PHYS 1320 (Spring 2024) Sonnenfeld Online HW #8 Faraday's Law / EM Waves

Problem 1: Suppose a 50 turn coil lies in the plane of the page in a uniform magnetic field that is directed into the page. The coil originally has an area of ***0.175*** m^2 . It is squished to have no area in ***0.15*** s.

Randomized Variables

A = ***0.175*** m^2
t = ***0.15*** s

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What is the magnitude of the average induced emf in volts if the uniform magnetic field has a strength of 1.5 T?
Numeric : A numeric value is expected and not an expression.
$\mathcal{E}$ = _____

Problem 2: An MRI technician moves his hand from a region of very low magnetic field strength into an MRI scanner's 2.00 T field with his fingers pointing in the direction of the field.
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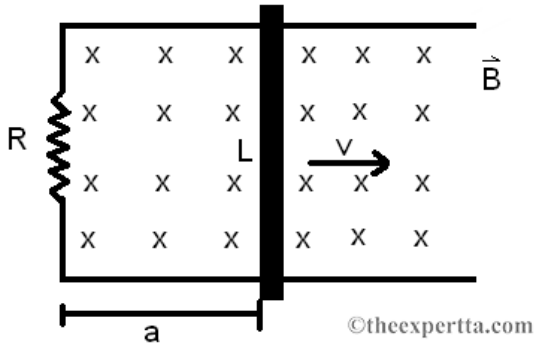
Find the average emf, in millivolts, induced in his wedding ring given its diameter is 2.41 cm, and assuming it takes 0.417 s to move it into the field.
Numeric : A numeric value is expected and not an expression.
$\mathcal{E}_{avg}$ = _____ mV

Problem 3: A conducting rod spans a gap of length L = ***0.045*** m and acts as the fourth side of a rectangular conducting loop, as shown in the figure. A constant magnetic field with magnitude B = ***0.65*** T pointing into the paper is in the region. The rod is pulled to the right by an external force, and moves with constant speed v = ***0.065*** m/s. The resistance in the wire is R = ***110*** Ω.



Randomized Variables

L = ***0.045*** m
B = ***0.65*** T
v = ***0.065*** m/s
R = ***110*** Ω

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Part (a) Express the magnitude of the magnetic flux going through the loop, Φ, in terms of B, a and L.
Expression :
Φ = _____

Select from the variables below to write your expression. Note that all variables may not be required.
β, **Δt**, **ε**, **θ**, **a**, **B**, **d**, **g**, **h**, **L**, **m**, **n**, **R**, **t**, **v**

Part (b) Express the change in the magnetic flux, $\Delta\Phi$, in terms of B, L, v and Δt.
Expression :
$\Delta\Phi$ = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **Δt**, **ε**, **θ**, **a**, **B**, **d**, **g**, **h**, **L**, **m**, **q**, **R**, **v**

Part (c) Express the magnitude of the average emf induced in the loop, ε, in terms of B, L, v.
Expression :
ε = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **Δt**, **ε**, **θ**, **a**, **B**, **d**, **g**, **h**, **L**, **m**, **R**, **t**, **v**

Part (d) Calculate the emf, in volts.
Numeric : A numeric value is expected and not an expression.
ε = _____

Part (e) Express the current induced in the loop, I, in terms of ε and R.
Expression :
I = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **Δt**, **ε**, **θ**, **a**, **B**, **d**, **g**, **h**, **L**, **m**, **R**, **t**, **v**

Part (f) Calculate the value of I, in amperes.
Numeric : A numeric value is expected and not an expression.
I = _____

Part (g) What is the direction of the current?
MultipleChoice :

1) Counterclockwise.
2) Clockwise.

Problem 4: Two conducting wires have currents in the direction indicated. The current through the wire on the left is increasing, and the current through the wire on the right is decreasing. Each wire has two loops placed near them.
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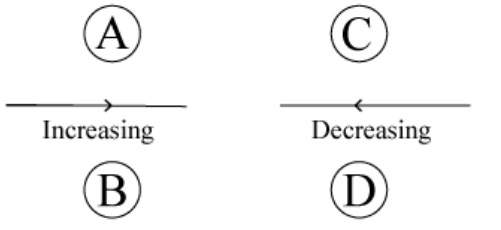

Which of the following gives the correct direction, clockwise (CW) or counterclockwise (CCW), of the induced EMF in the loops A,B,C,D?
MultipleChoice :

1) CW, CW, CCW, CCW
2) CCW, CW, CCW, CW
3) CW, CCW, CW, CCW
4) CCW, CCW, CW, CW

Problem 5: In the questions below there are 6 induction processes. The circle with the dot denotes a magnetic field pointing out of and the circle with the x denotes a magnetic field pointing into the screen. A line represents a conductor, while a bar denotes a sliding conductor. An arrow labeled “v” indicates the direction in which the conductor or sliding conductor is moving.

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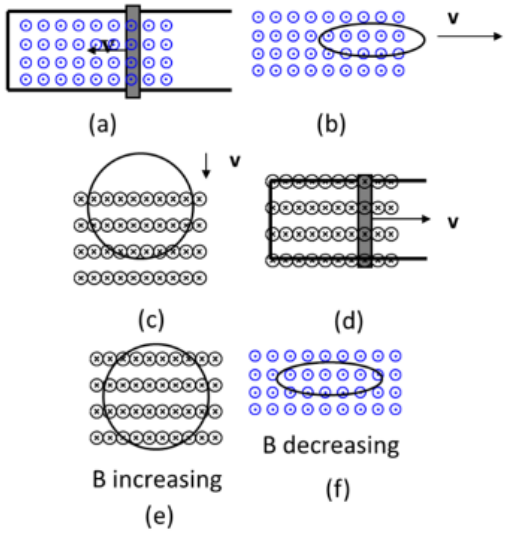
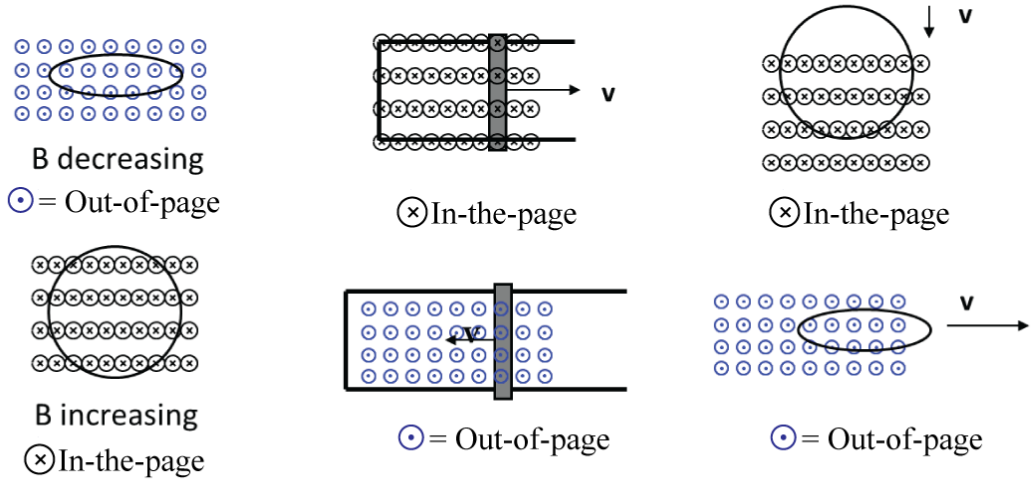


Use Lenz’s law to determine which of induced currents have a counterclockwise direction. Choose all that apply.
SchematicSelect :



Problem 6: A rectangular metal coil with *12* turns has a resistance of 4.7 Ω and dimensions as shown in the drawing. The magnetic field at all points inside the coil varies according to $B = B_0 e^{-\alpha t}$, where $B_0 = 0.45$ T and $\alpha = 250$ s^{-1}.
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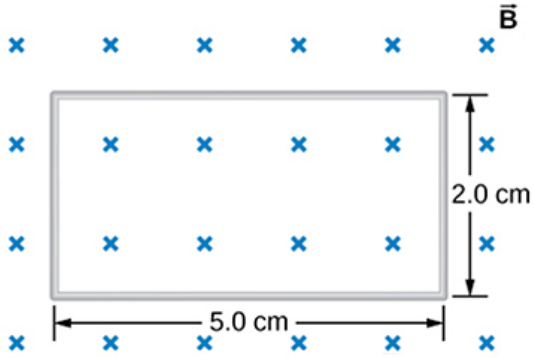

Part (a) What is the magnitude, in amperes, of the current induced in the loop at $t = 1.0$ ms?
Numeric : A numeric value is expected and not an expression.
I_1 = _____ A

Part (b) What is the magnitude, in amperes, of the current induced in the loop at $t = 20.0$ ms?
Numeric : A numeric value is expected and not an expression.
I_2 = _____ A

Problem 7: A single-turn rectangular wire loop has a resistance equal to 1.4 Ω and the dimensions shown in the drawing. The magnetic field at all points inside the loop varies according to $B = B_0 e^{-\alpha t}$, where $B_0 = 0.25$ T and $\alpha = 200$ s^{-1}.
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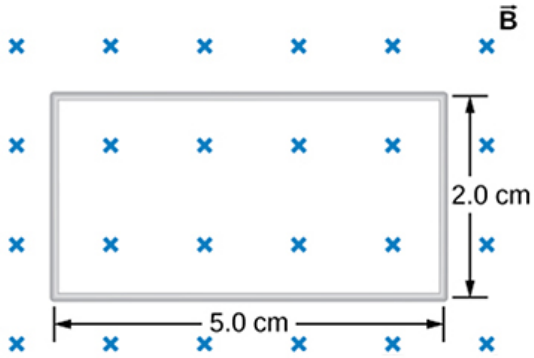

Part (a) What is the magnitude, in amperes, of the current induced in the loop at $t = 1.0$ ms?
Numeric : A numeric value is expected and not an expression.
I_1 = _____ A

Part (b) What is the magnitude, in amperes, of the current induced in the loop at $t = 20.0$ ms?
Numeric : A numeric value is expected and not an expression.
I_2 = _____ A

Problem 8: The magnetic field through a circular loop of radius $r = 5$ cm varies with time, as shown. The direction of the field is perpendicular to the loop.
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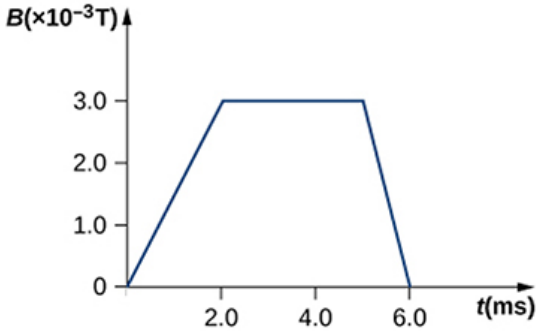

Part (a) What is the magnitude of the induced emf, ε_1, in millivolts, at time $t_1 = 1.0$ ms?
Numeric : A numeric value is expected and not an expression.
$|\varepsilon_1|$ = _____ mV

Part (b) What is the magnitude of the induced emf, ε_2, in millivolts, at the time $t_2 = 3.0$ ms?
Numeric : A numeric value is expected and not an expression.
$|\varepsilon_2|$ = _____ mV

Part (c) What is the magnitude of the induced emf, ε_3, in millivolts, at time $t_3 = 5.5$ ms?
Numeric : A numeric value is expected and not an expression.
$|\varepsilon_3|$ = _____ mV

Problem 9: The speed of light c is approximately 2.998×10^8 m/s.
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What (rather remarkable!) equation relates the speed of light to other fundamental electromagnetic constants?
Expression :
c = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **ε_0**, **μ_0**, **θ**, **a**, **d**, **g**, **h**, **j**, **k**, **m**, **P**, **S**, **t**

Problem 10: Electromagnetic radiation having a wavelength of ***12.5*** μm is classified as *infrared*.

Randomized Variables

λ = ***12.5*** μm

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What is its frequency in hertz?
Numeric : A numeric value is expected and not an expression.
f = _____

Problem 11: The frequency of an electromagnetic wave traveling in vacuum is f = ***4.9*** × 10^6 Hz.

Randomized Variables

f = ***4.9*** × 10^6 Hz

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Part (a) Express the wavelength of the wave, λ, in terms of f and the speed of light, c.
Expression :
λ = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **θ**, **a**, **c**, **d**, **f**, **g**, **h**, **i**, **j**, **k**, **m**, **P**, **t**

Part (b) Calculate the wavelength, λ, in meters.
Numeric : A numeric value is expected and not an expression.
λ = _____

Problem 12: The frequency range for AM radio is 540 to 1600 kHz. The frequency range for FM radio is 88.0 to 108 MHz.
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Part (a) Caculate the maximum wavelength for AM radio in meters.
Numeric : A numeric value is expected and not an expression.
$\lambda_{AM,max}$ = _____

Part (b) Caculate the minimum wavelength for AM radio in meters.
Numeric : A numeric value is expected and not an expression.

$\lambda_{AM,min}$ = _____

Part (c) Caculate the maximum wavelength for FM radio in meters.
Numeric : A numeric value is expected and not an expression.
$\lambda_{FM,max}$ = _____

Part (d) Caculate the minimum wavelength for FM radio in meters.
Numeric : A numeric value is expected and not an expression.
$\lambda_{FM,min}$ = _____

Problem 13: A radar used to detect the presence of aircraft receives a pulse that has reflected off an object ***8.5*** × 10^{-5} s after it was transmitted.

Randomized Variables

t = ***8.5*** × 10^{-5} s

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What is the distance in m from the radar station to the reflecting object?
Numeric : A numeric value is expected and not an expression.
d = _____

Problem 14: Consider a microscope that uses ultraviolet light of frequency 1.45×10^{15} Hz.
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Ignoring the details of the optical system, what is the approximate size, in meters, of the smallest feature observable through this microscope?
Numeric : A numeric value is expected and not an expression.
d = _____ m

Problem 15: A rectangular coil with N = ***880*** turns is moving to the right with a speed v = ***8.6*** m/s between the poles of a large electromagnet producing a magnetic field of magnitude B. The coil has a width a = ***12*** cm and length L = 5.5 cm.

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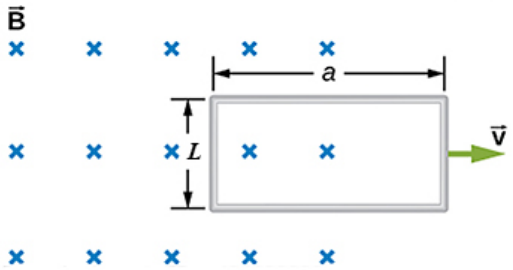

Part (a) Assuming that the magnetic field is uniform between the pole faces and negligible elsewhere, write an expression for the induced emf in the coil.
Expression :
ε = _____

Select from the variables below to write your expression. Note that all variables may not be required.
ε_0, **a**, **B**, **I**, **L**, **N**, **P**, **t**, **v**

Part (b) What is the magnitude of the emf ε induced in the coil in volts if the uniform magnetic field has a strength of 2.50 T?
Numeric : A numeric value is expected and not an expression.
ε = _____ V