HW#9 —Phy273—Fall 2000 Prof. Ted Jacobson
Due before class, Friday, Nov. 10, 2000 Room 4117, (301)405-6020
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Read in HRK Chapters 40,41,42
(*Maxwell's equations, Electromagnetic waves, The Nature and propagation of light*).
Read in Feynman Chapter 34 (*Relativistic effects in radiation*)

1. In physics we are usually more interested in approximate results rather than exact ones. In extracting approximate results it is often useful to make Taylor exapnsions, and it is often sufficient to keep only the first derivative term in the expansion, and it is often possible to do this "by inspection" by casting the expression to be approximated into the form $(1+\varepsilon)^n$, where $\varepsilon \ll 1$ is the small quantity one is expanding in.

(a) Show using the Taylor expansion that

$$(1+\varepsilon)^n = 1 + n\varepsilon + \frac{n(n-1)}{2}\varepsilon^2 + O(\varepsilon^3). \tag{1}$$

(b) If $n\varepsilon \ll 1$, one gets a good approximation keeping only the first two terms, i.e. $(1+\varepsilon)^n \simeq 1 + n\varepsilon$. Check this for $\varepsilon = 0.1$ and $n = -3/2$, by computing the exact and approximate results and comparing them. Also for this case evaluate the $O(\varepsilon^2)$ term in (1) and the ratio of this term to the $O(\varepsilon)$ term.

(c) Use the $O(\varepsilon)$ approxmation to approximate $1/(1+\varepsilon)$, $\sqrt{1+\varepsilon}$, $1/\sqrt{1+\varepsilon}$, $1/(1+\varepsilon)^3$.

2. HRK Ch. 40, Q26 (*Faraday's and Ampère's laws in acavity*)

3. HRK Ch. 40, P7 (*displacement current in a capacitor*)

4. HRK Ch. 40, P13 (*magnetic field in AC capacitor*)

5. HRK Ch. 41, Q4 (*characterizing radiation of different wavelengths & frequencies*)

6. HRK Ch. 41, Q9 (*deflection of em waves by em fields?*)

7. HRK Ch. 41, P2 (*Project Seafarer*)

8. HRK Ch. 41, P3 (*collider x-rays & VLF radio waves*)

9. HRK Ch. 41, P6 (*radiation pattern of magnetic dipole antenna*)

10. HRK Ch. 41, P18 (*E & B field energies in em wave*)

11. HRK Ch. 41, P22 (*spreading of laser beam intensity*)

12. HRK Ch. 41, P24 (*Arecibo radio antenna sensitivity*)

13. HRK Ch. 41, P39 (*em plane wave properties*)

Honors HW#9h:

1. Using the vector form of Maxwell's equations in empty space show that the 3d wave equation applies to all the components of the electric and magnetic field vectors. For example, $\partial^2\mathbf{E}/\partial t^2 = c^2\nabla^2\mathbf{E}$, and similarly for $\mathbf{B}$.

2. Show that the vacuum Maxwell equations imply that local field-energy conservation holds, i.e. $\partial u/\partial t + \nabla \cdot \mathbf{S} = 0$, where u is the energy density and $\mathbf{S}$ is the Poynting vector (i.e. the energy flux vector).