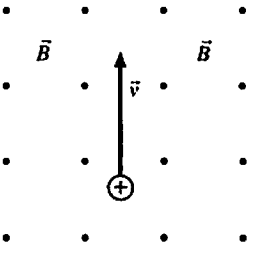
35 Electromagnetic Fields and Waves

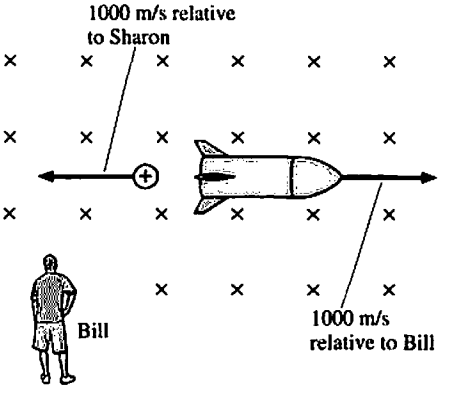
35.1 *E* or *B*? It Depends on Your Perspective



1. In frame S, a positive charge moves through the magnetic field shown.
   a. Draw a vector on the charge to show the magnetic force in S.
   b. What are the speed V and direction of a reference frame S′ in which there is no magnetic force? Explain.

   c. What are the type and direction of any fields in S′ that could cause the observed force on the charge?

2. Sharon drives her rocket through a magnetic field, traveling to the right at a speed of 1000 m/s as measured by Bill. As she passes Bill, she shoots a positive charge backward at a speed of 1000 m/s relative to her.
   a. According to Bill, what kind of force or forces act on the charge? In which directions? Explain.

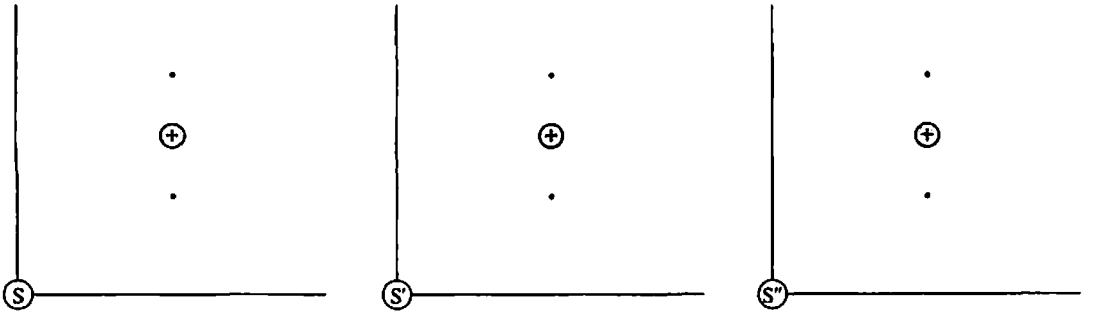


   b. According to Sharon, what kind of force or forces act on the charge? In which directions? Draw the forces on the charge.

3. In frame S, a positive charge moves to the right at speed v. Frame S′ travels to the right at speed $V = v$ relative to S. Frame S″ travels to the right at speed $V = 2v$ relative to S. The figure below shows the charge three times, once in each reference frame.

   a. For each:

   - Draw and label a velocity vector on the charge showing its motion in that frame.
   - Draw and label the electric and magnetic field vectors due to the charge at the points above and below the charge. Use the notation of circled × and ● to show fields into or out of the page.



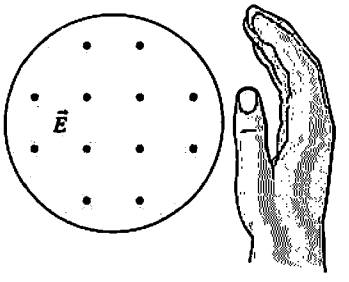
   b. Does it make sense to talk about "the" magnetic field? Why or why not?

35.2 The Field Laws Thus Far

35.3 The Displacement Current

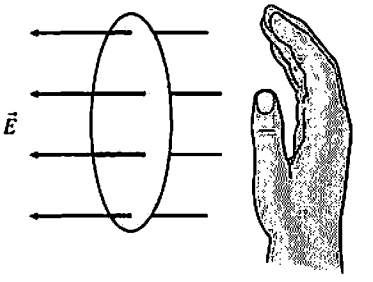
4. If you curl the fingers of your right hand as shown, is the electric flux positive or negative?

a.



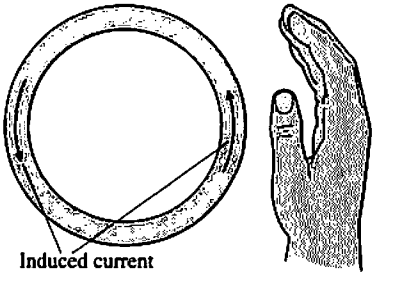
Sign of Φ_e _____

b.

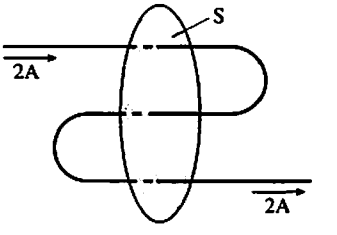


Sign of Φ_e _____

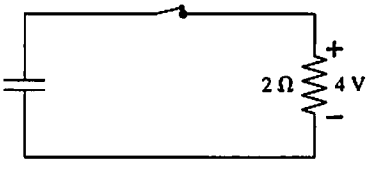
5. If you curl the fingers of your right hand as shown, is the emf positive or negative?



6. What is the current through surface S?



7. The capacitor in this circuit was initially charged, then the switch was closed. At this instant of time, the potential difference across the resistor is $\Delta V_R = 4$ V.



a. At this instant of time, what is the current through the resistor?

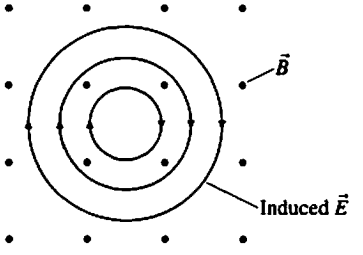
b. At this instant of time, what is the current through the space between the capacitor plates?

c. At this instant of time, what is the displacement current through the space between the capacitor plates?

d. Is the displacement current really a current? If so, what are the moving charges? If not, what is the displacement current?

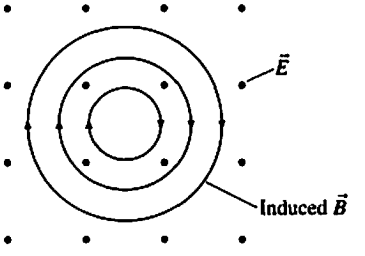
8. Consider these two situations:

a.



Is the magnetic field strength increasing, decreasing, or not changing? Explain.

b.



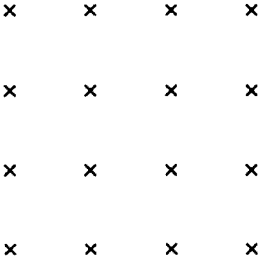
Is the electric field strength increasing, decreasing, or not changing? Explain.

9. Consider these two situations:

a. Draw the induced electric field.

$\vec{B}$-field rapidly increasing

b. Draw the induced magnetic field.



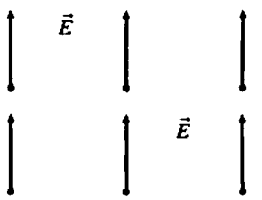
$\vec{E}$-field rapidly increasing

35.4 Maxwell's Equations

35.5 Electromagnetic Waves

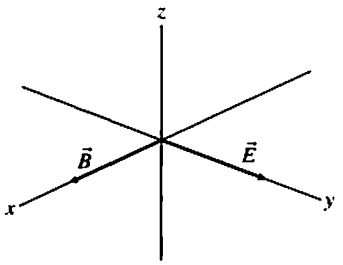
35.6 Properties of Electromagnetic Waves

10. This is an electromagnetic plane wave traveling into the page. Draw the magnetic field vectors $\vec{B}$ at the dots.

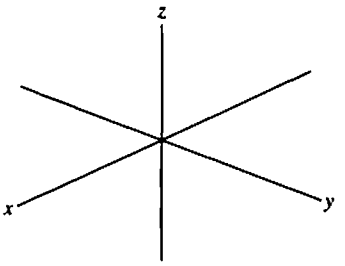


11. This is an electromagnetic wave at one instant of time.

a. Draw the velocity vector $\vec{v}_{em}$.

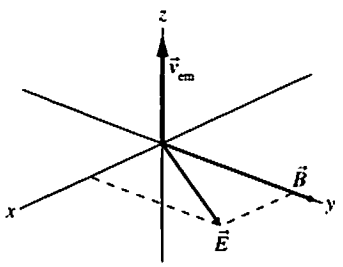


b. Draw $\vec{E}$, $\vec{B}$, and $\vec{v}_{em}$ a half cycle later.

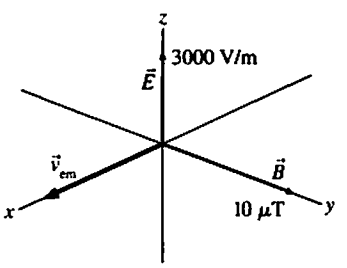


12. Do the following represent possible electromagnetic waves? If not, why not?

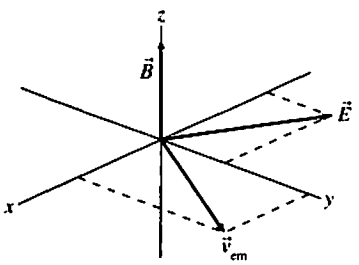
a.



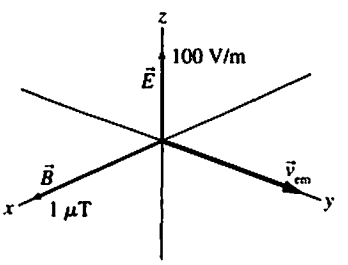
b.



c.



d.



13. The intensity of an electromagnetic wave is 10 W/m^2. What will be the intensity if:

a. The amplitude of the electric field is doubled?

b. The amplitude of the magnetic field is doubled?

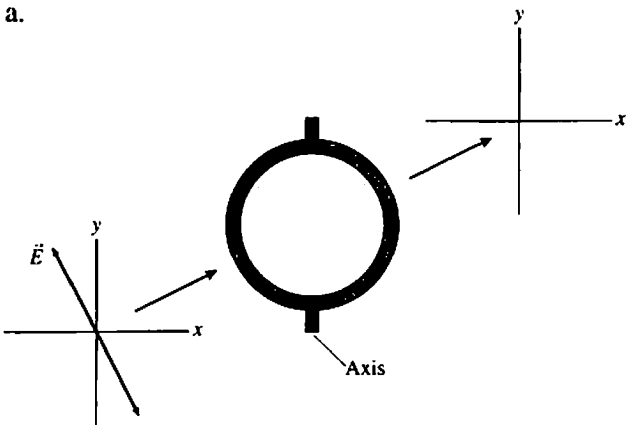
c. The amplitudes of both the electric field and the magnetic field are doubled?

d. The frequency is doubled?

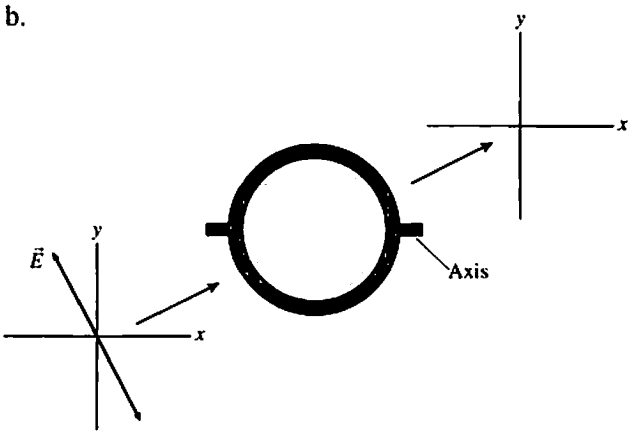
35.7 Polarization

14. A polarized electromagnetic wave passes through a polarizing filter. Draw the electric field of the wave after it has passed through the filter.

a.

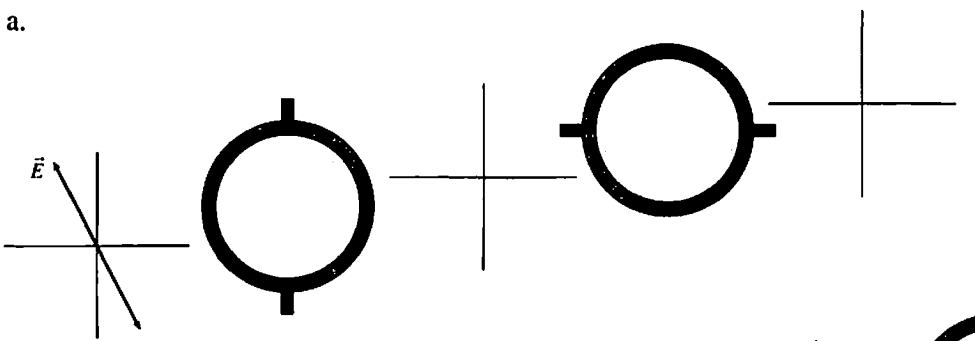


b.

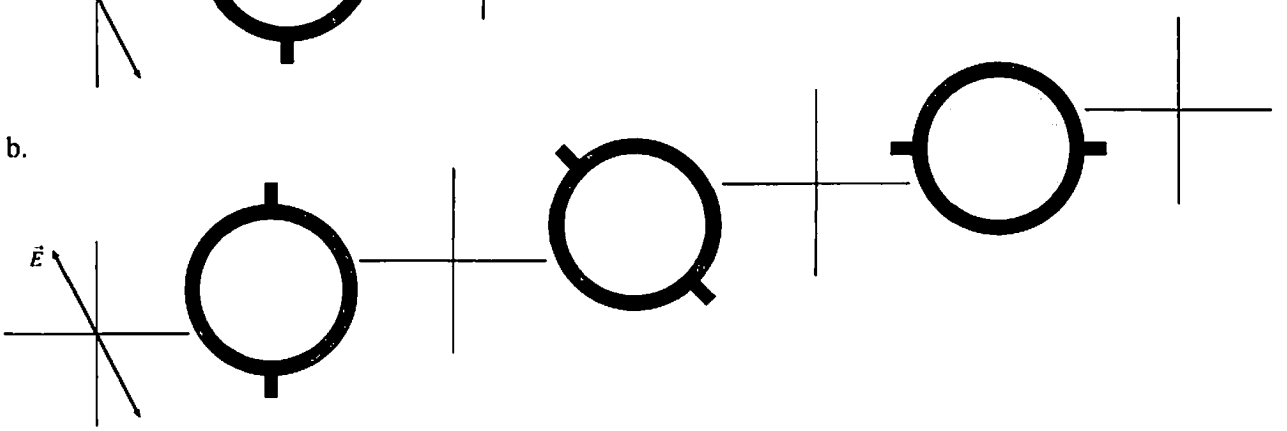


15. A polarized electromagnetic wave passes through a series of polarizing filters. Draw the electric field of the wave after it has passed through each filter.

a.



b.



16. The intensity of a polarized electromagnetic wave is 10 W/m^2. What will be the intensity of the wave after it passes through a polarizing filter whose axis makes the following angle with the plane of polarization?

$\theta = 0°$ _____ $\theta = 60°$ _____

$\theta = 30°$ _____ $\theta = 90°$ _____

$\theta = 45°$ _____