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, please 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.
SECTION A

1. When light passes from one transparent medium to another and refracts, which of the following properties remains constant?
   (A) wavelength  (B) index of refraction
   (C) wave speed  (D) wave frequency

2. The speed of light in vacuum is $3.0 \times 10^8$ m/s. If the speed of light in a piece of glass is $2.0 \times 10^8$ m/s, its index of refraction is
   (A) 0.5  (B) 0.67  (C) 1.5  (D) 2.0

3. A ray of light travels from air into oil then into water. The air–oil and oil–water interfaces are parallel to each other. Which of the following best represents the refracted ray? (Indices of refraction of air, oil and water are $n_{\text{air}} = 1.0$, $n_{\text{oil}} = 1.5$ and $n_{\text{water}} = 1.3$.)

4. The image created in a plane mirror is
   (A) virtual and upright.
   (B) virtual and inverted.
   (C) real and upright.
   (D) real and inverted.

5. A light ray in glass with index of refraction $n_g$ is incident on an interface with air ($n_{\text{air}} = 1$). If the angle of incidence is greater than $\sin^{-1}(\frac{1}{n_g})$, which of the following light rays best represents the light ray leaving the interface?
6. A transparent material has an index of refraction that depends on the wavelength of light as shown in the graph below. Which of the following most closely resembles the chromatic dispersion that would occur if a ray of white light is shone through a prism (in air) made of the material? (Recall that the wavelength of blue light is smaller than that of red light.)

![Graph showing index of refraction vs. wavelength]

7. A straight straw that is placed in a glass of water appears to be bent at the air–water boundary. What is responsible for this phenomenon?
(A) reflection  (B) refraction  (C) diffraction  (D) interference

8. A concave (converging) mirror is used to form a focused real image of an object on a screen. If the screen is moved towards the mirror, to keep the image in focus the object must be moved
(A) away from the mirror.
(B) towards the mirror.
(C) to the center of curvature of the mirror.
(D) to the focal point of the mirror.

9. When you look at an object through a diverging lens held at arms length, the image looks smaller because of which of the following reasons?

I. The image distance is larger than the object distance, so the image appears farther away and hence is smaller.
II. The angular magnification of the image at your eye is less than 1.

(A) I only
(B) II only
(C) I and II
(D) neither
10. Chromatic aberration, in which parallel light rays of different colors passing through a convex lens focus at different distances from the lens, is caused by
(A) interference of light of different wavelengths.
(B) diffraction of light.
(C) the polarization of light waves.
(D) the dispersion of glass (dependence of the index of refraction of glass on wavelength).

11. You are looking through a convex (i.e., converging) lens at mountains that is far away. The focal length of the lens is \( f = 0.10 \, \text{m} \). Your near-point (the closest distance at which you can see clearly) is 0.25 m. How far must your eye be from the lens so that you can see the real inverted image of the mountains clearly?
(A) 0.10 m  
(B) 0.15 m  
(C) 0.25 m  
(D) 0.35 m

12. A convex (converging) lens of radius \( R \) is used to produce a real image on a screen. If an opaque disk of radius \( R/2 \) is placed at the center of the lens, what happens to the image?
(A) The middle part of the image disappears.
(B) The outer part of the image disappears.
(C) The image becomes fainter.
(D) The image becomes blur.

13. After light passes through a polarizer that is oriented vertically, the intensity of the light is \( I_0 \). If that vertically polarized light is then sent through another polarizer that is oriented horizontally (i.e., the polarizers are “crossed”), the intensity of light that passes through the second polarizer is
(A) zero.  
(B) \( \frac{I_0}{4} \).  
(C) \( \frac{I_0}{2} \).  
(D) \( I_0 \).

14. Consider the situation in Question 13. How would you insert a third polarizer in between the two crossed polarizers in order that the maximum intensity of light passes through all three polarizers?
(A) The middle polarizer should be oriented vertically.
(B) The middle polarizer should be oriented horizontally.
(C) The middle polarizer should be oriented at an angle of 45° to both the horizontal and vertical polarizers.
(D) The amount of light that passes through the three polarizers is independent of the orientation of the middle polarizer.
The following pertains to questions 15, 16 and 17. Monochromatic light of wavelength $\lambda$ is incident upon a pair of narrow slits. Assume the light waves that arrive at the slits are in phase. A pattern as shown below is formed on a screen beyond the slits.

![Diagram of interference pattern]

15. In what orientation are the slits?
   
   (A) Vertical (i.e., $\parallel$).
   
   (B) Horizontal (i.e., $\equiv$).
   
   (C) Rotated clockwise (viewed from the direction of the incoming beam of light) an angle of 45 degrees from vertical (i.e., $\swarrow$).
   
   (D) Rotated counter-clockwise (viewed from the direction of the incoming beam of light) an angle 45 degrees from vertical (i.e., $\nwarrow$).

16. At the second order bright fringe on either side of the bright central spot on the screen (indicated by “second order maxima” on the diagram), the light from one opening travels
   
   (A) twice as far as light from the other opening.
   
   (B) three times as far as the light from the other opening.
   
   (C) a distance $\lambda/2$ further than the other opening.
   
   (D) a distance $2\lambda$ further than the other opening.

17. If the distance between the slits is decreased (and the wavelength of the light and the distance of the slits to the screen remain constant), what happens to the interference pattern on the screen?
   
   (A) The bright spots move further apart.
   
   (B) The bright spots move closer together.
   
   (C) The bright spots remain the same distance apart but become dimmer.
   
   (D) The bright spots remain the same distance apart but become fuzzier.
18. Which of the following best represents the light rays in an astronomical telescope? (The object is to the left, observer is on the right.)

19. In a basic compound microscope, the intermediate image that is created by the objective lens is

(A) real and upright.
(B) real and inverted.
(C) virtual and upright.
(D) virtual and inverted.

20. A CIA camera has an aperture (the opening that lets light in) that is $6 \times 10^{-2}$ m in diameter. If this camera is on an aeroplane flying at a height of $1 \times 10^4$ m, what is the smallest distance on the ground that the camera can resolve? Assume that the resolving ability of the camera is limited by diffraction, and the wavelength of light is $5 \times 10^{-7}$ m.

(A) 0.1 m  (B) 1 m  (C) 10 m  (D) 100 m

21. **Bonus:** A camera lens of index of refraction $n_2$ is coated with a material that has an index of refraction $n_1$. The relative sizes of the indices of refraction are $n_{\text{air}} \approx 1 < n_2 < n_1$. Which of the following thicknesses will make the lens non-reflecting to light of wavelength $\lambda$ in air? (Note that the relative sizes of the indices of refraction in this question are different from the case given in the Equation Sheet.)

(A) $\frac{\lambda}{16n_1}$  (B) $\frac{\lambda}{8n_1}$  (C) $\frac{\lambda}{4n_1}$  (D) $\frac{\lambda}{2n_1}$
Question 1

(a) A nearsighted person has a far point that is 2.0 m from her eyes. What is the power of lens should be prescribed to her to allow her to see clearly objects that are far away?

(b) A farsighted person wears glasses of power $+2.0 \text{ D}$. How far is the near point from his eyes? (Assume that the lens allows him to see objects that are as close at $\frac{1}{4} \text{ m}$ clearly.)

**Hint:** Remember that in both cases, the images produced by the lenses are *virtual*. Also, $\frac{1}{1/x} = x$. 
Question 2

The diagram below shows an object that is $\frac{1}{2}$ m away from an a concave (i.e., diverging) lens, with focal length of magnitude $\frac{1}{4}$ m.

(a) Draw the ray diagram (include at least 2 rays) on the diagram above. Indicate where the image is. (If you don’t have a ruler, you can use the edge of your equation sheet to draw straight lines.) The focal points are labelled $f$. [9 points]

(b) Calculate the image distance from the lens. Include the correct sign and unit. [8 points]

(c) What is the linear magnification factor of this image? (Include the correct sign.) [3 points]