Electricity & Magnetism – Problem Set # 4

TABLE OF INFORMATION

Rest mass of the electron	$m_e = 9.11 \times 10^{-31}$ kilogram $= 9.11 \times 10^{-28}$ gram
Magnitude of the electron charge	$e = 1.60 \times 10^{-19}$ coulomb $= 4.80 \times 10^{-10}$ statcoulomb (esu)
Avogadro's number	$N_0 = 6.02 \times 10^{23}$ per mole
Universal gas constant	$R = 8.31$ joules/(mole · K)
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ joule/K $= 1.38 \times 10^{-16}$ erg/K
Speed of light	$c = 3.00 \times 10^{8}$ m/s $= 3.00 \times 10^{10}$ cm/s
Planck's constant	$h = 6.63 \times 10^{-34}$ joule · second $= 4.14 \times 10^{-15}$ eV · second
	$\hbar = h/2\pi$
Vacuum permittivity	$\epsilon_0 = 8.85 \times 10^{-12}$ coulomb^2/(newton · meter^2)
Vacuum permeability	$\mu_0 = 4\pi \times 10^{-7}$ weber/(ampere · meter)
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ meter^3/(kilogram · second^2)
Acceleration due to gravity	$g = 9.80$ m/s^2 $= 980$ cm/s^2
1 atmosphere pressure	1 atm $= 1.0 \times 10^{5}$ newton/meter^2 $= 1.0 \times 10^{5}$ pascals (Pa)
1 angstrom	1 Å $= 1 \times 10^{-10}$ meter
	1 weber/m^2 = 1 tesla = 10^4 gauss

Moments of inertia about center of mass

Rod	$\frac{1}{12}M\ell^2$
Disc	$\frac{1}{2}MR^2$
Sphere	$\frac{2}{5}MR^2$

61. A sphere of radius R carries charge density proportional to the square of the distance from the center: $\rho = Ar^2$, where A is a positive constant. At a distance of $R/2$ from the center, the magnitude of the electric field is

(A) $A/4\pi\epsilon_0$

(B) $AR^3/40\epsilon_0$

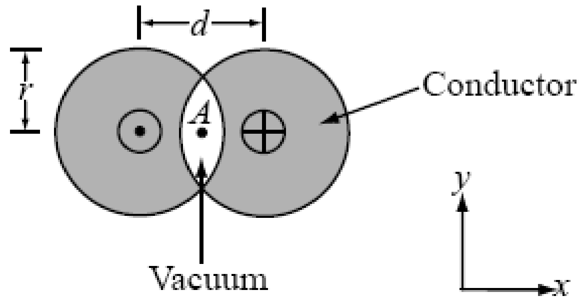
(C) $AR^3/24\epsilon_0$

(D) $AR^3/5\epsilon_0$

(E) $AR^3/3\epsilon_0$

62. Two capacitors of capacitances 1.0 microfarad and 2.0 microfarads are each charged by being connected across a 5.0-volt battery. They are disconnected from the battery and then connected to each other with resistive wires so that plates of opposite charge are connected together. What will be the magnitude of the final voltage across the 2.0-microfarad capacitor?

(A) 0 V
(B) 0.6 V
(C) 1.7 V
(D) 3.3 V
(E) 5.0 V

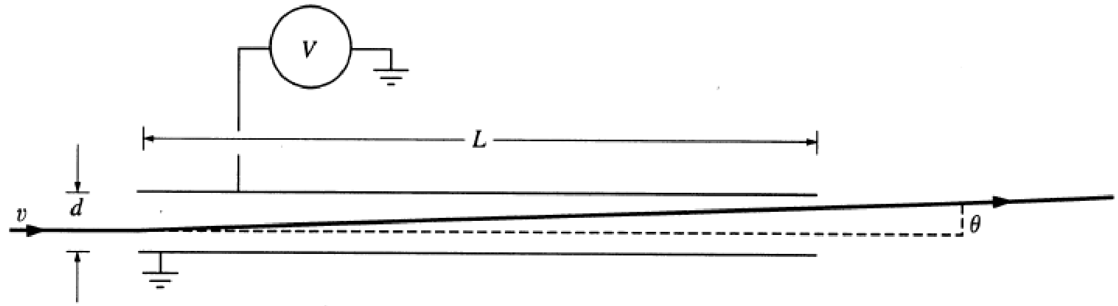


69. Two long conductors are arranged as shown above to form overlapping cylinders, each of radius r, whose centers are separated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along the shaded portion of the other, as shown. What are the magnitude and direction of the magnetic field at point A ?

    (A) $(\mu_0/2\pi)\pi dJ$, in the $+y$-direction
    (B) $(\mu_0/2\pi)d^2J/r$, in the $+y$-direction
    (C) $(\mu_0/2\pi)4d^2J/r$, in the $-y$-direction
    (D) $(\mu_0/2\pi)Jr^2/d$, in the $-y$-direction
    (E) There is no magnetic field at A.

70. A charged particle, A, moving at a speed much less than c, decelerates uniformly. A second particle, B, has one-half the mass, twice the charge, three times the velocity, and four times the acceleration of particle A. According to classical electrodynamics, the ratio P_B/P_A of the powers radiated is

    (A) 16
    (B) 32
    (C) 48
    (D) 64
    (E) 72

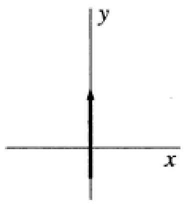


71. The figure above shows the trajectory of a particle that is deflected as it moves through the uniform electric field between parallel plates. There is potential difference V and distance d between the plates, and they have length L. The particle (mass m, charge q) has nonrelativistic speed v before it enters the field, and its direction at this time is perpendicular to the field. For small deflections, which of the following expressions is the best approximation to the deflection angle θ ?

(A) arctan ($(L/d)(Vq/mv^2)$)
(B) arctan ($(L/d)(Vq/mv^2)^2$)
(C) arctan ($(L/d)^2(Vq/mv^2)$)
(D) arctan ($(L/d)(2Vq/mv^2)^{1/2}$)
(E) arctan ($(L/d)^{1/2}(2Vq/mv^2)$)

86. A positively charged particle is moving in the xy-plane in a region where there is a non-zero uniform magnetic field B in the $+z$-direction and a non-zero uniform electric field E in the $+y$-direction. Which of the following is a possible trajectory for the particle?

(A)



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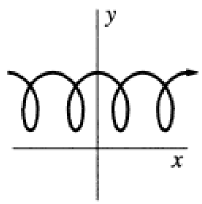

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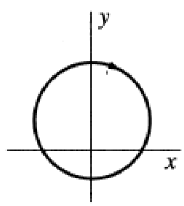

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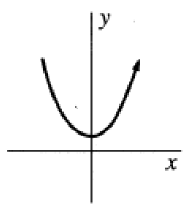
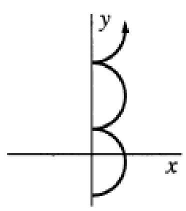
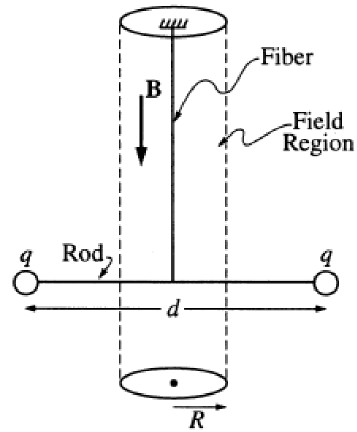


(E)





87. Two small pith balls, each carrying a charge q, are attached to the ends of a light rod of length d, which is suspended from the ceiling by a thin torsion-free fiber, as shown in the figure above. There is a uniform magnetic field **B**, pointing straight down, in the cylindrical region of radius R around the fiber. The system is initially at rest. If the magnetic field is turned off, which of the following describes what happens to the system?

(A) It rotates with angular momentum qBR^2.

(B) It rotates with angular momentum $\frac{1}{4}qBd^2$.

(C) It rotates with angular momentum $\frac{1}{2}qBRd$.

(D) It does not rotate because to do so would violate conservation of angular momentum.

(E) It does not move because magnetic forces do no work.

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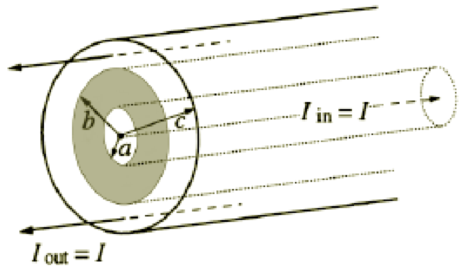
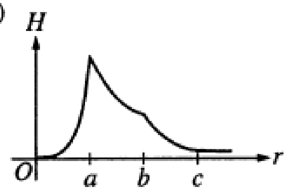
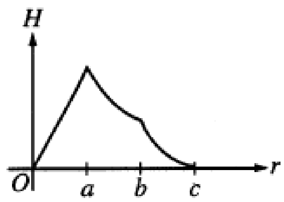


88. A coaxial cable has the cross section shown in the figure above. The shaded region is insulated. The regions in which $r < a$ and $b < r < c$ are conducting. A uniform dc current density of total current I flows along the inner part of the cable $(r < a)$ and returns along the outer part of the cable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

(A)



(B)



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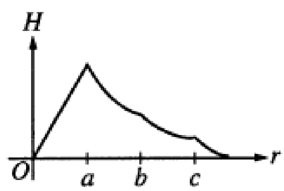

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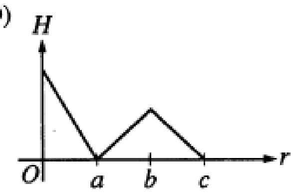
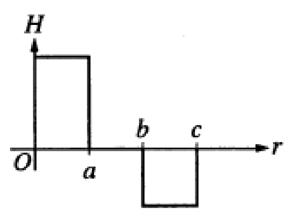
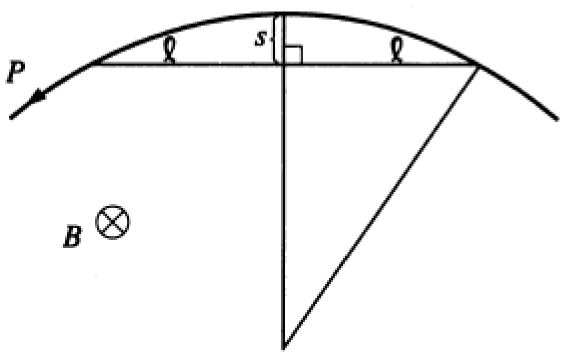


(E)





89. A particle with charge q and momentum p is moving in the horizontal plane under the action of a uniform vertical magnetic field of magnitude B. Measurements are made of the particle's trajectory to determine the "sagitta" s and half-chord length ℓ, as shown in the figure above. Which of the following expressions gives the particle's momentum in terms of q, B, s, and ℓ? (Assume $s << \ell$.)

(A) $qBs^2/2\ell$

(B) qBs^2/ℓ

(C) $qB\ell/s$

(D) $qB\ell^2/2s$

(E) $qB\ell^2/8s$