Color and Polarization

Color

- Determined by frequency of light reaching the eye
- Hot bodies produce different frequencies of light depending on temp. - red hot, white hot
- Color of opaque object depends on light frequencies reflected (or not absorbed)
- Color of transparent object depends on light transmitted (or not absorbed)

Human Vision

- Two types of cells detect light in the eye, rods and cones
- In dim light only rods operate and no color is seen
- 3 types of cones give color vision, each sensitive to different wavelengths: short (blue), medium (green) and long (red)

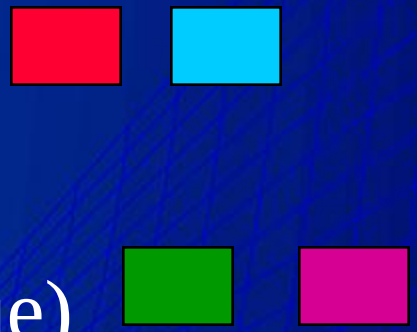
Additive Color Mixing

- Mixing light is additive process - color TV, stage lighting
- Primary colors of light are red, blue, green
- When primary colors are combined, produce white (polychromatic) light
- If one color is removed from white light, complimentary color is seen

Complimentary Colors

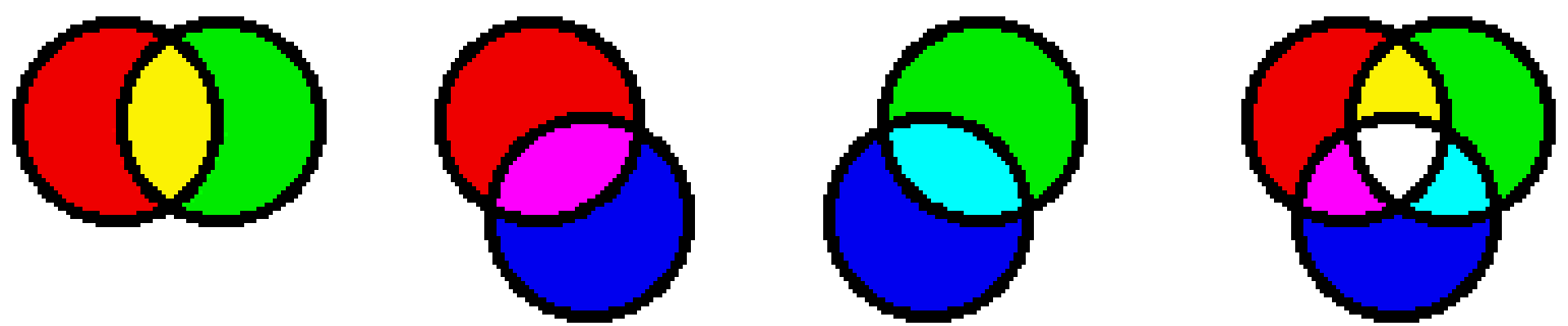
Complimentary color pairs

- Red and cyan (blue-green)
- Blue and yellow
- Green and magenta (red-blue)



Any color can be produced from a combination of red, blue, and green lights

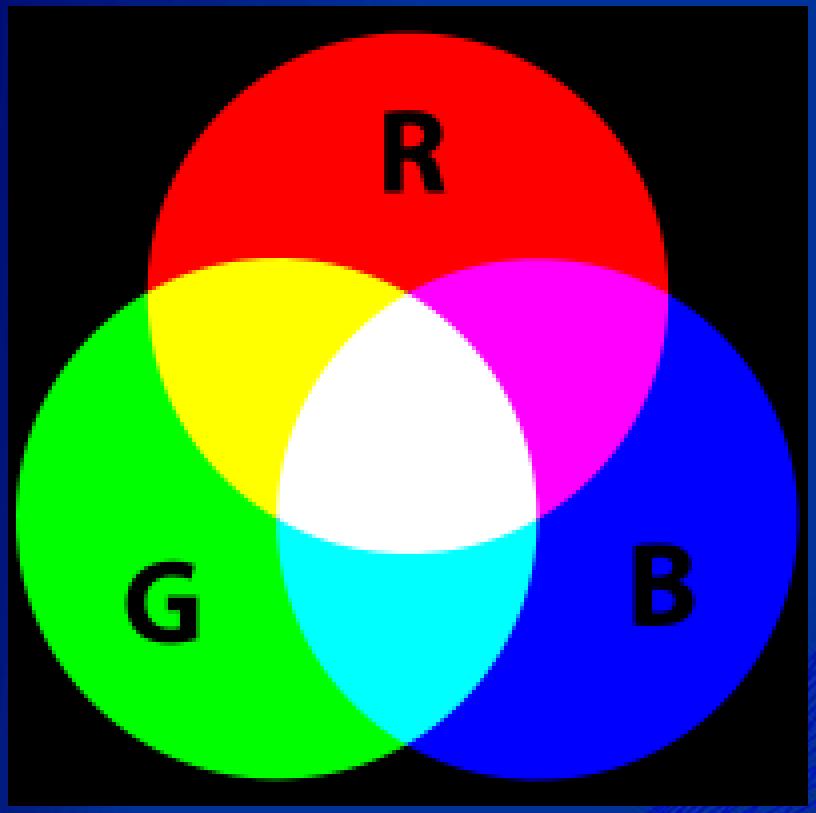
Additive Color Mixing

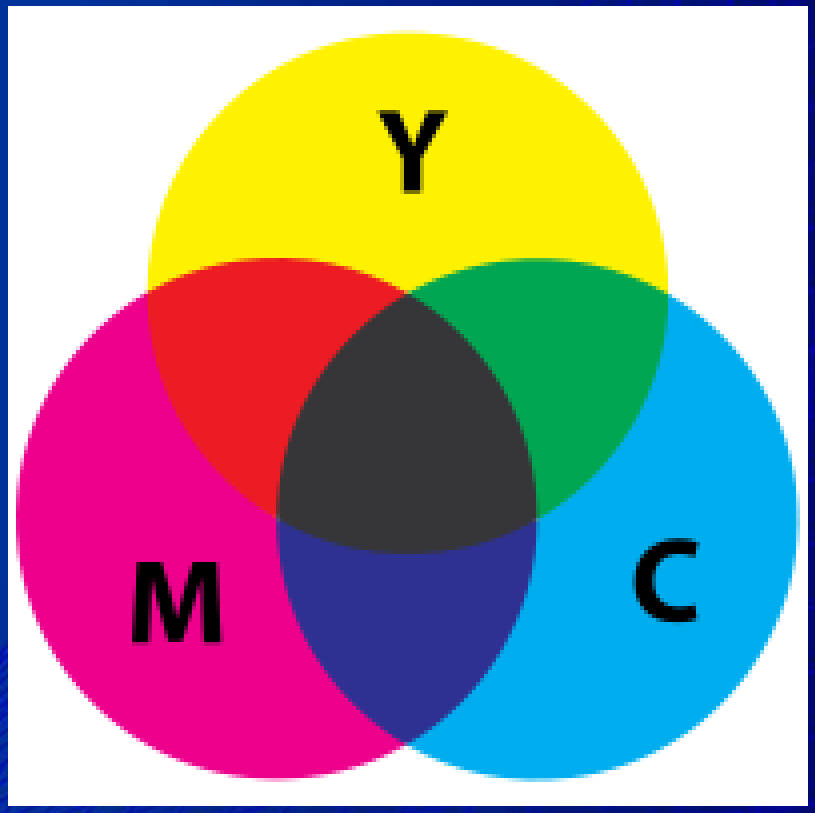


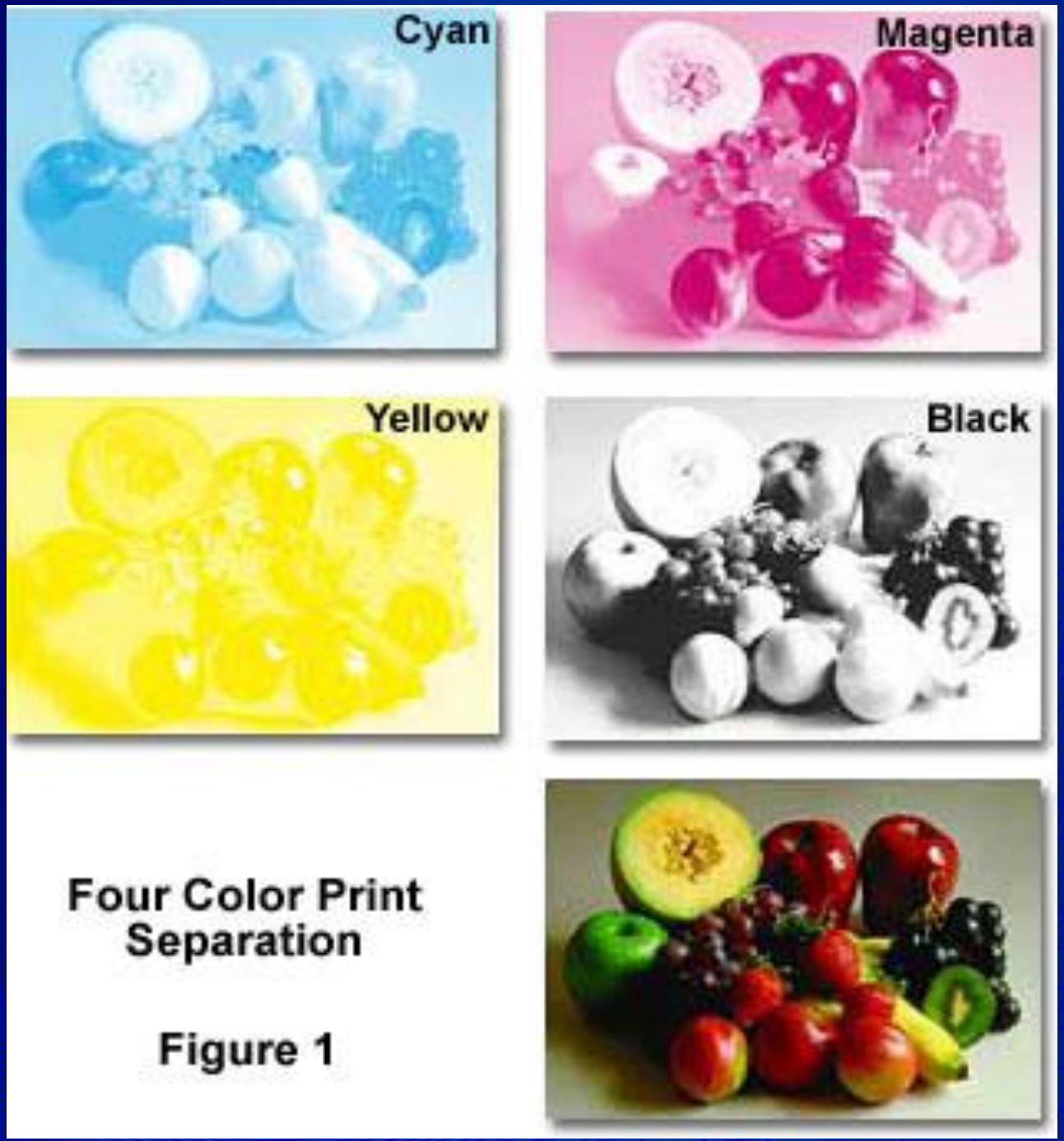
Subtractive Mixing

- Mixing of pigments is subtractive process
- pigment absorbs certain frequencies, reflecting the color we see
- Primary pigments are cyan, magenta, yellow
- Used in paints, color printing, color photography

Additive and Subtractive Mixing







CMYK print process

Java animation

Structural Colors

- Some colors due to scattering of light and polarization: no pigments for colors
- Blue light absorbed and scattered by air molecules, causes blue sky
- Red sunsets due to path of light from setting sun passing through more atmosphere, more blue scattering

Structural Colors

- Colors seen in feathers of blue jays and peacocks, and in blue eyes are due to scattering of light by the fine structure
- Color of sea water is cyan because water absorbs red and infrared

Polarization

- Wave oscillations confined to single plane
- Only transverse waves, (all e-m waves) can be polarized
- Normal light emissions unpolarized, plane of vibration random
- Occurs through interaction with matter

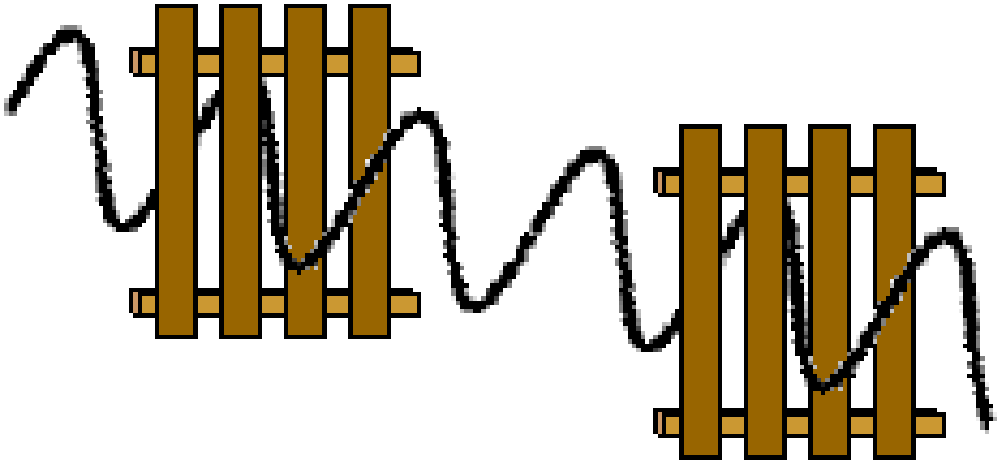
Polarization

- Electrical component of e-m waves interacts with matter
- Represent electrical oscillation by vector
- Polarization absorbs one component of vector, perpendicular component is transmitted

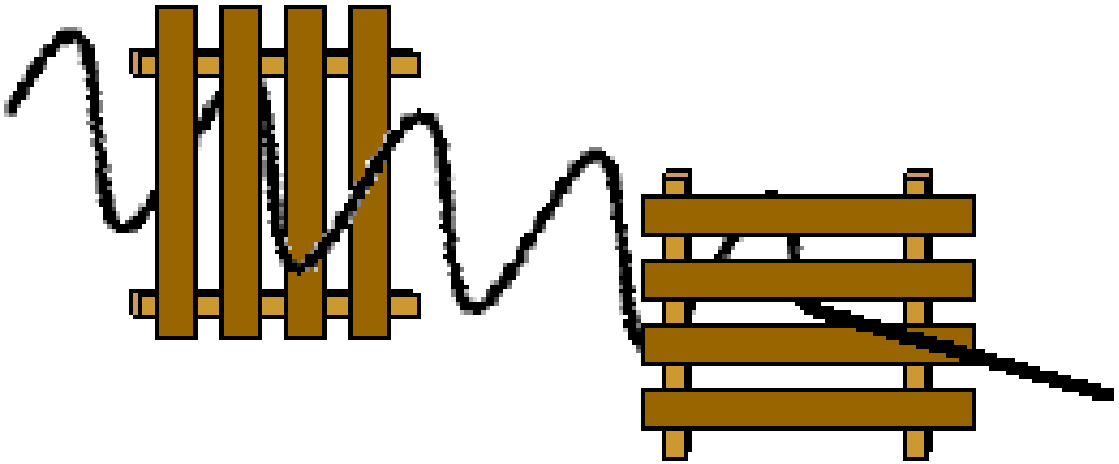
Selective Absorption

- Certain crystals transmit component of light aligned with crystal structure, absorb its perpendicular component - *dichroism*
- Result is light with all oscillations in same plane
- 1935 Edwin Land developed method to make polarizing filters, started Polaroid corp.
- Applications: sunglasses, filters for photography, microscopy, industry, research

The Picket Fence Analogy



When the pickets of both fences are aligned in the vertical direction, a vertical vibration can make it through both fences.

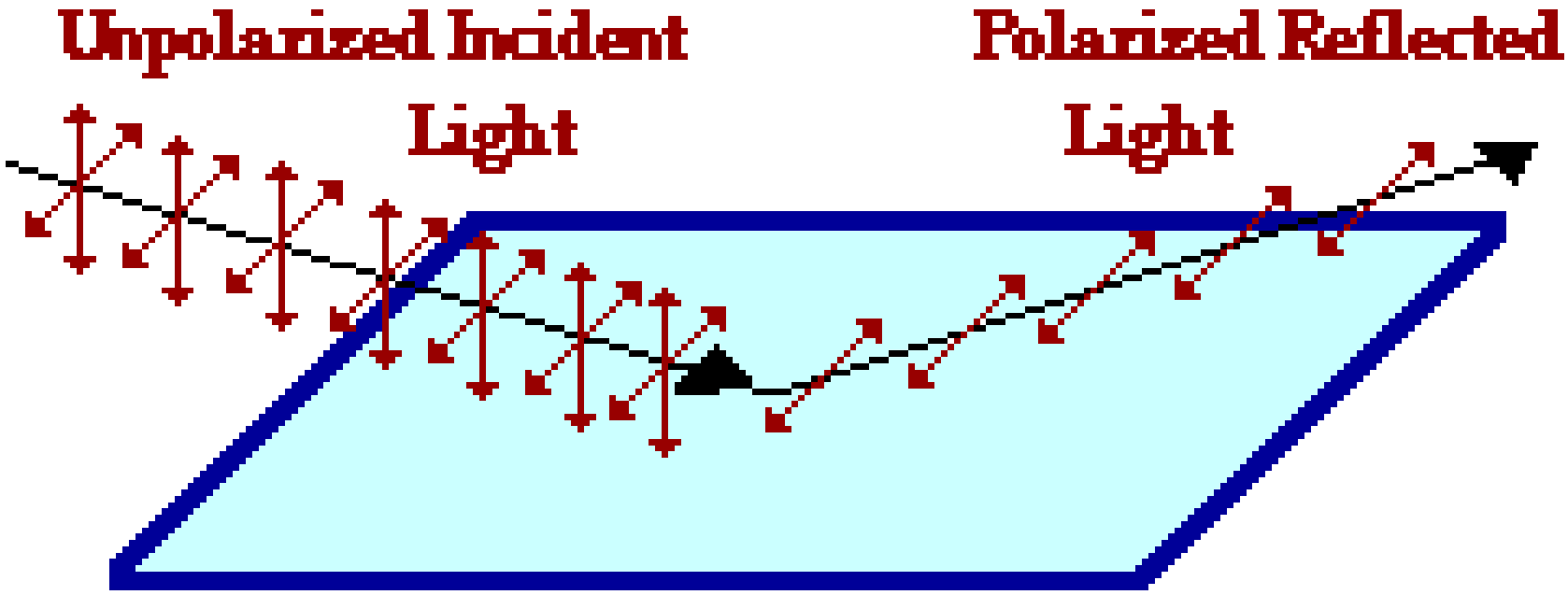


When the pickets of the second fence are horizontal, vertical vibrations which make it through the first fence will be blocked.

Polarization by Reflection

- Smooth, non-metallic surfaces reflect component of light parallel to surface; perpendicular component absorbed or refracted
- Maximum polarization occurs at Brewster's angle (polarizing angle)
- To reduce glare, Polaroid sunglasses have vertically aligned filters, block horizontally polarized, reflected light

Polarization by Reflection



Reflection of light off of non-metallic surfaces results in some degree of polarization parallel to the surface.

Polarization by Refraction

- Certain crystals (calcite) have different index of refraction for perpendicular components of light wave
- Two components are refracted differently
- Result is separation of components into 2 polarized beams or images

Polarization by Scattering

- Small particles in transparent medium will scatter light, cause partial polarization
- Size of particle determines frequency of light affected
- Light is momentarily absorbed and re-emitted in random direction

Uses of Polarized light

- Perpendicular polarized light beams can’t interfere
- If beam is rotated, interference results
- Certain plastics become doubly refractive when stressed; Can detect stress points with polarized light and detector

Optical Rotation

- Optically active substances rotate plane of incident light
- Amount of rotation measured by instrument called a polarimeter
- For example, sugar content can be measured by how much polarized light is rotated