Physics 227 - Second Common Hour Exam

28 October 2004

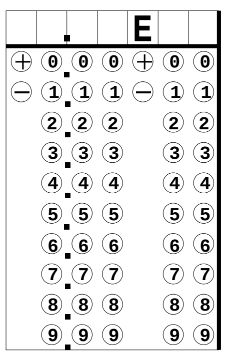
Profs. Shapiro and Schnetzer

⟹ Your name sticker with **exam code** ⟹

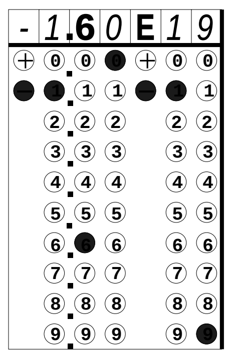
Your signature ______________________

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.



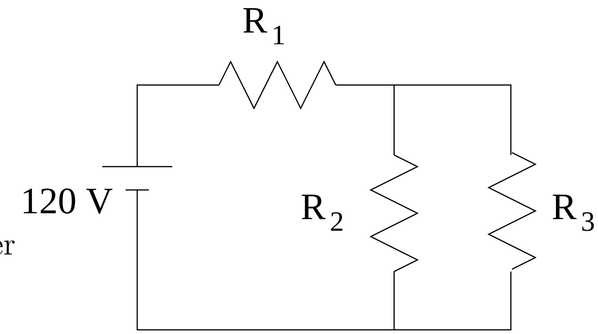
The electron's charge entered.

$-1.602176 \times 10^{-19}$ 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.

1. Three 40.0 Ω resistors are connected across a 60.0 V power source as shown in the figure. What is the power delivered to the resistor marked R_1?

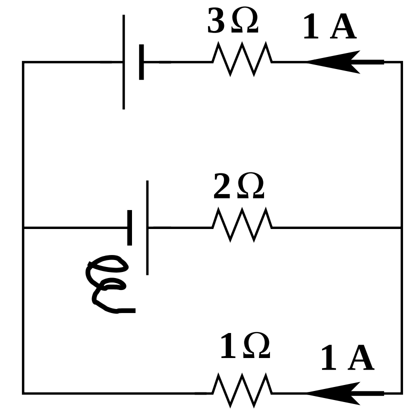


2. A parallel-plate capacitor has a plate area $A = 2.00$ m^2 and a plate separation $d = 2.00$ mm. If the capacitor is connected to a 12.0 V battery, how much electrical energy is stored in it?

3. A conducting rod of radius $r = 1.20$ mm and length $L = 5$ m carries a current of 300 A when a potential difference of $V = 6.00$ V is applied across the ends of the rod. What is the resistivity of the rod?

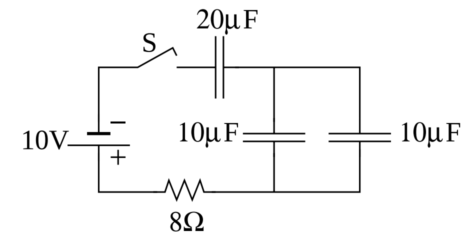
4. A rod of length $L = 3.00$ m lies along the x-axis with its left end at the origin. It has a **nonuniform** linear charge density (charge per unit length) $\lambda(x) = (2.00\ \mu\text{C/m}^2)\ x$. Taking the electric potential to be zero at infinity, what is the electric potential at the origin?

16. In the circuit shown, the Emf $\mathcal{E}$ of the lower battery is



a) 4 V
b) 5 V
c) 2 V
d) 3 V
e) 6 V

17. Consider the circuit shown. How long after the switch is closed will the current through the resistor reach $\frac{1}{e}$ of its initial value?



a) 2.4×10^{-4} sec
b) 1.2×10^{-5} sec
c) 3.2×10^{-4} sec
d) 2.0×10^{-4} sec
e) 8.0×10^{-5} sec

18. In our model of conductivity in ohmic metals, one feature is

a) the mean time between collisions is inversely proportional to the applied field.
b) the mean time between collisions is unaffected by the applied field.
c) the average speed of the electrons is proportional to the applied electric field.
d) the mean time between collisions is proportional to the applied electric field.
e) the mean time between collisions is inversely proportional to the drift velocity.

19. Two identical parallel plate capacitors, denoted (i) and (ii), of capacitance C are connected in parallel to a battery of voltage V. Capacitor (i) is then isolated from the battery while capacitor (ii) remains connected. The separation between the plates of each is doubled. If each capacitor initially stored energy U, the final energy stored by each, U_i and U_{ii}, is:

a) $U_i = U/2$; $U_{ii} = U/2$
b) $U_i = U/2$; $U_{ii} = 2U$
c) $U_i = 2U$; $U_{ii} = 2U$
d) $U_i = 2U$; $U_{ii} = U/2$
e) $U_i = U$; $U_{ii} = U$

20. The space between the plates of an uncharged parallel plate capacitor is initially filled with air ($\kappa = 1$). A battery is connected across the plates of this capacitor and, as a result, the potential difference across the plates becomes V_0 and each plate acquires a charge $\pm Q_0$. Keeping the battery connected, the space between the plates is completely filled with a dielectric ($\kappa = 2$) so that the potential difference becomes V, and the charge becomes $\pm Q$. After inserting the dielectric,

a) $V = V_0/2$
b) $Q = Q_0/2$
c) $V = 2V_0$
d) $Q = Q_0$
e) $Q = 2Q_0$

21. When two identical resistors are connected in series to a source of EMF, V_0, they draw power W_0. If the resistors instead are connected in parallel across V_0, the power drawn would be:

a) $\frac{1}{2}W_0$ b) $3W_0$ c) $4W_0$ d) $2W_0$ e) W_0

22. An electron moving in a plane perpendicular to a uniform magnetic field is observed to execute a circular orbit of radius 1 cm every 1 μs. What is the magnitude of the magnetic field?

a) (2.67×10^{-2}) T
b) (1.8×10^{-9}) T
c) 5 T
d) (3.6×10^{-5}) T
e) 3.31 T

23. A proton is moving in the negative x-direction. It enters a magnetic field, and the magnetic force on the proton is entirely in the positive z-direction. If the components of the magnetic field are $(B_x,\ B_y,\ B_z)$, which of the following is possible?

a) $B_x = 0; B_y < 0; B_z < 0$
b) $B_x = 0; B_y > 0; B_z = 0$
c) $B_x = 0; B_y < 0; B_z > 0$
d) $B_x > 0; B_y = 0; B_z = 0$
e) $B_x < 0; B_y < 0; B_z = 0$

24. An electron of charge $-e$ accelerates from rest from the negatively charged plate (surface charge density $-\sigma$) of a parallel plate capacitor to the positively charged plate (surface charge density $+\sigma$). The separation between the plates is d, and the area of each plate is A. What is the kinetic energy of the electron when it reaches the positively charged plate?

a) $\sigma e d/\epsilon_0$
b) $\sigma e/\epsilon_0 d$
c) $\sigma e d/2\epsilon_0$
d) $\sigma^2 A d/\epsilon_0$
e) $\sigma^2 A d/2\epsilon_0$

25. A 6.0 μF capacitor is charged to 50 V, and a 4.0 μF capacitor is charged to 30 V. The batteries are disconnected, and the two capacitors are connected to each other, with the two positive plates connected and the two negative plates connected. After they come to equilibrium, what is the final charge on the positive plate of the 6.0 μF capacitor?

a) 300 μC
b) 210 μC
c) 240 μC
d) 420 μC
e) 252 μC

26. Wires A and B are made of the same material, but the radius of wire A is twice that of B. The current in wire A is four times that in wire B. How are the drift speeds of charge carriers in the two wires related?

a) $v_A = 8v_B$
b) $v_A = 16v_B$
c) $v_A = 4v_B$
d) $v_A = 2v_B$
e) $v_A = v_B$

27. A 1.0m long horizontal wire carries a 3.0A current. Its mass is 0.01kg and the gravitational force on it is exactly balanced by the force from a horizontal magnetic field perpendicular to the wire. What is the magnitude of the magnetic field?

a) 0.33 T
b) none of the above.
c) 0.033 T
d) 33 T
e) 3.3 T

Some possibly useful information:
c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602×10^{-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
$k_e = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2$
$\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m/A}$
$g = 9.80 \text{ m/s}^2$
N_A = Avogadro's number = 6.022×10^{23} particles/mol
1 mHz = 10^{-3} Hz   1 kHz = 10^{+3} Hz
1 MHz = 10^{+6} Hz   1 GHz = 10^{+9} Hz
1 mC = 10^{-3} C   1 μC = 10^{-6} C
1 nC = 10^{-9} C   1 pC = 10^{-12} C