Astronomy 80 B: Light

Lecture 1: Introduction to the Properties of Light

1 April 2003

Jerry Nelson

Introduction

- **General subjects of class**
  - Principles of light
  - Natural phenomena (rainbows, etc)
  - Cameras
  - How humans (and other animals) detect light (vision)
  - Optical instruments
  - Color

Importance of Light to Humans

- **Light sense is the most important sense**
- **Humans have 6 senses**
  - Vision (70% of human sense receptors)
  - Hearing
  - Balance
  - Smell
  - Taste
  - Touch

Importance of Light to Humans-2

- **Processing of sensory signals**
  - Light has most signals
  - Light get 40% of cerebral cortex (processing)
- **For most people, vision is clearly most important, most used sense.**
- **Its interesting and fun to understand the basics of light and vision**
- **We can understand many visual experiences through a scientific and rational development of the principles of light and human vision**

Course plan

- **Course**
  - 5 unit course,
  - satisfies quantitative requirement (Q requirement):
    - Student must take at least one Q course
    - These courses provide methods for acquiring quantitative reasoning that involve use of advanced algebra, statistics, or calculus.
  - This course satisfies a T2 requirement (3 needed)
- **Class syllabus**
  - See handout
  - See web: www.ucolick.org/~jnelson/ay80b.html

Syllabus

- **Lectures**
  - 1 Fundamental properties of light
  - 2 geometrical optics: reflection
  - 3 more reflection, refraction
  - 4 more refraction
  - 5 QUIZ #1, mirages
  - 6 dispersion, mirrors and lenses
  - 7 atmospheric effects, rainbows, etc
  - 8 photography and cameras
  - 9 photography and cameras
  - 10 QUIZ #2, human eye and vision

Syllabus-2

- 11 vision, optical instruments
- 12 optical instruments
- 13 students read draft papers
- 14 field trip
- 15 vision, depth perception
- 16 QUIZ #3, color
- 17 color
- 18 waves, light sources, lasers
- 19 waves, photons
- 20 wave optics
- 11 June final exam, 4-7pm

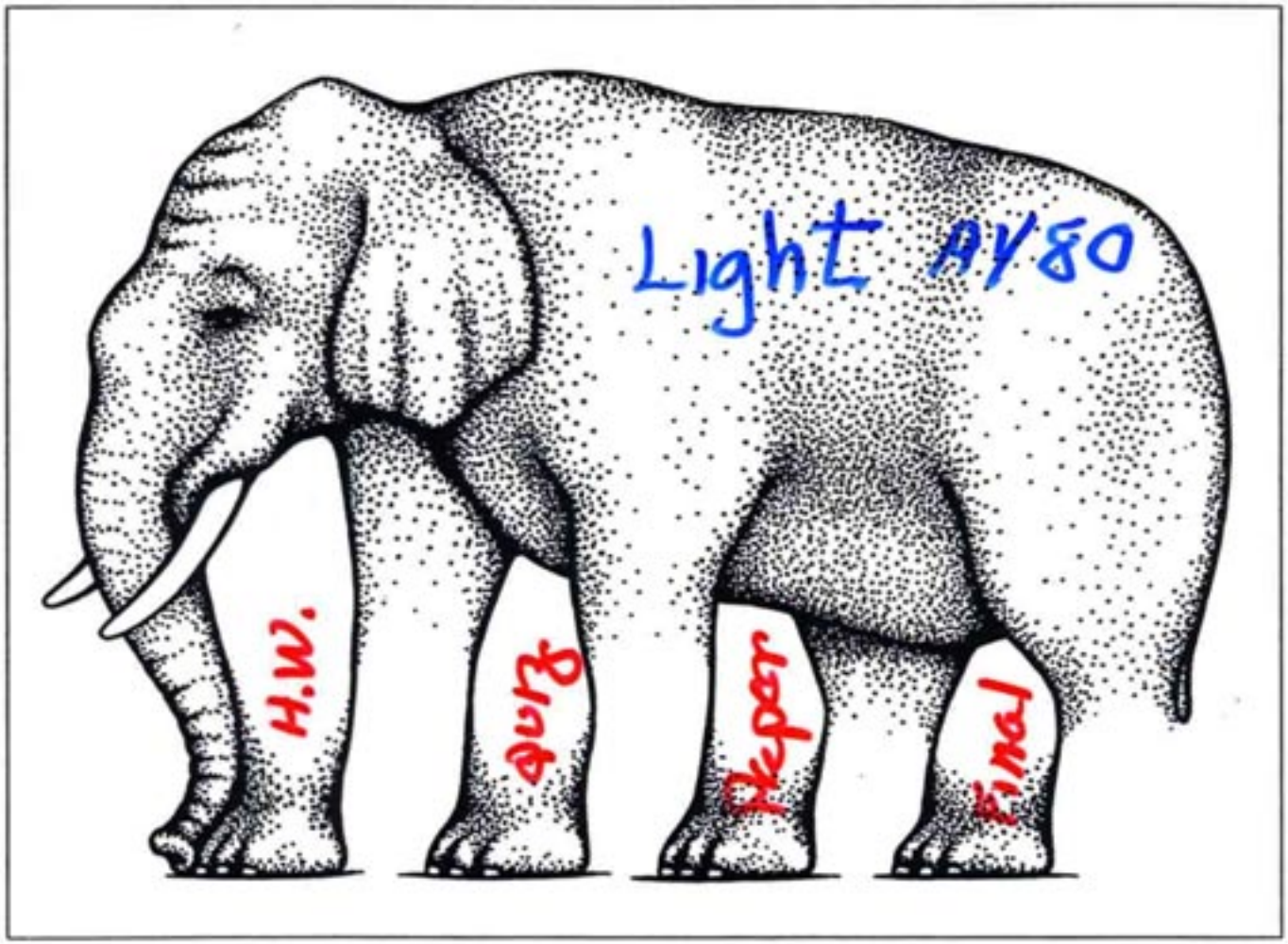
Course Plan-2

- **Lectures (19), Field trip, sections (20)**
- **section times (TBD)**
- **Office hours**
  - Jerry Nelson Wed 9-10:30 215 Center for Adaptive Optics
  - Stefan Meyer TBD
- **Book: Seeing the Light Falk, Brill, Stork**
  - On reserve in science library
  - At bookstore
  - Optional Book: QED: strange story of light by Richard Feynman
- **Lectures**
  - On web: www.ucolick.org/~jnelson/ay80b.html
  - In science library

Grading system

- **Grades are objectively determined**
  - 30% homework (9 sets)
  - 25% quizes (3 during quarter)
  - 25% final exam
  - 10% research paper
  - 10% evaluation of TA, professor
  - Must attend at least 5 section meetings to pass
    - Roll will be taken at section meetings
- **Homework**
  - Homework will be due at start of class on Thursdays, typically 10 problems, a random subset will be graded
- **Tools**
  - Ruler and straightedge

Grades

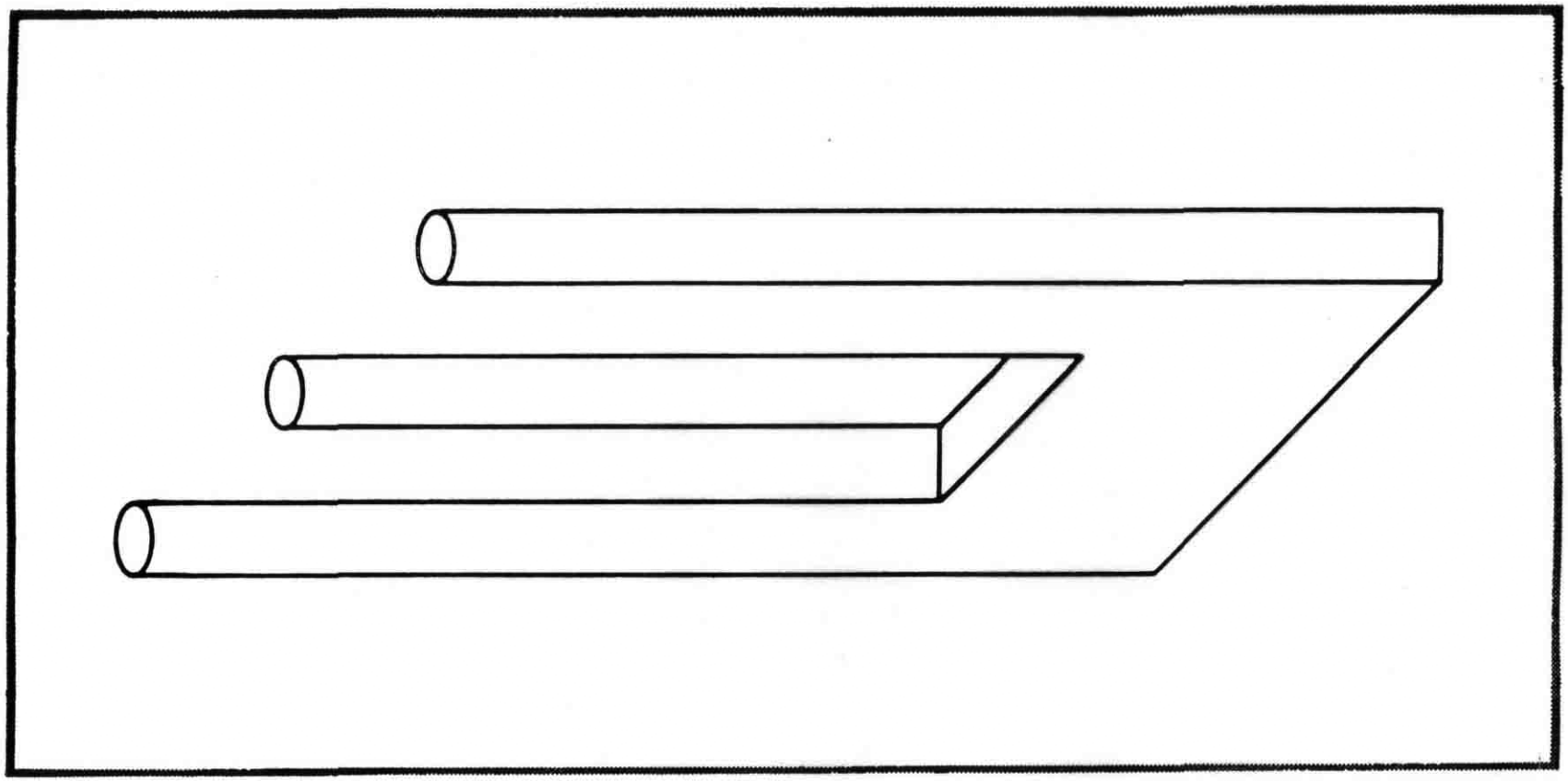


E1 L'EGS-ISTENTIAL QUANDARY

Who we are

- **My interests**
  - Telescope design
  - Instrument design
  - Adaptive Optics
  - Nature
- **Stefen Meyer**
- **Students**
  - name, class, major, interest in this course

Optical Illusion



AMBIGUOUS TRIDENT is confusing to observers who attempt to see it as a three-dimensional object. Two-dimensional perceivers see the pattern as being flat and are not confused.

Reality

- **Objective Reality**
  - is a part of our experiences that we share with essentially all others. These are frequently phenomena or experiences that can be repeated or re-created. Science has its domain in this realm. Its not required that we understand something "scientifically" or otherwise for it to be objective reality.
    - automobile engines
    - orbit of moon around the earth
    - energy source of the sun
    - waterfalls
    - ball lightning
    - starlight
    - sound of music
    - ordinary stuff

Reality-2

- **Subjective Reality**
  - Subjective reality includes personal experiences that are not shared with others, or can not be readily shared.
    - dreams
    - emotions
    - flying saucers
    - astral projection
    - astrology
    - levitation
    - auras
    - good looks
    - quality of music
- **What about mirages?**

Reality-3

- **These categories are not absolute.**
  - Some experiences relating to human vision for example are widely experienced but are not "objectively " present. Modern physiology and psychology are moving some of these experiences into "objective " reality.
- **The Search for a scientific understanding of light and the phenomenon of color has gone on for several centuries. This has involved work in three different disciplines:**
- **Physics**
  - how light is produced
  - how light is measured
  - how it interacts with materials
  - how the eye forms an image on the retina

Reality-4

- **Physiology**
  - how does light affect the light receptors in the retina
  - how are the subsequent neural impulses processed and transmitted along the nerve pathways to the visual cortex of the brain
- **Perceptual Psychology**
  - How is this information processed and interpreted by the brain to yield a perception

How light doesn't work

Light is Beautiful

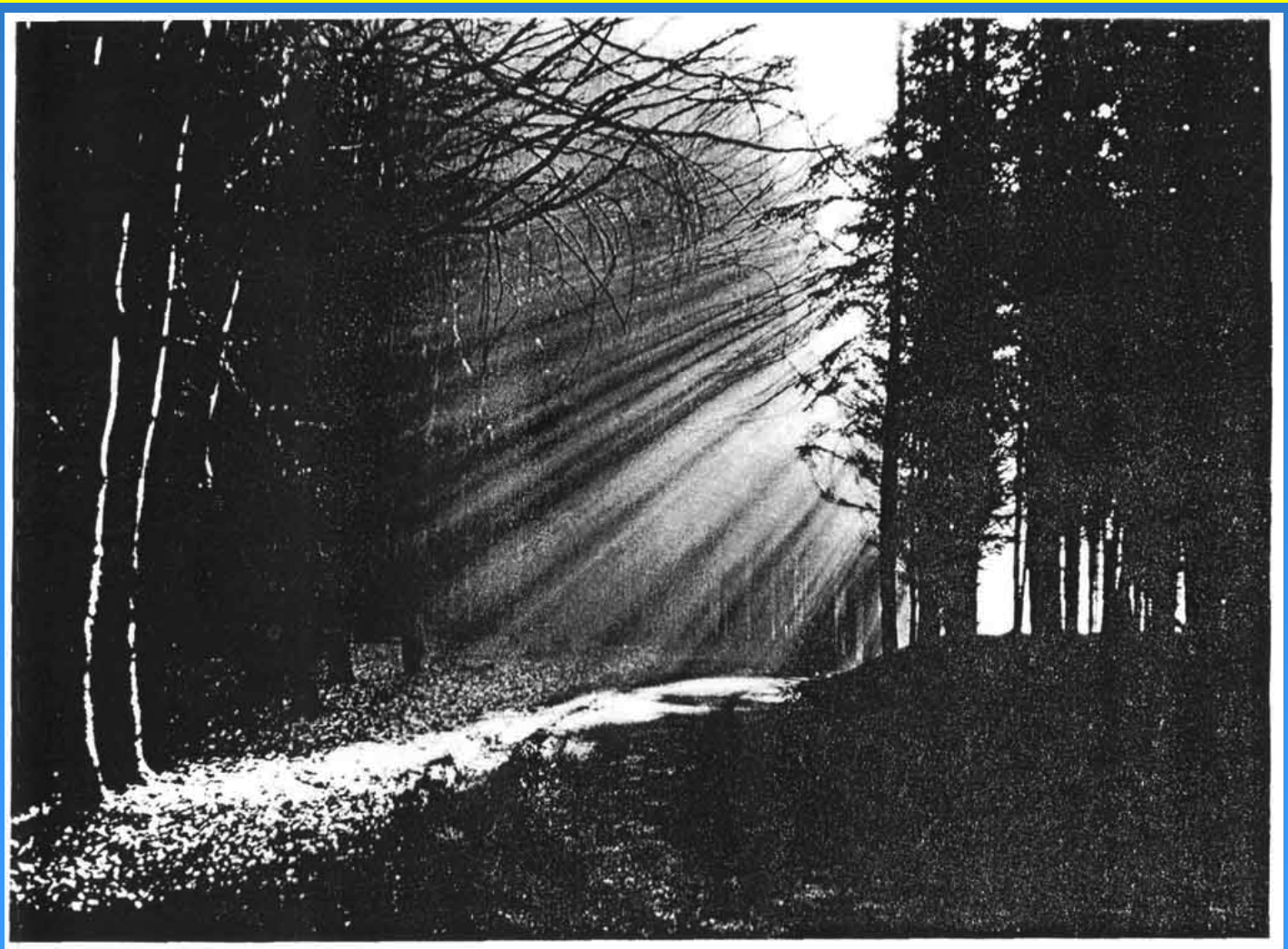
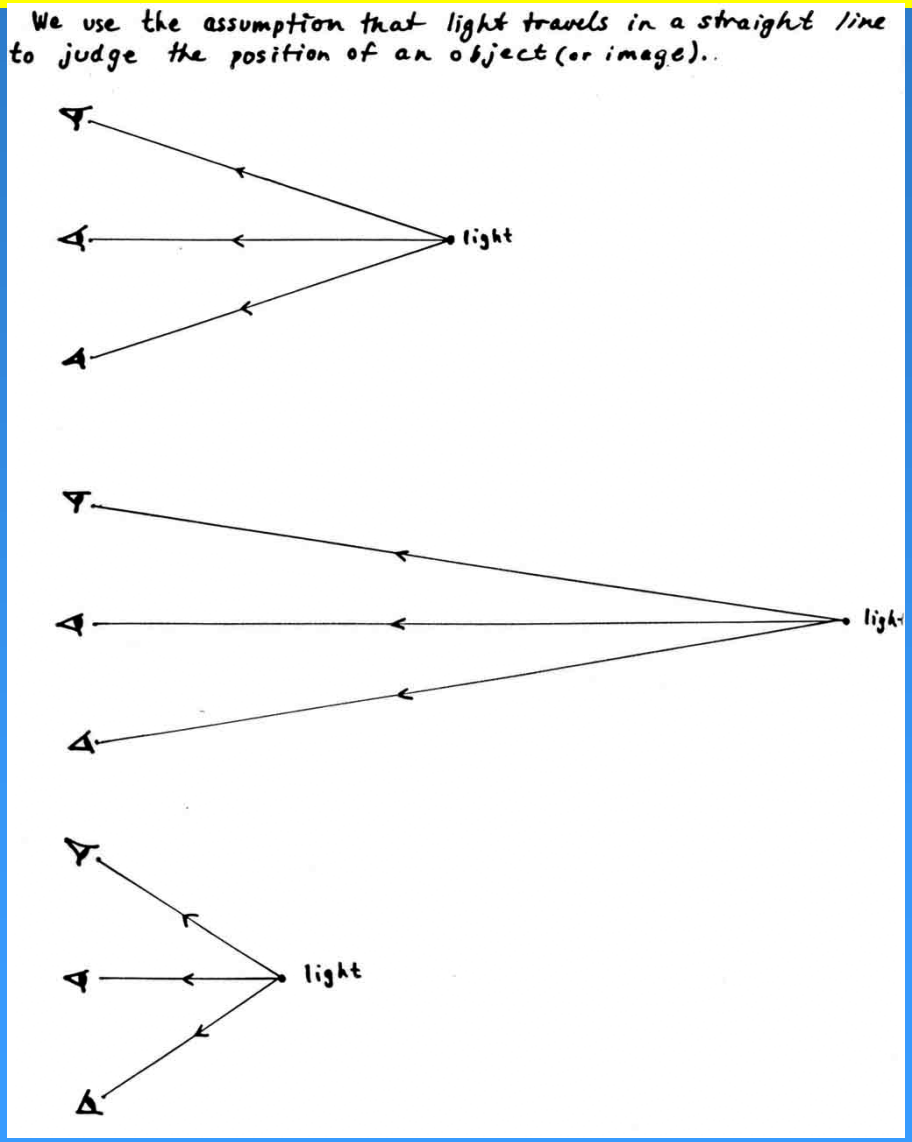
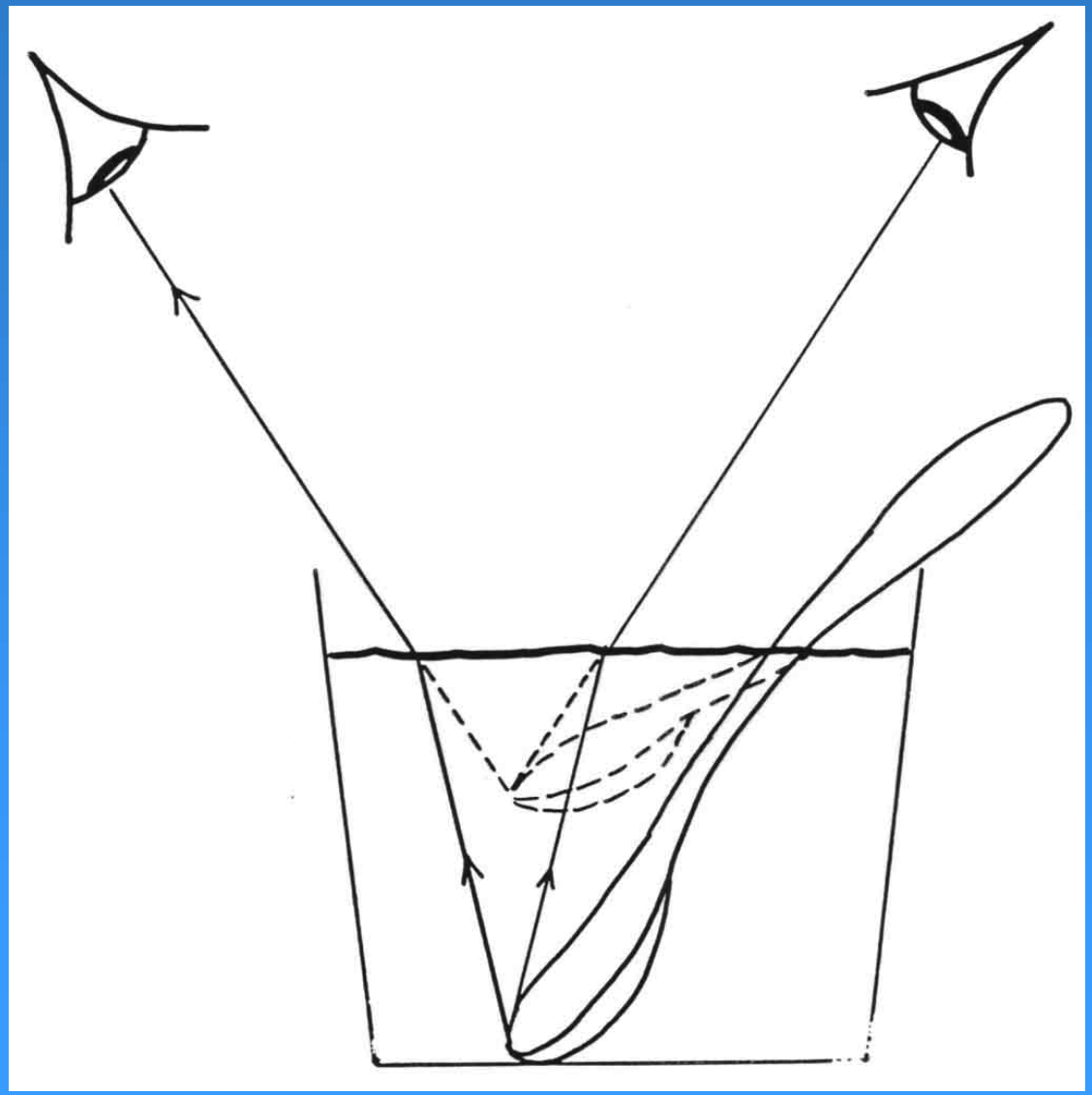


Figure 1-1 Sunlight passing through the foliage of a tree.

Light tends in straight lines



What we see isn't what is



What is the speed of light?

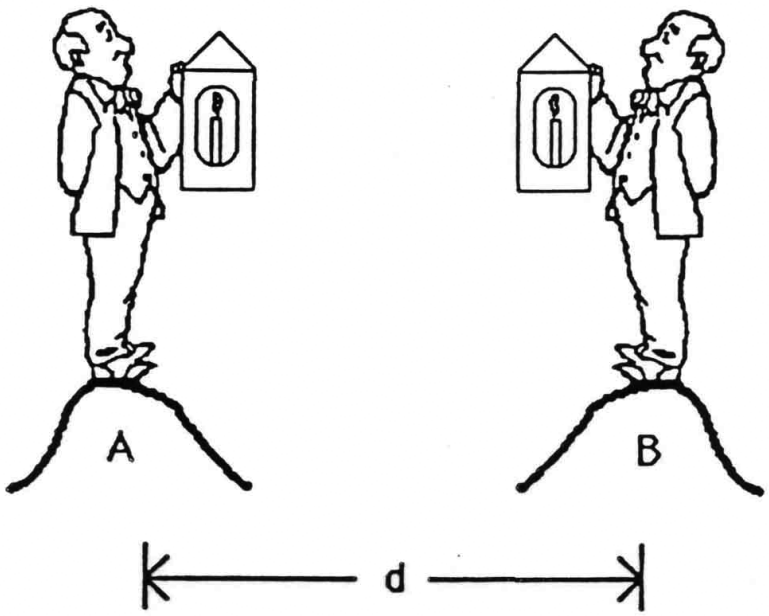
- **Sound propagates through material stuff**
  - Rocks
    - Water
    - Air
    - Etc
  - Sound speed is about 330 m/s (1000ft/s) in air, faster in rocks
  - Experience is that light is much faster than sound
    - Lightning, thunder
    - Distant events seen, then heard
- **Galileo (b. 1564) attempted to measure light speed**
- **Ole Roemer measured it crudely (17th century)**
- **Michelson measured it accurately (late 19th century)**

What is the speed of light-2

- **What does light propagate through- what is the medium?**
- **Evidence indicates the speed of light is a constant in a vacuum**
  - Independent of the wavelength of light
  - Independent of the speed of the source
  - Independent of the speed of the receiver
  - c = 300,000,000 m/s (186,000 miles/s)
- **This evidence makes the concept of the ether untenable**
- **This dilemma led to the theory of special relativity by Einstein (1905)**

Galileo's attempt to measure the speed of light

Galileo's attempt at determining the speed of light



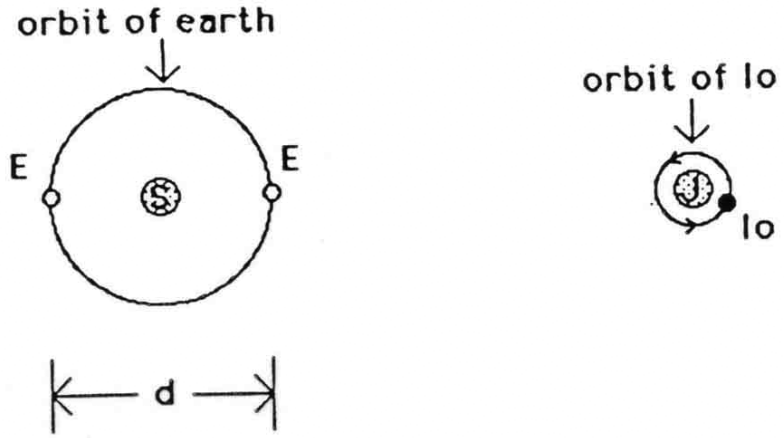
c = speed of light.

t = time required for light to travel from A to B and back to A.

$$v = \frac{2d}{t}.$$

Ole Roemer's determination of the speed of light

Ole Roemer's determination of the speed of light

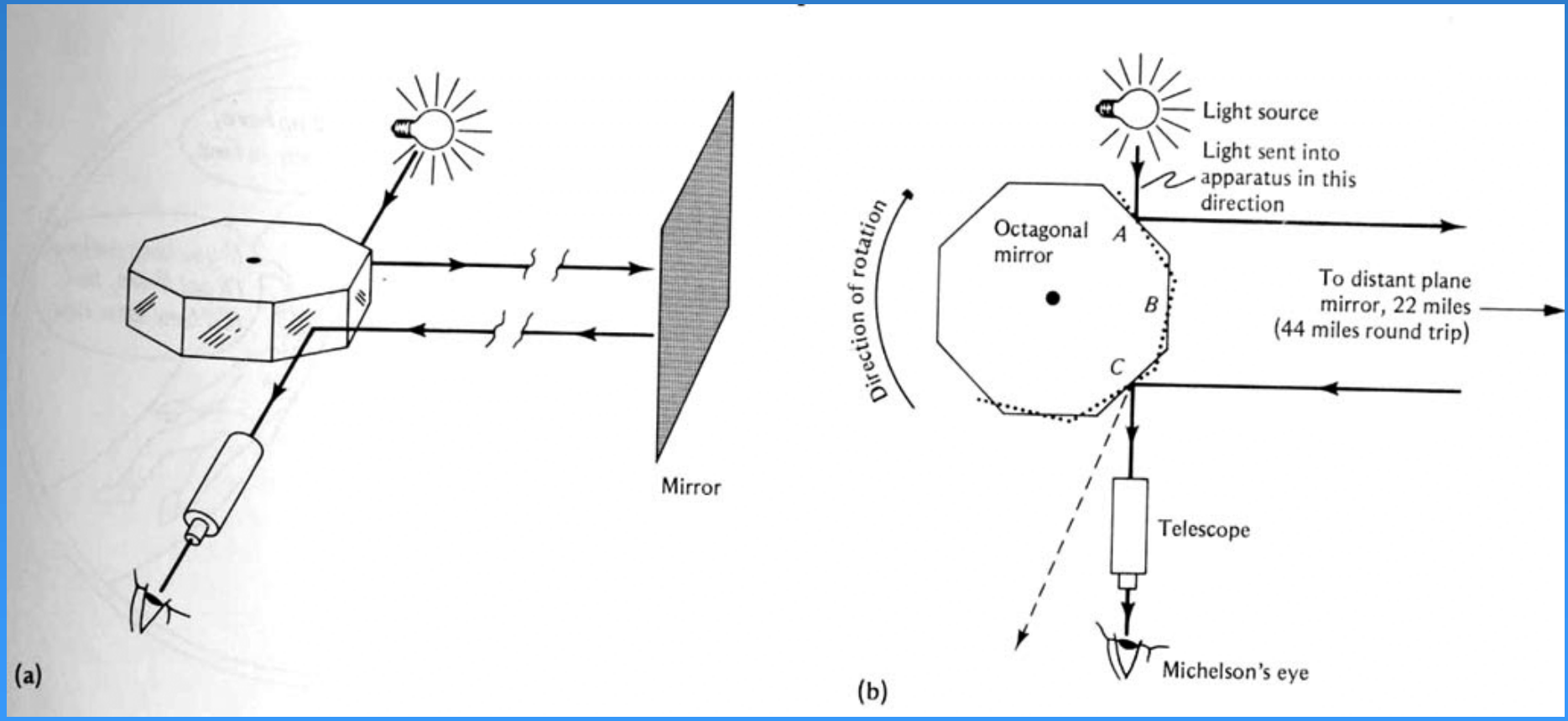


d = 186,000,000 miles

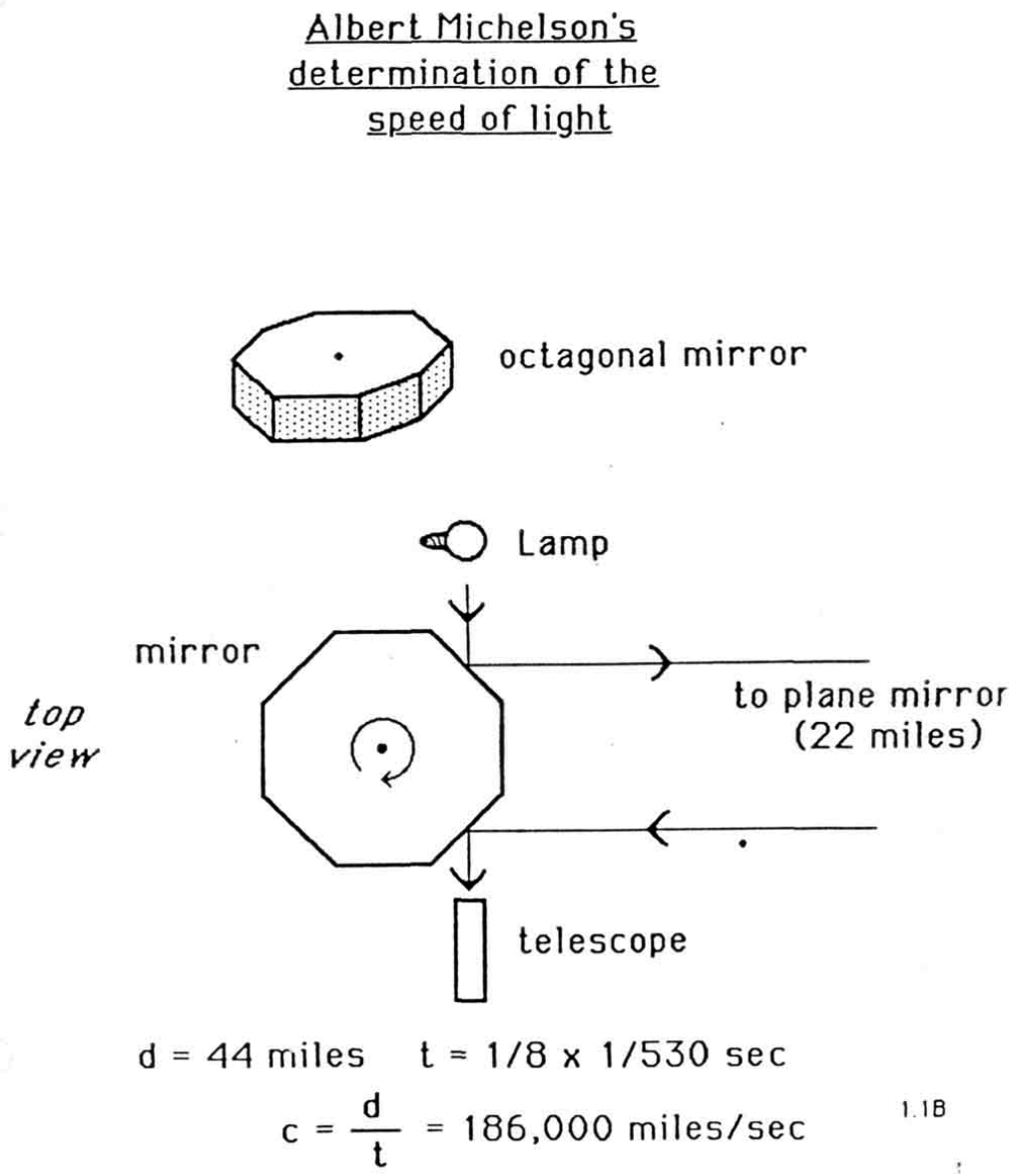
t = 17 minutes = 1000 sec

so $c = \frac{d}{t}$ = 186,000 miles/sec

Albert Michelson's determination of the speed of light-1



Albert Michelson's determination of the speed of light-2



Math Quiz

- Take quiz- 15 minutes
- Doesn’t count towards grade
- Allows me to judge the mathematical skills of class
- Allows you to judge the strength of your math skills