Name: _____ Class: _____ Date: _____ ID: A

Science Olympiad - Optics - Geometric and Physical Optics

Multiple Choice

Identify the choice that best completes the statement or answers the question. Indicate your answers in the blanks provided.

____ 1. The index of refraction n for a light-carrying medium is defined as the ratio

A) $\left(\frac{\text{speed of light in a vacuum}}{\text{speed of light in the medium}}\right)$

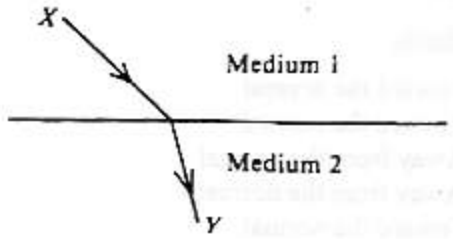
B) $\left(\frac{\text{speed of light in the medium}}{\text{speed of light in a vacuum}}\right)$

C) $\left(\frac{\text{speed of light in the medium}}{\text{frequency of light in the medium}}\right)$

D) $\left(\frac{\text{frequency of light in a vacuum}}{\text{frequency of light in the medium}}\right)$

E) $\left(\frac{\text{frequency of light in the medium}}{\text{wavelength of light in the medium}}\right)$

____ 2.



Light leaves a source at X and travels to Y along the path shown above. Which of the following statements is correct?

A) The index of refraction is the same for the two media
B) Light travels faster in medium 2 than in medium 1
C) Snell's law breaks down at the interface
D) Light would arrive at Y in less time by taking a straight line path from X to Y than it does taking the path shown above
E) Light leaving a source at Y and traveling to X would follow the same path shown above, but in reverse

___ 3. In progression from radio waves to infrared radiation, visible light, ultaviolet radiation, and gamma radiation, what changes would one observe in the character of the waves?

	Wavelength	Frequency	Photon Energy
A)	Increases	Increases	Increases
B)	Increases	Increases	Decreases
C)	Increases	Decreases	Decreases
D)	Decreases	Increases	Increases
E)	Decreases	Increases	Decreases

___ 4. National Public Radio is heard in Washington DC on WAMU, broadcasting on a frequency of 88.5 MHz. What is the wavelength of the radio waves that carry these signals?

A) 3.39 cm B) 88.5 cm C) 3.39 m D) 88.5 m E) 2102 m

___ 5. Observations that suggest that visible light has a wavelength much shorter than a centimeter include which of the following?

I. The colored pattern seen in a soap bubble

II. The colored pattern seen when light passes through a diffraction grating

III. The bending of light when it passes from one medium to another medium

A) I Only B) II Only C) III Only D) I and II E) All

___ 6. When light passes from air into water (which has a greater index of refraction than air), its frequency remains unchanged, and its path is bent from the original line. What happens to the speed, wavelength, and path of the light as it crosses cross the boundary from air into water?

	Speed	Wavelength	Bends
A)	Increases	Remains the Same	Toward the normal
B)	Increases	Increases	Toward the normal
C)	Increases	Increases	Away from the normal
D)	Remains the Same	Decreases	Away from the normal
E)	Decreases	Decreases	Toward the normal

___ 7. In terms of light refracted at an interface, the critical angle θ_c is

A) the minimum angle at which total internal reflection will occur
B) the maximum angle at which total internal reflection will occur
C) the angle at which the light exits the interface
D) the angle at which the light enters the interface
E) perpendicular to the interface

____ 8. In Young's famous experiment, alternating bands of light and dark appeared when a beam of light passed through two very small slits in one screen and was then projected on to a second screen. This experiment supported the notion that light is _____ in nature by revealing interference patterns resulting from _____.

A) wave-like, diffraction
B) particle-like, diffusion
C) wave-like, induction
D) wave-like, dispersion
E) particle-like, diffraction

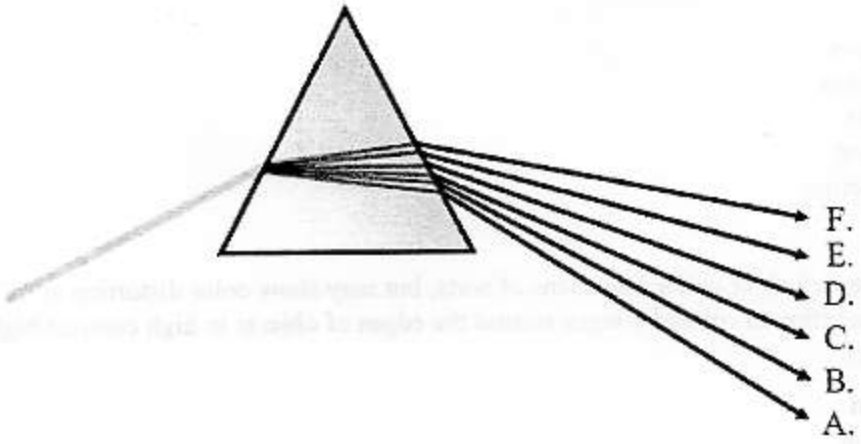
____ 9. A hemispherical glass paperweight will act as a lens of sorts, but may show color distortion at its edges. This effect, which can also manifest as colored fringes around the edges of objects in high contrast/high zoom photographs, is known as

A) spherical abberation
B) chromatic abberation
C) frequency modulation
D) distal diffusion
E) radial diffusion

____ 10. When a train passes by, the pitch of its whistle shifts from higher (as it approaches) to lower (as it recedes). This phenomenon, known as _____, is also manifest in light. In fact, the _____ observed in distant stellar spectra provide evidence to support the supposition that the universe is expanding.

A) The Doppler Effect, Red Shift
B) The Doppler Effect, Blue Shift
C) Huygen's Principle, Interference Pattern
D) Huygen's Principle, Blue Shift
E) The Doppler Effect Interference Pattern

Problem



11.

The figure above depicts a beam of white light entering and exiting a prism. From the choices below, fill in each of the following blanks with the correct color. Next to each color, indicate an approximate wavelength in nanometers.

A.) _____ ≈ _____ nm

B.) _____ ≈ _____ nm

C.) _____ ≈ _____ nm

D.) _____ ≈ _____ nm

E.) _____ ≈ _____ nm

F.) _____ ≈ _____ nm

CHOICES: Blue Green Orange Red Violet Yellow

The appearance of the visible spectrum is the result of the spatial sorting of white light according to its wavelength. What is the name of the physical phenomenon by which this "spreading out" occurs?

G.) _____

GEOMETRIC OPTICS

For each of the next three figures, construct a ray diagram (using *at least* two rays per figure) to indicate the relative position and size of the resulting image. Show "virtual rays" as dashed lines. Additionally, *calculate* and record the indicated values using the appropriate lens/mirror relationships. Show your work.

12. **Thin Converging Lens**

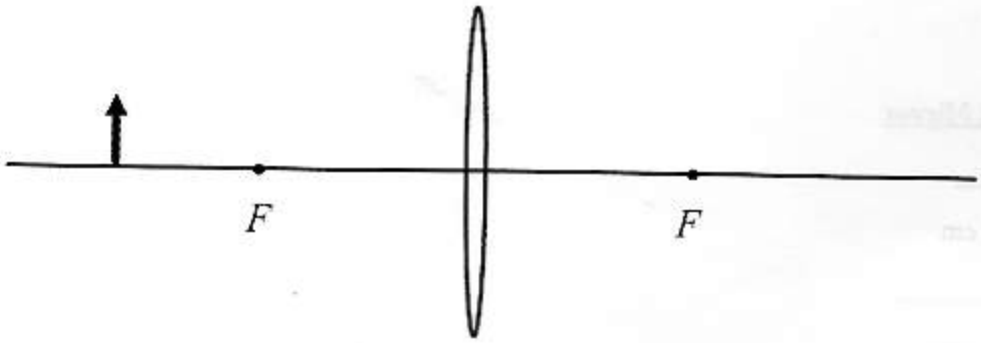
$f = 3$ cm

$d_o = 5$ cm

$d_i =$ _____

$m =$ _____

Is the image real or virtual? _____



13. **Concave Mirror**

$f = 12$ cm

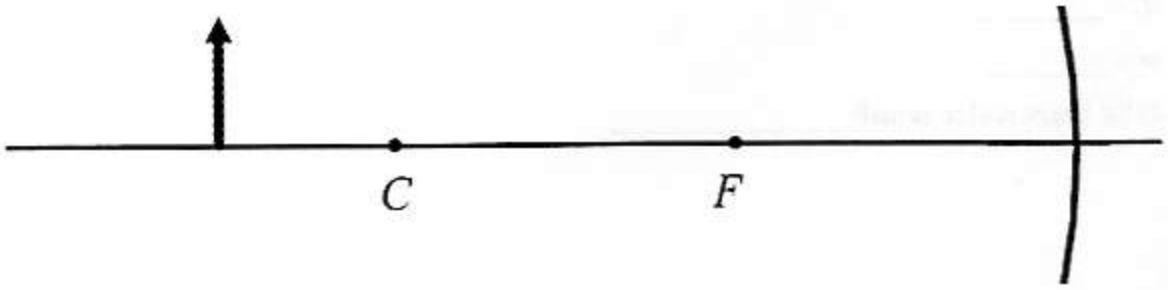
r (radius of curvature) = _____

$d_o = 30$ cm

d_i = _____

m = _____

Is the image real or virtual? _____



14. **Convex Mirror**

$f = -8$ cm

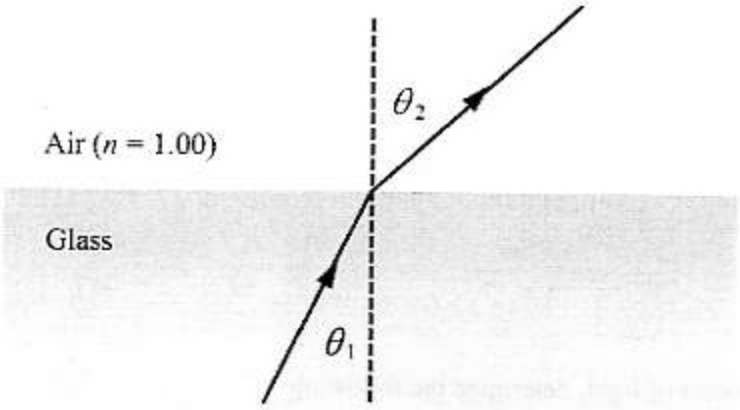
$d_o = 18$ cm

d_i = _____

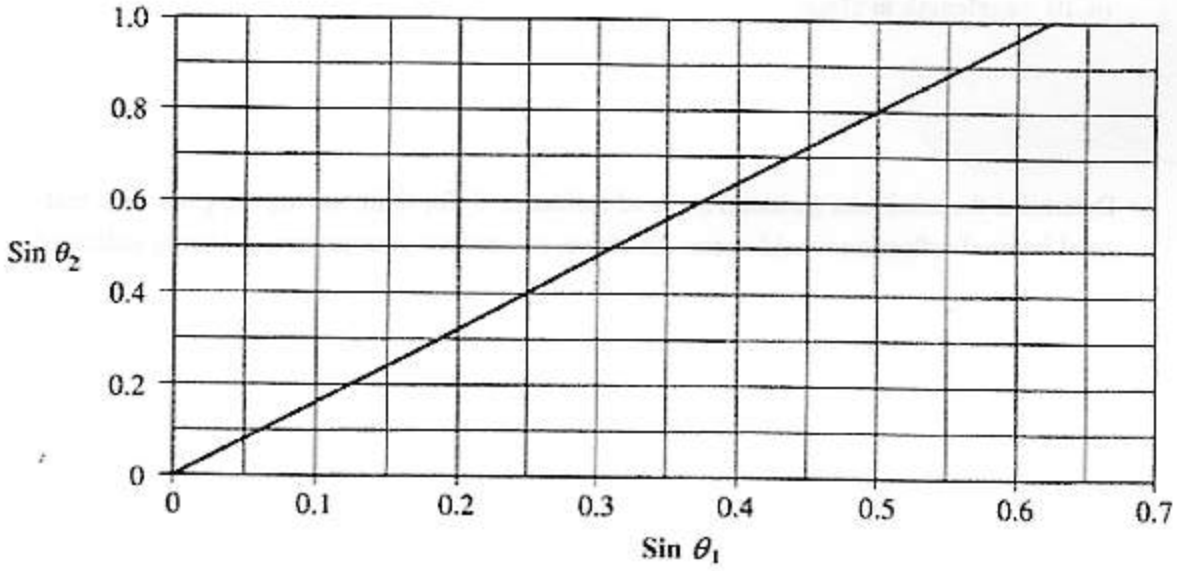
m = _____

Is the image real or virtual? _____

15.



In an experiment, a beam of monochromatic light (wavelength λ = 675 nm in air) passes from glass into air, as shown above. The incident and refracted angles are θ_1 and θ_2, respectively. In the experiment, angle θ_2 is measured for varying angles of incidence θ_1, and the sines of these meausured angles are used to obtain the line shown in the following graph.



a. Assuming an index of refraction of 1.00 for air, *use the graph* to determine a value for the index of refraction n_g of the glass for this color light.Explain how you obtained this value, making clear what information was obtained from the graph, and how it was used.

b. For this color of light, determine the following:

i. Its frequency in air: _____

ii. Its speed in glass: _____

iii. Its wavelength in glass: _____

c. Determine the minimum (critical) angle of incidence θ_c for light leaving the glass such that total internal reflection would occur. As above, ensure that your process is clearly indicated.