

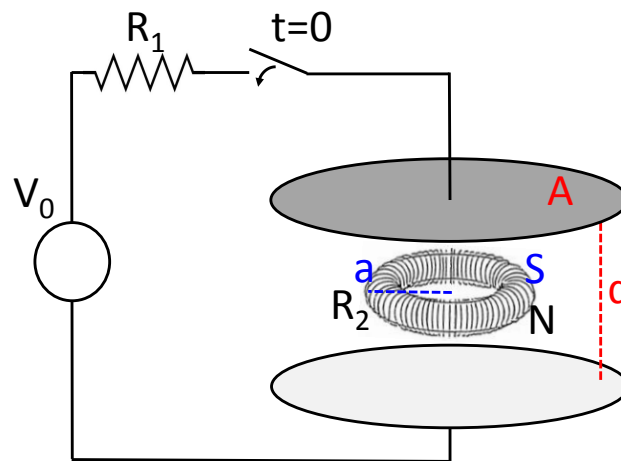
## Exercise Sheet 13

Discussion 11.12.2024

### Exercise 1 - Displacement current

Consider a capacitor made of two parallel plates in vacuum of area  $A$  at distance  $d \ll \sqrt{A}$ . A toroidal solenoid of radius  $a$  made of  $N$  coils of cross-section  $S$  with  $a \gg \sqrt{S}$  is placed between the two plates. The total resistance of the solenoid is  $R_2$ . At the time  $t = 0$  a switch closes a circuit which connects the capacitor in series with a resistor  $R_1$  and a battery  $V_0$ . The setup is shown in the figure.

- Calculate the electric field between the plates as function of time.
- Calculate the induced magnetic field inside the solenoid as function of time.
- Calculate the amount of charge that flows in the solenoid. For simplicity, do not consider the self-inductance of the solenoid.



### Exercise 2 - AC Magnetic Field

A capacitor made of two parallel circular plates of radius  $a$  in vacuum is connected to a AC source, thus the total charge in the capacitor varies as  $Q(t) = Q_0 \sin \omega t$ . Calculate the B-field between the two plates.

### Exercise 3 - Waves

Consider a function  $\psi = A \sin(Bx) \cos(Ct) + D$ , where  $x$  and  $t$  are space and time directions, and  $A, B, C, D$  are constants.

- Show that  $\psi$  is a solution of the wave equation.
- What is the speed of  $\psi$ ?

Consider a function  $\chi = (x - v_1 t)^2 + 1/\sqrt{x + v_2 t}$ .

- Find the condition for  $v_1$  and  $v_2$  in order to let  $\chi$  be a solution of the wave equation.