## Announcements

- MCAT Physics session here in Olin 268 next Tuesday, Feb. 25, from 8:00-9:00 pm
- Physics alumni panel Thursday, Feb. 27 at 7:30 pm in the Traditional Reading Room of Bertrand Library

## Physics & Astronomy Seminar

Chromatin remodeling: a view through electromagnetic lenses

Jean Paul Armache

Biochemistry and Molecular Biology
Penn State University

Olin 268. Thursday, Feb. 20 at 12:00

Pizza provided. Bring your own water bottle.

# Lecture 9 — Concept Test 1

A wave on a string is described by the equation

$$y(z,t) = 8\cos(2z + 4t),$$

where distance is in meters and time is in seconds.

**(a)** What is the wavelength of this wave?

1. $8$ m
2. $2$ m
3. $4$ m
4. $\pi/4$ m
5. $\pi$ m
6. $\pi/2$ m

**(b)** What is the propagation direction of this wave?

1. $+x$
2. $-x$
3. $+y$
4. $-y$
5. $+z$
6. $-z$

# Lecture 9 — Concept Test 2

Generate a traveling wave by oscillating the end of a slinky with a frequency of $2\,\mathrm{Hz}$. The resulting wavelength is $60\,\mathrm{cm}$. If we now increase the frequency to $4\,\mathrm{Hz}$ with the same slinky, what is the new wavelength for the wave?

1. 0
2. $15\,\mathrm{cm}$
3. $30\,\mathrm{cm}$
4. $60\,\mathrm{cm}$
5. $120\,\mathrm{cm}$
6. not enough information

## Maxwell's Equations of Electricity and Magnetism

- Gauss's law for electricity: $\oint \vec{E} \cdot d\vec{a} = q_{\text{enc}}/\epsilon_0$
- Gauss's law for magnetism: $\oint \vec{B} \cdot d\vec{a} = 0$
- Faraday's law: $\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$
- Ampere-Maxwell law: $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{\text{enc}} + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$

## Maxwell's Equations in Vacuum (no $q$ or $I$)

- $\oint \vec{E} \cdot d\vec{a} = 0$
- $\oint \vec{B} \cdot d\vec{a} = 0$
- $\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$
- $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$

# Lecture 9 — Concept Test 3

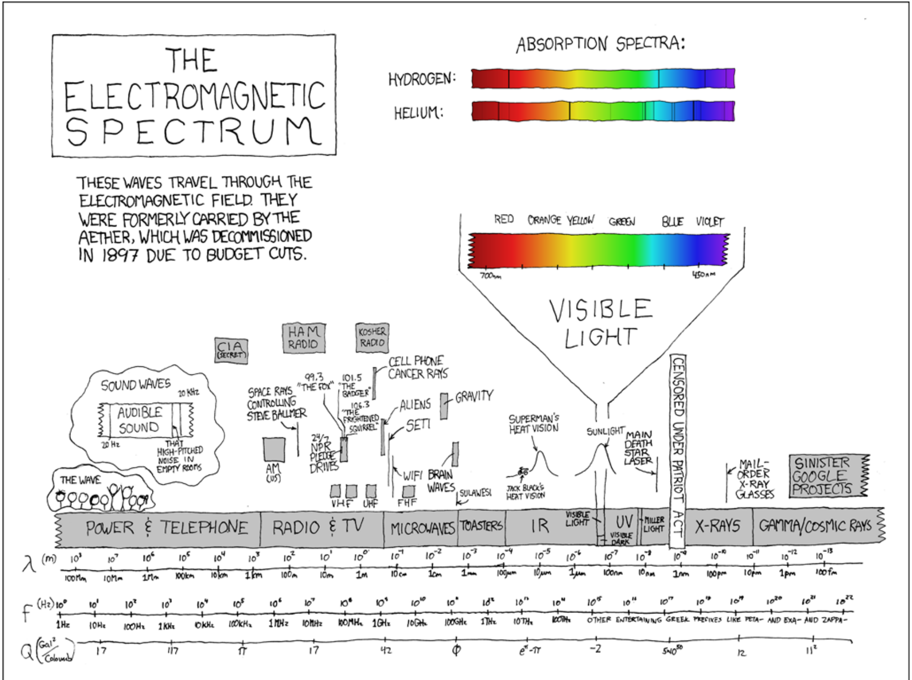
Suppose the electric field in an EM wave is described by the equation

$$\vec{E} = -E_0 \cos(kz - \omega t)\,\hat{\jmath}.$$

Which of the following could represent the magnetic field for this EM wave?

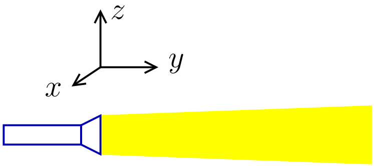
1. $\vec{B} = -\dfrac{E_0}{c} \cos(kz - \omega t)\,\hat{\jmath}$
2. $\vec{B} = \dfrac{E_0}{c} \cos(kz - \omega t)\,\hat{\jmath}$
3. $\vec{B} = -\dfrac{E_0}{c} \cos(kz - \omega t)\,\hat{\imath}$
4. $\vec{B} = \dfrac{E_0}{c} \cos(kz - \omega t)\,\hat{\imath}$
5. $\vec{B} = -\dfrac{E_0}{c} \cos(kz - \omega t)\,\hat{k}$
6. $\vec{B} = \dfrac{E_0}{c} \cos(kz - \omega t)\,\hat{k}$

xkcd.com/273


THE ELECTROMAGNETIC SPECTRUM
ABSORPTION SPECTRA:
HYDROGEN:
HELIUM:
THESE WAVES TRAVEL THROUGH THE ELECTROMAGNETIC FIELD. THEY WERE FORMERLY CARRIED BY THE AETHER, WHICH WAS DECOMMISSIONED IN 1897 DUE TO BUDGET CUTS.
RED ORANGE YELLOW GREEN BLUE VIOLET
700nm
450nm
VISIBLE LIGHT
CIA (SECRET)
HAM RADIO
KOSHER RADIO
CELL PHONE CANCER RAYS
SOUND WAVES
20 KHz
AUDIBLE SOUND
20 Hz
THAT HIGH-PITCHED NOISE IN EMPTY ROOMS
THE WAVE
SPACE RAYS CONTROLLING STEVE BALLMER
99.3 "THE FOX"
101.5 "THE BADGER"
106.3 "THE FRIGHTENED SQUIRREL"
24/7 NPR PLEDGE DRIVES
AM (US)
ALIENS
SETI
GRAVITY
WIFI
BRAIN WAVES
SULAWESI
VHF UHF FHF
SUPERMAN'S HEAT VISION
JACK BLACK'S HEAT VISION
SUNLIGHT
MAIN DEATH STAR LASER
CENSORED UNDER PATRIOT ACT
MAIL-ORDER X-RAY GLASSES
SINISTER GOOGLE PROJECTS
POWER & TELEPHONE
RADIO & TV
MICROWAVES
TOASTERS
IR
VISIBLE LIGHT
UV
VISIBLE DARK
MILLER LIGHT
X-RAYS
GAMMA/COSMIC RAYS
λ (m)
100Mm 10Mm 1Mm 100km 10km 1km 100m 10m 1m 10cm 1cm 1mm 100μm 10μm 1μm 100nm 10nm 1nm 100pm 10pm 1pm 100fm
f (Hz)
1Hz 10Hz 100Hz 1KHz 10KHz 100KHz 1MHz 10MHz 100MHz 1GHz 10GHz 100GHz 1THz 10THz 100THz
OTHER ENTERTAINING GREEK PREFIXES LIKE PETA- AND EXA- AND ZAPPA-
Q (Gal²/Coulomb)
17 117 1T 17 42 Φ 5 -2 12

# Lecture 9 — Concept Test 4

Consider a beam of light that is propagating along the $y$-axis and polarized along the $z$-axis. The light enters a diffuse vapor cloud.




**(a)** Along which axis do the electrons in the vapor cloud oscillate?

1. $\pm x$
2. $\pm y$
3. $\pm z$

**(b)** Along which axes can the re-radiated light propagate?

1. $\pm x$ and $\pm y$
2. $\pm x$ and $\pm z$
3. $\pm y$ and $\pm z$