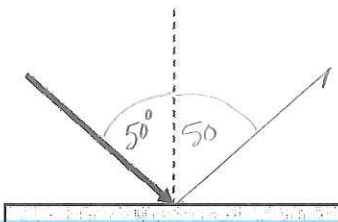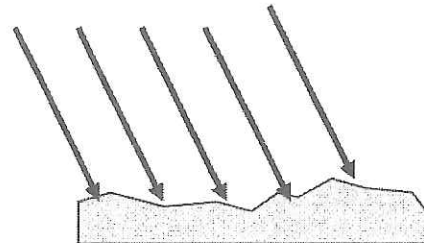# Skill 55: Law of Reflection

Reflection

Regular Reflection

Normal – perpendicular to surface

Law of Reflection
$\theta_i = \theta_r$

Diffuse Reflection

Reflection from an irregular surface

When a light ray approaches a surface, the angle is measured between the light ray and the normal line.

Remember that "normal" means perpendicular to the surface.

In reflection the incident angle (incoming angle) is equal to the reflected angle.
-Since the light does not change medium in reflection it does not speed up or slow down, therefore the angle relative to the normal line does not change.

290. Use a protractor to measure the angle of incidence in the diagram to the left above. Draw in the angle of reflection.

50^0

Skill 56- Snell's Law

291. REFRACTION – Bending of light upon entering a new medium

The frequency of a wave does not change once it is produced, even if it enters a new medium. When it enters a new medium it will change speed and wavelength

$$v = f\lambda \qquad \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} \qquad n = \frac{c}{v}$$

-Velocity/speed is ___directly___ related to wavelength.

- Index of refraction is ___inversely___ related to both velocity/speed and wavelength.

-The angle of incidence (θ_1 or θ_i) is a measure of the number of degrees between "straight on" (entering on the normal line) and the angle of the incoming ray upon the surface.

-The angle of the refraction (θ_2 or θ_r) is a measure of the number of degrees between "straight out" and the angle departing the surface in the new medium.

If the index of refraction increases it will bend "toward the normal" after entering new medium

If the index of refraction decreases it will bend "___away___ ___from___ the normal after entering new medium

normal

n2 > n1

θ_1

θ_2

normal

n2 < n1

θ_2

θ_1
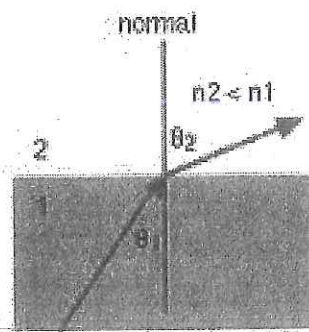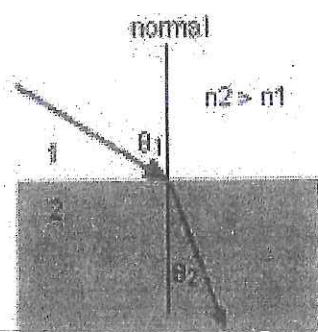
Refraction is a reversible process

Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ or, equivalently, $\sin\theta_1 / \sin\theta_2 = v_1 / v_2$

Refraction causes you to see an image in a different position than the actual position.

Air
(medium 2)

Apparent Position

Angle from Perpendicular

Observer

Water
(medium1)
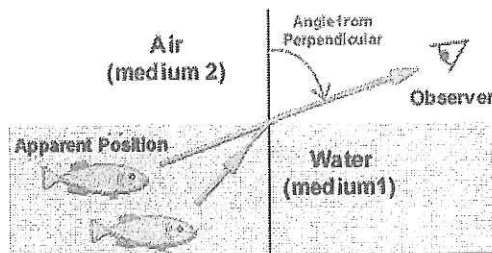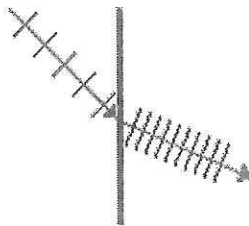
SNELL'S LAW: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{\sin\theta_1}{\sin\theta_2}$$

292. If the light ray enters a new medium at an angle of zero (___on the normal___) then the speed changes and the wavelength changes according to an ___inverse___ relationship with index of refraction "n". The ___frequency___ remains the same.

The Importance of the Angle of Approach
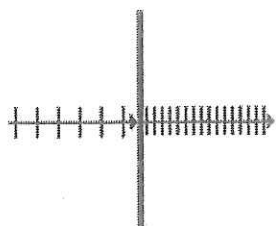
This light wave will not refract.   This light wave will refract.

Practice: Reflection and Refraction

293.   In order to study reflection or refraction we need a tool that allows us to analyze all surface shapes. This tool is the ___normal___ line, which is an imaginary line perpendicular to the surface at the point the ray hits.
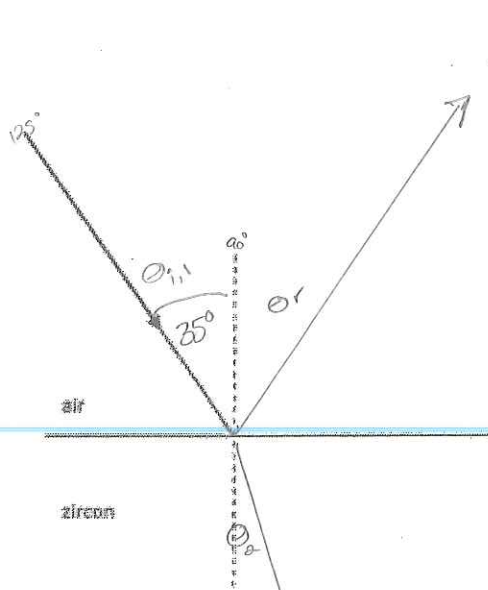
294.   Given the light ray and the surface shape draw in a normal line. If the point is curved you can draw in a tangent line for help
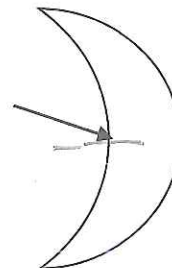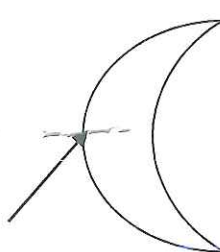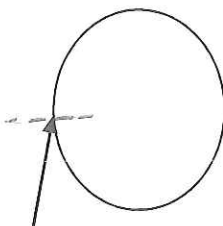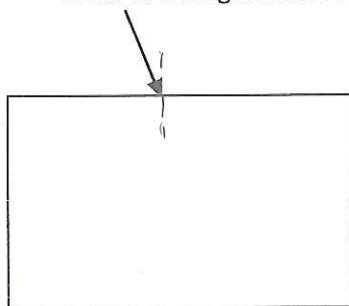
295.   Use a protractor to draw in the reflected ray.

Mirror

Mirror
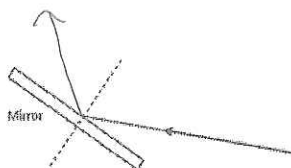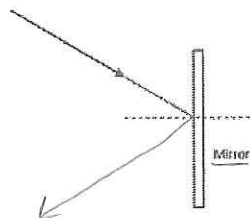
296. For each boundary below, draw the reflected and refracted ray. (Show work for any calculations)
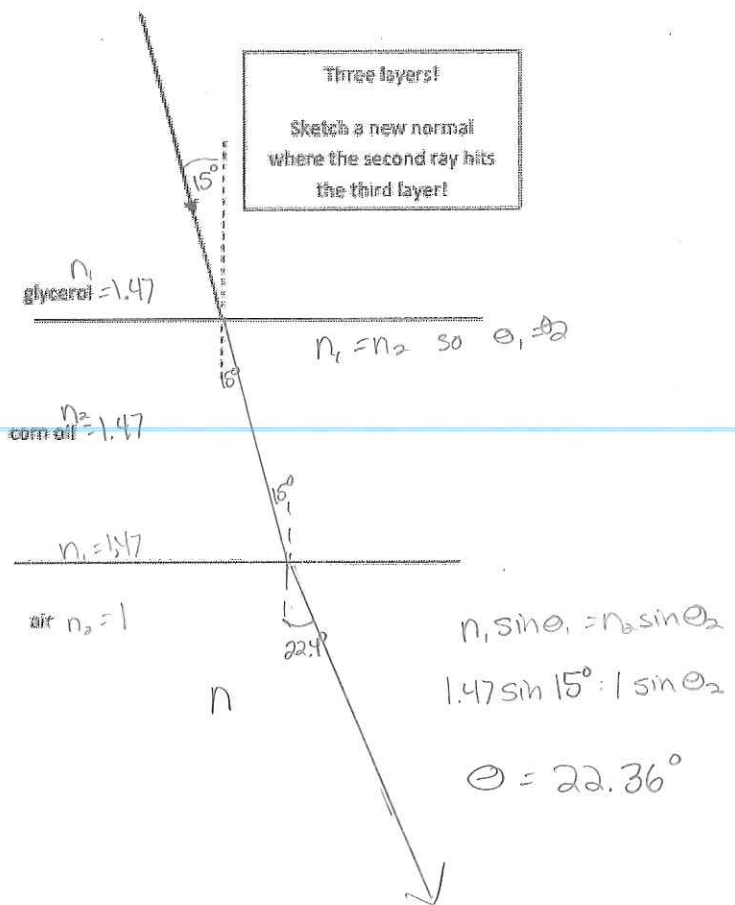
125°

$\theta_{i,1}$

90°

θ_r

35°

air

zircon

θ_2

$n_1 = 1$

$n_2 = 1.92$ (PRT)

$\theta_1 = 35°$

$\theta_2 = ?$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1 \sin 35° = 1.92 \sin\theta_2$

$\theta_2 = 17.4°$

Three layers!

Sketch a new normal where the second ray hits the third layer!

15°

n_1
glycerol = 1.47

$n_1 = n_2$ so $\theta_1 = \theta_2$

16°

n_2
corn oil = 1.47

15°

$n_1 = 1.47$

air $n_2 = 1$

22.4°

n

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1.47 \sin 15° = 1 \sin\theta_2$

$\theta = 22.36°$

297.

Normal

Air
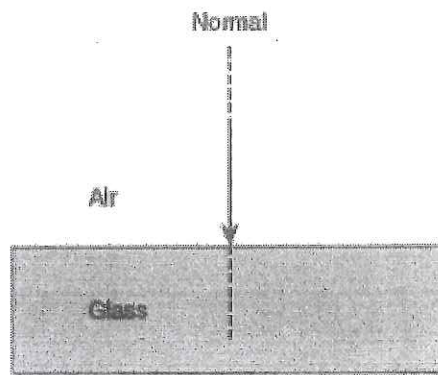
Glass

Which statement best describes the speed and the direction of the light ray as it passes into the glass?

(1) Only speed changes.
(2) Only direction changes.
(3) Both speed and direction change.
(4) Neither speed nor direction change.

298. Briefly summarize each of the following wave phenomena

Reflection — Bouncing of a wave off of a boundary

Refraction — Bending of a wave as it enters a new medium with a different "n"

Diffraction — Bending of a wave through an opening or around obstacle

Polarization — selecting waves by orientation (vertical or horizontal)

Interference — When two waves are in the same place at the same time

Standing Wave - pattern of nodes & antinodes formed by interference & reflection
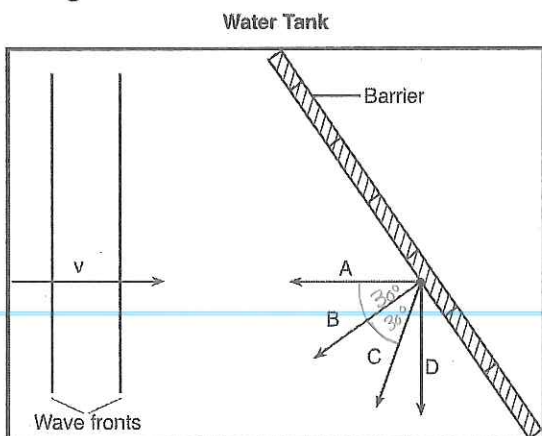
Resonance — when a wave from the environment causes a medium to vibrate at it natural frequency

Doppler Effect — the apparent change in frequency of a wave due to the relative motion of a source and an observer

299. The diagram below represents a view from above of a tank of water in which parallel wave fronts are traveling toward a barrier.

Water Tank

Which arrow represents the direction of travel for the wave fronts after being reflected from the barrier?
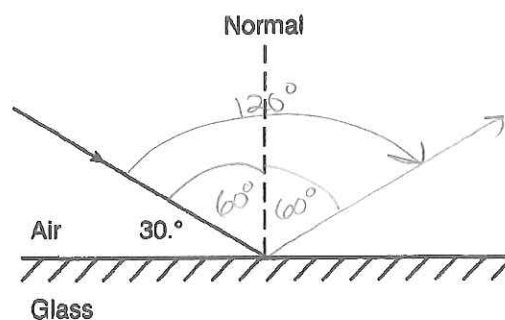
A) *A*   B) *B*   C) *C*   D) *D*

300. The diagram below represents a light ray reflecting from a plane mirror.
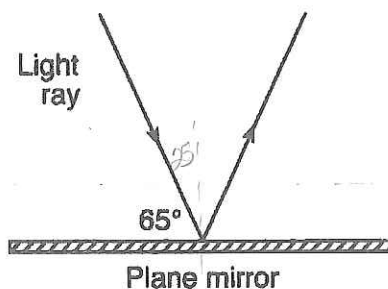
The angle of reflection for the light ray is
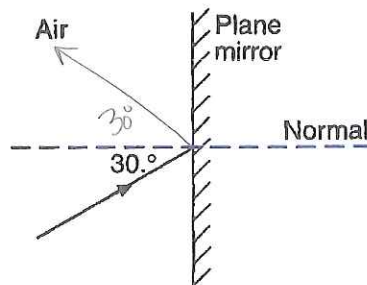
A) 25°   B) 35°   C) 50.°   D) 65°

301. The diagram below represents a light ray striking the boundary between air and glass.

What would be the angle between this light ray and its reflected ray?

A) 30.°   B) 60.°   C) 120.°   D) 150.°

302. A ray of monochromatic light traveling in air is incident on a plane mirror at an angle of 30.°, as shown in the diagram below.
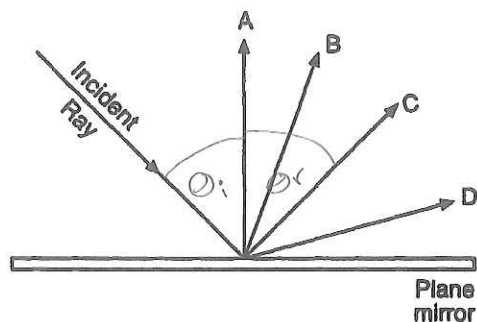

The angle of reflection for the light ray is

A) 15°   B) 30.°   C) 60.°   D) 90.°

303. A light ray is incident on a plane mirror as shown in the diagram below.

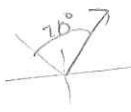Which ray best represents the reflected ray?

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

304. A ray of light strikes a plane mirror at an angle of incidence equal to 35°. The angle between the incident ray and the reflected ray is

A) 0°   B) 35°   C) 55°   D) 70°

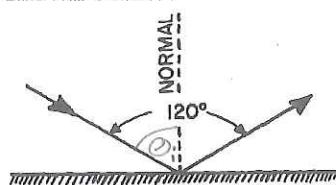305. When a ray of light strikes a mirror perpendicular to its surface, the angle of reflection is

A) 0°   B) 45°   C) 60°   D) 90°

306. A light ray is incident upon a plane mirror. If the angle of incidence is increased, the angle of reflection will

A) decrease   B) increase
C) remain the same
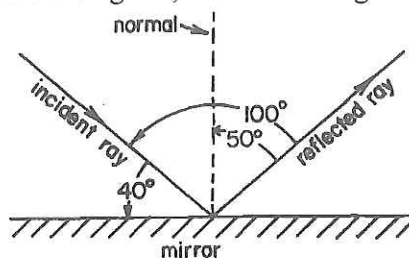
$$\theta_i = \theta_r$$

307. What is the angle of incidence of the light ray shown below?

A) 30°   B) 60°   C) 90°   D) 150°

308. The diagram below represents a light ray being reflected from a plane mirror. From the data given in the diagram, what is the angle of reflection?

A) 10   B) 40   C) 50   D) 100

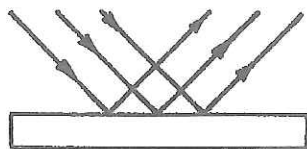309. The diagram below shows parallel rays of light incident on an irregular surface.
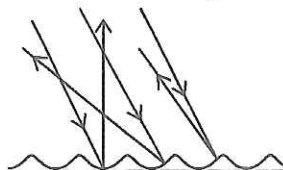
Which phenomenon of light is illustrated by the diagram?

A) diffraction   B) refraction
C) regular reflection   D) diffuse reflection
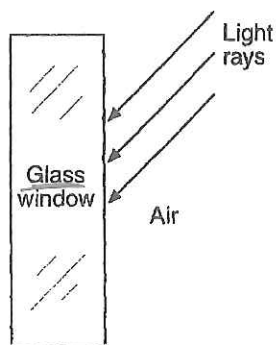
310. Which phenomenon of light is illustrated by the diagram below?

A) regular reflection   B) diffuse reflection
C) diffraction   D) refraction

311. The diagram below shows light rays in air about to strike a glass window.

When the rays reach the boundary between the air and the glass, the light is

A) totally refracted
B) totally reflected
C) partially reflected and partially diffracted
D) partially reflected and partially refracted

312. A light spring is attached to a heavier spring at one end. A pulse traveling along the light spring is incident on the boundary with the heavier spring. At this boundary, the pulse will be

A) totally reflected
B) totally absorbed
C) totally transmitted into the heavier spring
D) partially reflected and partially transmitted into the heavier spring

313. Which will generally occur when a pulse reaches a boundary between two different media?

A) The entire pulse will be reflected.
B) The entire pulse will be absorbed.
C) The entire pulse will be transmitted.
D) Part of the pulse will be transmitted and part will be reflected.

314. A ray of monochromatic yellow light ($f = 5.09 \times 10^{14}$ Hz) passes from water through flint glass and into medium X, as shown below.
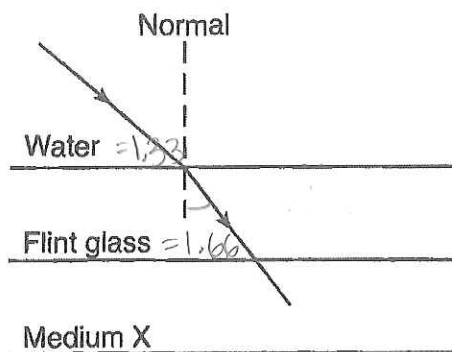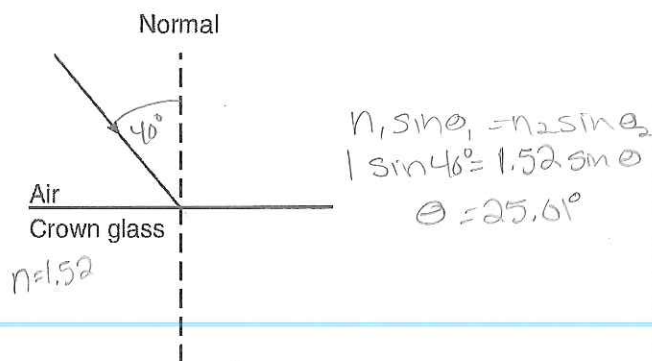

The absolute index of refraction of medium X is

A) less than 1.33
B) greater than 1.33 and less than 1.52
C) greater than 1.52 and less than 1.66
D) equal to 1.66

No change in θ from
Flint to Medium X
$n_x = n_{Flint} = 1.66$

315. A ray of light ($f = 5.09 \times 10^{14}$ Hz) traveling in air is incident at an angle of 40.° on an air-crown glass interface as shown below.

Normal

40°

Air
Crown glass

n=1.52

$n_1 \sin \theta_1 = n_2 \sin \theta_2$
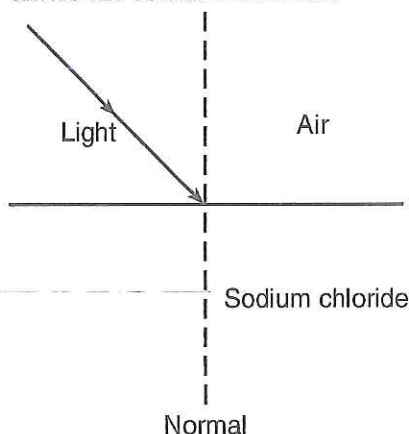$1 \sin 46° = 1.52 \sin \theta$
$\theta = 25.61°$

What is the angle of refraction for this light ray?

A) 25°   B) 37°   C) 40°   D) 78

$\theta_2 < \theta_1$

316. A ray of monochromatic light is incident on an air-sodium chloride boundary as shown in the diagram below. At the boundary, part of the ray is reflected back into the air and part is refracted as it enters the sodium chloride.
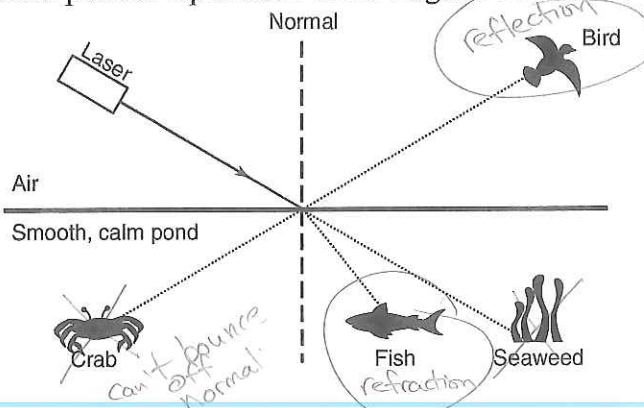
Light   Air

Sodium chloride

Normal θ_2

Compared to the ray's angle of refraction in the sodium chloride, the ray's angle of reflection in the air is

$\theta_i = \theta_r = \theta_1$

A) smaller   B) larger
C) the same

$\theta_i = \theta_r$ (reflection

$\theta_r = \theta_i = \theta_1 > \theta_2$

$n_2 > n_1$ so $\theta_2 < \theta_1$

inverse

317. A laser beam is directed at the surface of a smooth, calm pond as represented in the diagram below.

Normal   reflection   Bird

Laser

Air

Smooth, calm pond

Crab   can't bounce off normal

Fish   refraction   Seaweed

Which organisms could be illuminated by the laser light?

A) the bird and the fish
B) the bird and the seaweed
C) the crab and the seaweed
D) the crab and the fish

318. A pencil appears to be bent at a point where it enters the water in a beaker. This phenomenon is called

A) refraction   B) reflection
C) dispersion   D) rarefaction

319. Base your answer to the following question on the diagram below which represents a ray of yellow light ($l = 5.9 \times 10^{-7}$ meter in air) passing from air into Lucite. Angle θ_1 is 45°.
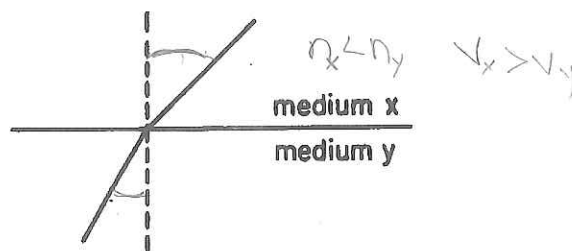
RAY N

45°

θ_1

AIR
LUCITE

θ_2

N
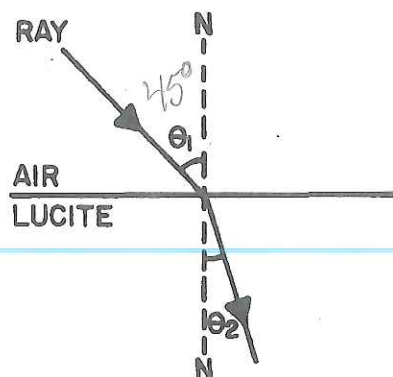
If the light ray were reversed in direction with the angle in the Lucite remaining the same, the angle in the air would be

A) less than 45°
B) 45°
C) between 45° and 72°
D) between 72° and 90°

light is a reversible process

320. The accompanying diagram represents a light ray passing from one medium into another.

$n_x < n_y$ $V_x > V_y$

medium x

medium y

The light ray must be traveling

A) from medium x into medium y   *light is reversible*
B) from medium y into medium x
C) faster in medium x than in medium y
D) faster in medium y than in medium x

all directly related

n is inverse to θ, λ & V

$\theta_x > \theta_y$ so $V_x > V_y$

$n_x < n_y$