Physics 227 SECOND COMMON HOUR EXAM

Thursday, October 31, 2002

Profs. Shapiro and Devlin

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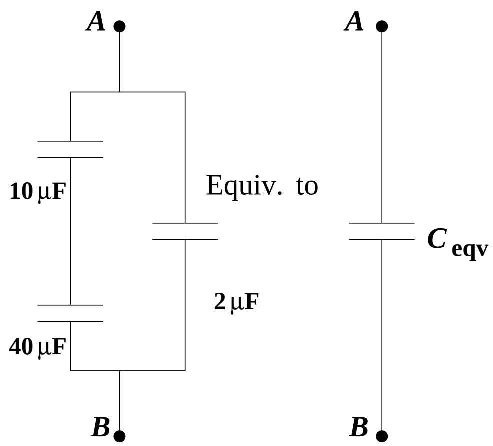
Your name sticker with **exam code**

18pt **Turn off and put away cell phones now!**

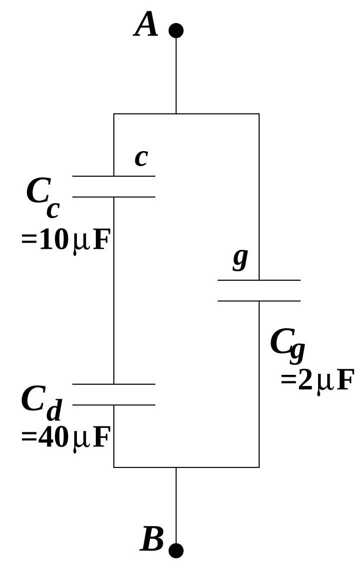
1. The exam will last from 8:00 - 9:20 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Social Security 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 one 8.5 x 11 inch sheet with formulas and notes.
7. There are 18 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 this cover page. Retain the rest of this exam for future reference and study.**
8. When you are asked to open the exam, make sure that your copy contains all 18 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 and have your student ID ready to show to the proctor during the exam.

1. Three capacitors are connected by conducting wires as shown. If any other circuitry were connected to the points A and B, the three together would act as an equivalent capacitor of capacitance C_{eqv}. What is C_{eqv}?



a) 2.13 μF
b) 52 μF
c) 1.6 μF
d) 1.92 μF
e) 10 μF

2. Three capacitors are connected by conducting wires as shown. Suppose A is connected to the positive terminal of a 12 V battery and B is connected to the negative terminal of that battery. What are the charges present at the plates c and g of the two capacitors, as shown

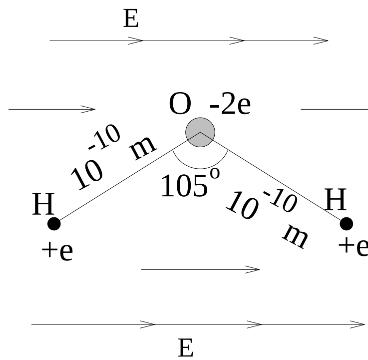


a) $Q_c = -24\,\mu$C, $Q_g = +24\,\mu$C
b) $Q_c = +120\,\mu$C, $Q_g = -24\,\mu$C
c) $Q_c = +96\,\mu$C, $Q_g = +24\,\mu$C
d) $Q_c = +120\,\mu$C, $Q_g = +24\,\mu$C
e) $Q_c = 0$, $Q_g = -24\,\mu$C

3. A parallel plate capacitor is charged by placing 90 V across the plates, and then isolated electrically. A dielectric is then inserted between the plates, and as a result the potential across the plates drops to 30 V. The energy of the system changes, due to the introduction of the dielectric

a) by increasing by a factor of 9
b) by increasing by a factor of 3
c) by decreasing by a factor of 3
d) by decreasing by a factor of 9
e) not at all — it stays the same

4. A water molecule as shown is in a region of uniform electric field $\mathbf{E} = 1000\hat{\imath}$ V/m. This molecule experiences



a) A counterclockwise torque
b) A net force to the right
c) A net force to the left
d) None of the above
e) A clockwise torque

5. The working element of a toaster is a nichrome wire which acts as a resistor. All other wires have negligible resistance. The toaster heats up the bread by consuming 1000 W of power when plugged into a DC voltage source of 110 V. What is the resistance of the nichrome wire?

a) 9.1 Ω
b) 12.1 Ω
c) $8.3 \times 10^{-2}\,\Omega$
d) $1.1 \times 10^{5}\,\Omega$
e) The information given is not sufficient — we need to be given the current drawn as well.

6. A cylindrical copper wire (resistivity = $1.70 \times 10^{-8}\,\Omega \cdot \text{m}$) with a diameter of 1×10^{-3} m and 0.01 m long is used to connect two points on a printed circuit board at room temperature. If the current in the wire is 10 mA, what is the potential drop across the wire?

a) 2.16 mV
b) 2.16 μV
c) 5.4 μV
d) 5.4 mV
e) 0.54 μV

7. A potential difference V is applied to a copper wire of diameter d. If d is doubled (keeping ℓ and the applied potential difference V unchanged) the drift velocity of the electrons is multiplied by

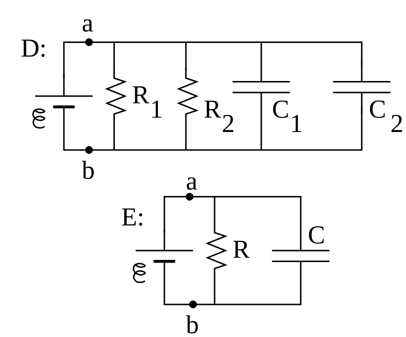
a) 4
b) 2
c) 0.5
d) 0.25
e) 1

8. A toaster with a nichrome heating element draws an initial current of 1.5 A at T = 20°C from a constant 120 V source. When the heating element reaches it's final temperature, it draws 1.13 A. What is the final temperature of the heating element? (note α_{nichrome}=0.4×10^{-3} K^{-1}).

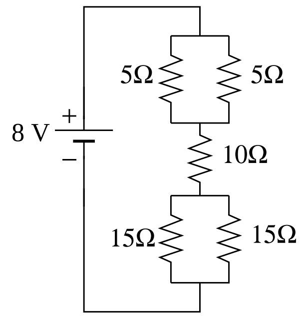
a) 110°C
b) 35°C
c) 1100°C
d) 840°C
e) 515°C

9. The circuit D will be equivalent to the circuit E if

a) $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{C_1} + \dfrac{1}{C_2}$, $C = R_1 + R_2 + C_1 + C_2$
b) $R = \dfrac{R_1 R_2}{R_1 + R_2}$, $C = C_1 + C_2$
c) $R = \dfrac{R_1 R_2}{R_1 + R_2}$, $C = \dfrac{C_1 C_2}{C_1 + C_2}$
d) $R = R_1 + R_2$, $C = \dfrac{C_1 C_2}{C_1 + C_2}$
e) $R = R_1 + R_2$, $C = C_1 + C_2$

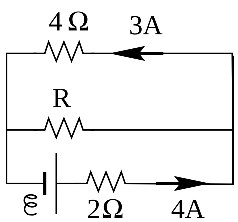


10. In the circuit shown, what is the current through the 10 Ω resistor?



a) 0.2A
b) 0.8A
c) 10A
d) 0.4A
e) 20A

11. What is the EMF of the battery? Assume zero internal resistance for the battery.



a) 4 V
b) 8 V
c) None of the other answers.
d) 20 V
e) 12 V

12. The wattage rating of a light bulb indicates the power dissipated by the bulb if it is place across a 110V DC potential difference. If a 50W bulb and 100W bulb are connected in series to a 110V DC source, how much power will be dissipated in the 50W bulb?

a) 50W b) 22W c) 0 d) 100W e) 11W

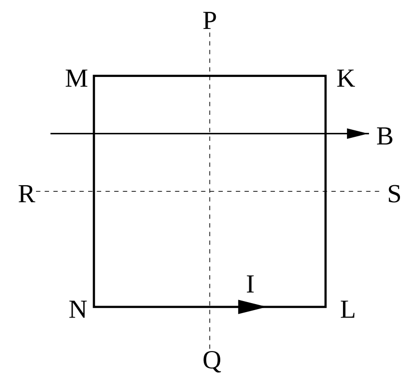
13. A Cs^- ion ($q = -e$) with velocity $\vec{v} = v_0\hat{\imath}$ encounters a uniform magnetic field given by $\vec{B} = B_0\hat{\jmath}$. The force exerted on this ion when it first encounters the field is:

a) $\vec{F} = -(ev_0B_0)\hat{\imath}$
b) $\vec{F} = (v_0B_0/e)\hat{k}$
c) $\vec{F} = -(ev_0B_0)\hat{\jmath}$
d) $\vec{F} = -(ev_0B_0)\hat{k}$
e) $\vec{F} = (ev_0B_0)\hat{\jmath}$

Note: $\hat{\imath}$, $\hat{\jmath}$, and $\hat{k}$ are unit vectors in the x, y, and z directions, respectively.

14. A square loop of wire lies in the plane of the page and carries a current I as shown. There is a uniform magnetic field $\vec{B}$ parallel to the side MK as indicated. The loop will tend to rotate:

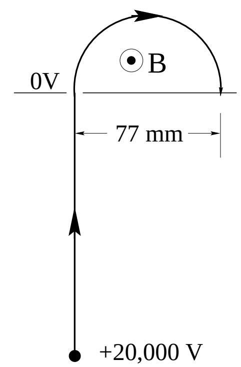
a) about RS with MK coming out of the page
b) about RS with MK going into the page
c) about an axis perpendicular to the page
d) about PQ with KL coming out of the page
e) about PQ with KL going into the page



15. An electron and a proton in the same uniform magnetic field trace out circles of the same radius, one clockwise and the other counterclockwise. What is the ratio of electron to proton momentum?

a) It depends on the magnetic field.
b) 1
c) (5.4×10^{-4})
d) It depends on the radius of the circle.
e) 1840

16. An ion is produced at rest from the filament of a vacuum tube which is at an electric potential of +20,000 V, relative to ground. It accelerates in the y direction towards a cathode, which is grounded, and then passes through the cathode into a region with a uniform magnetic field of 0.75 T in the z direction. In this region it makes a semicircular path of diameter 0.077 m. The ion is

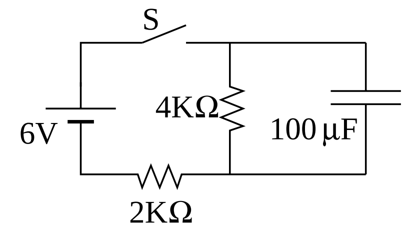


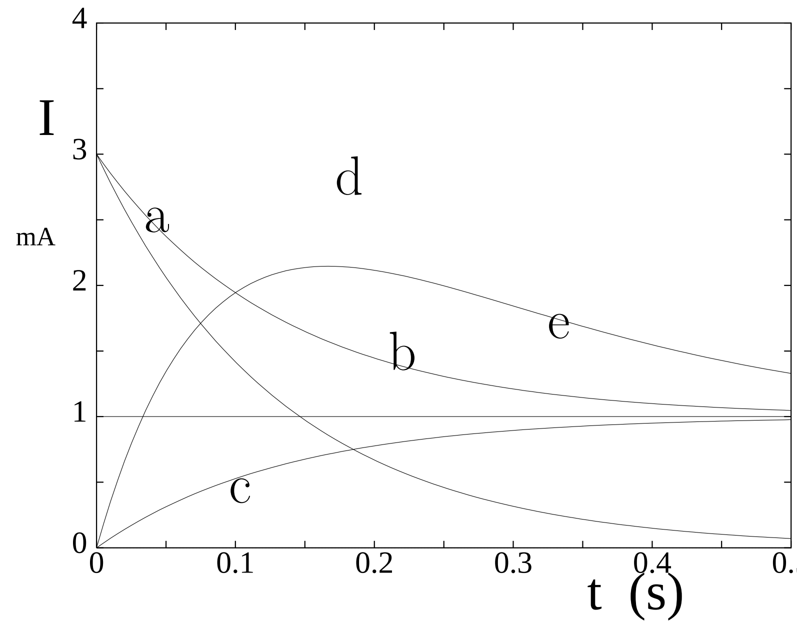
a) a singly ionized Beryllium atom, mass $\sim 8m_p$, charge $+e$
b) a doubly ionized Beryllium atom, mass $\sim 8m_p$, charge $+2e$
c) a proton, mass m_p, charge $+e$
d) a deuteron, mass $\sim 2m_p$, charge $+e$
e) a singly ionized Helium atom, mass $\sim 4m_p$, charge $+e$

17. In the Hall effect, we have a current flowing in the presence of a uniform magnetic field, and we get a potential difference across the conductor. The reason is

a) the charges in the wire are moving, so the electric fields are changing with time.
b) a changing magnetic field produces an induced EMF.
c) charges are bent from their paths until an electric field can be built up transverse to the wire, to stop them from bending.
d) the charges produced by the current repell each other, and produce a build up of charge on the surface of the conductor.
e) the conductor is not a perfect one, so there must be an electric field proportional to the current and the resistivity.

18. In the circuit shown, the switch had been open a long time, and there was no current flowing and no charge on the capacitor. Then, at time $t = 0$, the switch S was closed. Which graph correctly gives the current through the 2 KΩ resistor as a function of time after the switch is closed.





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
$k_e = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$
$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$
$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$
$g = 9.80\ \mathrm{m/s^2}$
1 mC = 10^{-3} C 1 μC = 10^{-6} C 1 nC = 10^{-9} C

$\text{pC} = 10^{-12}\ \text{C}$