

Sunlight 1

# Sunlight

Turn off all electronic devices

Sunlight 2

## Observations about Sunlight

- Sunlight appears whiter than most light
- Sunlight makes the sky appear blue
- Sunlight becomes redder at sunrise and sunset
- It reflects from many surfaces, even nonmetals
- It bends and separates into colors in materials

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## 5 Questions about Sunlight

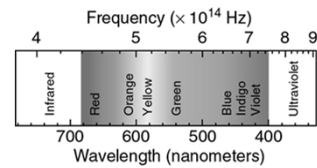
1. Why does sunlight appear white?
2. Why does the sky appear blue?
3. How does a rainbow break sunlight into colors?
4. Why are soap bubbles and oil films so colorful?
5. Why do polarizing sunglasses reduce glare?

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## Question 1

- Q: Why does sunlight appear white?  
 A: We perceive 5800 K thermal light as "white"

- Light is a class of electromagnetic waves
- Single-frequency light has a rainbow color
  - A thermal mixture of rainbow colors can look white

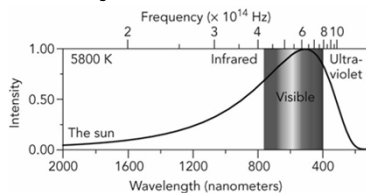


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## Spectrum of Sunlight

- Sunlight is thermal radiation—heat from the sun
- Charges in the sun's hot photosphere jitter thermally
  - Accelerating charges emits electromagnetic waves
  - The sun emits a black-body spectrum at 5800 K

We perceive thermal light at 5800 K as "white"



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## Question 2

- Q: Why does the sky appear blue?  
 A: Air particles Rayleigh-scatter bluish light best

- Rayleigh scattering occurs when
- passing sunlight polarizes tiny particles in the air,
  - this alternating polarization reemits light waves, so
  - air particles scatter light—they absorb and reemit it.

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## Rayleigh Scattering

Air particles are so small that they are

- ◆ much less  $\frac{1}{2}$  the wavelength of light
- ◆ poor antennas for light
- ◆ scatter long-wavelengths (reds) particularly poorly
- ◆ scatter short-wavelengths (violets) somewhat better

Rayleigh scattered sunlight appears bluish

Unscattered sunlight (solar disk) appears reddish

Effect is strongest at sunrise and sunset

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## Question 3

Q: How does a rainbow break sunlight into colors?

A: Rainbow colors take different paths in raindrops

Sunlight slows while it passes through matter

- ◆ Light waves electrically polarize the matter
- ◆ That polarization delays and slows the light wave
- ◆ Index of refraction = reduction factor for light's speed

Index of refraction varies slightly with color

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## Light at Interfaces

When light changes speed at an interface,

- ◆ relationship between electric & magnetic fields changes
- ◆ it refracts—its path bends as it cross the interface
  - ◆ it bends toward the perpendicular if it slows down
  - ◆ it bends away from the perpendicular if it speeds up
- ◆ it reflects—part of it bounces off the interface
  - ◆ the reflection is almost perfect for metal surfaces
  - ◆ the reflection is partial for insulator surfaces

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## Light and Dispersion

The rainbow colors of light in sunlight

- ◆ have different frequencies
- ◆ polarize material slightly differently
- ◆ and therefore travel at slightly different speeds

Index of refraction depends slightly on color

Violet light usually travels slower than red light

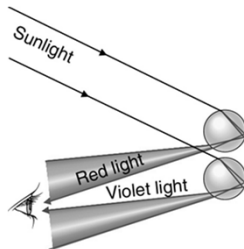
- ◆ violet light usually refracts more than red
- ◆ violet light usually reflects more than red

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## Rainbows

Occur when sunlight encounters water droplets

- ◆ and undergoes refraction, reflection, and dispersion.



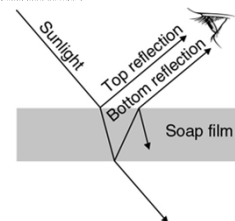
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## Question 4

Q: Why are soap bubbles and oil films so colorful?

A: They display color-dependent interference effects

- ◆ Light waves following different paths can interfere
- ◆ The two partial reflections from a soap or oil film can interfere
- ◆ Different colors of light can interfere differently



## Question 5

Q: Why do polarizing sunglasses reduce glare?

A: Glare is mostly horizontally polarized light

Sunlight is a uniform mix of polarizations

When sunlight partially reflects at a shallow angle

- ◊ its different polarizations reflect differently
- ◊ it becomes polarized—it is no longer a uniform mix

Polarizing sunglasses block horizontal polarization

## Reflection of Polarized Light

Polarization affects angled reflections

When light's electric field is parallel to a surface

- ◊ there is a large fluctuating surface polarization
- ◊ and thus a strong reflection.

When electric field is perpendicular to a surface

- ◊ there is a small fluctuating surface polarization
- ◊ and thus a weak reflection.

Glare is mostly polarized parallel to the surface

## Polarization and Sunlight

Polarizing sunglasses

- ◊ block horizontally polarized light
- ◊ and thus block glare from horizontal surfaces.

Rayleigh scattering has polarizing effects,

- ◊ so much of the blue sky is polarized light, too.
- ◊ Polarizing sunglasses darken much of the sky

## Summary about Sunlight

Sunlight is thermal light at about 5800 K

It undergoes Rayleigh scattering in the air

It bends and reflects from raindrops

It interferes colorfully in soap and oil films

It reflects in a polarizing fashion from surfaces