Electricity and Magnetism II

Griffiths Chapter 10 Potentials & Fields

Clicker Questions

If I tell you $\nabla \times \vec{F} = 0$, what can you conclude about **F**?

A) $\vec{F} = 0$

$B)$ $\vec{F} = \nabla f$ (for some f)

$C)$ $\vec{F} = \nabla \cdot \vec{g}$ (for some $\vec{g}$)

$D)$ $\vec{F} = \nabla \times \vec{g}$ (for some $\vec{g}$)

$E)$ Something else!

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If I tell you $\nabla f = 0$, what can you conclude about f?

A) $f = 0$

B) $f = \nabla g$ (for some g)

C) $f = \nabla \cdot \vec{g}$ (for some $\vec{g}$)

D) $f = \nabla \times \vec{g}$ (for some $\vec{g}$)

E) Something else!

10.5

$$\vec{B} = \nabla \times \vec{A}_{old}$$

$$\vec{E} = -\nabla V_{old} - \partial \vec{A}_{old} / \partial t$$

If I change gauge, so $\vec{A}_{new} = \vec{A}_{old} + \nabla f$

I claim B is unaffected. But, what about E?

A) Looks like E is also unaffected

B) Looks like we changed E, but that's ok

C) Looks like we changed E, that doesn't seem acceptable

D) What are we doing?

Why can't we use a scalar potential to find the magnetic field, as we have done with the electric field, i.e., why can't we use

$$\mathbf{B} = -\nabla V_B(\mathbf{r})$$

A. Because the divergence of **B** is always zero
B. Because only either **E** or **B** can be described with a scalar potential, not both
C. Because **B** can have a non-zero curl
D. I don't know/remember
E. None of the above (but I know the right reason!)

How have we been “setting the gauge” so far in this class?

A) Requiring **A** and V go to 0 at infinity
B) Putting a condition on **A** like: $\mathrm{A}=0$, or $\nabla \times \mathrm{A}=0$
C) Putting a condition on $\nabla \cdot \mathrm{A}$
D) Choosing the function “f” in the formula $\mathrm{A}' = \mathrm{A} + \nabla f$
E) Something else, none of these, MORE than one, not really sure…

In Coulomb's gauge (CG): $$V(\vec{r},t)=\frac{1}{4\pi\varepsilon_0}\iiint\frac{\rho(\vec{r}\,',t)}{|\vec{r}-\vec{r}\,'|}\,d^3\vec{r}\,'$$

In Lorentz' gauge:

$$V(\vec{r},t)=\frac{1}{4\pi\varepsilon_0}\iiint\frac{\rho(\vec{r}\,',t_R)}{|\vec{r}-\vec{r}\,'|}\,d^3\vec{r}\,' \qquad \text{where } t_R=t-\frac{|\vec{r}-\vec{r}\,'|}{c}$$

These look subtly different, which is correct?

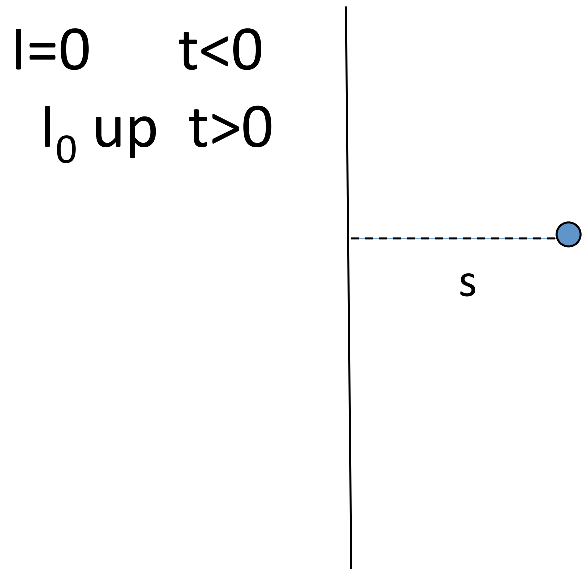
A) CG is unphysical and incorrect, it violates relativity
B) CG result is only correct for time independent problems, LG is what you want for time dependent problems
C) They only LOOK different, but in fact they give the same result for V when you work them out
D) Both are equally "correct", it's just a gauge choice. You can use *either* one in *any* situation
E) Something else is going on, none of the above articulates my opinion very well here!

How do you interpret

$$t_r \equiv t - \frac{|\vec{r} - \vec{r}\,'|}{c}$$

A) is the actual time of observation at point r.
B) is the time light needs to travel from r' to r.
C) is a time in the future when light emitted from point r at time t arrives at point r'.
D) is a time in the past such that light emitted from point r' arrives at r at time t.
E) None of these.

At what time, t, does an observer at s first know the current was turned on?



A) t=0

B) t=c s

C) t=s/c

D) Other!!

E) Not sure about this?

At what time t, after s/c, does an observer at s see current from the entire wire?

A) Immediately

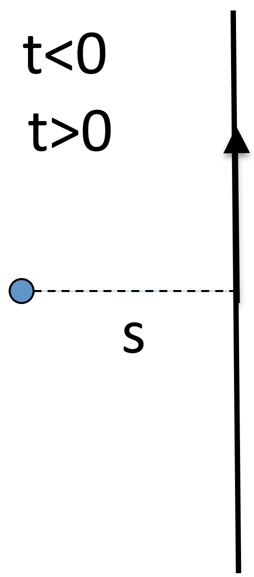
B) Never

C) Something else

At time $t = 0$, a current I_0 in an infinitely long <u>neutral</u> wire is turned on. When does observer at s first know the current was turned on? (We are working in the Lorentz gauge.)

$I=0 \quad t<0$

$I = I_0 \quad t>0$



Is there a non-zero potential V in the space around the wire at anytime after $t = 0$?

A) Yes B) No

Is there a non-zero electric field **E** in the space around the wire at anytime after $t=0$?

A) Yes B) No

$$I(t) = \begin{cases} 0 & t \le 0 \\ I_0 & t > 0 \end{cases}$$

$$\mathbf{A}(s,t) = \frac{\mu_0}{4\pi} \int_{-\infty}^{\infty} \frac{\mathbf{I}(z,t_R)}{\sqrt{s^2+z^2}} dz \qquad t_R \equiv t - \frac{\sqrt{s^2+z^2}}{c}$$

What is $I(z,t_R)$?

$$I(t) = \begin{cases} 0 & \mathrm{t} \le 0 \\ \mathrm{I}_0 & \mathrm{t}>0 \end{cases}$$

$$\mathbf{A}(s,t) = \frac{\mu_0}{4\pi} \int_{-??}^{??} \frac{I_0 \hat{z}}{\sqrt{s^2 + z^2}} dz$$

What should the limits of integration be?

A) -∞ to +∞

B) -ct to +ct

C) $-\sqrt{c^2t^2 + s^2}$ to $+\sqrt{c^2t^2 + s^2}$

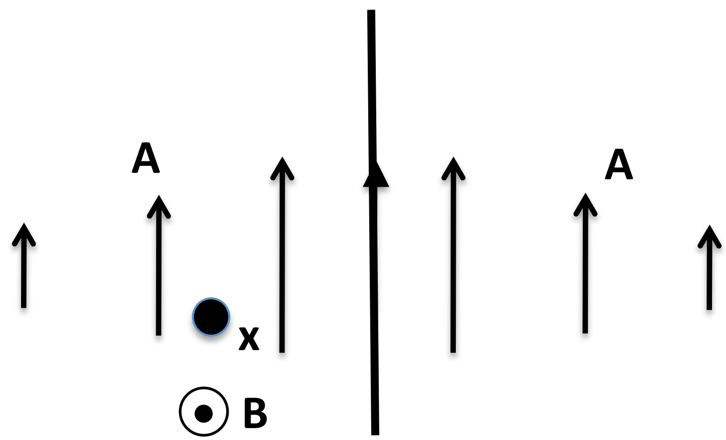
D) $-\sqrt{c^2t^2 - s^2}$ to $+\sqrt{c^2t^2 - s^2}$

E) Something else, not sure, ...

What is the direction of **A** near the wire?

A) +y B) –y C) +y on left , -y on right

D) Toward wire E) away from wire



What is the direction of **B** at point x?

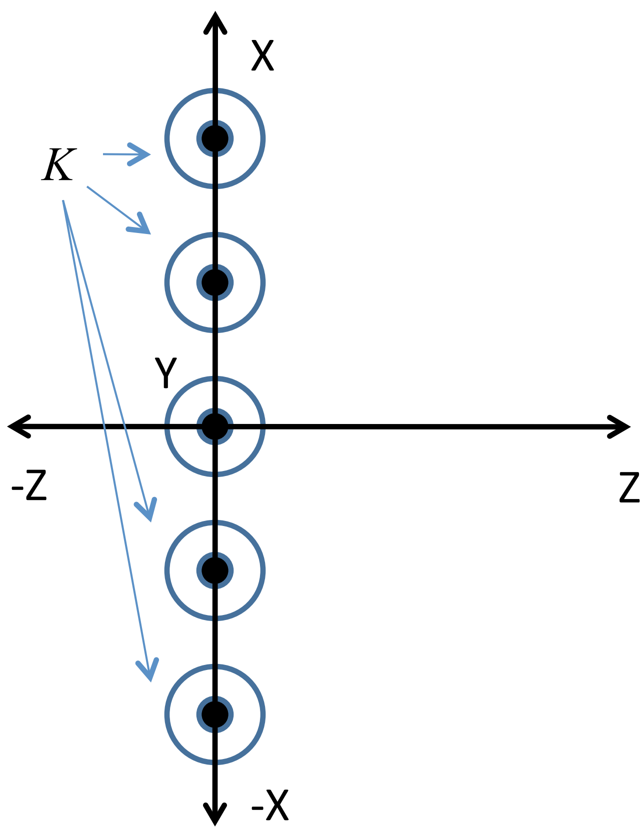
A) up B) down C) in

D) out E) other

What is the direction of **E** at point x?

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

A neutral, infinite current sheet, **K**, flows in the *x*-*y* plane, in the +*y* direction. To the right of the *x*-*y* plane, according to what you know from Phys 3310, the **E** and **B** field directions are:



A) **E** along *z*-axis, **B** is zero

B) **B** along *z*-axis, **E** is zero

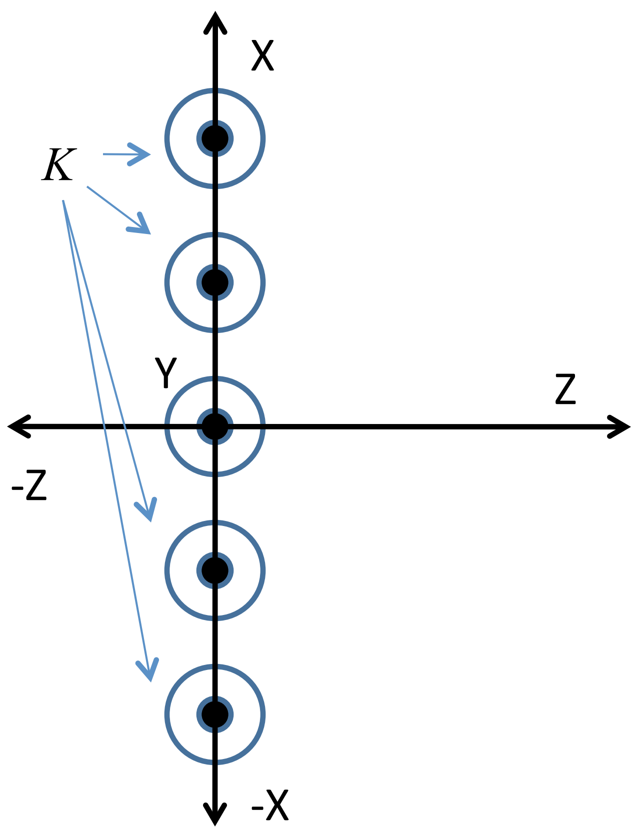
C) **B** along *y*, **E** along *z*

D) **B** along *x*, **E** along *y*

E) None of these

A neutral infinite current sheet, **K**, is turned on at *t*=0, flows in the *x-y* plane, in the +*y* direction.

Very shortly after t=0, the **E** and **B** fields:



A) Remain zero.

B) Immediately appear with their static values in all space.

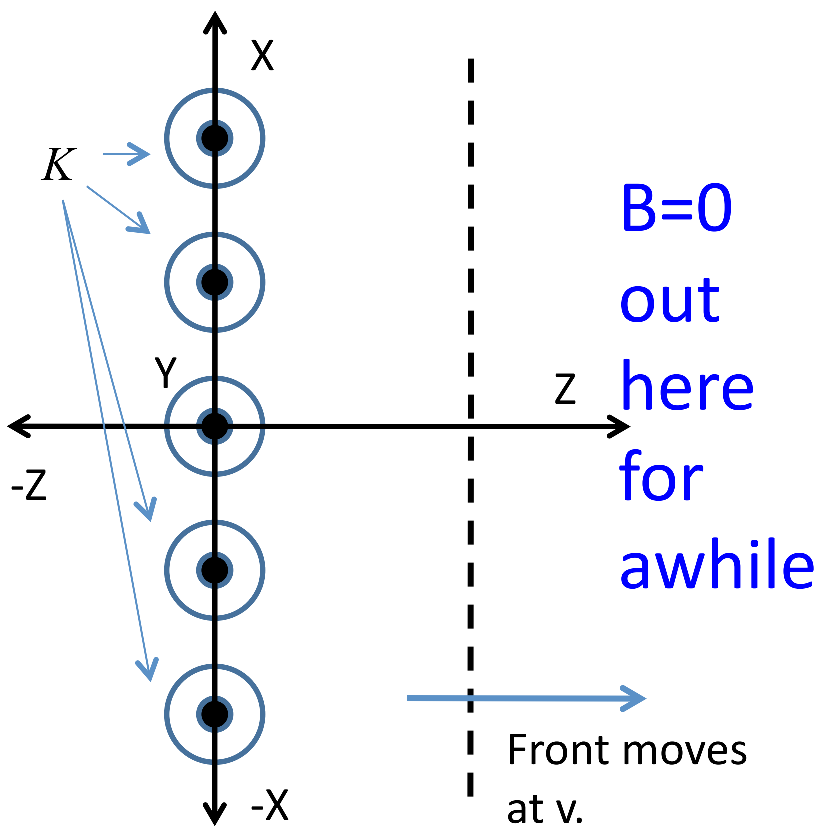
C) Appear only near **K**

D) Appear everywhere, but exponentially suppressed as you move farther away from **K.**

E) None of these

A neutral infinite current sheet, **K**, is turned on at *t*=0, flows in the *x*-*y* plane, in the +*y* direction.

Shortly afterwards, the **B** field near the sheet:



A) is in the *z*-direction

B) is in the *x*-direction

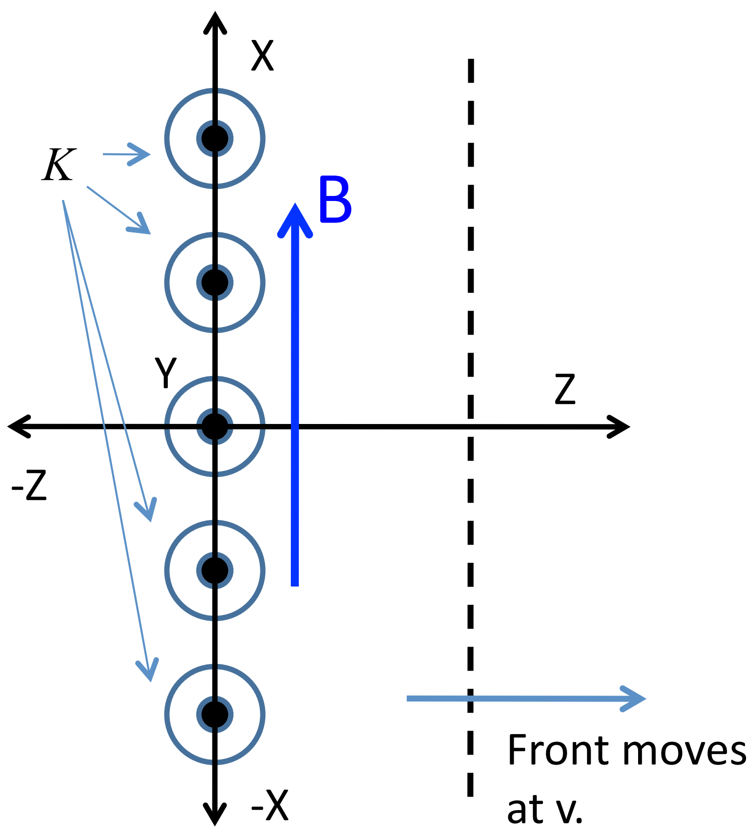
C) is in the *y*-direction

D) is actually zero close to **K**.

E) None of these

A neutral infinite current sheet, **K**, is turned on at t=0, flows in the x-y plane, in the +y-axis.

Shortly afterwards, the **E** field near the wavefront (but not past it):



A) is in the $-z$ direction

B) is in the $-x$ direction

C) is in the $-y$ direction

D) is actually zero close to *the front*.

E) None of these

B=0 out here for awhile

A neutral infinite current sheet, **K**, is turned on at t=0, flows in the x-y plane, in the +y direction.

Shortly afterwards, the **E** field very near the sheet:

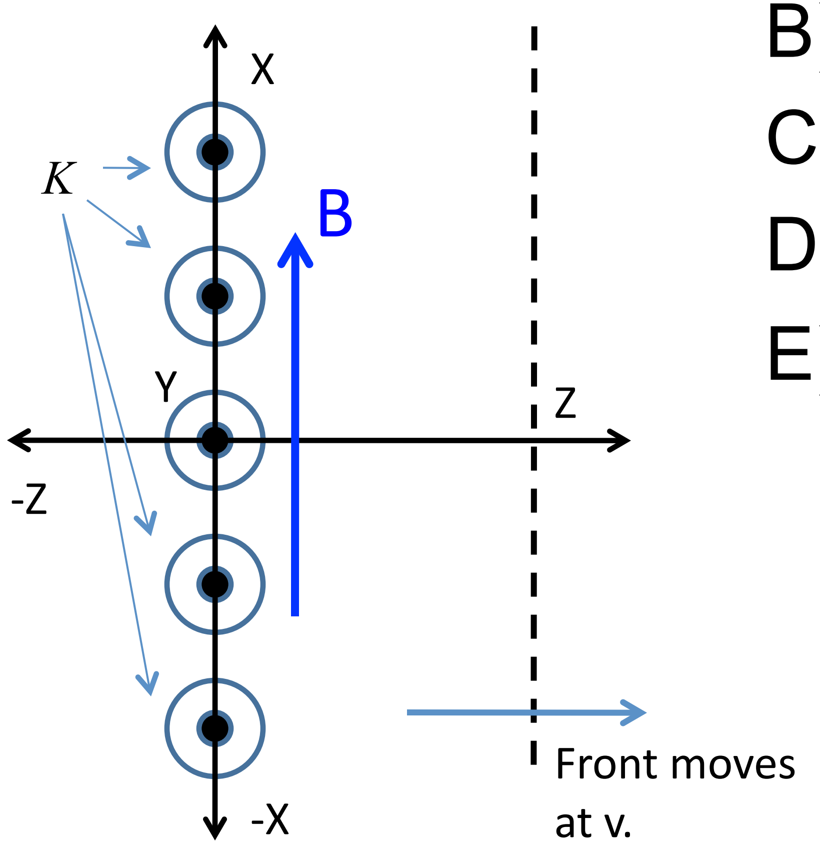
A) is in the -z-direction

B) is in the -x-direction

C) is in the -y-direction

D) is actually zero close to **K**.

E) None of these



B=0 out here for awhile