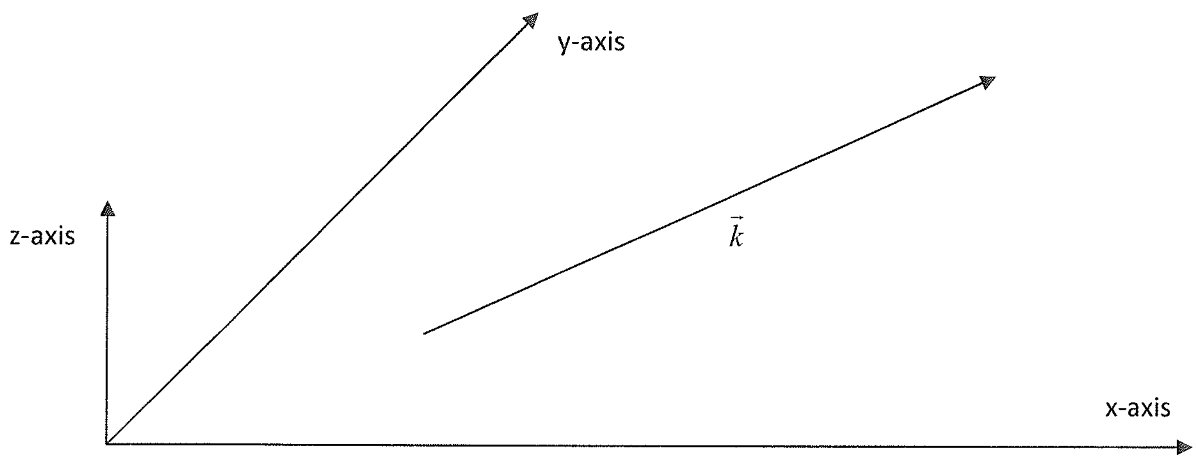
FO-2
August 2010 QE

In free space, a plane wave $\vec{E}(x,y) = E_o e^{-j\vec{k}\cdot\vec{r}}$ is propagating on the x-y plane. It is observed that the period of repetition along the x-axis (i.e. wavelength along that axis) is 3 meters. Along the y-axis the wavelength of the same wave was 4 meters. There is only one wave, but the measured wavelength on each axis is as above.



1.) 10 points. What is the radial frequency of oscillation of this wave?

2.) 10 points. Determine the angle, phi, that specifies the angle (relative to the x-axis) at which this waves propagate. Let phi be between 0 and 90 degrees. Answer to within +/- 5 degrees; an exact answer is not needed.

3.) 10 points. What is the propagation constant of the plane wave?

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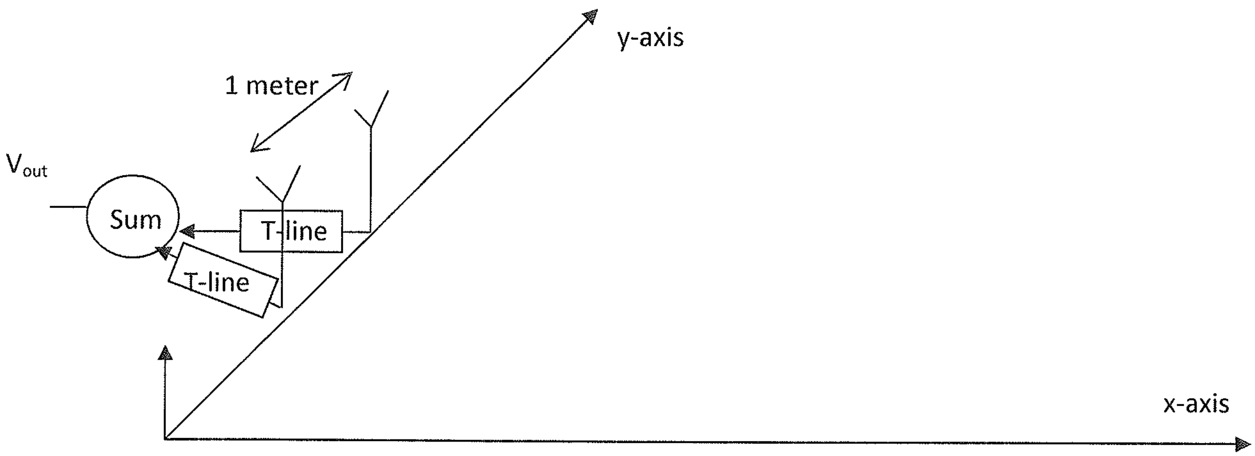
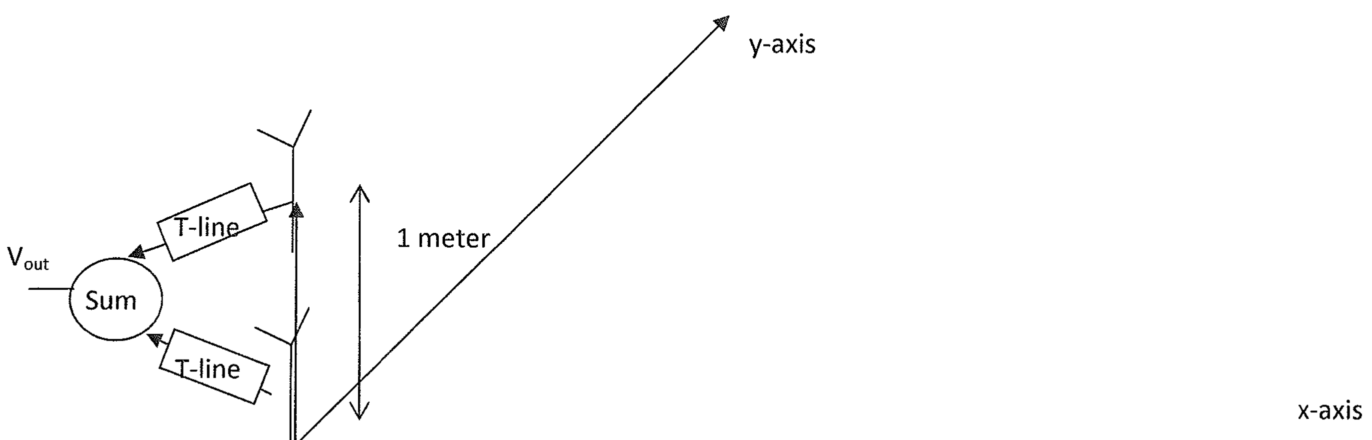
Consider two receive antennas that are located along the y-axis 1 meter apart. The same wave as described in problem 1-3 is incident on the antennas. The antennas are connected to transmission lines that are both a half wavelength long and connected to an ideal summing component, as depicted below. In this summing component $V1+V2=V_{out}$ where V1 and V2 are the voltages output from each transmission line.

Note- If you are not confident in your answers from above, you may use the propagation constant in the y-direction is pi/4 for ¾ of the points for the following questions.

4.) 20 points. What is the magnitude of the total received voltage from the two antennas, out of the summing component, V_{out}, relative to that received by a single antenna, ie. $|V1+V2|/|V1|$?

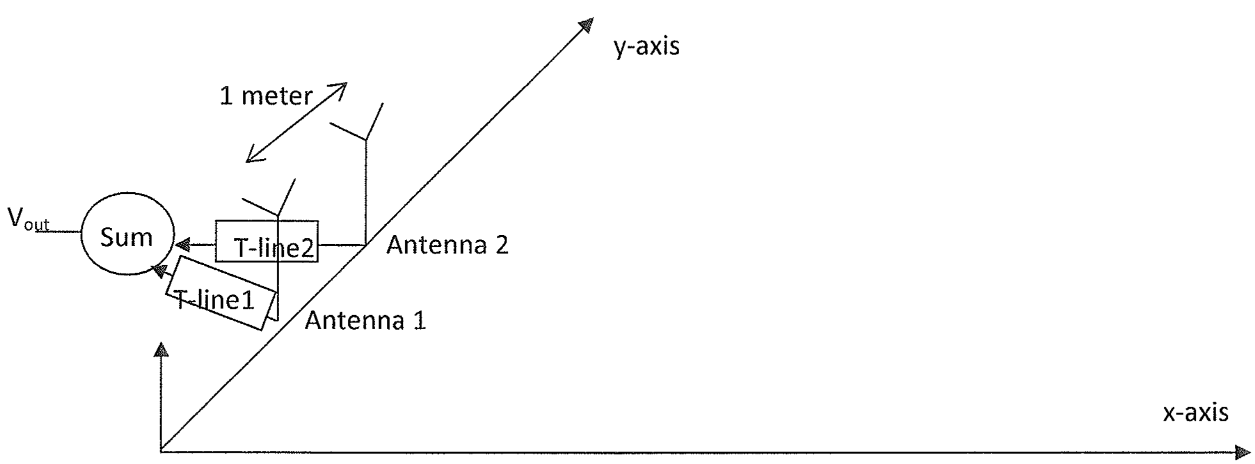


5.) 10 points. If these same antennas with the same half wavelength transmission line connections are moved such that they are separated by 1 meter on the z-axis, what is the magnitude of the total received voltage out of the summing component. Again answer relative to that received from a single antenna, $|V1+V2|/|V1|$. This is the same incoming wave as previous questions.



6.) 20 point. Once again you have antennas on the y-axis spaced 1 meter apart (same configuration as the figure in problem 4). You are to place a perfectly reflective sheet (conductivity → infinity) that is normal to the x-direction, ie. parallel to the y-z plane. At which value of x would you place the reflective sheet to have a maximum received voltage from the incoming wave?

7.) 20 points. The reflective sheet is removed. The antennas are still on the y-axis 1 meter apart, the same as problem 4. The same wave as the previous problems is assumed. Instead of being connected by two equal length transmission lines, we allow for transmission line 2, connected to antenna 2, to be longer than transmission line 1, connected to antenna 1. What is the difference in the electrical length of the two transmission lines in order to null out the incoming wave, i.e. to receive none of the incoming wave and have $V_{out}=0$. Answer in terms of the propagation constant, β.



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