Introductory Astronomy NAME:

Homework 6: Electromagnetic Radiation: Homeworks and solutions are posted on the course web site. Homeworks are **NOT** handed in and **NOT** marked. But many homework problems ($\sim$ 50–70 %) will turn up on exams.

1. Did you complete reading-homework-self-testing for the Introductory Astronomy Lecture (IAL) by the weekly due date?

   a) YYYessss! b) Jawohl! c) Da! d) Sí, sí. e) OMG no!

2. "Let's play *Jeopardy*! For $100, the answer is: It is fastest way nature has to convey information and energy relative to local inertial frames."

   What is _____, Alex?

   a) sound b) conduction c) electromagnetic radiation d) seismic waves e) convection

3. Standing waves on a string of length L with fixed ends must consist of an integral number of half wavelengths n (i.e., antinodes n): thus $L = n(\lambda/2)$. In musical terms, n is the harmonic number. What is the wavelength formula and, given the general frequency formula $f\lambda = v_{\rm phase}$, what is the frequency formula?

   a) $\lambda = 2L/n$; $f = n[v_{\rm phase}(2L)]$. b) $\lambda = 2Ln$; $f = n[v_{\rm phase}/(2L)]$.
   c) $\lambda = 2Ln$; $f = n[v_{\rm phase}(2L)]$. d) $\lambda = 2L/n$; $f = n[v_{\rm phase}/(2L)]$.
   e) $\lambda = 2Ln^2$; $f = n[v_{\rm phase}/(2L)]$.

4. The nature of the wave function (with conventional symbol Ψ) in quantum mechanics has been debated ever since quantum mechanics was discovered circa 1925–1926. One view is that it is just _____ like the probability for getting any face of a dice cube. The other view is that it is a real physical thing from which one can calculate the density of existence of a particle at any point in space. The particle existing in a superposition of positions. The latter view seems to be the majority view and your instructor adopts it. Of course, maybe the wave function is somewhere in between. Which view is right is a fundamentally important question. However, for all practical purposes (so far), it does not seem to matter which is right. Quantum mechanics is never wrong—there are mistakes in calculations and in experiments, but **NO** anomaly has ever resisted attack. Quantum mechanics is the best verified of all physical theories and your cell phone would **NOT** work if quantum mechanics did **NOT** work the way we think it does.

   a) physical b) informational c) loaded d) unreal e) both real and unreal

5. Electromagnetic radiation from the Sun is important, for among many other things, providing almost all of the energy for _____.

   What is _____, Alex?

   a) volcanoes b) night c) the biosphere d) plate tectonics e) earthquakes

6. "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 relative to a local inertial frame."

   What is the speed of _____, Alex?

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

7. At fireworks displays, the explosions produce a light flash and sounds.

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

8. AM radio typically broadcasts at about 1 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) 3×10^4 cm = 300 m. b) 1×10^4 cm = 100 m. c) 3×10^{-4} cm. d) 3×10^4 m.
e) 3×10^2 cm = 3 m.

9. The electromagnetic spectrum is:

   a) the distribution of electromagnetic radiation with respect to temperature.
   b) the spectrum of radiation emitted by a non-reflecting (i.e., blackbody) object at a uniform temperature.
   c) 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.
   d) the magnetic field of the Sun.
   e) independent of wavelength.

10. _____ is a form of electromagnetic radiation.

    a) Sound b) Wien c) Doppler d) The atom e) Visible light

11. 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.

12. 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 μm.

13. Astronomers must observe the gamma-ray, X-ray, and most of the ultraviolet bands from space since the Earth's atmosphere is quite _____ in those bands.

    a) transparent b) window-like c) hot d) opaque e) cold

14. The Moon has almost **NO** atmosphere. In what wavelength bands could an astronomer observe space from the Moon?

    a) In the ultraviolet and X-ray only. b) In no bands at all. c) In nearly no bands at all.
    d) In practically all bands, but only when the Moon is gibbous. e) In practically all bands.

15. 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 $\sim$ 400–700 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**.

16. 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.

17. The quantum or particle of light is called a/an:

    a) proton. b) electron. c) quarkon. d) lighton. e) photon.

18. The particle of light is the photon. The energy of an individual photon is inversely proportional to the wavelength of the light. The formula for photon energy is

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

    where h is a universal constant called Planck's constant, c is the vacuum speed of light, and λ 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).

19. What is the form of electromagnetic radiation that is usually most dangerous for life?

    a) ultraviolet light. b) protons. c) radio waves. d) visible light. e) gamma-rays.