Physics 227 Final Exam
December 18, 2007
Prof. Coleman and Prof. Rabe

Your name sticker ⇒ with exam code

SIGNATURE: _____

1. The exam will last from 4:00 p.m. to 7:00 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Identification Number.
4. Enter 227 under COURSE, and your section number (see label above) under SEC.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator, and two **handwritten** 8.5 x 11 inch sheets with formulas and notes, without attachments.
7. There are 30 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, **hand in the answer sheet and the cover page**. Retain this question paper for future reference and study.
8. When you are asked to open the exam, make sure that your copy contains all 30 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. Please **SIGN the cover sheet under your name sticker.** A proctor will check your name sticker and your student ID sometime during the exam. Please have them ready.

Useful Information

c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602 $\times 10^{-19}$ Coulombs
$q_p = +e$ = charge on a proton = +1.602 $\times 10^{-19}$ Coulombs
m_e = electron mass = 9.11×10^{-31} kg
m_p = proton mass = 1.67×10^{-27} kg
$k = 9 \times 10^9$ N m^2/C^2
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/(Nm^2)
$\mu_0 = 4\,\pi \times 10^{-7}$ T m/A
$g = 9.80$ m/s^2
1 $eV = 1.602 \times 10^{-19}$ J
1 mC = 10^{-3} C 1 μC = 10^{-6} C
1 nC = 10^{-9} C 1 pC = 10^{-12} C

1. A simple dipole antenna is connected to an AC voltage supply. Which of the following is true?

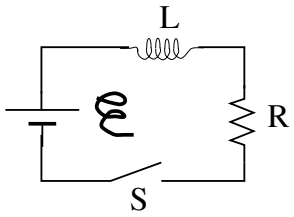
   a) If the frequency of the voltage supply is doubled, the power output will go up by a factor of 16.
   b) The intensity of the radiation decays with the fourth power of the distance.
   c) If the frequency of the voltage supply is doubled, the power output will go up by a factor of eight.
   d) The intensity of the radiation is a maximum in directions parallel or antiparallel to the antenna.
   e) The magnitude of the radiating component of the electric field depends linearly on the frequency of the voltage supply.

2. A parallel-plate capacitor has a plate separation of 1 mm and an area of 0.1 m^2. Suppose the space between the capacitor plates is a vacuum. If 1000 V is applied across the plate, what is the energy density inside the capacitor?

   a) 4.43 J/m^3
   b) 8.854 J/m^3
   c) 4.43×10^{-4} J/m^3
   d) 4.43×10^{-6} J/m^3
   e) 5.67×10^{22} J/m^3

3. In the LR circuit below, the current builds up to one-quarter of its steady (final) value in 2 seconds after the switch is closed. What is the time constant for this circuit?

   a) 0.58 sec
   b) 8.0 sec
   c) 2.8 sec
   d) 1.4 sec
   e) 7 sec

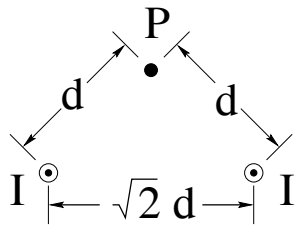


4. What is the frequency of light with wave length of (5.5×10^{-7}) m?

   a) (5.45×10^{14}) Hz
   b) (3.43×10^{15}) Hz
   c) (5.45×10^{16}) Hz
   d) (3.43×10^{17}) Hz
   e) None of the others

5. Two infinitely long, straight wires are each carrying a current I directed out of the plane of the paper, as shown in Figure 2. The wires are separated by a distance $\sqrt{2}d$. At a point equidistant from the two wires, and a distance d from each of them, the magnetic field strength is:

   a) zero
   b) $\dfrac{\mu_0 I}{2\pi d}$
   c) $\dfrac{\mu_0 I}{\sqrt{2}\pi d}$
   d) $\dfrac{\mu_0 I}{\pi d}$
   e) $\dfrac{\sqrt{2}\mu_0 I}{\pi d}$



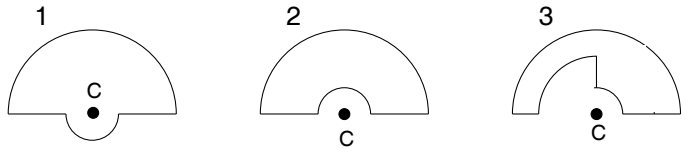
6. In an electromagnetic wave with electric field $\vec{E}$ and magnetic field $\vec{B}$ at a given point in space,

   a) $\vec{E}$ and $\vec{B}$ oscillate out of phase so that the energy density at that point alternates between $\vec{E}$ and $\vec{B}$, with the total constant.
   b) $\vec{E}$ and $\vec{B}$ oscillate in phase, with the $\vec{E}$ pointing in the direction of the propagation of the wave.
   c) $\vec{E}$ and $\vec{B}$ are proportional to each other in magnitude, but are perpendicular to each other.
   d) $\vec{E}$ lags behind $\vec{B}$ by 90° because it is the changing magnetic flux which produces the electric field.
   e) $\vec{E}$ is constant while $\vec{B}$ oscillates at the frequency of the wave.

7. A certain wire has resistance R. Another wire, of the same material, has half the length and half the diameter of the first wire. The resistance of the second wire is:

a) R/4 b) R/2 c) R d) 2R e) 4R

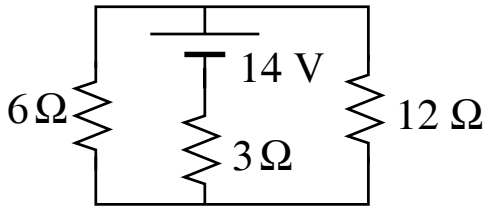
8. The diagrams show three circuits consisting of concentric circular arcs (either half or quarter circles of radii $r, 2r$, and $3r$) and radial lengths. The circuits carry the same current. Rank them according to the magnitudes of the magnetic fields they produce at C, **from greatest to least**.



a) 1, 2, 3
b) 3, 2, 1
c) 1, 3, 2
d) 2, 3, 1
e) 2, 1, 3

9. The current through the 3Ω resistor is:

a) 4.67 A
b) 2 A
c) 0.67 A
d) 8.17 A
e) 0.5 A



10. Two astronauts, Neil and Sally, try the following experiment. A piece of paper that is perfectly reflecting on one side and perfectly absorbing on the other is at rest in a vacuum. Simultaneously, Neil shines a 20W laser normal to the center of the reflecting side and Sally shines a different power laser normal to the center of the absorbing side. They observe the paper remains at rest and conclude that the power of Sally's laser is:

a) 20 W b) 10 W c) 5 W d) 40 W
e) 80 W

11. A square loop and a circular loop of equal area lie in a plane perpendicular to a uniform magnetic field. Each loop then rotates at the same angular frequency ω about an axis in its plane passes through its center. In which loop will the root-mean-square average induced emf be greater?

a) the square
b) the circle
c) It depends upon the orientation of the axis in the square.
d) It depends on ω.
e) The induced emf's are the same.

12. A series LRC circuit with R = 250 kΩ, C = 10 μF and an adjustable inductor is driven by an AC voltage source V = 8.9 V sin(2000 t). The power dissipated in the circuit will be maximum if the inductor is tuned to a value of:

a) 3 mH b) 125 mH c) 40 mH d) 25 mH
e) 2 mH

13. A circular capacitor of 1 cm radius and 1 mm gap is charged at a rate of 2 Coulombs/sec. What is the magnitude of the displacement current in the gap?

a) 1.8×10^{-11} Amps
b) 3.6×10^{11} Amps
c) 6.4×10^{3} Amps
d) 2×10^{3} Amps
e) 2 Amps

14. An LC circuit is to be designed to oscillate at a frequency of 4.0 MHz. If a 0.2 mH inductor is used, the capacitor should be

a) 1.25 mF
b) 313 pF
c) 7.9 pF
d) 199 μF
e) 50 pF

15. In the ionic NaCl molecule, $q_{Na} = +e$ and $q_{Cl} = -e$, and the interatomic separation is 1.25×10^{-10}m. How much energy is needed to separate these ions?

a) 1.84×10^{-18} eV
b) 45 eV
c) 1.28×10^{-9} J
d) 1.84×10^{-18} J
e) 11.5 J

16. A metal spherical shell of radius 1 cm is at a potential of 100 V (with respect to $r = \infty$). What is the net charge on the sphere?

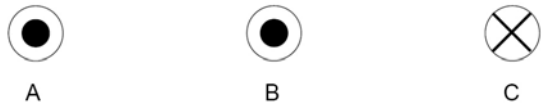
a) 9.99 μC
b) 3.33×10^{-9} C
c) 1.11×10^{9} C
d) 1.11×10^{7} C
e) 1.11×10^{-10} C

17. An RC circuit is driven by an AC voltage source V = (8.9 V) sin(625 t). The capacitor is 20 μF and the resistor is 80 Ω. The maximum voltage across the resistor and the maximum voltage across the capacitor are, respectively,

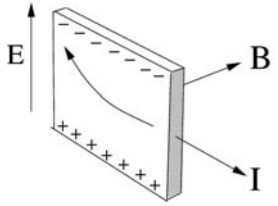
a) 4.45 V, 4.45 V
b) 6.29 V, 6.29 V
c) 6.29 V, 4.45 V
d) 8.9 V, 4.45 V
e) 8.9 V, 8.9 V

18. The diagram shows three equally spaced wires that are perpendicular to the page. The currents are all equal, two being out of the page and one being into the page. Rank the wires according to the magnitudes of the magnetic forces acting on them, **from greatest to least**.

a) A, B, C
b) B, A, C
c) B, C, A
d) A, C, B
e) C, B, A



19. A current passes through a conductor at right angles to an applied magnetic field $\vec{B}$. If the carriers are negatively charged, which of the figures below correctly represents the deflection of the carriers and the generation of an electric field $\vec{E}$?

a)


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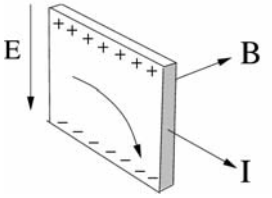

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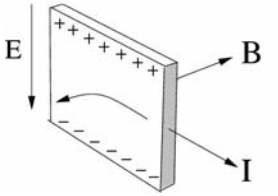
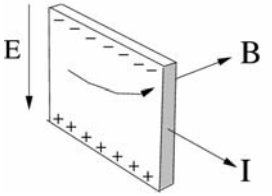
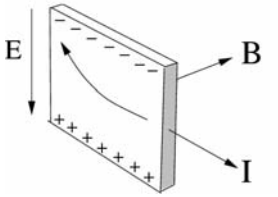


d)


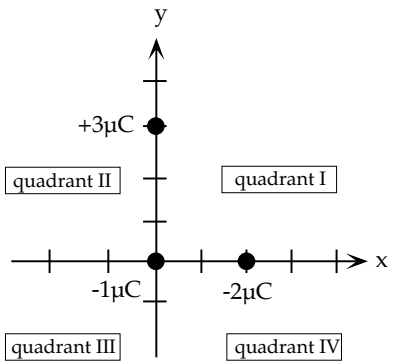
e)


20. A solid conducting sphere of radius R_s is centered at the origin. It is inside a hollow conducting sphere, also centered at the origin, of inner radius R_i and outer radius R_o where $R_o > R_i > R_s$. The net charge on the solid sphere is $+8\mu$C and charge on the outer surface of the hollow sphere is -3μC. Which of the following statements is **FALSE**?

a) The electric field at $r > R_o$ is the same as that produced by a -3μC point charge at the origin.
b) A charge of $+8\mu$C is uniformly distributed over the surface of the solid sphere.
c) The field inside the solid conductor is constant.
d) The electric field at $r > R_o$ is equal to zero.
e) The potential between the inner and outer surfaces of the hollow shell is constant.

21. The vector representing the net force on the charge at the origin:

a) lies in Quadrant I.
b) is zero.
c) lies in Quadrant II.
d) lies in Quadrant IV.
e) lies along the y-axis.



22. An RLC circuit with $R = 10^3\Omega$, $L = 0.25$H and $C = 3\mu$F is driven at an angular frequency of $\omega = 10^3$rad/s. In this circuit:

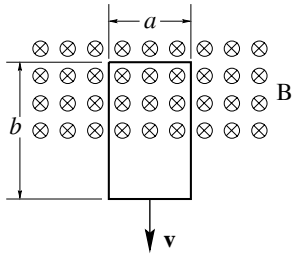
a) the source voltage leads the current.
b) the current and source voltage are in phase.
c) the source voltage lags the current.
d) the capacitive reactance is greater than the resistance.
e) the inductive reactance is greater than the resistance.

23. Suppose one has available: two copper sheets, a sheet of mica (d = 0.1 mm, $\kappa = 6$), a sheet of glass (d = 2 mm, $\kappa = 7$), and a slab of paraffin (d = 1 cm, $\kappa = 2$). Which of the following should be placed between the two copper sheets to obtain the largest capacitance?:

a) a 1 mm gap of air
b) the mica
c) the glass
d) the paraffin
e) the mica, glass, and paraffin

24. A rectangular loop of wire of dimensions a and b is being pulled with speed v out of a region of uniform magnetic field B that is directed into the paper. If the loop has a resistance R, what is the induced current in it, when it is partially out of the field region, as shown in the picture?

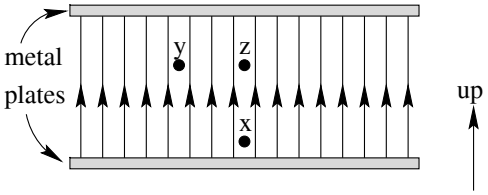
a) Bav/R, counterclockwise
b) Bbv/R, clockwise
c) Bav/R, clockwise
d) Bbv/R, counterclockwise
e) Zero



25. The figure 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.



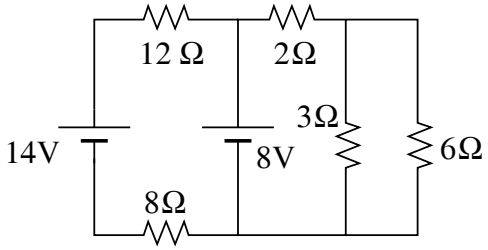
c. a positive charge at X experiences a greater force than if it were placed at Z.

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.

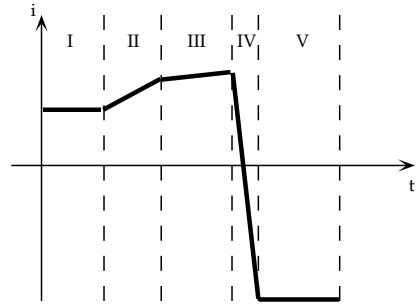
26. The current through the 2Ω resistor in the circuit shown is:

a) 4.67 A
b) 2 A
c) 6 A
d) 12 A
e) 0.5 A



27. The graph shows the current through an inductor as a function of time. During which interval is the magnitude of the potential difference across the inductor maximum?

a) I
b) II
c) III
d) IV
e) V



28. Initially, a long straight wire is carrying a current I, as shown in the figure. Next to the wire is a square conducting loop (in the plane of the paper), which, initially, has no electric current in it. Beginning at a certain time, the current in the straight wire is reduced, i.e. $dI/dt < 0$. Under this latter condition, which of the following statements is correct?

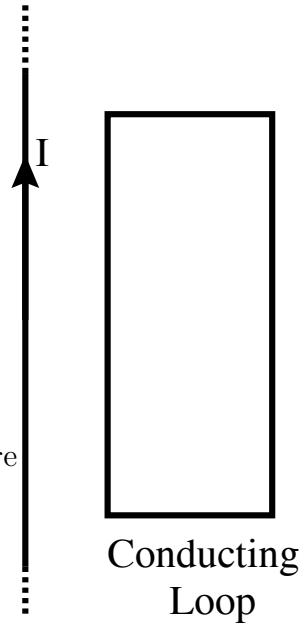
a) a clockwise current will be induced in the square loop, and it will feel a net force repelling it away from the straight wire.

b) a counter-clockwise current will be induced in the square loop, and it will feel a net force repelling it away from the straight wire.

c) a clockwise current will be induced in the square loop, and it will feel a net force attracting it towards the straight wire.

d) a counter-clockwise current will be induced in the square loop, and it will feel a net force attracting it towards the straight wire.

e) a current will be induced in the square loop, but it will feel no net force. There *will* be a torque, tending to twist the loop out of the plane of the paper.



29. If the current in an inductor is doubled, by what factor does the stored energy change?

a) 2 b) (1/2) c) doesn't change. d) (1/4) e) 4

30. A resistor connected to the secondary coil of a 10:1 stepdown transformer draws 10A of current and dissipates 1kW of power. The current through the primary coil is:

a) 1A b) 0.1A c) 10A d) 33A e) 3.3A