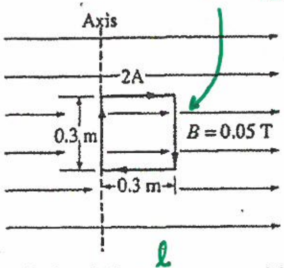
AP Questions

Name: ______________________ Date ______________

AP Physics

Electromagnetism

This side experience F



1) A square loop of wire 0.3 meter on a side carries a current of 2 amperes and is located in a uniform 0.05-tesla magnetic field. The left side of the loop is aligned along and attached to a fixed axis. When the plane of the loop is parallel to the magnetic field in the position shown above, what is the magnitude of the torque exerted on the loop about the axis?

l I B

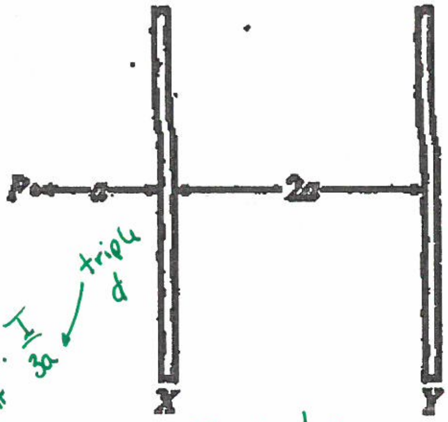
$\tau = F \cdot r$

$= (BlI)r$

$(.05)(.3)(2)(.3)$

- [✓ A)] 0.0090 N·m
- B) 1.11 N·m
- C) 0.278 N·m
- D) 0.00225 N·m
- E) 111 N·m

2) Two long parallel wires are a distance 2*a* apart, as shown below.



$B_1 = \frac{\mu}{2\pi} \cdot \frac{I}{a}$

$B_2 = \frac{\mu}{2\pi} \cdot \frac{I}{3a}$

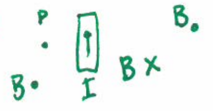
triple d

$B_{net} = B_0 + \frac{1}{3} B_0 = 4/3\, B_0$

Point *P* is in the plane of the wires and a distance *a* from wire *X*. When there is a current *I* in wire *X* and no current in wire *Y*, the magnitude of the magnetic field at *P* is B_0. When there are equal currents *I* in the same direction in both wires, the magnitude of the magnetic field at *P* is

- A) 2/3 B_0
- B) B_0
- C) 2 B_0
- [✓ D)] 4/3 B_0
- E) 10/9 B_0

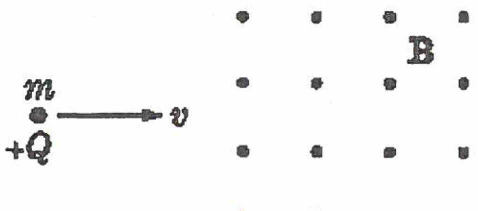
one wire



two wire

They add

Questions 3 and 4 refer to the following:



fingers out
thumb right
palm down

Right Hand

A particle of electric charge +*Q* and mass *m* initially moves along a straight line in the plane of the page with constant speed *v*, as shown above. The particle enters a uniform magnetic field of magnitude *B* directed out of the page and moves in a semicircular arc of radius *R*.

3) Which of the following best indicates the magnitude and the direction of the magnetic force **F** on the charge just after the charge enters the magnetic field?

- A) Magnitude: *QvB*
  Direction: ~~Out of the plane~~ of the page
- B) Magnitude: *QvB*
  Direction: ~~Toward the top~~ of the page
- [✓ C)] Magnitude: *QvB*
  Direction: Toward the bottom of the page
- D) ~~Magnitude: kQ^2/R^2~~
  Direction: Toward the bottom of the page
- E) ~~Magnitude: kQ^2/R^2~~
  Direction: T~~oward the top of the page~~

$\frac{kq^2}{r^2}$ = Force b/t 2 charg

4) If the magnetic field strength is increased, which of the following will be true about the radius *R*?

~~I.~~ *R* increases if the incident speed is held constant.

[✓ II.] For *R* to remain constant, the incident speed must be increased.

~~III.~~ For *R* to remain constant, the incident speed must be decreased.

- A) I only
- [✓ B)] II only
- C) I and III only
- D) III only
- E) I and II only

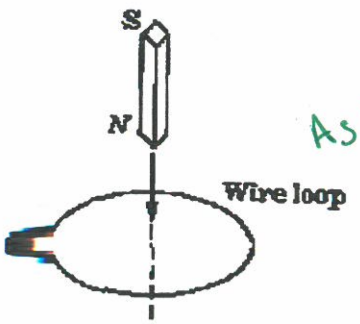
$qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB}$

↑B ↓r

↑v to balance

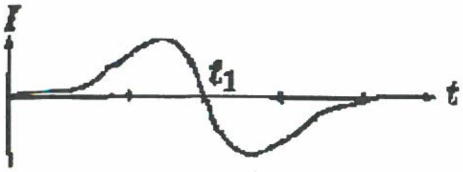
A bar magnet is lowered at constant speed through a loop of wire as shown in the diagram below.



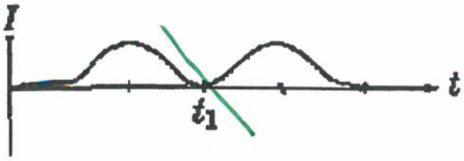
As N enters: magnet adds dots nature opposes + adds x I ccw

The time at which the midpoint of the bar magnet passes through the loop is t_1. Which of the following graphs best represents the time dependence of the induced current in the loop? (A positive current represents a counterclockwise current in the loop as viewed from above.)

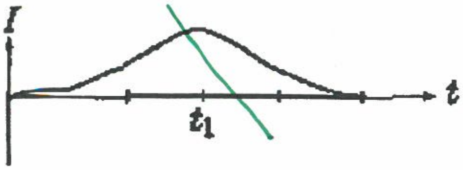
[✓ A)]



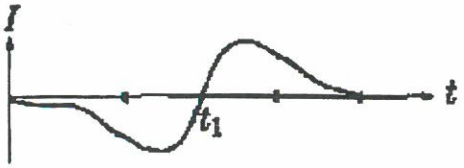
B)



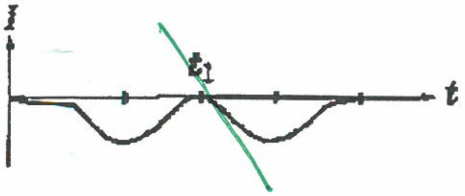
C)



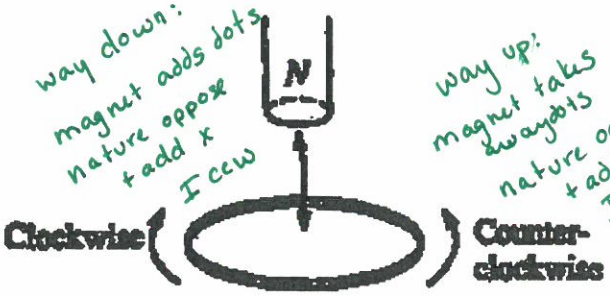
D)



E)



6)



way down: magnet adds dots nature oppose + add x I ccw

way up: magnet takes away dots nature oppose + add dots. I clockwise

In the figure above, the north pole of the magnet is first moved down toward the loop of wire, then withdrawn upward. As viewed from above, the induced current in the loop is

must have both for full movement

[✓ A)] first counterclockwise, then clockwise
B) always counterclockwise with decreasing magnitude
C) always counterclockwise with increasing magnitude
D) always clockwise with increasing magnitude
E) always clockwise with decreasing magnitude

7) A loop of wire enclosing an area of 1.5 m^2 is placed perpendicular to a magnetic field. The field is given in teslas as a function of time t in seconds by

$B(t) = 20t/3 - 5$

$20t/3 - 5$

at 3s ↓

$B_{final} = \frac{20(3)}{3} - 5 = 15\ T$

[redacted]

$B_0 = \frac{20(0)}{3} - 5$

-5 ↑ at zero sec

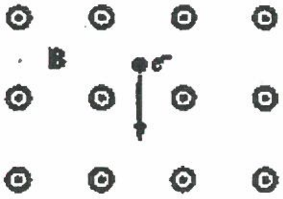
The induced emf in the loop at $t = 3$ s is most nearly

A) 0 V
B) 5 V
[✓ C)] 10 V
D) 15 V
E) 20 V

$\mathcal{E} = -\frac{\Delta\Phi}{t} = -\frac{\Delta BA}{t}$

$= -\frac{(15 - -5)(1.5)}{3}$

8)

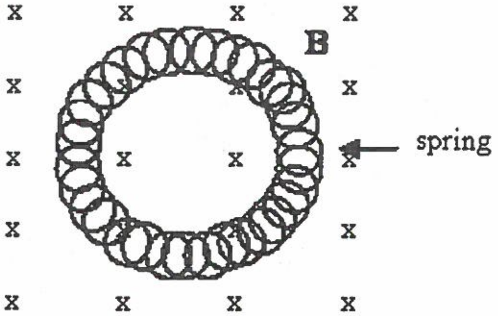


Left hand

An electron is in a uniform magnetic field B that is directed out of the plane of the page, as shown above. When the electron is moving in the plane of the page in the direction indicated by the arrow, the force on the electron is directed

A) into the page
B) toward the top of the page
[✓ C)] toward the right
D) toward the bottom of the page
E) toward the left

9)



A metal spring has its ends attached so that it forms a circle. It is placed in a uniform magnetic field, as shown above. Which of the following will $\boxed{\text{not}}$ cause a current to be induced in the spring?

$$\varepsilon = -\frac{\Delta\Phi}{t} = -\frac{\Delta BA\cos\theta}{t}$$

↑B ↓B

~~A) Moving the spring in and out of the magnetic field~~
~~B) Increasing the diameter of the circle by stretching the spring~~ ΔA
~~C) Rotating a spring about a diameter~~ $\Delta\cos\theta$
~~D) Changing the magnitude of the magnetic field~~ ΔB
[✓ E)] Moving the spring parallel to the magnetic field

10) A magnetic field of 0.1 T forces a proton beam of 1.5 mA to move in a circle of radius 0.1 m. The plane of the circle is perpendicular to the magnetic field.

Of the following, which is the best estimate of the speed of a proton in the beam as it moves in the circle?

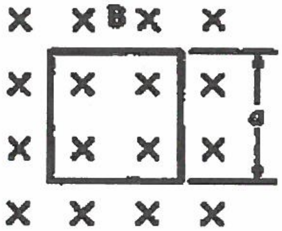
A) 10^{-2} m/s
B) 10^{3} m/s
C) 10^{8} m/s
D) 10^{15} m/s
[✓ E)] 10^{6} m/s

$$q\cancel{v}B = \frac{mv^{\cancel{2}}}{r}$$

$$v = \frac{qBr}{m}$$

$$\frac{(1.6\times10^{-19})(.1)(.1)}{1.67\times10^{-27}}$$

11)



A square loop of wire of resistance *R* and side *a* is oriented with its plane perpendicular to a magnetic field, as shown above. What must be the rate of change of the magnetic field in order to produce a current *I* in the loop?

A) *Ra/I*
[✓ B)] IR/a^2
C) *IRa*
D) *Ia/R*
E) Ia^2/R

↑ $\frac{\Delta B}{t} = ?$

② $\varepsilon = -\frac{\Delta BA}{t}$

$$\frac{\Delta B}{t} = \frac{\varepsilon}{A} = \frac{I\cdot R}{a\cdot a}$$

① $\varepsilon = I\cdot R$

$$= \frac{I\cdot R}{a^2}$$

12) A square loop of copper wire is initially placed perpendicular to the lines of a constant magnetic field of 5 x 10^{-3} tesla. The area enclosed by the loop is 0.2 square meter. The loop is then turned through an angle of 90° so that the plane of the loop is parallel to the field lines. The turn takes 0.1 second. The average emf induced in the loop during the turn is

B A t

$$\varepsilon = -\frac{\Delta BA\cos\theta}{t}$$

$$= -\frac{(5\times10^{-3})(.2)(\cos 90 - \cos 0)}{.1}$$

A) 1.0×10^{-4} V
B) 400 V
C) 100 V
D) 2.5×10^{-3} V
[✓ E)] 0.01 V

13)

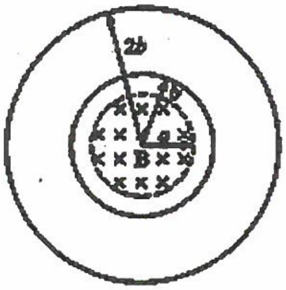
A wire in the plane of the page carries a current directed toward the top of the page, as shown above. If the wire is located in a uniform magnetic field **B** directed out of the page, the force on the wire resulting from the magnetic field is

I Right hand

A) directed into the page
B) directed to the left
C) zero
[✓ D)] directed to the right
E) directed out of the page

fingers out
thumb up
palm right

14)



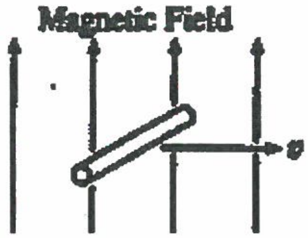
Two concentric circular loops of radii *b* and 2*b*, made of the same type of wire, line in the plane of the page, as shown above. A uniform magnetic field **B** that is perpendicular to the plane of the page passes through the loops. The field is confined to a region of radius *a*, where *a*<*b*, and is changing at a constant rate. The induced emf in the wire loop of radius *b* is **e**. What is the induced emf in the wire loop of radius 2*b*?

A) 2**e**
[✓ B)] **e**
C) zero
D) **e**/2
E) 4**e**

$$\varepsilon = -\frac{BA\cos\theta}{t}$$

Same BA
for both!

15)



A wire of constant length is moving in a constant magnetic field, as shown above. The wire and the velocity vector are perpendicular to each other and are both perpendicular to the field. Which of the following graphs best represents the potential difference e between the ends of the wire as a function of velocity?

← e ←

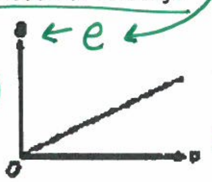
$\mathcal{E} = Blv$

← v

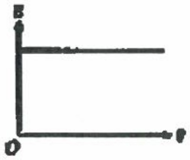
↑v ↑$\mathcal{E}$

linear

[✓ A)]

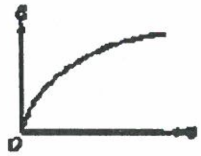


B)

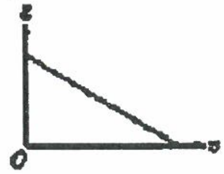


C)

D)



E)



16) Two long, parallel wires, fixed in space, carry currents I_1 and I_2. The force of attraction has magnitude F. What currents will give an attractive force of magnitude $4F$?

A) $4I_1$ and $4I_2$
[✓ B)] $2I_1$ and $2I_2$
C) I_1 and $[I_2$
D) $\backslash I_1$ and $\backslash I_2$
E) $2I_1$ and $\backslash I_2$

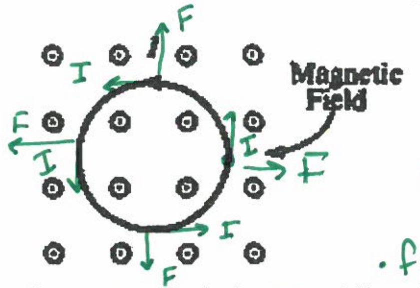
$\Sigma F = F_{B1} + F_{B2}$

$F_B = BlI$

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

double I
double B

17)



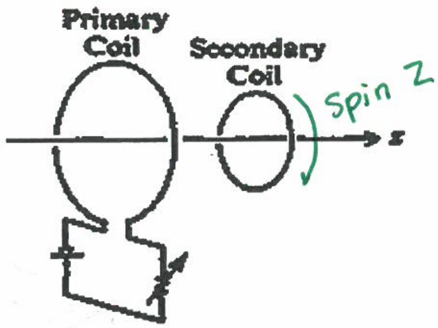
Right Hand

· figure out F at several spots

There is a counterclockwise current I in a circular loop of wire situated in an external magnetic field directed out of the page, as shown above. The effect of the forces that act on this current is to make the loop

A) rotate about an axis perpendicular to the page
[✓ B)] expand in size
C) contract in size
D) rotate about an axis in the plane of the page
E) accelerate into the page

18)



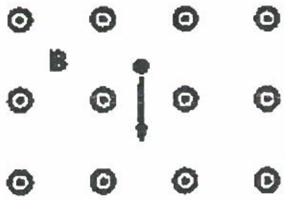
spin z axis

Two circular coils are situated perpendicular to the z-axis as shown above. There is a current in the primary coil. All of the following procedures will induce a current in the secondary coil EXCEPT

↳ need ΔΦ

~~A)~~ moving the secondary coil closer to the primary coil ↑B
~~B)~~ rotating the secondary coil about a diameter Δθ
[✓ C)] rotating the secondary coil about the z-axis spinning in place
~~D)~~ varying the current in the primary coil ΔI
~~E)~~ decreasing the cross-sectional area of the secondary coil ΔA

19)



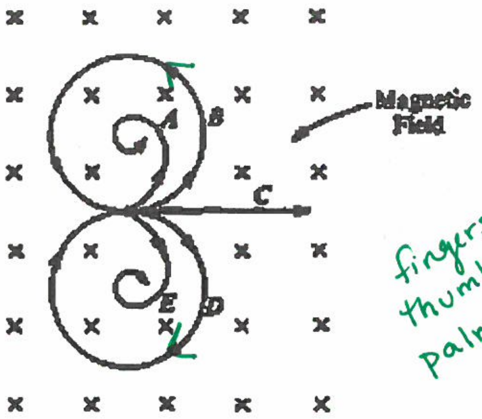
fingers out
thumb down
palm left

right hand

A proton is in a uniform magnetic field B that is directed out of the plane of the page, as shown above. When the proton is moving in the plane of the page in the direction indicated by the arrow, the force on the proton is directed

A) toward the top of the page
[✓ B)] toward the left
C) toward the bottom of the page
D) toward the right
E) into the page

20)



fingers in thumb right palm push down

D

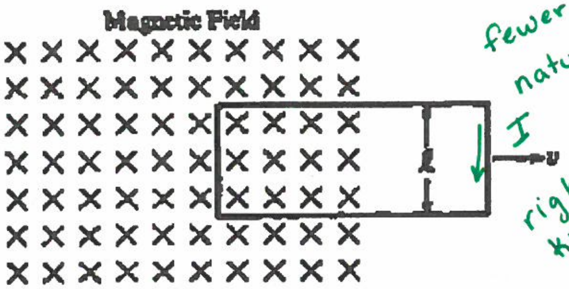
left hand

Which of the paths above represents the path of an electron traveling without any loss of energy through a uniform magnetic field directed into the page?

uniform radius

~~A) C~~ neutron
B) B
~~C) A~~
~~D) E~~
[✓ E) D]

21)



fewer x nature add x

I

right hand knuckles out thumb down

The figure above shows a rectangular loop of wire of width *l* and resistance *R*. One end of the loop is in a uniform magnetic field of strength **B** at right angles to the plane of the loop. The loop is pulled to the right at constant speed *v*. What are the magnitude and direction of the induced current in the loop?

A) ~~Magnitude: *BlvR*~~
Direction: ~~Counterclockwise~~
[✓ B)] Magnitude: *Blv/R*
Direction: Clockwise
C) Magnitude: *Blv/R*
~~Direction: Counterclockwise~~
D) ~~Magnitude: *BlvR*~~
Direction: Clockwise

$I = \frac{V}{R} = \frac{Blv}{R}$

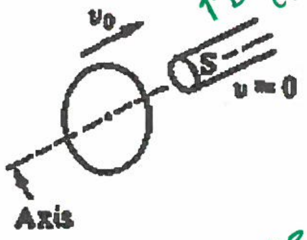
22) In each of the following situations, a bar magnet is aligned along the axis of a conducting loop. The magnet and the loop move with the indicated velocities. In which situation will the bar magnet NOT induce a current in the conducting loop?

Induce: ΔBA

NOT induce no ΔBA

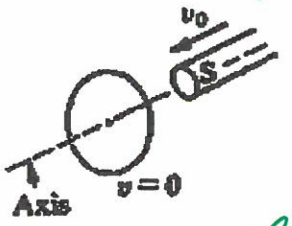
↑B close

~~A)~~



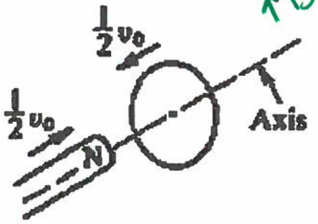
↑B close

~~B)~~



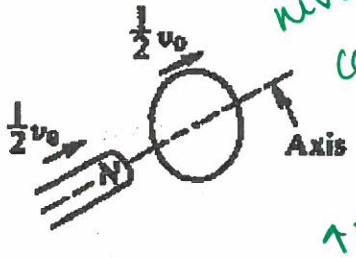
↑B approach

~~C)~~



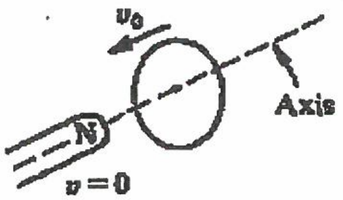
never catch up constant B

[✓ D)]

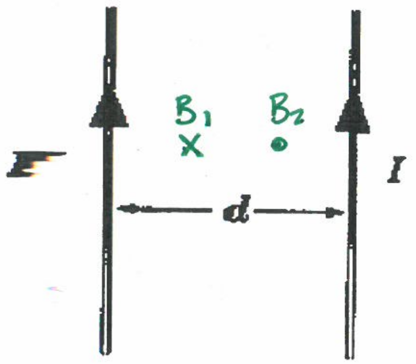


↑B closer

~~E)~~



3) Two long parallel wires, separated by a distance *d*, carry equal currents *I* toward the top of the page, as shown below.

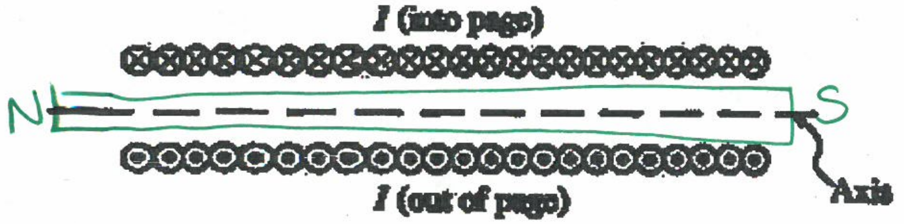


right hand
awkward thumbs up
Find B from each

The magnetic field due to the wires at a point halfway between them is

A) directed to the right
B) directed out of the page
C) directed into the page
[✓ D)] zero in magnitude
E) directed to the left

-) A cross section of a long solenoid that carries current *I* is shown below.

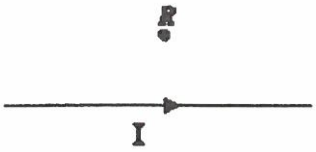


alternate right hand
fingers in above, out below
thumb left = N pole

All of the following statements about the magnetic field **B** inside the solenoid are correct EXCEPT:

A) ✓ The magnitude of **B** is proportional to the number of turns of wire per unit length.
B) ✓ **B** is directed to the left.
C) ✓ An approximate value for the magnitude of **B** may be determined by using Ampere's law.
[✓ D)] The magnitude of **B** is proportional to the distance from the axis of the solenoid.
E) ✓ The magnitude of **B** is proportional to the current *I*.

25)



right hand
thumb right
fingers curl

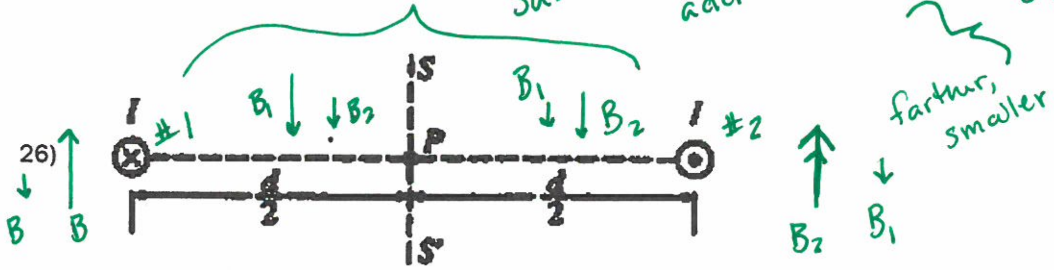
The direction of the magnetic field at point R caused by the current I in the wire shown above is

A) into the page
[✓ B)] out of the page
C) to the right
D) to the left
E) toward the wire

Same direction, add

opposite but too far from one wire to cancel

26)



Two long, parallel wires are separated by a distance *d*, as shown above. One wire carries a steady current *I* into the plane of the page while the other wire carries a steady current *I* out of the page. At what points in the plane of the page and outside the wires, besides points at infinity, is the magnetic field due to the currents zero?

~~A)~~ At all points on the line connecting the two wires
B) At all points on a circle of radius 2*d* centered on point *P*
~~C)~~ At all points on the line *SS'*
~~D)~~ Only at point *P*
[✓ E)] At no points

too far from one wire,
too close to other,
magnitude won't cancel

1)	A
2)	D
3)	C
4)	B
5)	A
6)	A
7)	C
8)	C
9)	E
10)	E
11)	B
12)	E
13)	D
14)	B
15)	A
16)	B
17)	B
18)	C
19)	B
20)	E
21)	B
22)	D
23)	D
24)	D
25)	B
26)	E