

Conceptual Physics**NAME:**

Homework 6a: Properties of Light: Homeworks are due usually a day after the corresponding textbook part/lecture is completed. Due dates will be announced in class. Multiple-choice problems will all be marked. **USE** the answer table for these problems. The rest of the homeworks will be marked for apparent completeness and some full-answer problems will/may be marked in detail. Make the full-answer solutions sufficiently detailed that the grader can follow your reasoning. Solutions will be posted eventually after the due dates. The solutions are intended to be (but not necessarily are) super-perfect and often go beyond full answers. For an argument or discussion problem, there really is no single right answer. The instructor's answer reflects his long experience in physics, but there could be objections to his arguments, assumptions, nuances, style, facts, etc.

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	26.	O	O	O	O	O
2.	O	O	O	O	O	27.	O	O	O	O	O
3.	O	O	O	O	O	28.	O	O	O	O	O
4.	O	O	O	O	O	29.	O	O	O	O	O
5.	O	O	O	O	O	30.	O	O	O	O	O
6.	O	O	O	O	O	31.	O	O	O	O	O
7.	O	O	O	O	O	32.	O	O	O	O	O
8.	O	O	O	O	O	33.	O	O	O	O	O
9.	O	O	O	O	O	34.	O	O	O	O	O
10.	O	O	O	O	O	35.	O	O	O	O	O
11.	O	O	O	O	O	36.	O	O	O	O	O
12.	O	O	O	O	O	37.	O	O	O	O	O
13.	O	O	O	O	O	38.	O	O	O	O	O
14.	O	O	O	O	O	39.	O	O	O	O	O
15.	O	O	O	O	O	40.	O	O	O	O	O
16.	O	O	O	O	O	41.	O	O	O	O	O
17.	O	O	O	O	O	42.	O	O	O	O	O
18.	O	O	O	O	O	43.	O	O	O	O	O
19.	O	O	O	O	O	44.	O	O	O	O	O
20.	O	O	O	O	O	45.	O	O	O	O	O
21.	O	O	O	O	O	46.	O	O	O	O	O
22.	O	O	O	O	O	47.	O	O	O	O	O
23.	O	O	O	O	O	48.	O	O	O	O	O
24.	O	O	O	O	O	49.	O	O	O	O	O
25.	O	O	O	O	O	50.	O	O	O	O	O

018 qmult 00100 1 4 5 easy deducto-memory: light definition

1. “Let’s play *Jeopardy!* For \$100, the answer is: The word has two meaning which must be distinguished by context as usual:
 - i) Visible light to which our eyes are sensitive.
 - ii) The whole range of electromagnetic radiation which is called the electromagnetic spectrum.”

What is _____, Alex?

- a) sound b) radio c) a wave phenomenon d) the ether e) light

SUGGESTED ANSWER: (e)

Wrong answers:

- a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2012jan01

018 qmult 00110 1 4 3 easy deducto-memory: IR light discovered

2. “Let’s play *Jeopardy!* For \$100, the answer is: He/she discovered the first form of non-visible light (infrared light) 1800feb11.”

Who is _____, Alex?

- a) Ben Franklin (1706–1790) b) Émilie du Châtelet (1706–1749)
 c) William Herschel (1738–1822) d) Caroline Herschel (1750–1848)
 e) Thomas Young (1773–1829)

SUGGESTED ANSWER: (c)

Wrong answers:

- a) A lot with electricity, not so much with light.
 b) The translator into French of Newton’s *Principia*.
 d) She was a helpmeet to her brother William.
 e) Many things including establishing (along with Augustin-Jean Fresnel (1788–1827)) the wave theory of light as the generally accepted theory. The theory had first been proposed (with evidence) in the 17th century by Christiaan Huygens, but had Huygens had failed to establish it as the generally accepted theory of light.

Redaction: Jeffery, 2012jan01

018 qmult 00120 1 1 2 easy memory: not an ancient known property of light

3. Which of the following property of light was **NOT** known since prehistory?

- a) ray-like propagation b) wave propagation c) reflection d) refraction
 e) production by hot sources

SUGGESTED ANSWER: (b)

Now it may be that at some point in pre-modern times that someone or other noticed wave propagation interference or diffraction, but they almost certainly didn’t recognize it as a wave effect. In fact, reflection and refraction are wave effects, but not recognized as such until the 19th century. The wave theory of light was first proposed by Christiaan Huygens (1629–1695) in the 17th century and became the established accepted theory with Thomas Young (1773–1829) in the 19th century.

Wrong answers:

- a) Exactly wrong.

Redaction: Jeffery, 2012jan01

018 qmult 00122 1 1 3 easy memory: Greeks begin systematic study of light general principles

4. The systematic study of light to establish general principles and results from those principles began (insofar as we know—which usually goes without saying) with the ancient:

- a) Sumerians, notably Utnapishtim (time of the Flood) and Gilgamesh (26 century BCE).
- b) Egyptians, notably Hatshepsut (1508–1458 BCE) and Akhenaten (14th century BCE).
- c) ancient Greeks, notably Euclid (fl. 300 BCE) and Ptolemy (c. 90–c. 170).
- d) Assyrians, notably Sennacherib (c. 730–681 BCE)
- e) Mayans, notably Sun god Kinich Ahau (eternal)

SUGGESTED ANSWER: (c)

Wrong answers:

- d) The Assyrians? How likely is that?

The Assyrian came down like the wolf on the fold,
And his cohorts were gleaming in purple and gold;
And the sheen of their spears was like stars on the sea,
When the blue wave rolls nightly on deep Galilee

Redaction: Jeffery, 2012jan01

018 qmult 00124 1 1 2 easy memory: Medieval Islamic scientists

5. In regard to the science of light, medieval Islamic scientists

- a) made no progress.
- b) made some progress.
- c) regressed.
- d) discovered the telescope.
- e) invented eyeglasses.

SUGGESTED ANSWER: (b)

Wrong answers:

- e) Invented in Italy circa 1286 it seems.

Redaction: Jeffery, 2012jan01

018 qmult 00126 1 1 1 easy memory: Newton explains light

6. Isaac Newton (1643–1727) explained light as:

- a) beams of classical particles—but he didn't use the word classical.
- b) beams of photons.
- c) beams of continuous matter.
- d) ether waves.
- e) electromagnetic waves.

SUGGESTED ANSWER: (a)

Wrong answers:

- b) Exactly wrong.
- c) Exactly wrong too.

Redaction: Jeffery, 2012jan01

018 qmult 00128 1 1 3 easy memory: wave nature of light

7. The wave nature of light was first posited by _____ and later established as the generally accepted theory by _____ along with Augustin-Jean Fresnel (1788–1827).

- a) Euclid (fl. 300 BCE); Ptolemy (c. 90–c. 170).
- b) Robert Hooke (1635–1703); Isaac Newton (1643–1727)
- c) Christiaan Huygens (1629–1695); Thomas Young (1773–1829)
- d) Blaise Pascal (1623–1662); Thomas Young (1773–1829)
- e) Émilie du Châtelet (1706–1749); David Rittenhouse (1732–1792)

SUGGESTED ANSWER: (c)

Wrong answers:

- e) Rittenhouse was the most famous American scientist of the 18th century after Ben Franklin.

Redaction: Jeffery, 2012jan01

018 qmult 00130 1 1 1 easy memory: ray-like propagation of waves

8. Wave phenomena in many contexts propagate like rays (i.e., beams of continuous matter) if _____, where λ is wavelength and ℓ is the characteristic size of obstacles or apertures in the path of the waves.

- a) $\lambda/\ell \ll 1$ b) $\lambda/\ell \gtrsim 1$ c) $\lambda/\ell \approx 1$ d) $\lambda \gtrsim \ell$ e) $\lambda \approx \ell$

SUGGESTED ANSWER: (a)

Wrong answers:

- b) Exactly wrong.
d) Same as answer (b).
e) Same as answer (c).

Redaction: Jeffery, 2012jan01

018 qmult 00134 1 1 3 easy memory: visible light and diffraction 1

9. Visible light (λ in range 400–700 nm) will show _____ interference and diffraction effects for obstacles of $1\ \mu\text{m}$ size.

- a) no b) zero c) obvious d) very tiny e) atomic size

SUGGESTED ANSWER: (c) This is a best answer since one could stretch meanings and say (d).

Wrong answers:

- d) Just not a best answer.

Redaction: Jeffery, 2012jan01

018 qmult 00140 1 4 2 easy deducto-memory: classical electromagnetism discovered

10. “Let’s play *Jeopardy!* For \$100, the answer is: In the 1860s, he unified electric and magnetic phenomena in what we now call classical electromagnetism. Classical electromagnetism is summarized in 4 equations (i.e., 4 mathematical laws) plus the electromagnetic force formula. The electric and magnetic properties of materials were taken as givens: their explanation required quantum mechanics which was not available before circa 1926. The 4 equations in the absence of charge and current can be reduced to a wave equation with a unique vacuum phase velocity

$$v = \frac{1}{\sqrt{\varepsilon_0\mu_0}},$$

where ε_0 (vacuum permittivity) and μ_0 (vacuum permeability) are constants determined from electromagnetic phenomena. The numerical value of v was equal within experimental error with the vacuum speed of light. In one of the great eureka moments of history, Prof. X then concluded that light was electromagnetic waves.”

Who is _____, Alex?

- a) Lord Kelvin (1824–1907) b) James Clerk Maxwell (1831–1879)
c) Lord Rayleigh (1842–1919) d) Oliver Heaviside (1850–1925)
e) George Francis FitzGerald (1851–1901)

SUGGESTED ANSWER: (b)

Wrong answers:

- a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2012jan01

018 qmult 00142 1 1 2 easy memory: maxwell equations explain all

11. Maxwell’s equations plus the electromagnetic force law account for all classical electromagnetic phenomena provided one takes the electromagnetic properties of materials as _____. Quantum mechanics is needed to understand these properties.

- a) classically derivable results b) givens c) takens d) borrows e) nothings

SUGGESTED ANSWER: (b)

Wrong answers:

- a) Exactly wrong.

Redaction: Jeffery, 2008jan01

018 qmult 00144 1 1 3 easy memory: Maxwell's prediction of EM waves

Extra keywords: speed of light

12. From his 4 equations, Maxwell was able to predict that light was:
- made of particles that are now called photons.
 - electromagnetic waves with phase velocity $c = 1/\sqrt{LC}$.
 - light was electromagnetic waves with phase velocity $c = 1/\sqrt{\mu_0\epsilon_0}$.
 - made of particles that are now called fluxons.
 - electromagnetic waves with phase velocity $c = \sqrt{T/\mu}$.

SUGGESTED ANSWER: (c)

Wrong answers:

- $1/\sqrt{LC}$ is the angular frequency of an LC circuit.
- $\sqrt{T/\mu}$ is the phase velocity of waves on a string where T is tension and μ is linear mass density.

Redaction: Jeffery, 2001jan01

018 qmult 00146 1 1 4 easy memory: Hertz discovers radio

13. In Maxwell's day it was already known that there were invisible forms of light (infrared and ultraviolet), but none of these form could be generated by macroscopic oscillations of charge. But one could—although I'm not sure if anyone did—predict that much lower frequency, longer wavelength electromagnetic radiation should exist and could be generated. In 1888, such electromagnetic radiation (which was soon called radio) was discovered by _____. This was a tremendous verification of Maxwell's equations.

- Galileo (1564–1642)
- Isaac Newton (1643–1727)
- James Clark Maxwell (1831–1879)
- Heinrich Hertz (1857–1894)
- Albert Einstein (1879–1955)

SUGGESTED ANSWER: (d)

As well as inventing radio, Hertz also invented C&W stations and talk radio. Fact.

Redaction: Jeffery, 2008jan01

018 qmult 00150 1 1 4 easy memory: ether discussed

14. Classical electromagnetism gave a unique value for the phase velocity of electromagnetic radiation. The 19th century scientists assumed this phase velocity was relative to the _____, a hypothetical medium of oscillation for electromagnetic waves. But velocity was _____ was rather mysterious since it had no known properties other than being the medium of electromagnetic radiation. A famous attempt (the Michelson-Morley experiment of 1887) to measure the motion relative to the _____ by detecting changes in the vacuum speed of light gave a null result. The vacuum speed of light seemed invariant. This was rather puzzling.

- light stuff
- vacuum
- phlogiston
- ether
- either

SUGGESTED ANSWER: (d)

Wrong answers:

- Makes sense.

Redaction: Jeffery, 2012jan01

018 qmult 00152 1 1 5 easy memory: Einstein's special relativity

15. In 1905, Albert Einstein (1879–1955) presented special relativity which was derived from two axioms: a) the relativity axiom which said the laws of physics should have the same formulae in all inertial frames of reference; b) the vacuum speed of light is the same relative to all inertial frames. The first axiom was well known; the second seemed bizarre since it violated ordinary notions of relative motions. Classical electromagnetism was consistent with the two axioms provided one uses the Lorentz transformations between inertial frames: these transformations are a part of special relativity. Einstein was guided to special relativity by the idea that classical electromagnetism had to be more fundamental than Newtonian physics and applied in all inertial frames and that no ether existed—electromagnetic waves were oscillations of the electromagnetic field all by itself without any medium required. Special relativity

includes corrections to Newtonian physics and the results that length and time became frame-dependent quantities. These results have been very well verified, but are only observable with high relative velocities or extremely precise measurements. Special relativity also includes the Einstein equation:

$$\text{a) } E = 2mc^2. \quad \text{b) } E = m/c^2. \quad \text{c) } E = (1/2)mc^2. \quad \text{d) } E = mc. \quad \text{e) } E = mc^2.$$

SUGGESTED ANSWER: (e)

Wrong answers:

- a) As Lurch would say AAARRRrrgh.

Redaction: Jeffery, 2012jan01

018 qmult 00154 1 1 1 easy memory: Einstein and photons

16. Also in 1905, Einstein further developed the idea first introduced by Max Planck in 1900 that light came in packets. These packets are now called _____ and are understood to be rest-massless quantum mechanical particles.

- a) photons b) lightons c) lichts d) protons e) electrons

SUGGESTED ANSWER: (a)

Wrong answers:

- c) Makes sense in German.

Redaction: Jeffery, 2012jan01

018 qmult 00200 2 1 2 easy memory: electromagnetic radiation 1

17. Electromagnetic radiation (EMR) is:

- a) a **WAVE PHENOMENON**. The EM waves, however, are **NOT EXCITATIONS OF A MEDIUM** as in most other familiar wave phenomena: e.g., sound waves are excitations of air; water waves of water. The EM waves are just self-propagating electromagnetic fields: any description of them as oscillations in a medium has turned out to be physically superfluous: i.e., adds nothing to physical understanding. Of course, EM waves can propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10} \text{ cm/s} \approx 3 \times 10^{10} \text{ cm/s}$. In matter, the speed of light is always **HIGHER**.
- b) a **WAVE PHENOMENON**. The EM waves, however, are **NOT EXCITATIONS OF A MEDIUM** as in most other familiar wave phenomena: e.g., sound waves are excitations of air; water waves of water. The EM waves are just self-propagating electromagnetic fields: any description of them as oscillations in a medium has turned out to be physically superfluous: i.e., adds nothing to physical understanding. Of course, EM waves can propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10} \text{ cm/s} \approx 3 \times 10^{10} \text{ cm/s}$. In matter, the speed of light is always **LOWER**.
- c) a **WAVE PHENOMENON**. The EM waves are excitations of the **ETHER**. The ether permeates all space and has no other effects than as the medium of the EM propagation. Of course, EM waves at the same time as propagating in the ether can also propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10} \text{ cm/s} \approx 3 \times 10^{10} \text{ cm/s}$. In matter, the speed of light is always **LOWER**.
- d) a **WAVE PHENOMENON**. The EM waves are excitations of the **ETHER**. The ether permeates all space and has no other effects than as the medium of the EM propagation. Of course, EM waves at the same time as propagating in the ether can also propagate through media such as air, water, glass, etc. The speed of light **IN VACUUM** is $2.99792458 \times 10^{10} \text{ cm/s} \approx 3 \times 10^{10} \text{ cm/s}$. In matter, the speed of light is always **HIGHER**.
- e) a **PARTICLE PHENOMENON** only.

SUGGESTED ANSWER: (b)

Wrong answers:

- a) The speed of light in a vacuum is the absolute highest speed in our philosophy.
 c) Einstein dispatched the ether to the realm of useless concepts.
 e) Well EM radiation actually has some particle properties, but it can never be called a particle phenomenon unqualified.

Redaction: Jeffery, 2001jan01

018 qmult 00210 1 1 3 easy memory: electromagnetic radiation directions

18. In a polarized electromagnetic radiation beam in vacuum, the electric and magnetic field are perpendicular to each other and _____ the direction of propagation.
- a) either are perpendicular to b) neither are perpendicular to c) both are perpendicular to
 d) both are aligned with e) are randomly oriented with respect to

SUGGESTED ANSWER: (c)

Wrong answers:

- e) A Lurch would say AAARRrrgh.

Redaction: Jeffery, 2012jan01

018 qmult 00212 1 1 2 easy memory: electromagnetic waves are transverse 1

19. Electromagnetic waves in vacuum are:
- a) oblique. b) transverse waves. c) neither transverse nor longitudinal waves.
 d) longitudinal waves. e) both transverse and longitudinal waves.

SUGGESTED ANSWER: (b)

Wrong answers:

- a) A nonsense answer.

Redaction: Jeffery, 2012jan01

018 qmult 00216 1 1 2 easy memory: polarized light

20. Natural light (which is just a name—there's no unnatural light) has an isotropic distribution of electric and magnetic field vector directions perpendicular to the propagation direction when looked at over space and time though not at one instant and place where, of course, the E-field and B-field vectors can only point in one direction. Light vectors that are not isotropically distributed are _____ to one degree or another in one way or another.
- a) marginalized b) polarized c) metabolized d) pasteurized e) metastasized

SUGGESTED ANSWER: (b)

Wrong answers:

- e) This is what cancer does.

Redaction: Jeffery, 2008jan01

018 qmult 00220 1 1 5 easy memory: frequency defined

21. In wave phenomena, frequency is the number of cycles (i.e., complete oscillations) per unit:
- a) cycle. b) pressure. c) energy. d) length. e) time.

SUGGESTED ANSWER: (e)

Wrong answers:

- a) A nonsense answer.

Redaction: Jeffery, 2012jan01

018 qmult 00224 1 1 2 easy memory: unit of frequency

22. The MKS unit of frequency is the inverse second (s^{-1}) which is given the special name:
- a) freq (Fr). b) hertz (Hz). c) heinrich (Hr). d) inse (I). e) cyclon (C).

SUGGESTED ANSWER: (b)

Wrong answers:

- a) A nonsense answer.

Redaction: Jeffery, 2012jan01

018 qmult 00230 1 1 1 easy memory: $f \lambda = c$

23. A well known formula relating frequency, wavelength, and vacuum light speed is:

- a) $f\lambda = c$. b) $f/\lambda = c$. c) $\lambda/P = c$. d) $P\lambda = c$. e) $fc = \lambda$.

SUGGESTED ANSWER: (a)

Wrong answers:

- b) Not dimensionally correct.
c) A correct formula but it doesn't contain frequency f .

Redaction: Jeffery, 2012jan01

018 qmult 00236 1 3 1 easy math: a radio wavelength calculation 1

24. 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) $\sim 3 \times 10^4$ 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)

Behold:

$$\lambda = \frac{c}{f} \approx \frac{3.00 \times 10^8}{10^6} = 300 \text{ m} .$$

Wrong answers:

- c) This is infrared light.

Redaction: Jeffery, 2001jan01

018 qmult 00240 1 4 4 easy deducto-memory: speed of light

25. "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 an effect or 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

018 qmult 00242 1 4 2 easy deducto-memory: fireworks sound and flash

26. 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:

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

Redaction: Jeffery, 2001jan01

018 qmult 00250 2 1 3 moderate memory: EMR spectrum

27. 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

018 qmult 00252 1 1 5 easy memory: electromagnetic spectrum continuum

28. As far as we know, electromagnetic radiation can have wavelength (or frequency) anywhere between 0 and infinity. Also as far as we know, the allowed wavelengths form a/an _____ like real numbers. It may be that there are no processes to create or destroy electromagnetic radiation above or below a certain wavelength or in some bands, but we do not know of any regions of the electromagnetic spectrum that are absolutely ruled out.

- a) set of 10^{10}
- b) set of 10^{100}
- c) finite discrete set
- d) infinite discrete set
- e) continuum

SUGGESTED ANSWER: (e)

Wrong answers:

- b) Maybe this is of order right if electromagnetic radiation comes in a discrete finite set that is too densely spaced in wavelength for us to notice.

Redaction: Jeffery, 2012jan01

018 qmult 00254 1 1 4 easy memory: short list of electromagnetic bands

29. A short list of the bands of the electromagnetic spectrum in order of increasing wavelength is γ ray, X-ray (typical wavelength 1 Å), ultraviolet (UV), visible ($\sim 0.4\text{--}0.7\ \mu\text{m}$),:

- a) cyan, indigo, radio.
- b) infrared red, radio.
- c) red, radio, infrared.
- d) infrared (IR), microwave (typical wavelength 1 cm), radio.
- e) radio, microwave (typical wavelength 1 cm), infrared (IR).

SUGGESTED ANSWER: (d)

Wrong answers:

- a) Cyan and indigo are visible light colors.

Redaction: Jeffery, 2012jan01

018 qmult 00260 2 1 3 moderate memory: visible light range

Extra keywords: CK-91-key-3

30. 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

018 qmult 00262 1 1 5 easy memory: visible light spectrum

31. 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

018 qmult 00266 1 1 3 easy memory: photopic and scotopic vision

32. Under well lit conditions, humans have _____ vision and under dim condtions _____ vision.

- a) phinnish; scottish b) scotopic; photopic c) photopic; scotopic
- d) telescopic; microscopic e) tele; vista

SUGGESTED ANSWER: (c)

Wrong answers:

- a) The Nationlist answer.
- b) Exactly wrong.

Redaction: Jeffery, 2012jan01

018 qmult 00300 1 1 2 easy memory: resonance

33. Many systems (many macroscopic systems and virtually all molecules, atoms, and nuclei) have natural oscillation or excitation states called _____. (The term is not used usually for many microscopic excitation states to which it can be applied in principle.) By natural, one means that these systems readily absorb energy and go into the _____ oscillation or excitation states. Therefore if there is a force or interaction that can transfer energy to these _____ oscillation or excitation states, one will often find the system in one of these states. If a force or interaction is not such that can transfer energy to these _____ oscillation or excitation states, the systems are often relatively unaffected by the force or interaction. The wording of this description is rather intricate in order to be general. There are many special cases that described more simply.

- a) eminence/eminences b) resonance/resonances c) prominence/prominences
- d) resound/resounds e) redoubt/redoubts

SUGGESTED ANSWER: (b)

Wrong answers:

- d) Well resonate obviously originated in something like re-sound.

Redaction: Jeffery, 2012jan01

018 qmult 00310 1 1 3 easy memory: simple pendulum resonance frequency

34. The simple pendulum is a pendulum where the bob can be regarded as point mass. The simple pendulum has a single resonance frequency. In the limit of small-amplitude oscilations, the resonance frequency is given by

$$f = \frac{1}{2\pi} \sqrt{\frac{g}{\ell}}$$

where g is the gravitational field and ℓ is the pendulum length. The period of resonance oscillation is given by:

$$\text{a) } p = 2\pi \frac{g}{\ell} . \quad \text{b) } p = 2\pi \frac{\ell}{g} . \quad \text{c) } p = 2\pi \sqrt{\frac{\ell}{g}} . \quad \text{d) } p = \frac{1}{2\pi} \sqrt{\frac{\ell}{g}} . \quad \text{e) } p = 2\pi \sqrt{\frac{g}{\ell}} .$$

SUGGESTED ANSWER: (c)

Behold:

$$p = \frac{1}{f} = 2\pi \sqrt{\frac{\ell}{g}} .$$

Wrong answers:

d) As Lurch would say AAARRRrrgh.

Redaction: Jeffery, 2012jan01

018 qmult 00320 1 1 1 easy memory: standing waves on a string 1

35. A string held taut between two endpoints has resonances that are standing wave states of transverse waves. In standing wave states, the wave patterns do not propagate, they merely scale up and with time. The resonances exist only at a discrete set of frequencies. Off resonance (i.e., off the resonance frequencies), one has traveling waves. But traveling waves since they are not resonances are rather hard to excite and in many cases nearly cancel and give only relatively small up and down motions in many cases. The half wavelength shapes of a standing wave are called antinodes. A standing wave pattern can only exist when an integer number of antinodes can be fitted between the endpoints. Thus, the condition for a standing wave state is

$$n \left(\frac{\lambda}{2} \right) = L ,$$

where $n = 1, 2, 3, \dots$ is the integer number of antinodes, λ is the wavelength, and L is the string length. The phase velocity v for waves on a string is fixed by the string tension and the string mass per unit length. It follows that the formula resonance frequencies (i.e., the standing wave state frequencies) is:

$$\text{a) } f = n \left(\frac{v}{2L} \right) . \quad \text{b) } f = n \left(\frac{2L}{v} \right) . \quad \text{c) } f = \frac{v}{2Ln} . \quad \text{d) } f = n \left(\frac{2v}{L} \right) . \quad \text{e) } f = \frac{v}{Ln} .$$

SUGGESTED ANSWER: (a)

Behold:

$$\begin{aligned} n \left(\frac{\lambda}{2} \right) &= L \\ \lambda &= \frac{2L}{n} \\ f &= \frac{v}{\lambda} \\ f &= n \left(\frac{v}{2L} \right) . \end{aligned}$$

Wrong answers:

b) Dimensionally incorrect.

Redaction: Jeffery, 2012jan01

018 qmult 00330 1 1 5 easy memory: light absorption

36. In materials, electromagnetic radiation is often absorbed by resonances. Metals are a special case since their free electrons allow strong absorption at any frequency lower than that of X-rays. The electromagnetic radiation energy that goes into a resonance can be dissipated to waste heat or emitted as different frequencies of electromagnetic radiation or emitted at the same frequency of the absorbed electromagnetic radiation. Resonance actually absorb over a band of electromagnetic radiation frequency: sometimes narrow, sometimes broad. Those materials, other than metals, with few or weak resonances in the visible are often _____ in the visible.

- a) prismatic b) red c) luminous d) opaque e) transparent

SUGGESTED ANSWER: (e)

Wrong answers:

- a) With dispersed white light coloring.

Redaction: Jeffery, 2012jan01

018 qmult 00350 2 5 3 moderate thinking: Canadian flag in red light

Extra keywords: physci KB-213-27

37. The Canadian flag in ordinary lighting is red and white. When viewed in red light it is:

- a) all white. b) red and black. c) all red. d) all black. e) red and white still.

SUGGESTED ANSWER: (c)

A white object reflects white light which is a mixture of all colors. Thus, a white object reflects all colors. So if only red light shines on a white object, then it will be reflect red light and look red.

Which reminds me of a joke I learnt when I was about 8: “What’s white and black and red all over? A big red people eater.” I seem to be conflating two jokes badly.

Wrong answers:

- e) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001jan01