Introduction to the Microwave Optics System and Reflection

Lab #6

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Objective

The objective of the lab is to practice using the microwave optics system, measure the relationship between distance and microwave strength, and test the law of reflection.

Introduction

Electromagnetic radiation is perpendicular transverse waves of magnetic and electric fields, all moving at the speed of light ($3 * 10^8$ m/s), ranging in type based on frequency and energy, with higher frequency meaning higher energy. The most high energy is gamma radiation, produced by nuclear reactions only, unlike all other forms which are produced by electronic movement. The next longest is x-rays, used in medical testing, followed by ultraviolet, then visible light (the only type humans can see), followed by infrared (used for night vision, based on black body radiation), then microwave radiation, and finally radio waves (used for all electronic communication signals).

Electromagnetic radiation can be polarized by a polarizer, only allowing waves of a specific orientation through, such that perpendicular polarizers block all waves as a result. Microwave strength is inversely proportional to the square of the distance, such that it decreases exponentially. In addition, the law of reflection states that if the radiation is reflected, the angle of incidence is equal to the angle of reflection, such that the microwave radiation picked up is greatest at that angle from it.

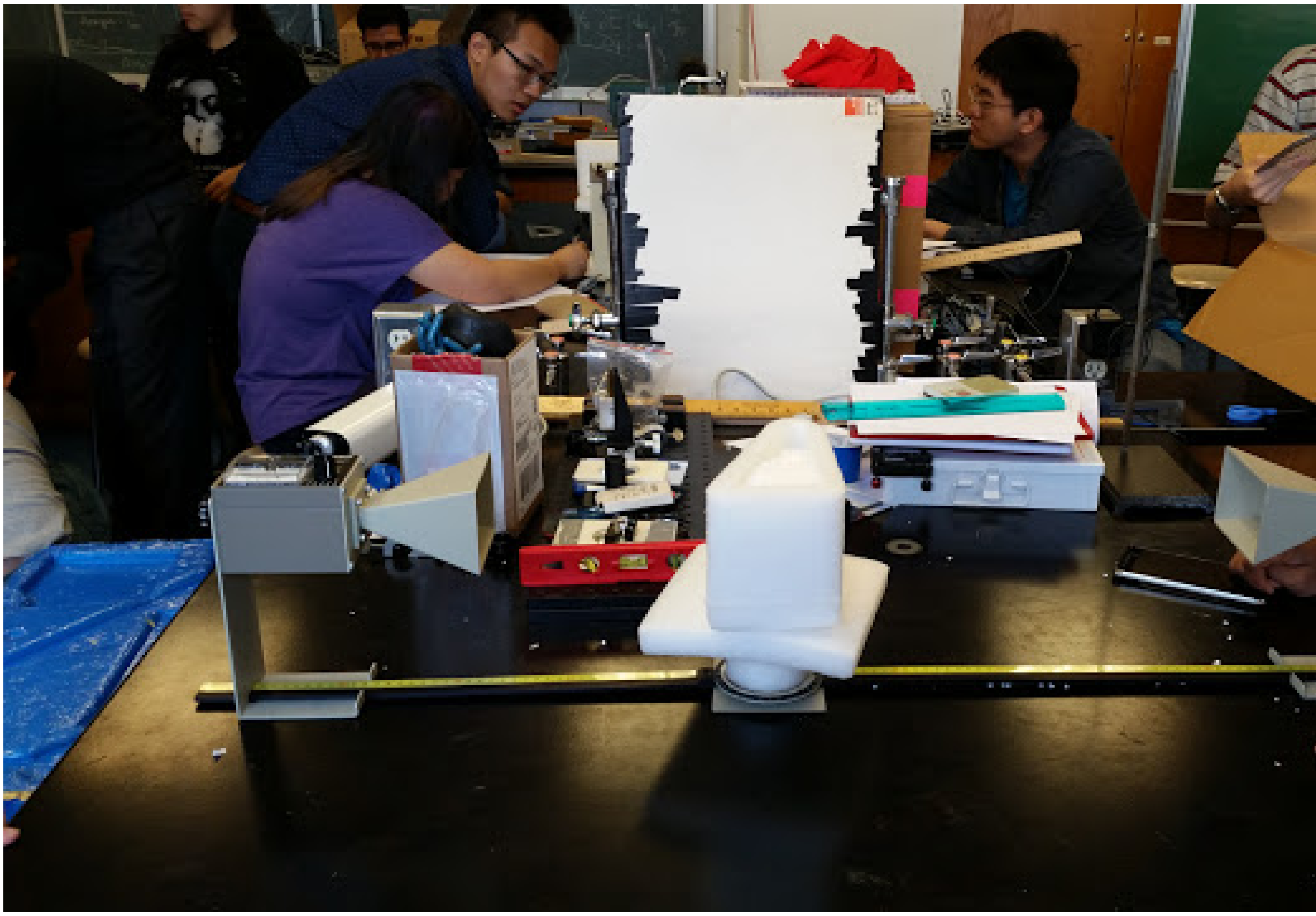
Procedures and Results

First, the transmitter and receiver are hooked onto the fixed arm, which is then fixed on the goniometer sliding measuring bar. After, the receiver must be set to 30x and then calibrated by the variable sensitivity dial, until the reading is 1 for 0.4 distance between the transmitter and receiver. It is then measured as the distance between them increases by 10 cm intervals until there is 1 meter between, recording the reading.

A reflector, parallel to the axis between the transmitter and receiver, has a reflector then moved closer to it to determine the change in readings, increasing as the reflector moves closer, due to the waves moving away from the axis reflecting back towards it.

After, the hand screw connecting the receiver to the fixed arm is loosened, such that it can be rotated, receiving from the same direction, but in different orientations, watching the change in reading on it. It is thus seen that when the orientations are perpendicular to each other, rather than parallel or anti-parallel, the readings on the receiver is 0, at the maximum when parallel or anti-parallel.

Next, the receiver is rotated, such that the angle between it and the original position is recorded for intervals of 10 degrees, measuring the meter reading, such that it starts at 1 for 0^o. Finally, it is set up similarly, with a reflector attached in the center, such that the angle of incidence is modified by rotating the reflector, then rotating the receiver, such that the angle of reflection to the receiver changes, finding the angle where the reading is greatest.



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Wave Strength vs Distance:

Distance (m)	Microwave Radiation Strength (M)
0.4	1
0.5	0.58
0.6	0.38
0.7	0.3
0.8	0.18
0.9	0.08
1	0.04

Wave Strength vs Angle:

Angles (^{o})	Microwave Radiation Strength (M)
0	1
10	0.52
20	0.36
30	0.04
40	0.02
50	0.01
60	0
70	0
80	0
90	0

Angle of Incidence vs Angle of Reflection:

Angle of Incidence (^{o})	Angle of Reflection (^{o})
10	10
20	20
30	27.5
40	35
50	45
60	65
70	60
80	70
90	70

Discussion

Sample calculations for the non-measured data are as shown using the formulas found above:

$$\text{Microwave Radiation Strength * Distance (0.4 m Distance)} = R * M = 0.4 * 1 = 0.4m$$

$$\text{Microwave Radiation Strength * Distance}^2 \text{ (0.4 m Distance)} = R^2 * M = 0.4^2 * 1 = 0.16m^2$$

Wave Strength vs Distance:

Microwave Radiation Strength * Distance (m)	Microwave Radiation Strength * Distance^2 (m^2)
0.4	0.16
0.29	0.145
0.228	0.137
0.21	0.147
0.144	0.115
0.072	0.065
1	0.04

When the prism is rotated, the intensity changes slightly, such that it must be refracting, since if it was reflected or absorbed, it wouldn't pass through under any orientation, such that it would be unaffected. Rather, since it is refracting, changing the orientation changes how much and the angle by which the waves are refracted, such that the reading would change.

$\theta_i = 22^o$ $\theta = 8^o$ $\theta_r = 30^o$

Conclusion

Electromagnetic radiation behaves as a plane wave, where the intensity of the wave is inversely proportional to the distance squared from the source. It is reflected by the law of reflections such that the angle of incidence against the reflector is equal to the angle of reflection.