YUSO 2017 OPTICS EXAMINATION

Part 1: Regular Questions – 60 pts, 75% of total

1. What color is seen if white light is shone onto a sheet of paper that absorbs green light? [1 pt.]
2. Why do printers use CMYK instead of RBG? [3 pts.]
3. How does a laser produce light? Name and define two qualities that describe laser light. [5 pts.]
4. What do Abbe numbers measure, and why were they useful? [2 pts.]
5. What parts of the eye require Vitamin A? Describe one of the first symptoms of Vitamin A deficiency. [3 pts.]. *Bonus: Why is the statement that "rabbits have excellent vision because they eat a lot of carrots, which are rich in Vitamin A" false?*
6. Suppose you have a double convex lens (n_1 = 1.24) with radii of curvatures r_1 = 20cm and r_2 = 10cm. In air, is this lens converging or diverging, and what is the focal length of this lens? (Give answers accurate to 1/100 cm) [4 pts.]
7. A man 1.5 m tall stands 5 meters from the front of a rectangular mirror with no obstructions. This mirror is sized and positioned such that the man can initially only see the top 0.5 meters of his body. If he doubles his distance away from the mirror, how much of his body can he see? [1 pt.]
    a) 0.25 meters
    b) 0.50 meters
    c) 1.00 meters
    d) 1.50 meters
8. In the previous question, how long must the mirror have been? [1 pt.]
    a) 0.25 meters
    b) 0.50 meters
    c) 1.00 meters
    d) 1.50 meters
9. Mirrors are able to "flip" the following axis, id est, one becomes the other when looking at an object in a flat, planar mirror: [1 pt.]
    a) left and right
    b) top and bottom
    c) both (a.) and (b.)
    d) none of the above

For problems 10 and 11: An object is placed 5.0 cm from the lens and is illuminated with red light. The focal length of the lens for red light is 8.0 cm.

10. The position of the image is (to the nearest 1/10 cm): [1 pt.]
    a) -3.1 cm
    b) 3.1 cm
    c) -13.0 cm
    d) 13.0 cm
11. The linear magnification of the image is (to the nearest 1/10 cm): [1 pt.]
12. Linear magnification is defined in two ways. List both of them. [2 pts.]
13. What causes chromatic aberration in prisms? [2 pts.]
14. Disperse light first passes through a horizontal polarizer and then a vertical polarizer. Assuming the incoming light has intensity 1, how and where would you place a polarizer to result in final intensity of $(\sqrt{3})/4$? [3 pts.]
15. You want to design a fiber optical cable where the cladding has index of refraction 1.253, and you want to choose material such that the cable has a critical angle of 80.89 degrees. To the nearest thousandth, what should the material's index of refraction be [2 pts.]

16. Less than a century ago, astronomy relied on chemical plates to take data. State two reasons why chemical photography plates were replaced by CCDs and CMOS. [2 pts.]
17. Explain how you would start a fire using only a convex lens and moonlight. [5 pts.]
18. An object is placed in front of a convex lens and a real image appears, magnified 5x. When the object is moved 6cm along the axis of the lens, a real image of magnification 2 is obtained. What is the diopter of the convex lens? [3 pts.]
19. When the object is placed 30 cm away from the lens, a piece of cardboard is placed in between the object and the lens, to cover half of the surface area of the lens. Is the image real or virtual? Where is the image located? How is the image different if the cardboard is removed? [3.5 pts.]
20. Suppose you have a telescope with magnification of 2.0x. The focal length of the eye lens is 3cm. Find the focal length of the objective lens and the length of the telescope. [3 pts.]
21. How does an absorption spectrum differ from an emission spectrum? What type of spectrum is produced by passing current through Neon gas? [3 pts.]
22. What shape are most modern telescope mirrors? [1 pt.]
23. Of what is the process of accommodation the primary function? [1 pt.]
24. What are the near and far points of normal human eyes? [2 pts.]
25. Individuals with a near point beyond the normal near point are commonly referred to as: (0.5pt)
26. Brewster's angle occurs when the incident angle is equal to the reflected angle. Derive this angle for light passing from material with index of refraction n_1 to denser material, index of refraction n_2, using Snell's law. What happens to the reflected rays at Brewster's angle? [4 pts.]
27. Draw a Plano-convex lens. [1 pt.]

Part 2: Math/Reading Comprehension Portion - 20 points, 25% of total

Alice, a mad scientist, wants to create a new type of lens. As a mad scientist, she follows the mad scientific method, which is the same as the normal scientific method, except you are really angry when things don't work out. Therefore, Alice shows all of her intermediate steps in her mad lab notebook. Not showing steps might make Alice even more mad. Don't worry, Alice cares more about intermediate steps than final answers. Make Alice happy again!

1. Alice first needs to create a double convex lens that can magnify an object 30 centimeters away by 2 times. One side of the lens has already been ground to have a radius of 12 centimeters and has a refractive index of 1.52. Assuming the polar ice caps have melted and all experiments are done under water, what must the radius of the other side be? (5 pts)
2. Now, Alice finds a pocket of air in the water. She wishes to create a telescope that can magnify objects five times, and she has another piece of lens, with one side already ground to a radius of 20 centimeters and with a reflective index of 1.33. The minimum radius Alice can grind the lens to is 1.0cm. How should she grind the other side of that lens? Which side does she grind (front/back)? Is this new lens the objective or eyepiece lens? (8 pts)
3. Alice now points this newly (and hastily) constructed telescope at the sun. She immediately burns her cornea, suffering irreparable visual damage. Next, she points the other end of the telescope at a sheet of glass (n = 1.52), followed by a sheet of diamond (n = 2.419), followed by a layer of arsenic trisulfide and sulfur in methylene iodide (n = 1.9). If she points her telescope at 45 degrees to the sheet of glass, and each of the following sheets are parallel, what angle is the light (measured to the vertical) in the water? (4 pts)
4. Now, you are left with a blind scientist standing in a pool of water with a hastily constructed telescope. What can Alice do next? If you guessed "place two filters in front of the telescope to block out exactly 79% of the light", you are correct! Alice only has access to horizontally polarized filters, but she is free to rotate them. Calculate the relative angle between the two filters to do exactly what you had guessed! (3 pts)