Physics 209: Classical Electromagnetism
Final Exam
Due by 12 noon, Dec 14, 2006
Ori Ganor

Directions

- Please try solving both problems below.
- Even if you do not reach a final answer, please explain your plan for the solution and please write down the relevant formulas. That may help for partial credit.
- No need to rederive standard expressions that we derived in the classroom or that appear in the textbook.
- You may use your favorite software such as `Mathematica` or `Maple` for algebraic manipulations and integrations (but you don't need to!).
- **Please return your solutions to me by Thursday 12/14, 12 noon.**
- When you are finished, you can either return a handwritten solution to my office 403 LeConte Hall (slide it under the door if there is no one there), or email the solutions to

  `origa@socrates.berkeley.edu`

  I can read `TeX, LaTeX, MSWord` and `PDF`. (Please don't email `Mathematica` notebook files.) If you choose to return a handwritten solution, it would be good if you could also email me a message so as to be sure that I got your solution.
- During the exam period, you can communicate with me via e-mail.
- The maximal number of points that you can get for each problem is indicated in brackets $[\cdots]$. These numbers are *tentative* and might change slightly.

Good luck!

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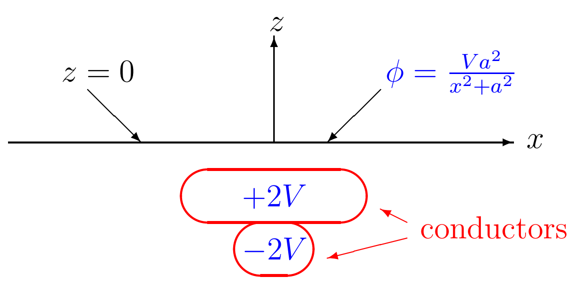
Problem 1: Electrostatics [45pts]



You are in charge of designing an experiment that requires a static potential of

$$\phi(x, y) = \frac{Va^2}{x^2 + a^2}, \qquad V \text{ and } a \text{ are constants}$$

along the $x - y$ plane $z = 0$. You decide to do this by designing a pair of appropriately shaped conductors to be placed somewhere below the plane $z = 0$, such that one will be kept at a constant potential $+2V$ and the other will be kept at a constant potential $-2V$. (See the figure, but note that the shapes are not the correct ones and do not depict the actual answer!) Given V, what shapes will you design for the (surface of) the conductors and where will you place them? (Everything is in vacuum.)

Note: Don't be surprised if you find that the two conductors need to touch at some point. You may assume that the surface of each conductor is coated with a thin but good insulator, and don't worry about electrical breakdown.

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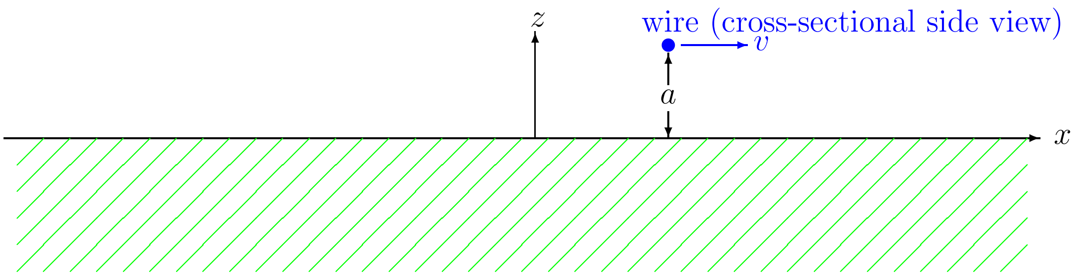
Problem 2: Radiation [55pts]



In this problem the space above the $x - y$ plane ($z > 0$) is vacuum, and the space below the $x - y$ plane ($z < 0$) is filled with an insulating dielectric material with electric permittivity $\epsilon(\omega)$ (that depends on the frequency $\omega/2\pi$) and magnetic permeability $\mu = \mu_0$.

A thin straight wire of uniform charge density (per length) is placed above the plane $z = 0$ at a distance a from it and parallel to the $\hat{y}$ axis, and is made to move with constant velocity v along the $\hat{x}$-axis, so that it occupies the spacetime events (ct, vt, y, a) where $-\infty < y < \infty$ is the y-coordinate, and $-\infty < t < \infty$ is time. σ is the wire's charge density in the lab frame, and the velocity v is larger than $1/\sqrt{\mu_0 \epsilon(\omega)}$ for at least some range of ω's.

Find an expression for the total power per unit length of (Cherenkov-like) radiation emitted.