CORNELL UNIVERSITY

Department of Physics

# Physics 214 Prelim II Fall 2001

**NAME:**

**SECTION:**

## Instructions

— You get 2 points for writing your name and section in (correctly).
— To receive credit, you must place your answers in the boxes provided whenever required.
— Closed book; no notes. You may use a calculator.
— Check that you have all **14** pages (including cover page). The formula sheet is distributed separately.

| Problem | Score | Grader |
|---|---|---|
| 0. ( 2 pts) | | |
| 1. (14 pts) | | |
| 2. (12 pts) | | |
| 3. (15 pts) | | |
| 4. (10 pts) | | |
| 5. (14 pts) | | |
| 6. (16 pts) | | |
| 7. (17 pts) | | |
| Total (100 pts) | | |

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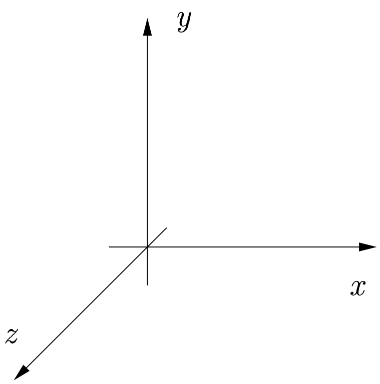
# 1 Problem 1: Electromagnetic Wave [14 points]

An electromagnetic wave hits a detector at $t = 0$. It reads $\vec{E} = E_0\hat{x} - E_0\hat{y}$ ($E > 0$) and $\vec{B} = B\hat{z}$ ($B > 0$).

## (a) (4 points)

***Draw the vectors $\vec{E}$ and $\vec{B}$.***

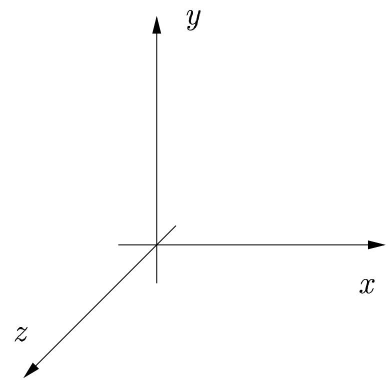



## (b) (4 points)

***What is $B$ in terms of $E_0$?***

## (c) (4 points)

What is the direction the wave is traveling? ***Draw a vector indicating this direction on the coordinate system provided and specify whether it is in the*** $xy$***,*** $xz$***, or*** $yz$ ***plane.***




## (d) (2 points)

Is the wave ***linearly (plane)*** or ***circularly*** polarized?

(A) Linearly.

(B) Circularly.

(C) Not enough information.

# 2 Problem 2: Polarization of Microwave [12 points]

Recall the microwave lab you did. Suppose a microwave traveling to the right ($+x$-direction) gives a reading on the receiver of intensity $I_0$ . Now, a polarization grid oriented in the vertical ($y$-) position is inserted between the generator and the receiver. (See Figure 1.)

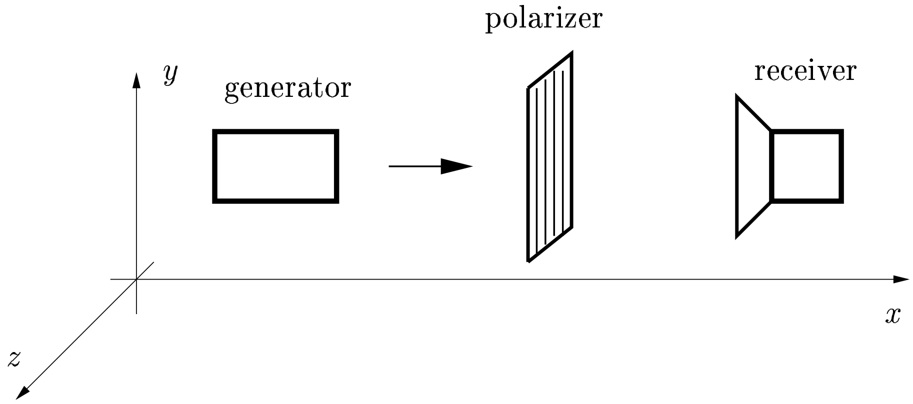



Figure 1: Lab II Experiment 1.

## (a) (4 points)

The receiver reading is zero, that is, the signal is completely screened by the polarization grid in the vertical position. In terms of the $xyz$-coordinate system given in the figure, ***what is the direction of the electric field of the microwave as it exits the generator?***

## (b) (4 points)

Suppose you insert a second polarization grid at a 45° angle in the $y$-$z$ plane between the *microwave generator* and the *vertical polarization grid.* ***What should the reading on the receiver be?***

(A) $I_0$

(B) zero

(C) $I_0/2$

(D) $I_0/4$

(E) $I_0/\sqrt{2}$

## (c) (4 points)

If, instead, the second polarization grid at a $45^o$ angle is placed between the the *vertical polarization grid* and the *receiver*, ***what is the reading now?***

(A) $I_0$

(B) zero

(C) $I_0/2$

(D) $I_0/4$

(E) $I_0/\sqrt{2}$

# 3 Problem 3: Interference [15 points]

Light passes through 3 identical narrow equally spaced slits and hit a screen relatively far away. Each hole allows light with intensity $I_o$ to reach the screen.

Hint: You may find it easier to work out this problem with phasor diagrams.

## (a) (5 points)

***What is the minimum intensity one can get at any point on the screen?***

## (b) (5 points)

***Write down*** the complex analysis for the intensity at such a minimum ***by filling in the phases in the expression below:***

$$I_{\min} = I_0 \left| 1 + e^{i(\quad)} + e^{i(\quad)} \right|^2$$

## (c) (5 points)

***What will be the intensity on that point of the screen if the middle slit is covered up?***

# 4 Problem 4: 3 unequal slits [10 points]

There are 3 narrow slits with different widths. The first slit allows light with intensity $I_1 = I_o$ to hit the screen. The second slit allows light with intensity $I_2 = 9I_o$ to hit the screen. What is the **maximum** and **minimum** values of $I_3$ that the 3 slits have a chance for complete destructive interference at some point on the screen?

***Provide your answers in the boxes below each question.***

maximum intensity/minimum intensity:

(A) $3I_0/I_0$

(B) $9I_0/I_0$

(C) $3I_0$/zero

(D) $9I_0$/zero

(E) $4I_0/I_0$

(F) $16I_0/4I_0$

(G) $4I_0$/zero

(H) $9I_0/4I_0$

(I) $16I_0/I_0$

(J) $4I_0/2I_0$

# 5 Problem 5: Radio Station [14 points]

Voice of America is building a radio station in Pakistan to beam AM radio signals to Afghanistan. They are given two identical antennas with radio wavelengths $\lambda = 200$m. They want to focus the signals on Kabul and Kandahar, which subtend an angle of 30 degrees from each other when viewed from the station.

## (a) (7 points)

***How far apart*** should the 2 antennas be if one wants ***neighboring maximum signals to reach the two cities?***

## (b) (7 points)

Suppose they are offered the option of 4 less powerful antennas, each with only half the power (i.e., intensity) of each of the original two. Should they trade the two antennas for the four less powerful antennas if they want to maximize the signal reaching the two cities? Or, there is no difference?

# 6 Problem 6: Traveling Wave [16 points]

Consider a string, the left end of which is fixed to the wall. There is a left-moving pulse along the string, traveling towards the wall, which is at $x = 0$. At $t = 0$, the string has the shape as shown below, with the pulse beginning a distance $2d$ from the wall.

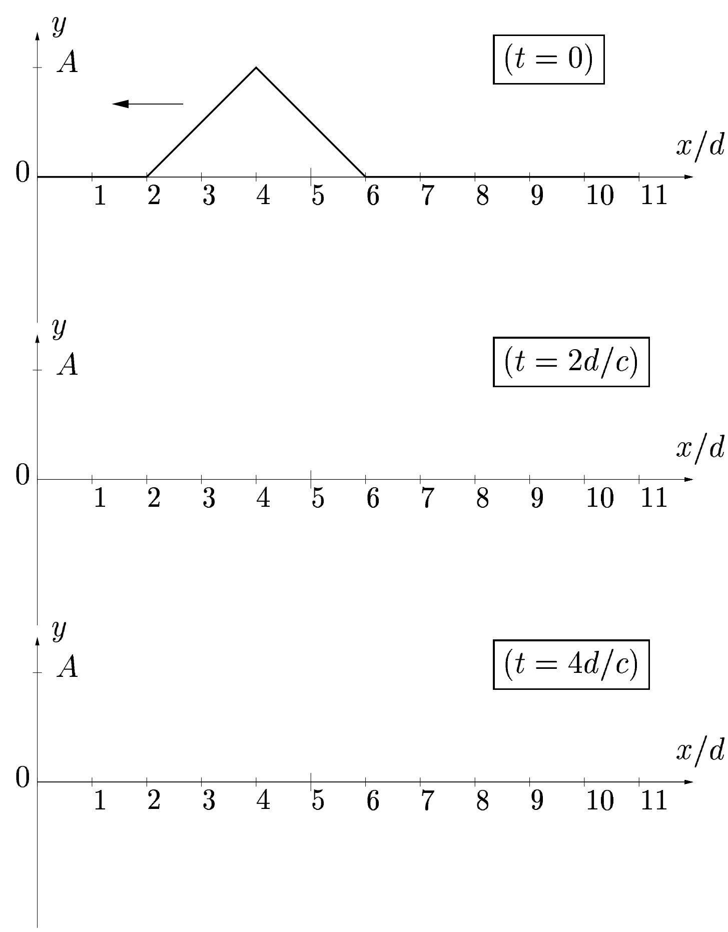
## (a) (4 points)

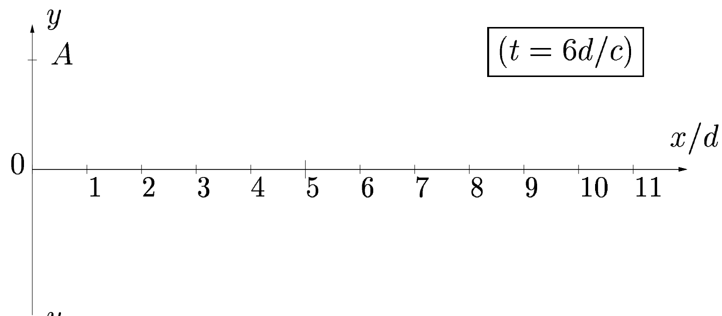
***What is the displacement*** $y(x = 0, t)$ ***at the wall?***

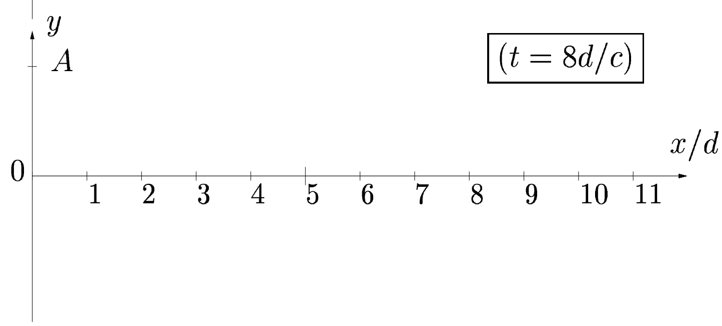
## (b) (12 points)

What does the string look like at $t = 2d/c$, $4d/c$, $6d/c$ and $8d/c$? ***Draw the shape of the string on the graphs:***

Hint: Imagine the string extends to the other side of the wall, and there is an imaginary right-moving pulse coming.

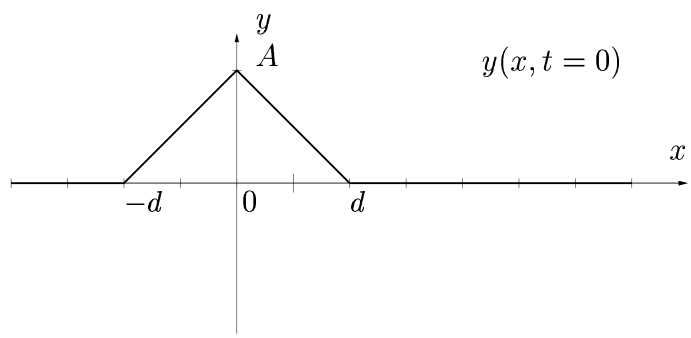



y
A
(t = 6d/c)
x/d
0
1
2
3
4
5
6
7
8
9
10
11

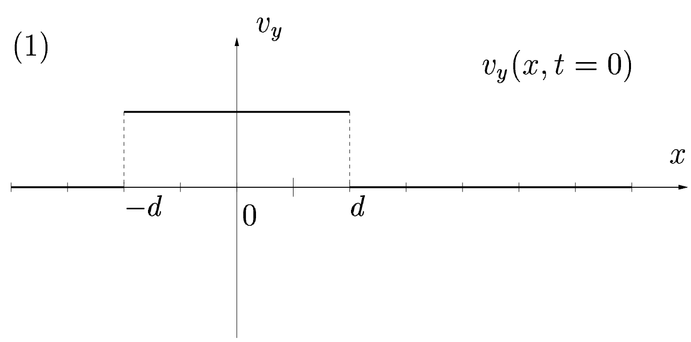

y
A
(t = 8d/c)
x/d
0
1
2
3
4
5
6
7
8
9
10
11

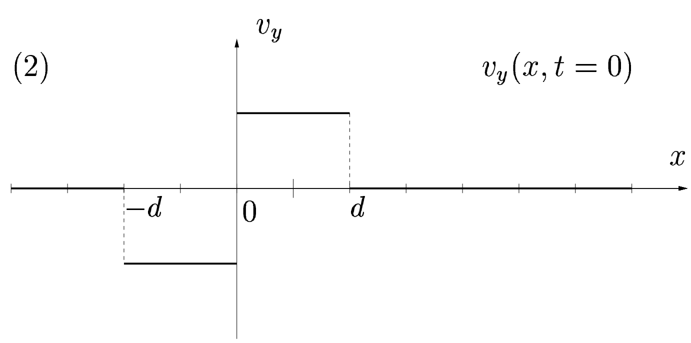
# 7 Problem 7: Transverse Wave [17 points]

At $t = 0$, a *very long* string with wave speed $c$ has the following shape, $y(x, t = 0)$ :




Consider the 2 possibilities of $v_y(x, t = 0)$, as shown.



## (a) (5 points)

***Which of the two possibilities may correspond to a pure left-moving traveling pulse?***
**(1)** or **(2)**

Hint: It is hard to work through all the math directly. Rather, imagine which way each side of the pulse must be going and try to continue that motion forward in time. Then, you can check that your guess is consistent with the initial conditions and adjust it if necessary.

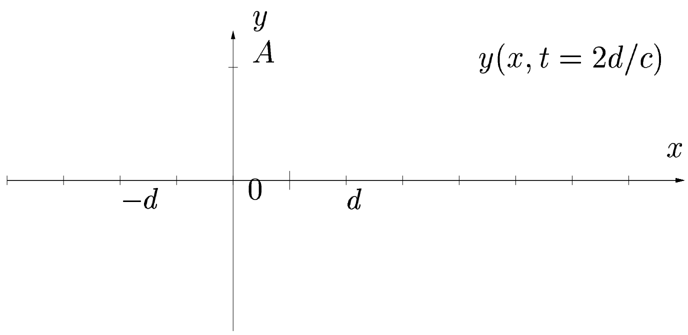
## (b) (5 points)

***What is the value of*** $v_y(x, t = 0)$ ***at*** $x = d/2$***?***

## (c) (7 points) Challenge problem!

Now consider the **other** choice of $v_y(x, t=0)$, where $v_0$ has the same value which you found in (b). If this were the initial velocity, what would the shape of the string be at t=2d/c? ***Sketch your result on the graph below.***

Hint: As in part (a), it is hard to work through all the math directly. Rather, imagine which way each side of the pulse must be going and try to continue that motion forward in time. Then, you can check that your guess is consistent with the initial conditions and adjust it if necessary.




Warning: We suggest that if you don't see the answer to this within a few minutes, that you take a quick guess and go back and check the rest of your exam first. Then, come back to this one only if you have time.

**END OF EXAM**