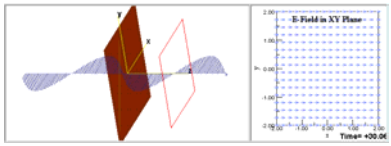
# *Worksheet for Exploration 32.2: Plane Waves and the Electric Field Equation*




You can change the position of the square (that shows you the field-vector representation of the electric field), as well as the maximum value of the electric field and the wavelength **(position is given in meters and time is given in nanoseconds**). Restart.

The electromagnetic plane wave in the animation above is described by the equation

$$\mathbf{E}\,(z, t) = E_{max} \sin (k\,z - \omega\,t)\,\mathbf{I},$$

where $k = 2\pi/\lambda$ ($\lambda$ is the wavelength) and $\omega = 2\pi f$ ($f$ is the frequency).

a. Explain why the equation is a function of z and t for this wave. Hints: What happens to the field as you move along the z-axis?

i. What happens when you press the play button and move along in time?

ii. Does the field vary or is it constant?

b. Why is this equation a vector equation with a component in the x direction?

c. What is the associated equation for the magnetic field (check in your book if needed)?

i. How does the wavelength of the magnetic field compare to the wavelength of the electric field?

ii. How do the two frequencies compare?

iii. How are $E_{max}$ and $B_{max}$ related?

iv. If the electric field is in the x-direction, what direction will the magnetic field be in?

v. Are the two fields in phase?

d. What do you predict will happen in both representations (the vector field view to the right and the wave view to the left) if you increase the amplitude? Change the amplitude to check your prediction. Did the frequency change? Why or why not?

e. What do you predict will happen in both representations if you increase the wavelength? Try it. This time did the frequency change? Why or why not?

f. Pick a value of the wavelength (λ) and measure it.

g. Measure the frequency (f) at this wavelength.

h. What is the value of λf? (It should be $3 \times 10^8$ m/s).

*Note: when you change the wavelength, you need to let the animation play long enough for the old wavelength to disappear from the axis by letting the animation run for 100-200 ns before making any measurements*