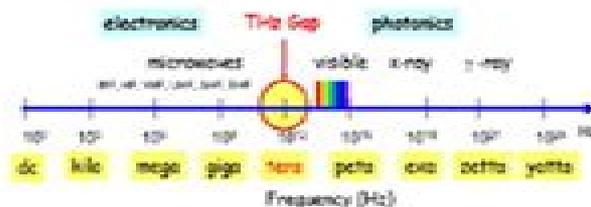


Chapter 7: Plane Electromagnetic Waves and Wave Propagation

T-Ray: Next frontier in Science and Technology

Terahertz wave (or **T-ray**), which is electromagnetic radiation in a frequency interval from 0.1 to 30 THz, lies a frequency range with rich science but limited technology.



1 THz = 1 ps = 300 μm = 33 cm⁻¹ = 4.1 meV = 47.6 °K

1

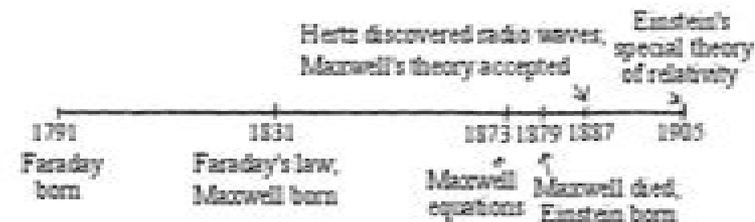
An Historical Perspective:



Faraday : Time-varying magnetic field generates electric field

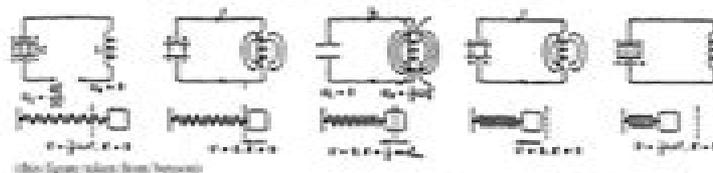


Maxwell : Time-varying electric field generates magnetic field

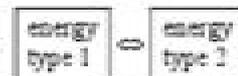


2

A Note about Oscillatory Behavior:



Common feature of oscillatory behavior:



⇒ Oscillations require $\left\{ \begin{array}{l} \text{energy storing mechanisms} \\ \text{energy exchange mechanism(s)} \end{array} \right.$

example	energy storing mechanisms	energy exchange mechanism(s)	medium
mass-spring system	$\frac{1}{2}mv^2, \frac{1}{2}kx^2$	restoring force	mass & spring
LC oscillator	$\frac{1}{2}LI^2, \frac{1}{2}CV^2$	Q, I	$L, C,$ & wire
EM wave	$\frac{\epsilon_0}{2}E^2, \frac{\mu_0}{2}H^2$	$\frac{dE}{dt}, \frac{dH}{dt}$	not required

Organization of Lecture Notes on Ch. 7:

In Jackson, plane waves in dielectric media are treated in Secs. 7.1 and 7.2. Various special cases (plasma medium and high-frequency limit) are treated in Sec. 7.5. Plane waves in conductors are treated in Sec. 5.10 [e.g. Eqs. (5.163)-(5.169)] and Sec. 8.1 [e.g. Eqs. (8.9), (8.10), (8.12), (8.14), and (8.15)] by methods different from those in Secs. 7.1 and 7.2.

Here, we will cover these sections in Jackson with a unified treatment of plane waves in both dielectrics and conductors, and at all frequencies. Equations in Jackson will be examined in greater detail, but in somewhat different order. So, in the lecture notes, the three sections on these materials will be numbered Secs. I, II, and III rather than following Jackson's section numbers. However, Secs. 7.3, 7.4, 7.8, and 7.9 of Jackson will be followed closely in subsequent lecture notes (and numbered as in Jackson).

We begin with a derivation of the generalized dielectric constant d_g , which is applicable to both dielectric and conducting media.

4

Chapter 7 Plane Electromagnetic Waves An Historical

Chao Zhang



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