Physics 220 – All Sections  
Midterm Exam #1 – Winter 2016

Instructor: Lawrence Rees

Do NOT write on this test. If this form has any writing on it, report it to the proctors immediately.
Be sure this forms has questions 1-34.
Mark the best answer for each problem on the answer form (the bubble sheet).
Be careful to enter your answers correctly. Your bubble sheet answer is your final answer.
No notes or written materials are allowed except for a foreign language dictionary.
Except for constants, you may not use any information or routines stored in your calculator.

Possibly useful information:

\[ k_e = 8.99 \times 10^9 \text{Nm}^2/\text{C}^2 \]
\[ \varepsilon_0 = 8.85 \times 10^{-12} \text{C}^2/(\text{Nm}^2) \]
\[ e = 1.60 \times 10^{-19} \text{C} \]
\[ c = 3.00 \times 10^8 \text{m/s} \]
proton mass: \( m_p = 1.67 \times 10^{-27} \text{kg} \)
electron mass: \( m_p = 9.11 \times 10^{-31} \text{kg} \)

The long side of a battery is positive.

\[ p = 10^{-12} \quad n = 10^{-9} \quad \mu = 10^{-6} \quad m = 10^{-3} \quad k = 10^3 \quad M = 10^6 \quad G = 10^9 \quad T = 10^{12} \]

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. Which is the head line?
   A. A (That is, mark A for A on the diagram)
   B. B
   C. C
   D. D
   E. S (That is, mark E for S on the diagram)
   F. T
   G. U
   H. P

3. A charge is moving along the $x$ axis at constant speed. As a thread moves outward away from the charge, its direction
   A. remains the same
   B. rotates so it points more toward the $x$ axis.
   C. rotates so it points more toward the $y$ axis.
   D. rotates so it points more toward the $+z$ axis.
   E. rotates so it points more toward the $-z$ axis.

4. A proton is traveling in the $+x$ direction in a region where there are threads pointing in the $+x$ direction and stubs pointing in the $+y$ direction. What is the direction of the magnetic force?
   A. $+x$
   B. $-x$
   C. $+y$
   D. $-y$
   E. $+z$
   F. $-z$

5. A proton is traveling in the $+x$ axis in a region of space where there is an electric field of 1320 V/m pointing downward. What is the force on the proton?
   A. $2.62 \times 10^{-9}$ N
   B. $2.11 \times 10^{-16}$ N
   C. $1.70 \times 10^{-23}$ N
   D. $1.64 \times 10^{10}$ N
6. An electron is traveling through a uniform magnetic field. Its speed increases when

A. the electron travels in the same direction as the magnetic field.
B. the electron travels in the opposite direction to the magnetic field.
C. the electron travels perpendicular to the magnetic field.
D. A uniform magnetic field can never change the speed of the electron.
E. A uniform magnetic field can never accelerate an electron.

7. A capacitor is made of two thin plates of metal held parallel to each other a distance of 2.33 mm apart. One terminal of a 24.0 V battery is connected to one of the capacitor plates. The other terminal of the battery is connected to the other plate. What is the magnitude of the electric field between the capacitor plates?

A. 24.0 V/m
B. 0.0559 V/m
C. 10300 V/m
D. 97.1 μV/m

8. When the electric field is represented by field vectors, the strength of the field is determined by:

A. how close the field vectors are to each other
B. the length of the field vectors
C. the direction of the field vectors
D. Field vectors cannot show the strength of the field.

9. In 1.00 μs, \(3.55 \times 10^{12}\) electrons pass through a battery. How much current passes through the battery?

A. \(3.55 \times 10^{18}\) A
B. \(5.68 \times 10^{-7}\) A
C. 0.568 A
D. \(5.68 \times 10^{-13}\) A
10. In the illustration, the values of the resistances are $R_1 = 12.4 \, \Omega$ and $R_2 = 20.5 \, \Omega$. The voltage is $V = 24.0 \, V$. Find the current through the battery.

A. 0.729 A  
B. 1.38 A  
C. 3.11 A  
D. 185 A  
E. None of above.

11. In the illustration, the values of the resistances are $R_1 = 12.4 \, \Omega$ and $R_2 = 20.5 \, \Omega$. The voltage is $V = 24.0 \, V$. Find the current $I$.

A. 0.729 A  
B. 3.11 A  
C. 185 A  
D. 1.18 A  
E. 1.94 A
Standard Questions (3 point each – everyone must answer these questions)

12. You can do a simple electrostatics experiment with an empty aluminum soda can and a plastic comb. Set the can sideways (so the can can roll) on a level table. Run the comb through your hair several times and place it to one side of the can. What happens and why?

A. The can rolls toward the comb because the comb is negatively charged whereas the can is positively charged.
B. The can rolls away from the comb as both are negatively charged.
C. Nothing happens because electrostatic forces are too weak to make the can move.
D. Nothing happens because the comb is initially neutral and cannot be charged by running it through your hair.
E. Nothing happens because atoms in a conductor cannot become polarized.
F. The can rolls toward the comb because the electrons in the can are repelled from the negatively charged comb and the positive charge on the side of the can nearest the comb is drawn toward the comb.
G. The can rolls away from the comb because, as a conductor, electrons are repelled from the negatively charged comb, causing a net force on the can away from the comb.

13. At time $t = 0$, a thread (its head) is emitted from a positive charge at point $S$. At time $t = T$, the head arrives at point $P$ while the source moves to point $U$. At time $t = T/2$, which figure best represents the thread (the dashed, orange arrow)?

A  
B  
C  
D  
E  
F
14. At time $t = 0$, a thread (its head) is emitted from a negative charge at point $S$. At time $t = T$, the head arrives at point $P$ while the source moves to point $U$. At time $t = T$, what is the direction of the stub at point $P$?

A. toward the top of the page  
B. toward the bottom of the page  
C. toward the right  
D. toward the left  
E. into the page (away from you)  
F. out of the page (toward you)

For problems 15 and 16: A proton is traveling northeast (45° east of north) at a velocity of $3.40 \times 10^7$ m/s. A magnetic field of 0.240 T points downward.

15. What is the direction of the magnetic force on the proton?
A. north  
B. northeast  
C. east  
D. southeast  
E. south  
F. southwest  
G. west  
H. northwest  
I. up  
J. down

16. What is the magnitude of the force on the proton?
A. $4.62 \times 10^{-13}$ N  
B. $1.84 \times 10^{-12}$ N  
C. $1.31 \times 10^{-12}$ N  
D. $9.23 \times 10^{-13}$ N  
E. $6.53 \times 10^{-13}$ N
17. A long platform moves without acceleration in empty space. On the platform there is a set of synchronized clocks. An identical clock is aboard a spaceship that flies by at 0.750 of the speed of light. When the clock on the spaceship reads \( t = 0 \), a nearby clock on the platform also reads \( t = 0 \). When the clock on the spaceship reads \( t = 0.200 \mu s \), what does the platform clock nearest the spaceship read?
A. 0.0875 \( \mu s \)
B. 0.132 \( \mu s \)
C. 0.200 \( \mu s \)
D. 0.302 \( \mu s \)
E. 0.457 \( \mu s \)

For problems 18 and 19: Two particles are located in the \( x-y \) plane. The first particle has a charge of +1.20 \( \mu C \) and is located at \((x,y) = (5.32 \text{ cm, } 2.17 \text{ cm})\). The second particle has a charge of –2.32 \( \mu C \) and is located at \((x,y) = (4.63 \text{ cm, } 1.14 \text{ cm})\).

18. What is the **x-component** of the force on the **second** particle?
A. 90.6 N
B. 163 N
C. 2.02 N
D. –2.02 N
E. –163 N
F. –90.6 N

19. What is the electric potential at the origin of the coordinate system?
A. –0.437 MV
B. –0.250 MV
C. –0.188 MV
D. 0.188 MV
E. 0.250 MV
F. 0.437 MV

20. Which of the following statements is **not** true concerning field contours?
A. Contour surfaces are always perpendicular to field lines.
B. A field contour is composed of multiple surfaces.
C. The distance between any two adjacent surfaces of a contour is always the same.
D. In regions of space where there is no field, there are no contour surfaces.

21. To the right is a depiction of several field lines. Which of the following is **not** true about the field?
A. The field is largest in magnitude at point 1.
B. the field is larger in magnitude at point 4 than at point 2.
C. The field points to the right at point 3.
D. The field points downward at point 5.
22. An electric potential is given by the equation \( V = \alpha x^2 \) where \( \alpha \) is a constant. Which of the following is true concerning the electric field?

A. \( E = 2\alpha x \)
B. \( E = -2\alpha x \)
C. \( E = 2\alpha x + C \)
D. \( E = -2\alpha x + C \)
E. \( E = \alpha x^3 / 3 \)
F. \( E = -\alpha x^3 / 3 \)
G. \( E = \frac{\alpha x^3}{3} + C \)
H. \( E = -\frac{\alpha x^3}{3} + C \)

23. When a proton is moving in a constant magnetic field (with no other forces acting on the proton) which of the following is not a possible motion?

A. moving in a straight line at constant speed
B. moving in a circular path
C. spiraling inward toward the center of a circle (with decreasing radius)
D. moving in a helical path

For problems 24-26. A mass spectrometer is shown in the diagram to the right. An ion is first accelerated in a constant electric field and then passes into a constant magnetic field. The voltage difference across the first region is \( V = 2400 \text{ V} \). The magnetic field has a value of 0.855 T and is directed into the page.

24. If the ion is positive hydrogen ion (a proton), what is the kinetic energy of the ion after pass through the acceleration stage, where there is an electric field?

A. 1200 V
B. 2400 V
C. \( 1.92 \times 10^{-16} \text{ J} \)
D. \( 3.84 \times 10^{-16} \text{ J} \)
E. \( 7.68 \times 10^{-16} \text{ J} \)

25. If the kinetic energy in joules is \( 5.00 \times 10^{-16} \text{ J} \), what is the velocity of the proton? (The mass is given in the information at the beginning of the test.)

A. \( 1.29 \times 10^5 \text{ m/s} \)
B. \( 2.58 \times 10^5 \text{ m/s} \)
C. \( 3.87 \times 10^5 \text{ m/s} \)
D. \( 5.47 \times 10^5 \text{ m/s} \)
E. \( 7.74 \times 10^5 \text{ m/s} \)
26. If the velocity of the proton is \(5.00 \times 10^5\) m/s, what is the radius of curvature of its path in the magnetic field?
A. 6.10 mm
B. 23.4 mm
C. 5.32 cm
D. 12.4 cm
E. 1.18 m

27. A solid spherical conductor of radius 2.50 cm has a net charge of \(+1.43\mu\text{C}\). A point charge of \(-2.86\mu\text{C}\) is placed just outside the conductor. What is the magnitude of the electric field at the center of the conductor? (Assume that the system is in static equilibrium; that is, no charges are moving.)
A. 0 V/m
B. 5.14 MV/m
C. 20.6 MV/m
D. 41.1 MV/m
E. 8.22 MV/m

28. Which of the following would be a (reasonably) good representation of the electric field lines around conducting spheres and a conducting plane? (For simplicity, each drawing represents a slice through the center of the spheres rather than a 3-D picture of all the field lines.)

29. A cube of material has a length of \(a = 2.50\) cm on a side. Wires are to be attached to the center of two opposite faces to make a resistor. The resistivity of the material is 0.800 \(\Omega\text{m}\). What is the resistance of the block?
A. 0.02 \(\Omega\)
B. 3.20 \(\Omega\)
C. 6.40 \(\Omega\)
D. 12.8 \(\Omega\)
E. 32.0 \(\Omega\)
For problems 30 and 31, consider the following circuit:

30. Which resistors in the circuit below are in series?
   
   A. Resistors A and B  
   B. Resistors B and C  
   C. Resistors F and G  
   D. Resistors D and F  
   E. Resistors E and G  
   F. None of the above

31. Which resistors in the circuit are in parallel?
   
   A. Resistors A and B  
   B. Resistors B and C  
   C. Resistors F and G  
   D. Resistors D and F  
   E. Resistors E and G  
   F. None of the above

32. Three resistors are arranged as shown in the figure. The values of the resistances are $R_1 = 16 \, \Omega$, $R_2 = 24 \, \Omega$, and $R_3 = 20 \, \Omega$. The equivalent resistance of the network is:
   
   A. 6.49 $\, \Omega$  
   B. 13.3 $\, \Omega$  
   C. 29.6 $\, \Omega$  
   D. 32.9 $\, \Omega$  
   E. 60.0 $\, \Omega$
33. Three resistors are connected to a 12.0 V battery as shown in the figure. The values of the resistances are \( R_1 = 10 \, \Omega \), \( R_2 = 24 \, \Omega \), and \( R_3 = 20 \, \Omega \). What is the current flowing through \( R_3 \)?

A. 8.8 A  
B. 2.3 A  
C. 0.60 A  
D. 0.50 A

34. Four resistors are connected as shown in the figure. The values of the resistances are \( R_1 = 12 \, \Omega \), \( R_2 = 15 \, \Omega \), \( R_3 = 20 \, \Omega \), and \( R_4 = 25 \, \Omega \). What is the current flowing through \( R_2 \) if the network is connected to a 12 V battery?

A. 0.60 A  
B. 0.26 A  
C. 0.15 A  
D. 0.11 A