Physics 262: Physics for Life Sciences II  
Section 801: First Midterm Test

- Time allowed: 75 minutes
- No calculators allowed. Section A has 20 multiple choice questions plus one bonus question, worth 3 points each.
- Section B has 2 homework-type problems, each worth 20 points. Where appropriate, show how you obtained your answers.
- Points will not be deducted for incorrect answers in the multiple choice section. Therefore, it is to your advantage to answer all section A questions, including the bonus question, even if the answers are pure guesses.

This right-angled triangle is useful:
SECTION A

1. Refraction is caused by the fact that
   (A) light in different media have different speeds.
   (B) in a given medium, the speed of light depends on the wavelength.
   (C) the frequency of light changes when it goes from one medium to another.
   (D) light is a longitudinal wave.

2. The figure below shows a monochromatic light ray (bold line) passing from a material 1 to 2 then to 3. The relative size of the angles is $\theta_3 < \theta_1 < \theta_2$.

   ![Diagram of light ray angles](image)

   In which material is the wavelength of the light the largest?
   (A) Material 1   (B) Material 2   (C) Material 3   (D) Same in all

3. Light that traveling from water (index of refraction $n = 1.33$) to air (index of refraction $n = 1.00$) is totally internally reflected when the angle of incidence is greater than
   (A) $1.33\, \text{rad}$   (B) $\frac{1}{1.33}\, \text{rad}$   (C) $\sin^{-1}(1.33)$   (D) $\sin^{-1}\left(\frac{1}{1.33}\right)$

4. White light that passes through a glass prism is split into different colors because of what phenomenon?
   (A) Interference due to different path lengths of light which pass through the prism.
   (B) Polarization of the light.
   (C) Dispersion (speed depends on wavelength in glass).
   (D) Total internal reflection within the glass.
5. An object under water appears to be at a smaller depth than it actually is because of
   (A) refraction (B) reflection (C) diffraction (D) interference

The following pertains to questions 6, 7 and 8. You are looking through a convex (i.e., converging) lens at mountains that is far away. See the figure below. The focal length of the lens is 0.15 m.

6. The image of the mountains is
   (A) real and inverted.
   (B) virtual and inverted.
   (C) real and upright.
   (D) virtual and upright.

7. Where is the image of the mountains formed in the above figure?
   (A) At infinity to the left of the lens.
   (B) At infinity to the right of the lens.
   (C) 0.15 m to the left of the lens.
   (D) 0.15 m to the right of the lens.

8. Where should your eye be so that you can see the image of the mountains clearly? Your near-point (the closest distance at which you can see clearly) is 0.25 m.
   (A) At least 0.15 m from the lens.
   (B) At least 0.25 m from the lens.
   (C) At least 0.25 m from the image.
   (D) At least 0.40 m from the image.
9. An image created by a diverging lens (assume the object distance is positive)
   (A) is always real.
   (B) is always virtual.
   (C) can be real or virtual.
   (D) is always magnified (i.e., the magnitude of the linear magnification is greater than 1).

10. If you look at your reflection at the underside of a shiny spoon, it will be [hint: what kind of mirror does the underside of a spoon look like?]
   (A) upright and diminished (i.e., magnitude of the linear magnification is less than 1).
   (B) upright and magnified.
   (C) inverted and diminished.
   (D) inverted and magnified.

   The following pertains to questions 11 and 12. In a Young’s double-slit experiment, monochromatic light that passes through the double slits produces an interference pattern of bright and dark fringes on a screen.

11. What happens if the spacing between the slits is decreased?
   (A) The fringes on the screen move further apart.
   (B) The fringes on the screen move closer together.
   (C) The dark and bright fringes change places.
   (D) There is no change in the fringes.

12. The difference in the distance from the slits to the dark fringes immediately to either side of the bright central maximum is
   (A) zero.
   (B) half a wavelength.
   (C) one wavelength.
   (D) two wavelengths.

13. A person uses a magnifying glass to obtain an angular magnification of $5.0 \times$ when the image is at infinity. The focal length of the magnifying glass is (assume the person has a near point at 25 cm)
   (A) $-125 \text{ cm}$  (B) $+125 \text{ cm}$  (C) $-5.0 \text{ cm}$  (D) $+5 \text{ cm}$
14. A thin film of index of refraction \( n_{\text{film}} \) is on a piece of glass of index refraction \( n_{\text{glass}} \). Assume initially that \( n_{\text{glass}} > n_{\text{film}} > 1 \). Due to irregularities in the thickness of the film, monochromatic light reflecting off the film and glass produces an interference pattern of bright and dark regions. Now, suppose that the index of refraction of the glass is decreased so that \( n_{\text{film}} > n_{\text{glass}} > 1 \). What happens to the interference pattern, if everything else is unchanged?

(A) The bright and dark regions expand in size.
(B) The bright and dark regions shrink in size.
(C) The dark and bright regions change places.
(D) There is no change in the interference pattern.

15. A farsighted person cannot see anything closer than 2.0 m clearly. In order to allow the person to see objects that are \( \frac{1}{4} \) m away, what is the power of the lens that should be prescribed? (Remember, you want the lens to create, for an object at \( \frac{1}{4} \) m, a virtual image of at the person’s nearpoint.)

\[(A) -3.5 \text{ D} \quad (B) -4.5 \text{ D} \quad (C) +3.5 \text{ D} \quad (D) +4.5 \text{ D}\]

16. A nearsighted person cannot see anything farther than 2.0 m. In order to allow a person to see objects that are very far away, what power of lens should be prescribed?

\[(A) +2.0 \text{ D} \quad (B) +0.5 \text{ D} \quad (C) -0.5 \text{ D} \quad (D) -2.0 \text{ D}\]

17. Which of the following will improve the resolution of a diffraction-limited optical instrument, such as an astronomical telescope?

(A) Decrease the focal length of the objective lens (the first lens that the light rays pass through).
(B) Increase the wavelength of the light collected by the instrument.
(C) Increase the size of the aperture of the instrument.
(D) Increase the angle subtended by the final image.

18. Which of these statements best explains why a compound microscope enables us to see details of a small objects more clearly?

(A) The image formed by the microscope is real.
(B) The image formed by the microscope subtends a larger angle than the object does when it is placed at the near point of the eye.
(C) The microscope places the image at the near point of the eye.
(D) The microscope places the image at the pupil of the eye.
19. An astronomical telescope

(A) creates an upright image.
(B) consists of two converging lenses.
(C) consists of two diverging lenses.
(D) consists of one converging lens and one diverging lens.

The following pertains to questions 20 and 21. Light passes through a polarizer that is oriented vertically. The intensity of light after passing through the vertical polarizer is $I_0$. (Assume all polarizers are ideal.)

20. If the light that has passed through the vertical polarizer is then incident on a second polarizer (the “analyzer”) that is oriented horizontally, what is the intensity of light that passes through the analyzer?

(A) $I_0$  (B) $I_0/2$  (C) $I_0/4$  (D) zero

21. Bonus (more challenging) — In between the vertically oriented polarizer and horizontally oriented analyzer, another polarizer is inserted at an angle of $37^\circ$ to the vertical direction. Now, what is the intensity of the light that passes through the analyzer? (See right-angled triangle at the front of this test.)

(A) zero  (B) $\left(\frac{4}{5}\right)^4 I_0$  (C) $\left(\frac{4}{5}\right)^2 \left(\frac{3}{5}\right)^2 I_0$  (D) $\left(\frac{3}{5}\right)^4 I_0$
1. Two people stand 6.0 m apart and 4.0 m away from a large plane mirror in a dark room. One of them shines a flashlight on the mirror so that the reflected beam directly strikes the other person.

(a) Draw the light ray on the figure below. [8 points]

(b) What is the angle of incidence of the light ray? (Remember, the angle of incidence is the angle between the light ray and the normal to the mirror.) You may leave your answer as the inverse of a trigonometric function. [12 points]
2. In the diagram below, the arrow is the object, and the focal point and center of curvature of the concave (converging) mirror are indicated by “f” and “C”, respectively.

(a) Draw at least two light rays emanating from the tip of the arrow that reflect from the mirror, and indicate the position of the image. [10 pt]

(b) If the focal distance is $\frac{1}{6}$ m and the object is $\frac{1}{4}$ m away, what is the distance of the image from the mirror? [7 points]

(c) What is the linear magnification of the image? [3 points]