Sunlight

Turn off all electronic devices

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

5 Questions about Sunlight

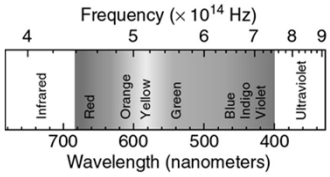
1. Why does sunlight appear white?
2. Why does the sky appear blue?
3. How does a rainbow break sunlight into colors?
4. Why are soap bubbles and oil films so colorful?
5. Why do polarizing sunglasses reduce glare?

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

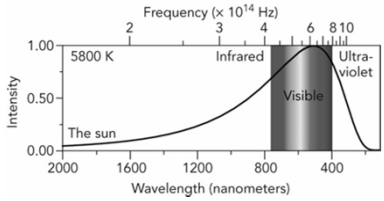


Spectrum of Sunlight

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"



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 ½ 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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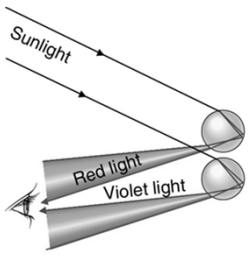
Rainbows

Occur when sunlight encounters water droplets
- and undergoes refraction, reflection, and dispersion.



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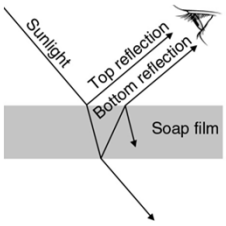
Question 4

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



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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

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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

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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

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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