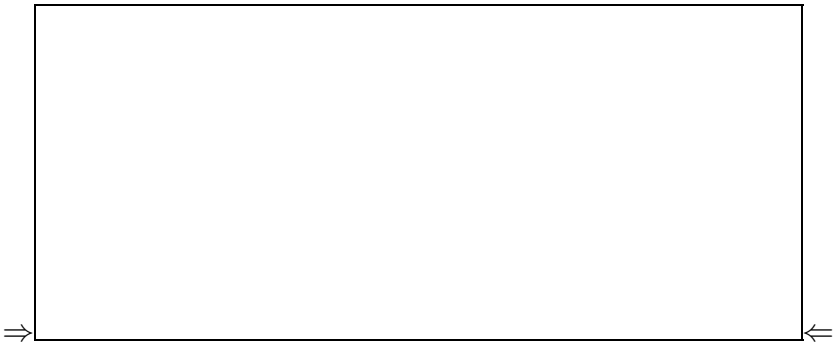
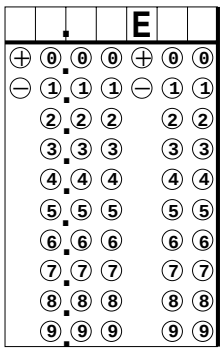
Physics 227 - Second Hour Exam
6 November 2003
Profs. Shapiro and Conway



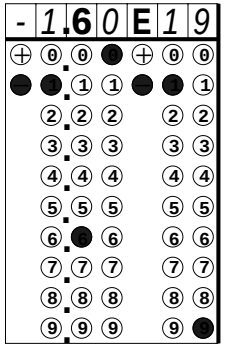
Your name sticker with **exam code**

Turn off and put away cell phones now!

1. **THIS EXAM INCLUDES QUESTIONS WHICH REQUIRE A NUMERICAL ANSWER.**
The format on the machine-graded answer sheets requires that you express your answer is a very specific format. Several examples are shown below:
5.30 should be entered as **+5.30+00**
437 should be entered as **+4.37+02**
0.62458 should be entered as **+6.25−01**



Form for numerical answers.



The electron's charge entered.

$-1.602176 \times 10^{-19}$ should be entered as **−1.60−19**.
Note that all answers should be accurate to three **significant** digits. A sample fragment of the mark-sense form is shown.

NOTE THAT MULTIPLE CHOICE QUESTIONS START WITH THE FIFTH QUESTION, BUT ITS NUMBER IS 16; ENTER THE ANSWERS ON THE MARK SENSE FORM ACCORDING TO THEIR PROBLEM NUMBERS, WHICH INCREASE HORIZONTALLY ACROSS THE FORM.

2. The exam will last from 8:00 pm to 9:20 pm Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
3. 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.
4. Under STUDENT # enter your 9-digit student ID.
5. Enter 227 under COURSE, and your section number (see label above) under SEC.
6. Under CODE enter the exam code given above.
7. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
8. There are 16 questions on the exam. Several questions require you to enter a numerical answers as described above. **Be sure to fill in the circles as well as writing your answer in the boxes.** The remainder are multiple-choice. For each multiple-choice 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.
9. When you are asked to open the exam, make sure that your copy contains all 16 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.
10. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

electromagnetic permittivity ϵ_0	8.854×10^{-12} C^2/N-m^2
electromagnetic constant $k_e \equiv \frac{1}{4\pi\epsilon_0}$	8.9875×10^{9} N-m^2/C^2
electron charge	1.602×10^{-19} C
electron mass	9.11×10^{-31} kg
protonn mass	1.67×10^{-27} kg
unit of electric potential	1 V = 1 J/C
magnetic permeability μ_0	$4\pi \times 10^{-7}$ T-m/A

1. A 25.0 μF parallel plate capacitor is charged to 20.00 μC and then disconnected from the circuit. A dielectric is then inserted into the gap between the plates. After this the voltage across the capacitor plates is found to be 0.500 V. Calculate the dielectric constant κ of the inserted material.

2. Calculate the magnitude of the dipole moment of two point charges of +3e and -3e separated by 4.00 nanometers, in units of C-m.

3. A 5.00 V battery, a 500 kΩ resistor, and a 8.00 μF capacitor are connected in series with a switch. Initially the capacitor has no charge. Calculate the charge on the capacitor (in μC) 1.00 seconds after the switch is closed.

4. A proton moves in a circular orbit with a frequency of 4×10^6 revolutions per second, due to the presence of a uniform magnetic field. Find the magnitude of the magnetic field, in units of Tesla.

16. A kitchen toaster uses a nichrome-wire heating element which has a resistivity of $1.50 \times 10^{-6}\Omega \cdot$ m (at room temperature, 20°C) and a temperature coefficient of $0.4 \times 10^{-3}(^\circ\text{C}^{-1})$. When the toaster is hot, the wires are at 300°C above room temperature and draw 550 Watts from a standard 115-V household outlet. From among the answers below, choose the minimum current rating for a fuse or circuit breaker which will **not** blow out when the toaster is first turned on (i.e. the wires at room temperature). Assume nothing else is on the same circuit.

    a) 6.0 A
    b) 3.0 A
    c) 7.0 A
    d) 5.0 A
    e) 4.0 A

17. Two straight wires A and B of circular cross-section are made of the same metal and have equal lengths, but the resistance of wire A is four times greater than that of wire B. How do their radii compare?

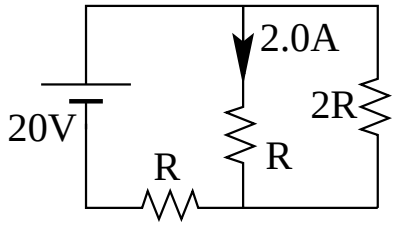
    a) $r_A = 4r_B$
    b) $r_A = 2r_B$
    c) $r_A = r_B/16$
    d) $r_A = r_B/4$
    e) $r_A = r_B/2$

18. A toaster of resistance 10 Ω is connected to a 110 V dc source. What will be the approximate cost of operating the toaster for 2 minutes, if electricity in New Jersey costs 12 cents per kilowatt-hour?

    a) About 10 cents
    b) About 2 cents
    c) About 1 cent
    d) About 5 cents
    e) About 0.5 cent

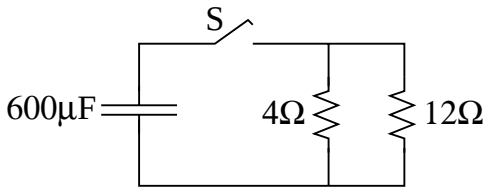
19. In the figure, note that two of the resistors have the same resistance R, while the one on the far right has resistance 2R. The current through the middle resistor is 2.0 A down. What is the value of R?

a) 5.0Ω
b) 6.0Ω
c) 4.0Ω
d) 15.0Ω
e) 10.0Ω



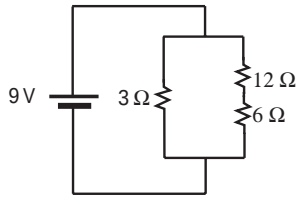
20. The capacitor shown in the circuit always starts initially charged. In the version shown, the current in the circuit takes a certain amount of time to reach $\frac{1}{e}$ of its initial value. Then the switch is opened, the 12Ω resistor is replaced by a 2.4Ω resistor, and the switch is closed again. The time it will take the current in the circuit to reach $\frac{1}{e}$ of its initial value is:

a) 10 times greater
b) halved
c) unchanged
d) doubled
e) tripled



21. What is the voltage drop across the 12Ω resistor in the figure?

a) $6V$
b) $1V$
c) $2V$
d) $4V$
e) $3V$

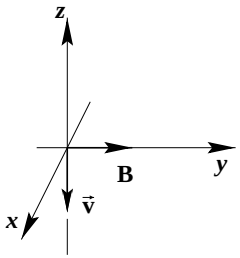


22. An electron is shot with a random direction into a region of uniform non-zero magnetic field and zero electric field. Its path will in general be

a) a parabola
b) a circle
c) a straight line
d) a helix
e) a hyperbola

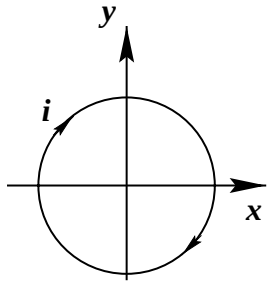
23. Consider an proton in a uniform magnetic field of magnitude 2 T in the $+y$ direction. When the velocity of the proton is 5×10^6 m/s in the $-z$ direction, the magnitude and direction of the magnetic force on the proton is

a) 3.2×10^{-12} N in the $+y$ direction
b) 1.6×10^{-12} N in the $-x$ direction
c) 1.6×10^{-12} N in the $+x$ direction
d) 3.2×10^{-12} N in the $-y$ direction
e) 9.7×10^{-12} N in the $-z$ direction



24. A 20 loop circular coil of radius 5.0 cm lies in the x-y plane in a uniform magnetic field of magnitude 0.80 T in the $+x$ direction. The current in the loop is 6.0 A (as shown in the figure). The magnitude of the torque acting on the coil is

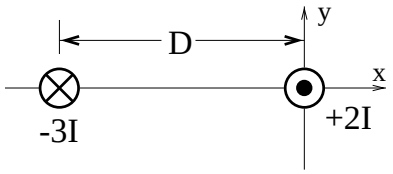
a) 0.94 N-m
b) 0.00 N-m
c) 0.75 N-m
d) 0.50 N-m
e) 0.25 N-m



The z-axis is coming out of the page.

25. At $x = 0$, a long straight wire carries current $2I$ **out** of the plane of the paper. At $x = -D$, another long straight wire carries current $3I$ **into** the plane of the paper. What is the direction of the force on the wire at $x = -D$?

a) none of the other answers
b) in the negative x-direction
c) in the positive y-direction
d) in the negative y-direction
e) in the positive x-direction



26. A long solenoid of 800 turns of wire is 30 cm in length. If it carries a current of 2.0 A, what is the magnetic field inside the solenoid at its center?

a) About 3.4 mT
b) About 1.0 mT
c) About 1.7 mT
d) About 6.7 mT
e) About 2.0 mT

27. Which of the following statements is **false**?

a) The magnetic force does zero work on a charged particle moving in a magnetic field.
b) The net magnetic flux through any closed surface is zero.
c) A current-carrying closed loop of wire in a constant, uniform magnetic field has zero net magnetic force on it.
d) If a comb is given a net electric charge by passing it through one's hair, it still won't be attracted to magnets at rest.
e) The magnetic torque on a current-carrying coil of wire has its maximum magnitude when the magnetic field is perpendicular to the plane of the coil.