University of Akron July 2, 2009

Physics 262: Physics for Life Sciences II
First Examination

- Time allowed: 90 minutes
- Calculators are **not** allowed.
- Section A has 20 multiple choice questions plus 3 more challenging 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.
- Solutions will be posted on the course web site: `http://www.physics.uakron.edu/dept/faculty/benhu/262-m09/index.htm` after everyone has turned in their answer sheets.

For the mathematically challenged:

$$10^a \times 10^b = 10^{a+b}$$

$$\frac{10^a}{10^b} = 10^{a-b}$$

$$\frac{1}{1/a} = a$$

SECTION A

1. A light ray

   (A) is parallel to all other light rays.

   (B) is perpendicular to the wave fronts of light.

   (C) always travels in a straight line, even when passing between materials with different indices of refraction.

   (D) interferes constructively with other light rays of the same wavelength.

2. When a monochromatic beam of light that has wavelength $6.0 \times 10^{-7}\,\text{m}$ and frequency $5.0 \times 10^{14}\,\text{Hz}$ in vacuum enters a piece of glass of index of refraction 2.0, its wavelength and frequency in the glass are, respectively,

   (A) $6.0 \times 10^{-7}\,\text{m}$ and $5.0 \times 10^{14}\,\text{Hz}$.

   (B) $3.0 \times 10^{-7}\,\text{m}$ and $5.0 \times 10^{14}\,\text{Hz}$.

   (C) $6.0 \times 10^{-7}\,\text{m}$ and $2.5 \times 10^{14}\,\text{Hz}$.

   (D) $3.0 \times 10^{-7}\,\text{m}$ and $2.5 \times 10^{14}\,\text{Hz}$.

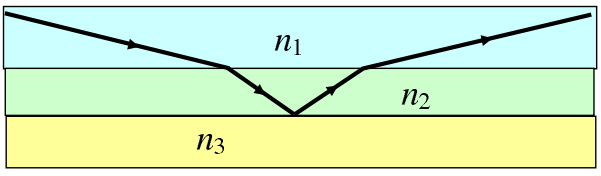
3. Which of the following statements is (are) true?

   I. Virtual images cannot be projected onto a screen.

   II. Virtual images can be seen without a screen, but real images cannot be seen unless they are projected onto a screen.

   (A) I only (B) II only (C) I and II (D) Neither

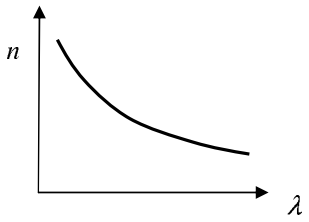
4. The following figure shows a light ray passing from a transparent medium of index of refraction n_1 into another transparent medium of index of refraction n_2, and then totally internally reflecting of the interface of a third transparent medium of index of refraction n_3. How are n_1, n_2 and n_3 related? (Assume that the interfaces parallel to each other.)

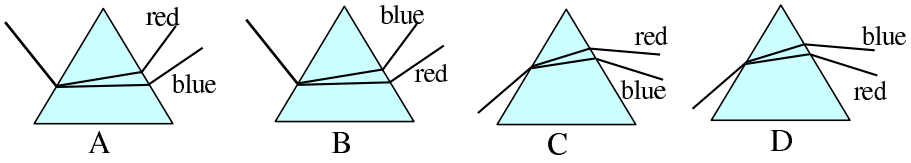


   (A) $n_1 > n_2 > n_3$ (B) $n_2 > n_1 > n_3$

   (C) $n_3 > n_1 > n_2$ (D) $n_3 > n_2 > n_1$

5. A transparent material has an index of refraction (n) that depends on the wavelength of light (λ) 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 made of the material? (Recall that the wavelength of blue light is smaller than that of red light.)





6. A convex (converging) lens is used to produce a real image on a screen. If the top half of the lens is blocked off by an opaque material, what happens to the image and why?

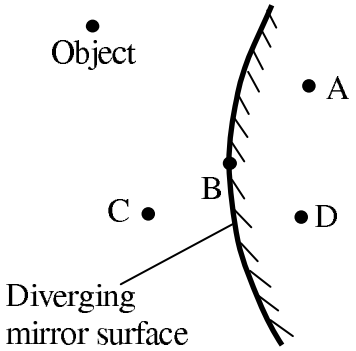
   (A) The bottom half of the image disappears because the image is inverted.

   (B) The top half of the image disappears because the image is real.

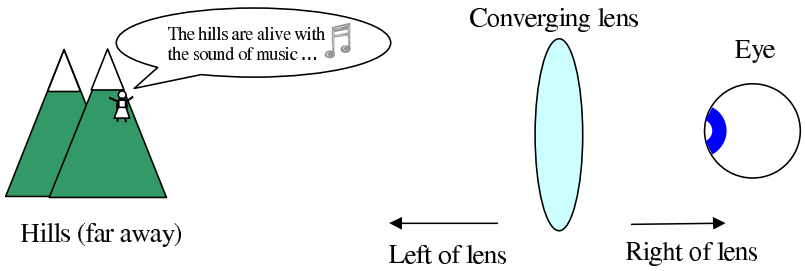
   (C) The image remains the same size but it becomes fainter because there are less light rays.

   (D) The image becomes sharper because there is an decrease in diffraction.

7. Which of the following dots best represents the location of the image of the object from the reflection off the diverging mirror?



The following pertains to questions 8, 9 and 10. You are looking through a convex (*i.e.*, converging) lens at far-away hills. See the figure below. The focal length of the lens is +0.10 m. Your near-point (the closest distance at which you can see clearly) is 0.25 m.



8. Where is the image of the hills formed in the above figure?

   (A) 0.20 m to the left of the lens.

   (B) 0.10 m to the left of the lens.

   (C) 0.10 m to the right of the lens.

   (D) 0.20 m to the right of the lens.

9. How far must your eye be from the lens so that you can see the image of the hills clearly?

   (A) 0.10 m (B) 0.15 m (C) 0.25 m (D) 0.35 m

10. The image of the hills is

    (A) real and inverted. (B) virtual and inverted.

    (C) real and upright. (D) virtual and upright.

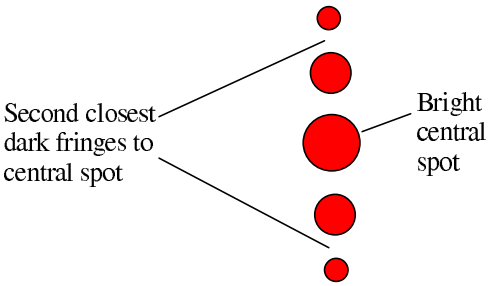
11. You look at an object across the room through a diverging lens that is held at arm's length. The image appears smaller to you compared to looking at the object directly (*i.e.*, not through any lens), for which of the following reasons?

    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

The following pertains to questions 12, 13 and 14. Monochromatic light of wavelength λ 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.



12. In what orientation are the slits?

    (A) Vertical (*i.e.*, $\|$).

    (B) Horizontal (*i.e.*, $=$).

    (C) Rotated clockwise (viewed from the direction of the incoming beam of light) an angle of 45 degrees from vertical (*i.e.*, //)

    (D) Rotated counter-clockwise (viewed from the direction of the incoming beam of light) an angle 45 degrees from vertical (*i.e.*, \\ )

13. At the second closest dark fringe on either side of the bright central spot on the screen, the light from one opening travels

    (A) 3/2 times as far as light from the other opening.

    (B) three times as far as the light from the other opening.

    (C) a distance $3\lambda/2$ further than the other opening

    (D) a distance 3λ further than the other opening.

14. 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.

15. The multi-colored patterns that are observed on oil slicks on water are primarily due to

    (A) reflection coefficients that vary according to the polarization of the light.

    (B) dispersion of the light (*i.e.*, index of refraction varies with the wavelength) in oil.

    (C) diffraction of the light waves from the oil molecules.

    (D) thin-film interference with varying thickness of the oil slick.

16. Light

    (A) is longitudinal wave.

    (B) is a transverse wave which has only one direction of polarization.

    (C) is a transverse wave whose polarization can be decomposed into two perpendicular components.

    (D) has both longitudinal and transverse wave characteristics.

17. A nearsighted person wears corrective lenses. One of the focal points of the corrective lenses should be

    (A) at infinity.

    (B) at the person's retina.

    (C) at the person's pupil.

    (D) at the person's far point.

18. The near point of a farsighted person is 1 m. When she puts on contact lenses, she can comfortably read a down to 1/4 m. What is the lens power of her contact lenses?

    (A) +5 D (B) +3 D (C) −3 D (D) −5 D

19. What major advantage does a reflecting telescope (which uses mirrors) have over a refracting telescope (which using lenses)?

    (A) Mirrors do not suffer from chromatic aberration.

    (B) Mirrors do not suffer from spherical aberration.

    (C) Images from mirrors are not limited by diffraction effects.

    (D) None of the above.

20. Fill in the blank with the correct answer: In both microscopes and astronomical telescopes, the objective lens produces a _____ image which is then magnified by the eyepiece.

    (A) virtual upright

    (B) virtual inverted

    (C) real upright

    (D) real inverted

21. **Bonus 1:** A fish eye is well-suited to seeing under water. What can you way about the fish's vision when it is taken out of water? **Hint**: Think about the difference in the refraction of the light at the cornea (the outer transparent covering) of the fish's eye when the fish is in water compared to when it is in the air.

    (A) It would suffer from astigmatism.

    (B) It would be nearsighted.

    (C) It would be farsighted.

    (D) It's field of vision is reduced by approximately 50%.

22. **Bonus 2:** In between a vertically oriented polarizer and a horizontally oriented polarizer, a third polarizer is inserted at an angle of θ with respect to the vertical direction. If unpolarized light of intensity I_0 is incident on the vertically oriented polarizer, what is the intensity of the light after is passes through all three polarizers?

    (A) $I_0 \cos^2 \theta$

    (B) $\frac{1}{2} I_0 \cos^2 \theta$

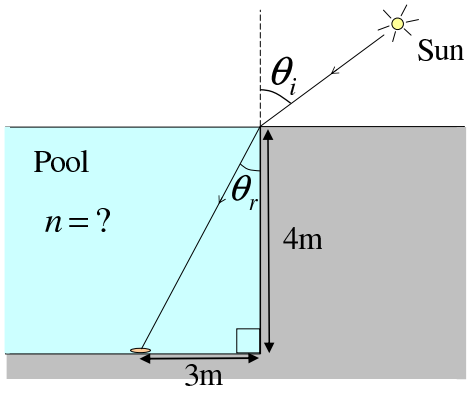
    (C) $I_0 \cos^2\theta \, \cos^2(90^\text{o} - \theta)$

    (D) $\frac{1}{2} I_0 \cos^2\theta \, \cos^2(90^\text{o} - \theta)$

23. **Bonus 3:** A CIA camera has an aperture (the opening that lets light in) that is $6 \times 10^{-2}\,\text{m}$ in diameter. If this camera is on an aeroplane flying at a height of $1 \times 10^4\,\text{m}$, 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 $5 \times 10^{-7}\,\text{m}$.

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

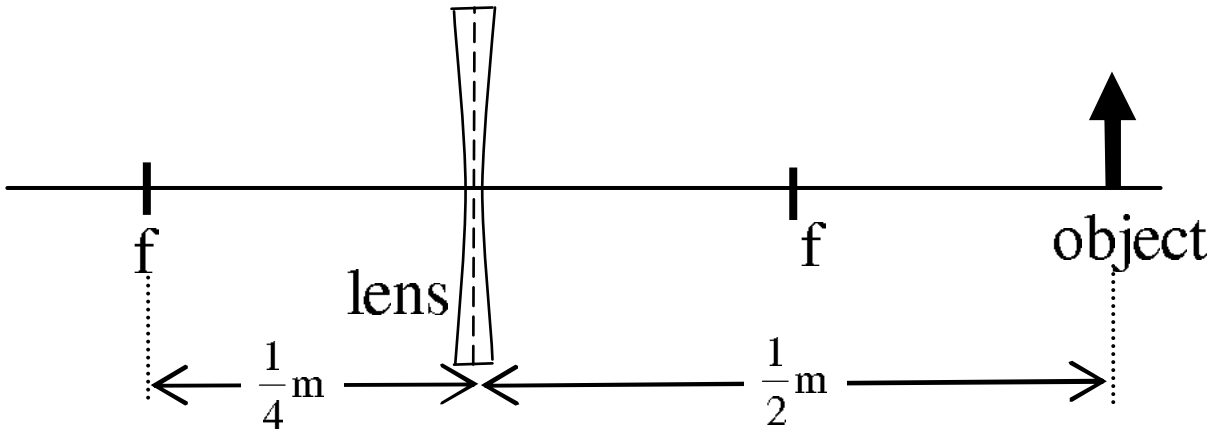
1. A coin lies at the bottom of a pool at a depth of 4 m, at a distance of 3 m from a vertical wall. Light rays from the sun that pass close to the edge of the pool illuminate the coin, as shown in the figure below. The angle of incidence and refraction of the light ray are θ_i and θ_r, respectively.



   (a) What is θ_r? You may express your answer in terms of $\sin^{-1}$. (Hints: Pythagoras' theorem for right-angled triangles: Square of hypotenuse = sum of squares of two other sides. Also, $\sqrt{25} = 5$.) [10 points]

   (b) If $\sin\theta_i = \frac{4}{5}$, what is the index of refraction of the liquid? You may express your answer in terms of fraction.(Air has index of refraction of 1.) [10 points]

2. The diagram below represents an object that is $\frac{1}{2}$ m away from an a concave (diverging) lens with focal length of magnitude $\frac{1}{4}$ 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. [11 points]

(b) *Calculate* where the image should be. Include the correct sign in your answer. (Your answer can be expressed as a fraction.) [8 points]

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