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Name _

Electrodynamics, Physics 323 Spring 2004 Second midterm Instructor: David Cobden 8.20 am, May 19, 2004

You have 60 minutes. End on the buzzer at 9.20. Answer all 12 questions.

Write your name on every page and your ID on the first page.

Write all your working on these question sheets. Use this cover page for extra working (you might get credit for it.)

It is important to show your calculation or derivation. You may not get full marks just for stating the correct answer if you don't show how you get it.

Watch the blackboard for corrections or clarifications during the exam.

This is a closed book exam. No notes allowed. No calculators.

 $c = 3 \times 10^8$ m/s.

Don't turn this page until I say 'go'.

Why the Sky is Blue by John Ciardi

I don't suppose you happen to know Why the sky is blue? It's because the snow Takes out the white. That leaves it clean For the trees and grass to take out the green. Then pears and bananas start to mellow, And bit by bit they take out the yellow. The sunsets, of course, take out the red And pour it into the ocean bed Or behind the mountains in the west. You take all that out and the rest Couldn't be anything else but blue. Look for yourself. You can see it's true.

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I. 1. [6] The vector potential sometimes obeys the following equation: $\Box^2 \mathbf{A}(\mathbf{x},t) = -\mathbf{m}_0 \mathbf{J}(\mathbf{x},t)$.

Write \Box^2 explicitly in terms of derivatives. What is the condition for this equation to be valid?

2. [14] A circular wire loop centered on the *z*-axis carries a current I(t). Find the (retarded) vector potential $\mathbf{A}(\mathbf{x},t)$ and the scalar potential $V(\mathbf{x},t)$ along the *z*-axis only.

3. [8] Hence show that the electric field along the axis of the loop is always zero.

II. Which of the following are true? 3 points for a correct answer; -1 for a wrong answer; 0 for no answer.

- 4. [9] A charge radiates whenever:
- (a) it is moving in whatever manner
- (b) it is being accelerated
- (c) it is bound in an atom
- 5. [9] A radially pulsating charged sphere:
- (a) emits electromagnetic radiation
- (b) creates a static magnetic field
- (c) can set a nearby electrified particle (which never touches the sphere) in motion
- 6. [9] Radiation emitted by an antenna has the angular distribution characteristic of dipole radiation when:
- (a) the wavelength is long compared with the antenna
- (b) the wavelength is short compared with the antenna
- (c) the antenna has the appropriate shape

III. A radio station has an antenna on top of Queen Anne Hill which is a vertical wire. It emits a power of 100 kW at 90 MHz.

7. [5] What is the intensity of radiation emitted directly upwards into space?

8. [5] What length, in meters, should the antenna have to work best?

9. [15] Obtain a rough estimate of the strength of the electric field on the UW campus, approximately 4 km away, in V/m.

10. [4] Is the radiation on campus polarized, and if so, in which direction?

11. [6] Estimate the magnetic field on campus also, and describe its direction.

12. [10] Using the fact that the total power radiated by an oscillating electric dipole p is $P = \frac{\mathbf{m}_0 \ddot{p}^2}{6\mathbf{p}c}$, or otherwise, *estimate roughly* the average current I flowing in the antenna.