Exercise 33.9 - Enhanced - with Solution

Complete

Light traveling in air is incident on the surface of a block of plastic at an angle of 62.4 $^\circ$ to the normal and is bent so that it makes a 49.7 $^\circ$ angle with the normal in the plastic.

You may want to review (Page) .

For related problemsolving tips and strategies, you may want to view a Video Tutor Solution of Reflection and refraction.

Review | Constants

Part A

Find the speed of light in the plastic.

Express your answer in meters per second.

$v =$ 2.58×10^{8} $\mathrm{m/s}$

Exercise 33.11 - Enhanced - with Solution

Review | Constants

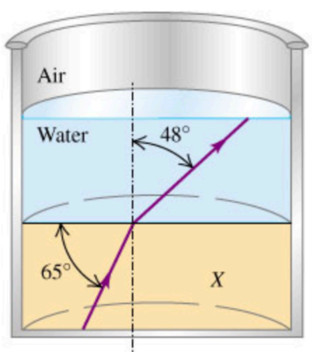
As shown in the figure (Figure 1), a layer of water covers a slab of material X in a beaker. A ray of light traveling upwards follows the path indicated.

You may want to review (Page) .

For related problem-solving tips and strategies, you may want to view a Video Tutor Solution of Reflection and refraction.

Figure

1 of 1



Part A

Using the information on the figure, find the index of refraction of material X .

n_x =

Submit Request Answer

Part B

Find the angle the light makes with the normal in the air.

Express your answer in degrees.

ϕ = °

Submit Request Answer

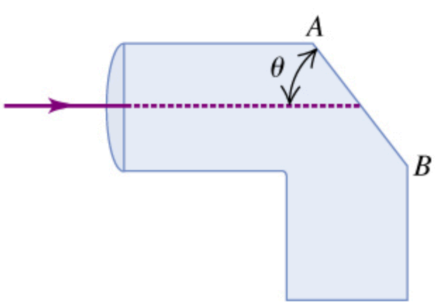
Light enters a solid tube made of plastic having an index of refraction of 1.62. The light travels parallel to the upper part of the tube. (See the figure (Figure 1).) You want to cut the face AB so that all the light will reflect back into the tube after it first strikes that face.

You may want to review (Page) .

For related problem-solving tips and strategies, you may want to view a Video Tutor Solution of A leaky periscope.

Figure

1 of 1



Review | Constants

Part A

What is the largest that θ can be if the tube is in air?

Express your answer in degrees.

θ_{max1} = °

Submit Request Answer

Part B

If the tube is immersed in water of refractive index 1.333, what is the largest that θ can be?

Express your answer in degrees.

θ_{max2} = °

Review | Constants

At the very end of Wagner's series of operas *Ring of the Nibelung,* Brünnhilde takes the golden ring from the finger of the dead Siegfried and throws it into the Rhine, where it sinks to the bottom of the river.

Part A

Assuming that the ring is small enough compared to the depth of the river to be treated as a point and that depth of the Rhine where the ring goes in is 10.8 m , what is the area of the largest circle at the surface of the water over which light from the ring could escape from the water? Use 1.33 for the index of refraction of water.

Express your answer in meters squared.

A = m^2

Submit Request Answer

Provide Feedback

Next

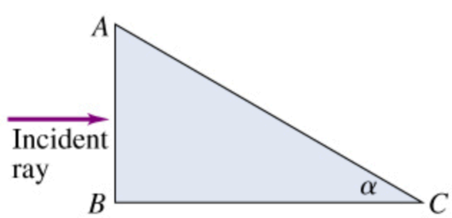
Exercise 33.21 - Enhanced - with Feedback

Review | Constants

Light is incident along the normal on face AB of a glass prism of refractive index 1.52, as shown in the figure (Figure 1).

Figure

1 of 1



Part A

Find the largest value the angle α can have without any light refracted out of the prism at face AC if the prism is immersed in air.

Express your answer in degrees.

$\alpha =$ °

Submit Request Answer

Part B

Find the largest value the angle α can have without any light refracted out of the prism at face AC if the prism is immersed in water.

Express your answer in degrees.

$\alpha =$ °

A ray of light is incident in air on a block of a transparent solid whose index of refraction is n.

Review | Constants

Part A

If n = 1.40, what is the *largest* angle of incidence θ_a for which total internal reflection will occur at the vertical face (point A shown in the figure (Figure 1))?

Express your answer in degrees.

θ = °

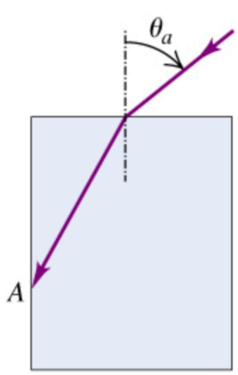
Submit Request Answer

Provide Feedback

Next

Figure

1 of 1



Problem 33.43 - Enhanced - with Feedback

A glass plate 2.55 mm thick, with an index of refraction of 1.70, is placed between a point source of light with wavelength 580 nm (in vacuum) and a screen. The distance from source to screen is 1.45 cm .

Review | Constants

Part A

How many wavelengths are there between the source and the screen?

ΑΣφ ?

Submit Request Answer

Provide Feedback

Next

Problem 33.47

Review | Constants

A thin layer of ice $(n = 1.309)$ floats on the surface of water $(n = 1.333)$ in a bucket. A ray of light from the bottom of the bucket travels upward through the water.

Part A

What is the largest angle with respect to the normal that the ray can make at the ice-water interface and still pass out into the air above the ice?

Express your answer in degrees.

$\theta =$ $^\circ$

Submit Request Answer

Part B

What is this angle after the ice melts?

Express your answer in degrees.

$\theta =$ $^\circ$

Light is incident normally on the short face of a $30^\circ - 60^\circ - 90^\circ$ prism (Figure 1). A drop of liquid is placed on the hypotenuse of the prism.

Review | Constants

Part A

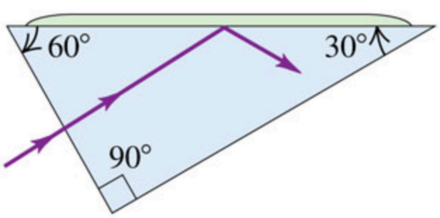
If the index of the prism is 1.54, find the maximum index that the liquid may have for the light to be totally reflected.

$n =$

Submit Request Answer

Figure

1 of 1



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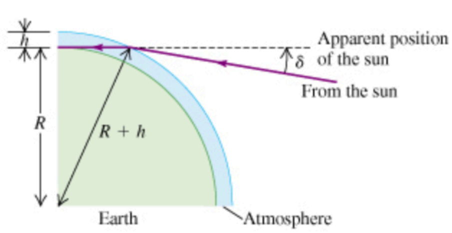
Next

When the sun is either rising or setting and appears to be just on the horizon, it is in fact *below* the horizon. The explanation for this seeming paradox is that light from the sun bends slightly when entering the earth's atmosphere, as shown in the figure (Figure 1). Since our perception is based on the idea that light travels in straight lines, we perceive the light to be coming from an apparent position that is an angle δ above the sun's true position.

Figure



Review | Constants

Part A

Make the simplifying assumptions that the atmosphere has uniform density, and hence uniform index of refraction n, and extends to a height h above the earth's surface, at which point it abruptly stops. Find the angle δ.

Express your answer in terms of n, h and the radius of the earth R.

- $arcsin(\frac{nR}{R+h}) - arcsin(\frac{R}{R+h})$
- $arccos(\frac{nR}{R+h}) - arcsin(\frac{R}{R+h})$
- $arcsin(\frac{nR}{R+h}) - arccos(\frac{R}{R+h})$
- $arctan(\frac{nR}{R+h}) - arctan(\frac{R}{R+h})$

Submit Request Answer

Part B

Calculate δ using $n = 1.0003$, $h = 20\mathrm{km}$ and $R = 6378\mathrm{km}$.

Express your answer in degrees.

Part C

How does this compare to the angular radius of the sun, which is about one quarter of a degree? (In actuality a light ray from the sun bends gradually, not abruptly, since the density and refractive index of the atmosphere change gradually with altitude.)

- ○ δ is much smaller than the radius of the sun
- ○ δ is much greater than the radius of the sun
- ○ They are comparable

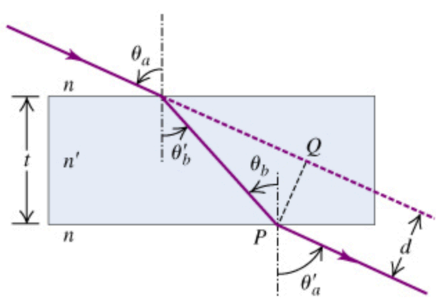
Submit

Request Answer

Review | Constants

Light is incident in air at an angle θ_a (see the figure (Figure 1)) on the upper surface of a transparent plate, the surfaces of the plate being plane and parallel to each other.

Figure



Part A

Find the lateral displacement d of the emergent beam.

- $d = \frac{t \sin(\theta_a - \theta'_b)}{\cos\theta'_b}$
- $d = \frac{t \sin(\theta_a - \theta'_b)}{\sin\theta'_b}$
- $d = \frac{t \cos(\theta_a - \theta'_b)}{\tan\theta'_b}$
- $d = \frac{t \tan(\theta_a - \theta'_b)}{\cos\theta'_b}$

Submit Request Answer

Part B

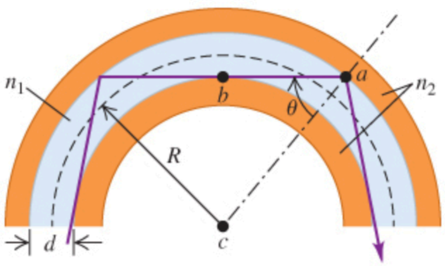
A ray of light is incident at an angle of 66.0° on one surface of a glass plate 2.40 cm thick with an index of refraction 1.80. The medium on either side of the plate is air. Find the lateral displacement between the incident and emergent rays.

Express your answer in centimeters.

Review | Constants

A fiber-optic cable consists of a thin cylindrical core with thickness d made of a material with index of refraction n_1, surrounded by cladding made of a material with index of refraction $n_2 < n_1$. Light rays traveling within the core remain trapped in the core provided they do not strike the core-cladding interface at an angle larger than the critical angle for total internal reflection.

Figure



Part A

(Figure 1) shows a light ray traveling within a cable bent to its critical extent, beyond which light will leak out of the core. The radius of curvature of the center of the core is R. Derive an expression for the angle of incidence at which the indicated light ray strikes the outer edge of the core. (*Hint*: Construct a right triangle with vertices a, b, and c as in the figure.)

Express your answer in terms of d, R.

$\sin\theta$ =

Submit Request Answer

Part B

Determine the critical radius R.

Express your answer in terms of n_1, n_2, and d.

R =

Part C

A typical fiber-optic cable has a 50.0-μm-thick core with index of refraction 1.4475 and has a cladding with index of refraction 1.4440. What is the minimum radius of curvature for this cable?

Express your answer to three significant figures and include the appropriate units.

μÅ ?

R = Value Units

Submit Request Answer

Part D

If a light ray traversed a 1.00 km length of such a cable bent to its critical extent, and if the ray were maximally angled within the core as shown in the figure, what would be the extra distance, beyond 1.00 km, traveled by the ray owing to its multiple reflections? Keep extra digits in intermediate steps to reduce rounding errors.

Express your answer to three significant figures and include the appropriate units.

μÅ ?

ΔL = Value Units

Part E

How much longer would it take light to travel 1.00 km through the cable than 1.00 km in air?

Express your answer to three significant figures and include the appropriate units.

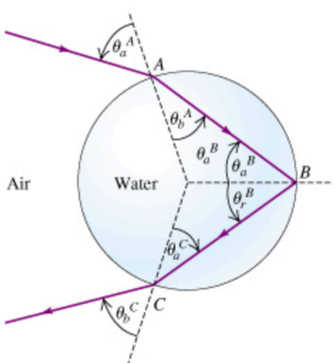
Δt = Value Units

Submit Request Answer

Review | Constants

A rainbow is produced by the reflection of sunlight by spherical drops of water in the air. Figure (Figure 1)shows a ray that refracts into a drop at point A, is reflected from the back surface of the drop at point B, and refracts back into the air at point C. The angles of incidence and refraction, θ_a and θ_b, are shown at points A and C and the angles of incidence and reflection, θ_a and θ_r, are shown at point B.

Figure



Part A

Find the angle Δ in radians between the ray before it enters the drop at A and after it exits at C (the total angular deflection of the ray). (*Hint*: Find the angular deflections that occur at A, B, and C, and add them to get Δ) .

- $\Delta = 2\theta_a^A - 4\theta_b^A + \pi$
- $\Delta = 2\theta_a^A - 2\theta_b^A + \pi$
- $\Delta = 2\theta_a^A - 4\theta_b^A$
- $\Delta = \theta_a^A + \theta_b^A + 2\pi$

Submit Request Answer

Part B

Use Snell's law to write Δ (the angle in radians between the ray before it enters the drop at A and after it exits at C) in terms of $\theta = \theta_a^A$ and n, the refractive index of the water in the drop.

Express your answer in terms of θ and n.

ΑΣφ ?

Δ =

Part C

A rainbow will form when the angular deflection Δ is *stationary* in the incident angle θ_a^A that is, when $d\Delta/d\theta_a^A = 0$. If this condition is satisfied, all the rays with incident angles close to θ_a^A will be sent back in the same direction, producing a bright zone in the sky. Let θ_1 be the value of θ_a^A for which this occurs. Find θ_1. (*Hint*: You may find the derivative formula $d\,(arcsin\,u(x))/dx = (1-u^2)^{-1/2}\,(du/dx)$ helpful.)

- $cos^2\,\theta_1 = \frac{1}{3}\,(n^2-1)$
- $sin^2\,\theta_1 = \frac{1}{3}\,(n^2-1)$
- $cos^2\,\theta_1 = \frac{1}{2}\,(n-1)$
- $sin^2\,\theta_1 = \frac{1}{2}\,(n-1)$

Submit Request Answer

Part D

The index of refraction in water is 1.342 for violet light and 1.330 for red light. Find θ_1 for violet and red light.

Express your answer in degrees to four significant figures separated by a comma.

ΑΣφ ?

Part E

Find Δ for violet and red light.

Express your answer in degrees to four significant figures separated by a comma.

Δ_{violet} , Δ_{red} = $^{\circ}$

Submit Request Answer

Part F

When you view the rainbow, which color, red or violet, is higher above the horizon?

- red
- violet

Submit Request Answer