PHYSNET

MISN-0-515

ELECTROMAGNETIC RADIATION

Electricity and Magnetism

Project PHYSNET Physics Bldg. Michigan State University East Lansing, MI

ELECTROMAGNETIC RADIATION

by

R. Young

Title: **Electromagnetic Radiation**

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Input Skills:

1. Vocabulary: linear damping force (MISN-0-29).
2. State Maxwell's equations (MISN-0-513).
3. Determine the Poynting vector for an electromagnetic field and calculate the flow of electromagnetic power (MISN-0-513).
4. Express the gradient, divergence, and curl operators in spherical polar coordinates (MISN-0-503).

Output Skills (Knowledge):

K1. Vocabulary: inhomogeneous wave equation, retarded time, retarded scalar potential, retarded vector potential, gauge transformation, Lorentz condition, Lorentz gauge, radiation resisitance.

K2. Derive the radiation fields and the average radiated power of an oscillating electric or magnetic dipole.

K3. Derive the average power radiated by an electron in the field of an electromagnetic wave.

Output Skills (Rule Application):

R1. Calculate the average radiated power and the radiation resistance of a given electric or magnetic dipole.

Output Skills (Problem Solving):

S1. Determine the relative efficiency of electric and magnetic dipole radiation.

External Resources (Required):

1. J. Reitz, F. Milford and R. Christy, *Foundations of Electromagnetic Theory*, 4th Edition, Addison-Wesley (1993).

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New authors, reviewers and field testers are welcome.

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1. Introduction

In this Unit, Maxwell's equations are applied to electromagnetic radiation from prescribed charge-current distributions. Radiation problems involve solutions to the inhomogeneous wave equation with (specified) sources. These solutions must represent outgoing waves and fall off as $1/r$ for large distances. The charge distributions treated involve an oscillating electric dipole, a half-wave antenna, and an oscillating magnetic dipole. In addition, the power radiated by a group of slowly moving charges and an accelerated charge will be treated.

2. Procedures

1. Read Sec. 20-1, 20-2 and 20-3 of the text

2. Solve these problems:

Prob	Type
20-2	Power density, total power, and radiation resistance of an oscillating electric dipole
20-3	Radiation fields and total power of an oscillating magnetic dipole
20-4	Comparison of electric and magnetic dipole as radiators

3. Show that the total power radiated by a electron that is free to move in an electric field of the form

$$E = E_0 cos\,\omega(t - x/c)$$

is

$$P = \frac{1}{12\pi\epsilon_0}\frac{e^4 E_0^2}{m_e^2 c^3}\,.$$

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