Physics 214/224, Practice Quiz 2

Primary instructor: Yurii Maravin

WID:_____ NAME:_____

Instructions. Print and sign your name on this quiz and on your scantron card. In doing so, you are acknowledging the KSU Honor Code: "On my honor as a student I have neither given nor received unauthorized aid on this academic work."

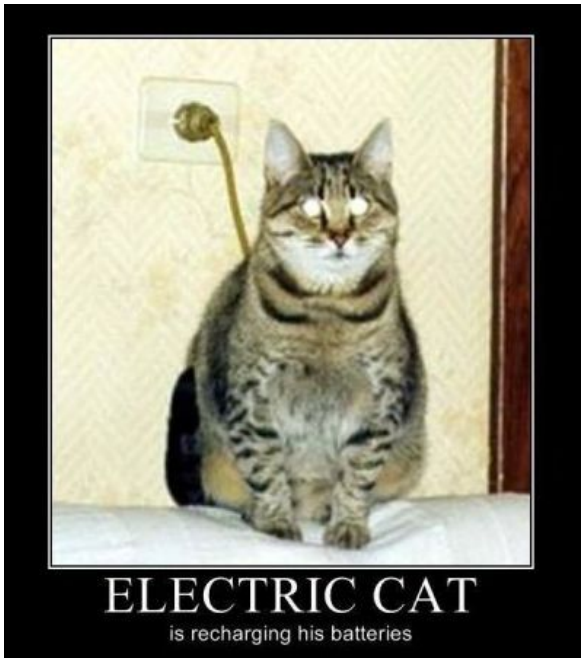
For two quick points, circle your studio instructor:

Lohman (TU 7:30) Washburn (TU 9:30) Maravin (TU 9:30)

Maravin (TU 11:30) Lohman (TU 1:30) Washburn (TU 3:30)

Lohman (WF 7:30) Rodnova (WF 9:30) Rodnova (WF 11:30)

Work alone and answer all questions. Part I questions must be answered on the Scantron cards. Put your name on your card. Color in the correct box completely for every answer with a pencil. If you make a mistake, erase thoroughly. **Don't forget to color in the boxes for your WID. If we have to correct this by hand we may take off five points from your score!** Part II must be answered in the space provided on the test. The last page is a detachable equation sheet. You may use a calculator. You may ask the proctors questions of clarification. Show your work in a clear and organized manner. You may receive partial credit for partial solutions. Solutions lacking supporting calculations will receive no points.



Part I: All questions to be answered on your Scantron card (42 points total)

1. (3 points) Equipotential surfaces are the surfaces
   (a) with the same potential
   (b) the same electric field strength
   (c) the same charges

2. (3 points) The potential difference between two points is 100 V. If a particle with a charge 2 C is transported from one of these points to the other, the magnitude of the work done is:
   (a) 2 J
   (b) 50 J
   (c) 100 V
   (d) 200 J
   (e) 100 J

3. (3 points) A parallel-plate capacitor C has a charge Q. The actual charges on its plates are
   (a) Q, Q
   (b) $Q/2$, $Q/2$
   (c) Q, $-Q$
   (d) Q, 0
   (e) $Q/2$, $Q/2$

4. (3 points) A car battery is rated at 80 $\mathrm{A} \cdot \mathrm{h}$. An ampere-hour is a unit of:
   (a) power
   (b) charge
   (c) current
   (d) force
   (e) energy

5. (3 points) In schematic diagrams, currents are indicated using arrows. What do the arrows indicate?
   (a) the direction of motion of the electrons
   (b) the direction that positive charge carriers would move
   (c) the direction of motion of the charge carriers
   (d) nothing, they are just a convenient drawing tool

6. (3 points) A wire with a length of 150 m and a radius of 0.15 mm carries a current with a uniform current density of 2.8×10^7 A/m^2. The current is:

   (a) 300 A
   (b) 5.9 A
   (c) 0.63 A
   (d) 26000 A
   (e) 2.0 A

7. (3 points) Lightbulb A, a 60W model, and lightbulb B, a 40W model, are connected in parallel across a 120V power supply. Which statement below is *false*

   (a) The voltage difference across lightbulb B is 120V
   (b) More current flows through the battery than through lightbulb B
   (c) Lightbulb B has a higher resistance than lightbulb A
   (d) Less current flows through lightbulb A than lightbulb B

8. (3 points) Five cylindrical wires are made of the same material. Their lengths and radii are the following.

Wire number	Length	Radius
1	ℓ	r
2	$3\ell/2$	$r/2$
3	$\ell/2$	$r/2$
4	ℓ	$r/2$
5	5ℓ	$r/2$

   Rank the wires according to their resistances, least to greatest.

   (a) 1, 2, 3, 4, 5
   (b) 1 and 2 tie, then 5, 3, 4
   (c) 5, 4, 3, 2, 1
   (d) 1, 3, 4, 2, 5
   (e) 1, 2, 3, 4, 5

9. (3 points) The internal resistance in a real battery causes what to happen when the battery is connected to a resistive "load"? (Pick the best answer)

   (a) The voltage across the battery terminals decreases when the battery is connected to low resistance loads.
   (b) The battery warms when connected to low resistance loads.
   (c) The current supplied by the battery falls to less than the nominal battery voltage divided by the load resistance
   (d) All of the above

10. (3 points) A capacitor is being discharged through a resistance 10 Ω. In about 10 seconds, the voltage on the capacitor changed from 10 V to about 3.3 V. What is the capacitance of the capacitor?

    (a) 1 pF
    (b) 1 nF
    (c) 1 μF
    (d) 1 mF
    (e) 1 F

The next four questions refer to the following figure below. The solid lines in the figure above represent high conductivity copper wire. The left capacitor has $C_L = 0.1$ μF, the right capacitor has $C_R = 0.22$ μF, and the battery establishes a voltage difference $V = 9$ V between its terminals.

11. (3 points) Which statement below is most correct?

    (a) The two capacitors store the same charge
    (b) The two capacitors have the same ratio of charge to voltage across their leads
    (c) The two capacitors have the same voltage between their leads
    (d) The two capacitors store the same energy

12. (3 points) What is the total energy stored in the two capacitors?

    (a) 9.0 V
    (b) 13.0 μJ
    (c) 4.05 μJ
    (d) 8.91 μJ

13. (3 points) How much charge do the two capacitors together store?

    (a) 0.90 μC
    (b) 1.98 μC
    (c) 2.88 μC

(d) 1.44 μC

14. (3 points) What is the absolute voltage difference between the two leads of the 0.1 μF capacitor C_L?

    (a) 0.0 V

    (b) 2.8 V

    (c) 6.2 V

    (d) 9.0 V

Part II: Work out this part in the space provided. Show your work! (56 points total)

15. (12 points) You have the following at your disposal: a box of twelve 9V batteries, a box of forty 1000 Ω resistors, and a box of forty 1 μF capacitors. Draw clear diagrams to indicate how you would connect parts together to make the following (you need not use all the available parts):

    (a) (4 points) A 3500 Ω resistor

    (b) (4 points) A 0.15 μF capacitor

    (c) (4 points) A 36 V battery

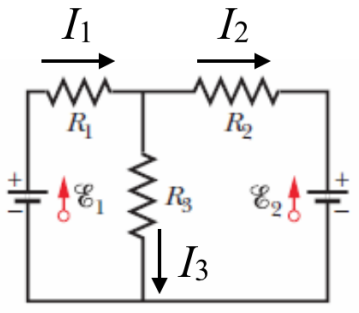
16. (16 points) Consider a charged conducting sphere of radius R that has an electric field on the surface E_0.

(a) (4 points) Determine the electric charge of the sphere.

(b) (4 points) Assuming the electric potential is zero at infinity, what is the electric potential on the surface of the sphere?

(c) (4 points) What is the capacitance of this sphere?

(d) (4 points) How much of energy is stored in this sphere? (*Hint: A single sphere can be approximated as a capacitor, with capacitance derived above.*)

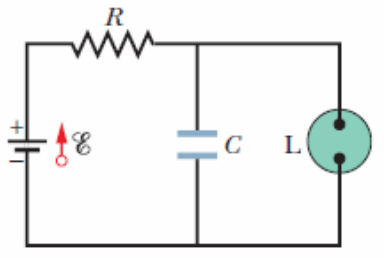


17. (16 points) Call I_1, I_2, and I_3 the current flowing through the resistors labeled R_1, R_2, and R_3, respectively. To help the graders out, use the directions of the currents shown in the figure.

    (a) (8 points) Deduce three independent equations for three unknown currents. Use the symbolic values for resistances and voltages.

    (b) (4 points) Take $\mathcal{E}_1 = 10$ V, $\mathcal{E}_2 = 20$ V, $R_1 = R_2 = 1000\ \Omega$, $R_3 = 10^6\ \Omega$. Solve for the currents. You can solve your equations from part (a) for this, but if you can see a simpler path to a very good estimate of the exact answer, use it, explaining whatever approximation you make in one sentence. (*Hint: Wow, R_3 is a very big resistance!*)

    (c) (4 points) Do the same thing for the case $R_1 = R_3 = 1000\ \Omega$ and $R_2 = 1\ \Omega$, with the voltages on batteries being the same as above. (*Hint: R_2 is very small! What can you tell about the voltage difference across R_3?*)



18. (12 points) The figure above shows the circuit of a flashing lamp, like those attached to barrels at highway construction sites. The fluorescent lamp L (of negligible capacitance) is connected in parallel across the capacitor C of the RC circuit. There is a current through the lamp only when the potential difference across it reaches the breakdown voltage V_{L}; then the capacitor discharges completely through the lamp and the lamp flashes briefly.

    (a) (4 points) For a lamp with breakdown voltage $V_{\mathrm{L}} = 62$ V wired to a 100 V ideal battery, and a 0.25 μF capacitor what resistance R is needed for the flashes to happen twice per second? (*Hint: A capacitor charges to 62% of its final voltage in time* τ_{RC})

    (b) (4 points) How much of energy will be delivered to the fluorescent lamp in each flash (assume all the energy of the capacitor will go to the lamp).

    (c) (4 points) Estimate how long does it take for the capacitor to almost fully discharge through the lamp, if the lamp resistance is about 100 Ω?