Science Olympiad National Tournament

May 2011

Optics Exam

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Instructions:

1. **READ ALL THESE INSTRUCTIONS CAREFULLY BEFORE STARTING!**
2. Do not open this test until instructed to.
3. Be sure to write legibly.
4. Fill out your school name and number on EVERY PAGE. Abbreviations are acceptable.
5. Only the answers in the answer boxes will be scored. If you decide to change an answer after entering it you may thoroughly cross it out and create a new box next to the printed one to enter the answer.
6. Where relevant, answers must include APPROPRIATE SI UNITS and significant figures.
7. The testing period is over at 45 minutes past the start time. We will give time warnings at 5 and 1 minutes. Stop writing when told to. Be sure to turn in ALL pages.
8. Each question is worth 1 point. An answer either is fully correct and gets 1 point or is wrong and gets no points.
9. The score from the tie-breaker question at the end will be used only in case of a tie.

Helpful Hints:

1. The test is printed two-sided. Be sure to look at the back of the pages.
2. The pages may be separated during the testing period and worked on independently by both team members if so desired.
3. You can email Dr. Chalker at the address above for an electronic copy of this exam after the tournament. Note the email address is NOT OSU.EDU.
4. You may write on the blank areas available on the test to do calculations.
5. The test is intentionally long so that most teams will likely NOT complete all questions. I recommend quickly reviewing the questions before beginning and tackling the ones you know best first.

School Name:_____ School Number:_____

Part 1: Geometric Optics

1. What is the index of refraction for a vacuum?

2. If the index of refraction of a material is 1.33, what is the speed of light in the material?

3. What is the speed of white light in a vacuum?

4. Light traveling through water reaches air at an angle of incidence of 40.0^{o}. At what angle of refraction does the light travel into the air? ($n_{air} = 1.0003$, $n_{water} = 1.33$)

5. Light travels from water into air. What is the largest incident angle that will result in a refracted ray?

6. Light with a frequency of 7.5×10^{14} Hz is traveling through water. What is its wavelength?

7. The speed of light in a substance is 1.5×10^{8} m/s. What is the index of refraction of the substance?

8. The angle of incidence of a light beam on a prism is 20^{o} and the angle of emergence is 30^{o}. The prism angle is 45^{o}. What is the angle of deviation?

9. The apex angle of a prism is 50.0^{o} and the index of refraction of the prism material is 1.66. What is the minimum deviation angle?

10. What an Abbe number the measure of?

11. In a typical atmospheric primary rainbow, which color of visible light is on the upper part of the arc?

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12. A man is 160cm tall and standing in front of a flat mirror. How tall must the mirror be for him to see his entire body in it?

13. An object is placed 40 cm away from a concave mirror with a focal length of 20 cm. List 3 characteristics of the resulting image.

14. What is the name of the theory that states that all points on a wave front serve as point sources of spherical secondary wavelets?

15. An object is 25.0 cm away from a thin converging lens with a 10.0 cm focal length. What is the image distance?

16. If the object in the previous question is 8.0 cm tall, what is the height of the resulting image?

17. What is the magnification of a thin converging lens with an object at 30.0 cm and its image at 25.0 cm?

18. What are the only types of images that can be formed by a convex mirror?

19. What is diopter of a concave mirror with a focal length of 40cm?

20. If a concave lens has a radius of curvature on one side of 40 cm and 60 cm on the other side, and is made out of a material with an index of refraction of 1.75, what is the focal length?

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Part 2: Physical Optics

1. What color light do you get if you add red and green light?

2. If white light shines on a sheet of paper that absorbs green light, what color does the paper appear?

3. What is the term for adding black to a color?

4. The intensity of radiation from the Sun is ~1370 W/m^2 on Earth (1 AU from the sun). What is the Sun's intensity at Mercury (0.387 AU)?

5. What is the approximate upper wavelength that rod cells are sensitive to?

6. Approximately how many rod cells are in a typical human eye?

7. What is the approximate field of view size of the eye's blind spot?

8. What is the approximate smallest diameter of a human pupil?

9. What is the name of the fluid that helps maintain the shape of the eyeball?

10. Which color of visible light has the greatest wavelength?

11. What color is light with a frequency of 650 THz?

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12. What is the name of the EM region between radio and infrared rays?

13. If you are listening to FM radio station 101.5 MHz, what is the wavelength of the radio waves your radio is tuned to?

14. What color light does the hottest types of stars radiate?

15. If an object known to emit a wavelength of 555 nm is observed to have a Doppler shift of 8 nm, how fast is it moving relative to the observer?

16. In a recreation of Young's double slit experiment, light has a wavelength of 546 nm, the slits are 0.12 mm apart, and the screen is 55 cm away. What is the distance between adjacent maxima near the screen center?

17. What is the energy of a photon of light with a wavelength of 700 nm?

18. What is the shortest wavelength in the hydrogen Balmer series?

19. An electron has a de Broglie wavelength of 3.9×10^{-10} m. What is its momentum?

20. What is the wavelength of light emitted from a ruby laser?

Tiebreaker Question

Name as many SI photometry and radiometry units and their matching symbols as you can.

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