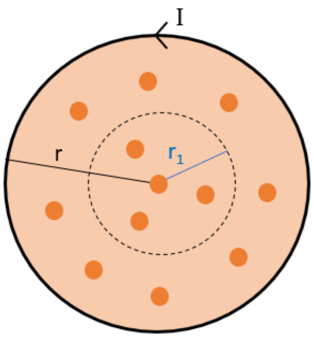
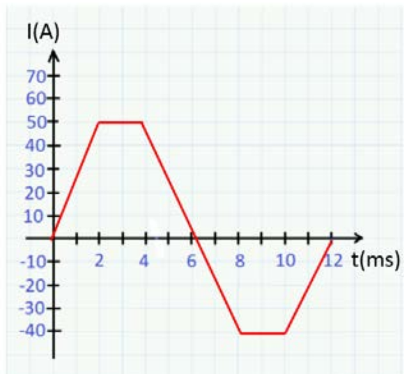
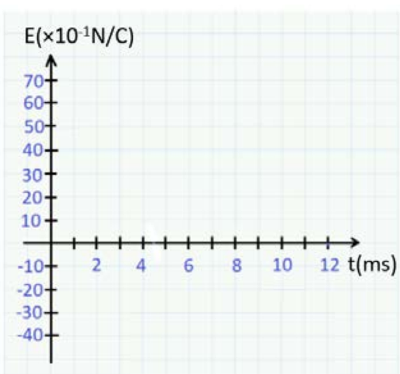
HW 12: Faraday's Law @ Maxwell-Ampere's Law

Problem 1. Consider the top-down view of a solenoid. It has an r = 10cm radius, and length ℓ = 20cm, 1000 turns, and a (presently) counter-clockwise current I, producing a (presently) out-of-the-page magnetic field B. To the right is plotted the current in the solenoid as a function of time (+ corresponds to CCW, and – to CW):

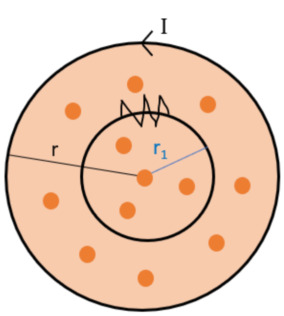




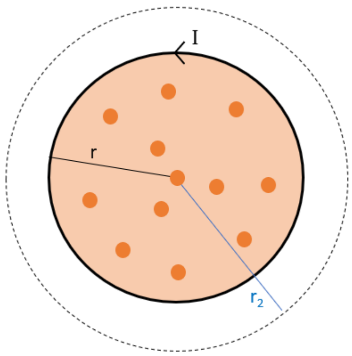
(a) Let r_1 = 5cm. Plot the electric field induced along this radius as a function of time (+ corresponds to CCW, and – to CW).

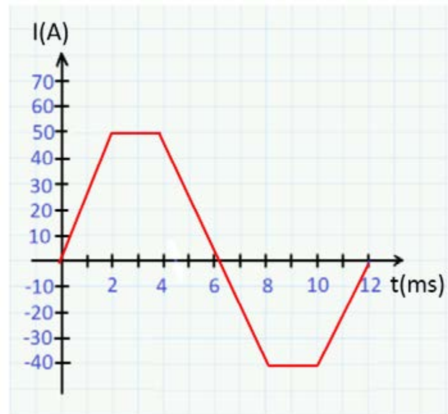


(b) Say we place a 50 turn wire loop connected to a 10Ω resistor inside the solenoid at the same radius r_1. What is the max current that flows through the resistor during this interval? What is the max power?

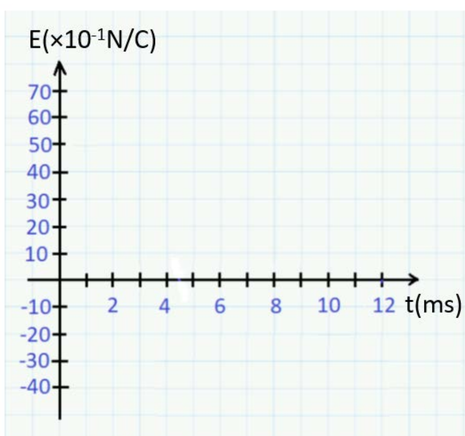


Problem 2. Consider our same solenoid again. This time let's consider points outside its radius.

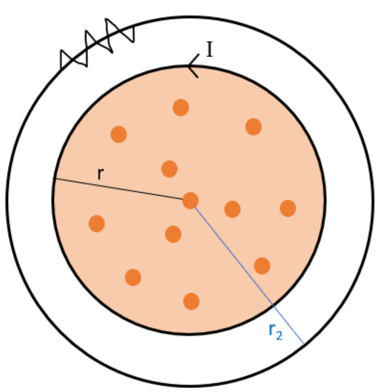




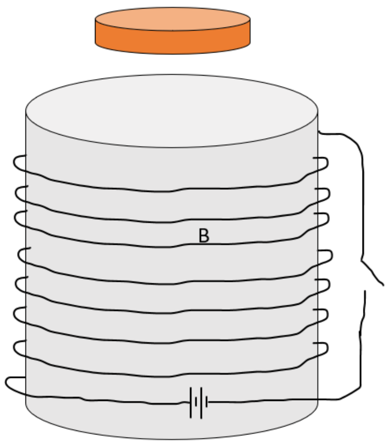
(a) Let r_2 = 15cm. Plot the electric field induced along this radius as a function of time (+ corresponds to CCW, and – to CW).



(b) Say we place a 50 turn wire loop connected to a 10Ω resistor outside the solenoid at the same radius r_2. What is the max current that flows through the resistor during this interval? What is the max power?



Problem 3. Say we hold a copper ring above a solenoid.

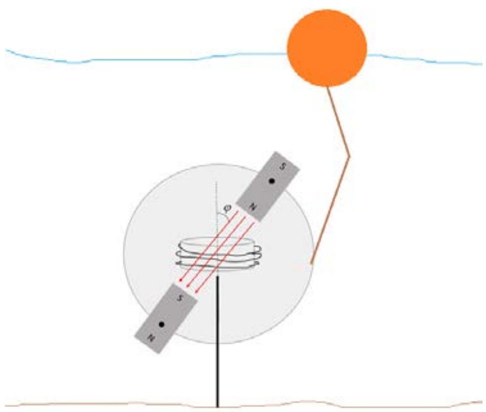


(a) When we flip the switch a current will be induced in the ring (via Faraday's law). Determine the direction of the resultant force the solenoid will exert on the ring.

(b) when the switch has been closed for a long time what will be the force?

(c) Then if we open the switch what will be the direction of the force?

Problem 4. A mechanism for generating power from the sea has been proposed. Basically you attach a a buoy to a wheel on which two magnets are mounted over a bunch of wire loops. As the waves roll in, the buoy will bob up and down, rotating the wheel and magnets, changing the magnetic flux through the loops, and thus generating current. Say we have 200 such wire loops with circumference 15cm, the magnetic field is 2T, and the frequency of oscillation of the buoy is 1Hz. Finally let's say we place 50 000 of these out in the ocean.



(a) What would be the total emf generated by these contraptions as a function of time?

(b) If we connect our contraption(s) to some huge device which has an effective resistance of 1MΩ, what max power would it deliver?

Problem 5. Consider the following circuit, a parallel plate capacitor (radius R) connected to a battery. Suppose that at this instant, current I is flowing through the wire. We know that the B field a distance r away from the long straight wires in the circuit is $B = \mu_0 I/2\pi r$. But what is the induced B field in between the capacitor plates ? Derive a symbolic expression in terms of I and r.