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.

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001 qmult 00007 1 4 1 easy deducto-memory: reading-homework-self-testing done 2

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!

   SUGGESTED ANSWER: (a),(b),(c),(d)

   Wrong answers:
   e) As Lurch would say AAAARGH.

   Redaction: Jeffery, 2008jan01

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006 qmult 00100 1 4 5 easy deducto-memory: What light does for nature

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) convection d) seismic waves
   e) electromagnetic radiation

   SUGGESTED ANSWER: (e)

   Wrong answers:
   a) As Lurch would say AAAARGH.

   Redaction: Jeffery, 2008jan01

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006 qmult 00120 1 1 4 easy memory: standing waves on a string

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

   SUGGESTED ANSWER: (d)

   Wrong answers:
   c) Everything is wrong. **Redaction:** Jeffery, 2008jan01

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006 qmult 00160 1 1 1 easy memory: wave function nature

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

   SUGGESTED ANSWER: (a)

Wrong answers:
c) Now would yours truly do that?

Redaction: Jeffery, 2008jan01

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006 qmult 00200 1 4 4 easy deducto-memory: emr powers the biosphere

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) plate tectonics d) the biosphere e) earthquakes

SUGGESTED ANSWER: (d)

Wrong answers:
a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2008jan01

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006 qmult 00310 1 4 4 easy deducto-memory: speed of light

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."

   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

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006 qmult 00312 1 4 2 easy deducto-memory: fireworks sound and flash

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

   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:
d) Sound seen? Flash heard?
e) The old pointless firework display.

Redaction: Jeffery, 2001jan01

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006 qmult 00750 1 3 1 easy math: wavelength calculation

8. AM radio typically broadcasts at about $1\,\mathrm{MHz} = 10^6$ cycles per second. What is the **APPROXIMATE** wavelength of this radiation? (Just use the vacuum speed of light $c = 2.99792458 \times 10^{10}\,\mathrm{cm/s}$ for the calculation: it is good enough for the present purpose.)

   a) $3 \times 10^4\,\mathrm{cm} = 300\,\mathrm{m}$. b) $1 \times 10^4\,\mathrm{cm} = 100\,\mathrm{m}$. c) $3 \times 10^{-4}\,\mathrm{cm}$. d) $3 \times 10^4\,\mathrm{m}$.
   e) $3 \times 10^2\,\mathrm{cm} = 3\,\mathrm{m}$.

SUGGESTED ANSWER: (a)

Behold:

$$\lambda = \frac{c}{f} \approx \frac{3.00 \times 10^{10}}{10^6} = 3 \times 10^4\,\mathrm{cm} = 300\,\mathrm{m}\ .$$

Wrong answers:
c) This is infrared light.

Redaction: Jeffery, 2001jan01

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006 qmult 00900 2 1 3 moderate memory: EMR spectrum
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.

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 00950 1 1 5 easy memory: visible light
Extra keywords: CK-90-1
10. _____ is a form of electromagnetic radiation.

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

SUGGESTED ANSWER: (e)

Wrong answers:
a) Well no.

Redaction: Jeffery, 2001jan01

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006 qmult 00960 1 1 5 easy memory: visible light spectrum, visible band
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.

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 00962 2 1 3 moderate memory: visible light range
Extra keywords: CK-91-key-3
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.

SUGGESTED ANSWER: (c)

Wrong answers:
e) This is, more or less, the infrared band.

Redaction: Jeffery, 2001jan01

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006 qmult 00970 1 1 4 easy memory: opaque bands
Extra keywords: CK-92-14

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

SUGGESTED ANSWER: (d)

Wrong answers:
e) Cold?

Redaction: Jeffery, 2001jan01

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006 qmult 00972 1 4 5 easy deducto-memory: light windows on Moon

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.

SUGGESTED ANSWER: (e)

If we can in observe in all bands from the Earth because of atmosphere, then on the nearly atmosphereless Moon, we should be able to observe in nearly all bands.

Wrong answers:
b) Seems unlikely.

Redaction: Jeffery, 2001jan01

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006 qmult 00990 1 4 4 yasy deducto-memory: human eye wavelength range

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**.

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

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006 qmult 00992 2 4 2 moderate deducto-memory: nocturnal animals

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.

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

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006 qmult 01100 1 1 5 easy memory: particle of light is called a photon

Extra keywords: CK-91-photon

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

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

SUGGESTED ANSWER: (e)

Wrong answers:

c) For some reason, it's quarks rather than quarkons. Well I know why actually: Murray Gell-mann knew *Finnegan's Wake* somewhat and somewhere in there the seagulls call "Three quarks for Muster Mark" whatever that means.

Redaction: Jeffery, 2001jan01

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006 qmult 01104 1 3 1 easy math: photon energy calculation

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).

SUGGESTED ANSWER: (a)

Wrong answers:

e) As Lurch would say: "Aaarh."

Redaction: Jeffery, 2001jan01

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006 qmult 01150 2 1 1 moderate memory: most dangerous gamma rays

Extra keywords: CK-90-2

19. 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