USNA Physics Department

LCDR Shivok’s SP212

2016 Second Exam PRACTICE VERSION

Chapters 25 → 27 (with infinitesimal review)


If you use these problems to help you determine the areas in which you are weak, I believe they will help you prepare for the Second Examination. DO NOT confine your study to just these problems. This is a REVIEW PROBLEM exercise, NOT an all encompassing gouge!

Exam II Breakdown

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| Chapter 27         | 4         | 24     |
| Total part b       |           | 24     |
Chapter 25 (19 points)

1. **(4 points)** Figure below shows a simple circuit of a parallel-plate capacitor of plate area \( A = 6.40 \times 10^{-5} \text{ m}^2 \) and plate separation \( d = 0.300 \text{ mm} \). The battery has a potential difference of \( V = 12.0 \text{ V} \). We move a slab of porcelain (dielectric constant \( \kappa = 6.50 \)) into the capacitor’s gap, filling it. What are the following initially and after the porcelain is in place: capacitance, plate potential difference, plate charge, and electric field magnitude between the plates?

![Simple Circuit Diagram](image)

Show all work:

2. **(3 points)** Figure below shows a capacitor with a layer of paper (dielectric constant \( \kappa_{\text{die}} = 3.50 \) and thickness \( d_{\text{die}} = 2.00 \text{ mm} \)) and a layer of air (dielectric constant \( \kappa_{\text{a}} = 1.00 \) and thickness \( d_{\text{air}} = 5.00 \text{ mm} \)). The plate area is \( A = 4.00 \times 10^{-4} \text{ m}^2 \). **What is the capacitance?**

![Capacitor Diagram](image)

Show all work:
3. (5 points) In Figure below, a 20.0 V battery is connected across capacitors of capacitances $C_1 = C_6 = 3.00 \mu F$ and $C_3 = C_5 = 2.00 \times C_2 = 2.00 \times C_4 = 4.00 \mu F$. What are (a) the equivalent capacitance $C_{eq}$ of the capacitors and (b) the charge stored by $C_{eq}$? What are (c) $V_1$ and (d) $q_1$ of capacitor 1, (e) $V_2$ and (f) $q_2$ of capacitor 2, and (g) $V_3$ and (h) $q_3$ of capacitor 3?

Show all work:
4. **(3 points)** Figure below shows an isolated metallic sphere of radius $R = 0.800$ cm and having charge $q = 3.0$ fC. The sphere is an isolated spherical capacitor. That is, it is one plate of the capacitor and the environment is the other plate. **How much energy $U$ is stored in the electric field from radial distance $r_1 = R = 0.800$ cm to $r_2 = 1.40$ cm?**

Show all work:
5. **(4 points)** Figure below shows a circuit section of four air-filled capacitors that is connected to a larger circuit. The graph below the section shows the electric potential $V(x)$ as a function of position $x$ along the lower part of the section, through capacitor 4. Similarly, the graph above the section shows the electric potential $V(x)$ as a function of position $x$ along the upper part of the section, through capacitors 1, 2, and 3. Capacitor 3 has a capacitance of 0.80 μF. **What are the capacitances of (a) capacitor 1 and (b) capacitor 2?**

Show all work:
6. **(2 points)** Figure \(a\) gives the magnitude \(E(x)\) of the electric fields that have been set up by a battery along a resistive rod of length 9.00 mm (Fig. \(b\)). The vertical scale is set by \[ E_x = 4.00 \times 10^3 \frac{V}{m} \]. The rod consists of three sections of the same material but with different radii. (The schematic diagram of Fig. \(b\) does not indicate the different radii.)

The radius of section 3 is 2.00 mm. **What is the radius of section 2?**

![Figure a and b](image)

A) 1.39 mm  
B) 1.22 mm  
C) 1.55 mm  
D) 1.69 mm  
E) 2.54 mm  

Show all work:

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7. **(1 point)** Figure below gives the electric potential \(V(x)\) along a copper wire carrying uniform current, from a point of higher potential \(V_s = 12.0 \mu V\) at \(x = 0\) to a point of zero potential at \(x_s = 3.00 \text{ m}\). The wire has a radius of 2.00 mm. **What is the current in the wire?**

![Figure](image)

A) 2.97 A  
B) 2.97\times10^{-1} A  
C) 2.97\times10^{-4}A  
D) 2.97 mA  
E) None of the above  

Show all work:
8. (2 points) A cylindrical metal rod is 1.60 m long and 5.50 mm in diameter. The resistance between its two ends (at 20°C) is $1.09 \times 10^{-3} \, \Omega$. (a) What is the material? (b) A round disk, 2.00 cm in diameter and 1.00 mm thick, is formed of the same material. What is the resistance between the round faces, assuming that each face is an equipotential surface?

Show all work:
Chapter 27 (24 points)

9. (2 points) Figure below (a) shows two ideal batteries with emfs $\xi_1 = 12.0 \text{ V}$ and $\xi_2 = 4.0 \text{ V}$, connected to a resistor of resistance $R = 2.0 \text{ } \Omega$. **What are the terminal-to-terminal potentials across battery 1 and battery 2? Are the batteries supplying or absorbing energy, and at what rate?**

[Diagram of two batteries connected in series to a resistor]

**Show all work:**

10. (2 points) Figure Below (a) shows part of a circuit in which a current of $i = 2.20 \text{ A}$ enters and leaves an arrangement of three parallel resistors ($R_1 = 2.0 \text{ } \Omega$, $R_2 = 4.0 \text{ } \Omega$, and $R_3 = 6.0 \text{ } \Omega$). **What is the current through resistor 2?**

[Diagram of three parallel resistors with current i entering and leaving]

A) $6.00 \times 10^{-2} \text{ A}$  
B) $6.00 \times 10^{-1} \text{ A}$  
C) $6.25 \times 10^{-4} \text{ A}$  
D) $6.13 \times 10^{-5} \text{ A}$  
E) None of the above

**Show all work:**
11. (11 points) Given the following circuit with \( R_1 = R_4 = 5\,\Omega \), \( R_2 = R_5 = 10\,\Omega \), \( R_3 = 20\,\Omega \), \( \mathcal{E}_1 = 5\,\text{V} \), \( \mathcal{E}_2 = 10\,\text{V} \), \( \mathcal{E}_3 = 14\,\text{V} \). The current going through battery 1 is \( i_1 \); the current going through battery 2 is \( i_2 \); the current going through battery 3 is \( i_3 \). Determine the magnitude and direction of the current through each of the batteries.

(Note: for ease of finding partial credit (if needed) start your KVL's from points A and/or B and show the path you took.)

Show all work:
12. **(2 points)** Figure below shows a resistor of resistance \( R = 20 \, \Omega \) and a capacitor of capacitance \( C = 30 \, \mu \text{F} \). The capacitor initially has charge \( q_0 = 360 \, \mu \text{C} \).

The switch is closed at time \( t = 0 \). At \( t = 1.0 \, \text{ms} \), what are \( q \), \( V \), and \( i \)?

![Resistor and Capacitor Diagram]

Show all work:

13. **(3 points)** Consider the circuit shown below. The switch has been in position 1 for a long time. At \( t = 0 \) the switch is moved to position 2. At \( t = 4.0 \, \text{s} \), the charge on the capacitor is closest to:

A) 0.88 C  
B) 2.1 C  
C) 3.5 C  
D) 4.6 C  
E) None of the above

Show all work:
14. (2 points) For the resistor network shown below, the equivalent resistance between points a and b is closest to:

A) 1.0 Ω.
B) 2.0 Ω.
C) 7.0 Ω.
D) 4.0 Ω.
E) 3.0 Ω.

15. (2 points) In the diagram, the current in the 2-Ω resistor is 6 A. What is the potential difference between points 1 and 2?

Show ALL work:
16. **(4 points)** Suppose that a $-2.0$ C charge is in a region of space where the electric potential is given by $V = (4y^2 + 6)$ volts. As the $-2.0$ C charge moves from a point at $y = 1.0$ m to a point at $y = 2.0$ m, the electric potential energy of the charge

A. does not change.
B. increases by 24 J.
C. increases by 36 J.
D. decreases by 24 J.
E. decreases by 36 J.

*Show all work:* 

Show all work:
17. **(6 points)** Figure (a) shows a rod with a uniformly distributed charge \( Q = 2.00 \text{ fC} \) and length \( L = 12.00 \text{ cm} \). It symmetrically straddles the \( y \) axis.

**Set up the integral required to find the net electric field at point \( P \),** which is at distance \( D = 3.00 \text{ cm} \) on the **perpendicular bisector** (here, the \( y \) axis).

**(DO NOT TRY TO SOLVE THE INTEGRAL, only setup!)**

**Ensure your answer includes the terms of \( Q \) and \( L \) though!**

Show all work:
18. (2 points) Imagine a simple deuterium (isotope 2H, also known as heavy hydrogen) atom, if the electron undergoes uniform circular motion around a fixed nucleus, containing one proton and one neutron, at an equidistant radius of $0.529 \times 10^{-10}$m.

a) What is the force vector on the electron at the position drawn?

Show all work:

b) What is the required speed of the electron?

Show all work:
Make sure you showed all your work for all problems! Do the idiot check on your math… Does 50 – 30 = 20 or did you fat finger the calculator?