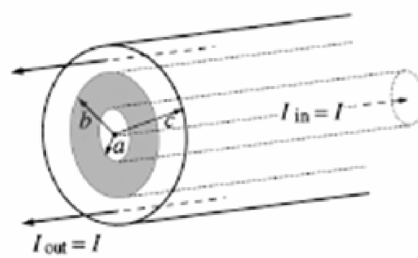
Problem 1:

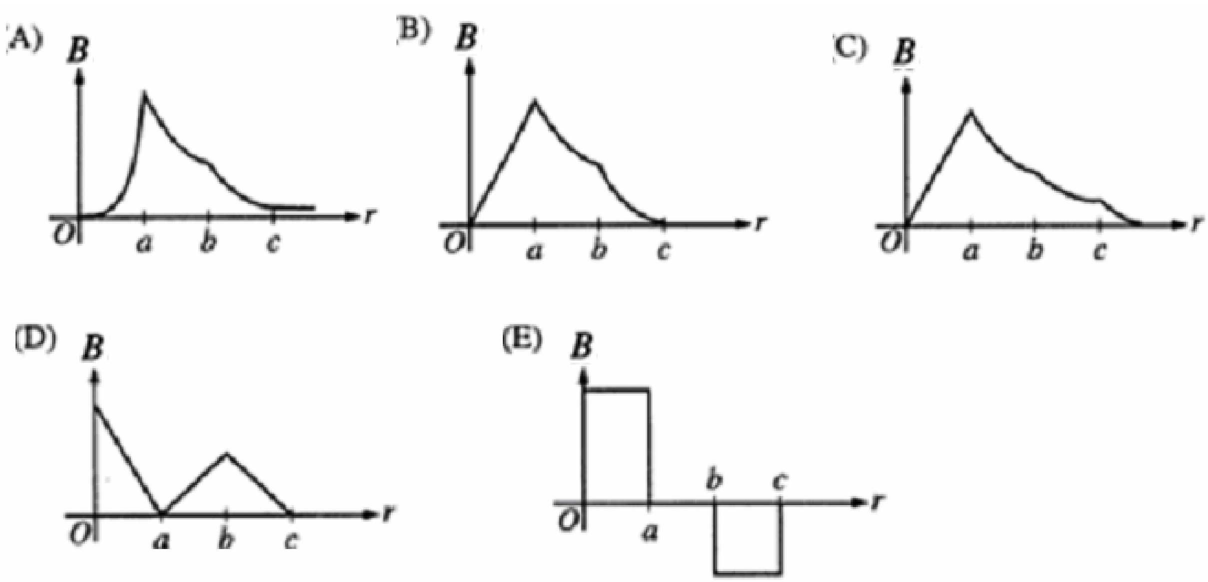
A resistor in a circuit dissipates energy at a rate of 1 W. If the voltage across the resistor is doubled, what will be the new rate of energy dissipation?

(A) 0.25 W
(B) 0.5 W
(C) 1 W
(D) 2 W
(E) 4 W

Problem 2:

A coaxial cable has the cross section shown in the figure. The shaded region is insulated. The regions in which $r < a$ and $b < r < c$ are conducting. A uniform dc current density of total current I flows along the inner part of the cable ($r < a$) and returns along the outer part of the cable ($b < r < c$) in the directions shown. The radial dependence of the magnitude of the magnetic field, B, is shown by which of the following?





Problem 3:

The inductor shown is formed by winding wire N times around a toroidal piece of iron of permeability μ. The major radius of the toroid is R and the minor radius is a, with a << R. What is the inductance if this inductor?

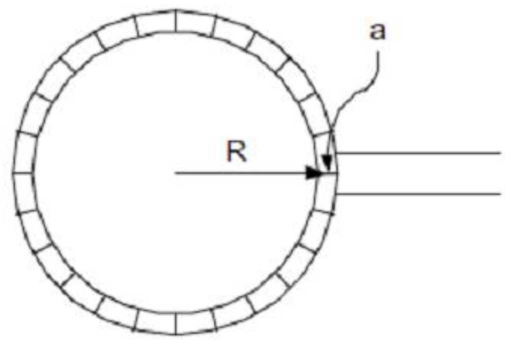
(A) $\frac{\mu_0 N a^2}{2R}$

(B) $\frac{\mu N a^2}{2R}$

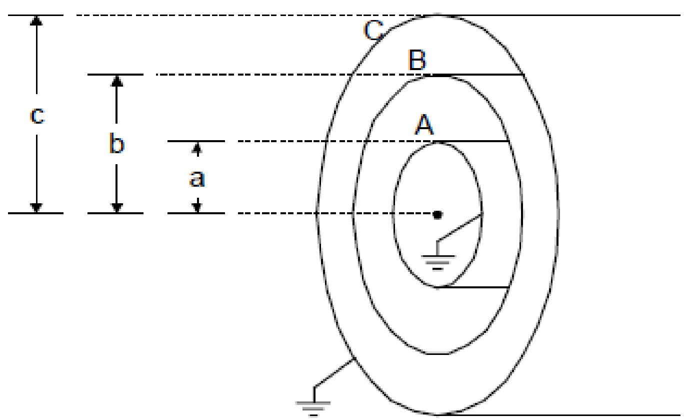
(C) $\frac{\mu N^2 a^2}{2R}$

(D) $\frac{\mu N^2 R}{2}$

(E) $\frac{\mu_0 N^2 a^2}{2R}$



Problem 4:



Three long concentric conducting cylinders A, B, and C have radii a, b, and c, respectively, as shown above. The thickness of each cylinder is much smaller than a. The innermost and ountermost cylinders are grounded. A charge Q is placed on cylinder B. If end effects are negligible, the ratio of the charge on the inner surface of B to the charge on the outer surface of B, Q_{inner}/Q_{outer}, is

(A) 0

(B) 1

(C) $\frac{\ln(b/a)}{\ln(c/b)}$

(D) $\frac{\ln(c/b)}{\ln(b/a)}$

(E) $\frac{\ln(c/a)}{\ln(b/c)}$

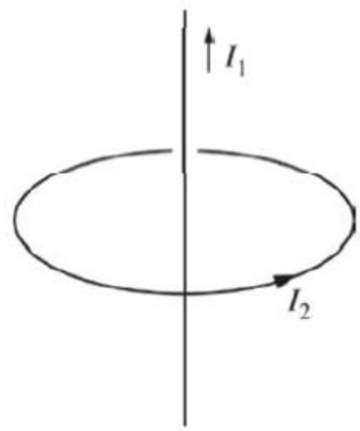
Problem 5:

The potential difference across the terminals of a battery is 10 volts if no current is drawn from it. When a 4-ohm resistor is connected across the terminals, a current of 2 amperes is drawn from the battery. This resistor is then removed and replaced with a variable resistor that can have any value of resistance from 0 to ∞. If the internal resistance of the battery is constant, the maximum power P the battery can deliver to the variable resistor is

(A) 16 Watts
(B) 25 Watts
(C) 50 Watts
(D) 100 Watts
(E) arbitrarily large as the resistance goes to zero

Problem 6:

An infinitely long, straight wire carrying current I_1 passes through the center of a circular loop of wire carrying current I_2, as shown. The long wire is perpendicular to the plane of the loop. Which of the following describes the magnetic force on the loop?



(A) Outward, along a radius of the loop.
(B) Inward, along a radius of the loop.
(C) Upward, along the axis of the loop.
(D) Downward, along the axis of the loop.
(E) There is no magnetic force on the loop.

Problem 7:

If the outward electric flux through the surface of a cube is negative, then one can be certain that the cube contains

(A) a net negative charge
(B) a net positive charge
(C) only negative charges
(D) only positive charges
(E) both positive and negative charges

Problem 8:

A particle with positive charge q is at the center of a spherical shell of inner radius R and outer radius R+ΔR, as shown . The shell carries a positive charge Q that is uniformly distributed throughout the shell. What is the work done on the particle in bringing it from r = 0 to r = R?

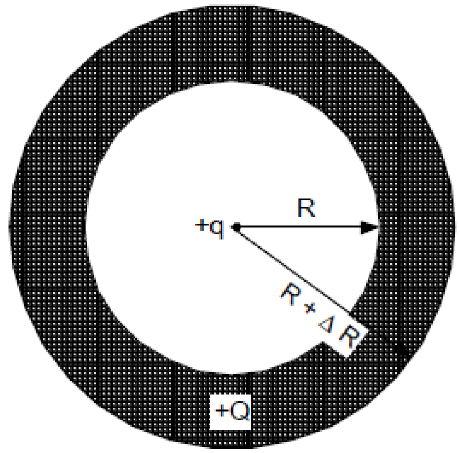
(A) 0

(B) $\frac{1}{4\pi\varepsilon_0}\frac{qQ}{R}$

(C) $-\frac{1}{4\pi\varepsilon_0}\frac{qQ}{R}$

(D) $\frac{1}{8\pi\varepsilon_0}\frac{qQR^2}{(R+\Delta R)^3 - R^3}$

(E) $-\frac{1}{8\pi\varepsilon_0}\frac{qQR^2}{(R+\Delta R)^3 - R^3}$



Problem 9:

A wire loop that encloses an area of 10 cm^2 has a resistance of 5 Ω . The loop is placed in a magnetic field of 0.5 T with its plane perpendicular to the field. The loop is suddenly removed from the field. How much charge flows past a given point in the wire?

(A) 10^{-4} C

(B) 10^{-3} C

(C) 10^{-2} C

(D) 10^{-1} C

(E) 1 C

Problem 10:

The circuit shown in the figure consists of eight resistors, each with resistance R, and a battery with terminal voltage V and negligible internal resistance. What is the current flowing through the battery?

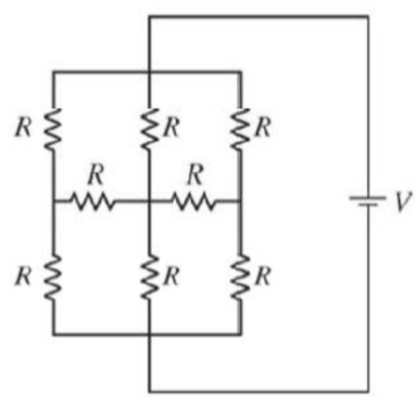
(A) $\frac{1}{3}\frac{V}{R}$

(B) $\frac{1}{2}\frac{V}{R}$

(C) $\frac{V}{R}$

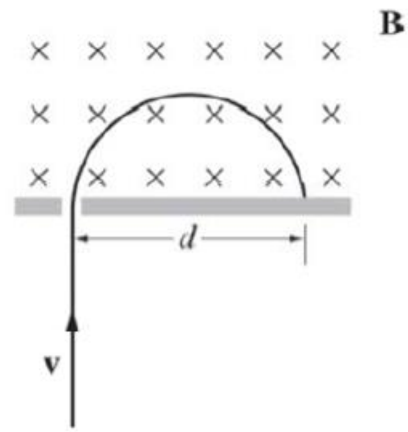
(D) $\frac{3}{2}\frac{V}{R}$

(E) $3\frac{V}{R}$



Problem 11:

A particle with mass m and charge q, moving with a velocity $\mathbf{v}$, enters a region of uniform magnetic field $\mathbf{B}$, as shown in the figure . The particle strikes the wall at a distance d from the entrance slit. If the particle's velocity stays the same but its charge-to-mass ratio is doubled, at what distance from the entrance slit will the particle strike the wall?



(A) $2d$

(B) $\sqrt{2}d$

(C) d

(D) $\frac{1}{\sqrt{2}}d$

(E) $\frac{1}{2}d$

Problem 12:

A very long, thin, straight wire carries a uniform charge density of λ per unit length. Which of the following gives the magnitude of the electric field at a radial distance r from the wire?

(A) $\frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$ (B) $\frac{1}{2\pi\varepsilon_0}\frac{r}{\lambda}$ (C) $\frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{\lambda^2}{r^2}$ (E) $\frac{1}{4\pi\varepsilon_0}\lambda \ln r$

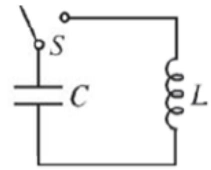
Problem 13:

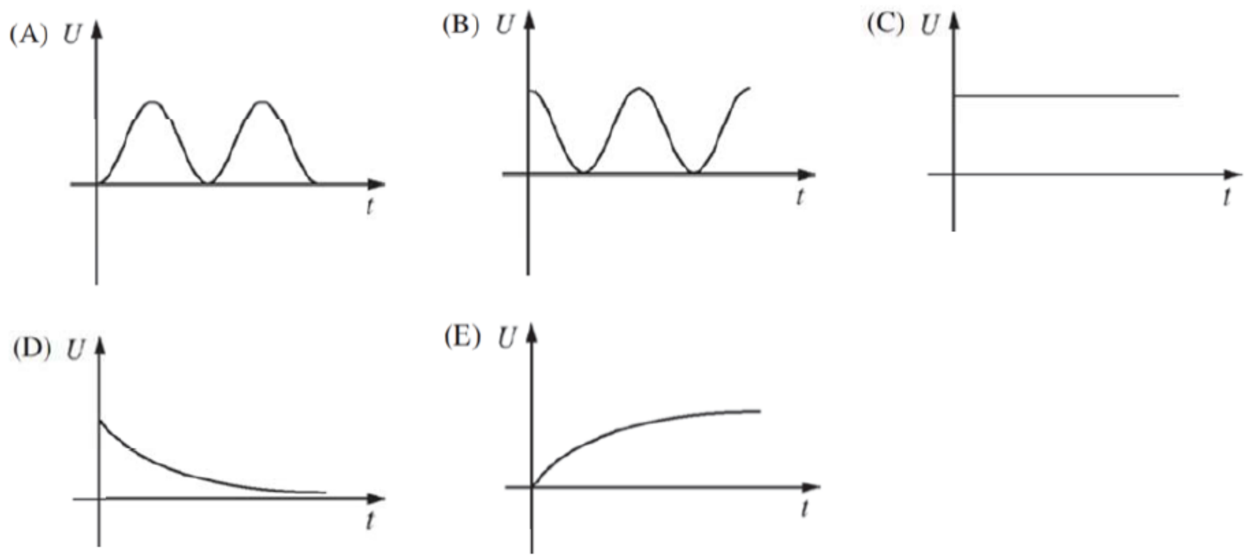
A parallel-plate capacitor has a charge of 10^{-15} C. The potential difference across the capacitor is 10^4 V and the plates are in vacuum. If a second capacitor has identical dimensions and the same charge as the first one, but has a dielectric with dielectric constant K = 5 between the plates, the potential difference across this second capacitor would be most nearly

(A) 0 V.
(B) 2000V.
(C) 10000 V.
(D) 20000 V.
(E) 50000 V.

Problem 14:

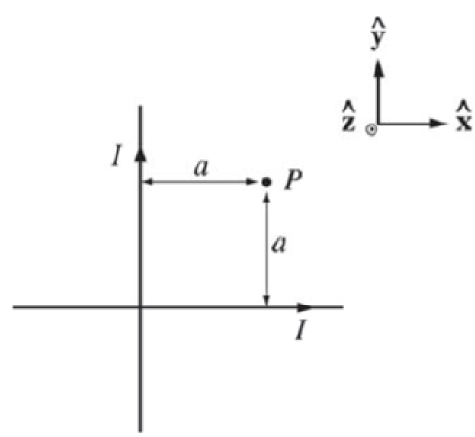
The capacitor in the circuit is charged. If switch S is closed at time $t = 0$, which of the following represents the magnetic energy, U, in the inductor as a function of time? (Assume that the capacitor and inductor are ideal.)





Problem 15:

Consider two very long, straight, insulated wires oriented at right angles. The wires carry currents of equal magnitude I in the directions shown in the figure above. What is the net magnetic field at point P ?



(A) $\frac{\mu_0 I}{2\pi a}(\hat{\mathbf{x}} + \hat{\mathbf{y}})$

(B) $-\frac{\mu_0 I}{2\pi a}(\hat{\mathbf{x}} + \hat{\mathbf{y}})$

(C) $\frac{\mu_0 I}{\pi a}\hat{\mathbf{z}}$

(D) $-\frac{\mu_0 I}{\pi a}\hat{\mathbf{z}}$

(E) $\mathbf{0}$