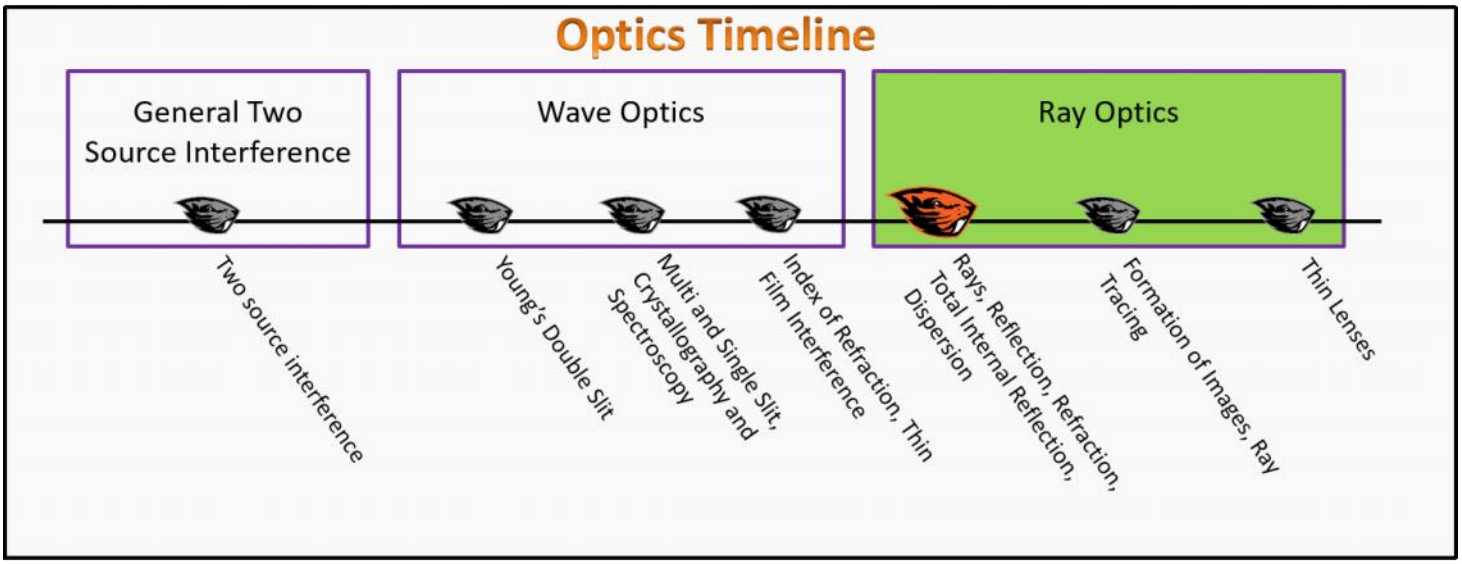
# RO.2.L1 - Template

Monday, April 15, 2019 7:41 AM

# Ray Optics
## Foundation Stage (RO.2.L1)

**Lecture 1**
**Rays, Reflection, Refraction, Total Internal Reflection, Dispersion**




**Textbook Chapters** (* Calculus version)

- **BoxSand** :: KC videos ( Snell's Law of Refraction )
- **Knight** (College Physics : A strategic approach 3rd) ::
- ***Knight** (Physics for Scientists and Engineers 4th) ::
- **Giancoli** (Physics Principles with Applications 7th) ::

**Warm up**

**RO.2.L1-1:**

**Description:** Conceptual question about diffraction.

**Learning Objectives:** [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

**Problem Statement:** Which of the following apparatus causes light to diffract?

## Selected Learning Objectives

1. Coming soon to a lecture template near you.

## Key Terms

- Ray model of light
- Incident angle
- Reflection
- Reflected angle
- Law of reflection
- Refraction
- Refracted angle
- Snell's law
- Total internal reflection
- Critical angle
- Dispersion

## Key Equations

| | |
|---|---|
| | |

## Key Concepts

- Coming soon to a lecture template near you.

## Questions

### Act I: Rays Model of Light

**RO.2.L1-2:**

**Description:** Conceptual question about diffraction and interference. (2 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Which of the following statements are true?

(1) Sound is a wave, while light is really a ray.
(2) Some objects emit rays of light, while other sources emit waves.
(3) Light can be modeled as a ray or a wave at the same time.
(4) Waves can bend but rays only ever travel in a straight line.

**RO.2.L1-3:**

**Description:** Differentiate between double slit interference patterns and multi-slit interference patterns. (2 minutes + 2 minutes)

**Learning Objectives:** [?]

**Problem Statement:** When would you use the ray model vs the wave model of light to analyze a system?

(1) Use the wave model when your surfing and the ray model when buying sunglasses.
(2) Use the wave model for sound and the ray model for light.
(3) Use the wave model when light interacts with objects that have a size on the order of the light's wavelength.
(4) Use the ray model when light interacts with objects that have a size much larger than the light's wavelength.
(5) Use the wave model when light is interacting with anything and the ray model when the light is not interacting with anyt hing.

**RO.2.L1-4:**

**Description:** Differentiate between double slit interference patterns and multi-slit interference patterns. (2 minutes )

**Learning Objectives:** [?]

**Problem Statement:** Which of the following happens when light crosses a boundary of different index of refractions?

(1) Reflection.
(2) Transmission.
(3) Absorption.
(4) Scattering.
(5) Brody wags his tail.

## Act II: Reflection

**RO.2.L1-5:**

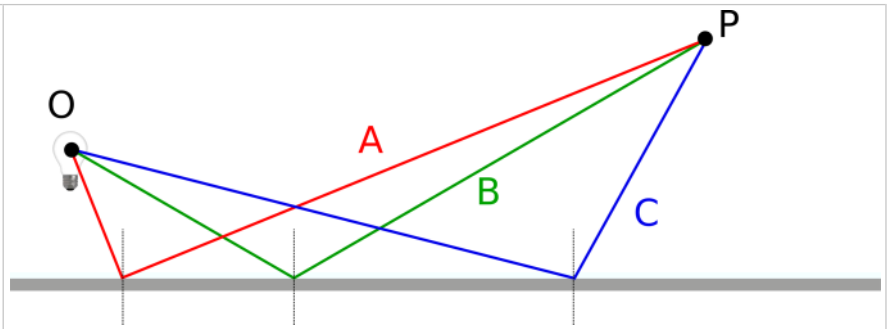
**Description:** Conceptual question about diffraction and white light. Proportional reasoning with diffraction grating math model for PLD. (2 minutes + 4 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Rays of light travel from an object O to an observer at P via a reflecting surface. Which of the three paths provides

the shortest path from **O** to **P**?

(1) Path 1.
(2) Path 2.
(3) Path 3.
(4) All three are the same.
(5) The answer depends on the roughness of the surface.



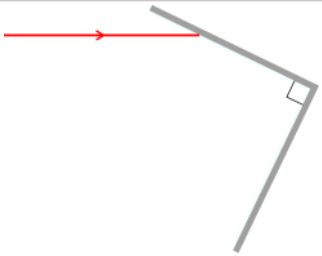

**RO.2.L1-6:**

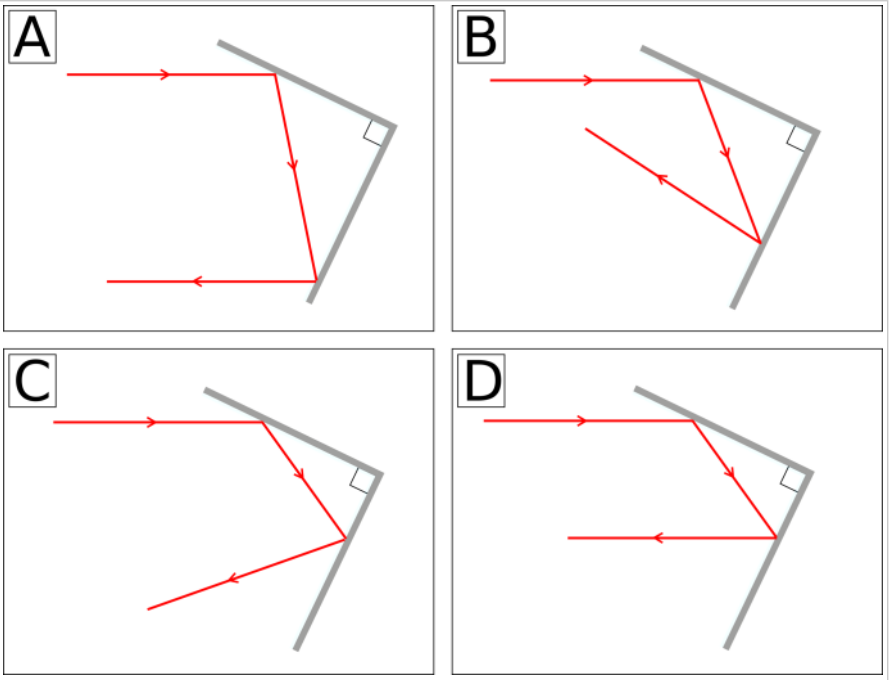
**Description:** Diffraction grating question given wavelength, lines per distance, screen distance, and fringe of interest, find the angle. (2 minutes + 3 minutes + 3 minutes + 6 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Light enters horizontally into the combination of two perpendicular mirrors as shown below. Which of the following images best represent the path the given light ray takes after reflecting off the surfaces?

(1) A
(2) B
(3) C
(4) D



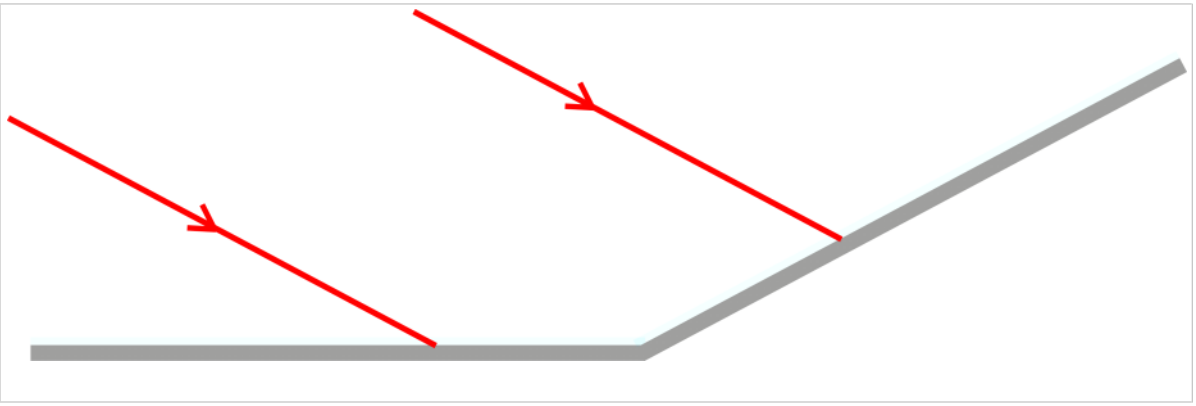


**RO.2.L1-7:**

**Description:** Conceptual question about shining a laser on a DVD and observing an interference pattern. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Two reflecting surfaces are used to make the shape shown below. The sunlight from very far away is represented by the two rays shown in the image. Sketch the path of each ray after reflecting off each surface.



## Act III: Refraction

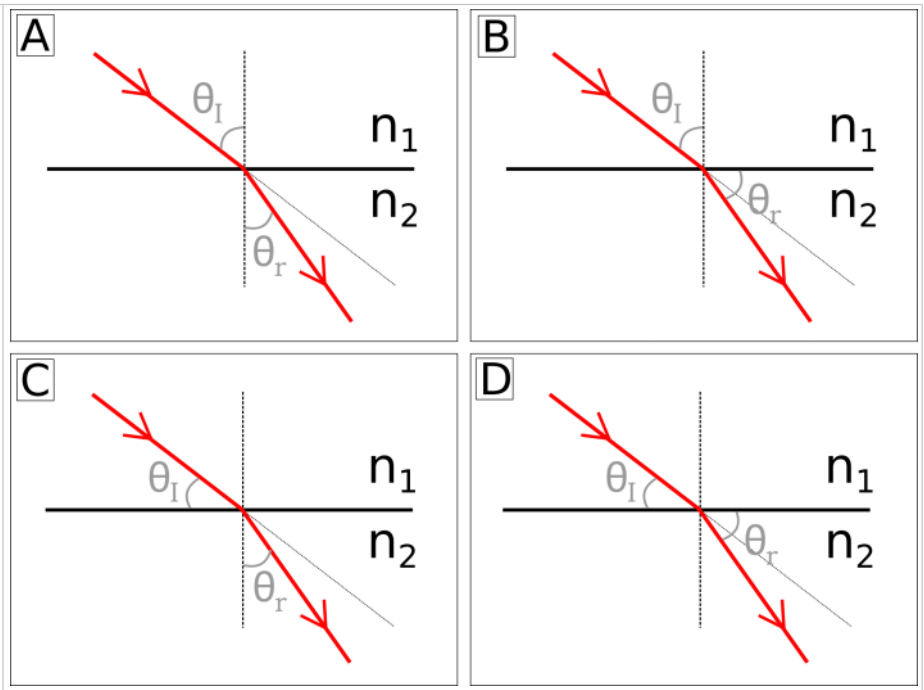
**RO.2.L1-8:**

**Description:** Conceptual question comparing multi-slit and single slit analysis. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** The angle of reflection is equal to the angle of incidence: $\theta_I = \theta_R$. The refracted angle is related to the angle of incidence by the mathematical model: $n_1 \sin(\theta_I) = n_2 \sin(\theta_r)$. Which of the following physical representations correctly match the given mathematical model for refraction?

(1) A
(2) B
(3) C
(4) D




**RO.2.L1-9:**

**Description:** Proportional reasoning with single slit PLD math model. (4 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Light traveling in air strikes a horizontal piece of glass. The light makes an angle of 20 degrees with respect to the horizontal surface. The index of refraction for air and glass are $\mathbf{n_{air}}$ = 1 and $\mathbf{n_{glass}}$ = 1.52. Calculate the refracted angle?

(1) ####
(2) ###
(3) ####
(4) ####

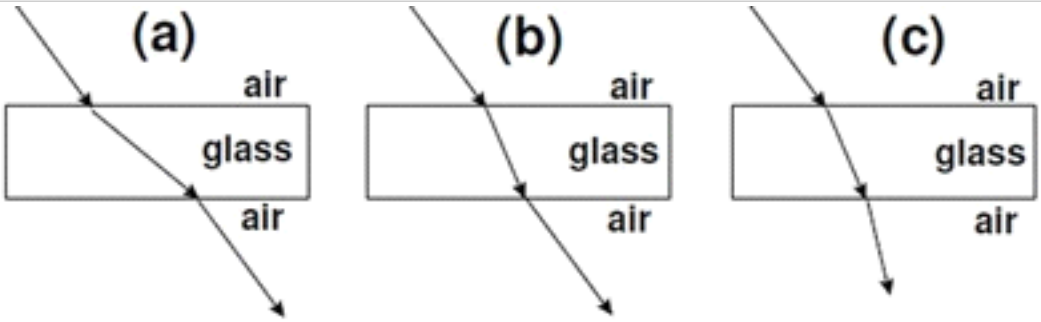
**RO.2.L1-10:**

**Description:** Conceptual question about small angle approximation with single slit apparatus. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Which of the ray diagrams shown below are possible?

(1) A
(2) B
(3) C



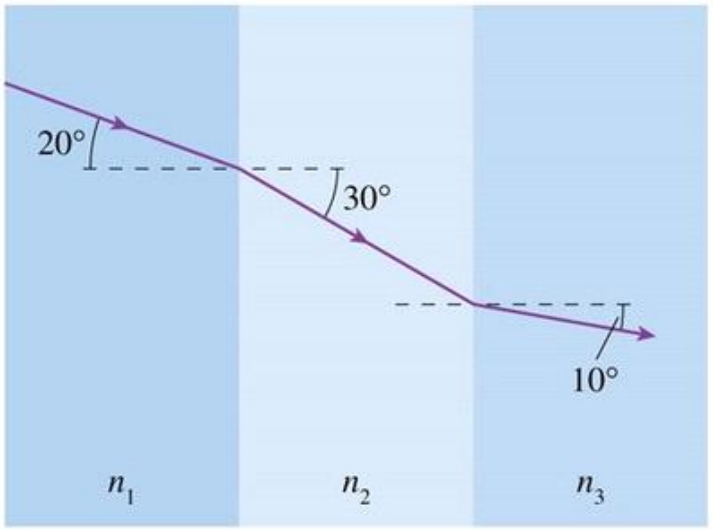
**RO.2.L1-11:**

**Description:** Proportional reasoning question for single slit apparatus. (5 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Rank the following mediums based on index of refraction.

(1) $n_1 > n_2 > n_3$
(2) $n_3 > n_1 > n_2$
(3) $n_2 > n_3 > n_1$
(4) $n_3 > n_2 > n_1$

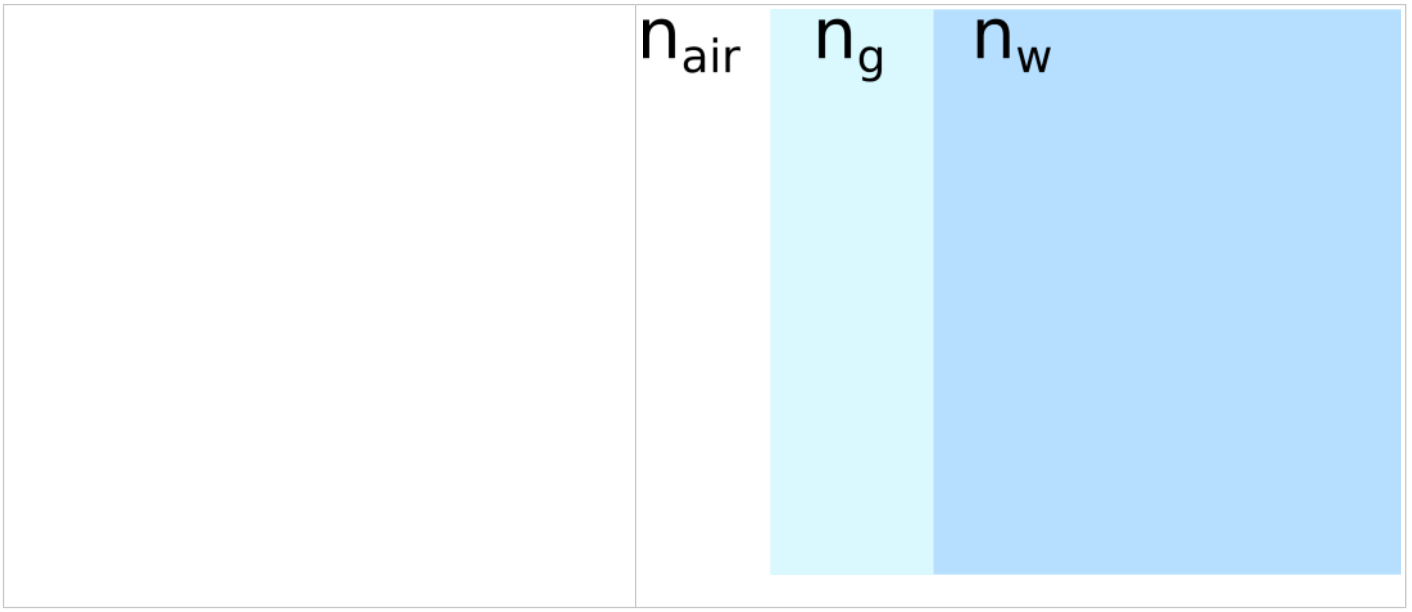


**RO.2.L1-12:**

**Description:** Given screen distance, wavelength, distance between two dark fringes, find slit width for single slit apparatus. (6 minutes)

**Learning Objectives:** [?]

**Problem Statement:** An aquarium filled with water has flat glass sides and an index of refraction of 1.54. A beam of light from the outside air strikes the glass at a 43.5 degree angle to the perpendicular as shown below. What is the angle of refraction when the light ray enters the water? $\mathbf{n_{water}} = 1.33$




**RO.2.L1-13:**

**Description:** Conceptual question about diffraction comparing light and sound. (4 minutes)

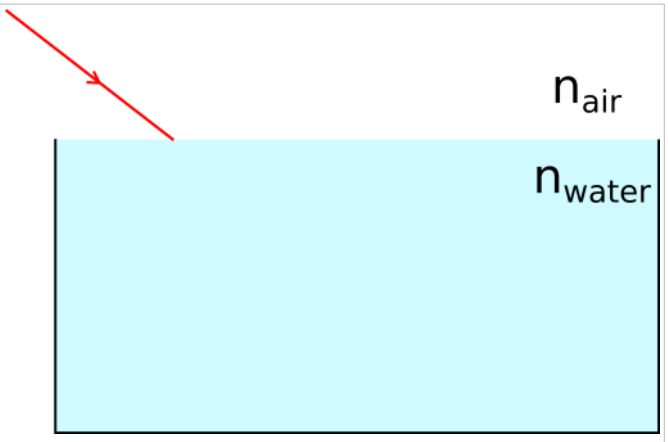
**Learning Objectives:** [?]

**Problem Statement:** Light of wavelength 569 nm in a vacuum strikes the surface of a liquid at an angle of 31.2 degrees with respect to the normal of the surface. The liquid has an index of refraction of 1.52. The depth of the liquid is 10 meters. We wish to determine the time it takes for the light to travel from the surface of the liquid to the bottom.

**(a)** Which of the following physics analysis tools might be useful for this system?

(1) Kinematics
(2) Force analysis
(3) Momentum analysis
(4) Energy analysis
(5) Snell's law

**(b)** How long does it take for light to travel from the surface to the bottom?




## Act IV: Application of Refraction | Total Internal Reflection

**RO.2.L1-14:**

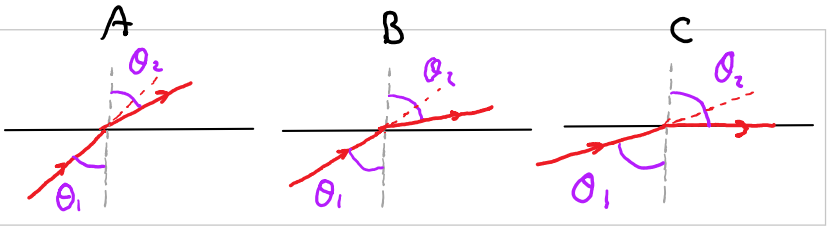
**Description:** Conceptual question about crystallography. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** A beam of light is shown onto a horizontal flat surface. The light is originally in a material with an index $\mathbf{n_1}$ and the flat surface has an index $\mathbf{n_2}$. The image below shows this system when the beam is shown at a few different angles.

**(a)** Use Snell's law to find $\sin(\boldsymbol{\theta_1})$ for the third image **C**.

(1) $\sin(\boldsymbol{\theta_1}) = \mathbf{n_2} / \mathbf{n_1}$
(2) $\sin(\boldsymbol{\theta_1}) = \mathbf{n_2} / \mathbf{n_1} \sin(90°)$
(3) $\sin(\boldsymbol{\theta_1}) = \mathbf{n_1} / \mathbf{n_2}$
(4) $\sin(\boldsymbol{\theta_1}) = \mathbf{n_1} / \mathbf{n_2} \sin(90°)$




**(b)** For this specific system in the third image C, θ1 is often referred to as the

(1) important angle.
(2) critical angle.

(3) angley angle.

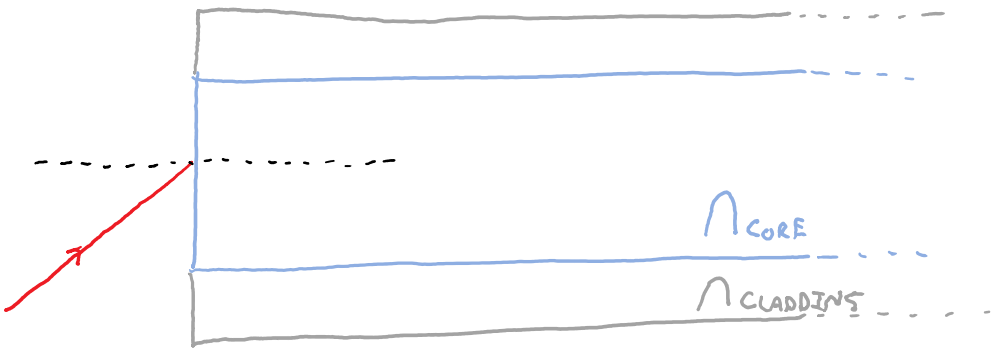
**RO.2.L1-15:**

**Description:** Conceptual question about crystallography. (4 minutes)

**Learning Objectives:** [?]

**Problem Statement:** A horizontal section of fiber optic cable consists of an inner glass core with index of refraction of 1.50 and an outer cladding of index 1.45. What is the minimum incident angle such that the light never escapes the inner core?

| | |
|---|---|
| (1) ### | |
| (2) #### | |
| (3) #### | |
| (4) ### | |




## Act V: Dispersion

**RO.2.L1-16:**

**Description:** Conceptual question about spectroscopy. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Which of the following statements are true regarding dispersion?

(1) Dispersion is the phenomena that different frequencies of light refract at different angles.
(2) Dispersion is the phenomena that the index of refraction depends on the frequency of the light.
(3) Dispersion is the phenomena that creates a rainbow when sunlight shines through a prism.

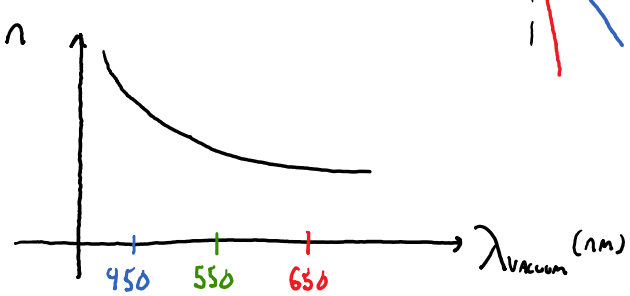
**RO.2.L1-17:**

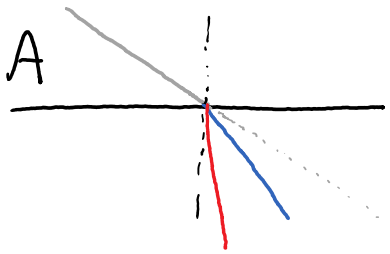
**Description:** Conceptual question about spectroscopy. (3 minutes)

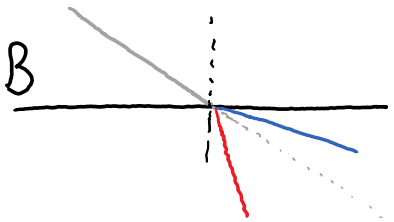
**Learning Objectives:** [?]

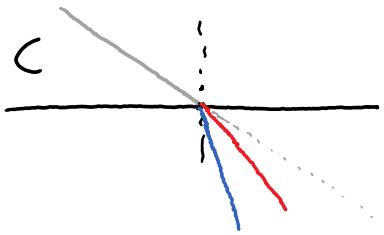
**Problem Statement:** The typical frequency dependence of the index of refraction is shown below. Which of the following physical representations correctly represents the refracted blue and red light rays when white light is incident on a piece of glass at some angle relative to the normal?

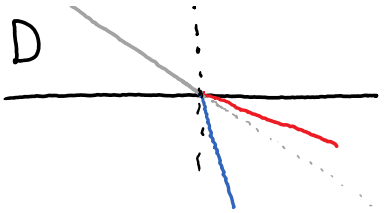
| | | |
|---|---|---|
| (1) A<br>(2) B<br>(3) C<br>(4) D | | |



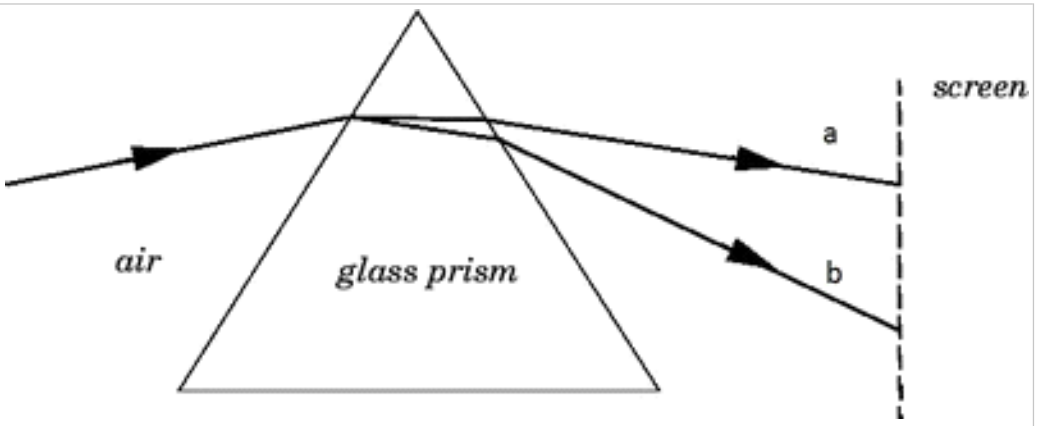

**RO.2.L1-18:**

**Description:** Conceptual question about spectroscopy. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** White light enters a glass prism. When the light leaves the prism, the colors have been separated. Match each ray after leaving the prism, red or violet.

(1) A - Violet ; B - Red
(2) A - Red ; B - Violet




**RO.2.L1-19:**

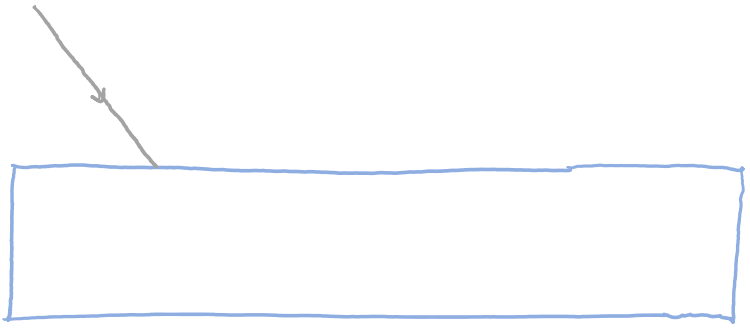
**Description:** Conceptual question about spectroscopy. (3 minutes )

**Learning Objectives:** [?]

**Problem Statement:** A rectangular slab of glass surrounded by air on all sides has white light shone onto it at an angle as shown in the image below. Sketch the red and blue rays when the light enters and leaves the glass.

**Problem Statement:** A rectangular slab of glass surrounded by air on all sides has white light shone onto it at an angle as shown in the image below. Sketch the red and blue rays when the light enters and leaves the glass.

IMG



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## Conceptual questions for discussion

1. Coming soon to a lecture template near you.

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## Hints

**WO.2.L2-1**: No hints.

**WO.2.L2-2**: No hints.

**WO.2.L2-3**: No hints.

**WO.2.L2-4**: No hints.

**WO.2.L2-5**: No hints.

**WO.2.L2-6**: No hints.

**WO.2.L2-7**: No hints.

**WO.2.L2-8**: No hints.

**WO.2.L2-9**: No hints.

**WO.2.L2-10**: No hints.

**WO.2.L2-11**: No hints.

**WO.2.L2-12**: No hints.

**WO.2.L2-13**: No hints.

**WO.2.L2-14**: No hints.

**WO.2.L2-15**: No hints.

**WO.2.L2-16**: No hints.

**WO.2.L2-17**: No hints.

**WO.2.L2-18**: No hints.

**WO.2.L2-19**: No hints.

**WO.2.L2-20**: No hints.