

# Workbook



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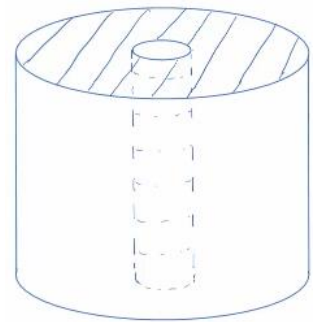
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# Resistors, Current and Current Density

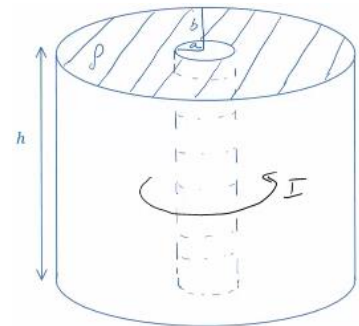
## Resistors, Current and Current Density

### Questions

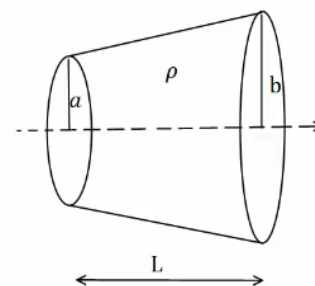
- 1) A cylindrical shell of height  $h$ , inner radius  $a$  and outer radius  $b$  is given. Between  $0 < r < a$  the space is empty, and between  $a < r < b$  the cylinder is filled by a material of given resistivity,  $\rho$ . A voltage source,  $V_0$ , is connected to the cylindrical shell as shown.
- Calculate the total resistance.
  - Calculate the current density.
  - Calculate the electric field inside of the conductor.



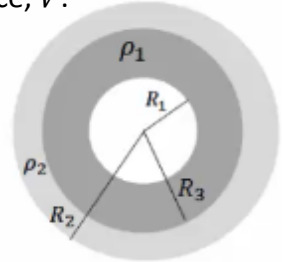
- 2) A cylindrical shell of height  $h$ , inner radius  $a$  and outer radius  $b$  is given. Between  $0 < r < a$  the space is empty, and between  $a < r < b$  the cylinder is filled by a material of given resistivity,  $\rho$ . The current flows in the  $\theta$  direction.
- Calculate the total resistance.
  - Calculate the current density.
  - Calculate the electric field inside of the conductor.



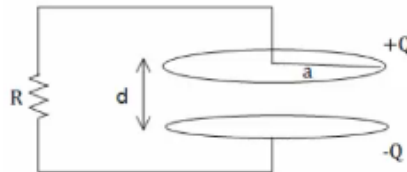
- 3) A conical frustum of length  $L$ , small base radius  $a$ , and large base radius  $b$  is given. Its resistivity is  $\rho$ . Calculate the resistance between the two bases.



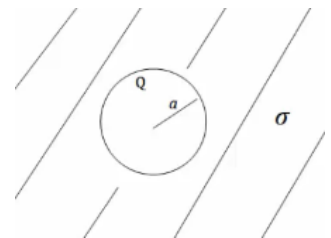
- 4) A spherical shell shaped resistor, of inner radius  $R_1$  and outer radius  $R_2$ , is made of a material with resistivity  $\rho_1$  in the region  $R_1 < r < R_2$  (see diagram), and resistivity  $\rho_2$  in the region  $R_2 < r < R_3$ .
- The current is in the radial direction. Calculate the total resistance of the shell.
  - Calculate the current density in the resistor if it is connected to a voltage source,  $V$ .
  - What is the electric field in the resistor?
  - Calculate the surface and volumetric charge distribution of the shell.



- 5) A parallel plate capacitor, of charge  $Q$ , is connected to a resistor, of resistance  $R$ . The radius of the capacitor plate is  $a$  and the distance between the plates is  $d$ , such that  $d \ll a$ .
- Calculate the current in the circuit.
  - Calculate the current density on the capacitor plate.
  - The resistor is removed.  
A material of resistivity  $\rho$  fills the gap between the capacitor plates. Given this information, answer questions 1 and 2.

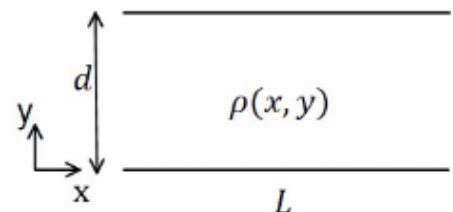


- 6) A conducting spherical shell of radius  $a$  is placed inside a material of conductivity  $\sigma$ . The charge on the shell is  $q(t = 0) = Q$ .
- Calculate the charge on the shell as a function of time.
  - Calculate the current density and the electric field inside the resistor.



- 7) Two parallel plates of dimension  $L \times L$  are placed a distance  $d$  from one another, such that  $L \gg d$ . Between the two plates a conducting material of resistivity  $\rho(x, y)$  is inserted. Calculate the resistance along the  $y$ -axis when:

- $\rho = \rho_0 \sin\left(\frac{\pi y}{d}\right)$
- $\rho = \rho_0 \frac{\sin\left(\frac{\pi y}{d}\right)}{\sin\left(\frac{\pi x}{L}\right)}$



\*for the solutions go see the videos