Science Olympiad

2012 Battle of Valley Forge

Optics C

School Name: _____

Team Number _____

Do not open this pack until instructed to do so.

Part 1 – Geometric Optics (30 points):

Directions: Fill in your response for each question in the space provided on the answer sheet corresponding to that question. Incorrect or missing units will count as an incorrect answer. Ambiguous or illegible responses will be scored as incorrect.

For questions 1-4, refer to the diagrams at right:

1. This figure best represents the Law of Refraction.

2. This figure best represents Specular Reflection.

3. This figure best represents the Law of Reflection.

4. This figure best represents Diffuse Reflection.
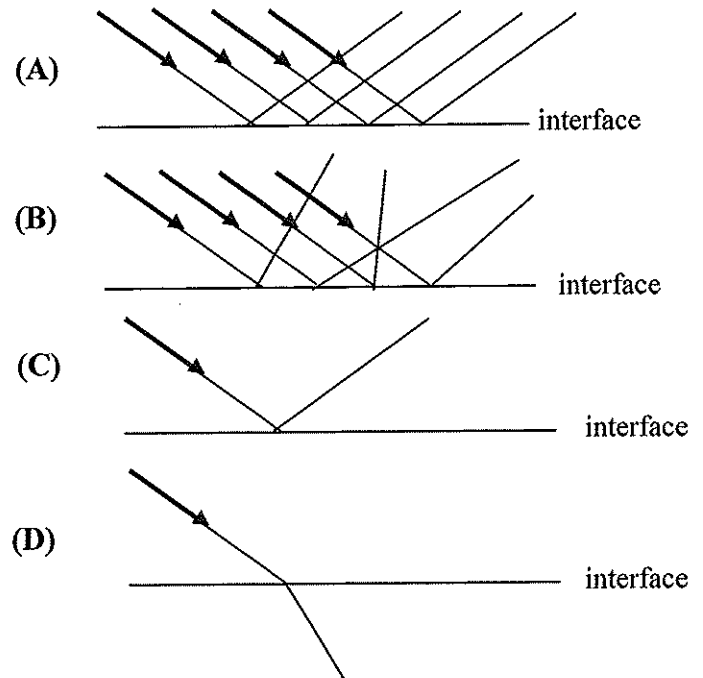
The following information applies to questions 5-8:

Light of wavelength 680 nm in air enters water, making an angle of 40° with the normal. The index of refraction of water is 1.33. To three significant figures,

5. Find the angle of reflection.

6. Find the angle of refraction.

7. Find the frequency, in Hz, of light in the water.

8. Find the wavelength, in nm, of light in the water.

9.   White light is dispersed into its various colors as it passes through a prism because
   A)   The critical angle depends of the frequency of the incident light.
   B)   The angle of incidence depends on the frequency of the incident light.
   C)   The angle of reflection depends on the frequency of the incident light.
   D)   The speed of light in the prism depends on the frequency of the incident light.

10.   What is the minimum length of a plane mirror so that a 1.90 m tall man standing 2.50 m from the mirror can see all of himself in the mirror?
   A)   0.95 m
   B)   1.31 m
   C)   1.90 m
   D)   3.80 m
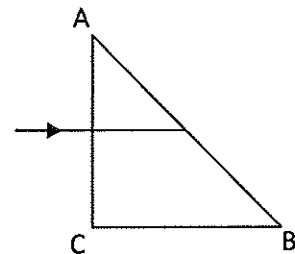
11.   A prism whose angles are 45°, 45°, and 90° is illuminated by light entering as shown in the figure at right. To three significant figures, what is the minimum index of refraction the glass must have so that no light leaves the glass through the side AB?

Questions 12-15:
A converging **lens** has a focal length of 15 cm. An object is placed 60 cm from the lens as shown in the figure below.
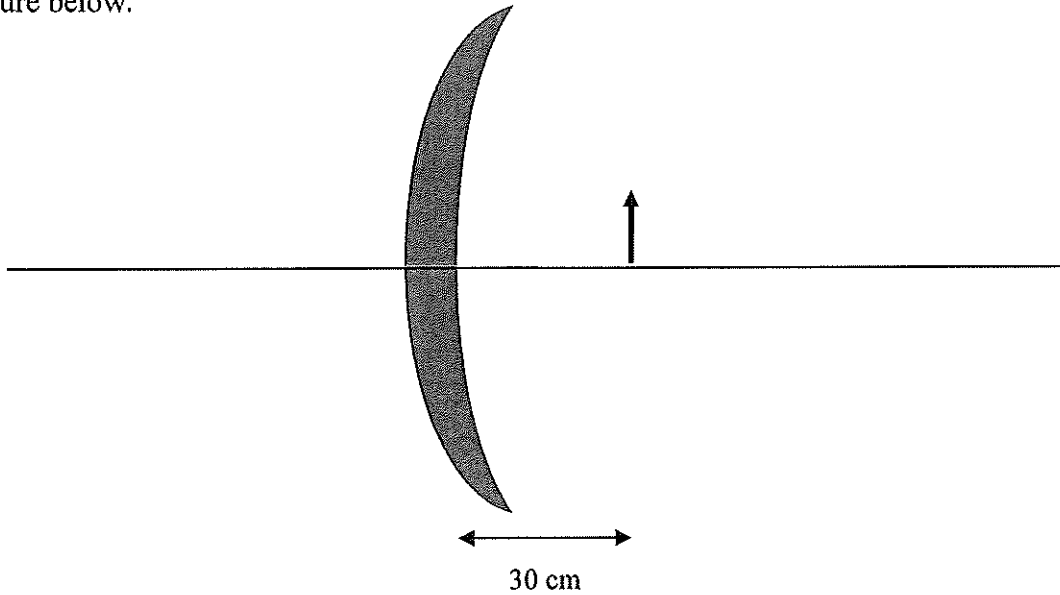
12.   How far from the lens, in cm, will the image be?

13.   Determine the magnification of the image

14.   The image is
   A)   Real and erect.
   B)   Real and inverted.
   C)   Virtual and erect.
   D)   Virtual and inverted.

15.   Construct a ray diagram for this problem on the figure on the answer sheet.

60 cm
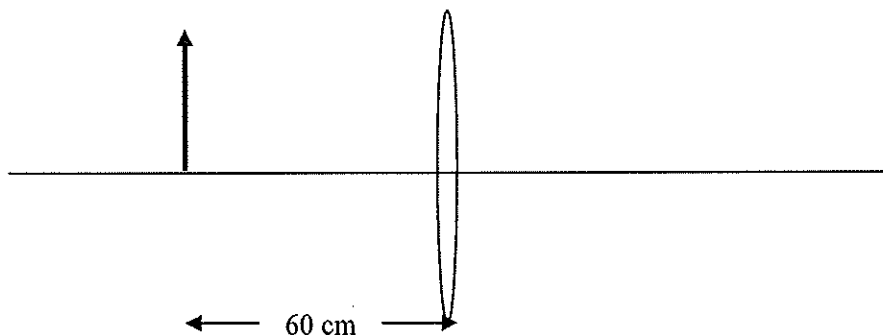
Questions 16-19:

A **mirror** has a focal length of 45 cm. An object is placed 30 cm from the mirror as shown in the figure below.

30 cm

16. How far from the lens, in cm, will the image be?

17. Determine the magnification of the image

18. The image is
    E) Real and erect.
    F) Real and inverted.
    G) Virtual and erect.
    H) Virtual and inverted.

19. Construct a ray diagram for this problem on the figure on the answer sheet.

20. What is the speed of light in water?

Part 3 – Physical Optics (30 points):

Use the table below to answer questions 21-35.

Answer Choice	Radiation Type
A	Gamma Rays
B	Infrared Radiation
C	Microwave Radiation
D	Radio Wave
E	Ultraviolet Radiation
F	Visible Light
G	X-Rays

21. This is produced by atomic transitions where an electron jumps from a very excited state into the ground state in high atomic number atoms.

22. Radiation often associated with heat.

23. Radiation emitted by oscillating electric currents.

24. Radiation also known as Bremsstrahlung.

25. Radiation produced by rotational or vibrational molecular excitations.

26. Detected by rods and cones.

27. Produced by nuclear transitions.

28. Lowest frequency radiation.

29. Highest energy radiation.

30. Lowest energy radiation that is harmful to biological molecules.

31. Electromagnetic radiation of wavelength 2.5 m is of this type.

32. Electromagnetic radiation of wavelength 2.5 cm is of this type.

33. Electromagnetic radiation of wavelength 2.5 nm is of this type.

34. Electromagnetic radiation of frequency $5.0 \times 10^{+17}$ Hz is of this type.

35. Electromagnetic radiation of frequency $1.5 \times 10^{+8}$ Hz is of this type.

36. In 1987, a supernova was observed in the Large Magellanic Cloud, a nearby dwarf galaxy. This supernova is estimated to be 1.76 x 10²¹ m from the Earth. How many years prior to our observation of it did the explosion actually occur?

37. A galaxy is moving away from us at 5.8 x 10⁶ m/s. Its light appears to observers to have a frequency of 5.6 x 10¹⁴ Hz. What is the emitted frequency of the light, in Hz?

38. Earth is 2.5 times farther from the sun than is Mercury. How much brighter does the sun appear on the surface of Mercury compared to the surface of the Earth?

39. What is the energy, in Joules, of a photon of wavelength 525 nm, which is in the middle of the green part of the visible spectrum?

40. Which of the following light color combinations is incorrect?
    A)   Red plus green produces yellow.
    B)   Red plus yellow produces magenta.
    C)   Blue plus green produces cyan.
    D)   Blue plus yellow produces white.

41. What is meant by color by subtraction of light?
    A)   Adding green, red, and blue light produces white light.
    B)   Exciting phosphors with electrons in a television produces color.
    C)   Paint color is changed by subtracting certain colors, such as producing blue paint from green by removing yellow.
    D)   The color that an object appears to be is a result of the material absorbing specific light wavelengths and reflecting the rest.

42. What happens to the image formed by a convex lens when half of the lens is covered?
    A)   Half of the image disappears.
    B)   The image gets blurry.
    C)   The image inverts.
    D)   The image dims.

43. The retina of the eye cotains these two types of photoreceptor cells.

44. A laser beam at 638 nm illuminates two narrow slits. The third-order band of the resulting pattern is 7.5 cm from the central bright band. The screen is 2.475 m from the slits. How far apart are the slits?
    A)   5.8 x 10⁻⁸ m
    B)   6.3 x 10⁻⁷ m
    C)   2.1 x 10⁻⁵ m
    D)   6.3 x 10⁻⁵ m

45. If the light from the sun is passed through a prism or a diffraction grating, the resulting spectrum contains a rainbow of color with many very narrow dark bands. This spectrum is called a(n)

    A) Absorption spectrum
    B) Continuous spectrum
    C) Emission spectrum
    D) Interference spectrum

46. If current is passed through a tube containing Helium gas, and the resulting light passed through a diffraction grating, the resulting spectrum is called a(n)

    A) Absorption spectrum
    B) Continuous spectrum
    C) Emission spectrum
    D) Interference spectrum

47. If white light is passed through a diffraction grating, the resulting spectrum is called a(n)

    A) Absorption spectrum
    B) Continuous spectrum
    C) Emission spectrum
    D) Interference spectrum

48. Suppose a single laser beam is passed through a beam splitter (point A), so that two beams of equal intensity are sent along two different, but equal length, paths (I and II). The two beams are then recombined at a single point (point B), as in the diagram below. In terms of the original intensity, what will be the intensity at the point B?
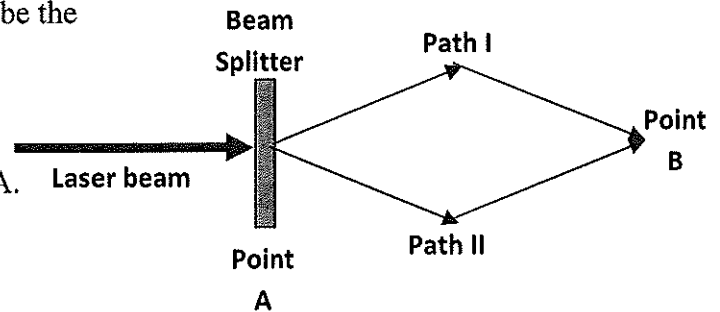
    A) The same intensity as at point A.
    B) Twice the intensity as at point A.
    C) Four times the intensity as at point A.
    D) Zero intensity.

49. The reason for your answer in the previous problems can be described as due to

    A) Constructive interference.
    B) Destructive interference.
    C) Double slit diffraction.
    D) Single slit refraction.

50. Red light travels fastest through

    A) Air
    B) Diamond
    C) Vacuum
    D) Water

Part 1 – Geometric

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

11 _____

12 _____

13 _____

14 _____

15 see below

16 _____

17 _____

18 _____

19 see below

20 _____

Part 2 - Physical

21 _____

22 _____

23 _____

24 _____

25 _____

26 _____

27 _____

28 _____

29 _____

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31 _____

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_____

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50 _____

15)
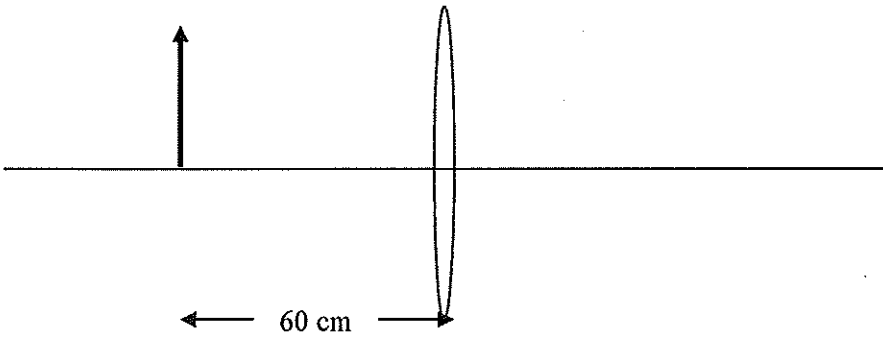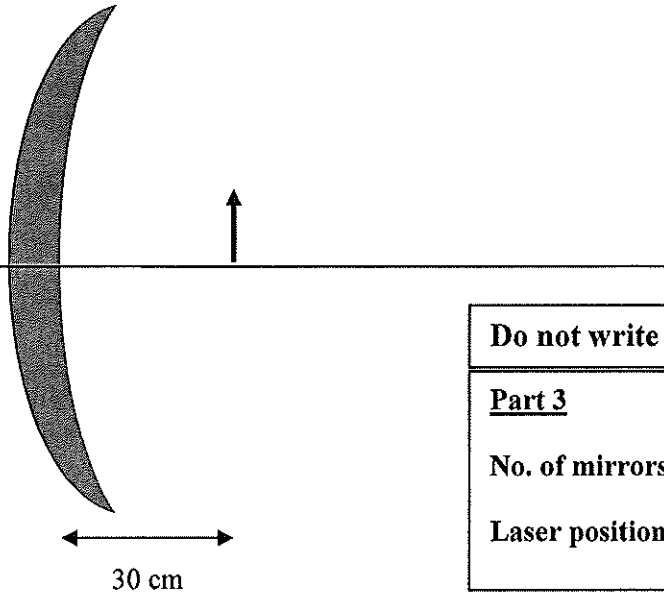
← 60 cm →

19)

← 30 cm →

Do not write below.

Part 3   Laser Shoot

No. of mirrors _____

Laser position _____

Part 1 – Geometric

1 D
2 A
3 C
4 B
5 40.0°
6 28.9°
7 4.41×10^{14} Hz
8 511 nm
9 D
10 A
11 1.41
12 20 cm
13 -1/3
14 B
15 see below
16 90 cm
17 +3
18 G
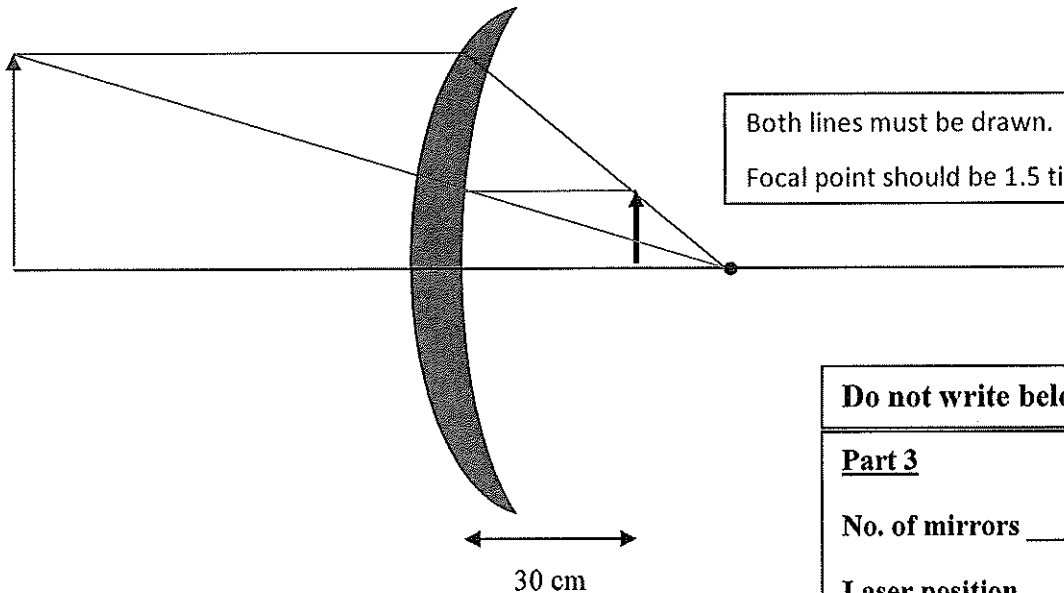19 see below
20 2.26×10^8 m/s

Part 2 - Physical

21 G
22 B
23 D
24 G
25 C
26 F
27 A
28 D
29 A
30 E
31 D
32 C
33 G
34 G
35 D
36 186,000 years
37 5.71×10^{14} Hz
38 6.25
39 3.78×10^{-19} J
40 B
41 D
42 D
43 rods
    cones
44 D
45 A
46 C
47 B
48 A
49 A
50 C

15)
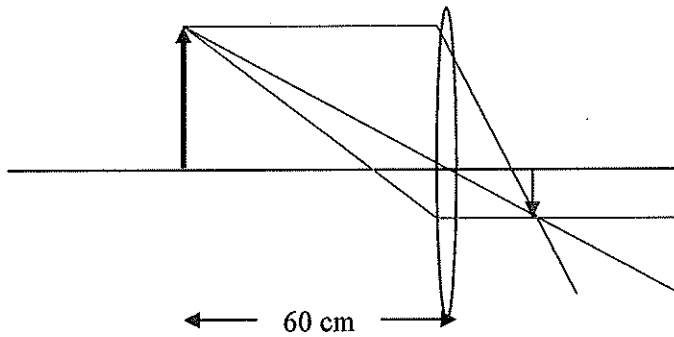
Two of three lines must be drawn.

Focal point should be ¼ distance of object.

60 cm

19)

Both lines must be drawn.

Focal point should be 1.5 times object distance.

30 cm

Do not write below.

Part 3   **Laser Shoot**

No. of mirrors _____

Laser position _____