1.1) [5] A photon with an energy of 3 eV would be ...
   a) reddish
   b) bluish
   c) ultraviolet
   d) infrared
   e) X-ray

1.3) [5] The frequency of a traveling wave is **halved**. What happens to the velocity of the wave?
   a) multiplied by 4
   b) multiplied by 2
   c) multiplied by the square root of 2
   d) multiplied by 1 (unchanged)
   e) multiplied by 1/2

1.4) [5] What happens to the frequency of light when it passes through glass compared to the frequency in vacuum?
   a) increases by a factor of n (index of refraction)
   b) decreases by a factor of n (index of refraction)
   c) stays the same
   d) stays the same, but the phase is changed by half a wave (flipped)
   e) $3 \times 10^8$ Hz

1.5) [5] If you look at the sun through polarizing sunglasses (bad idea!) how much of the sun's light comes through the sunglasses?
   a) all
   b) half
   c) $\cos^2(\text{latitude})$
   d) $\cos^2(\text{angle of sun above horizon})$
   e) $(1/2) \cos^2(\text{angle of sun above horizon})$
1.6) [5] Light passes through a pair of slits to form an interference pattern on a screen. Which of the following actions would not increase the separation between successive fringes on the screen?
   a) increasing the slit separation
   b) increasing the wavelength of the light
   c) increasing the distance to the screen
   d) all of the above would increase the separation between the fringes
   e) none of the above would increase the separation between the fringes

1.7) [5] The reason that there are two slits in Young's double-slit experiment is...
   a) to increase the intensity
   b) one slit is for frequency and the other is for wavelength
   c) one slit is for E-fields and the other is for B-fields
   d) one slit for each vertical polarization and the other for horizontal polarization
   e) to create a path length difference

1.8) [5] An air wedge is formed from two glass plates which are in contact at their left edges. There are twelve dark fringes when the reflection is viewed from above using monochromatic light. The left edge of the top plate is now slowly lifted until the plates are parallel. During this process...
   a) the dark fringes remain stationary
   b) the number of dark fringes stays the same but the fringes move to the left
   c) the number of dark fringes increases
   d) the number of dark fringes decreases
   e) can't tell without knowing the index of refraction of the glass

1.9) [5] A spaceship is traveling with a speed of 0.80c compared to an observer. The headlights of the spaceship emit light ahead of the spaceship. What is the speed of the emitted light as measured by the observer?
   a) 0.20c
   b) 0.80c
   c) 1.00c
   d) 1.28c
   e) 1.80c

1.10) [5] The spaceship U.S.S. Enterprise, traveling through the galaxy, sends out a smaller explorer craft that travels to a nearby planet and signals its findings back. The proper time for the trip to the planet is measured by an observer...
   a) on board the Enterprise
   b) on board the explorer craft
   c) on the planet
   d) at the center of the galaxy
   e) none of the above
1.15) [5] Why don't we readily observe wave-phenomena such as the uncertainty principle for macroscopic objects like baseballs?
   a) the uncertainty principle only applies to electrons
   b) the wavelengths associated with macroscopic objects are too large
   c) the wavelengths associated with macroscopic objects are too small
   d) the position of baseballs can be measured to infinite precision
   e) we do observe the uncertainty principle for macroscopic objects
      (haven't you ever seen me hit?)

1.16) [5] We explained a number of phenomena by saying particles have wave-like properties. Which of the following phenomena was explained by instead saying that a wave has particle-like properties?
   a) photoelectric effect
   b) Bohr atom = quantization of angular momentum
   c) tunneling
   d) uncertainty principle
   e) none of the above

1.18) [5] What is the longest wavelength of light which may be absorbed by a hydrogen atom in the first excited state?
   a) 91 nm
   b) 122 nm
   c) 365 nm
   d) 656 nm
   e) 1876 nm
1.19) [5] According to the quantum-mechanical model (and not the Bohr model) of the atom, which statement best describes the motion of the electron in the ground state of a hydrogen atom?
   a) attached to the side of the proton (nucleus)
   b) oscillating back and forth in a straight line through the nucleus
   c) in a circular orbit around the nucleus
   d) a very good chance of being found somewhere in the immediate vicinity of the nucleus
   e) moving away from the nucleus with a kinetic energy of 13.6 eV

1.22) [5] The absolute value of the wave function is proportional to the...
   a) speed of the electron
   b) probability
   c) probability squared
   d) square root of the probability
   e) sine of the probability
1.23) [5] How does the mass of a nucleus compare to the sum of the masses of the protons and neutrons which form the nucleus?
   a) always less
   b) always more
   c) always equal
   d) depends on whether or not the nucleus is radioactive
   e) can only be determined by measuring that particular isotope

1.30) [5] What element & isotope remains after $^{34}$P decays by beta radiation?
   a) $^{34}$P
   b) $^{35}$P
   c) $^{34}$S
   d) $^{30}$Al
   e) $^{34}$Se
3) $^{32}\text{P}$ decays by beta radiation with a half life of 12.43 s.

3.1) [9] What fraction of an initial sample of $^{32}\text{P}$ remains after one minute?

3.2) [8] A sample of $^{32}\text{P}$ has an initial decay rate of 150 $\mu$Ci. How many phosphorus nuclei are in the initial sample?

3.3) [8] An adult male (75 kg) swallows an 150 $\mu$Ci sample of $^{32}\text{P}$. What is the dose he receives in mrem (millirems), averaged over the whole body, as all of the nuclei decay? The $\beta$ particle has a kinetic energy of 5.6 MeV and a quality factor of 1.