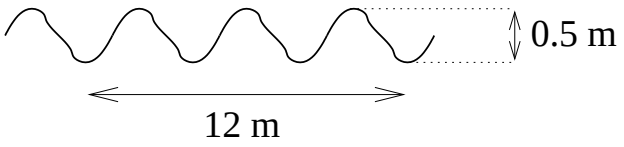
Physics 102 Exam 2 **Solutions**
31 March 2006 Prof L. Weinstein

Please give a short explanation for all multiple choice questions (unless otherwise noted). Show your work for all numerical answers.

Useful numbers: Atmospheric pressure = 10^5 Pa = 100,000 N/m^2
Absolute zero = 0 K = –273^o C = –459^o F
Density of water = 1000 kg/m^3
Density of air at room temperature = 1.2 kg/m^3
The speed of sound in air (at 20^o C, 1 atmosphere) is $v = 340$ m/s
The speed of sound in water is $v = 1500$ m/s
Speed of light in vacuum $c = 3.0 * 10^8$ m/s

1. (20 points) You shake the end of a rope up and down repeatedly at a rate of 6 times a second to cause a wave to move along the rope. The figure shows a snapshot in time of part of the rope. The wave is moving from left to right. What are the wavelength, amplitude, period and velocity of the wave? (Your answer for each item should be a number with the appropriate units [eg: period = 5 s, amplitude = 5 m].)



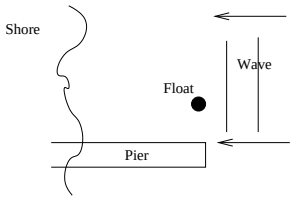
The frequency $f = 6$ Hz so that the period $T = 0.17$ s.

There are 3 complete wavelengths in a distance of 12 m so that the wavelength λ = 12m/4 = 3 m.

The amplitude is 0.25 m.

$v = \lambda/T = 4\text{m}/0.167\text{s} = 24$ **m/s.**

2. You are standing over the ocean on a pier that extends about 50 m from the shore. You drop a float into the water. A wave then passes by heading toward the shore. After the wave has passed, the position of the float is now



(a) much closer to the shore
(b) **about the same**
(c) much farther away from the shore
(d) need more information

The wave is a travelling disturbance. The disturbance travels, not the water. The wave lifts the float and then lowers it again.

3. Rank the following from highest to lowest frequency: radio wave, green light, microwave, x-ray, yellow light.

(highest) x-ray, green, yellow, microwave, radio wave (lowest)

4. Two violins play the musical note 'A' at 440 Hz. One is out of tune and plays the note at 442 Hz. What frequency or frequencies do you hear?

   You hear the average tone ($f = 441$ Hz) and the beat frequency ($f = 2$ Hz).

5. A red cloth is illuminated by magenta light. What color does it appear?

   Magenta light has both red and blue. Red cloth absorbs green and blue and reflects red. The blue light is absorbed and the red light is reflected. The cloth appears red.

6. During rush hour on route 64, there are about 3200 cars per hour. The traffic noise is measured at that time to be 80 dB. In order to reduce the traffic noise to 70 dB, you would have to reduce the number of cars per hour from 3200 to

   (a) less than 80
   (b) 80
   (c) between 80 and 320
   (d) **320**
   (e) 3190
   (f) need more information

   Each 10 dB is a factor of ten in intensity.

7. (no explanation needed) A wave travels a distance of 1 meter in 1 second with a frequency of 1 hertz. Its amplitude is

   (a) less than 1 meter
   (b) 1 meter
   (c) more than 1 meter
   (d) **need more information**

8. Suppose you live in an alternate universe where the speed of light is only 200 mi/hr (about 100 m/s). You drive toward a traffic light at 60 mi/hr. The yellow light is emitted at a frequency of $5.5 \cdot 10^{14}$ Hz. What frequency light do you observe?

   (a) less than $5.5 \cdot 10^{14}$ Hz
   (b) $5.5 \cdot 10^{14}$ Hz (ie: unchanged)
   (c) **more than** $5.5 \cdot 10^{14}$ **Hz**
   (d) need more information

   Because you are driving toward the light, the light will be doppler shifted to higher frequency. This happens with sound also. It is much more noticeable with sound because the speed of sound (760 mph or 340 m/s) is much closer to car speeds (60 mph or 30 m/s). If the speed of light was only 200 mph, then we would see doppler shifts too!

9. (no explanation needed) In the previous problem, what will happen to the apparent colors of the traffic light?

   (a) The green light will appear red
   (b) **The red light will appear green**
   (c) The colors will not change

(d) need more information

The frequency will increase so the red light will appear green.

10. (no explanation needed) If you double the period of a wave, then the frequency

    (a) quarters
    (b) **halves**
    (c) stays the same
    (d) doubles
    (e) quadruples
    (f) need more information

    frequency = 1 / period or $f = 1/T$

11. (no explanation needed) Sound waves cannot travel in (circle all that apply)

    (a) air
    (b) water
    (c) steel
    (d) **vacuum**
    (e) need more information

12. (no explanation needed) Sound waves refract when there is a change in

    (a) frequency
    (b) wavelength
    (c) **speed**
    (d) all of the above
    (e) none of the above

13. You make an exact copy of tuba that is half the size of the original. Compared to the full size tuba, what notes will the smaller tuba produce?

    (a) **higher notes**
    (b) the same notes
    (c) lower notes
    (d) need more information

    The smaller instrument will make notes with a shorter wavelength (and thus with a higher frequency).

14. A guitar string is plucked. Its fundamental frequency is 440 Hz. What is the frequency of its next higher harmonic?

    The wavelength of the fundamental frequency is $\lambda = 2L$ **since 1/2 of a wave fits in the string length. The next harmonic has one entire wavelength fit in the string length so that** $\lambda = L$ **and thus** $f_h = 880$ **Hz.**

15. A light beam from a flashlight travels through the air, then through a pane of glass (index of refraction $n = 1.3$) and then through the air. a) What is the speed of the light when it is in the glass? b) What is the speed of the light after it leaves the glass?

a) $v_{glass} = c/n = 3 \cdot 10^8 \mathbf{m/s}/1.3 = 2.3 \cdot 10^8$ **m/s.**

b) $v = c = 3 \cdot 10^8$ **m/s.**

16. (no explanation needed) If a light signal and a radio signal were emitted simultaneously from Alpha Centauri (a nearby star), then first signal to reach the Earth would be the

(a) radio signal
(b) light signal
(c) **both the same**
(d) need more information

both are electromagnetic waves and both travel at the speed of light

17. The Moon would be at its fullest just before a

(a) solar eclipse
(b) **lunar eclipse**
(c) both of these
(d) none of these
(e) need more information

During a lunar eclipse, the Earth casts its shadow on the moon. For this to happen, the Moon must be full. Immediately before a solar eclipse, we see the dark side of the moon.

18. Plants need energy from the light they absorb to live and grow. You have three identical plants placed in the sunlight. One has a red filter placed over it, the second a green filter, and third has a blue filter. Which plant or plants will grow the least (circle as many as apply)?

(a) The one with the red filter
(b) **The one with the green filter**
(c) The one with the blue filter
(d) all the same
(e) need more information

Green plants reflect green light. The green filter blocks the other colors. Therefore, the plant will not absorb any light.

19. (no explanation needed) A sheet of green paper will appear black when illuminated with

(a) green light
(b) **magenta light**
(c) yellow light
(d) cyan light
(e) none of these

Magenta light contains red and blue. Green paper absorbs red and blue. Therefore no light is reflected and the paper appers black.