Physics 220 – All Sections
Midterm Exam #2 – Winter 2016

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Instructions
1. Do NOT write on this test. If this form has any writing on it, report it to the proctors immediately.
2. Be sure your test has questions numbered 1 through 34.
3. There are no time limits.
4. Except for constants, you may not use any information or routines stored in your calculator.
5. Unless stated otherwise, use SI units.
6. If you do not believe there is a correct answer, mark what you believe to be the best answer.
7. No notes or written materials are allowed except for a foreign language dictionary.

Possibly Useful Information:
e =1.602 \times 10^{-19} \, C
k_e = 8.99 \times 10^9 \, SI \, units
\mu_0 = 4\pi \times 10^{-7} \, SI \, units
\varepsilon_0 = 8.85 \times 10^{-12} \, SI \, units
c = 3.00 \times 10^8 \, m/s
G=10^9, M=10^9, k=10^3, m=10^{-3}, \mu=10^{-6}, n=10^{-9}, p=10^{-12}

All students must answer Question #1

1. Have you already passed Basic Test #1 online (9 or 10 correct answers)?
   A. Yes (Mark answer J on Questions 2-11; do not work these problems.)
   B. No (You MUST answer both the Basic Questions and the Standard Questions!)
Basic Questions (3 points each – mark J for each answer if you have passed the Basic Test online)

2. Near a long current-carrying wire, which is true?
A. The magnetic field lines radiate uniformly outward in all directions.
B. The magnetic field contour consists of half-planes that are equally spaced around the wire.
C. The magnetic field lines primarily radiate toward a second wire with current in the same direction.
D. The magnetic field contour surfaces are circular loops around the wire.

3. In the figure, what do the circular loops represent?
A. magnetic field contours which are distorted cylinders in three dimensions
B. electric field contours which are distorted spheres in three dimensions
C. magnetic field lines which are distorted circles in three dimensions
D. electric field lines which are distorted circles in three dimensions

4. Two capacitors are connected in series. Their capacitances are $C_1 = 10.1 \ \mu F$ and $C_2 = 8.00 \ \mu F$. What is their combined capacitance?
A. 4.46 μF
B. 5.00 μF
C. 8.00 μF
D. 12.2 μF
E. 19.1 μF

5. Find $Q$, the total charge on all the capacitors in the figure. The battery has a voltage of $V=$12.0 V. The capacitances are $C_1=6.00 \ \mu F$, $C_2=11.1 \ \mu F$, and $C_3=24.0 \ \mu F$.
A. 3.35 μC
B. 61.5 μC
C. 87.1 μC
D. 163 μC
E. 493 μC
6. You wish to store $Q=1.20 \text{ mC}$ of charge in a $C=203 \mu\text{F}$ capacitor. What voltage would you need on the capacitor?

A. $0.243 \mu\text{V}$  
B. $0.169 \text{ V}$  
C. $2.43 \text{ V}$  
D. $5.91 \text{ V}$  
E. $4.11 \text{ MV}$

7. If you know the total electric flux through a Gaussian surface, which of the following do you also know?

A. the total electric charge within the Gaussian surface  
B. the total positive charge within the Gaussian surface  
C. the total negative charge within the Gaussian surface  
D. the current flowing through the Gaussian surface  
E. the current flowing on the Gaussian surface  
F. All of the above

8. Which of the following are used to prove that the electric field inside a hollow spherical charge distribution is zero?

A. Gauss's law only  
B. Ampere's law only  
C. Symmetry only  
D. $E=0$ inside a conductor only  
E. Both A and B  
F. Both A and C  
G. Both A and D  
H. Both B and C  
I. Both B and D

9. A charged sphere of radius $R$ has a charge density $\rho = \alpha r^2$ where $\alpha$ is a constant. Find the electric field at a radius $r$ outside the sphere.

A. $E(r) = \frac{\alpha r^3}{5 \varepsilon_0}$  
B. $E(r) = \frac{\alpha R^5}{5 \varepsilon_0 r^2}$  
C. $E(r) = \frac{4 \alpha r^3}{\varepsilon_0}$  
D. $E(r) = \frac{4 \alpha R^5}{\varepsilon_0 r^2}$  
E. $E(r) = \frac{4 \alpha r}{\varepsilon_0}$  
F. $E(r) = \frac{4 \alpha R^3}{\varepsilon_0 r^2}$
10. A square lies in the x-y plane with its center at the origin. The length of each side of the square is \( L = 2.40 \text{ cm} \). The square has a surface charge density of \( \sigma = \alpha y^2 \) where \( \alpha = 26.4 \text{ mC/m}^4 \). (Note that you need to express your distances in meters.) What is the total charge on the square?

A. 0.730 nC  
B. 1.45 nC  
C. 2.92 nC  
D. 5.84 nC  
E. 7.62 nC

11. How do you count the net number of surfaces pierced by an Amperian loop?

A. Each time the loop pierces a surface you add one to your count.  
B. Each time the loop pierces a surface in the direction of the surface, you add one. Each time it goes opposite the direction of the surface, you subtract one.  
C. Each time you pierce a surface in the +x or +y direction you add one. Each time you pierce the surface going in the –x or –y direction you subtract one.  
D. Each time you pass out of a contour surface, you add one. Each time you pass into a contour surface, you subtract one.
Standard Questions (3 point each – everyone must answer these questions)

Problems 12 through 14 use the figure shown to the right.

12. Which of the following equations is not valid?
   A. $I_5 + I_6 = I_1$
   B. $I_2 + I_4 = I_5$
   C. $I_1 + I_2 = I_3$
   D. $I_3 + I_4 + I_6 = 0$

13. Which of the following equations is not valid?
   A. $8 - 2I_1 + 4I_3 - 6I_6 = 0$
   B. $7I_5 + 5I_4 - 6I_6 = 0$
   C. $-3I_2 - 7I_5 + 6I_6 - 4I_3 = 0$
   D. $-3I_2 + 5I_4 + 4I_3 = 0$

14. How many loop equations would you need to use to solve for all the currents in the figure using Kirchoff’s laws?
   A. 1
   B. 2
   C. 3
   D. 4
   E. 5
   F. 6

15. The figure on the right represents the electric field contours of two charges. At point A, the electric field points to the right. What is true of the electric field at points B and C?
   A. B is right and C is right
   B. B is right and C is left
   C. B is left and C is right
   D. B is left and C is left
16. If the figure for Problem 15 were to represent the magnetic field of two parallel wires, which could be true? (‘Up’ is to the top of the page and ‘down’ is to bottom of the page.)

A. The fields at A and B are right and the field at C is left.
B. The fields at A and C are right and the field at B is left.
C. The fields at A, B, and C are all to the right.
D. The fields at A and B are up and the field at C is down.
E. The fields at A and C are up and the field at B is down.
F. The fields at A, B, and C are all up.

17. If the figure in problem 15 represents the magnetic field lines of two parallel wires, which of the following figures would best represent the magnetic field contours of the same wires?

![Diagram of magnetic field contours]

A. A
B. B
C. C
D. D

18. Which of the following statements is not correct concerning field contours?

A. Contour surfaces are always perpendicular to field lines.
B. The number of contour surfaces per meter pierced by a field line is proportional to the strength of the field.
C. The magnetic field contours of a long current-carrying wire are half-planes with one edge lying on the wire.
D. All of the above are correct.

19. Three parallel wires pass through the corners of an equilateral triangle as shown to the right. (The wires are in and out of the page, not on the lines joining the corners.) Each wire carries a current of 0.0320 A out of the page. The wires are each a distance of \( d = 6.40 \text{ cm} \) from the center of the triangle. What is the magnitude of the magnetic field at the center of the triangle? (Remember that magnetic field is a vector!)

A. 0
B. 0.100 \( \mu \text{T} \)
C. 0.200 \( \mu \text{T} \)
D. 0.300 \( \mu \text{T} \)
E. 0.458 \( \mu \text{T} \)
20. Consider the network of capacitors shown to the right. When the two ends of the network are connected to a battery, how does the voltage across the 4 μF capacitor compare to the voltage across the 3 μF capacitor?

A. The voltage is 9/4 times the voltage across the 3 μF capacitor.
B. The voltage is twice as large as the voltage across the 3 μF capacitor.
C. The voltage is the same as the voltage across the 3 μF capacitor.
D. The voltage is half as large as the voltage across the 3 μF capacitor.
E. The voltage is 4/9 the voltage across the 3 μF capacitor.

21. Four capacitors are connected as shown in the figure. The values of the capacitors are \( C_1 = 15 \) μF, \( C_2 = 20 \) μF, \( C_3 = 25 \) μF, and \( C_4 = 30 \) μF. If a 12.0 V battery is connected across these capacitors, what is the voltage on \( C_2 \)?

A. 1.09 V
B. 2.18 V
C. 3.46 V
D. 5.68 V
E. 11.8 V

22. A battery is connected to a parallel plate capacitor that has air between the plates. A slab of dielectric is inserted between the plates while the battery remains connected. Which of the following happens?
A. The voltage across the capacitor decreases.
B. The total electric field between the plates decreases.
C. The charge on the capacitor increases.
D. The capacitance remains constant.
E. All of the above happen.

23. A parallel-plate capacitor has circular plates of radius 2.00 cm. The plates are located on either side of a dielectric sheet of thickness 0.200 mm and dielectric constant \( \kappa = 1.25 \). A similar capacitor with identical circular plates has no dielectric but has the same capacitance. How far apart are the plates of the second capacitor?

A. 0.080 mm
B. 0.160 mm
C. 0.250 mm
D. 0.500 mm
E. 0.750 mm
24. Some charges are placed inside the large globe in the Harold B. Lee Library. (They’re placed on insulating posts, in case you’re wondering how you could do that.) There is a total charge of +24.0 μC within the northern hemisphere (north of the equator and inside the globe) and a total charge of −12.0 μC within the southern hemisphere (south of the equator and inside the globe). Over the surface of the northern hemisphere of the globe \( \int \vec{E} \cdot d\vec{A} = 2.04 \times 10^6 \) Vm. What is \( \int \vec{E} \cdot d\vec{A} \) over the surface of the southern hemisphere of the globe? (Note that these two integrals are not integrals over complete Gaussian surfaces, just integrals over the surface of the globe on the norther and southern hemispheres.)

**Hints:** Consider the flux through the entire outside surface of the globe.

A. \(-6.84 \times 10^5\) Vm
B. \(-1.37 \times 10^6\) Vm
C. \(-2.04 \times 10^6\) Vm
D. \(+2.04 \times 10^6\) Vm
E. \(+6.84 \times 10^5\) Vm

25. To prove that the excess charge goes to the outside surface of a conductor, we invoked Gauss’s law along with:

A. the fact that the electric field inside a conductor is zero
B. the fact that the electric field inside a hollow sphere is zero
C. Coulomb’s law
D. Gauss’s law of magnetism
E. symmetry

26. Which of the following is *not* a consequence of Gauss’s Law of Magnetism?

A. There are no magnetic monopoles.
B. Magnetic field lines never spread from a point like electric field lines.
C. magnetic field lines always form closed loops.
D. Magnetic field lines going into a Gaussian surface always leave a Gaussian surface.
E. All of the above are true.

27. You have five 1.20 μF capacitors. You want to connect these together in some fashion with a battery to store 1.00 J of energy. What is the minimum voltage you can apply to the network of capacitors to accomplish this?

A. 12.8 V
B. 577 V
C. 1.29 kV
D. 2.89 kV
E. 167 kV
28. A sphere of radius \( R \) has a charge density of \( \rho = \alpha r \) where \( \alpha \) is a constant. Find the magnitude of the electric field inside the sphere.

A. \( E = \frac{\alpha R^4}{4\epsilon_0 r^2} \)

B. \( E = \frac{\alpha r^2}{4\epsilon_0} \)

C. \( E = \frac{\alpha R^3}{3\epsilon_0 r} \)

D. \( E = \frac{\alpha r^2}{3\epsilon_0} \)

29. A cylinder of length \( L \) and radius \( R \) has a charge density of \( \rho = \alpha r \) where \( \alpha \) is a constant. Find the magnitude of the electric field outside the cylinder.

A. \( E = \frac{\alpha R^4}{4\epsilon_0 r^2} \)

B. \( E = \frac{\alpha r^2}{4\epsilon_0} \)

C. \( E = \frac{\alpha R^3}{3\epsilon_0 r} \)

D. \( E = \frac{\alpha r^2}{3\epsilon_0} \)

30. A plane of charge has a surface charge density \( \sigma = 4.00 \mu C/m^2 \). What is the magnitude of the electric field 5.00 m from the plane? (Note: The plane is not a conductor.)

A. \( 1.77\times10^{-17} \) V/m
B. \( 3.54\times10^{-17} \) V/m
C. 2 \( \mu \)V/m
D. 45 kV/m
E. 90 kV/m
F. 226 kV/m
G. 452 kV/m
31. A long, cylindrical wire of radius $R$ has a current density of $j = 3\alpha r^2$ where $\alpha$ is a constant. Find the magnitude of the magnetic field at a radius $r$ inside the wire.

A. $B = \mu_0 \frac{3\alpha R^4}{4r}$  
B. $B = \mu_0 \frac{6\alpha r^4}{5}$  
C. $B = \mu_0 \frac{3\alpha r^3}{4}$  
D. $B = \mu_0 \frac{\alpha r^2}{2\pi}$

32. A long, cylindrical wire of radius $R$ has a current density of $j = 3\alpha r^2$ where $\alpha$ is a constant. Find the magnitude of the magnetic field at a radius $r$ outside the wire.

A. $B = \mu_0 \frac{3\alpha R^4}{4r}$  
B. $B = \mu_0 \frac{6\alpha R^4}{5}$  
C. $B = \mu_0 \frac{3\alpha r^3}{4}$  
D. $B = \mu_0 \frac{\alpha R^3}{2\pi r}$

33. Which of the following is not true concerning the magnetic field of a solenoid:

A. the field is stronger near the axis of the solenoid and falls off as the distance from the axis increases  
B. the field is very small outside the solenoid  
C. the field depends on the number of turns per unit length rather than on the total number of turns in the coil  
D. all of the above are true.

34. Ampère’s Law states that the net number of contour surfaces pierced by an Amperian loop is proportional to

A. The current flowing through the wire  
B. The net current flowing through the Amperian loop  
C. The current flowing within a Gaussian surface surrounding the wire  
D. The charge in a Gaussian surface inside the wire  
E. The integral $\oint_S \mathbf{j} \cdot d\mathbf{V}$