

# Workbook



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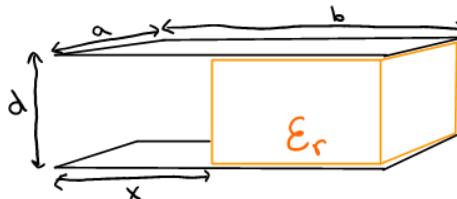
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# Capacitors

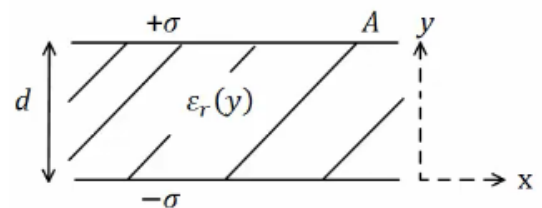
## Capacitors

### Questions

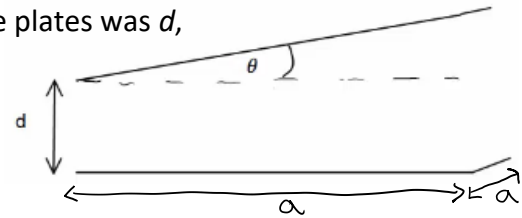
- 1) A cylindrical capacitor is given. Its length is  $L$ , its inner radius is  $a$  and its outer radius is  $b$ .
  - a. Calculate the capacitance.
  - b. Now two dielectric materials are put in between the plates.  $k_1$  is between  $a$  and  $d$ ,  $k_2$  is from  $d$  until  $b$ . Calculate the capacitance.
  - c. A dielectric material is inserted between the plates. Its constant is dependent on the radius,  $k(r) = k_0 \frac{r}{b}$ . Calculate the capacitance in this case.
  - d. We return to the case with the two dielectric materials (from Q2). Calculate the surface area charge distribution.
  
- 2) We are given the following capacitor. The plate length is  $b$ , the plate width is  $a$ , and the distance between the plates is  $d$ . A distance  $x$  away from the left edge of the capacitor a dielectric material of constant  $\epsilon_r$  is inserted.
  - a. Calculate the capacitance of the capacitor.
  - b. A voltage source  $V_0$  is connected. Calculate the charge distribution on capacitor's plates.



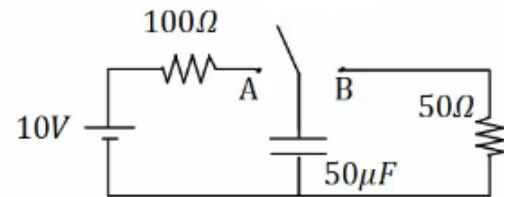
- 3) A parallel plate capacitor is charged with  $\pm\sigma$ . The area of the plates is  $A$ , and the distance between the two plates is  $d$ . A dielectric material is placed between the plates. Its dielectric constant is dependent on  $y$  and is given by  $\epsilon_r(y) = 1 + \left(\frac{y}{d}\right)^2$ . The lower plate is located at  $y = 0$ . Calculate the capacitance.



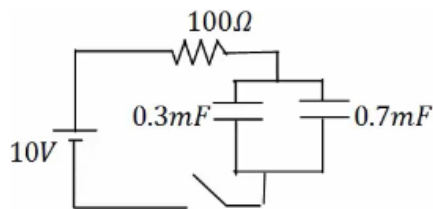
- 4) A parallel plate capacitor was partially deformed at production. Each plate is of length and width  $a$ . The distance between the plates was  $d$ , but now the upper plate has a deviation of  $\theta$ , where  $\theta \ll \pi$ . What is the capacitance of this capacitor as a function of  $\theta$ ? What is the charge distribution,  $\sigma$ , on the capacitor's plates?



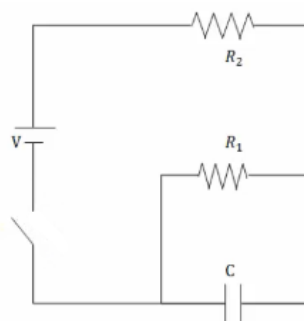
- 5) At  $t=0$  the switch is switched to point A. At  $t=0.01$  the switch is switched to point B.
- What is the voltage across the capacitor as a function of time?
  - What is the charge on the capacitor at  $t=0.02$ ?
  - What is the current as a function of time?
  - Draw graphs representing the current, and voltage as a function of time.



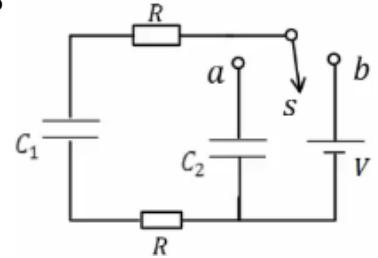
- 6) In the following circuit, at  $t=0$ , the switch is closed.
- What is the RC time constant for this circuit?
  - Calculate the voltage and charge on each capacitor at times  $t=0.2s$  and  $t=0.8s$ .



- 7) In the following circuit, at  $t=0$ , the capacitor has no charge and the switch is closed. Calculate the charge on the capacitor and the current in each resistor as a function of time. We are given  $V, R_1, R_2, C$ .



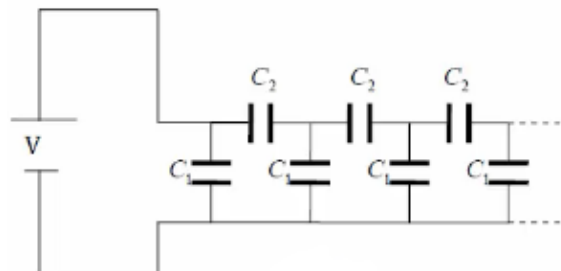
- 8) In the following circuit, capacitor  $C_1$  is charged with charge  $Q_0$ , before the switch is switched to  $a$ .
- Write an equation which can be solved to give us the charge on  $C_1$  as a function of time.
  - Solve the equation and calculate the charge on each capacitor as a function of time.
  - What are the currents through each resistor, as a function of time?



- 9) Two spheres of radii  $a$  and  $b$  are placed far apart, and have charges  $+Q$  and  $-Q$ , respectively.
- Calculate the total electrostatic energy of the system.
  - Using the answer to question 1, calculate the capacitance of the system.
  - If the spheres were to be joined via a very long wire of resistance  $R$ , what would be the RC time constant for the discharge of the system?



- 10) Calculate the total capacitance of the following infinite ladder circuit. Assume that the capacitance of each capacitor is given.



\*For the solutions go see the videos