Summer 2008 July 2, 2008

Physics 262: Physics for Life Sciences II
First Exam

- Time allowed: 90 minutes
- Calculators are **not** allowed.
- Section A has 20 multiple choice questions plus 3 bonus questions, 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 questions), even if the answers are complete guesses.

SECTION A

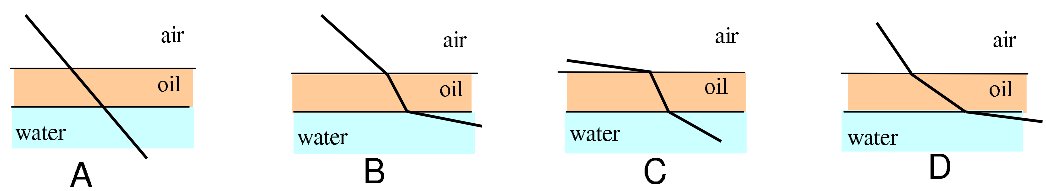
1. When light passes from one transparent medium to another and refracts, which of the following properties remains constant?

   (A) wavelength (B) refractive index (C) wave speed (D) wave frequency

2. The speed of light in vacuum is 3.0×10^8 m/s. The speed of light in a piece of glass with index of refraction 2.0 is

   (A) 1.5×10^8 m/s (B) 3.0×10^8 m/s
   (C) 4.5×10^8 m/s (D) 6.0×10^8 m/s

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 $n_{\text{water}} = 1.3$.)



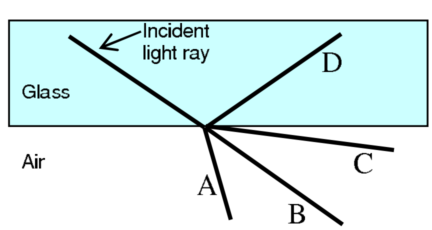
4. The image created in a plane mirror is

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

5. Your height is h, and you stand a distance d from a plane mirror. What is the minimum height of a plane mirror that will allow you to see your entire image from head to foot?

   (A) h (B) $h/2$ (C) d (D) $d/2$.

6. 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 **less** than $\sin^{-1}(\frac{1}{n_g})$, which of the following light rays best represents the light ray leaving the interface?



7. While lying at the bottom of a swimming pool, a diver looks straight up at the surface of the (calm) water and sees the sky above. But when she looks off the the side she sees the bottom of the pool. What causes this?

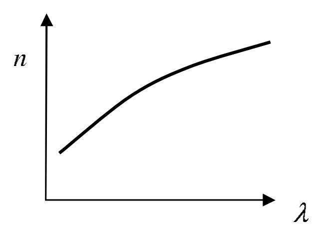
   (A) She must be hallucinating, because this cannot happen.

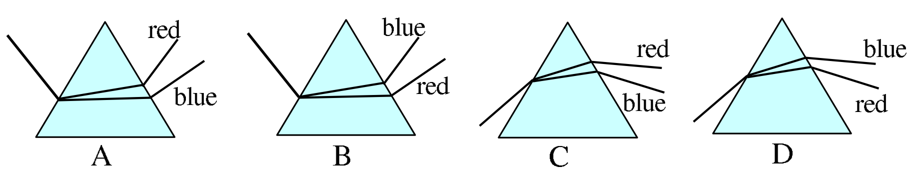
   (B) There is interference between the light from the sky and the light from the bottom of the pool.

   (C) Light from the bottom of the pool is totally internally reflected for large enough angle of incidence.

   (D) Light from the bottom of the pool diffracts off the surface of the water.

8. 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.)





9. An object under water appears to be at a smaller depth than it actually is because of which phenomenon?

   (A) reflection (B) refraction (C) diffraction (D) interference

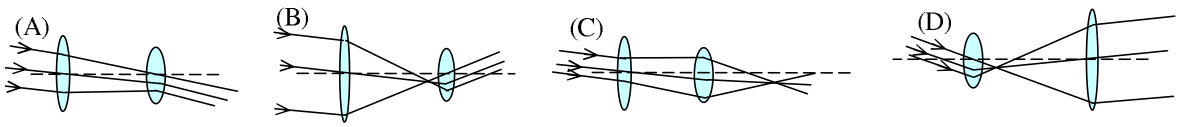
10. When you look at an object through a diverging lens held at arms length, the image looks smaller because of which of the following reasons?

    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

11. Which of the following best represents the light rays in an astronomical telescope? (The object is to the left, observer is on the right.)



12. A convex (converging) lens
    - (A) always produces a real image.
    - (B) always produces a virtual image.
    - (C) always produces and inverted image.
    - (D) can produce either a real or virtual image.

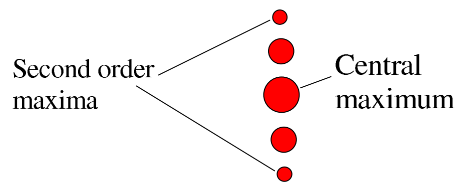
13. Parallel light rays of different colors passing through a converging lens converge at different distances from the lens. This phenomenon, called chromatic abberation, is caused by
    - (A) interference of light of different wavelengths.
    - (B) the dependence of the angle of diffraction on wavelength ($\sin\theta = \lambda/d$).
    - (C) the polarization of light waves.
    - (D) the dispersion of glass (dependence of the index of refraction of glass on wavelength).

14. You are looking through a concave (*i.e.*, diverging) lens at mountains that is far away. The focal length of the lens is $f = -0.1\,\text{m}$. Your near-point (the closest distance at which you can see clearly) is $0.25\,\text{m}$. How far must your eye be from the lens so that you can see the image of the mountains clearly?

    (A) $0.10\,\text{m}$ (B) $0.15\,\text{m}$ (C) $0.25\,\text{m}$ (D) $0.35\,\text{m}$

15. 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.

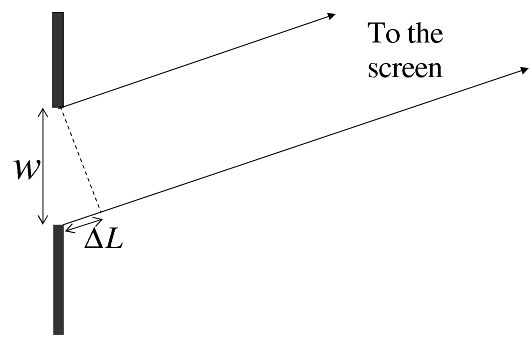
16. What is the angle between the central maximum and the second-order maximum of the two-slit diffraction pattern, if the wavelength of the light is λ and the separation of the slits is d?



(A) $2\sin^{-1}\left(\dfrac{\lambda}{d}\right)$ (B) $2\sin\left(\dfrac{\lambda}{d}\right)$ (C) $\sin^{-1}\left(\dfrac{2\lambda}{d}\right)$ (D) $\sin\left(\dfrac{2\lambda}{d}\right)$.

17. The first *minimum* in a diffraction pattern of light of wavelength λ passing through a slit of width w is due to a path length difference ΔL (see figure below) equal to

(A) $w/2$ (B) w (C) $\lambda/2$ (D) λ



18. What ultimately limits the ability of a reflecting telescope to resolve distant closely-spaced objects?

(A) Interference of different wavelengths of light (B) Diffraction
(C) Chromatic aberration (D) Refraction

19. A convex (converging) lens can be used to form a focused real image of an object on a screen. If the object is moved further away from the lens, to keep the image in focus the screen must be

(A) moved towards the lens.

(B) kept in place.

(C) moved away from the lens.

(D) moved to the focal point of the lens.

20. 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, 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.

21. **Bonus No. 1:** Consider the situation in Question 20. If another polarizer is inserted in between the two polarizers, at an angle of 45° with respect to both the horizontal and vertical directions, what is the intensity of light that passes through all three polarizers? ($\cos 45^\circ = 1/\sqrt{2}$)

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

22. **Bonus No. 2:** A camera lens of index of refraction n_2 is coated with a material that has an index of refraction $n_1 > n_2$. Which of the following thicknesses will make the lens non-reflecting to light of wavelength λ in air? (Note that this situation is slightly different from the case given in the Equation Sheet because here, $n_0 > n_2 > n_1$.)

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

23. **Bonus No. 3:** Someone suggests setting up a radio channel with nation-wide coverage by building radio transmitters every 30 or 40 km throughout the country, with all transmitters broadcasting at exactly the same frequency, so that drivers won't have to keep adjusting their radios as they drove across the country. Would you fund this idea, and why? (Radio waves are are like light waves but with much larger wavelengths.)

(A) Yes, this sounds like a great idea. I'll fund this project, after I hand over the money to this nice gentleman who sold me the Brooklyn Bridge.

(B) No, the time difference for signals from two different transmitters to reach a listener would result in an annoying "echoing" effect. (Radio waves travel at the speed of light, 3×10^8 m/s.)

(C) No, the signals from different transmitters will destructively interfere at certain spots, giving rise to areas with poor or no reception.

(D) No, radio signals from one transmitter will be absorbed by neighboring transmitters, producing feedback that would damage the transmitters.

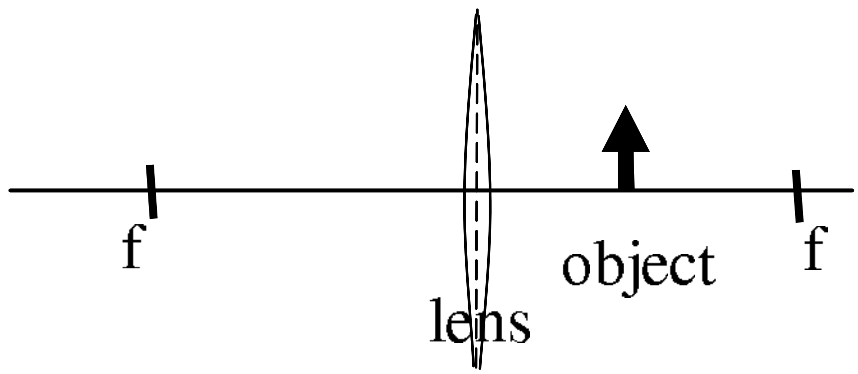
Section B (Exam 1, Phys 262, Summer 08) **Name:** ________________

1. A nearsighted woman has an uncorrected far point (farthest point the person can see clearly) of 0.2 m.

(a) When her vision is **uncorrected**, she looks at an point object that is 0.5 m away from her eye. Sketch (at least two) light rays that emanate from the object and enter her eye in this situation. [10 points]

(b) What power lens should she use, so that she can clearly see objects very far away? (Make sure you include the correct sign in your answer.) [10 points]

2. The diagram below represents an object that is 1 m away from an a convex (converging) lens with focal length of magnitude 2 m.



(a) Draw the ray diagram (include at least 2 rays) for the above situation. Indicate where the image is. (If you don't have a ruler, you can use the edges of a sheet of paper to draw straight lines.) The focal points are labelled f. [10 points]

(b) *Calculate* where the image should be. Include the correct sign. [7 points]

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