

## Introductory Astronomy

**Homework 6: Light and Electromagnetic Radiation** Not to be handed in. Homework solutions are posted already.

006 qmult 00050 1 4 4 easy deducto-memory: speed of light

1. "Let's play *Jeopardy!* For \$100, the answer is: In modern physics, it is the highest physical speed: i.e., the highest speed at which information can propagate."

What is the speed of \_\_\_\_\_, Alex?

- a) sound      b) thought      c) rumor      d) light in vacuum      e) rumor in an information vacuum

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

- b) Physically no, but in imagination yes, but we're talking physics.  
e) Well yes, but I'm not going to accept it as a right answer anyway.

**Redaction:** Jeffery, 2001jan01

006 qmult 00052 1 4 2 easy deducto-memory: firework sound and flash

2. At firework displays, the explosions produce a light flash and sound.

- a) The sound is heard before the flash is seen.  
b) The flash is seen before the sound is heard.  
c) Sound and flash come simultaneously.  
d) The sound is seen before the flash is heard.  
e) Neither effect is noticed by the spectators.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

- b) No.  
d) Sound seen? Flash heard?  
e) The old pointless firework display.

**Redaction:** Jeffery, 2001jan01

006 qmult 00100 1 1 5 easy memory: visible light spectrum

3. Visible light is conventionally divided into:

- a) violet, blue, green, yellow, orange, radio.  
b) X-ray, violet, blue green, yellow, orange, tangerine, red.  
c) Gamma-ray, X-ray, ultraviolet, visible, infrared, microwave, radio.  
d) mauve, navy, forest lawn, goldenrod, tamarind, cerise.  
e) violet, blue, green, yellow, orange, red.

**SUGGESTED ANSWER:** (e)

**Wrong answers:**

- a) radio is not visible.  
b) X-ray is not visible.

- c) This is the conventional divisions of the whole electromagnetic spectrum, not of visible light.  
 d) Well, maybe some of these are halfway synonyms, but tamarind? What color is tamarind?  
 A tamarind is tropical fruit tree and and its fruit: my *American College Dictionary* (1960)—  
 the most authoritative desk dictionary ever published: it says so right on the cover—fails to  
 elucidate the color of tamarind.

**Redaction:** Jeffery, 2001jan01

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006 qmult 00200 2 4 3 moderate deducto-memory: waves and photons

4. Electromagnetic radiation (EMR) is:
- a wave phenomenon. The propagation speed is that of sound.
  - a wave phenomenon. However, EMR also acts as if it came in packets called **protons**.
  - a wave phenomenon. However, EMR also acts as if it came in packets called **photons**.
  - a wave phenomenon. However, EMR also acts as if it came in packets called **electrons**.
  - a particle phenomenon.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

- a) Sound?

**Redaction:** Jeffery, 2001jan01

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006 qmult 00400 1 3 1 easy math: wavelength calculation

5. AM radio typically broadcasts at about  $1\text{ MHz} = 10^6$  cycles per second. What is the approximate wavelength of this radiation? (Just use the vacuum speed of light  $c = 2.99792458 \times 10^{10}$  cm/s for the calculation: it is good enough for the present purpose.)
- a)  $\sim 3 \times 10^4$  cm = 300 m.      b)  $\sim 1 \times 10^4$  cm = 100 m.      c)  $\sim 3 \times 10^{-4}$  cm.      d)  $\sim 3 \times 10^4$  m.  
 e)  $\sim 3 \times 10^2$  cm = 3 m.

**SUGGESTED ANSWER:** (a) Recall  $\lambda = c/f$ .

**Wrong answers:**

- c) This is infrared light.

**Redaction:** Jeffery, 2001jan01

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006 qmult 00500 2 1 3 moderate memory: EMR spectrum

6. The electromagnetic spectrum is:
- the distribution of electromagnetic radiation with respect to temperature.
  - the spectrum of radiation emitted by a non-reflecting (i.e., blackbody) object at a uniform temperature.
  - the entire wavelength range of electromagnetic radiation: i.e., the electromagnetic radiation range from zero to infinite wavelength, not counting the limit end points themselves.
  - the magnetic field of the Sun.
  - independent of wavelength.

**SUGGESTED ANSWER:** (c) You know, defining electromagnetic spectrum is trickier than it seems.

**Wrong answers:**

- b) This is the definition of a blackbody spectrum which is a particular example of an electromagnetic spectrum. It is not definition of the electromagnetic spectrum.

**Redaction:** Jeffery, 2001jan01

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006 qmult 00520 2 1 1 moderate memory: most dangerous gamma rays

**Extra keywords:** CK-90-2

7. What is the form of electromagnetic radiation that is usually most dangerous for life?
- a) Gamma-rays.      b) Protons.      c) Radio waves.      d) Visible light.      e) Ultraviolet light.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

- b) Protons are not even electromagnetic radiation.

**Redaction:** Jeffery, 2001jan01

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006 qmult 00530 2 1 3 moderate memory: visible light range

**Extra keywords:** CK-91-key-3

8. The wavelength range of visible light is about:
- a) 1–20 cm.      b) 0.1–10 nm.      c) 400–700 nm.      d) 700–1000 nm.      e) 0.700–1000 microns.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

- e) This is, more or less, the infrared band.

**Redaction:** Jeffery, 2001jan01

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006 qmult 00550 1 4 4 yasy deducto-memory: human eye wavelength range

9. The Earth's atmosphere has various windows in which it is relatively transparent to electromagnetic radiation. The visible window extends from the very near ultraviolet to the near infrared. The intensity maximum of the solar spectrum actually falls in this window. Now the human eye is sensitive to electromagnetic radiation in the wavelength band  $\sim 400\text{--}700\text{ nm}$  which falls in the visible window and which spans the maximum intensity region of the solar spectrum. Why might the human-eye sensitivity wavelength region be located where it is?
- a) Well the visible window is round and so is the eye.
- b) The eye may have evolved to be sensitive to the form of radiation that was **LEAST ABUNDANT** on the Earth's surface. In this way radio emission for communication would be unnecessary, except during geomagnetic storms. Finally, the conclusion has to be that X-rays are not ordinarily visible.
- c) The eye may have evolved to be sensitive to a form of radiation that was **ABUNDANT** on the Earth's surface thereby making a **BAD USE** of the electromagnetic radiation resource.
- d) The eye may have evolved to be sensitive to a form of radiation that was **ABUNDANT** on the Earth's surface thereby making a **GOOD USE** of the electromagnetic radiation resource.
- e) The eye may have evolved to be sensitive to a form of radiation that was **ABUNDANT** on the Earth's surface thereby making use of **RADIO WAVES**.

**SUGGESTED ANSWER:** (d) There are lots of red herrings out of which people can see what is true and what is not. And the right answer isn't the longest answer.

See HI-96 and Intro-Astro Lecture 7: Spectra.

**Wrong answers:**

- b) I can't make head or tail of this myself.

**Redaction:** Jeffery, 2001jan01

006 qmult 00600 2 4 2 moderate deducto-memory: nocturnal animals

10. Why do nocturnal animals usually have large pupils in their eyes?

- a) For better vision in **DAY** conditions (when light levels are high) they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **SQUARE OF APERTURE DIAMETER**.
- b) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **SQUARE OF APERTURE DIAMETER**.
- c) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **APERTURE DIAMETER**.
- d) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). Light gathering power is proportional to the **4TH POWER OF APERTURE DIAMETER**.
- e) For better vision in **NIGHT** conditions (when light levels are low), they have evolved large pupils (which are the apertures of the eyes). The large pupils allow them to see in the **RADIO**. All animals can actually see in the radio, but diffraction effects with small apertures make radio images too blurry to notice ordinarily.

**SUGGESTED ANSWER:** (b) One has to remember or intuit that light gathering power is proportional to the square of an aperture diameter.

**Wrong answers:**

- e) I hope no thinks they see in the radio.

**Redaction:** Jeffery, 2001jan01

006 qmult 00620 1 3 1 easy math: photon energy

11. The "particle" of light is the photon. The energy of an individual photon is inversely proportional to the wavelength of the light:

$$E = \frac{hc}{\lambda},$$

where  $h$  is a universal constant called Planck's constant,  $c$  is the vacuum speed of light, and  $\lambda$  is wavelength. If the wavelength of light is changed by a multiplicative factor of 3, the energy of its photons is changed by a multiplicative factor of:

- a) 1/3.    b) 3.    c) 9.    d) 1/9.    e) 1 (i.e., it is unchanged).

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

- e) As Lurch would say: "Aaahh."

**Redaction:** Jeffery, 2001jan01