during the exam.

1. Extra Credit: What is your form code?
   
   (a) A  
   (b) B  
   (c) C  
   (d) I don't want any extra credit.  
   (e) $\sqrt{2}$
2. The diagram shows two pairs of heavily charged plastic cubes. Cubes 1 and 2 attract each other and so do cubes 1 and 3.

Which of the following illustrates the forces of 2 on 3 and 3 on 2?

(A)       (B)       (C)       (D)       (E)

3. A positively charged metal sphere A is brought into contact with an uncharged metal sphere B. As a result:

A. both spheres are positively charged
B. A is positively charged and B is neutral
C. A is positively charged and B is negatively charged
D. A is neutral and B is positively charged
E. A is neutral and B is negatively charged
4. Two small charged objects repel each other with a force $F$ when separated by a distance $d$. If the charge on each object is reduced to one-fourth of its original value and the distance between them is reduced to $d/2$ the force becomes:

A. $F/16$
B. $F/8$
C. $F/4$
D. $F/2$
E. $F$

5. Charge Q is on the y axis a distance 'a' from the origin and charge q is on the x axis a distance 'd' from the origin. The value of d for which the x component of the force on q is the greatest is:

A. 0
B. a
C. $\sqrt{2}a$
D. $a/2$
E. $a/\sqrt{2}$
6. Point charges are located at two vertices of an equilateral triangle and the electric field is zero at the third vertex. We conclude:

A. the two charges have opposite signs and the same magnitude
B. the two charges have opposite signs and the different magnitudes
C. the two charges are identical
D. the two charges have the same sign but different magnitude
E. at least one other charge is present

7. The diagram shows the electric field lines due to two charged parallel metal plates. We conclude that:

A. the upper plate is positive and the lower plate is negative
B. a positive charge at X would experience the same force if it were placed at Y
C. a positive charge at X experiences a greater force than if it were placed at Z
D. a positive charge at X experiences less force than if it were placed at Z
E. a negative charge at X could have its weight balanced by the electrical force
8. Positive charge $Q$ is uniformly distributed on a semicircular rod. What is the direction of the electric field at point $P$, the center of the semicircle?

- A. $\uparrow$
- B. $\downarrow$
- C. $\leftarrow$
- D. $\rightarrow$
- E. $\nur$
10. A uniform electric field of 300 N/C makes an angle of 25° with the dipole moment of an electric dipole. If the moment has a magnitude of $2 \times 10^{-9}$ C · m, the torque exerted by the field has a magnitude of:

A. $6.7 \times 10^{-12}$ N · m
B. $2.5 \times 10^{-7}$ N · m
C. $5.4 \times 10^{-7}$ N · m
D. $6.0 \times 10^{-7}$ N · m
E. $2.8 \times 10^{-7}$ N · m

11. The flux of the electric field $(24 \mathbf{i} + 30 \mathbf{j} + 16 \mathbf{k})$ N/C through a 2.0 m² portion of the yz plane is:

A. 32 N · m² /C
B. 34 N · m² /C
C. 42 N · m² /C
D. 48 N · m² /C
E. 60 N · m² /C
12. A point charge is placed at the center of a spherical Gaussian surface. The electric flux $\phi_E$ is changed:

A. if the sphere is replaced by a cube of the same volume
B. if the sphere is replaced by a cube of one-tenth the volume
C. if the point charge is moved off center (but still inside the original sphere)
D. if the point charge is moved to just outside the sphere
E. if a second point charge is placed just outside the sphere

13. Which of the following graphs represents the magnitude of the electric field as a function of the distance from the center of a solid charged conducting sphere of radius R?

![](image)
14. A charge $Q$ is placed on a conducting spherical shell with inner radius $R_1$ and outer radius $R_2$. A point charge $q$ is placed at the center of the cavity. The magnitude of the electric field at a point outside the shell, a distance $r$ from the center, is:

A. $Q/4\pi \varepsilon_0 R_1^2$
B. $Q/4\pi \varepsilon_0 (R_1^2 - r^2)$
C. $q/4\pi \varepsilon_0 r^2$
D. $(q + Q)/4\pi \varepsilon_0 r^2$
E. $(q + Q)/4\pi \varepsilon_0 (R_1^2 - r^2)$

15. Two large INSULATING parallel plates carry positive charge of equal magnitude that is distributed uniformly over their surfaces. Rank the points 1 through 5 according to the magnitude of the electric field at the points, least to greatest.

A. 1,2,3,4,5
B. 5,4,3,2,1
C. 1, 4, and 5 tie, then 2 and 3 tie
D. 2 and 3 tie, then 1 and 4 tie, then 5
E. 2 and 3 tie, then 1, 4, 5 tie
16. A $5.5 \times 10^{-8}$ C charge is fixed at the origin. A $-2.3 \times 10^{-8}$ C charge is moved from $x = 3.5$ cm on the x axis to $y = 3.5$ cm on the y axis. The change in the potential energy of the two-charge system is:

A. $3.2 \times 10^{-4}$ J  
B. $-3.2 \times 10^{-4}$ J  
C. $9.3 \times 10^{-3}$ J  
D. $-9.3 \times 10^{-3}$ J  
E. 0

17. During a lightning discharge, 30 C of charge moves through a potential difference of $1.0 \times 10^8$ V in $2.0 \times 10^{-2}$ s. The energy released by this lightning bolt is:

A. $1.5 \times 10^{11}$ J  
B. $3.0 \times 10^9$ J  
C. $6.0 \times 10^7$ J  
D. $3.3 \times 10^6$ J  
E. 1500 J
18. Three possible configurations for an electron e and a proton p are shown below. Take the zero of potential to be at infinity and rank the three configurations according to the potential at S, from most negative to most positive.

A. 1, 2, 3
B. 3, 2, 1
C. 2, 3, 1
D. 1 and 2 tie, then 3
E. 1 and 3 tie, then 2

19. The equipotential surfaces associated with an isolated point charge are:

A. radially outward from the charge
B. vertical planes
C. horizontal planes
D. concentric spheres centered at the charge
E. concentric cylinders with the charge on the axis.
20. Each plate of a capacitor stores a charge of magnitude 1 mC when a 100 V potential difference is applied. The capacitance is:

A. 5 μF
B. 10 μF
C. 50 μF
D. 100 μF
E. none of these

21. The plate areas and plate separations of five parallel plate capacitors are

- capacitor 1: area \( A_o \), separation \( d_o \)
- capacitor 2: area \( 2A_o \), separation \( 2d_o \)
- capacitor 3: area \( 2A_o \), separation \( d_o/2 \)
- capacitor 4: area \( A_o/2 \), separation \( 2d_o \)
- capacitor 5: area \( A_o \), separation \( d_o/2 \)

Rank these according to their capacitances, least to greatest.

A. 1, 2, 3, 4, 5
B. 5, 4, 3, 2, 1
C. 5, 3 and 4 tie, then 1, 2
D. 4, 1 and 2 tie, then 5, 3
E. 3, 5, 1 and 2 tie, 1, 4
Some Useful Formulae

Electron charge
-1.6 x 10^{-19} C

Electron mass
9.11 x 10^{-31} kg

Proton mass
1.67 x 10^{-27} kg

\( k_e = \frac{1}{4\pi \varepsilon_0} \)

\( \varepsilon_0 = 8.85 \times 10^{-12} \frac{F}{m} \)

\( \mu_0 = 4\pi \times 10^7 \frac{N}{A^2} \)

Coulomb's Law

\[ |\vec{F}| = \frac{kQ_1Q_2}{r^2} \]

Field around Pt charge

\[ |\vec{E}| = \frac{kQ}{r^2} \]

Potential around Pt charge

\[ V(r) = \frac{kQ}{r} \]

Potential E. due to a pair of Pt charges

\[ U(r) = \frac{kQ_1Q_2}{r_{12}} \]

Electric Potential

\[ \Delta V = -\int_{\text{line}} \vec{E} \cdot d\vec{l} \]

Capacitors in Series

\[ \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_1} + \ldots \]

Capacitors in Parallel

\[ C_{eq} = C_1 + C_2 + \ldots \]

\[ C = \frac{Q}{V} \]

Energy of a Charged Capacitor

\[ U = \frac{1}{2} CV^2 \]

Electrical Flux Through a Surface

\[ \Phi_e = \int_{\text{surface}} \vec{E} \cdot d\vec{A} \]

Gauss' Law

\[ \oint_{\text{surface}} \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0} \]
Answers

2 (B)
3 (A)
4 (C)
5 (E)
6 (E)
7 (B)
8 (D)
9 (B)
10 (B)
11 (D)
12 (D)
13 (C)
14 (D)
15 (E)

(REMAINING QUESTIONS DO NOT APPLY TO SPRING 99 MID TERM1)