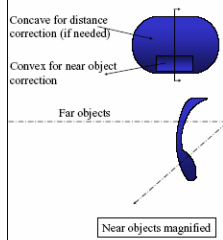


Bifocal Eyeglasses



Eye may need one prescription for distant viewing and another for near viewing

Close-up lens is in lower half, where you look to read (just like bifocal eyeglasses)

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Acuity Test

- Approximate Eye Resolution is 1 minute of arc = 1/60 of a degree = 1/30 of diameter of full moon

$$\frac{x}{y} = \frac{\text{distance to chart (20ft)}}{\text{distance needed to make letters in the last correct line = 5 arc min}}$$



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Binocular Vision

- We have two eyes (unlike a camera)
- Second eye increases field (angle) of view
 - fields of view overlap considerably
- Brain combines two images into one perception
- Helps gauge depth of three-dimensional scene
- In the next slide, how do we know whether we are looking at a painting in the window or the scene outside the window?

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Binocular vision

Rene Magritte, "The human condition I"



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Binocular Vision

- Depth cues help visualize three-dimensional scene
 - Accommodation: Focus your eyes on object
 - Convergence: Change angle when we view near or distant object
 - Parallax: Change eye position by moving head
- These cues do not exist when viewing a two-dimensional scene (such as a painting), but artists try to tease us

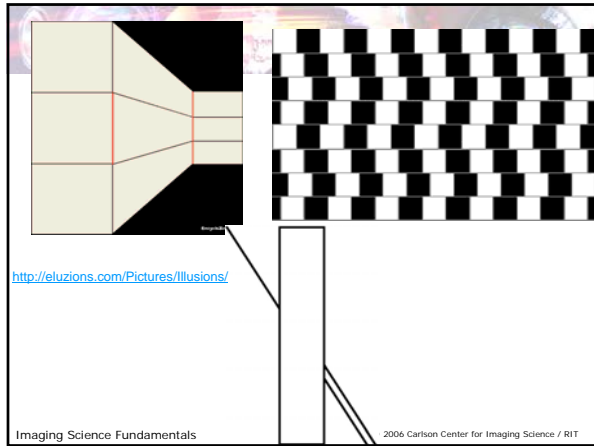
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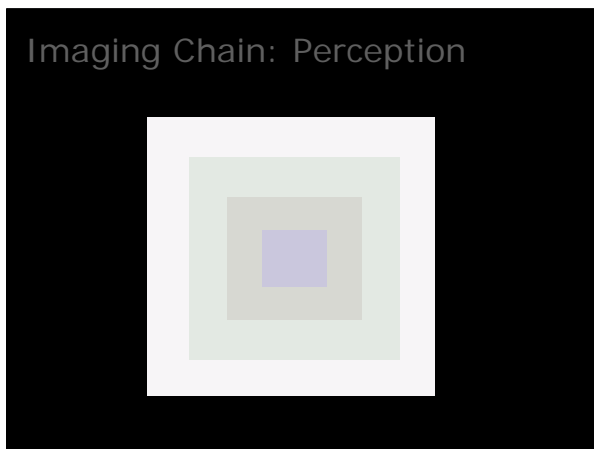
Famous Examples
by M. C. Escher

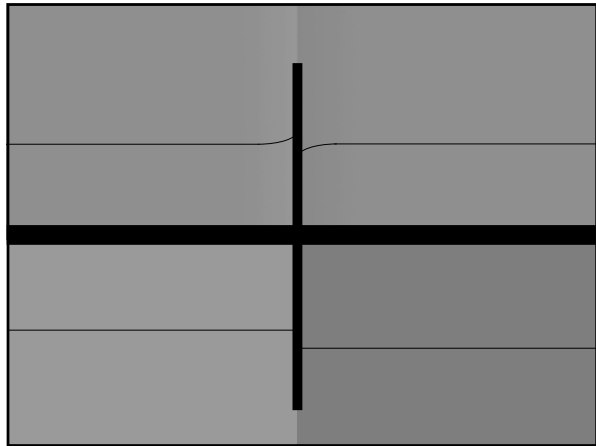
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Imaging Chain: Perception


⊗ If you can read this you must be cheating!

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Imaging Chain: Perception

Stare at the 'X.' Do not move your eyes.

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An Imaging System Through the Chain

Electrophotography = "Xerography"

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College of Science
Rochester Institute of Technology

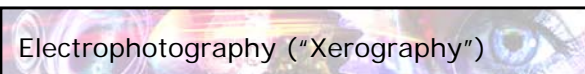
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Invention

- Chester F. Carlson in Astoria, NY (Queens) in 1938
 - Battelle Institute took over for commercialization
 - Subject of the book *Copies in Seconds*, David Owen, Simon & Schuster, 2004

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Electrophotography ("Xerography")

- Many major corporations (IBM, Kodak) turned down offer from Battelle to make photocopiers in the 1950s
 - Thought there was no market for a device to make multiple copies of a single document
- Today copiers (and laser printers) are a multibillion dollar industry, with copiers in virtually every business and many homes

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Electrophotography ("Xerography")

- Electrophotographic copiers are very common and they offer a view into many elements in the imaging chain.



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Source

- A number of different sources are used in copiers. Fluorescent³ and incandescent bulbs are common.
- Fluorescent sources are more efficient, richer in short wavelength radiation, and longer lasting than incandescent bulbs.

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Source – Incandescent Lamps

- Typical light bulbs create light by *incandescence*
 - Energy released is function of temperature
 - At temperatures below melting point of metals, most energy emitted by incandescent bulbs is in the *near infrared* (NIR) region of electromagnetic spectrum
⇒ less visible light ⇒ low efficiency

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Source – Fluorescent

- Fluorescent bulbs use electron interactions to emit light from low-pressure gas
- Electron spontaneously emits photon when returns to a lower-energy orbit
- Wavelengths depend on change in energy
 - larger changes \Rightarrow shorter wavelengths

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Source – Fluorescent Lamps

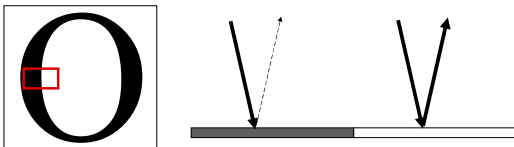
- High-energy UV photons interact with *phosphors* coated on inside of bulb
- UV photons excite electrons in the phosphors
- Phosphors emit lower-energy (visible) photons when they return to lower energy states
- Fluorescence creates visible photons

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Object

- Copiers duplicate *reflective* originals
 - Different regions reflect different amounts of light from the source.

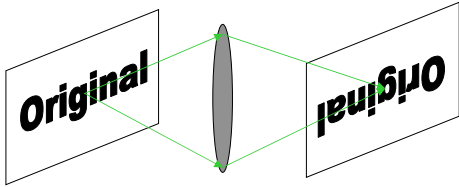


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The Imaging Chain: Collection

- Many copiers use traditional lenses to project reflected light onto sensor
- Latest use ganged pair of light and sensor

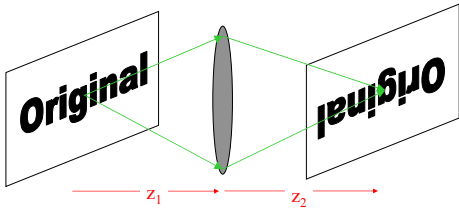


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The Imaging Chain: Collection

- What are distances z_1 and z_2 for image to be same size as object?

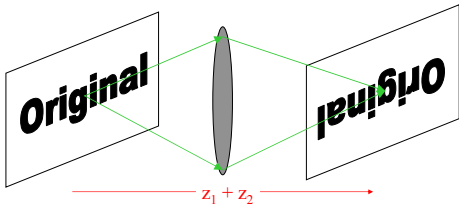


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The Imaging Chain: Collection

- To make "100%" copies (1:1 magnification), the object and image distances must be EQUAL. The *focal length* of the lens must be $\frac{1}{4}$ of $z_1 + z_2$.

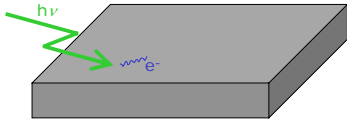


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The Imaging Chain: Detector

- Electrophotographic process relies on the *photoelectric effect*
 - Photons striking some materials can 'free up' electrons by elevating energy into the *conduction bands*
 - $E = hv$

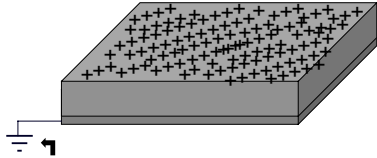


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Detector: Photoconductors

- *Photoconductors are insulators* in the dark
 - They do not conduct electricity
 - ▶ charges cannot move



Signifies connection to "ground" or "earth" (in UK)

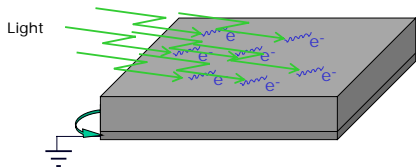
- Think of as infinitely large sink where charges can go

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Detector: Photoconductors

- *Photoconductors are conductors* when exposed to light (duh!)
 - electricity can be *conducted*
 - ▶ charges can move on surface



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Surface of *Selenium*

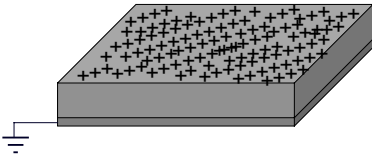
- One of the first photoconductors ever discovered
 - used in early television
- Response of selenium is "slow"
 - free charges don't move very fast
 - Bad for TV
 - OK for copiers

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The Imaging Chain: Processing

- While in dark, photoconductor is charged by applying ("spraying") positive ions onto surface of selenium drum
- Static charge is maintained because surface is *insulator* in the dark

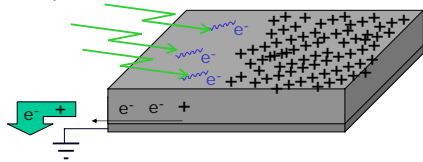


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The Imaging Chain: Processing

- Light from original projected onto surface
- Makes exposed regions *conductive*
 - charges can **move**
 - Charge is drained to ground where surface is *exposed*



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Dust with Black Particles (with e⁻)

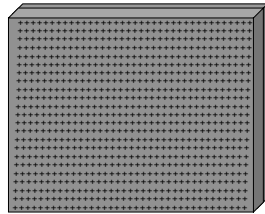
- "Toner" particles
 - analogous to ink
- Negative charge "sticks" to remaining positive charges on selenium drum

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Processing: Charge Photoconductor

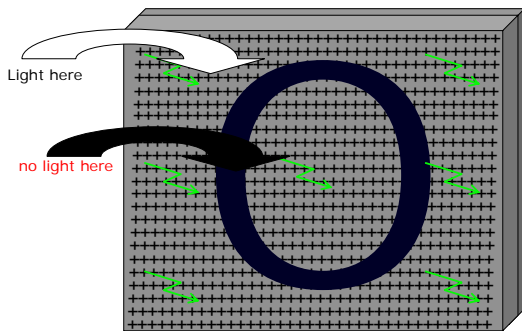
- "Corona Wire"
 - Thin wire charged with protons, "sprays" positive charge onto selenium



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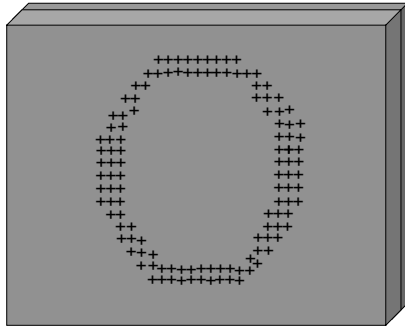
Processing: Expose



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Processing: Latent image (remaining positive charges)

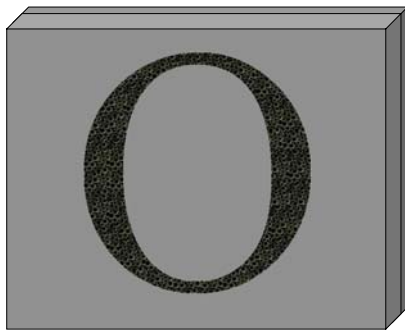


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Processing: Transfer charged toner to drum

- Toner is a black "flour" with negative charges
 - attracted to + charges



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Processing: Transfer toner to paper

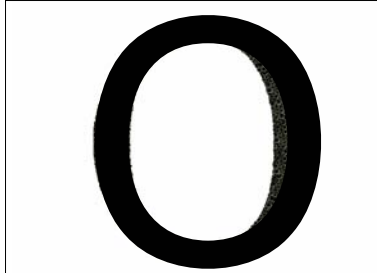


Toner can still "rub off" (onto your hands! Ecchh!)

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Processing: Fuse toner to paper



Apply heat in the "fuser" to make toner stick to paper

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Difference Between Copier and Laser Printer

- "Image" of desired page is written on drum by scanned laser or array of light-emitting diodes (LEDs) rather than by lens

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