HPS Electromagnetic Waves and Behavior 2021 Name Key

Objectives: Describe the composition and production of EM waves. (Obj 2) Compare and contrast regions of the EM spectrum based on frequency, wavelength, and energy. (Obj 4) Describe the different behaviors of waves.

Visit the website and answer the questions: https://science.nasa.gov/ems/01_intro

INTRODUCTION TO THE EM SPECTRUM

1. What are atmospheric windows? Why do they exist?
- regions of the EM spectrum w/ λ that can pass thru the atm.
- some EM radiation is reflected or absorbed by gases in Earth's atm (water vapor, CO_2, O_2) while some radiation passes thru.
2. Why is it necessary to have space-based instruments to study sources of high-energy radiation in space?
instruments need to be positioned above Earth's energy-absorbing atm to "see" higher E & even some lower E light sources

A. ANATOMY OF AN EM WAVE

3. How are EM waves created? What do they carry?
EW waves are created by vibration of charged particles & changing mag. or elect. fields. No medium needed, they carry E only.
4. Describe the nature of EM waves. Use the key terms electric field and magnetic field. Insert or draw a picture.
changing mag field induces changing elect. field & vice versa.

5. Why are different EM waves described in different terms? ie. Radio and microwaves - frequency (Hz), infrared and visible light – wavelength (m), x-rays and gamma rays – energy (eV)
All 3 are mathematically related. Allows for convenient use of units that aren't too large or small
6. Describe the shortest and longest wavelengths of the EM spectrum according to the site.
Shortest – fraction of the size of an atom
longest - larger than the diameter of our planet

B. WAVE BEHAVIORS

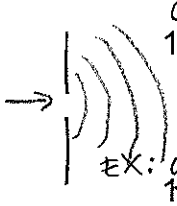
7. What can happen when light encounters an object? What determines the behavior?
transmitted, reflected, absorbed, refracted, diffracted, or scattered depending on the composition of the obj & the λ of light
8. Describe reflection. Draw a picture. Give an example.
Light hits an obj & bounces off. The color of an obj is the λ that is reflected, while all other λ are absorbed.

telescopes
echos
mirrors
radar
record
studio

– used to map topography of moon → longer it takes for light to reflect and come back to Earth, the lower the elevation.

EX: Urban Heat Island Effect can make a city hotter because of the E absorbing asphalt & roofs

9. Describe absorption. Draw a picture. Give an example.
absorption is when photons from light hit atoms/mols causing them to vibrate. ↑vibrations = ↑Temp - emitted as thermal E - Dark absorbs more & light absorbs less (reflects more). Thermal E radiates as longer λ

10. Describe diffraction. Draw a picture. Give an example.

bending of a wave due to an obstacle or slit, depends on size of obstacle or slit & wavelength (longer λ = ↑diff, sm slit = ↑diff), EX: greatest showman, songbird tweet vs. owl hoot - tweets have shorter λ so they don't diffract as much as long λ hoots.

11. Describe scatter. Draw a picture. Give an example.

Light bounces off an obj. in a variety of directions. Depends on λ of light & size & structure of obj. EX: blue sky

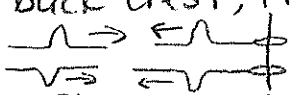
Spectrometers use diffraction (and interference) of light from slits to separate into sep. λ. faint peaks of E at specific

12. Describe refraction. Draw a picture. Give an example.
bending of a wave as it encounters a new medium (always accompanied by change in wave speed) EX: Rainbows, glasses, spearfishing

Explore Refraction - Google "Wave on a String PhET"

13. Set the sim to pulse and fixed end. Set damping to 0 and tension to high. Send a single pulse and record your observations about the behavior of the pulse below.
Amp. stayed same, wave flipped (crest → trough)

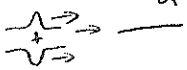
14. Keep all other settings the same and set the sim to loose end. Record your observations about the behavior of the pulse below.
Amp stayed same, crest came back crest, flipped to trough & then trough came back trough



15. *Constructive Interference. Draw a picture. Give an example. (reference textbook)

2 or more waves combine to form a wave w/a larger displacement (crest meets crest or trough meets trough) EX: lasers, stereo speakers, Concert hall

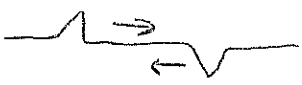
16. *Destructive Interference. Draw a picture. Give an example. (reference textbook)



2 or more waves combine to produce a wave w/a smaller displacement (crest meets trough) EX: noise cancelling headphones, muffler

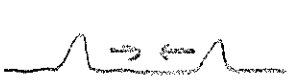
Explore Interference - Wave on a String PhET

17. Set the sim the same as Fixed End. Send a single pulse down the string. When that pulse is about halfway to the other end, send a second pulse. Record your observations about the interaction between the two waves below. (Hint: you can pause the simulation and use the "step" button to view the interaction of the waves more slowly.)



destructive interference

18. Reset the sim and switch to Loose End. Send a single pulse down the string. When that pulse is about halfway to the other end, send a second pulse. Record your observations about the interaction between the two waves below.



constructive interference