# Exam 2

P208 Fall 2009,  
Instructor: Prof. Abanov  
10/12/09

Name__________________  Section______________  
(print)

<table>
<thead>
<tr>
<th>Section</th>
<th>Instructor</th>
<th>Time</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>501</td>
<td>Fuller, Melissa</td>
<td>Tues, 2:20-5:10</td>
<td>516 Li, Feng</td>
</tr>
<tr>
<td>502</td>
<td>Mahony, James</td>
<td>Tues, 3:55-6:45</td>
<td>517 Amin, Vivek</td>
</tr>
<tr>
<td>503</td>
<td>Chen, Jason</td>
<td>Tues, 4:55-7:45</td>
<td>518 Chen, Jason</td>
</tr>
<tr>
<td>504</td>
<td>Ferguson, Jim</td>
<td>Tues, 5:55-8:45</td>
<td>519 Russell, Charles</td>
</tr>
<tr>
<td>505</td>
<td>Zhang, Xiwen</td>
<td>Tues, 6:55-9:55</td>
<td>520 Zhang, Xiwen</td>
</tr>
</tbody>
</table>
Problem 1.

A parallel plate air capacitor is made using square \( L \text{ by } L \) plates. The distance between the plates is \( d \). A metal slab having thickness \( a \ (a<d) \) and the same shape as the plates is inserted in the middle between the plates as shown on the figure.

What is the capacitance of this capacitor without the slab? ____________

What is the capacitance of this arrangement with the slab? ____________

How will the capacitance change if we move the slab up or down (without touching the plates)? ____________

How will the capacitance change if we move the slab a distance \( x \) to the right? _____

Or to the left? _______
Problem 2.

A parallel plate air capacitor is made using square $L$ by $L$ plates. The distance between the plates is $d$. A metal slab having thickness $a$ ($a<d$) and the same shape as the plates is inserted in the middle between the plates as shown on the figure. The capacitor is connected to the battery with emf $V$.

What is the charge on the capacitor without the slab?________

What is the charge on the plates when the slab is inserted?________

What will the charge on the plates be if you move the slab the distance $x$ to the right?________

What is the total work done by the battery after you have moved the slab?________

What is the change of the energy stored in the capacitor?________

What is the total work done by YOU after you have moved the slab?________

What is the minimal force you have to apply to the slab in order move it?________
Problem 3.

In the figure $C_1 = C_4 = 6 \mu F$ and $C_2 = C_3 = 3 \mu F$. The potential difference between points $a$ and $b$ is kept $V_{ab} = 3V$ by a battery.

What is the charge on each capacitor? $C_1$, $C_2$, $C_3$, $C_4$.

What is the potential difference between points $a$ and $c$, $V_{ac}$?

What is the potential difference between points $a$ and $d$, $V_{ad}$?

What is the potential difference between points $c$ and $d$, $V_{cd}$?
Problem 4.

A current $I = 1.6\, \text{A}$ is in a copper wire (resistivity $\rho = 1.7 \times 10^{-8} \, \Omega \cdot \text{m}$) with cross section area $A = 5.88 \times 10^{-7} \, \text{m}^2$ and length $L = 100\, \text{m}$.

What is the resistance of the wire?_______

How many electrons are crossing a cross section of the wire each second?_______

What is the current density in the wire?_______

What is the magnitude of the electric field in the wire?_______

What is the potential difference between the ends of the wire?_______
Problem 5.
A battery with $E=12\,\text{V}$ and internal resistance $r=3\,\text{k}\Omega$ is connected to a simple circuit with a total resistance of $R=9\,\text{k}\Omega$.

What is the current through the battery?_____

What is the potential difference between the battery's terminals?_____

How much power does the battery supply to the simple circuit?_____

How much power dissipates inside the battery?______
Problem 6.
You have a meter with resistance 30\,\Omega and full-scale current \( I_{fs} = 1\,mA \).

Design an ammeter with a range 0 to 50mA (draw schematics and calculate the resistance of the shunt resistor).

What is the total resistance of your ammeter?_________
Problem 7.

In the circuit shown in the picture

\[ E = 12 \text{V}, \quad R_1 = 2k \Omega, \quad R_2 = 1k \Omega, \quad R_3 = 2k \Omega, \quad R_4 = 2k \Omega, \quad R_5 = 4k \Omega. \]

What is the potential difference between points \( a \) and \( b \) ________

What is the current at point \( a \) of the circuit?______

What is the current at point \( c \) ?_______

What is the current at point \( d \) ?_______

What is the potential difference between points \( c \) and \( d \) ?_______
Problem 8.

In the circuit shown in the figure  \( R_1 = 1k \Omega \),  \( R_2 = 4k \Omega \),  \( R_3 = 3k \Omega \),  \( I_2 = 4mA \), and  \( I_3 = 6mA \) (directions of  \( I_2 \) and  \( I_3 \) are shown).

What is the magnitude and direction (show in the figure) of the current  \( I_1 \)?

What is the value of the emf  \( E_1 \)?

What is  \( E_2 \)?
Problem 9.
In the circuit shown in the figure \( E=12 \, V \), \( r=2k \, \Omega \), \( R=4k \, \Omega \), and \( C=4 \mu F \). Initially the capacitor is uncharged. The switch is closed at moment \( t_0 \).

What is the current in point “a” immediately after \( t_0 \) ?

What is the current in point “a” after a very long time?  

What is the charge on the capacitor \( C \) long after time \( t_0 \)?  

Problem 10.

In the circuit shown on the figure $R_1 = 3k \, \Omega$, $R_2 = 9k \, \Omega$, and $R_3 = 5k \, \Omega$.

What is the necessary value of $R_4$ such that the potential difference between points $a$ and $b$ is 0?________

For $R_4$ which you calculated before what will be the current through a $12k \, \Omega$ resistor placed between the points $a$ and $b$?________
Extra Problems.

Please take this page with you. You have all the time till the final exam to solve these problems. The first student who solves one of the problems will get 5 bonus points for this exam.

Extra Problem 1.
The capacitance of each capacitor of the infinite series shown in the picture is $C=1\mu F$. Find the total capacitance between points $a$ and $b$.

Extra Problem 2.
An infinite square lattice is made of identical capacitors of capacitance $C=1\mu F$. Find the capacitance between nearest neighbor vertices $a$ and $b$. 

...