YUSO 2017 OPTICS
ANSWER KEY

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

1. Magenta [1 pt.]

2. 3 *points, award 1 point partial credit for each correct part.*

I. CMYK are primary colors of ink. Cyan, Magenta, and Yellow each absorb a single color of light - Red, green, and blue respectively.

II. Printers produce material that is intended to reflect light, which is subtractive color mixing.

III. RBG is used for performing additive color mixing.

3. *5 points; award partial credit as indicated.*

I. Lasers produce light by pumping electrons, population inversion of electrons, and then storing in an optical cavity for release. [3 pts]

II. Laser light is coherent - they have a constant phase. [1 pt.]

III. Laser light is monochromatic - all light waves have the same frequency. [1 pt.]

4. 2 *points, award 1 point partial credit for each correct part.*

I. They are a measure of dispersion. (Bonus 0.5 pts - they measure the Fraunhofer D-, F-, and C- spectral lines).

II. They classify materials based on their chromaticity.

5. *3 points; award partial credit as indicated.*

I. Vitamin A is needed in both rods and cones [2 pts]

II. A lack of vitamin A will degrade rhodopsin in retina, resulting in night blindness. [1 pt.]
(bonus 1pt - Rabbits do not have great vision as they can only distinguish between greens and blues. A rabbit's primary diet is not carrots, and will die from sugar overdose if they keep on eating carrots! (The writer will not verify the truth of that, go ask a bio major.))

6. 4 *points, award 1 point partial credit for each correct part.*

I. converging lens

II. K_shape = 1/20 - 1/(-10) = 3/20

*III. 1/f = ((1.24/1.00) - 1)*3/20*

IV. f = 27.78 cm

7. *b) 0.50 meters [1 pt.]

8. *a) 0.25 meters [1 pt.]

9. *d) none of the above [1 pt.]

10. *c) -13.0 cm [1 pt.]

11. *2.6x* [1 pt.]

12. 2 *points, award 1 point partial credit for each correct part.*

I. Image height over object height

II. Image distance over object distance.

13. 2 *points, award 1 point partial credit for each correct part.*

I. The index of refraction varies for different wavelengths.

II. The phase velocity is dependent on the wave frequency, creating index of refraction discrepancy.

14. *3 points; award partial credit as indicated.*

I. Between the first and second polarizers [1 pt.]

II. Polarizer tilted 30 degrees relative to the horizontal. [2 pts.]

15. 2 *points, award 1 point partial credit for work and 1 point for answer.*

I. n = 1.269

II. Sample work: arcsin(1.253/1.269) = 80.8919 degrees

16. 2 *points, award 1 point partial credit for each correct part. 3 possible answers are given below:*

I. Low efficiency photon detectors, unable to detect many regions of light.
II. Nonlinear detectors - detected certain wavelengths less than other regions
III. Resolution too low to capture detail.

(do not accept vague answers. give ½ point partial credit for answer based on data analysis.)

17. *5 points; award partial credit as indicated.*

I. You cannot do this! [1 pt.]
II. Using only a lens, you can at maximum raise something to the surface temperature of what your light source. [2 pts.]
III. Lenses cannot violate the second law of thermodynamics. [2 pts.]
IV. BONUS - This was on what-if xkcd! [1 pt.]

18. 3 *points, award 1 point partial credit for each correct part.*

I. 1/5u + 1/u = 1/f
II. 1/(2*(u+6)) + 1/(u+6) = 1/f
III. diopter = 1/f = 0.05 cm^-1 (no points for incorrect units).

19. *3.5 points; award partial credit as indicated.*

I. Real image [0.5 pt.]
II. 1/30 + 1/v = 1/20 [1 pt.]
III. v = 60cm [1 pt.]
IV. If cardboard is removed, the image is brighter. [1 pt.]

20. 3 *points, award 1 point partial credit for each correct part.*

I. M = 2 = f_o/ 3cm
II. f_o = 6cm
III. length = 9cm

21. 3 *points, award 1 point partial credit for each correct part.*

I. Absorption spectra result from certain wavelengths being removed from a continuous spectrum.
II. Emission spectra are single wavelengths that are bright, against a dark spectral background.
III. An emission spectrum is produced.

22. Parabolic [1 pt.]
23. Cillary body [1 pt.]
24. 25cm, infinity [1 pt. each]
25. Far-sighted [0.5 pt.]
26. 4 *points, award 1 point partial credit for each correct part.*

I. $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$
II. $n_1 \sin(\theta_B) = n_2 \cos(\theta_B)$
III. $\theta_B = \arctan(n_2/n_1)$
IV. Reflected rays are all polarized completely.

27. Draw a Plano-convex lens. (1.opt)
(looks like a flat side and a curved inward side lol)

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

1. *1 point for each part, total of 5 points (no points for final answer if no units)*
M = q/p, 2 = -q / 30, q = 60 cm
1/p + 1/q = 1/f, 1/30 + 1/60 = 1/20, f = 20cm
1/f = (n_g – n / n) (1/r_1 – 1/r_2)
1/20 = (1.52 – 1.33) / 1.33 * (1/n – 1/12)

N = 2.3 cm

2. *8pts total, 1pt for each part. No pts for no units (intermediate steps okay)*
If only solution,
1/f = (n_g – 1 / 1) (1/2.3 – 1/12)
1/f = .52 * .35, f = 5.47 cm
M = f_o / f_e, 5 = f_o / 5.47 , f_o = 27.35 cm
1/f = (n_g – n / n) (1/r_1 – 1/r_2)
1/27.35 = (1.33 – 1)/(1) * (1/r_1 – 1/20)
R_1 = 6.21 cm,
Front
Objective lens

3. *4 points (1 pt for each line, 1 pt max for writing down Snell's law)*
Sin t_1 / sin t_2 = n_2 / n_1
Sin (45) / sin(t_2) = 1.52 / 1, T_2 = 27.72 degrees

Sin t_2 / sin t_3 = n_3 / n_2
Sin(27.72) / sin(t_3) = 2.419 / 1.52 , T_3 = 47.75 degrees

Sin t_3 / sin t_4 = n_4 / n_3
Sin (47.75) / sin(t_4) = 1.9 / 2.419, T_4 = 70.46 degrees

4. *3 pts, 1 pt per line.*
Block 79% = remaining 21%.
First filter results in 0.5*I_0, second filter results in cos^2(theta) * 0.5 * I_0 = 0.21
Theta = 49.60 degrees