# Electromagnetc Theory: PHYS330

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# Class Notes

# Warm-Up 1

Suppose we have an electron traveling at 1 percent of the speed of light, with a velocity vector

$$\vec{v} = \frac{|\vec{v}|}{\sqrt{2}}\hat{i} + \frac{|\vec{v}|}{\sqrt{2}}\hat{j} \tag{1}$$

The electron is traveling in a $\vec{B}$-field of 0.5 Gauss ($0.5 \times 10^{-4}$ Tesla) that is pointed in the z-direction. What is the force on the electron? *[Hint: $\vec{F} = q\vec{v} \times \vec{B}$]*

# Answer

Answers (build up the answer from smaller pieces):

$$\vec{v} = a(\hat{i} + \hat{j}) \tag{2}$$

$$\vec{B} = B\hat{k} \tag{3}$$

$$\vec{v} \times \vec{B} = aB(\hat{i} \times \hat{k} + \hat{j} \times \hat{k}) \tag{4}$$

$$\vec{v} \times \vec{B} = aB(\hat{i} - \hat{j}) \tag{5}$$

$$\vec{v} \times \vec{B} = \frac{|\vec{v}|B}{\sqrt{2}}(\hat{i} - \hat{j}) \tag{6}$$

Now, we want to add $q$, and the values of $B$ and $v$ ...

# Warm-Up 2

Suppose we have a function that describes the *potential energy* of a system:

$$U(x, y, z) = mgz \tag{7}$$

Take the gradient and multiply by minus one. What do you get? *[Hint: $\vec{F} = -\nabla U(x, y, z)$.]*

## Warm-Up 2

Answer:

$$-\nabla U(x, y, z) = -\left(\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}\right) mgz \qquad (8)$$

Take the gradient and multiply by minus one. What do you get?
*[Hint: $\vec{F} = -\nabla U(x, y, z)$.]*

# More Class Notes

## Gradient of $r = \sqrt{x^2 + y^2 + z^2}$

$$\nabla r = \left( \hat{i}\frac{\partial r}{\partial x} + \hat{j}\frac{\partial r}{\partial y} + \hat{k}\frac{\partial r}{\partial z} \right) \tag{9}$$

(Break the problem into pieces ... )

$$\frac{\partial r}{\partial x} = \frac{\partial}{\partial x}(x^2 + ...)^{1/2} = \frac{1}{2}(x^2 + ...)^{-1/2}(2x) \tag{10}$$
$$\frac{\partial r}{\partial y} = \frac{\partial}{\partial y}(y^2 + ...)^{1/2} = \frac{1}{2}(y^2 + ...)^{-1/2}(2y) \tag{11}$$
$$\frac{\partial r}{\partial z} = \frac{\partial}{\partial z}(z^2 + ...)^{1/2} = \frac{1}{2}(z^2 + ...)^{-1/2}(2z) \tag{12}$$

The result is:

$$\nabla r = \hat{r} \tag{13}$$