ELECTROMAGNETIC RADIATION

Electricity and Magnetism

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R. Young

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Title: Electromagnetic Radiation

Author: R.D. Young, Dept. of Physics, Ill. State Univ

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Input Skills:
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 resistance.
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):
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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:

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<td>20-2</td>
<td>Power density, total power, and radiation resistance of an oscillating electric dipole</td>
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<tr>
<td>20-3</td>
<td>Radiation fields and total power of an oscillating magnetic dipole</td>
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<td>20-4</td>
<td>Comparison of electric and magnetic dipole as radiators</td>
</tr>
</tbody>
</table>

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

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

is

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

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