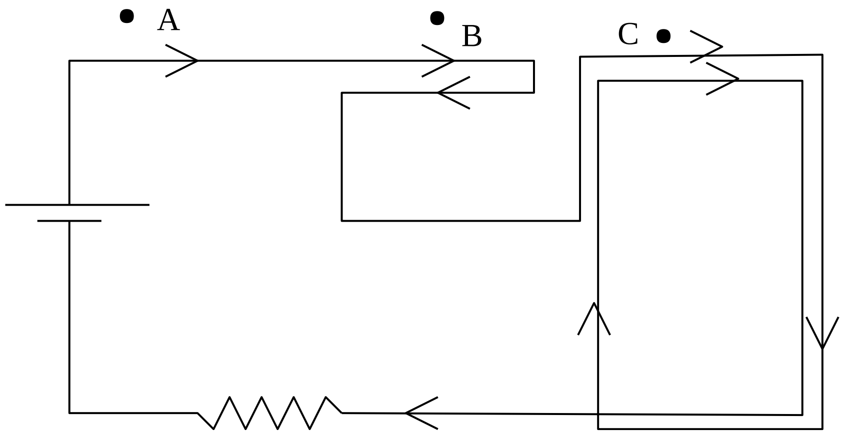
B2-1. A magnetic compass is placed at the points A, B, and C near an electric circuit which has the following twisty shape:



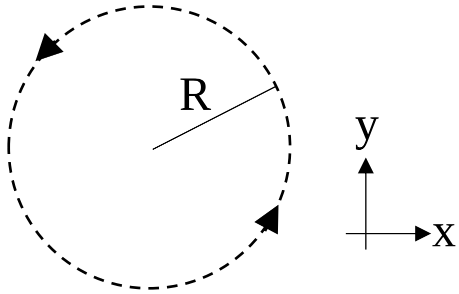
The relative size of the B-field at these points, in order from biggest to smallest, is..

A) ABC B) CBA C) BCA
D) ACB E) None of these.

Answer: CAB (None of these)

B2-2. Notice that $\oint d\vec{\ell}$ and $\oint d\ell$ are different. $\oint d\vec{\ell}$ is the line integral of a vector displacement element $d\vec{\ell}$. $\oint d\ell$ is the line integral of a scalar length element $d\ell$.

Consider the CCW circular loop of radius R in the xy plane.



Part A. What is the value of $\oint d\ell$?

A) zero B) $2\pi R$ C) R D) None of these

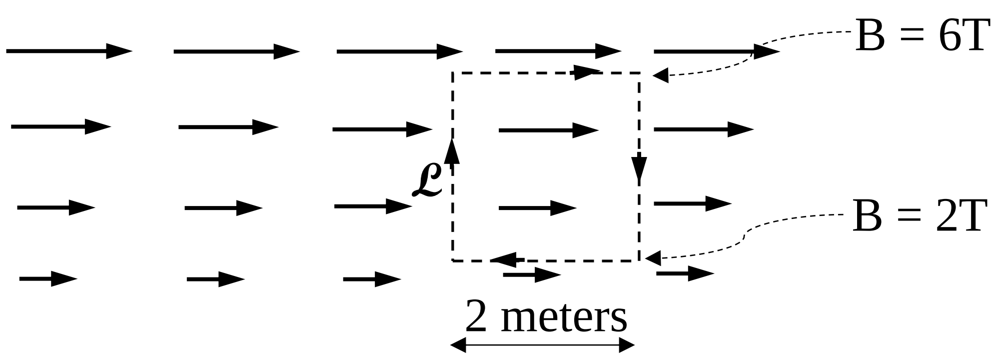
Part B. What is the value of $\oint d\vec{\ell}$?

A) zero B) $2\pi R$ C) $2\pi R\,\hat{z}$ D) None of these

Answers: $\oint d\ell = 2\pi R$, $\oint d\vec{\ell} = 0$

B2-3. What is the value of the line integral $\oint \vec{B}\cdot d\vec{\ell}$ around imaginary square CW loop $\mathcal{L}$ in the figure? The loop is 2 meters on a side, and the non-uniform B-field is given by

$\vec{B} = \left(2\,{}^{T}\!/\!_{m}\right) y\,\hat{x}$ (where y is in meters). B=6T on the top side of the loop, and B=2T on the bottom of the loop.



The value of $\oint \vec{B}\cdot d\vec{\ell}$ is…

A) zero B) 4T·m C) 8 T·m

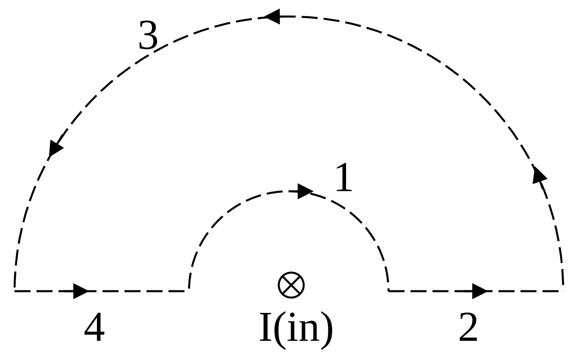
D)12 T·m E) 16 T·m

Answer: 8 T m

B2-4. The imaginary loop $\mathcal{L}$ near a wire with current I has 4 segments labeled 1, 2, 3, and 4, as shown.

What is the sign of $\int \vec{B} \cdot d\vec{\ell}$ for each of the segments?

For 1, 2, 3, 4, the line integral is



A) + + 0 –

B) 0 + – 0

C) + 0 – 0

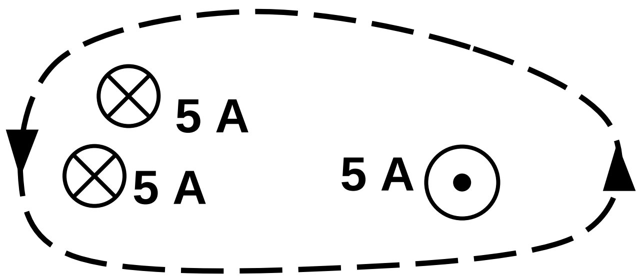
D) + 0 + 0

E) None of these

Answer: + 0 – 0

B2-5. We need a sign convention for I_thru.

Place the fingers of your right hand around the imaginary loop and your thumb points in the direction of positive I_thru. What is I_thru here, where all three wires have 5 A?

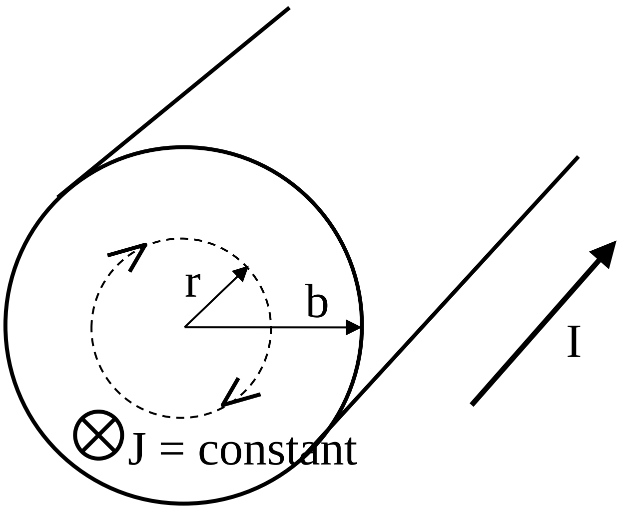


A) +15 A
B) –10 A
C) +10 A
D) –5 A
E) None of these

Answer: –5 A

B2-6. A long straight copper wire has radius b and carries a constant current of magnitude I. The current density of magnitude $J=I/(\pi b^2)$ is uniform throughout the wire.

Part A What is the current contained in the circular loop £, with radius r < b, centered on the wire's center as shown?



A) $\left(\frac{r}{b}\right) I$

B) $\left(\frac{r}{b}\right)^2 I$

C) $\left(\frac{r}{b}\right)^3 I$

D) None of these

Part B How does the magnitude of the B-field a distance $r < b$ from the center of the wire depend on r?

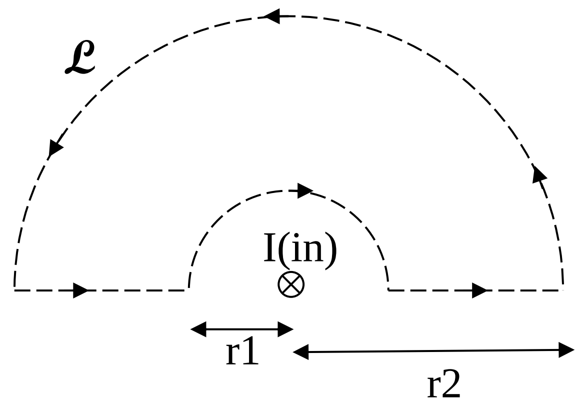
A) $B \propto r$ B) B = constant C) $B \propto 1/r$

D) $B \propto 1/r^2$ E) None of these

Answers: $I_{enc} = \left(\frac{r}{b}\right)^2 I$, $B \propto r$

B2-7. The imaginary loop $\mathcal{L}$ near a long straight wire with current I has inner radius r1 and outer radius r2.

What is the value of $\oint \vec{B}\cdot d\vec{\ell}$ for this loop?



A) $\dfrac{\mu_0 I}{2\pi r_1} - \dfrac{\mu_0 I}{2\pi r_2}$

B) $\dfrac{\mu_0 I}{2\pi(r_2 - r_1)}$

C) $\mu_0 I$

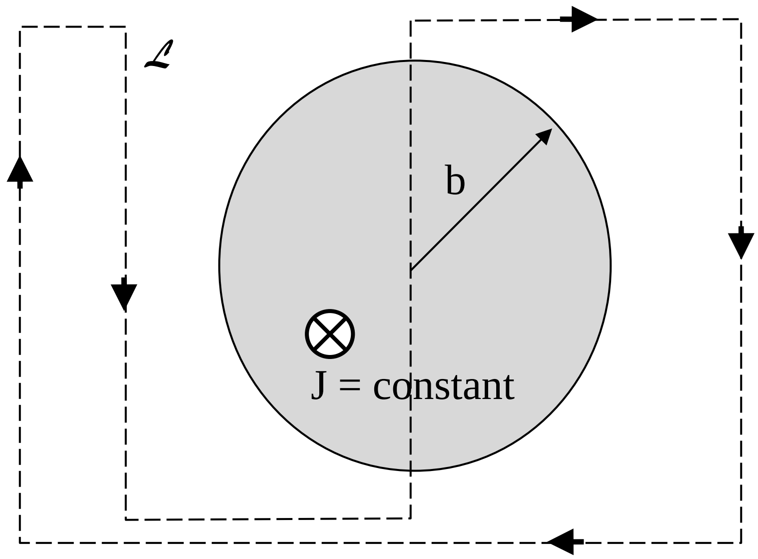
D) zero

E) None of these

Answer: zero. Notice that $I_{enc} = 0$

B2-8. A wire of radius b has a uniform current density J, and so carries a total current $I = J\,\pi b^2$.

For the torturous loop $\mathcal{L}$ shown below, what is the value of $\oint_L \vec{B} \cdot d\vec{\ell}$?



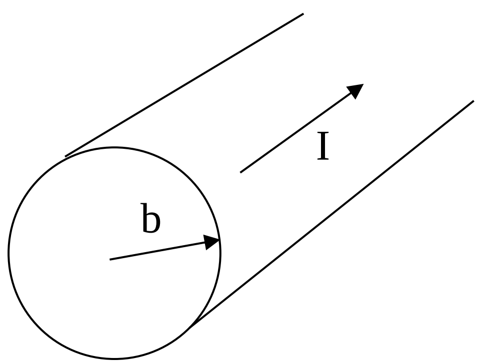
A) $+\mu_0 I/2$

B) $> \mu_0 I/2$, $< \mu_0 I$

C) $< \mu_0 I/2$

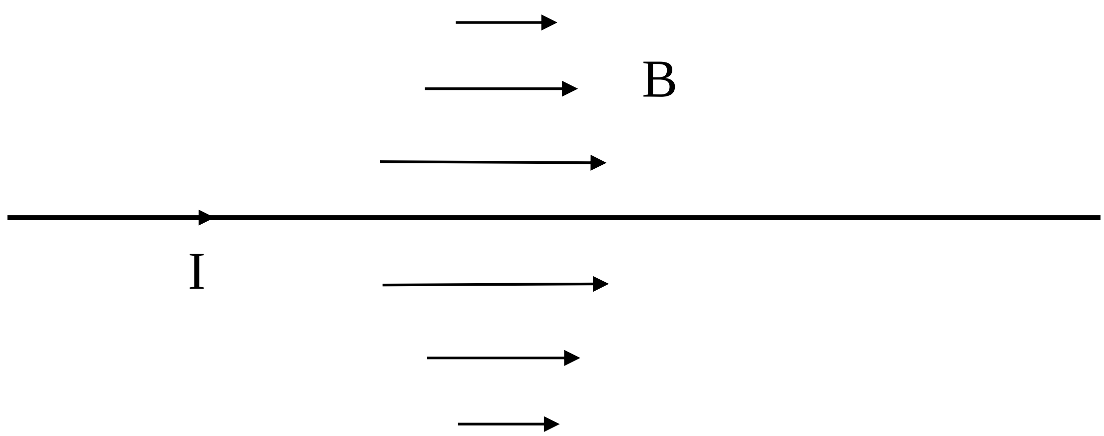
D) $+\mu_0 I$

E) None of these



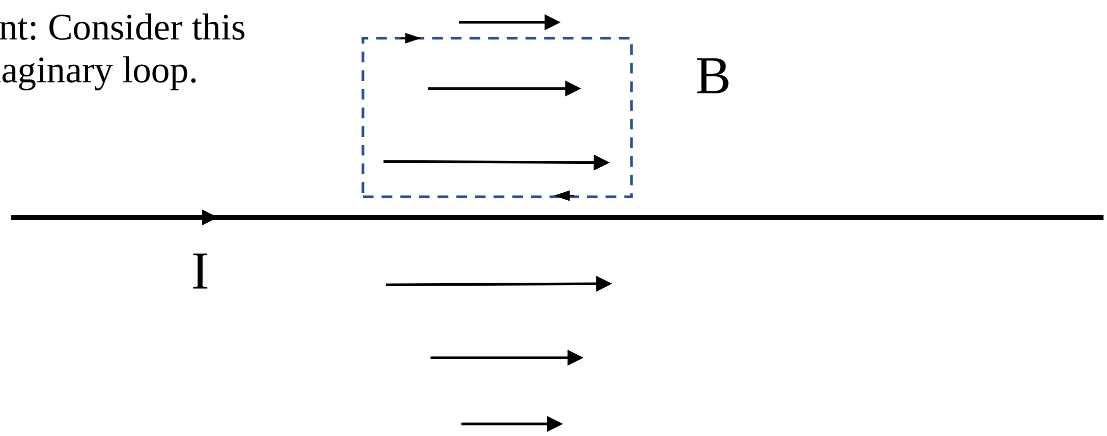
Answer: $+\mu_0 I/2$

B2-9.
A student proposes the B-field of a very long straight wire with current I is **longitudinal**, so that the B-field outside the wire is parallel to the axis of the wire, and, as shown in the figure, the B-field magnitude decreases with distance from the wire.



A) This is possible.
B) Not possible because it would violate Ampere's Law
C) Not possible because it would violate Gauss's Law for **B**
D) This is not possible for some other reason.

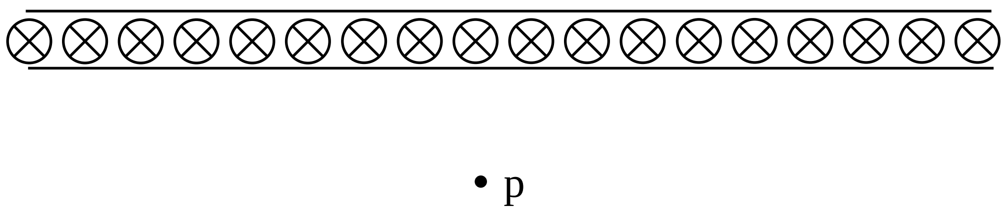
Hint: Consider this imaginary loop.

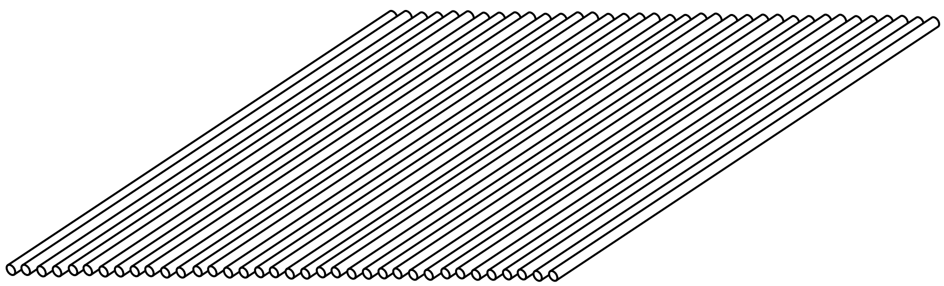


Answer: Not possible because it would violate Ampere's Law

B2-10. An inifinite sheet of current into the page produces a magnetic field at point P in which direction?

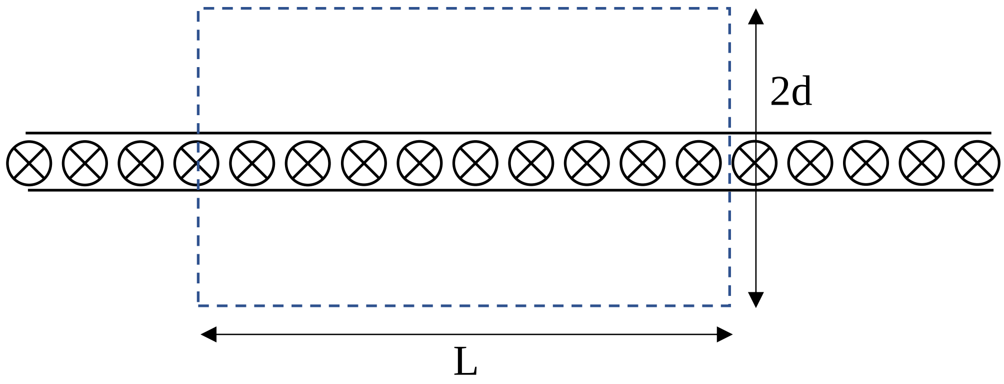
A) $\rightarrow$ B) $\downarrow$ C) $\leftarrow$ D) $\uparrow$ E)None of these





Answer: $\leftarrow$ (left)

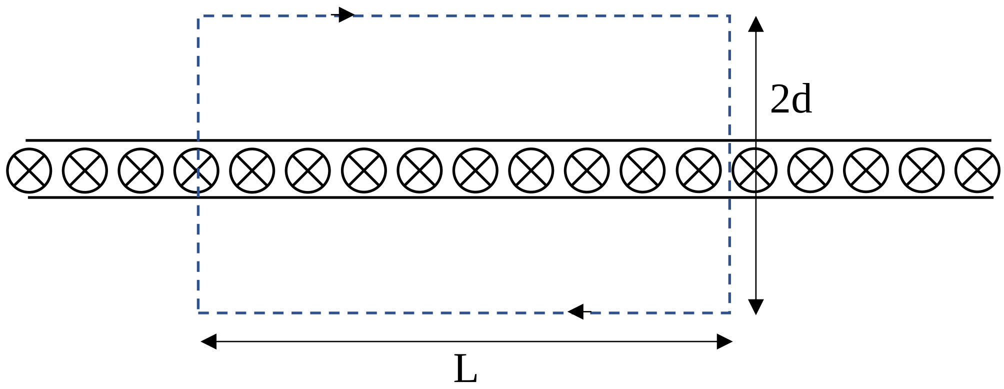
B2-11. Suppose the current per length of the sheet is λ (units of A/m). How much current is enclosed by this Amperian loop?



A) λL B) λd C) $2\lambda L$ D) $2\lambda d$ E) zero

Answer: λL

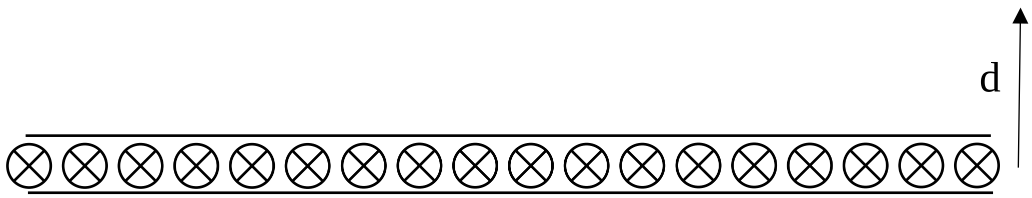
B2-12. Let B be the magnitude of the B-field at the top and bottom of the loop shown. (From symmetry, the B-field must have the same magnitude at equal distances above and below the sheet. What is the value of the integral $\oint \vec{B} \cdot d\vec{\ell}$ for this loop ?



A) BLd B) 4BLd C) 2BL
D) BL E) None of these

Answer: 2BL

B2-13. What is the magnitude B of the B-field a distance d away from a large uniform sheet of current with current per length λ?



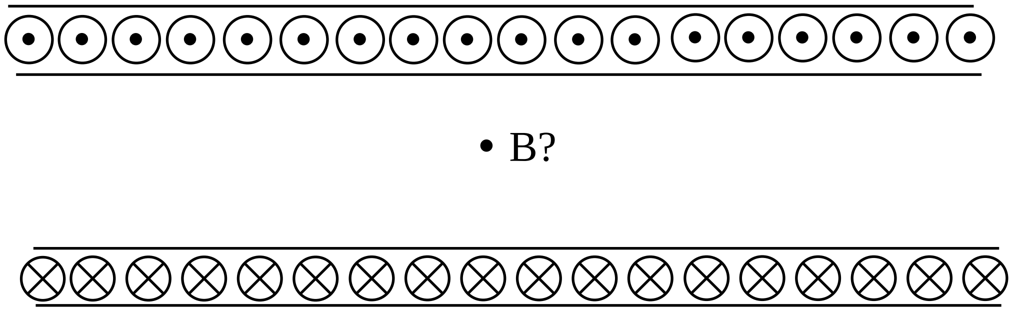
A) $\frac{\mu_0 \lambda}{2}$ B) $\frac{\mu_0 \lambda}{2d}$ C) $\frac{\mu_0 d}{2\lambda}$ D) $\frac{2\mu_0 d}{\lambda}$

E) None of these

Answer: $\frac{\mu_0 \lambda}{2}$ (derived using Ampere's Law)

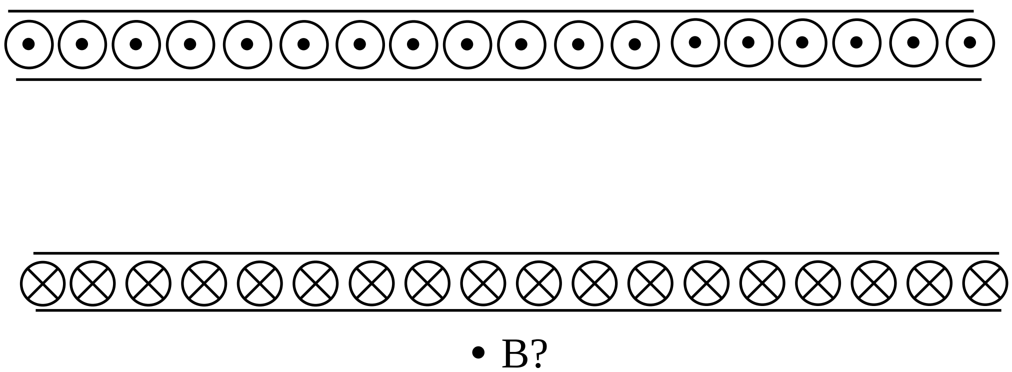
B2-14. Two parallel, inifinite, uniform sheets of current, each with the same magnitude current/length = λ are as shown. What is the direction of the B-field in the region between the sheets?

A) $\rightarrow$ B) $\downarrow$ C) $\leftarrow$ D) $\uparrow$ E)None of these



Answer: $\rightarrow$ (right)

B2-15. What is the direction of the B-field in the region below both sheets?

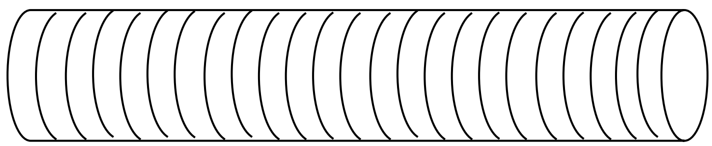


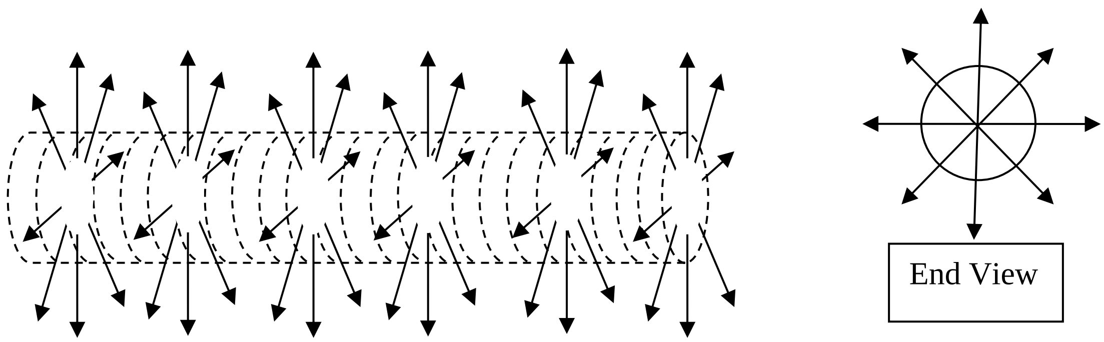
A) $\rightarrow$ B) $\downarrow$ C) $\leftarrow$ D) $\uparrow$ E)None of these

---

Answer: None of these. The B-field is zero at that point.

B2-16.
A student proposes the magnetic field of a very long solenoid with current I has cylindrical symmetry, so that the B-field everywhere points away from the center line of the solenoid.

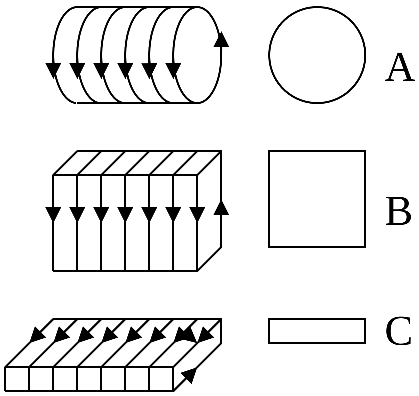




A) This is possible.
B) Not possible because it would violate Ampere’s Law
C) Not possible because it would violate Gauss’s Law for **B**
D) This is not possible for some other reason.

Answer: Not possible because it would violate Gauss’s Law for **B**

B2-17. Three long straight solenoids all of length L and all with the same (large) number of closely-packed turns N, all with the same current I, have different cross-sections as shown.



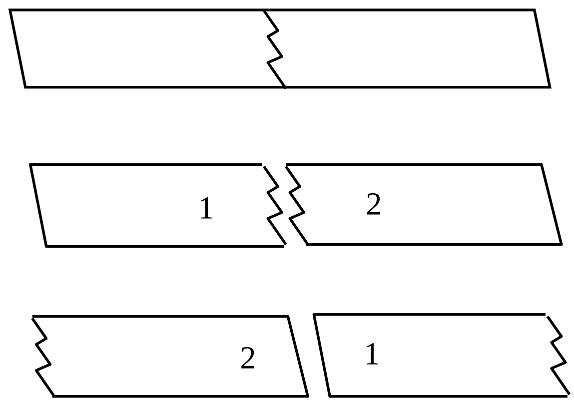
Part A: Which solenoid has the largest field B at its center?

D) All three have the same field B.

Part B: True(A) or False(B): All three solenoids have uniform B-fields in their interiors.

Answer: True!

B2-18. A permanent bar magnet is broken in half. The two pieces are interchanged, keeping their orientations fixed, as shown below. Do the pieces attract or repel?



A) Attract

B) Repel

C) Neither! There is no net force.

Answer: Attract