```
      frame.setZRange(false, 0, 0.2);
      frame.addDrawable(charge);
   }

   public void initialize() {
      gridSize = control.getInt("size");
      Exy = new double[2][gridSize][gridSize];
      // maximum speed of charge
      charge.vmax = control.getDouble("vmax");
      charge.dt = control.getDouble("dt");
      frame.setAll(Exy);
      initArrays();
   }

   private void initArrays() {
      charge.resetPath();
      calculateFields();
   }

   private void calculateFields() {
      double[] fields = new double[3]; // Ex, Ey, Bz
      for(int i = 0;i<gridSize;i++) {
         for(int j = 0;j<gridSize;j++) {
            // x location where we calculate the field
            double x = frame.indexToX(i);
            // y location where we calculate the field
            double y = frame.indexToY(j);
            // return the retarded time
            charge.calculateRetardedField(x, y, fields);
            Exy[0][i][j] = fields[0]; // Ex
            Exy[1][i][j] = fields[1]; // Ey
         }
      }
      frame.setAll(Exy);
   }

   public void reset() {
      control.setValue("size", 31);
      control.setValue("dt", 0.5);
      control.setValue("vmax", 0.9);
      initialize();
   }

   protected void doStep() {
      charge.step();
      calculateFields();
   }

   public static void main(String[] args) {
      SimulationControl.createApp(new RadiatingEFieldApp());
   }
}
```


Problem 10.19 Field lines from an accelerating charge

(a) Read the code for `RadiatingEFieldApp` carefully to understand the correspondence between the program and the analytic results, (10.40) and (10.42), discussed in the text.

(b) Describe qualitatively the nature of the electric and magnetic fields from an oscillating point charge. How does the electric field differ from that of a static charge at the origin? What happens as the speed increases? The physics breaks down if the maximum speed is greater than c. Does the algorithm break down? Explain.

(c) Modify `RadiatingEFieldApp` to show the z-component of the magnetic field in the xy-plane using a `Scalar2DFrame`.

(d) Modify the program to observe a charge moving with uniform circular motion about the origin. What happens as the speed of the charge approaches the speed of light? ■

Problem 10.20 Spatial dependence of the radiating fields

(a) As waves propagate from an accelerating point source, the total power that passes through a spherical surface of radius R remains constant. Because the surface area is proportional to R^2, the power per unit area or intensity is proportional to $1/R^2$. Also, because the intensity is proportional to E^2, we expect that $E \propto 1/R$ far from the source. Modify the program to verify this result for a charge that is oscillating along the x-axis according to $x(t) = 0.2\cos t$. Plot $|E|$ as a function of the observation time t for a fixed position, such as $\mathbf{R} = (10, 10, 0)$. The field should oscillate in time. Find the amplitude of this oscillation. Next double the distance of the observation point from the origin. How does the amplitude depend on R?

(b) Repeat part (a) for several directions and distances. Generate a polar diagram showing the amplitude as a function of angle in the xy-plane. Is the radiation greatest along the line in which the charge oscillates? ■

Problem 10.21 Fields from a charge moving at constant velocity

(a) Use `RadiationApp` to calculate $\mathbf{E}$ due to a charged particle moving at constant velocity toward the origin, for example, $x(t_{\text{ret}}) = 1 - 2t_{\text{ret}}$. Take a snapshot at $t = 0.5$ and compare the field lines with those you expect from a stationary charge.

(b) Modify `RadiationApp` so that $x(t_{\text{ret}}) = 1 - 2t_{\text{ret}}$ for $t_{\text{ret}} < 0.5$ and $x(t_{\text{ret}}) = 0$ for $t_{\text{ret}} > 0.5$. Describe the field lines for $t > 0.5$. Does the particle accelerate at any time? Is there any radiation? ■

Problem 10.22 Frequency dependence of an oscillating charge

(a) The radiated power at any point in space is proportional to E^2. Plot $|E|$ versus time at a fixed observation point (for example, $X = 10$, $Y = Z = 0$) and calculate the