

Team Number:

Team Name:

Student Names:

Science Olympiad 2011

Practice Optics C

By ichaelm

Do not look under this page until instructed. Once you are, you will have 50 minutes to complete this test. Put all answers on separate sheets of paper. Use units when appropriate. Round all numerical answers to at least 6 significant digits. Your answers do not need to be in order. You may write on this test packet and separate the pages. You may use any number of calculators or writing implements if you have them now. You may not share with other teams during the test.

This test is entirely written.

Section 1: Geometric Optics

For questions 1-3, you have to write a mathematical formula or equation. You must define all variables, and explain sign conventions when necessary.

1. Lens maker's equation
2. Thin lens equation
3. Snell's law
4. What kind of lens curvature is used in most magnifying glasses?
5. What kind of lens curvature would someone who is nearsighted need in their glasses?
6. What kind of lens curvature would someone who is nearsighted need in their contact lenses?
7. A ray of light traveling through air (refractive index exactly 1.0003) is reflected off of a mirror. The angle of incidence is exactly 0.5 radians. What is the angle of reflection?
8. When a ray of light traveling through the air strikes a body of water, in what direction does it bend?
9. A ray of light traveling through air (refractive index exactly 1.0003) strikes the surface of a transparent solid (refractive index exactly 2.5) at an incident angle of exactly 0.7 radians. What is the angle of refraction?
10. Describe the procedure one could use to determine the refractive index of a rectangular transparent solid block, given a flat surface, a laser, a protractor, and a calculator.
11. A fiber optic cable has a refractive index of exactly 2.11. It is in a vacuum. Light is traveling through it, and bouncing off its boundaries. In order for none of the light to escape the cable, what is the minimum angle of incidence that the light can strike the boundary?
12. A biconcave lens has two spherical surfaces. The surface facing towards a collimated light source has a radius of curvature of exactly 30 cm, and the surface facing away from the light source has a radius of curvature of exactly 70 cm. The thickness of the lens at its axis is exactly 1 mm. The lens is made of Pyrex, which has a refractive index of exactly 1.474. Use the lens maker's equation to determine the focal length of the lens.

13. What do you see if you hold up a spoon at arm's length, so that the concave surface is facing you? Why?
14. Why does white light disperse into different colors in a prism?
15. Which color of visible light bends the most in a prism?
16. In the year 1800, William Herschel set up a prism to separate light from the sun into its different colors. He set up several thermometers in the way of the dispersed beam, as well as one just beyond red, where there was no color. To his surprise, the highest temperature reading came from the thermometer just beyond the red light. Why did this happen? What did Herschel discover?
17. Have you ever looked inside a rectangular fish tank and noticed that no matter what side you looked in from, the two sides next to it looked like mirrors? If you haven't, then imagine it. Why does this happen?
18. State Huygens's principal in your own words.

Section 2: Physical Optics

19. List the 7 regions of the electromagnetic spectrum in order from lowest frequency to highest frequency. Label which end of the spectrum has the highest energy, and which has the longest wavelength.
20. What are the two types of photoreceptor cells in the human eye? What is the specific function of each?
21. Explain why a screen, like a TV or a computer monitor, is able to trick the eye into thinking it's seeing millions of colors, when it's actually only seeing three. Hint: The answer is not "Because the dots are so small!"
22. What three colors of light is the human eye most sensitive to?

Questions 23-24 take place in a room with no lighting, with all the walls painted white.

23. You turn on a green flashlight and a red flashlight, both of equal brightness. What color do the walls appear?
24. You hold up a magenta object and turn on a blue flashlight. What color does the object appear?
25. Define the word intensity, as applied to light.
26. The earth is one astronomical unit from the sun, and it receives 174 petawatts of electromagnetic radiation from the sun. If the earth were two astronomical units from the sun, how much radiation would it receive?
27. In a binary star system, two stars orbit each other at extremely high velocities. At a certain point in time, one star is moving towards us, and the other is moving away from us. How can we instantly tell which is which?
28. What is the speed of light through a medium with a refractive index of exactly 2?
29. Do photons ever have zero mass?
30. Give an example of when light behaves like a particle, and an example of when it behaves like a wave.