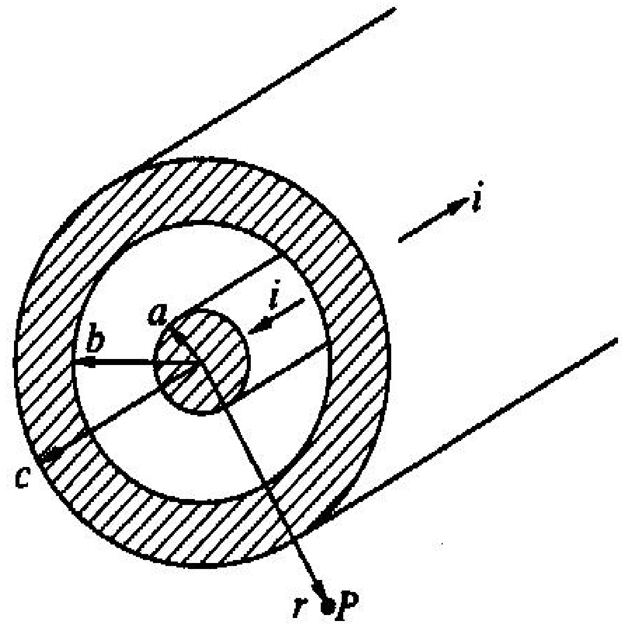
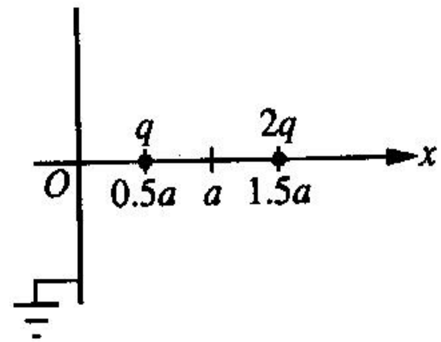


9. A coaxial cable having radii $a, b,$ and c carries equal and opposite currents of magnitude i on the inner and outer conductors. What is the magnitude of the magnetic induction at point P outside of the cable at a distance r from the axis?

(A) Zero (B) $\frac{\mu_0 ir}{2\pi a^2}$ (C) $\frac{\mu_0 i}{2\pi r}$

(D) $\frac{\mu_0 i}{2\pi r} \frac{c^2 - r^2}{c^2 - b^2}$ (E) $\frac{\mu_0 i}{2\pi r} \frac{r^2 - b^2}{c^2 - b^2}$



10. Two positive charges of q and $2q$ coulombs are located on the x-axis at $x = 0.5a$ and $1.5a$, respectively, as shown above. There is an infinite, grounded conducting plane at $x = 0$. What is the magnitude of the net force on the charge q?

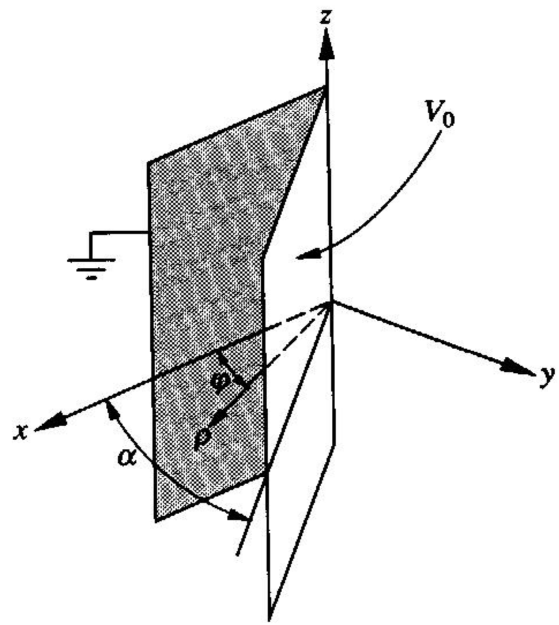
(A) $\frac{1}{4\pi\epsilon_0}\frac{q^2}{a^2}$

(B) $\frac{1}{4\pi\epsilon_0}\frac{3q^2}{2a^2}$

(C) $\frac{1}{4\pi\epsilon_0}\frac{2q^2}{a^2}$

(D) $\frac{1}{4\pi\epsilon_0}\frac{3q^2}{a^2}$

(E) $\frac{1}{4\pi\epsilon_0}\frac{7q^2}{2a^2}$



12. Two large conducting plates form a wedge of angle α as shown in the diagram above. The plates are insulated from each other; one has a potential V_0 and the other is grounded. Assuming that the plates are large enough so that the potential difference between them is independent of the cylindrical coordinates z and ρ, the potential anywhere between the plates as a function of the angle φ is

(A) $\dfrac{V_0}{\alpha}$

(B) $\dfrac{V_0\varphi}{\alpha}$

(C) $\dfrac{V_0\alpha}{\varphi}$

(D) $\dfrac{V_0\varphi^2}{\alpha}$

(E) $\dfrac{V_0\alpha}{\varphi^2}$

18. In transmitting high frequency signals on a coaxial cable, it is important that the cable be terminated at an end with its characteristic impedance in order to avoid

(A) leakage of the signal out of the cable
(B) overheating of the cable
(C) reflection of signals from the terminated end of the cable
(D) attenuation of the signal propagating in the cable
(E) production of image currents in the outer conductor

21. A soap film with index of refraction greater than air is formed on a circular wire frame that is held in a vertical plane. The film is viewed by reflected light from a white-light source. Bands of color are observed at the lower parts of the soap film, but the area near the top appears black. A correct explanation for this phenomenon would involve which of the following?

I. The top of the soap film absorbs all of the light incident on it; none is transmitted.
II. The thickness of the top part of the soap film has become much less than a wavelength of visible light.
III. There is a phase change of 180° for all wavelengths of light reflected from the front surface of the soap film.
IV. There is no phase change for any wavelength of light reflected from the back surface of the soap film.

(A) I only
(B) II and III only
(C) III and IV only
(D) I, II, and III
(E) II, III, and IV

34. A conducting cavity is driven as an electromagnetic resonator. If perfect conductivity is assumed, the transverse and normal field components must obey which of the following conditions at the inner cavity walls?

(A) $E_n = 0$, $B_n = 0$

(B) $E_n = 0$, $B_t = 0$

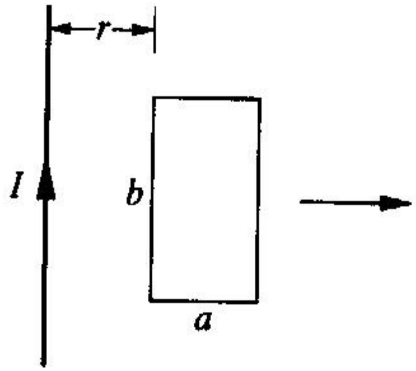
(C) $E_t = 0$, $B_t = 0$

(D) $E_t = 0$, $B_n = 0$

(E) None of the above

36. A plane-polarized electromagnetic wave is incident normally on a flat, perfectly conducting surface. Upon reflection at the surface, which of the following is true?

(A) Both the electric vector and magnetic vector are reversed.
(B) Neither the electric vector nor the magnetic vector is reversed.
(C) The electric vector is reversed; the magnetic vector is not.
(D) The magnetic vector is reversed; the electric vector is not.
(E) The directions of the electric and magnetic vectors are interchanged.



A rectangular loop of wire with dimensions shown above is coplanar with a long wire carrying current I. The distance between the wire and the left side of the loop is r. The loop is pulled to the right as indicated.

54. What are the directions of the induced current in the loop and the magnetic forces on the left and the right sides of the loop as the loop is pulled?

	Induced Current	Force on Left Side	Force on Right Side
(A)	Counterclockwise	To the left	To the right
(B)	Counterclockwise	To the left	To the left
(C)	Counterclockwise	To the right	To the left
(D)	Clockwise	To the right	To the left
(E)	Clockwise	To the left	To the right

55. What is the magnitude of the net force on the loop when the induced current is i?

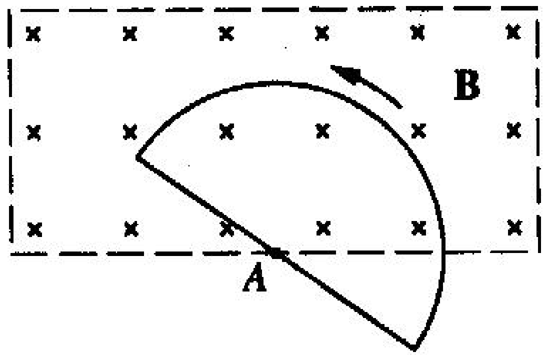
(A) $\frac{\mu_0 iI}{2\pi}\ln\left(\frac{r+a}{r}\right)$

(B) $\frac{\mu_0 iI}{2\pi}\ln\left(\frac{r}{r+a}\right)$

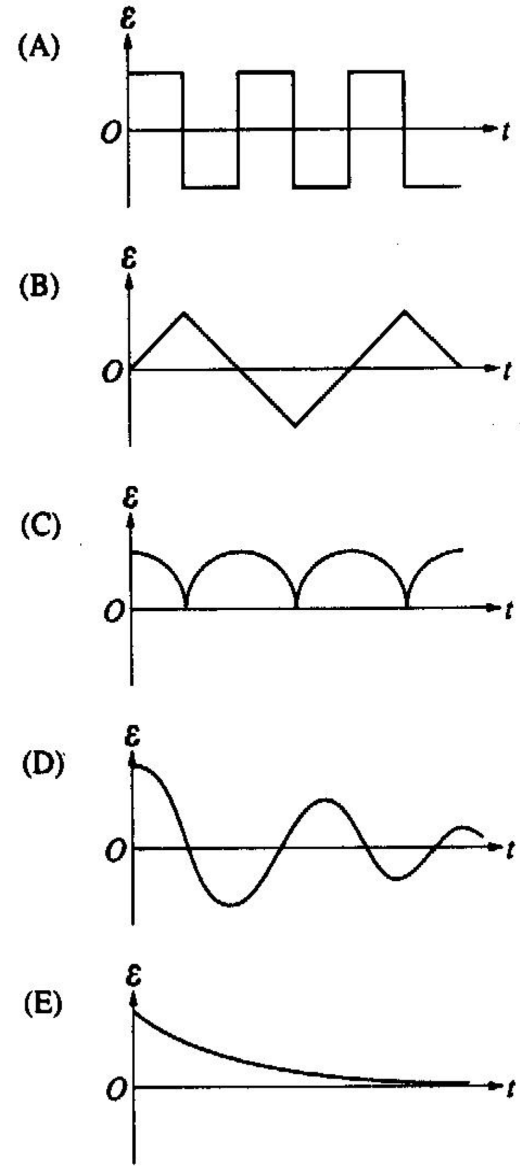
(C) $\frac{\mu_0 iI}{2\pi}\frac{b}{a}$

(D) $\frac{\mu_0 iI}{2\pi}\frac{ab}{r(r+a)}$

(E) $\frac{\mu_0 iI}{2\pi}\frac{r(r+a)}{ab}$



57. A uniform and constant magnetic field **B** is directed perpendicularly into the plane of the page everywhere within a rectangular region as shown above. A wire circuit in the shape of a semicircle is uniformly rotated counterclockwise in the plane of the page about an axis A. The axis A is perpendicular to the page at the edge of the field and directed through the center of the straight-line portion of the circuit. Which of the following graphs best approximates the emf $\mathcal{E}$ induced in the circuit as a function of time t?



60. An electron in a metal has an effective mass $m^* = 0.1m_e$. If this metal is placed in a magnetic field of magnitude 1 tesla, the cyclotron resonance frequency, ω_c, is most nearly

(A) 930 rad/s

(B) 8.5×10^6 rad/s

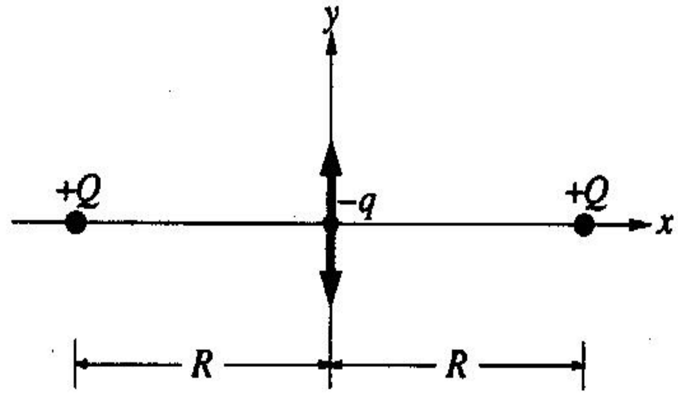
(C) 2.8×10^{11} rad/s

(D) 1.8×10^{12} rad/s

(E) 7.7×10^{20} rad/s

64. If an electric field is given in a certain region by $E_x = 0$, $E_y = 0$, $E_z = kz$, where k is a nonzero constant, which of the following is true?

(A) There is a time-varying magnetic field.
(B) There is charge density in the region.
(C) The electric field cannot be constant in time.
(D) The electric field is impossible under any circumstances.
(E) None of the above



65. Two point charges with the same charge $+Q$ are fixed along the x-axis and are a distance $2R$ apart as shown. A small particle with mass m and charge $-q$ is placed at the midpoint between them. What is the angular frequency ω of small oscillations of this particle along the y-direction?

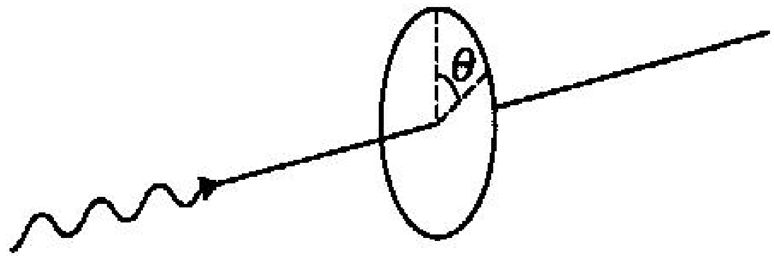
(A) $\dfrac{Qq}{2\pi\epsilon_0 mR^2}$

(B) $\dfrac{Qq}{4\pi\epsilon_0 mR^2}$

(C) $\dfrac{Qq}{2\pi\epsilon_0 mR^3}$

(D) $\left(\dfrac{Qq}{4\pi\epsilon_0 mR^2}\right)^{\frac{1}{2}}$

(E) $\left(\dfrac{Qq}{2\pi\epsilon_0 mR^3}\right)^{\frac{1}{2}}$



67. A steady beam of light is normally incident on a piece of polaroid. As the polaroid is rotated around the beam axis, the transmitted intensity varies as $A + B\cos 2\theta$, where θ is the angle of rotation, and A and B are constants with $A > B > 0$. Which of the following may be correctly concluded about the incident light?

(A) The light is completely unpolarized.
(B) The light is completely plane polarized.
(C) The light is partly plane polarized and partly unpolarized.
(D) The light is partly circularly polarized and partly unpolarized.
(E) The light is completely circularly polarized.

69. A fast charged particle passes perpendicularly through a thin glass sheet of index of refraction 1.5. The particle emits light in the glass. The minimum speed of the particle is

(A) $\frac{1}{3}c$

(B) $\frac{4}{9}c$

(C) $\frac{5}{9}c$

(D) $\frac{2}{3}c$

(E) c

80. A beam of electrons is accelerated through a potential difference of 25 kilovolts in an x-ray tube. The continuous x-ray spectrum emitted by the target of the tube will have a short wavelength limit of most nearly

(A) 0.1 Å

(B) 0.5 Å

(C) 2 Å

(D) 25 Å

(E) 50 Å

84. An electron oscillates back and forth along the $+$ and $-$ x-axes, consequently emitting electromagnetic radiation. Which of the following statements concerning the radiation is NOT true?

(A) The total rate of radiation of energy into all directions is proportional to the square of the electron's acceleration.

(B) The total rate of radiation of energy into all directions is proportional to the square of the electron's charge.

(C) Far from the electron, the rate at which radiated energy crosses a perpendicular unit area decreases as the inverse square of the distance from the electron.

(D) Far from the electron, the rate at which radiated energy crosses a perpendicular unit area is a maximum when the unit area is located on the $+$ or $-$ x-axes.

(E) Far from the electron, the radiated energy is carried equally by the transverse electric and the transverse magnetic fields.

88. A parallel-plate capacitor is connected to a battery. V_0 is the potential difference between the plates, Q_0 the charge on the positive plate, E_0 the magnitude of the electric field, and D_0 the magnitude of the displacement vector. The original vacuum between the plates is filled with a dielectric and then the battery is disconnected. If the corresponding electrical parameters for the final state of the capacitor are denoted by a subscript f, which of the following is true?

(A) $V_f > V_0$

(B) $V_f < V_0$

(C) $Q_f = Q_0$

(D) $E_f > E_0$

(E) $D_f > D_0$

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