Name: Solutions

2049 Exam 3 **16 questions**

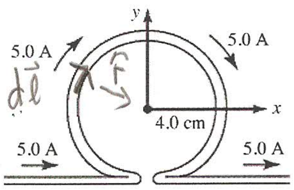
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) As shown in the figure, a wire is bent into the shape of a tightly closed omega (Ω), with a circular loop of radius 4.0 cm and two long straight sections. The loop is in the xy-plane, with the center at the origin. The straight sections are parallel to the x-axis. The wire carries a 5.0-A current, as shown. What is the magnitude of the magnetic field at the center of the loop? ($\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A)

HINT: The field is the superpostion of two fields, one due to the loop ($\vec{B}_1$) and one due to a straight wire ($\vec{B}_2$). Recall that arc length can be expressed as (radius)*(angle).

$\vec{B}_1 = \frac{\mu_0 I}{2\pi R}$ $\boxed{\text{OUT}}$

$\vec{B}_{TOTAL} = \frac{\mu_0 I}{2R}\left(1 - \frac{1}{\pi}\right)$



$\int d\vec{B} = \int \frac{\mu_0 I \, d\vec{l} \times \hat{r}}{4\pi r^2}$

$\vec{B}_2 = \frac{\mu_0 I}{4\pi R^2} \int_0^{2\pi} R \, d\theta = \frac{\mu_0 I}{2R}$ $\boxed{\text{IN}}$

A) 54 μT ✓ ☺ B) 104 μT C) 80 μT D) 40 μT E) 25 μT

2) Two long parallel wires carry currents of 20 A and 5 A in opposite directions. The wires are separated by 0.20 m. What is the magnitude of the magnetic field midway between the two wires? ($\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A)

20 A 5 A

$B = \frac{\mu_0 20}{2\pi(0.1)} + \frac{\mu_0 5}{2\pi(0.1)}$

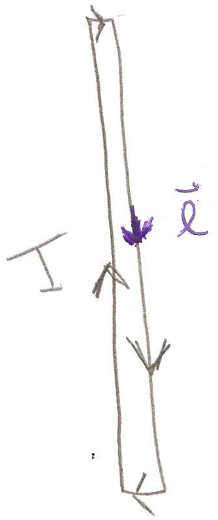
A) 3.0 × 10^{-5} T B) 1.0 × 10^{-5} T C) 2.0 × 10^{-5} T D) 4.0 × 10^{-5} T E) 5.0 × 10^{-5} T ✓

3) A rectangular loop of wire measures 1.0 m by 1.0 cm. If a 7.0-A current flows through the wire, what is the magnitude of the magnetic force on the centermost 1.0-cm segment of the 1.0-m side of the loop? ($\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A)

HINT: Make a reasonable approximation and save yourself a lot of effort. *

A) 7.8 × 10^{-7} N B) 9.8 × 10^{-6} N ✓ C) 4.9 × 10^{-6} N D) 9.8 × 10^{-8} N

@ location of $\vec{l}$, $\vec{B} = \frac{\mu_0(7)}{2\pi(0.01)}$ $\boxed{\text{IN}}$ * due to left wire



$\vec{F}_{\text{on } \vec{l}} = 7 * (\vec{l} \times \vec{B}) = 7(0.01)\left[\frac{\mu_0 7}{2\pi(0.01)}\right]$ $\boxed{\text{RIGHT}}$

OVER →

4) The figure shows four different sets of insulated wires that cross each other at right angles without actually making electrical contact. The magnitude of the current is the same in all the wires, and the directions of current flow are as indicated. For which (if any) configuration will the magnetic field at the center of the square formed by the wires be equal to zero?

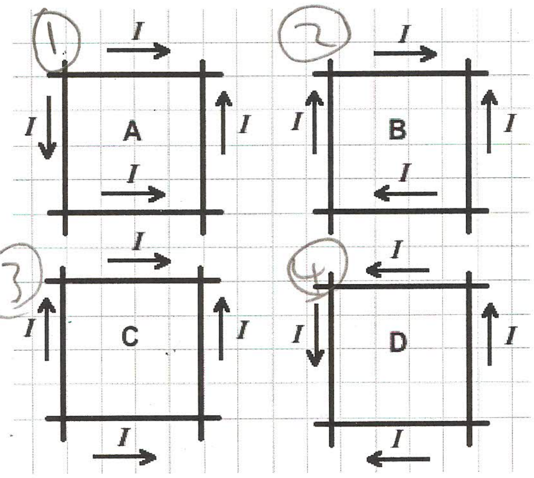
@center

① → 3 out, 1 in

② → 3 in, 1 out

③ → 2 out, 2 in ✓

④ → 3 out, 1 in



I $\vec{B}$

Superposition

A) A
B) B
C) C ✓
D) D
E) The field is not equal to zero in any of these cases.

5) A loop of wire is placed inside a large solenoid so that the plane of the loop is perpendicular to the axis of the solenoid. To be clear, the loop is oriented in the same way the coils of the solenoid are oriented. Current can be made to flow through the loop of wire if ________.

✓ A) the loop of wire is rotating within the solenoid, and a constant current is flowing through the solenoid wire. Changes Φ_B

✓ B) the current flowing through the solenoid is decreasing with time. Changes Φ_B

Φ_B ✗ Constant C) a constant current is flowing through the solenoid wire.

D) All of the above statements are true.

E) Only two of the above statements are true.

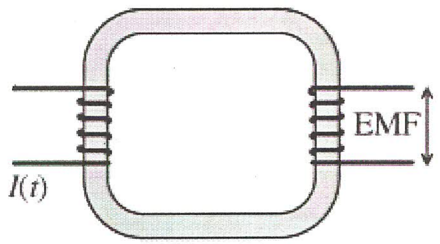
$$\Delta V = -\frac{d\Phi_B}{dt}$$

6) An AC current is flowing through the primary of a transformer, and the magnitude of the current as a function of time is shown below. At which moment in time is the induced EMF across the secondary of the transformer a maximum?

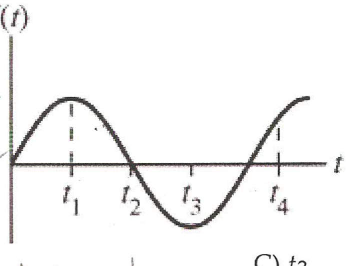
$\Delta V = -\frac{d\Phi_B}{dt}$

$\Phi_B = \int \vec{B}\cdot d\vec{A}$

time dependent because I(t)



Max. $\frac{d\Phi}{dt}$ when Max. $\frac{dI}{dt}$



A lot of understanding needed here

A) t_1 B) t_2 C) t_3 D) t_4

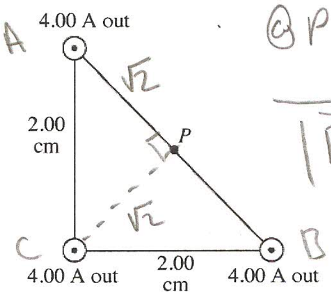
|slope| is greatest

7) Consider a coil composed of ten loops of wire. Each loop has an area of 0.23 m^2. The coil has a very large resistance and is placed in a 0.047 tesla uniform magnetic field, oriented so that the maximum flux goes through the coil. The coil is then rotated so that the flux through it goes to zero in 0.34 s. What is the magnitude of the average voltage induced in the coil over this time interval?

$|\Delta V| = \left|\frac{\Delta\Phi_B}{\Delta t}\right| = \left|\frac{0 - 10(0.23)(0.047)}{0.34}\right|$

A) 0.00 V B) 1.0 V C) 0.0032 V D) 0.32 V E) 0.032 V

8) Three very long, straight, parallel wires each carry currents of 4.00 A, directed out of the page as shown in the figure. The wires pass through the vertices of a right isosceles triangle of side 2.00 cm. What is the magnitude of the magnetic field at point *P* at the midpoint of the hypotenuse of the triangle?



@ P, $\vec{B}_A$ cancels $\vec{B}_B$ (symmetry)

$|\vec{B}_C|_{@P} = \frac{\mu_0(4)}{2\pi(\sqrt{0.02})} = 5.66\times10^{-6}$

A) 4.42 × 10^{-6} T B) 5.66 × 10^{-6} T C) 1.77 × 10^{-5} T D) 1.26 × 10^{-4} T E) 1.77 × 10^{-6} T

9) A circular loop of wire lies in the plane of the paper. An increasing magnetic field points out of the paper. What is the direction of the induced current in the loop?

A) clockwise then counter-clockwise
B) clockwise
C) counter-clockwise
D) counter-clockwise then clockwise
E) There is no current induced in the loop.

$\vec{B}$ is increasing

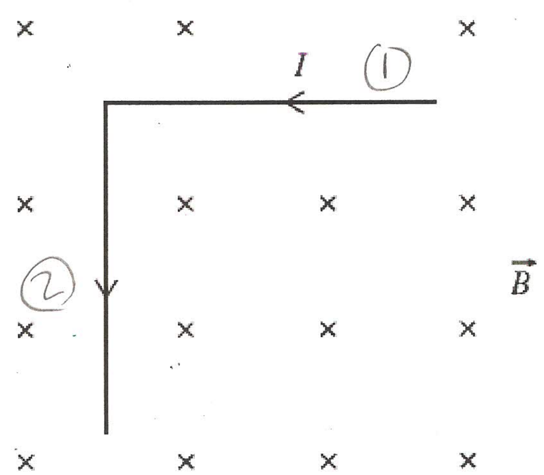
∴ Induced current must have mag. field going $\boxed{\text{In}}$ through loop. ⇒ CW

10) An L–shaped metal machine part is made of two equal–length segments that are perpendicular to each other and carry a 4.50–A current as shown in the figure. This part has a total length of 3.00 m, and it is in an external 1.20–T magnetic field that is oriented perpendicular to the plane of the part, as shown. What is the magnitude of the NET magnetic force that the field exerts on the part?

$\vec{F}_1 = I\vec{l}_1 \times \vec{B}$
$= -4.5(1.5)(1.2)\hat{j}$

$\vec{F}_2 = I\vec{l}_2 \times \vec{B}$
$= +4.5(1.5)(1.2)\hat{i}$

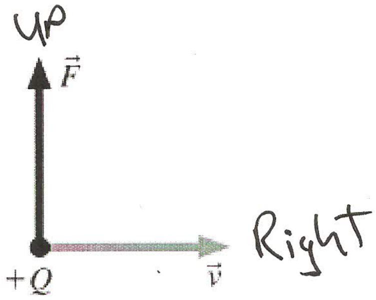
$\therefore \vec{F} = 8.1\hat{i} - 8.1\hat{j}$
$|\vec{F}| = 11.5$



A) 32.4 N B) 22.9 N C) 16.2 N D) 11.5 N E) 8.10 N

11) A positive charge is moving to the right and experiences a vertical (upward) magnetic force. In which direction is the magnetic field?

$\vec{F} = q\vec{v} \times \vec{B}$



A) to the right
B) upward
C) to the left
D) into the page
E) out of the page

$\vec{F} = q\vec{v} \times B$
Negative !!

12) An electron is moving in the plane of this paper and to the right. It enters a magnetic field. If the electron experiences a magnetic deflection that is down, the direction of the magnetic field in this region is ________________.

A) down B) out C) up D) in E) left

$\vec{v}$ $\vec{F}$

13) At what distance from the central axis of a long straight thin wire carrying a current of 5.0 A is the magnitude of the magnetic field due to the wire equal to the strength of the Earth's magnetic field of about 5.0×10^{-5} T? ($\mu_0 = 4\pi \times 10^{-7}$ T • m/A)

$B = \frac{\mu_0 I}{2\pi r}$

A) 1.0 cm B) 2.0 cm C) 4.0 cm D) 5.0 cm E) 3.0 cm

$\therefore r = \frac{\mu_0 I}{2\pi B} = 0.02$ meters

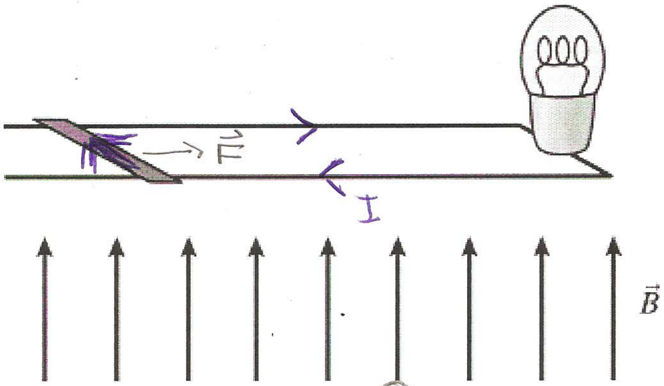
$B = \frac{\mu_0 I}{2\pi r}$ ∴ $I = \frac{2\pi r B}{\mu_0} = 0.011\text{ A}.$

14) The magnitude of a magnetic field a distance 2.0 μm from a wire is 11.0×10^{-4} T. How much current is flowing through the wire. Assume the wire is the only contributor to the magnetic field.

A) 11 mA ✓ B) 7 mA C) 69 mA D) 138 mA

15) A conducting bar is free to slide horizontally on the rails of a conducting frame, as shown in the figure below. A light bulb is attached to the right end of the rails. A spatially uniform magnetic field is oriented vertically (perpendicular to the horizontal plane of the rails and bar). Initially the bar is stationary. The strength of the ① magnetic field begins increasing in time at a constant rate, which induces a current through the bar, frame, and light bulb. The bar begins to move due to the magnetic force exerted on it. Once the bar begins to move, the brightness of the light bulb ____________________.

HINT: Figure out which direction the current flows through the bar. Then consider how the motion of the bar affects the changing the flux through the loop.



① → Induces the current shown

② → $\vec{F} = I\vec{\ell} \times \vec{B}$ moves bar to right.

③ → Increasing $\vec{B}$ is increasing Φ_B, but motion acts to decrease Φ_B. This makes $\left(\frac{d\Phi_B}{dt}\right)$ less that what it was,

⇒ bulb dims

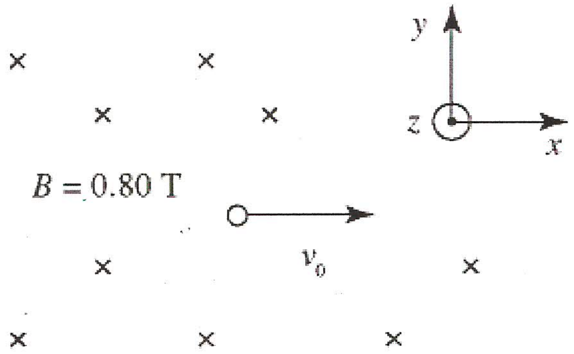
A) stays the same.
B) decreases.
C) increases.
D) suddenly drops to zero.

Yes; lots to consider ☺.

OVER →

16) A uniform magnetic field of magnitude 0.80 T in the negative z direction is present in a region of space, as shown in the figure. A uniform electric field is also present and is set at 76,000 V/m in the $+y$ direction. An electron is projected with an initial velocity $v_0 = 9.5 \times 10^4$ m/s in the $+x$ direction. The y component of the initial force on the electron is closest to which of the following quantities? ($e = -1.60 \times 10^{-19}$ C)

NOTE that the figure is showing the coordinate system at the top right, where the z axis is coming out of th e page.



A) -2.4×10^{-14} N ✓
B) $+2.4 \times 10^{-14}$ N
C) -1.0×10^{-14} N
D) zero
E) $+1.0 \times 10^{-14}$ N

$$\vec{F}_B = q\vec{v} \times \vec{B} = -1.6\times10^{-19}(9.5\times10^{4})(0.8)\hat{j}$$

$$+ \quad \vec{F}_E = q\vec{E} = -1.6\times10^{-19}(76000)\hat{j}$$

$$\vec{F}_{TOTAL} = -2.4\times10^{-14}\,\hat{j}$$