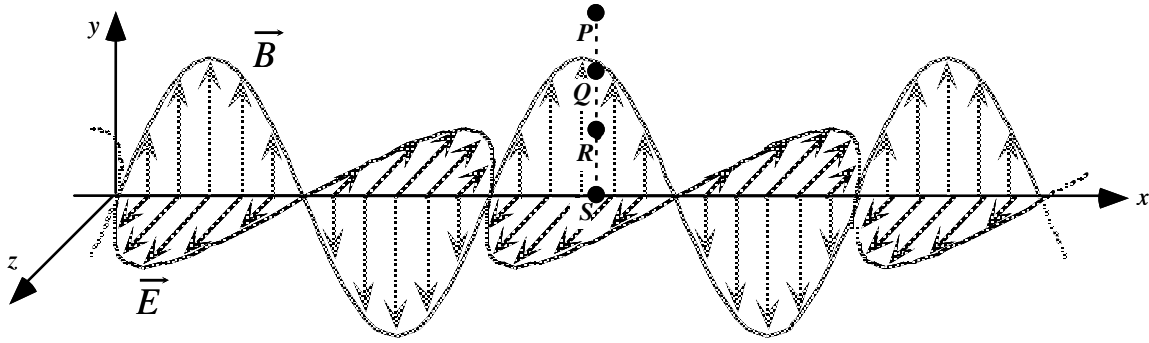Shown below are mathematical and pictorial representations of an electromagnetic plane wave propagating through empty space. The electric field is parallel to the *z*-axis.

$$\vec{B}\ (x,\ y,\ z,\ t) = B_o\ \sin(kx + \omega t)\ \hat{y}$$

The points *P, Q, R,* and *S* in the diagram above lie in the *x–y* plane. Each of the questions relates to the instant shown.

1. Which statement below correctly relates the magnitude of the *electric field* at points *P* and *S?* **[3]**

a) $E_P > E_S > 0$ b) $E_P > E_S = 0$ c) $E_P = E_S > 0$
d) $E_P = E_S = 0$ e) $E_S > E_P > 0$ f) $E_S > E_P = 0$

2. Explain your reasoning. **[2]**

3. Which statement below correctly relates the magnitude of the *electric field* at points *Q* and *R?* **[3]**

a) $E_Q > E_R > 0$ b) $E_Q > E_R = 0$ c) $E_Q = E_R > 0$
d) $E_Q = E_R = 0$ e) $E_R > E_Q > 0$ f) $E_R > E_Q = 0$

4. Explain your reasoning. **[2]**

5. Write an expression for the electric field **E**(x,y,z,t). (Remember to express the amplitude of the electric field in terms of the amplitude of the magnetic field.) **[4]**

6. In which direction is the wave traveling? **[3]**

7. Suppose that the diagram above represents a radio wave. In order to obtain the best reception with a radio, how would you orient the antenna? Remember, the optimal orientation to maximize reception is with the antenna parallel (or antiparallel) to the electric field. **[3]**

        a. parallel to the *x*-axis
        b. parallel to the *y*-axis
        c. parallel to the *z*-axis
        d. parallel to the *y-z* plane and at an angle of 45° with respect to the *y*-axis
        e. any orientation parallel to the *y-z* plane.