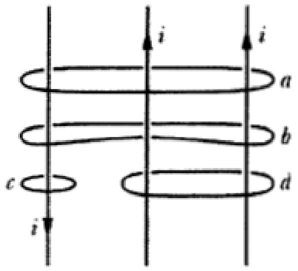
1) The figure above shows three currents of equal magnitude, whose directions are indicated. Also shown are four loops to be used in an Ampere's Law calculation. Rank the loops in order of decreasing **magnitude** of $\oint$ **B** ds along each loop. That is, rank them from largest (first) to smallest (last) magnitude. Be sure to note carefully whether the loop passes over or under the currents.



a: $-i + i + i = i$

b: $-i + i = 0$

c: $-i$

d: $i + i = 2i$

$\Longrightarrow$ d > c = a > b

2) Light with a wavelength of 420 nm passes from air into glass that has a refractive index of 1.5. Indicate whether the follow quantities *increase*, *decrease*, or remain the *same* in the glass as compared to the air by circling the correct choice.

(a) frequency	(b) wavelength	(c) speed	(d) angular frequency
SAME	*DECREASE*	*DECREASE*	*SAME*

$v = f\lambda$ f depends on source only so Remains the same

v decreases in the glass, $n_{glass} = \frac{c}{v_{glass}}$

$\lambda = \frac{v}{f}$, so λ decreases

$\omega = 2\pi f$, remains the same

3) For each of the following statements (all are true), circle the ones which are true **because of Gauss' Law for magnetism**.

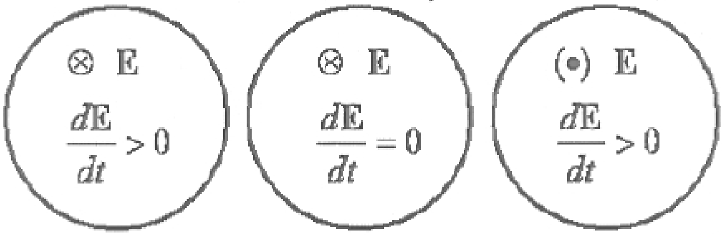
(a) magnetic field lines form closed loops

(b) a time-varying electric field produces a magnetic field

(c) magnetic monopoles do not exist

(d) a magnetic field cannot decrease in one coordinate direction while remaining constant in the other two coordinate directions

4) The figure shows the inside of three capacitor plates, with electric fields perpendicular through them as shown. The rate of change of the electric field is also indicated. In each case, which way does the induced magnetic field — if any — point around the plates?



a b c

Circle one each for clockwise (CW), counterclockwise (CCW), or no magnetic field (NONE):

(a) CW CCW NONE

$\vec{E}$ $\otimes$ increasing. i_D is <u>same</u> direction as change in $\vec{E}$, i_D $\otimes$

so $\vec{B}_{ind}$ <u>CW</u>

(b) CW CCW NONE

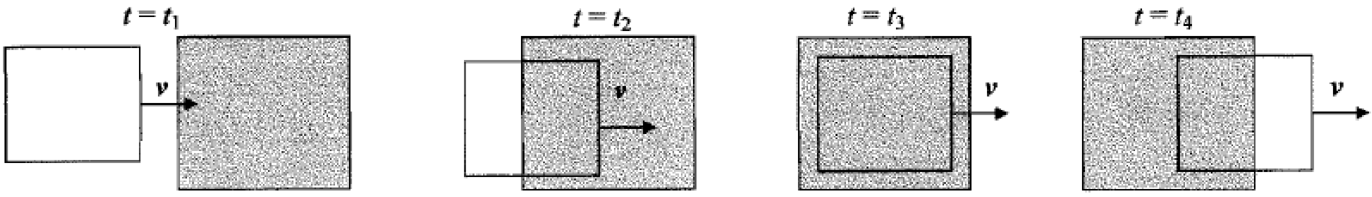
No $\vec{B}_{ind}$, $\oint \vec{B} \cdot d\vec{s} \propto \frac{d\Phi_E}{dt}$

(c) CW CCW NONE

$\vec{E}$ $\odot$ increasing i_D same direction as change in $\vec{E}$,

so i_D $\odot$ $\Rightarrow$ $\vec{B}_{ind}$ <u>CCW</u>

5) **A square conducting loop is moved to the right at a constant speed $|v|$ relative to the shaded region which contains a uniform magnetic field pointed out of the page. The loop and region with magnetic field are shown at four different times in the drawings below where $t_4 > t_3 > t_2 > t_1$.**

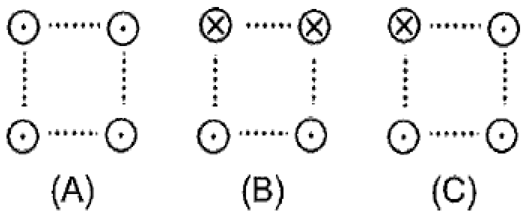


For each time, indicate whether the induced current flows clockwise, counter clockwise, or is zero in the loop.

t_1: $\Phi_B = 0$, <u>$i_1 = 0$</u> t_2: Φ_B increasing, $\vec{B}_{ind}$ $\otimes$, i_2 <u>clockwise</u>

t_3: Φ_B not changing, <u>$i_3 = 0$</u> t_4: Φ_B decreasing. $\vec{B}_{ind}$ $\odot$, i_4 <u>counter - cw</u>

6) The figure below shows four arrangements in which long parallel wires carry equal currents i directly into or out of the page at the corners of identical squares.



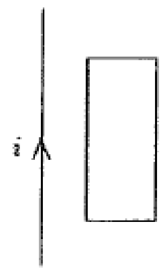
(i) For square B, what is the direction of the magnetic field, with respect to the page, at the center of the square? Circle one:

Out (•)   *In* ⊗   *Up* ↑   *Down* ↓ $\boxed{\textit{Left} \leftarrow}$ *Right* →   *Field is Zero* ($\vec{B} = 0$)

(ii) Rank the sections according to the magnitude of the magnitude of the magnetic field at the center of each square, greatest first. Circle one:

$B_A > B_B > B_C$ $B_C > B_B > B_A$ $B_A > B_C > B_B$ $\boxed{B_B > B_C > B_A}$ $B_A = B_B = B_C$

7) A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries a constant current i, as shown.



(i) While the wire is being moved toward the rectangle, the induced current in the rectangle is:

A. zero   B. clockwise   X C. counterclockwise   D. into the page   E. out of the page

(ii) The wire is now held in place, and the current i is turned off. While the current is being turned off, the induced current in the rectangle is:

A. zero   X B. clockwise   C. counterclockwise   D. into the page   E. out of the page

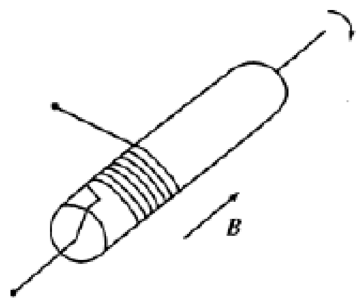
8) **What is the magnitude of the net force on the loop when the induced current is i?**

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

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

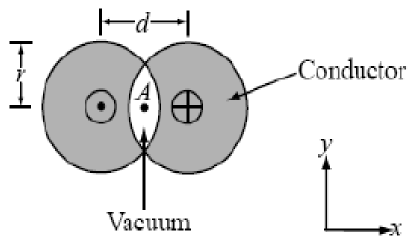
9) A series RLC circuit is used in a radio to tune to an FM station broadcasting at 103.7 MHz. The resistance in the circuit is 10 ohms and the inductance is 2.0 microhenries. What is the best estimate of the capacitance that should be used?

(A) 200 pF   (B) 50 pF   X (C) 1 pF   (D) 0.2 pF   (E) 0.02 pF



10) A wire is being wound around a rotating wooden cylinder of radius R. One end of the wire is connected to the axis of the cylinder, as shown in the figure above. The cylinder is placed in a uniform magnetic field of magnitude B parallel to its axis and rotates at N revolutions per second. What is the potential difference between the open ends of the wire?

(A) 0   (B) $2\pi NBR$ X (C) πNBR^2 (D) BR^2/N (E) πNBR^3



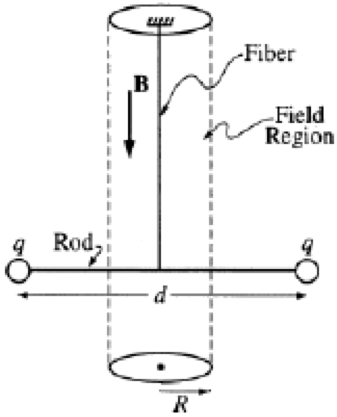
11) Two long conductors are arranged as shown above to form overlapping cylinders, each of radius r, whose centers are separated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along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

X (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.

12) 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.

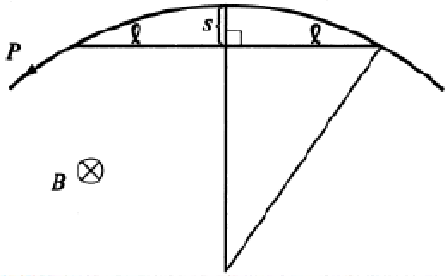
(B) It rotates with angular momentum $\frac{1}{4}qBd^2$.

(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.

13) 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 $s \ll \ell$.)

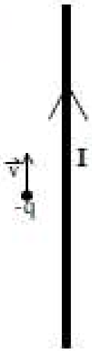


(A) $qBs^2/2\ell$ (B) qBs^2/ℓ (C) $qB\ell/s$ (D) $qB\ell^2/2s$ (E) $qB\ell^2/8s$

14) A charged particle, q, is moving with speed v perpendicular to a uniform magnetic field. A second identical charged particle is moving with speed $2v$ perpendicular to the same magnetic field. The time to complete one full circular revolution for the first particle is T_1. The time to complete one full circular revolution for the particle moving with speed $2v$ is

(a) $\frac{T_1}{4}$. (b) $\frac{T_1}{2}$. (c) T_1. (d) $2T_1$. (e) $4T_1$.

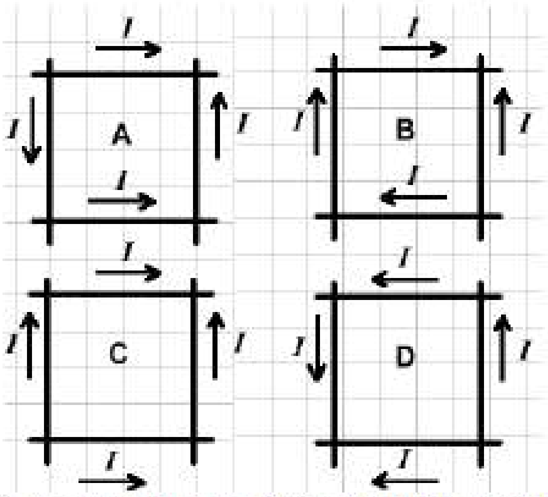
15) A negative charge $-q$ is moving parallel to a long straight wire carrying a constant current as illustrated in the figure below. Which arrow correctly describes the direction of the magnetic force experienced by the charge?



(a) ⊗(into the page) (b) ⟵ (c) ⟶

(d) ⊙(out of the page) (e) 0

16) The figure below shows four *different* sets of wires that cross each other *without actually touching.* The magnitude of the current is the same in all four cases, and the directions of current flow are as indicated. For which configuration will the magnetic field at the center of the square formed by the wires be equal to zero?



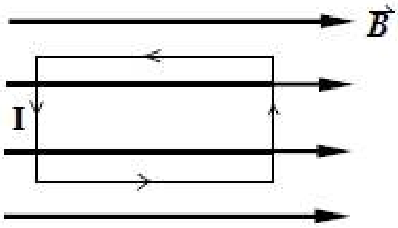
(a) A.

(b) B.

(c) C.

(d) D.

17) A rectangular loop of wire of length l and width w carrying current I is placed in a uniform magnetic field $\vec{B}$ as shown in the figure below. The magnetic field is parallel to the plane containing the loop. Which of the following statement(s) is (are) correct?



I. The current loop experiences a net force.

II. The current loop experiences no net force.

III. The magnetic dipole moment of the current loop, $\vec{\mu}$, points into the page.

IV. The magnetic dipole moment of the current loop, $\vec{\mu}$, points out of the page.

V. The current loop experiences no net torque.

VI. The current loop experiences a net torque.

(a) Only II and V are correct.

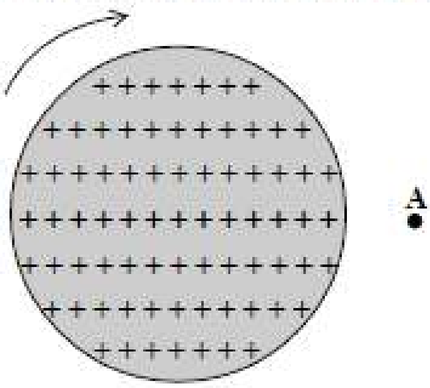
(b) Only I and VI are correct.

(c) Only I, III and IV are correct.

(d) Only II, IV and V are correct.

(e) Only II IV and VI are correct.

18) A positively charged disk is rotated clockwise as shown in the figure below. What it the direction of the magnetic field at point **A** in the plane of the disk?



(a) ⊗(into the page)

(b) $\longrightarrow$

(c) $\longleftarrow$

(d) ⊙(out of the page)

(e) 0

19) The current through an infinitely long solenoid is decreased linearly as a function of time. The figure below represents a cross section of the solenoid with the direction of the arrow indicating the current and the dots indicating the direction of the magnetic field. An electron is placed *initially at rest* outside the solenoid. The force the electron experiences at the instant it is released is best represented by which of the following arrows

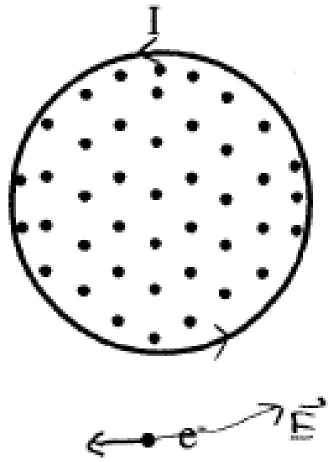
(A) ←

(B) ↘

(C) ↖

(D) →

(E) 0



20) The electric current in a solenoid is uniformly decreased from its inititial value to zero. During that time an electric field is generated inside the solenoid. Which of the following statement applies to the electric field?

→ A) The magnitude of the electric field is constant in time but increases along the radial direction away from the axis of the solenoid

B) There is no relationship between the electric field inside the solenoid and the variation of its electric current

C) The magnitude of the electric field is the same at every point within the solenoid but it decreases uniformly in time at the same rate as the electric current

D) The magnitude of the electric field is the same everywhere within the solenoid and is constant in time.

E) The magnitude of the electric field is constant in time but decreases along the radial direction away from the axis of the solenoid

21) Starting from zero, an electric current is established in a circuit made of a battery of emf E, a resistor of resistance R and an inductor of inductance L. The electric current eventually reaches its steady-state value. What would be the effect of using an inductor with a larger inductance in this circuit?

A) The steady-state value of the current would be larger, and it would take more time to reach it

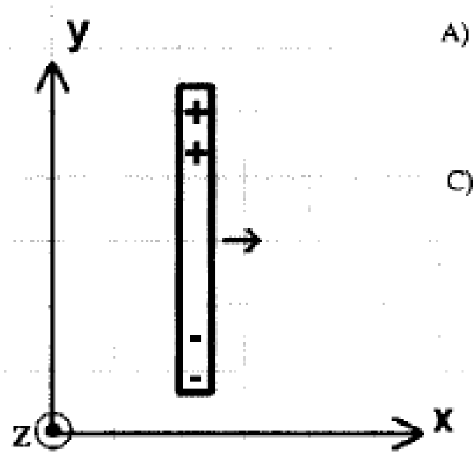
B) The steady-state value of the current would be the same, and it would take less time to reach it

C) The steady-state value of the current would be the same, and it would take the same amount of time to reach it

D) The steady-state value of the current would be larger, and it would take the same amount of time to reach it

→ E) The steady-state value of the current would be the same, and it would take more time to reach it

22) A metallic rod moves at constant speed in the positive x direction inside a uniform magnetic field as shown in the figure below. Positive and negative charges build up on the rod as indicated. What is the direction of the magnetic field?



A) Positive y

B) Negative y

C) Positive z

D) Negative z

E) Negative x

23) At time t = 0 s, the switch is closed in the circuit shown below. Which of the following graphs best describes the potential difference V_R across the resistance as a function of time t?