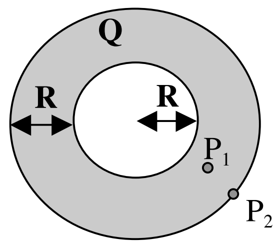
Problems 1, 2

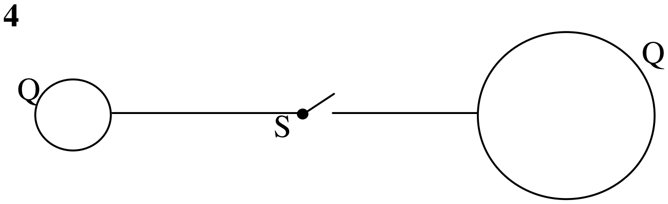


The figure shows a non-conducting spherical shell of inner radius R and outer radius 2R (i.e. radial thickness R) with charge Q uniformly distributed throughout its volume.

Prob 1: The electric field at point P_1 at distance 1.5R from the center is 1N/C. The electric field at point P_2 on the outer surface of the shell, i.e. at distance 2R from the center, is
1.66N/C

Prob 2: Assume this shell now becomes conducting, having the same total charge Q. The electric fields at P_1 and P_2 now (call them E_1 and E_2):
E_1 is 0, E_2 is same as in prob 1

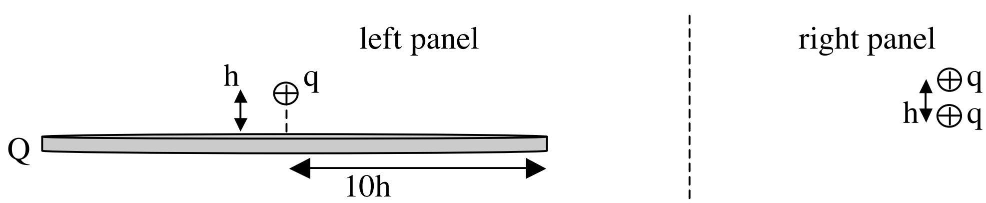
Problems 3, 4



The two metallic spheres shown have radius R and 3R respectively, with R=0.5m, and initially have the same charge Q=2C each. They are at a distance d>>R. They are connected by a metallic wire of resistance 3Ω which has a switch S that is open. Then the switch S is closed.
Prob 3: A long time after the switch S is closed, the charge on the small sphere is
Q/2

Prob 4: Immediately after the switch S is closed, the current in the wire (in A) is the product of k (Coulomb constant) times
0.89

Problems 5, 6

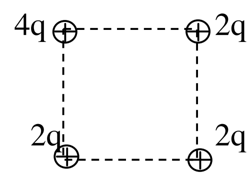


Note: there is no interaction between the charges on the left panel and those on the right panel.

Prob 5: On the left panel, a charge q is at a very small distance h from a thin circular charged plate of radius 10h that has total charge Q uniformly distributed. The force on this charge q is identical to the force on the upper charge q of the right panel, where another charge q is at distance h below it. The ratio Q/q is approximately
50

Prob 6: suppose the charge q on the left panel, and the upper charge q on the right panel, are both moved down a distance h/2, keeping the circular plate on the left panel and the lower charge on the right panel in the same position. Then the ratio of the forces on the charges we moved, left / right, is
0.25

Problems 7, 8



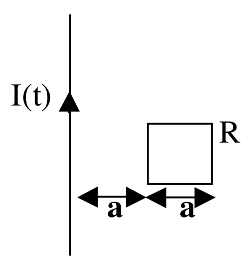
The four charges shown are on the vertices of a square of side length a.

Prob 7: The magnitude of the electric field acting on charge 2q in the lower right corner is 2N/C. The magnitude of the electric field acting on charge 4q is
1.6N/C

Prob 8: the magnitude of the electric field at distance d=100a from the center of this square is approximately

$$10^{-3}\frac{q}{4\pi\varepsilon_0 a^2}$$

Problems 9, 10, 11



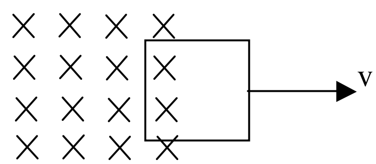
The figure shows a straight vertical long wire carrying a time-dependent current $I(t)=I_0\, t^2/\tau^2$, with I_0=100A and τ=1s. The square loop shown has resistance R=1Ω and sides of length **a**=25cm. Two sides of the square loop are parallel to the long wire, with the closest one at distance **a** from the long wire.

Prob 9: At time t=1s, at the center of the square, the magnetic field due to the long wire has magnitude ? and points ?
53μT, into paper

Prob 10: the current induced in the square loop at time t=1s has magnitude
6.9μA
Hint: you need to do an integral

Prob 11: the current induced in the square loop at time t=2s flows
counterclockwise

Problems 12, 13, 14

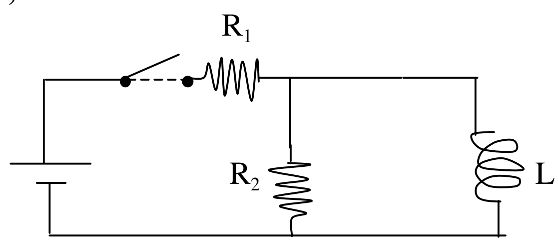


Prob 12: The square loop of wire shown has resistance 30Ω and side length 0.2m. It is being pulled out of a region of constant uniform magnetic field B=2.5T pointing into the paper, at a speed v=40m/s. The induced current in the loop is
0.66A

Prob 13: The force that needs to be applied to pull the loop out at constant speed is
0.33N

Prob 14: The total energy supplied by the external force in pulling the loop out of the magnetic field region is
0.067J

Problems 15, 16



In the circuit shown, R_1=10Ω, R_2=20Ω and L=5H. The switch has been open for a long time, then it is closed. Immediately after closing the switch the current through R_2 is 2A.

Prob 15: a long time after the switch is closed the current through R_2 is
0A

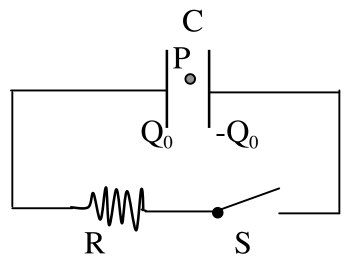
Prob 16: subsequently, the switch is opened again. 1s after the switch is opened the current through R_2 is
0.11A

Problems 17, 18
In a series driven RLC circuit, the impedance at resonance is 60Ω, the resonance frequency is $\omega=2000s^{-1}$ and the inductance is 10mH.

Prob 17: what is the impedance at frequency $\omega=4000s^{-1}$?
67Ω

Prob 18: at $\omega=4000s^{-1}$, the phase difference between current and voltage is:
current lags voltage by 27°

Problems 19, 20, 21



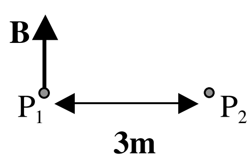
In the circuit shown, the parallel plate capacitor has capacitance 3mF and has round plates of radius a=0.4m. The resistor has resistance 250Ω. Initially the charge on the capacitor is Q_0=5C, with the left capacitor plate having positive charge, and the switch S is open. At time t=0 the switch S is closed.

Prob 19: the current through the resistor at time t=1s is
1.76A

Prob 20: the magnetic field at point P inside the capacitor, located at distance 0.1m above its symmetry axis, at the moment when the current through the resistor is I=1A, is
$\frac{\mu_0 I}{2\pi a} \times C$, with C=
0.25

Prob 21: at that moment, the magnetic field at point P points
into the paper

Problem 22



The figure shows two points, P_1 and P_2, separated by a distance 3m in the horizontal direction. There is a plane electromagnetic wave propagating in direction normal to the paper. The magnetic field B from this electromagnetic wave at point P_1 is shown at time t_0, pointing up. The frequency of this electromagnetic wave is $f=0.5x10^8$ cycles/s (Hz) ($f=\omega/2\pi$). At point P_1 there is a positive charge, and at point P_2 there is a negative charge, both charges are at rest. The forces on these charges due to the fields of the electromagnetic wave at time t_0:

point in opposite directions, horizontally;