

Quiz Answer

A really, really long train is traveling at v m/s from Pittsburgh to Funky Town (in fact, you might say that there is a “Long Train Running”). This train carries λ coulombs of charge per meter on a giant thin rod along its entire length. Dick Cheney is riding on the train, and Bill Clinton is standing on the ground outside the train.

Note:

$$B_{\text{wire}} = \frac{\mu_0}{4\pi} \frac{2I}{r} \text{ for a long wire.}$$

While Amperes are an SI base unit, you may let $A = \frac{C}{s}$, passing a point.

Dick Cheney has a magnetic field detector, namely a compass, and sticks it out the window so that he is detecting magnetic field d meters away from the rod. How much magnetic field does Dick Cheney detect due to the rod? (Hint: How fast are the charges on the rod going, from Dick Cheney’s point of view?)

Dick Cheney detects no magnetic field. According to his observations, there is no current from the rod. It’s not moving at all as far as he’s concerned.

Bill Clinton also has a magnetic field detector (a compass). He holds his detector over his head outside the train, d meters away from the rod so that he can detect the magnetic field due to the rod on the train. How much magnetic field does Bill Clinton detect?

$$A = \frac{C}{s} \quad I = \lambda \frac{C}{m} v \frac{m}{s} = \lambda v$$

$$B_{\text{wire}} = \frac{\mu_0}{4\pi} \frac{2I}{r} = \frac{\mu_0}{4\pi} \frac{2\lambda v}{d}$$

(I chose different values of λ , v and d for either class. Substitution gives the results.)

Obviously, at least one of our politicians must be lying. For 2 extra credit points, who is lying and why?

In this case, both politicians are being truthful. This shows you that magnetic (and electric, as it were) fields are not universally constant for all observers! What you are seeing is a relativistic effect, even though we haven’t used any relativity at all!

Labs: Experiment 18.1, 18.2, 18.3, 18.4, 18.5 In-Class