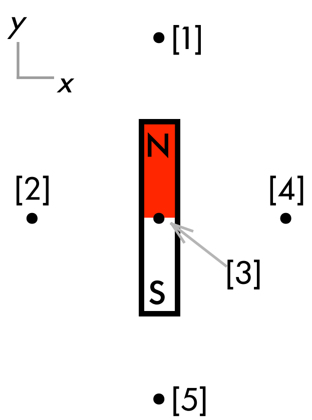
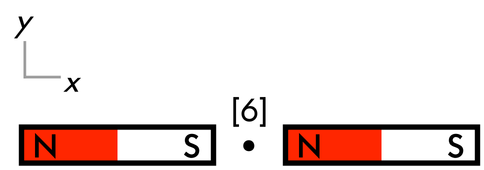
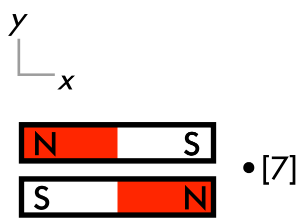
A magnet, or a pair of magnets create magnetic fields. The magnet and pair of magnets are separated far apart such that they can be considered isolated from each other.

Draw the direction of the magnetic field vector at each location (1)-(7). These directions will be one of the following choices (or if there is no magnetic field at that location, then specify so):

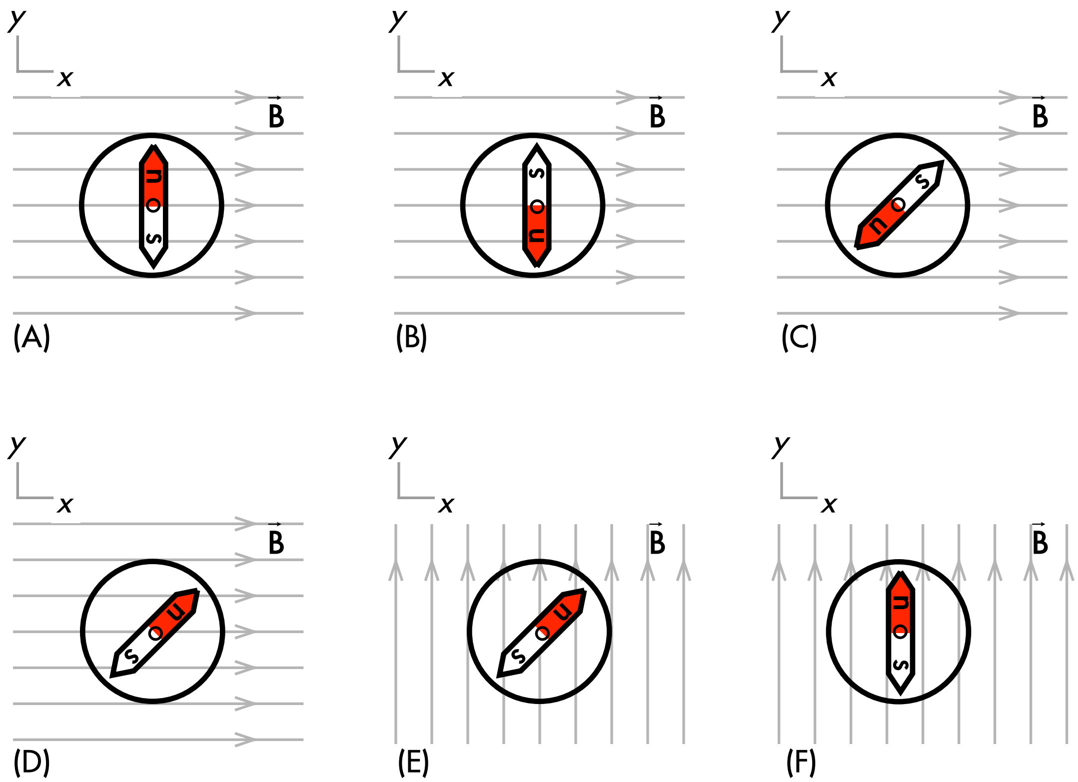
(A) Up ↑.
(B) Down ↓.
(C) Left ←.
(D) Right →.
(E) Into the page ⊗.
(F) Out of the page ⊙.
(G) (No direction, as the magnetic field is zero.)
(H) (Unsure/lost/guessing/help!)







Compasses are placed in magnetic fields, and their needles are allowed to rotate from their initially stationary positions.



8. Identify the compass(es) (if any) with needles that will remain stationary.

Compass(es) with stationary needles:

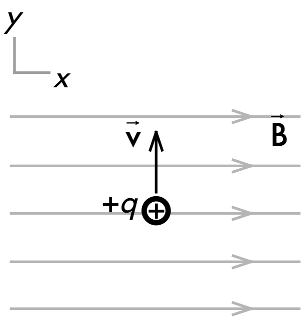
9. Identify the compass(es) (if any) with needles that will begin to rotate clockwise, or counterclockwise.

Compass(es) with clockwise rotating needles:

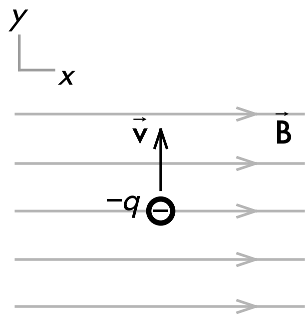
Compass(es) with counterclockwise rotating needles:

10. For each compass, draw in the final orientation of their needles, after coming to rest.

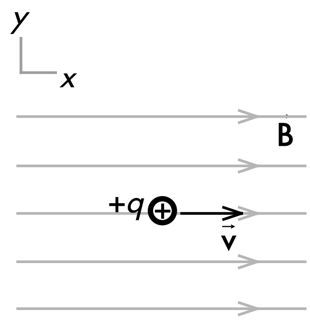
Charges move through magnetic fields.



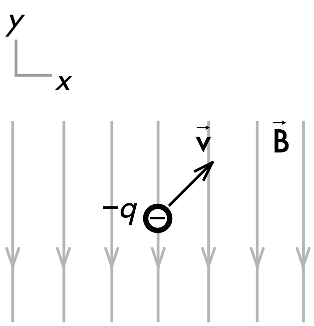
[11]



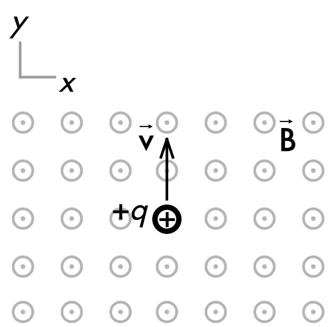
[12]



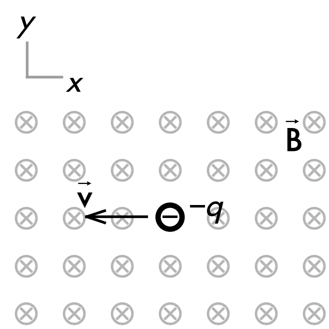
[13]



[14]



[15]

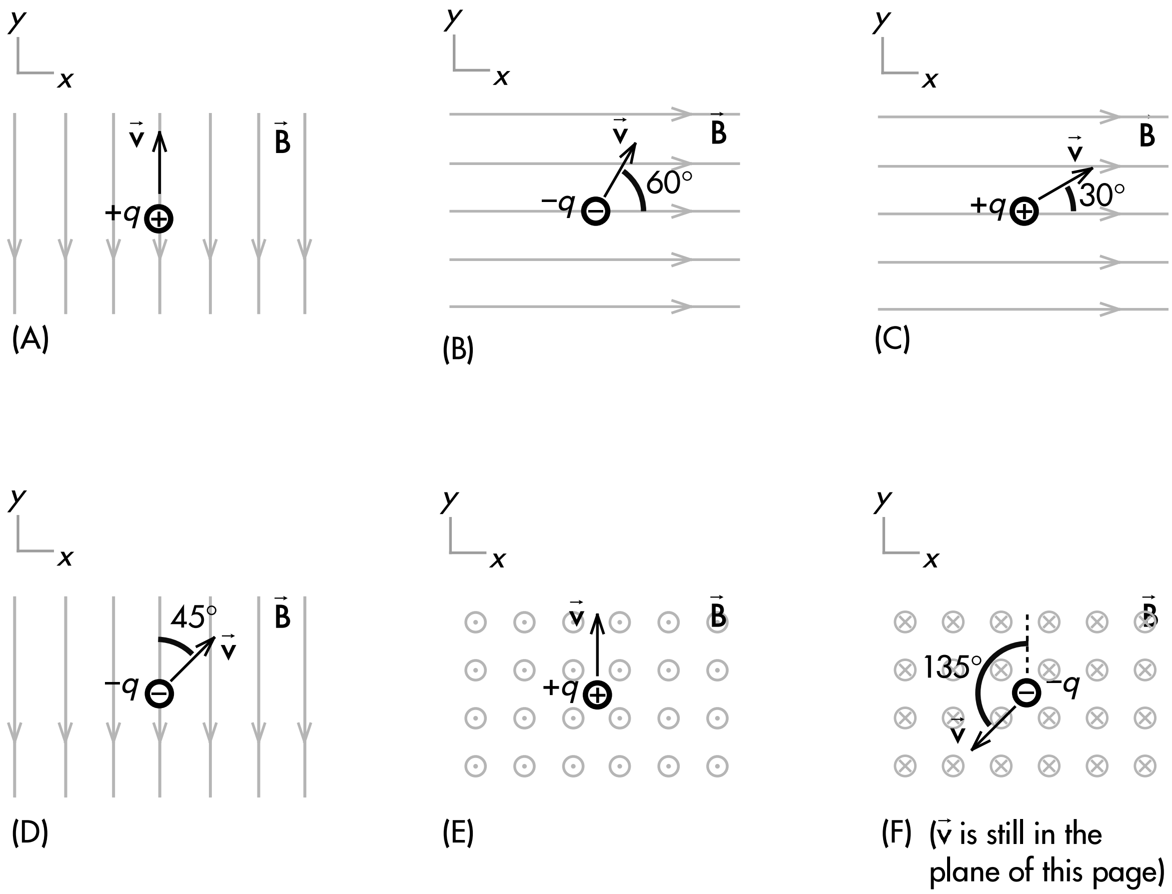


[16]

Determine the direction of the force of the magnetic field on these moving charges. These directions will be one of the following choices (or if there is no magnetic force on the moving charge, then specify so):

(A) Up ↑.
(B) Down ↓.
(C) Left ←.
(D) Right →.
(E) Into the page ⊗.
(F) Out of the page ⊙.
(G) (No direction, as the force of the magnetic field is zero.)
(H) (Unsure/lost/guessing/help!)

Charges move through magnetic fields. The amounts of all charges are identical (regardless of ± sign). All charges move at the same speed (regardless of direction). All magnetic fields are the same strength (regardless of direction).



17. Rank the force of the magnetic field on these moving charges from smallest to largest magnitude. Indicate ties, if any.

______ ______ ______ ______ ______ ______

(smallest F) (largest F)

18. Draw the directions of the force of the magnetic field on these moving charges. (If there is no force exerted on the moving charge, then specify so.)

19. The tip of a compass needle that "points north" is a magnetic __________ pole, and located in the Arctic Ocean off the shores of northern Canada is Earth's magnetic __________ pole.
(A) north; north.
(B) north; south.
(C) south; north.
(D) south; south.
(E) (Unsure/guessing/lost/help!)

---

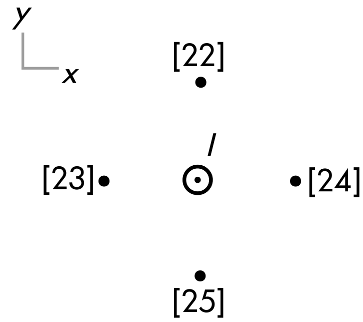
20. A magnetic field exerts a force on a moving charge.

[Increasing / Decreasing] the [amount of charge / speed / magnetic field strength] would __________ the magnitude of the force of the magnetic field exerted on the charge.
(A) increase.
(B) have no effect on.
(C) decrease.
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

---

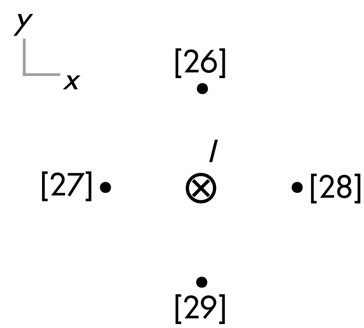
21. Two parallel wires with [the same amount / different amounts] of current, flowing in [the same direction / opposite directions] will exert __________ magnetic forces on each other.
(A) attractive.
(B) repulsive.
(C) (Neither of the above choices, as there would be no magnetic force.)
(D) (Not enough information.)
(E) (Unsure/guessing/lost/help!)

A current-carrying wire, or a pair of current-carrying wires create magnetic fields. Each wire carries the same amount of current. The wire and pair of wires are separated far apart such that they can be considered isolated from each other.

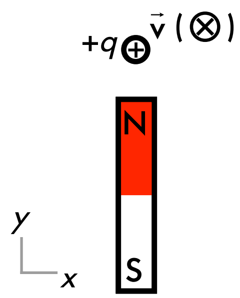


Draw the direction of the magnetic field vector at each location. These directions will be one of the following choices (or if there is no magnetic field at that location, then specify so):

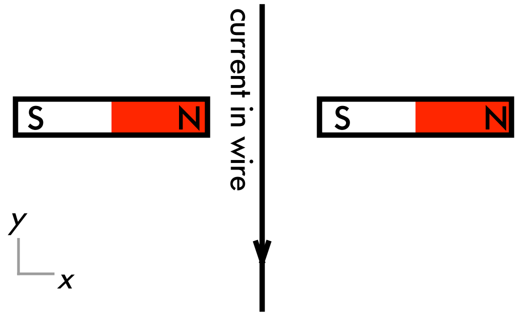
(A) Up ↑.
(B) Down ↓.
(C) Left ←.
(D) Right →.
(E) Into the page ⊗.
(F) Out of the page ⊙.
(G) (No direction, as the magnetic field is zero.)
(H) (Unsure/lost/guessing/help!)



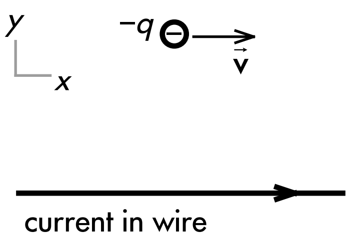
Point charges or charges in a current-carrying wire move near a magnet, pair of magnets, or a current carrying wire.



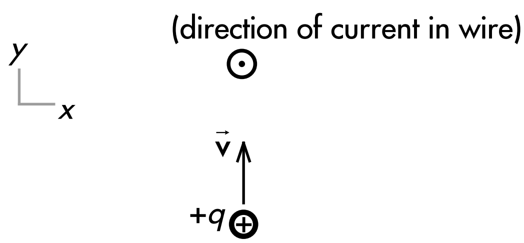
[36] $+q$ moving into page



[37] current-carrying wire between magnets



[38] $-q$ moving alongside wire



[39] $+q$ moving upwards towards wire

Determine the direction of the magnetic field at each location of these moving charges. These directions will be one of the following choices (or if there is no magnetic field at the location of the moving charge, then specify so):

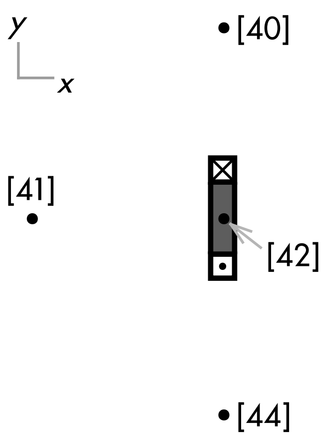
(A) Up ↑.
(B) Down ↓.
(C) Left ←.
(D) Right →.
(E) Into the page ⊗.
(F) Out of the page ⊙.
(G) (No direction, this quantity is zero.)
(H) (Unsure/lost/guessing/help!)

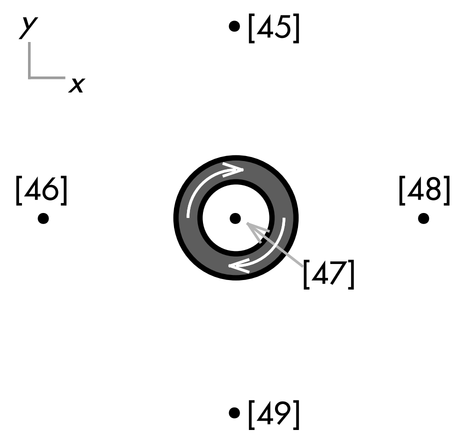
Then determine the direction of the force of the magnetic field on these moving charges. Use the same (A)-(H) choices as above. (If there is no magnetic field on the moving charge, then specify so.)

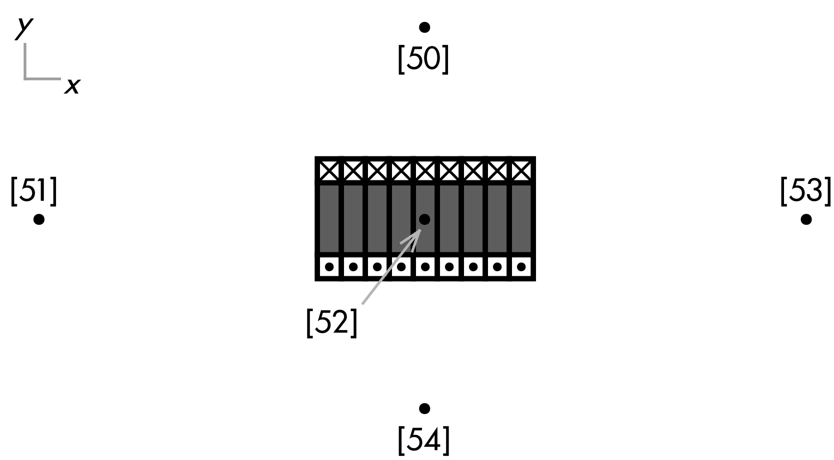
Circular loops of current-carrying wire, or a solenoid (stack of current-carrying wire loops) create magnetic fields. These loops are separated far apart such that they can be considered isolated from each other.

Draw the direction of the magnetic field vector at each location. These directions will be one of the following choices (or if there is no magnetic field at that location, then specify so):

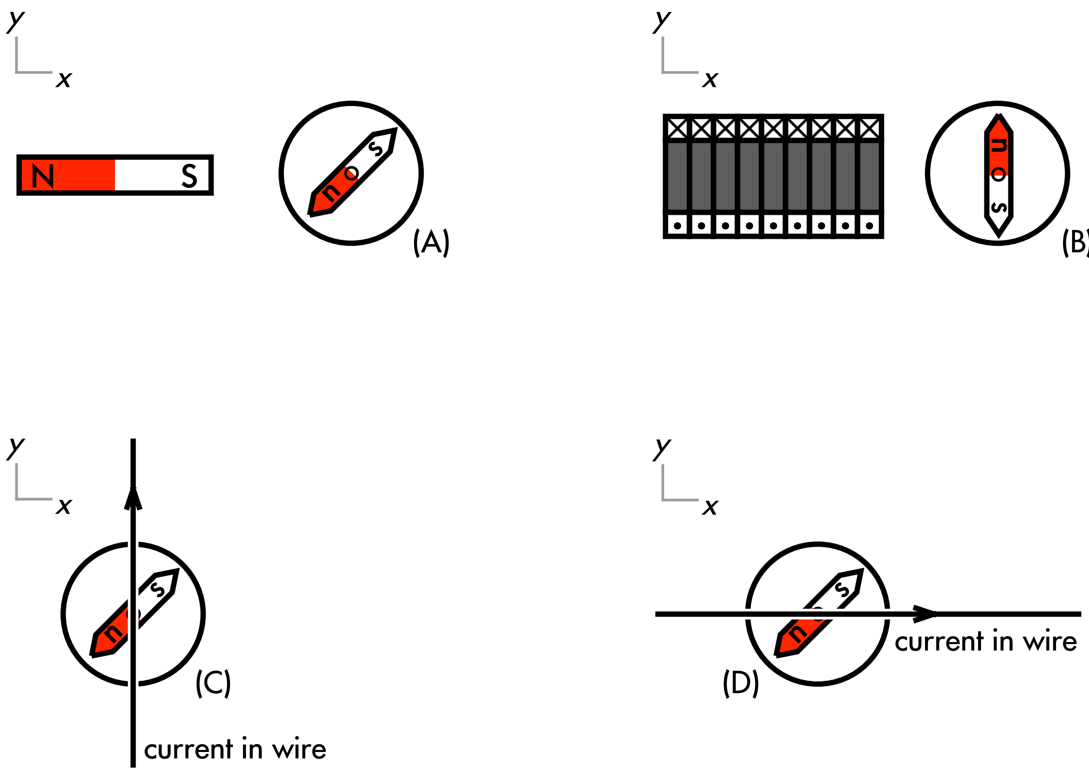
(A) Up ↑.
(B) Down ↓.
(C) Left ←.
(D) Right →.
(E) Into the page ⊗.
(F) Out of the page ⊙.
(G) (No direction, as the magnetic field is zero.)
(H) (Unsure/lost/guessing/help!)







Compasses are placed near magnets, solenoids (stack of current-carrying loops), and current-carrying wires. The compass needles are allowed to rotate from their initially stationary positions.



55. Identify the compass(es) (if any) with needles that will remain stationary.

Compass(es) with stationary needles:

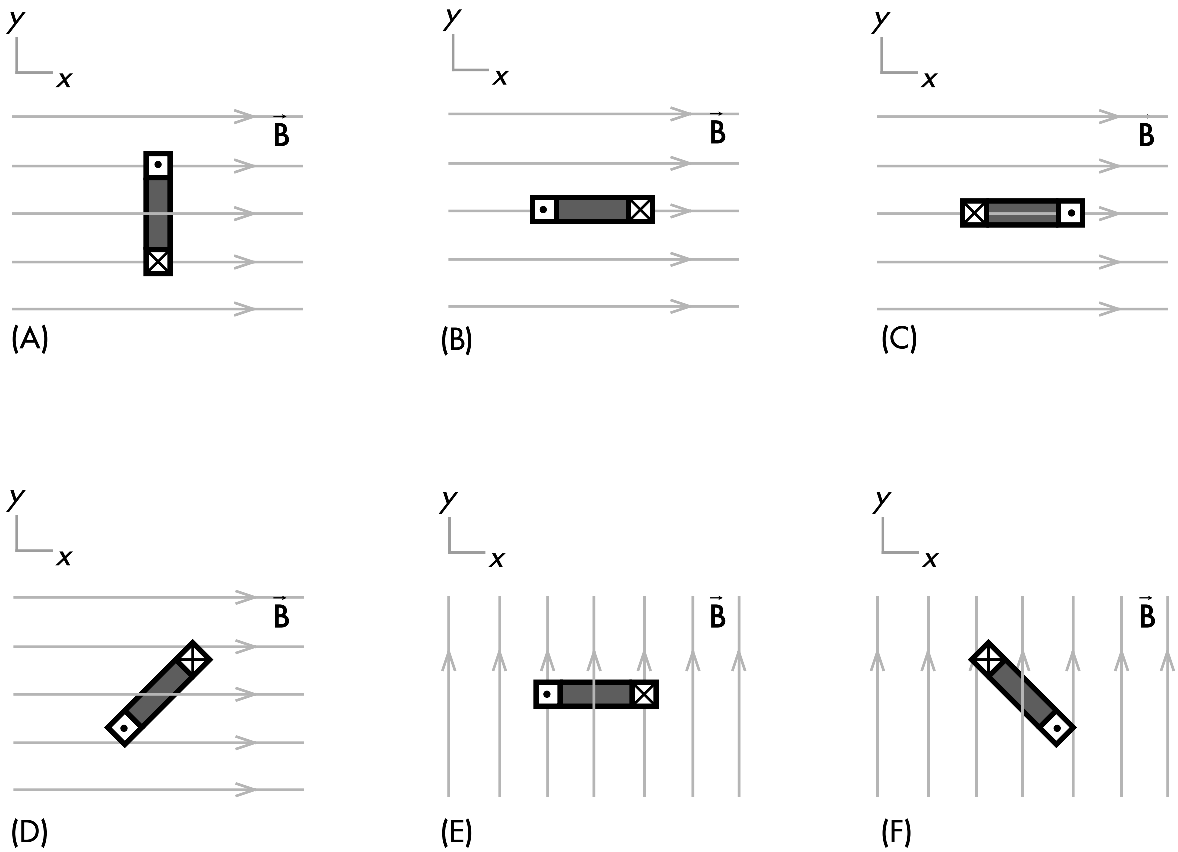
56. Identify the compass(es) (if any) with needles that will begin to rotate clockwise, or counterclockwise.

Compass(es) with clockwise rotating needles:

Compass(es) with counterclockwise rotating needles:

57. For each compass, draw in the final orientation of their needles, after coming to rest.

Circular loops of current-carrying wire are placed in magnetic fields. The loops are allowed to rotate from their initially stationary positions.



58. Identify the loop(s) (if any) that will remain stationary.

Stationary loop(s):

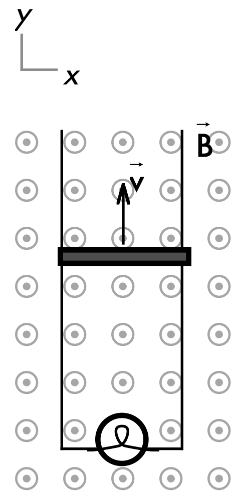
59. Identify the loop(s) (if any) that will begin to rotate clockwise, or counterclockwise.

Clockwise rotating loops:

Counterclockwise rotating loops:

60. For each loop, draw in the final orientation, after coming to rest.

A conducting rod in a uniform external magnetic field is allowed to slide on top of metal rails, which are connected to a light bulb to form a complete circuit.



61. While the rod is [moving upwards / stationary / moving downwards], the __________ end is at a higher potential.

(A) left.
(B) right.
(C) (both ends will have the same potential.)
(D) (Unsure/guessing/lost/help!)

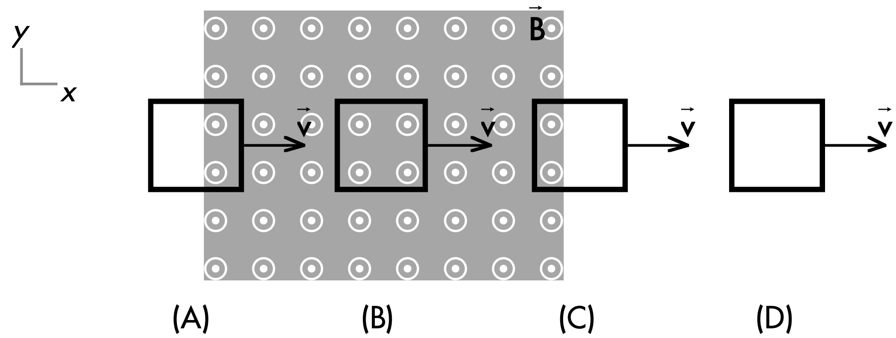
62. While the rod is [moving upwards / stationary / moving downwards], current will flow __________ through the light bulb.

(A) left to right.
(B) right to left.
(C) (no current flows through the light bulb.)
(D) (Unsure/guessing/lost/help!)

63. [Increasing / Decreasing] the [rod length / speed of the rod / magnetic field strength] would __________ the current flowing through the light bulb.

(A) increase.
(B) have no effect on.
(C) decrease.
(D) (Unsure/guessing/lost/help!)

A square metal loop moves at constant velocity. An external magnetic field has uniform magnitude and direction in a certain region, and is zero everywhere outside of this region. The loop has a resistance R.



64. Identify the loop(s) (if any) with no induced current flowing through it.

Loop(s) with no induced current:

65. Identify the loop(s) (if any) with clockwise, or counterclockwise induced current.

Loop(s) with clockwise induced currents:

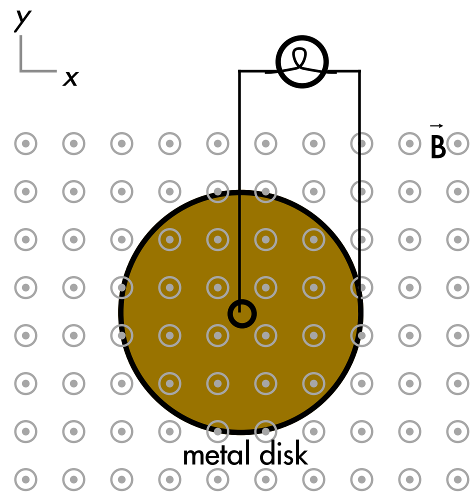
Loop(s) with counterclockwise induced currents:

66. [Increasing / Decreasing] the [loop area[1] / speed of the loop / magnetic field strength] would __________ the maximum amount of current flowing through the loop.

(A) increase.
(B) have no effect on.
(C) decrease.
(D) (Unsure/guessing/lost/help!)

[1] Assume that the loop is still smaller than the magnetic field region.

A solid metal disk rotates at a constant rate in a uniform external magnetic field. The central axis and edge of the disk are connected to a light bulb to form a complete circuit.



67. While the disk is [rotating clockwise / stationary / rotating counterclockwise], the __________ of the disk is at a higher potential.

(A) center.
(B) edge.
(C) (both center and edge will have the same potential.)
(D) (Unsure/guessing/lost/help!)

68. [Increasing / Decreasing] the [disk radius[2] / rotation speed / magnetic field strength] would __________ the maximum amount of induced emf in the disk.

(A) increase.
(B) have no effect on.
(C) decrease.
(D) (Unsure/guessing/lost/help!)

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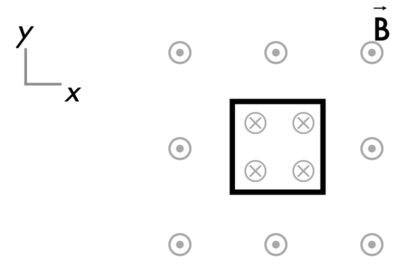
[2] Assume that the disk can still fit completely inside the magnetic field.

69. The magnetic field of a square metal loop is shown at right. The direction of current in the loop is:
(A) clockwise.
(B) counterclockwise.
(C) (No direction, as there is no current in the loop.)
(D) (Unsure/guessing/lost/help!)



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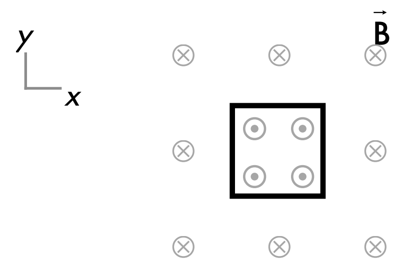
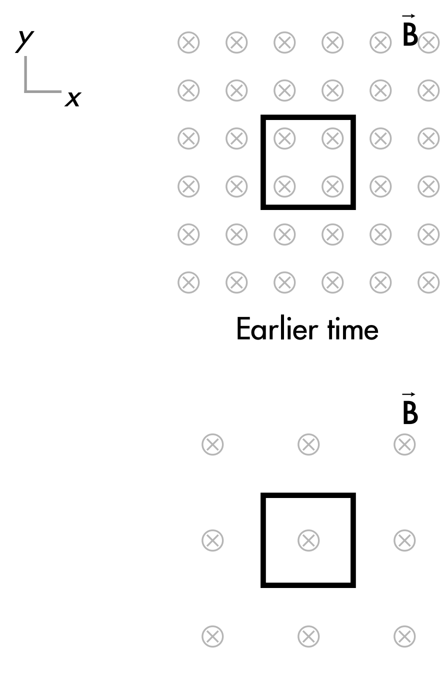
70. The magnetic field of a square metal loop is shown at right. The direction of current in the loop is:
(A) clockwise.
(B) counterclockwise.
(C) (No direction, as there is no current in the loop.)
(D) (Unsure/guessing/lost/help!)



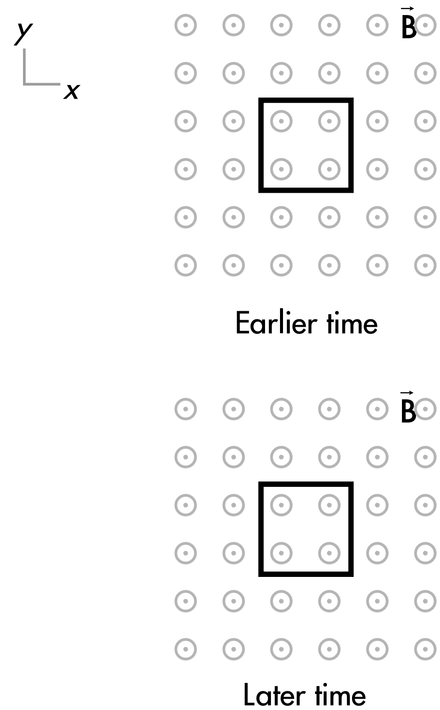
A square metal loop is in an external magnetic field with a magnitude that is decreasing over time. The loop has a resistance *R*.



71. The direction of the external magnetic field through the square loop is __________; while the magnetic flux magnitude through the square loop is:
(A) into the page; decreasing.
(B) into the page; constant.
(C) into the page; increasing.
(D) out of the page; decreasing.
(E) out of the page; constant.
(F) out of the page; increasing.
(G) (Unsure/guessing/lost/help!)

72. The direction of current induced in the loop is:
(A) clockwise.
(B) counterclockwise.
(C) (No direction, as there is no induced current.)
(D) (Unsure/guessing/lost/help!)

A square metal loop is in an external magnetic field that remains constant over time. The loop has a resistance *R*.

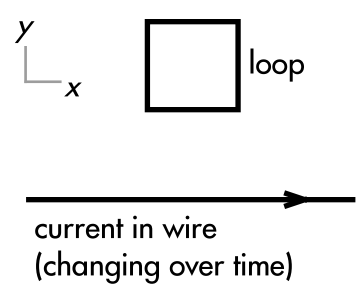


73. The direction of the external magnetic field through the square loop is __________; while the magnetic flux magnitude through the square loop is:
(A) into the page; decreasing.
(B) into the page; constant.
(C) into the page; increasing.
(D) out of the page; decreasing.
(E) out of the page; constant.
(F) out of the page; increasing.
(G) (Unsure/guessing/lost/help!)

74. The direction of current induced in the loop is:
(A) clockwise.
(B) counterclockwise.
(C) (No direction, as there is no induced current.)
(D) (Unsure/guessing/lost/help!)

The current in a long straight wire is [decreasing / increasing] over time.

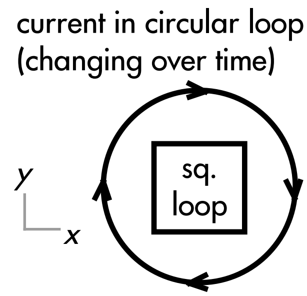
A square metal loop (with a resistance *R*) is located above the wire.



75. The direction of the straight wire's magnetic field through the square loop is __________; while the magnetic flux magnitude through the square loop is:
(A) into the page; decreasing.
(B) into the page; constant.
(C) into the page; increasing.
(D) out of the page; decreasing.
(E) out of the page; constant.
(F) out of the page; increasing.
(G) (Unsure/guessing/lost/help!)

76. The direction of the current induced in the square loop is:
(A) clockwise.
(B) counterclockwise.
(C) (No direction, as there is no induced current.)
(D) (Unsure/guessing/lost/help!)

The current in a circular loop is $\begin{bmatrix}\text{decreasing}\\\text{increasing}\end{bmatrix}$ over time. A square metal loop (with a resistance R) is located inside the circular loop.



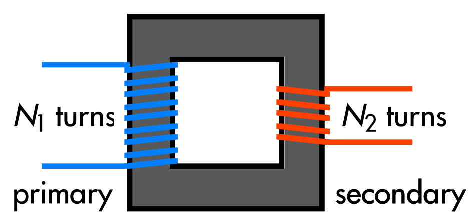
77. The direction of the circular loop's magnetic field through the square loop is ___________; while the magnetic flux magnitude through the square loop is:

(A) into the page; decreasing.
(B) into the page; constant.
(C) into the page; increasing.
(D) out of the page; decreasing.
(E) out of the page; constant.
(F) out of the page; increasing.
(G) (Unsure/guessing/lost/help!)

78. The direction of the current induced in the square loop is:

(A) clockwise.
(B) counterclockwise.
(C) (No direction, as there is no induced current.)
(D) (Unsure/guessing/lost/help!)

The primary coil of an ideal iron core transformer has N_1 turns; the secondary coil has N_2 turns, where $N_1 > N_2$. An alternating current is sent through the primary coil. The emf in the primary has an amplitude of 170 V.



79. Which side of the transformer has a greater $\begin{bmatrix}\text{flux } \Phi\\\text{emf amplitude } \mathcal{E}\\\text{current amplitude } I\\\text{power } P\end{bmatrix}$?

(A) Primary.
(B) Secondary.
(C) (There is a tie.)
(D) (Unsure/guessing/lost/help!)

80. $\begin{bmatrix}\text{Current}\\\text{Electric potential}\\\text{Force}\\\text{Inductance}\\\text{Magnetic field}\\\text{Magnetic flux}\\\text{Power}\\\text{Resistance}\end{bmatrix}$ is measured in units of:

(A) A (amperes).
(B) H (henrys).
(C) N (newtons).
(D) Ω (ohms).
(E) T (teslas).
(F) V (volts).
(G) Wb (webers).
(H) W (watts).

81. The unit of $\begin{bmatrix}\text{A (amperes)}\\\text{H (henrys)}\\\text{N (newtons)}\\\Omega\text{ (ohms)}\\\text{T (teslas)}\\\text{V (volts)}\\\text{Wb (webers)}\\\text{W (watts)}\end{bmatrix}$ is a measure of:

(A) current.
(B) electric potential.
(C) force.
(D) inductance.
(E) magnetic field.
(F) magnetic flux.
(G) power.
(H) resistance.

Equations and constants:

$\vec{\mathbf{F}}_B = q\vec{\mathbf{v}}\times\vec{\mathbf{B}} = qvB\sin\theta$; $\vec{\mathbf{F}} = I\vec{\mathbf{L}}\times\vec{\mathbf{B}} = ILB\sin\theta$; $B = \frac{\mu_0 I}{2\pi r}$; $\mu_0 = 4\pi\times10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}$; $\mathcal{E} = vBL$;

$\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$; $\Phi_B = BA\cos\theta$; $\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}$; $I = \frac{\Delta V}{R}$; $P = I(\Delta V)$.