OPTICS QUESTION BOOKLET

Athens Area High School Science Olympiad
Invitational Tournament
January 14, 2012

School_____Team #_____

Student 1:_____

Print Name Signature

Student 2:_____

Print Name Signature

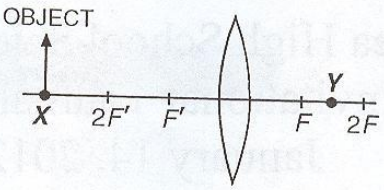
(Please print name then sign)

Directions: There are 35 multiple choice questions for Part 1, Geometric Optics. There are 30 multiple choice questions for Part 2, Physical Optics. Place all answers on the Answer Sheet, not in this booklet. You may pull the booklet apart, but must staple the pages back together in order upon turning it in.

Any ties will be broken by questions 25 through 29 on Part 1, in order until the tie is broken.

Part 1, Geometric Optics: Questions 1-35. Answers must go on the answer sheet.

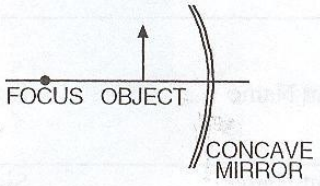
1. The diagram below represents an object 0.030 meter high placed at point *X*, 0.60 meter from the center of the lens. An image is formed at point *Y*, 0.30 meter from the center of the lens.



The image formed is

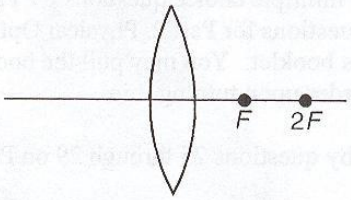
A) real and erect
B) virtual and erect
C) virtual and inverted
D) real and inverted

2. The diagram below represents an object in front of a concave mirror. The image of the object formed by the mirror is



A) virtual and smaller than the object
B) real and larger than the object
C) real and smaller than the object
D) virtual and larger than the object

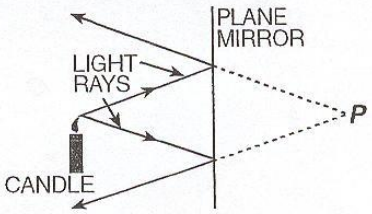
3. The diagram below shows a convex (converging) lens with focal length *F*.



Where should an object be placed to produce a virtual image?

A) at 2*F*
B) at *F*
C) between *F* and the lens
D) between 2*F* and *F*

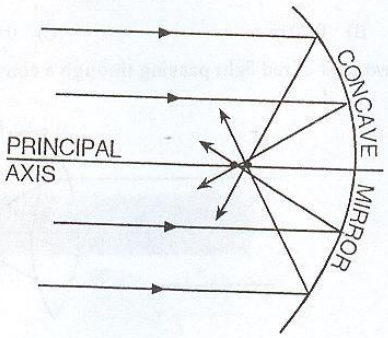
4. The diagram below represents two light rays emerging from a candle flame and being reflected from a plane mirror.



What does point *P* represent?

A) the focal point of the mirror
B) the virtual image point of the candle flame
C) the center of curvature of the mirror
D) the real image point of the candle flame

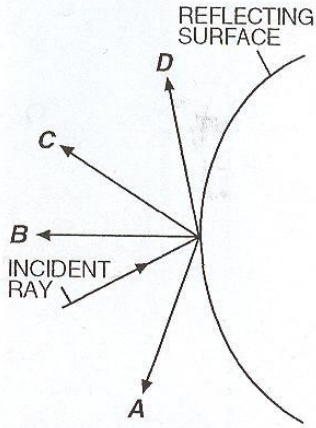
5. The diagram below shows parallel monochromatic incident light rays being reflected from a concave mirror.



Which phenomenon does the diagram illustrate?

A) spherical aberration
B) dispersion
C) refraction
D) chromatic aberration

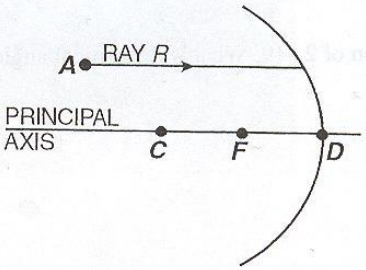
6. A light ray is incident upon a cylindrical reflecting surface as shown in the diagram below.



The ray will most likely be reflected toward letter

A) *A* B) *B* C) *C* D) *D*

7. The diagram below shows light ray *R* parallel to the principal axis of a spherical concave (converging) mirror. Point *F* is the focal point of the mirror and *C* is the center of curvature.



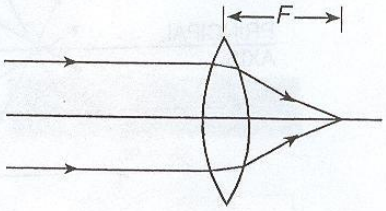
After reflecting, the light ray will pass through point

A) *A* B) *F* C) *D* D) *C*

8. An object is located 0.12 meter in front of a concave (converging) mirror of 0.16-meter radius. What is the distance between the image and the mirror?

A) 0.48 m B) 0.20 m C) 0.07 m D) 0.24 m

9. The diagram below represents two rays of red light passing through a converging lens.



If the two rays were blue light, distance *F* would be

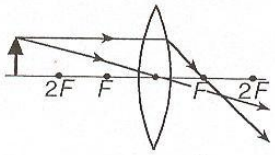
A) shorter B) the same C) longer

10. An object 0.16 meter tall is placed 0.20 meter in front of a concave (diverging) lens. What is the size of the image that is formed 0.10 meter from the lens?

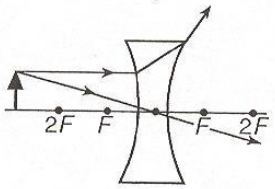
A) 0.040 m B) 0.16 m C) 0.32 m D) 0.080 m

11. Which ray diagram is incorrect?

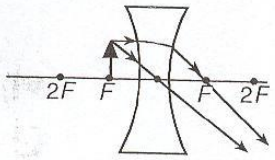
A)



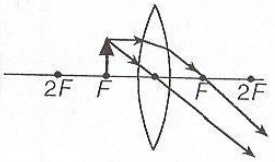
B)



C)



D)



12. As a teacher showed slides by projecting them on a fixed screen, a student complained that the image was too small. The teacher enlarged the image by moving the projector away from the screen, but the image blurred. The image should then have been brought into focus by

A) moving the lens closer to the slide
B) moving the lens away from the slide
C) increasing the power of the projector lamp
D) decreasing the amount of light in the room

13. Diamond has an index of refraction of 2.419. What is the critical angle for internal reflection inside a diamond that is in air?

a. 24.4°
b. 48.8°
c. 155°
d. 131°

14. Dez pours carbon tetrachloride ($n = 1.46$) into a container made of crown glass ($n = 1.52$). The light ray in glass incident on the glass-to-liquid boundary makes an angle of 30° with the normal. Find the angle of the corresponding refracted ray.

a. 55.5°
b. 29.4°
c. 31.4°
d. 19.2°

15. A monochromatic beam of light in air has a wavelength of 589 nm in air. It passes through glass ($n = 1.52$) and then through carbon disulfide ($n = 1.63$). What is its wavelength in the carbon disulfide?

a. 361 nm
b. 387.5 nm
c. 895 nm
d. 960 nm

16 A beam of light in air is incident on the surface of a rectangular block of clear plastic ($n = 1.49$). If the velocity of the beam before it enters the plastic is 3.00×10^8 m/s, what is its velocity inside the block?

a. 3.00×10^8 m/s
b. 1.93×10^8 m/s
c. 2.01×10^8 m/s
d. 1.35×10^8 m/s

17. A fish is 1.2 m beneath the surface of a still pond of water. At what maximum angle can the fish look toward the surface (measured with respect to the normal to the surface) in order to see a fisherman sitting on a distant bank? (for water, $n = 1.333$)

a. 18.6°
b. 37.2°
c. 48.6°
d. The fish will not see the fisherman at any angle.

18 A ray of light is incident on the mid-point of a glass prism surface at an angle of 20° with the normal. For the glass, $n = 1.60$, and the prism apex angle is 35°. What is the angle of incidence at the glass-to-air surface on the side opposite where the ray exits the prism?

a. 38.0°
b. 35.1°
c. 22.7°
d. 12.3°

19. An oil film floats on a water surface. The indices of refraction for water and oil, respectively, are 1.333 and 1.466. If a ray of light is incident on the air-to-oil surface at an angle of 37.0° with the normal, what is the angle of the refracted ray in the water?

a. 18.1°
b. 24.2°
c. 26.8°
d. 37.0°

2. When viewing your image in a hand-held mirror, if you move the mirror away at a speed v, the image appears to

a. also move away at v.
b. move away at 2v.
c. move away at v/2.
d. not move.

21. An underwater scuba diver sees the sun at an apparent angle of 30.0° from the vertical. How far is the sun above the horizon? ($n_{water} = 1.333$)

a. 22.0°
b. 41.8°
c. 48.2°
d. 68.0°

22. A small underwater pool light is 1 m below the surface of a swimming pool. What is the radius of the circle of light on the surface, from which light emerges from the water? ($n_{water} = 1.333$).

a. 0.57 m
b. 0.77 m
c. 1.13 m
d. 1.43 m

23. A certain kind of glass has $n_{blue} = 1.650$ for blue light and $n_{red} = 1.610$ for red light. If a beam of white light (containing all colors) is incident at an angle of 30.0°, what is the angle between the red and blue light inside the glass?

a. 0.22°
b. 0.45°
c. 1.90°
d. 1.81°

24. Two thin lenses with 10.0-cm focal lengths at are mounted at opposite ends of a 30.0-cm long tube. An object is located 45.0 cm from one end of the tube. How far from the opposite end is the final image?

a. 12.8 cm
b. 24.0 cm
c. 25.6 cm
d. 33.6 cm

25- A solid glass sphere with a radius of 5.00 cm and index of refraction of 1.52 has a small coin embedded 3.00 cm from the front surface of the sphere. For the viewer looking at the coin through the glass, at what distance from the front surface of the glass does the coin's image appear to be located?

a. 2.48 cm
b. 3.20 cm
c. 5.00 cm
d. 6.85 cm

26 Two thin lenses with focal lengths 25.0 cm and 30.0 cm are placed in contact in an orientation so that their optic axes coincide. What is the focal length of the two in combination?

a. 13.6 cm
b. 27.5 cm
c. 55.0 cm
d. 150 cm

27 Two convex thin lenses with focal lengths 10.0 cm and 20.0 cm are aligned on a common axis, running left to right, the 10-cm lens being on the left. A distance of 20.0 cm separates the lenses. An object is located at a distance of 15.0 cm to the left of the 10-cm lens. Where will the final image appear as measured from the 20-cm lens?

a. –13.3 cm
b. –6.67 cm
c. +6.67 cm
d. +13.3 cm

28 A converging lens with two convex surfaces has a front surface with radius of curvature of 10.0 cm; the back surface has radius of curvature of 20.0 cm and it is made from material with an index of refraction of 2.50. What is the focal length of the lens?

a. 4.44 cm
b. 13.3 cm
c. –13.3 cm
d. 0.250 cm

29 A goldfish is swimming in water (n = 1.33) inside a spherical plastic bowl of index of refraction 1.33. If the goldfish is 10 cm from the front wall of the 15-cm radius bowl, where does the goldfish appear to an observer in front of the bowl?

a. 6.0 cm behind the plastic
b. 7.0 cm behind the plastic
c. 8.0 cm behind the plastic
d. 9.0 cm behind the plastic

30. You are building a compound microscope with an objective lens of focal length 0.70 cm and an eyepiece lens of focal length 5.0 cm. You mount the lenses 18 cm apart. What is the maximum magnification of your microscope?

a. 3.1
b. 7.3
c. 67
d. 130

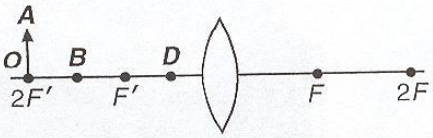
31. A refracting astronomical telescope has objective and eyepiece lenses of focal lengths 20.0 cm and 0.40 cm, respectively. What is the magnification of this instrument?

a. 19.6
b. 27
c. 50
d. 94

32. A microscope has an objective lens with an aperture diameter 0.60 cm. A monochromatic light source of wavelength 580 nm is used to illuminate the object. It is determined that the minimum angle of resolution is 1.18×10^{-4} rad. If the present lens were replaced by one with an aperture of diameter 0.90 cm, what would the minimum angle of resolution now become? ($1 \text{ nm} = 10^{-9}$ m)

a. 1.5×10^{-4} rad
b. 1.8×10^{-4} rad
c. 0.88×10^{-4} rad
d. 0.79×10^{-4} rad

The diagram below represents an object *OA* located near a crown glass lens with a focal length of 1.0 meter. *F* is the principal focus of the lens.



33. Compared to the focal length of the crown glass lens in the diagram, the focal length of a flint glass lens with identical curvature would be

A) shorter B) the same C) longer

34. Compared to the original lens, another crown glass lens with less curvature would have a focal length which is

A) shorter B) longer C) the same

35. Moving the object from point *O* to point *D* will cause its image to

A) continuously decrease in size
B) change from erect to inverted
C) continuously move towards the lens
D) change from real to virtual

Part 2, Physical Optics: Questions 1-30. Answers must go on the answer sheet.

1. Tripling the wavelength of the radiation from a monochromatic source will change the energy content of the individually radiated photons by what factor?

a. 0.33
b. 1.0
c. 1.73
d. 3.0

2. Photon A has an energy of 2.0×10^{-19} J. Photon B has 4 times the frequency of Photon A. What is the energy of Photon B?

a. 0.50×10^{-19} J
b. 1.0×10^{-19} J
c. 8.0×10^{-19} J
d. 32×10^{-19} J

3. A camera lens is initially set at *f*/16 for a shutter speed of 1/60 s. If the amount of lighting on the subject is unchanged and the lens is set at *f*/5.6, what is the proper shutter speed at this setting?

a. 1/500 s
b. 1/250 s
c. 1/8 s
d. 1/16 s

4. The ciliary muscle is instrumental in changing the shape of which eye part?

a. iris
b. lens
c. pupil
d. retina

5. Which eye defect is corrected by a lens having different curvatures in two perpendicular directions?

a. myopia
b. presbyopia
c. hyperopia
d. astigmatism

6. A Young's double slit has a slit separation of 2.50×10^{-5} m on which a monochromatic light beam is directed. The resultant bright fringes on a screen 1.00 m from the double slit are separated by 2.30×10^{-2} m. What is the wavelength of this beam? (1 nm = 10^{-9} m)

a. 373 nm
b. 454 nm
c. 575 nm
d. 667 nm

7. Two narrow slits are 0.025 mm apart. When a laser shines on them, bright fringes form on a screen that is a meter away. These fringes are 3.0 cm apart. What is the separation between the second order bright fringe and the central fringe?

a. 8.6 cm
b. 6.0 cm
c. 5.3 cm
d. 2.6 cm

8. An energy of 13.6 eV is needed to ionize an electron from the ground state of a hydrogen atom. What wavelength is needed if a photon accomplishes this task?

a. 60 nm
b. 80 nm
c. 70 nm
d. 90 nm
e. 40 nm

9. How much energy does a photon of AM-radiation have whose frequency is 63 kHz?

a. 1.0×10^{-38} J
b. 6.6×10^{-30} J
c. 4.2×10^{-29} J
d. 3.1×10^{-30} J
e. 13.1×10^{-29} J

10. How much energy does a photon of FM-radiation have whose frequency is 89.7 Mhz?

a. 2.2×10^{-33} J
b. 9.5×10^{-27} J
c. 7.4×10^{-42} J
d. 5.9×10^{-26} J
e. 3.7×10^{-25} J

11. It is estimated that nine photons of 1.06 micron ($1\mu = 10^{-6}$ m) infrared radiation are needed to excite an electron from its valence state. This corresponds to an energy (in eV) of

a. 13.6
b. 1.2
c. 3.3
d. 5.2
e. 10

12. When a photon is scattered from an electron, there will be an increase in the photon's
A) wavelength.
B) momentum.
C) speed.
D) frequency.
E) energy.

13. The Earth is 1.49 x 1011 meters from the sun. If the solar radiation at the top of the Earth's atmosphere is 1340 W/m2, what is the total power output of the sun?

A) 7×10^{27} W
B.) 2×10^{30} W
C) 6.62×10^{26} W
D) 3.73×10^{26} W
E) 2.98×10^{25} W

14. Find the force exerted by reflecting sunlight off a reflecting aluminum sheet in space if the area normal to the sunlight is 10,000 m2 and the solar intensity is 1350 W/m2.

a. 0.72 N
b. 0.09 N
c. 9 N
d. 45 N
e. 0.18 N

15. A 100-kW radio station emits EM waves in all directions from an antenna on top of a mountain. What is the intensity of the signal at a distance of 10 km?

a. 8×10^{-5} W/m^2
b. 8×10^{-6} W/m^2
c. 3mW/m^2
d. 0.8 W/m^2
e. 2.5×10^{-5} W/m^2

16. Find the frequency of X-rays of wavelength 1 A = 10^{-10} m.

a. 3×10^{18} Hz
b. 3×10^{10} MHz
c. 6×10^{9} Hz
d. 3×10^{8} Hz
e. 3×10^{20} Hz

17. Green light has a wavelength of 5.4×10^{-7} m. What is the frequency of this EM-wave in air?

a. 5.55×10^{14} Hz
b. 6×10^{11} Hz
c. 9×10^{8} Hz
d. 3×10^{10} MHz
e. 1.8×10^{15} Hz

18. Light of wavelength 500 nm shines on a soap bubble film ($n = 1.46$). For what soap film thickness, other than the minimum thickness, will constructive interference occur?

a. 63 nm
b. 86 nm
c. 172 nm
d. 257 nm

19. A silicon monoxide thin film ($n = 1.45$) of thickness 90.0 nm is applied to a camera lens made of glass ($n = 1.55$). This will result in a destructive interference for reflected light of what wavelength?

a. 720 nm
b. 558 nm
c. 522 nm
d. 450 nm

2. A Young's double-slit apparatus is set up so that a screen is positioned 1.6 m from the double slits and the spacing between the two slits is 0.040 mm. What is the distance between alternating bright fringes on the screen if the light source has a wavelength of 630 nm? (1 nm $= 10^{-9}$ m)

a. 0.016 m
b. 0.025 m
c. 0.032 m
d. 0.047 m

2. Electromagnetic radiation of wavelength 3.5 meters is which type?
A) visible
B) ultraviolet
C) microwaves
D) AM-radio
E) FM-radio

22 Electromagnetic radiation of wavelength 0.3 pico-meters is which type?
A) visible
B) ultraviolet
C) X-rays
D) FM-radio
E) gamma rays

23 Electromagnetic radiation of wavelength 2.5 cm is which type?
A) AM-radio
B) visible
C) microwaves
D) ultraviolet
E) FM-radio

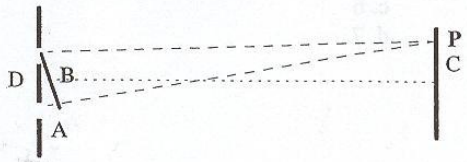
24. Electromagnetic radiation of wavelength 200. nano-meters is which type?

A) ultraviolet
B) visible
C) microwaves
D) X-rays
E) AM radio

25. Electromagnetic radiation of wavelength 3.5 meters is which type?

A) ultraviolet
B) microwaves
C) AM-radio
D) visible
E) FM-radio

26. After light from a source passes through two slits, a first order bright spot is seen on the wall at point P. Which distance is equal to the wavelength of the light?



a. the extra distance one beam must travel
b. the distance between beams as they leave the slit
c. the distance of point P from the central point of the interference pattern
d. the distance between slits

27. If the 2nd order fringe in Young's double-slit experiment occurs at an angle of 45.0°, what is the relationship between the wavelength λ and the distance between slits, d?

a. $d = 1.41\lambda$
b. $d = 2.00\lambda$
c. $d = 2.83\lambda$
d. $d = 4.00\lambda$

28 LCD stands for

a. linearly collimated diffraction.
b. longitudinally combined depolarization.
c. liquid crystal display.
d. lighted compact disk.

29. A diffraction grating with 10 000 lines/cm will exhibit the first order maximum for light of wavelength 510 nm at what angle? (1 nm = 10^{-9} m)

a. 0.51°
b. 0.62°
c. 15.3°
d. 31°

30. What is the highest order maximum for wavelength 450 nm than can be obtained with a grating with 600 lines per mm?

a. 3
b. 4
c. 6
d. 7

ANS- KEY

Geometric Optics
Part 1

1. D
2. D
3. C
4. B
5. A
6. C
7. B
8. D
9. A
10. D
11. C
12. A
13. A
14. C
15. A
16. C
17. C
18. C
19. C
20. B
21. C
22. C
23. B
24. B
25. A
26. A
27. C
28. A
29. D
30. D
31. C
32. D
33. A
34. B
35. D

Do Not Write Below:

Score, Part 1, Q 1-35:_____

Physical Optics
Part 2

1. A
2. C
3. A
4. B
5. D
6. C
7. B
8. D
9. C
10. D
11. E
12. A
13. D
14. B
15. A
16. A
17. A
18. D
19. C
20. B
21. E
22. E
23. C
24. A
25. E
26. A
27. C
28. C
29. D
30. A

Do Not Write Below:

Score, Part 2, Q 1-30:_____