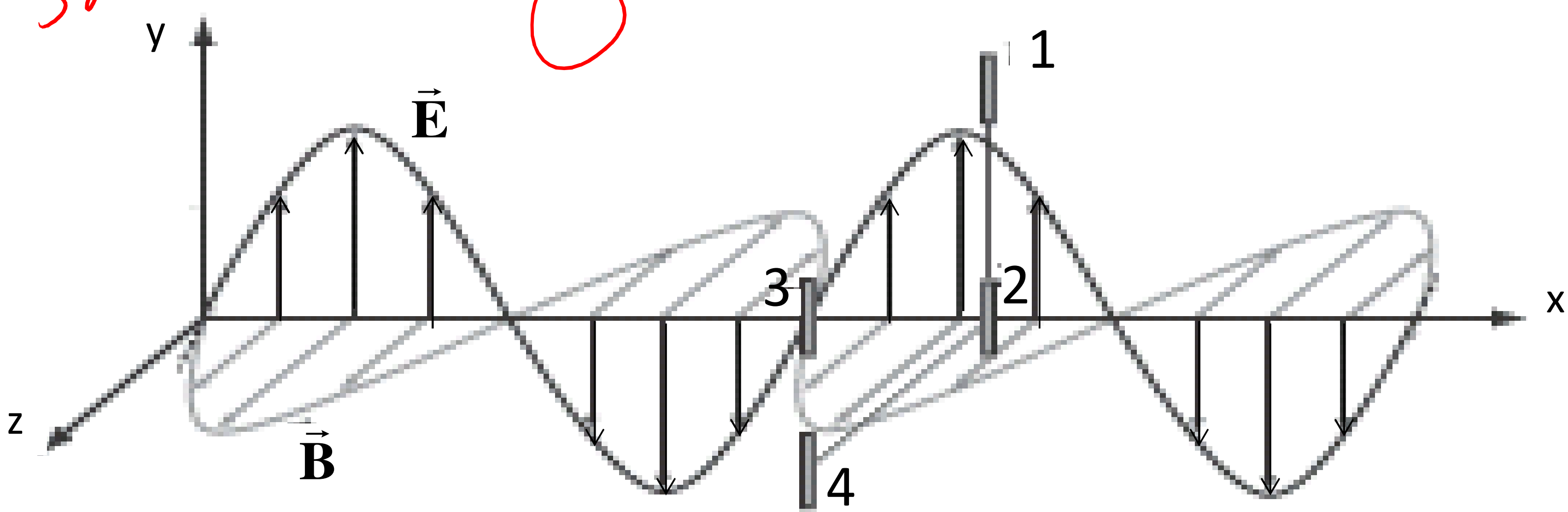
An electromagnetic plane wave propagates to the right.
Four vertical antennas are labeled 1-4.
1,2, and 3 lie in the *x*-*y* plane.
1,2, and 4 have the same *x*-coordinate, but antenna 4 is located further out in the *z*-direction.

Rank the time-averaged signals received by each antenna.

12 A) 1=2=3>4   9 B) 3>2>1=4   C) 1=2=4>3 6

D) 1=2=3=4   E) 3>1=2=4

32   0



The electric field for a plane wave is given by:

$$\vec{\mathbf{E}}(\vec{\mathbf{x}},t) = \vec{E}_0 e^{i(\vec{\mathbf{k}}\cdot\vec{\mathbf{x}}-\omega t)}$$

Suppose $\mathbf{E_0}$ points in the +x direction.
In which direction is this wave moving?

A) The x ($\hat{\imath}$) direction. 2

B) The radial ($\hat{\boldsymbol{r}}$) direction 4

C) A direction *perpendicular* to both $\vec{\boldsymbol{k}}$ and $\vec{\boldsymbol{x}}$ 4

D) The $\vec{\boldsymbol{k}}$ direction 34

E) The $\hat{k}$ direction 1

If I have an E-field expressible as such:

$$\vec{\mathbf{E}}(\vec{\mathbf{x}},t) = -E_0 e^{i(ky-\omega t)}\hat{k}$$

How should I write the associated B-field?

A) $B_0 e^{i(ky-\omega t)}\hat{k}$

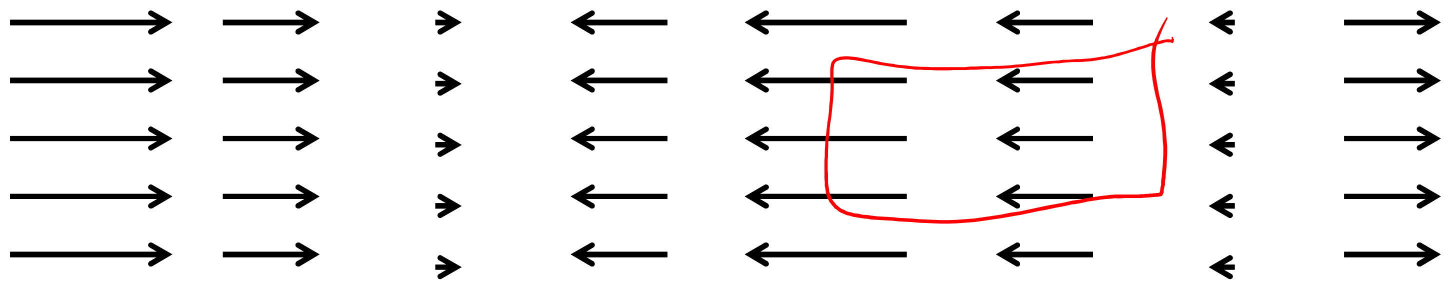
B) $-B_0 e^{i(ky-\omega t)}\hat{k}$

C) $-B_0 e^{i(ky-\omega t)}\hat{\imath}$

D) $-B_0 e^{i(ky-\omega t)}\hat{\jmath}$

E) $B_0 e^{i(ky-\omega t)}\hat{\jmath}$

Here is a snapshot in time of a longitudinal wave:

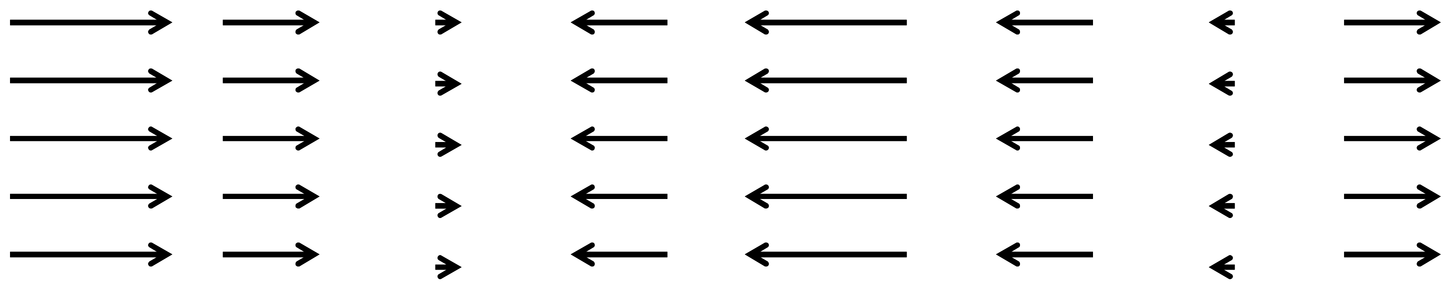


The divergence of this field is:

A) Zero
B) Non-zero
C) Can't tell

$$\nabla \cdot \bar{E} = \frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z}$$

Electromagnetic fields in vacuum with divergence are:

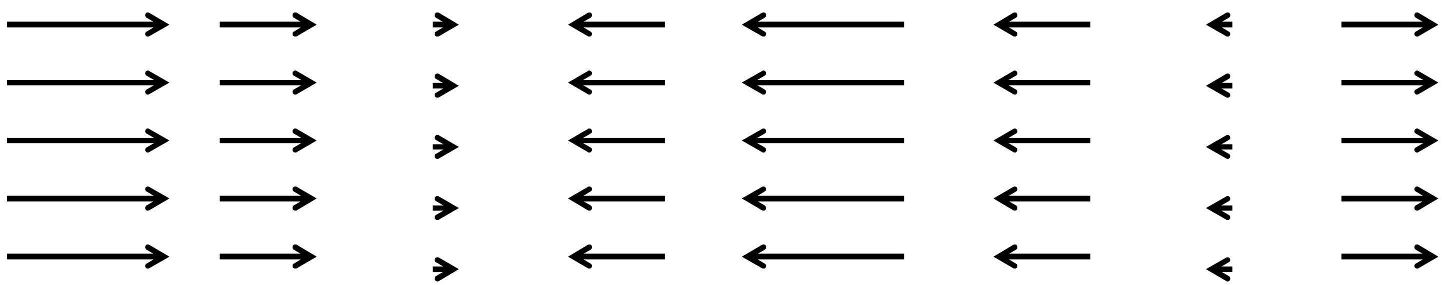


$\nabla \cdot \bar{B} = 0$

$\nabla \cdot \bar{E} = 0$

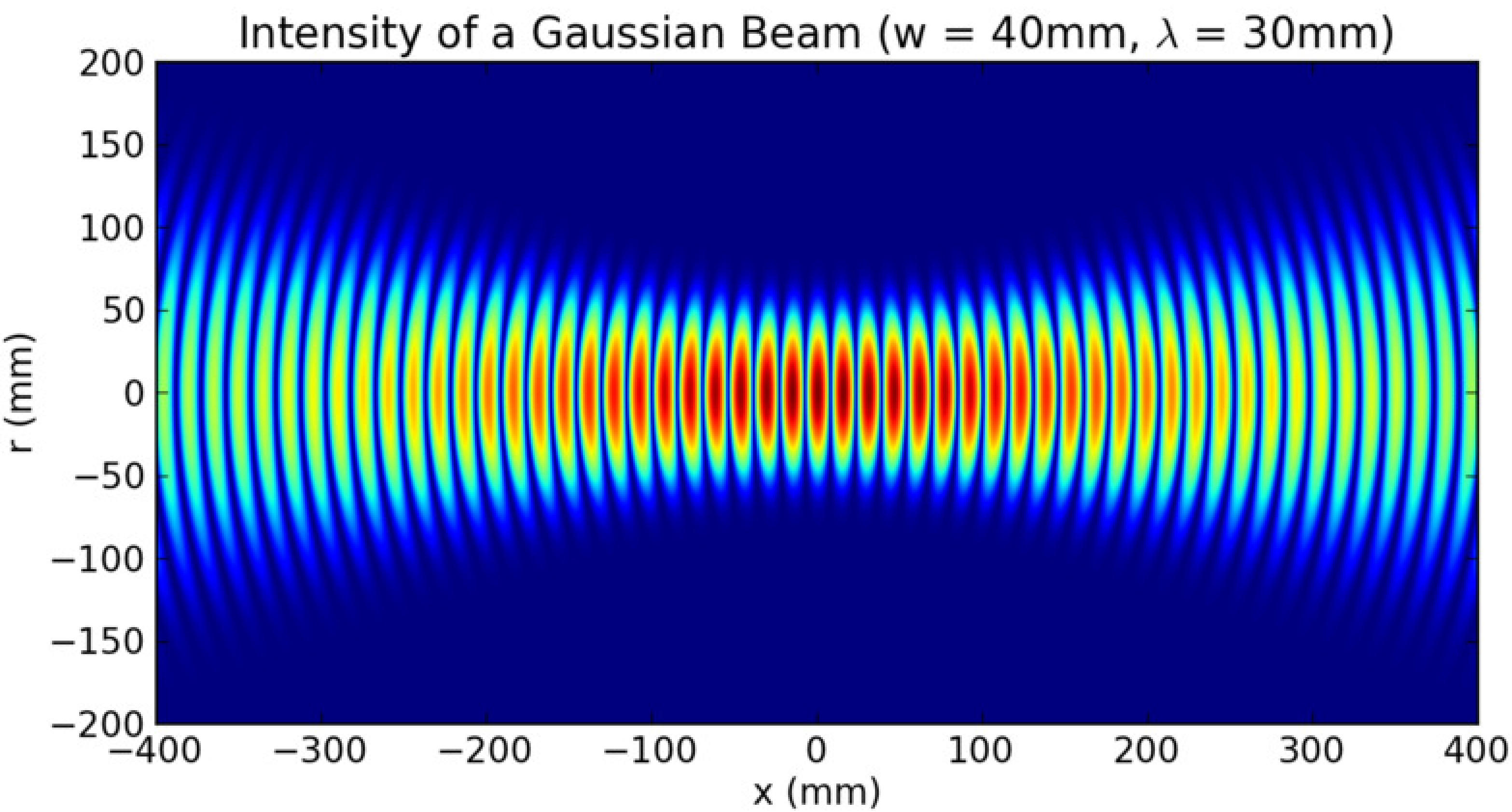
A) Allowed
B) Not allowed

Electromagnetic fields in vacuum that have a longitudinal component are:



A) Allowed 14

B) Not allowed 28



Intensity of a Gaussian Beam (w = 40mm, λ = 30mm)
200
150
100
50
0
−50
−100
−150
−200
r (mm)
−400
−300
−200
−100
0
100
200
300
400
x (mm)

1

PHYSICAL REVIEW A VOLUME 41, NUMBER 7 1 APRIL 1990

Longitudinal field components for laser beams in vacuum

Lorenzo Cicchitelli and H. Hora
Department of Theoretical Physics, University of New South Wales, Kensington 2033, Australia

R. Postle
Department of Theoretical Physics and the School of Fiber Science and Technology, University of New South Wales, Kensington 2033, Australia

(Received 11 January 1989)

The discovery of Lax, Louisell, and Knight (LLK) [Phys. Rev. **9**, 378 (1974)] that electromagnetic beams in vacuum do have a longitudinal component can be proved experimentally from the polarization independence of the energy of electrons from the focus of a laser. For this purpose we had to develop the LLK paraxial approximation to a Maxwellian exact solution for a Gaussian beam. Inserting the exact solutions into the Maxwellian stress tensor expression of the nonlinear force for the electron acceleration demonstrates a polarization dependence if only the transversal optical components are used. Including the exact longitudinal fields results in the experimentally proven polarization independence.