Division C Optics KEY
2017-2018 Captains Exchange

1.) If a laser beam is reflected off a mirror lying on a table and bounces off a nearby wall at a 30 degree angle, what was the angle of incidence of the beam on the mirror?
   A. 30 degrees
   B. 45 degrees
   C. 60 degrees
   D. 70 degrees

2.) Which of the following best describes the phenomenon of light bending as it passes from one medium to another?
   A. Reflection
   B. Refraction
   C. Diffusion
   D. Effusion

3.) An incandescent light bulb is shown through a glass prism. The certain wavelength of the light is then directed into a glass cuvette containing an unknown concentration of protein. Commonly, this process is called spectroscopy and is used to determine the concentrations of DNA, RNA, and proteins in solutions. The indices of reflection of air, glass, and the solution are 1, 1.5, and 1.3, respectively. The red light, selected for by the prism, is shown through air onto the glass cuvette at an angle of 30° to the normal. At what angle to normal does the light have when it is in the glass?
   A. 19.5°
   B. 30°
   C. 45°
   D. 22°

4.) The index of refraction of medium A is 1.15 and the index of refraction in medium B is 1.5. Find the medium which light will travel fastest in and give that speed.
   A. Medium A, (3.77 x 10^8 m/s)
   B. Medium B, (2.00 x 10^8 m/s)
   C. Medium A, (2.60 x 10^8 m/s)
   D. Medium B, (1.50 x 10^8 m/s)

5.) Choose the option below which does not occur when light passes from a medium with a higher refractive index to that of a lower refractive index.
   A. An increase in frequency
   B. An increase in velocity
   C. An increase in wavelength
   D. A bend away from the normal line

6.) If a real object is placed in front of a convex mirror (f < 0), then the image is

    A. virtual, erect and enlarged in height relative to the object
    B. real, erect and reduced in height relative to the object
    C. real, inverted and enlarged in height relative to the object
    D. virtual, erect and reduced in height relative to the object

7.) 33. Earth is 2.5 times further from the Sun than Mercury. How many times brighter does the Sun appear on Mercury than on Earth?
    A. 2.00
    B. 3.86
    C. 6.25
    D. 9.08

8.) Calculate the energy of a photon having a wavelength of 230 nanometers. (2)

    8.65×10^{-19} J or 5.4eV

9.) A beam of light has a wavelength of 660 nm. What color is this light?

    A. Red
    B. Yellow
    C. Blue
    D. Violet

10.) If the velocity of light through as unknown liquid is measured at 2.4 x 108 m/s, what is the index of refraction of this liquid?

    A. 2.50
    B. 1.25
    C. 2.25
    D. 1.60

11.) If an image is placed to the left of a converging lens, which of the following statements are true?
    A. The image can be upright or inverted
    B. The image is always to the right of the lens
    C. The image is always smaller or the same size as the lens

12.) Choose which best describes the image of a concave mirror when the distance of the object is more than two times the focal distance from the mirror.
    A. Virtual, upright, magnification > 1
    B. Real, inverted, magnification < 1
    C. Virtual, upright, magnification < 1
    D. Real, inverted, magnification > 1

13.) A camera uses a _____ to form a _____ image.
   A. Converging lens, real image
   B. Converging lens, virtual image
   C. Diverging lens, real image
   D. Diverging lens, virtual image

14.) Convex lenses form what types of images?
   A. Real
   B. Virtual
   C. Real and Virtual
   D. Inverted

15.) If an object is placed 30 cm away from a mirror with a focal length of 20 cm, how far away would the image form?
   A. 50 cm
   B. 60 cm
   C. 70 cm
   D. 80 cm

16.) In the previous question, how much magnification would the object experience?
   A. -2
   B. +2
   C. -1
   D. +1

17.) True or False, the object mentioned in question 15 would be flipped
   A. True
   B. False

18.) What is yellow's complimentary color?
   A. Magenta
   B. Green
   C. Orange
   D. Blue

19.) Yellow light shines on a piece of paper that is blue in white light. The paper appears to be what color in yellow light?
   A. Black
   B. Yellow
   C. Blue
   D. Magenta

20.) If a 15 inch cylinder is 60 in. away from a convex lens, what would the cylinder's image distance be?
   A. 10 in
   B. 20 in
   C. 30 in
   D. 40 in

21.) What would the height of the cylinder in the previous question be?
   A. 3 in
   B. 4 in
   C. 5 in
   D. 6 in

22.) A glass lens has a focal length of 15 cm in air and x cm when complete immersed in a liquid. If the glass has a refractive index of 1.59 and the liquid a refractive index of 1.29, find x.

X = 19.4 cm

23.) To the nearest degree, calculate the critical angle for a benzene/acetone interface.
   n_b = 1.501 n_a = 1.360 θ_c = *arcsin(1.360)* = 65°

In a double-slit experiment, the distance from the central maximum to the third maximum is .010 meters. The slit spacing is 5.00 E -6 meters, and the distance to the screen is 3.00 meters.

24.) Determine the wavelength of light used in the experiment. 5.6 nm
25.) Find the path difference. 16.8 nm
26.) Calculate the angle to the nearest hundredth of a degree. 0.19 degrees

27.) An object is placed in front of a thin lens with focal length 10 cm. Calculate the distance of the image from the lens if the object is placed. 30 cm, real, inverted, magnified

28.) An object is placed in front of a thin lens with focal length 10 cm. Calculate the distance of the image from the lens if the object is placed 5 cm from the lens. Is it real or virtual? Upright or inverted? Magnified or diminished? -10 cm, virtual, upright, magnified

29.) An equilateral triangular glass prism (n = 1.5) is placed with its side flat on a table. For what incident angle θ does the transmitted light exit at the same angle? If the prism is submerged in water (n = 1.33) and the incident angle remains the same, what is the new transmitted angle?

48.59 degrees, 20.76 degrees

30.) White light enters from one side of an equilateral triangular prism, is internally reflected at a second side, and exits from the third side. Calculate the maximum incidence angle (critical angle) that allows for this trajectory. Note that this trajectory is symmetrical. Is the light exiting the prism white light? No. Is the light collimated? Yes

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$$\frac{1}{f} = \frac{n - n_o}{n_o} \left(\frac{1}{R_1} - \frac{1}{R_2} \right) \xrightarrow{-constant}$$

X = 38 cm

$$\frac{1}{x} = \frac{1.59 - 1.29}{1.29} \bullet 0.11294$$

$$\frac{1}{15} = \frac{1.59 - 1}{1} \bullet C \longrightarrow C = 0.11294$$

Y = 38 cm

23.) To the nearest degree, calculate the critical angle for a benzene/acetone interface.

$$n_b = 1.501 \quad n_a = 1.360 \quad \theta_c = arcsin\left(\frac{1.360}{1.501}\right) = 65°$$

24. Use condition for max:

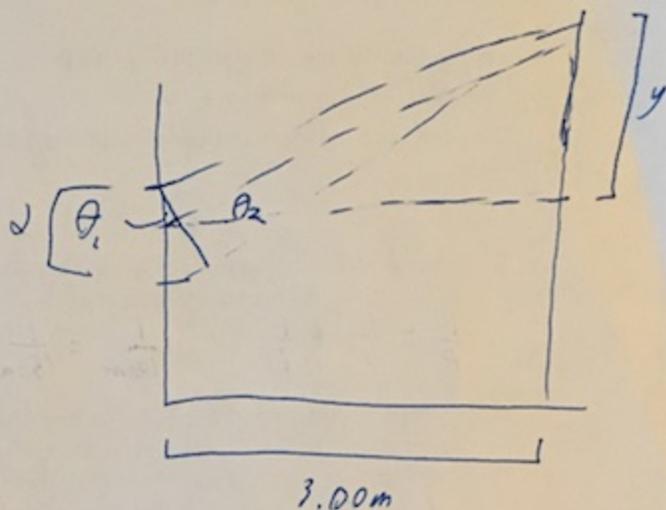$$0.10m = \frac{3 \cdot \lambda \cdot 3.00m}{5.00 \times 10^{-6}m}$$

$$\lambda = 5.6 \, nm$$

25. Path diff:

Diff = $d \cdot \sin \theta$

Diff = $5.00 \times 10^{-6} \cdot \sin(0.19)$

Diff = $16.7 \, nm$

3.00m

26. Angle - opposite = $0.010 \, m$

— adj = $3.00m$

Angle = $\arctan\left(\frac{0.010m}{3.00m}\right)$

Angle = $0.19°$

In a double-slit experiment, the distance from the central maximum to the third maximum is .010 meters. The slit spacing is 5.00 E -6 meters, and the distance to the screen is 3.00 meters.

24.) Determine the wavelength of light used in the experiment. 5.6 nm

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27.) An object is placed in front of a thin lens with focal length 10 cm. Calculate the distance of the image from the lens if the object is placed. 30 cm, real, inverted, magnified

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$ $$\frac{1}{10cm} = \frac{1}{15cm} + \frac{1}{i}$$ $$i = 30cm$$ real ~~virtual~~ upright magnified

28.) An object is placed in front of a thin lens with focal length 10 cm. Calculate the distance of the image from the lens if the object is placed 5 cm from the lens. Is it real or virtual? Upright or inverted? Magnified or diminished? -10 cm, virtual, upright, magnified

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$ $$\frac{1}{10} = \frac{1}{5} + \frac{1}{i}$$ $$i = -10cm$$ virtual upright magnified

29.) An equilateral triangular glass prism (n = 1.5) is placed with its side flat on a table. For what incident angle θ does the transmitted light exit at the same angle? If the prism is submerged in water (n = 1.33) and the incident angle remains the same, what is the new transmitted angle?

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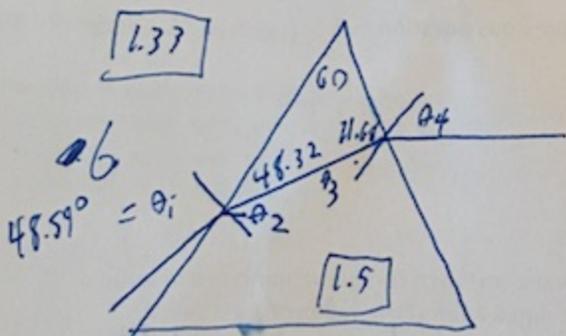L because of chromatic aberration

29. d.
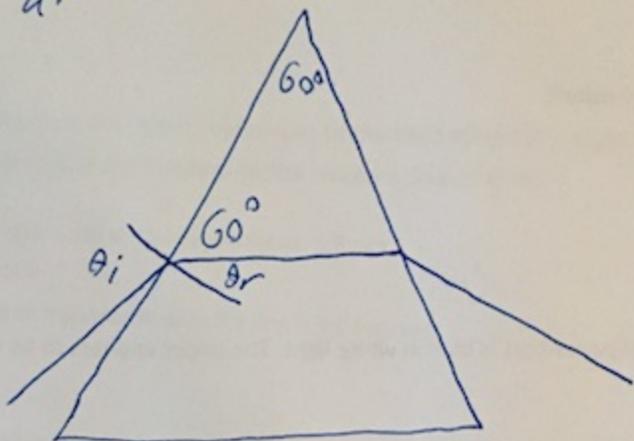
$$\theta r = 30°$$

$$\sin \theta r \, n_2 = n_1 \sin \theta_i$$

$$\sin 30° \cdot 1.5 = 1 \cdot \sin \theta_i$$

$$\theta_i = 48.59°$$

1.33

b

$$48.59° = \theta_i$$

1.5

$$\sin(\theta_2) \cdot 1.5 = \sin(46.59°) \cdot 1.33$$

$$\theta_2 = 41.68$$

$$\theta_3 = 18.62$$

$$\sin \theta_4 \cdot 1.33 = 1.5 \cdot \sin(18.62)$$

$$\theta_4 = 20.76°$$