$C = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ $V = C = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$

8-9 Electromagnetic Radiation

The theory of light

Now finally armed with the correct laws of electricity, Maxwell proceeded to derive the theory of light. Specifically, he proved that a changing current will radiate electromagnetic waves with a velocity $v = c$ where c is the experimental proportionality constant in the equation for force between currents. He also showed that in such radiation the electromagnetic wave consists of E and B perpendicular to each other and also that both are perpendicular to the direction of the wave motion. In addition, E and B were shown to have the same magnitude. In 1864 this was indeed a crowning achievement of theoretical physics. Here the fundamental explanation of all electric, magnetic, and optical phenomena were supposedly given in one simple set of basic laws (Eqs. 8–24, 8–25, and 8–26). In addition, Maxwell's theory predicted that electromagnetic waves of any frequency, no matter how low, should be radiated with the velocity of light. This theory was first experimentally verified by Hertz in 1888, and by 1901 Marconi had succeeded in transmitting electromagnetic waves all the way across the Atlantic Ocean. These electromagnetic waves of lower frequency than light and infrared waves came to be known as radio waves.

Normally the derivation of electromagnetic radiation requires calculus and differential equations. However, now that we have worked so hard in the last two chapters to develop the complete set of Maxwell equations, it would be a shame to give up just before the grand climax. The following noncalculus explanation of electromagnetic radiation was worked out for this book with the help of Professor R. Feynman, a physicist at California Institute of Technology.

For the radiation source we shall use an infinite sheet of current. As shown on page 164 the magnetic field produced by a current running down a plane of i statcoulombs per centimeter is (see Eq. 8–17)

$B = \frac{\mu_0}{2} i$

$$B = \frac{2\pi i}{c}$$