Team Number: C - ______
Student 1: ______________________
Student 2: ______________________

CyFalls 2016
Science Olympiad Invitational
Optics Exam

Brought to you by: The High School for the Performing and Visual Arts

Permitted materials:
Calculators, Writing Utensils, Reference Materials in a 3 ring binder, Any Measuring Tools, Pre-Made Templates. No Mirrors or Lasers are allowed

Basic Instructions: There are 2 parts to this exam as noted in the official Science Olympiad rules. You will have 50 minutes total at this event but part of your time (~ 6 minutes) will be used to transition to, compete in and transition from the Laser Shoot. During the Laser Shoot you will have exactly 4 minutes to set your mirrors. Be sure to listen closely for your team name and number and be ready with your materials to compete.
Answer Document

(All answers MUST be clearly marked on this page to receive credit)

Questions with asterisk (*) are tie breakers in order of appearance.

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

Team number: C ___
As shown above, a beam of white light is separated into separate colors when it passes through a glass prism. Red light is refracted through a smaller angle than violet light because red light has a

(A) slower speed in glass than violet light
(B) faster speed in glass than violet light
(C) slower speed in the incident beam than violet light
(D) faster speed in the incident beam than violet light
(E) greater intensity than violet light

A ray of light in glass that is incident on an interface with ice, as shown above, is partially reflected and partially refracted. The index of refraction \( n \) for each of the two media is given in the figure. How do the angle of reflection and the angle of refraction compare with the angle of incidence \( \theta \)?

<table>
<thead>
<tr>
<th>Angle of Reflection</th>
<th>Angle of Refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Same</td>
<td>Larger</td>
</tr>
<tr>
<td>(B) Same</td>
<td>Smaller</td>
</tr>
<tr>
<td>(C) Smaller</td>
<td>Same</td>
</tr>
<tr>
<td>(D) Smaller</td>
<td>Smaller</td>
</tr>
<tr>
<td>(E) Larger</td>
<td>Larger</td>
</tr>
</tbody>
</table>

When one uses a magnifying glass to read fine print, one uses a

(A) converging lens to produce a virtual image of the print
(B) converging lens to produce a real image of the print
(C) mirror to produce a virtual image of the print
(D) diverging lens to produce a real image of the print
(E) diverging lens to produce a virtual image of the print

The critical angle for a transparent material in air is 30°. The index of refraction of the material is most nearly

(A) 0.33
(B) 0.50
(C) 1.0
(D) 1.5
(E) 2.0
An object $O$ is located at point $P$ to the left of a converging lens, as shown in the figure above. $F_1$ and $F_2$ are the focal points of the lens.

Use information above for 5 and 6

5* If the focal length of the lens is 0.40 m and point $P$ is 0.30 m to the left of the lens, where is the image of the object located?

(A) 1.2 m to the left of the lens
(B) 0.17 m to the left of the lens
(C) At the lens
(D) 0.17 m to the right of the lens
(E) 1.2 m to the right of the lens

6 Which of the following characterizes the image when the object is in the position shown?

(A) Real, inverted, and smaller than the object
(B) Real, upright, and larger than the object
(C) Real, inverted, and larger than the object
(D) Virtual, upright, and larger than the object
(E) Virtual, upright, and smaller than the object

8 An object is placed as shown in the figure above. The center of curvature $C$ and the focal point $F$ of the reflecting surface are marked. As compared with the object, the image formed by the reflecting surface is

(A) erect and larger
(B) erect and the same size
(C) erect and smaller
(D) inverted and larger
(E) inverted and smaller

9 The spherical mirror shown above has a center of curvature at point $c$. Which point is nearest to the focal point?

(A) $a$
(B) $b$
(C) $c$
(D) $d$
(E) $e$

An object is placed near a plane mirror, as shown above. Which of the labeled points is the position of the image?

(A) $A$  (B) $B$  (C) $C$  (D) $D$  (E) $E$
A light ray \( R \) in medium I strikes a sphere of medium II with angle of incidence \( \theta \) as shown above. The figure shows five possible subsequent paths for the light ray.

10* Which path is possible if medium I is air and medium II is glass?

(A) A
(B) B
(C) C
(D) D
(E) E

11 Which path is possible if medium I is glass and medium II is air?

(A) A
(B) B
(C) C
(D) D
(E) E

12 An object is placed on the axis of a converging thin lens of focal length 2 cm, at a distance of 8 cm from the lens. The distance between the image and the lens is most nearly

(A) 0.4 cm
(B) 0.8 cm
(C) 1.6 cm
(D) 2.0 cm
(E) 2.7 cm

13* A large lens is used to focus an image of an object onto a screen. If the left half of the lens is covered with a dark card, which of the following occurs?

(A) The left half of the image disappears.
(B) The right half of the image disappears.
(C) The image becomes blurred.
(D) The image becomes dimmer.
(E) No image is formed.

14 A physics student places an object 6.0 cm from a converging lens of focal length 9.0 cm. What is the magnitude of the magnification of the image produced?

(A) 0.6
(B) 1.5
(C) 2.0
(D) 3.0
(E) 3.6
15 A concave mirror with a radius of curvature of 1.0 m is used to collect light from a distant star. The distance between the mirror and the image of the star is most nearly

(A) 0.25 m
(B) 0.50 m
(C) 0.75 m
(D) 1.0 m
(E) 2.0 m

16 When light passes from air into water, the frequency of the light remains the same. What happens to the speed and the wavelength of light as it crosses the boundary in going from air into water?

<table>
<thead>
<tr>
<th>Speed</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Increases</td>
<td>Remains the same</td>
</tr>
<tr>
<td>(B) Remains the same</td>
<td>Decreases</td>
</tr>
<tr>
<td>(C) Remains the same</td>
<td>Remains the same</td>
</tr>
<tr>
<td>(D) Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>(E) Decreases</td>
<td>Decreases</td>
</tr>
</tbody>
</table>

17 An object is placed at a distance of 1.5f from a converging lens of focal length f, as shown above. What type of image is formed and what is its size relative to the object?

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Virtual</td>
<td>Larger</td>
</tr>
<tr>
<td>(B) Virtual</td>
<td>Same size</td>
</tr>
<tr>
<td>(C) Virtual</td>
<td>Smaller</td>
</tr>
<tr>
<td>(D) Real</td>
<td>Larger</td>
</tr>
<tr>
<td>(E) Real</td>
<td>Smaller</td>
</tr>
</tbody>
</table>

18 A light ray passes through substances 1, 2, and 3, as shown above. The indices of refraction for these three substances are \( n_1 \), \( n_2 \), and \( n_3 \), respectively. Ray segments in 1 and in 3 are parallel. From the directions of the ray, one can conclude that

(A) \( n_3 \) must be the same as \( n_1 \)
(B) \( n_2 \) must be less than \( n_1 \)
(C) \( n_2 \) must be less than \( n_3 \)
(D) \( n_1 \) must be equal to 1.00
(E) all three indices must be the same

19 When you look at the red petals of a rose, the color light you're seeing is

(A) red.
(B) green.
(C) white minus red.
(D) a mixture of green and yellow.
(E) cyan.

20 When the color yellow is seen on an old CRT TV screen, the phosphors being activated on the screen are

(A) mainly yellow.
(B) blue and red.
(C) green and yellow.
(D) red and green.
21 A beam of white light is incident on a triangular glass prism with an index of refraction of about 1.5 for visible light, producing a spectrum. Initially, the prism is in a glass aquarium filled with air, as shown above. If the aquarium is filled with water with an index of refraction of 1.3, which of the following is true?

(A) No spectrum is produced.
(B) A spectrum is produced, but the deviation of the beam is opposite to that in air.
(C) The positions of red and violet are reversed in the spectrum.
(D) The spectrum produced has greater separation between red and violet than that produced in air.
(E) The spectrum produced has less separation between red and violet than that produced in air.

22 Polarization is a property of

A) transverse waves.
B) longitudinal waves.
C) all waves.
D) None of these.

23 The light in this room leaves the light bulbs, hits the wall and then travels to your eyes. What type of reflection is taking place?

A) Specular
B) Diffuse
C) Rectangular
D) Paint
25 An object is Red under normal white light. What color would it appear to be if all of the lights in the room were turned off except for one Yellow light?
A) Yellow
B) Red
C) Cyan
D) Green
E) Orange

26* An object is Cyan under normal white light. What color would it appear to be if all of the lights in the room were turned off except for one Magenta light?
A) Red
B) Blue
C) Green
D) Magenta
E) Black

27 What type of lens is needed to fix someone’s eyesight who is farsighted?
A) Concave
B) Convex

28 What direction does a polarizing filter need to be in order to cancel out the glare from light reflected off the windows on the side of a building?
A) Right Handed
B) Left Handed
C) Horizontal
D) Vertical
E) None of the above

29 What part of the eye is responsible for “absorbing” incoming photons of light and turning them into electrical signals sent to your brain?
A) Choroid
B) Retina
C) Cornea
D) Pupil
E) Iris

30 What type of lens is the lens in the eye?
A) Double Convex
B) Double Concave
C) Planar Convex
D) Planar Concave
E) Planar

31 A particular film absorbs 400 nm - 500 nm wavelength of light (Violet to Blue) when light is incident upon its surface. What color would the “glare” on the lens appear to be?
A) Red
B) Green
C) Blue
D) Yellow
E) Cyan

32 What do the dark lines mean on an absorption spectra developed for a chemical which is to be coated on top of a surface?
A) Light that was scattered away upon contact.
B) Light that was not present initially.
C) Light that was merged with a nearby color.
D) Light that is still present but is too dim to see because the other colors are brighter.
E) Light that was absorbed upon contact.

33* Light of several wavelengths is incident from above on a thin film of index 1.5 and thickness of 300 nm that’s coated on a surface with an index of 1.6. Which wavelength will produce the most reflected light?
A) 400 nm
B) 450 nm
C) 500 nm
D) 550 nm
E) 650 nm