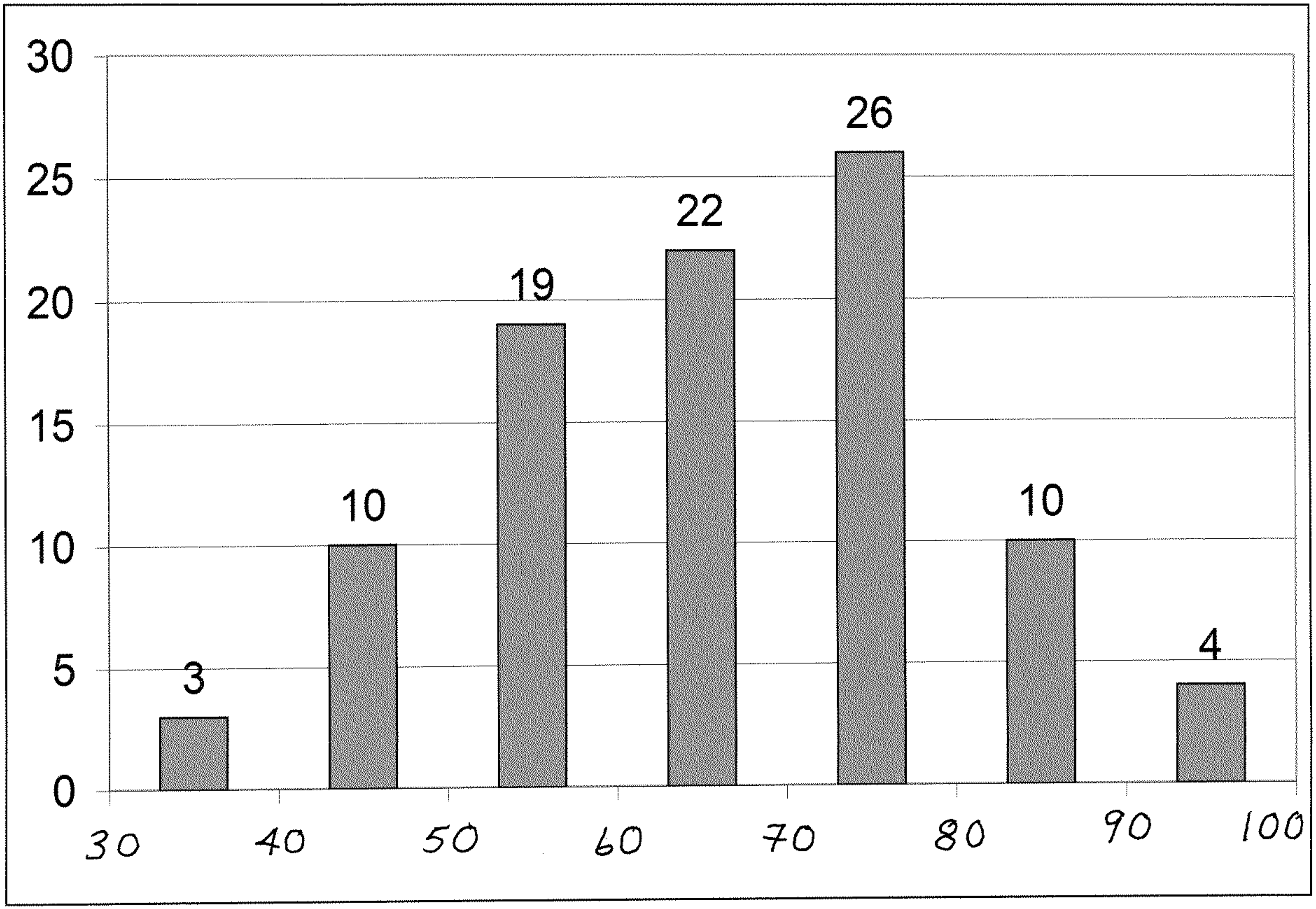
Lecture

3/29/05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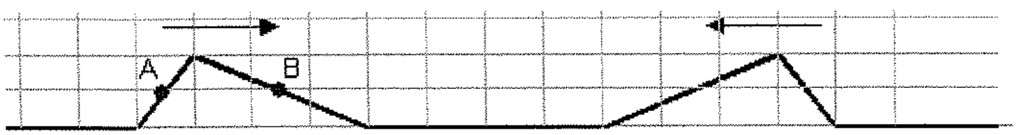
Physics 122 **Midterm 1** **Langenberg**

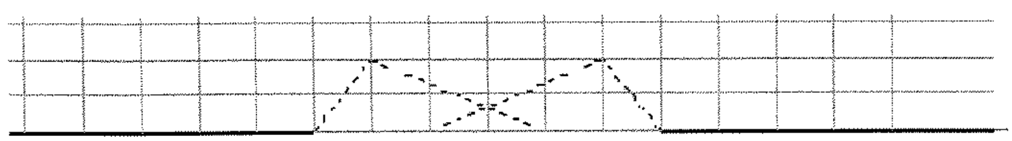
NAME_______________________________**SECTION**__________**POINTS**______________

1. (20 points) Two pulses are moving on a taut string, one to the right and the other to the left. At the time $t = 0$, the string has the shape shown below. Each side of the boxes in the grid has length 1 cm. (They are meant to be square, but are a little distorted in the picture.)



Each box in the grid has a side of 1 cm.

a. The leading edges of the pulses will just touch in a time of 0.05 sec. What is the speed with which each pulse is traveling?
b. Two points on the string are marked with heavy black dots and with the letters A and B. At the instant shown, what are the velocities of the dots? Give magnitude and direction (up, down, left, right, or some combination of them).
c. On the figure below are shown dotted lines indicating where the pulses would be at a time $t = 0.075$. Draw a heavy line to show what the shape of the string would look like at this instant.



Explain why you think it would look like this.

Physics 122 **Midterm 1** **Langenberg**

NAME______________________________**SECTION**__________**POINTS**______________

2. (20 points) Fluorescent bulbs deliver the same amount of light as comparable incandescent bulbs using much less power. If one kW-hr costs 7¢, estimate the amount of money you would save each month by replacing all the 75 W incandescent bulbs in your house by 10 W fluorescent ones. *Be sure to clearly state your assumptions, since grading on this problem will be mostly based on your reasoning, not on your numerical answer.*

Physics 122 **Midterm 1** **Langenberg**

NAME______________________________**SECTION**__________**POINTS**______________

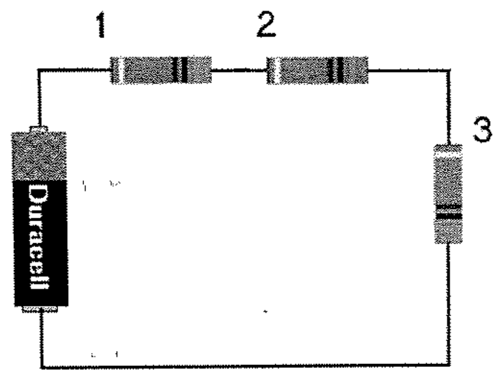
3. (20 points) Sketch the electric field lines and the equipotential surfaces associated with two point charges of equal magnitude but opposite sign, separated by a distance d (an electric dipole). Include as much explanatory text as you think is needed to convince the grader that you understand what you are doing.

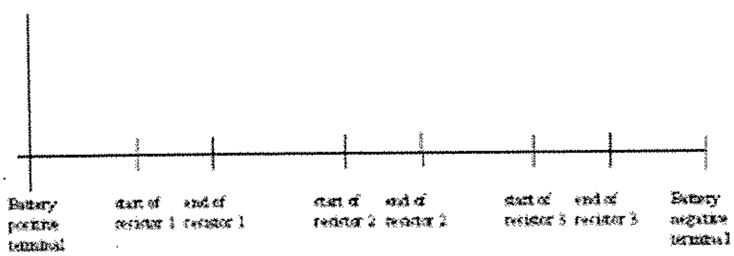
Physics 122 **Midterm 1** **Langenberg**

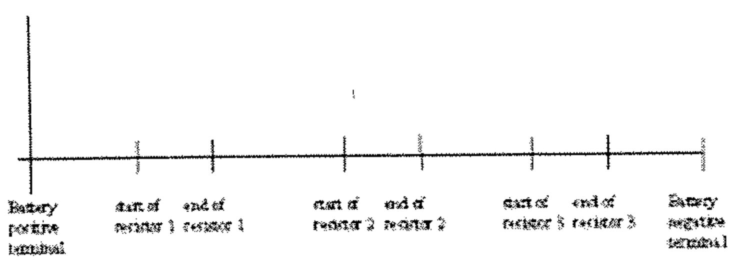
NAME______________________________**SECTION**__________**POINTS**_______________

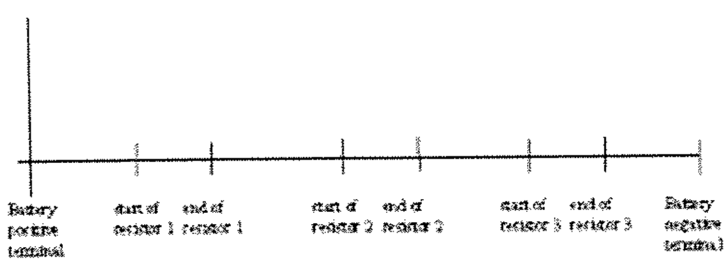
4. (20 points)

The circuit shown in the diagram at the right contains a battery and 3 resistors. The battery has an EMF of 5 V, $R_1 = 2\ \Omega$, $R_2 = 3\ \Omega$, and $R_3 = 5\ \Omega$. Below are shown 3 graphs tracking some quantity around the circuit. On the first, plot the voltage a test charge would experience as it moved throughout the circuit. On the second, plot the electric field a test charge would experience as it moved through the circuit. On the third, plot the current one would measure crossing a plane perpendicular to the wire of the circuit as one goes through the circuit.







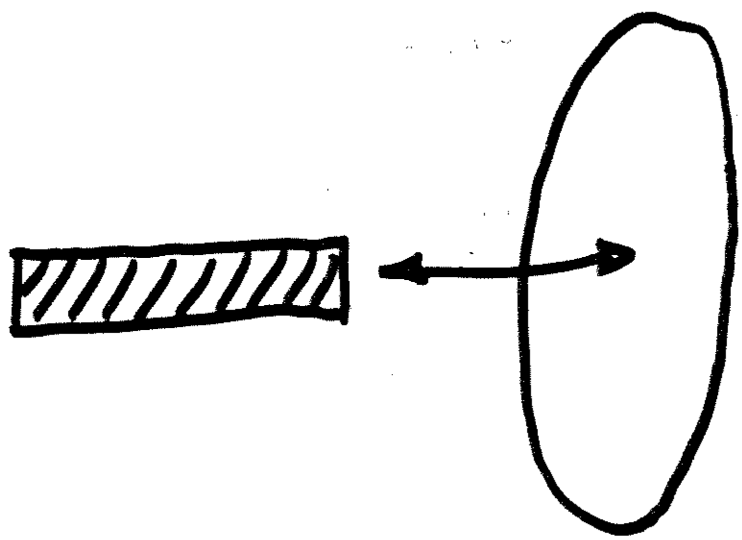


Physics 122 **Midterm 1** **Langenberg**

NAME______________________________**SECTION**__________**POINTS**______________

5. (20 points) You have been introduced to three different kinds of forces (gravitational, electric, and magnetic), each of which can be described in terms of a "field." Write a concise explanatory description of these forces, including their sources, their similarities, and their differences, and explain how the associated fields can be detected. Imagine that your description is intended for a friend who is a psychology major and has never taken a physics course.

ANOTHER CONNECTION BETWEEN ELECTRICITY AND MAGNETISM



INDUCTION!

MAXWELL'S EQUATIONS

(The crowning glory of 19th century physics)

$$\nabla \cdot \vec{E} = \frac{1}{\epsilon_0}\rho$$ (Gauss's Law)

$$\nabla \cdot \vec{B} = 0$$ (No Name)

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$ (Faraday's Law)

$$\nabla \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

(Ampere's Law with Maxwell's inspired addition)

And don't forget to connect with Newton

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

(Lorentz's Equation)

ASTOUNDING SURPRISE

$$\sqrt{\mu_0 \epsilon_0} = \frac{1}{c}$$

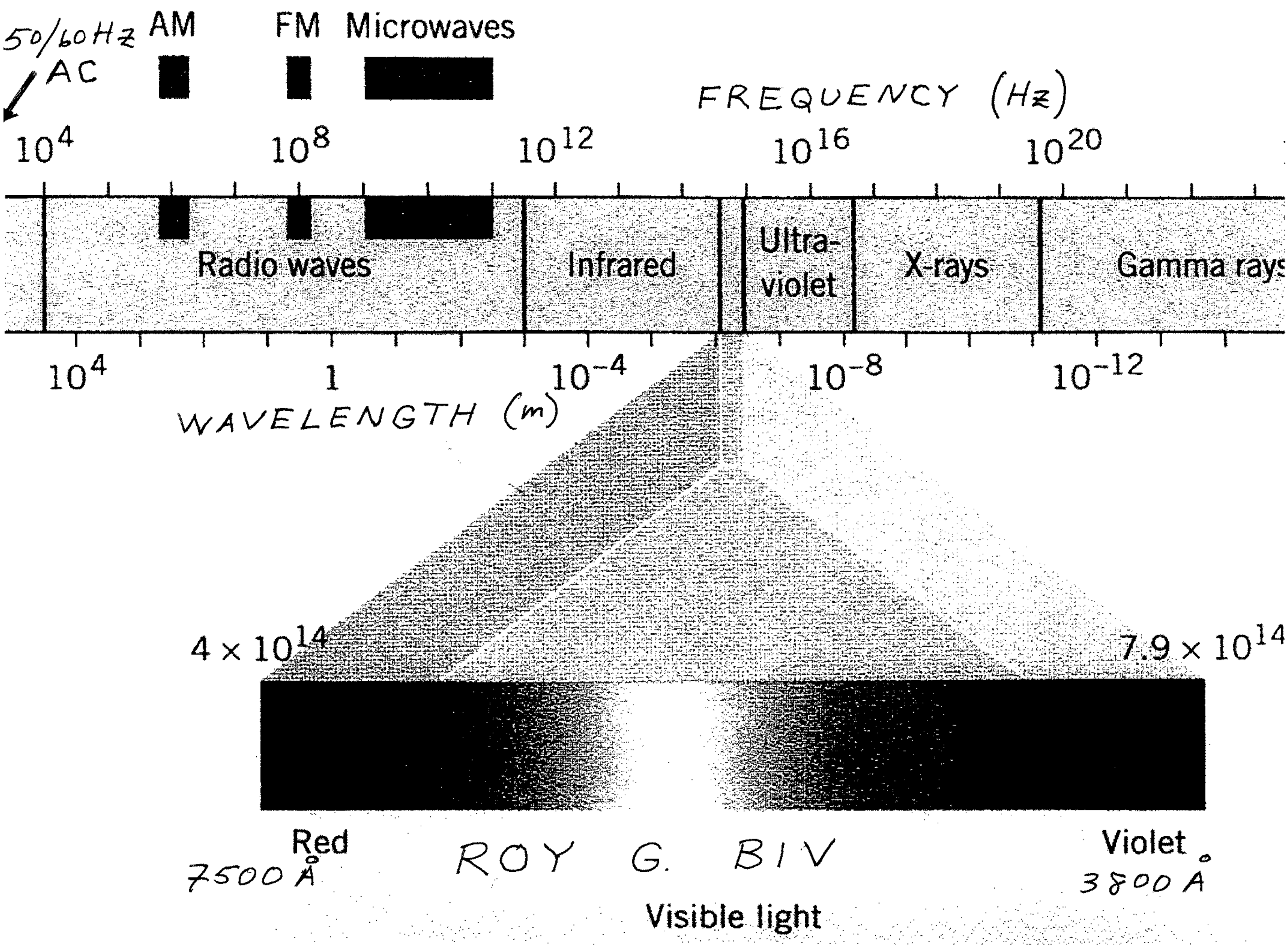
Maxwell's equations predict and describe electromagnetic waves.

SECOND ASTOUNDING SURPRISE

c does <u>not</u> depend on (inertial) frame of reference!

[cf. A. Einstein, Zeitschrift für Physik, 1905]

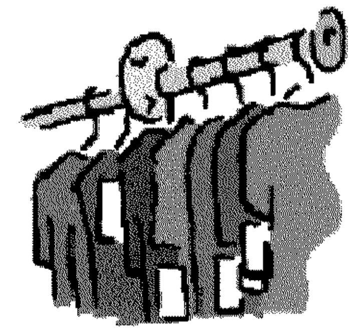
(PART OF) THE ELECTROMAGNETIC SPECTRUM



Light

- For the next few weeks
  we will study the properties of light.
- Light is a phenomenon with which we have considerable experience.
- Light gives us much of our information about the world that we tend to take it for granted and not think about what we know and how we know it.
- Studying the physics of light involves not only the physics of the external world, but the psychology of how we interpret the information we get.

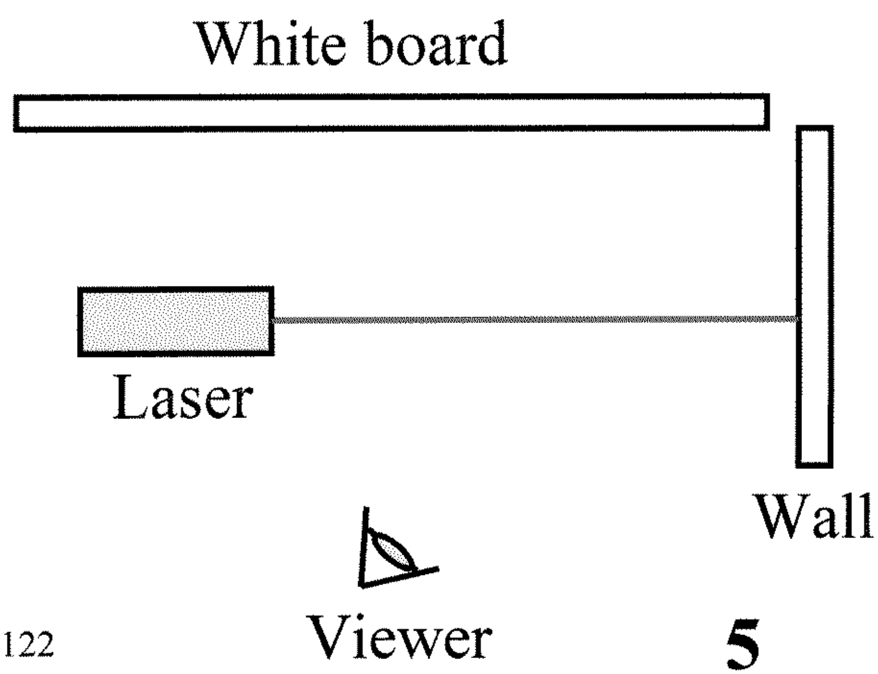
Shopping for Ideas: Light



- Let's begin by searching for experiences with vision that tell us something about the nature of light.

Prediction

- If I shine a laser beam in front of a white board onto a wall (picture as shown from above) what will I see?
  - A. a thin red line against the white board
  - B. a spot on the wall.



  - 1. A only
  - 2. B only
  - 3. A and B
  - 4. nothing

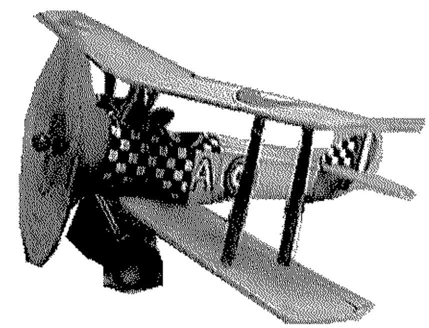
Some Questions

- How do we see?
- Can cats see in the dark?
- Can you “see” light?
- How do we decide how far away from us something is?
- Can you “feel” someone watching you from behind?

Some Foothold Ideas

- Certain objects (the sun, bulbs,…) give off light.
- Other objects scatter light.
- We only see something when light coming from it enters our eyes.
- …

Models of Light and Vision



- Historical models of light
  - Light comes out of the eye
  - Visible objects are sources of light
  - Some objects are sources of light, others are seen by scattered light
- Scientific models of light
  - Rays
  - Waves (Electromagnetic)
  - Photons (quantum “wavicles”)

Scientific Models of Light

- Light is a complex phenomena. Different situations are most easily treated with different descriptions (models).
- Models of light
  - *Rays* – energy moving in straight lines
  - *Waves* – electromagnetic oscillations
  - *Photons* – quanta (discrete packets) of energy having both wave-like and particle-like properties.
- Each of the models in this list can be interpreted (in principle) as a restriction (approximation) of the model below it.

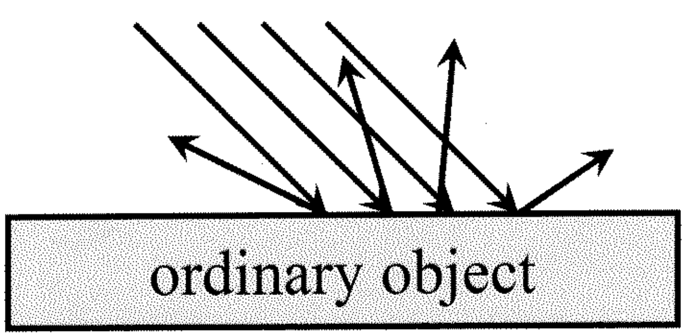
How do we see?

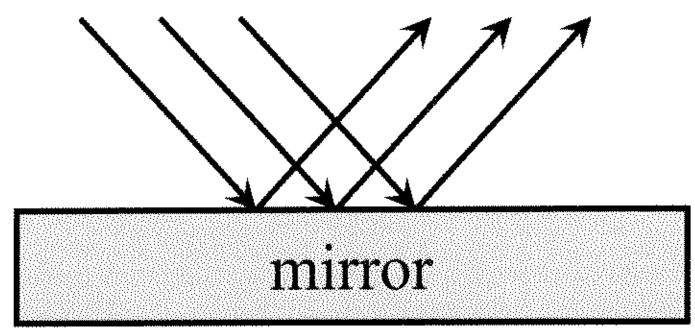
- We see by light entering our eyes and setting off energy receptors on our retina.
- These individual receptors (rods and cones) are like the individual dots on a TV or computer screen or the dots that can be seen using a magnifying glass on a newspaper photo.
- Our brains put these dots together into coherent, continuous images.
- Sometimes our brain can have trouble interpreting or can misinterpret the information given it by the retina. This can be either a problem or a benefit.

This is a ...?

Seeing things

- To see something, light has to come into our eyes.
- Some objects (e.g., the sun, a light bulb) serve as sources of light.
- Other object scatter that light into our eyes.
  - For most objects, light scatters from them in all directions.
  - For some objects (mirrors) light scatters from them in controlled directions.

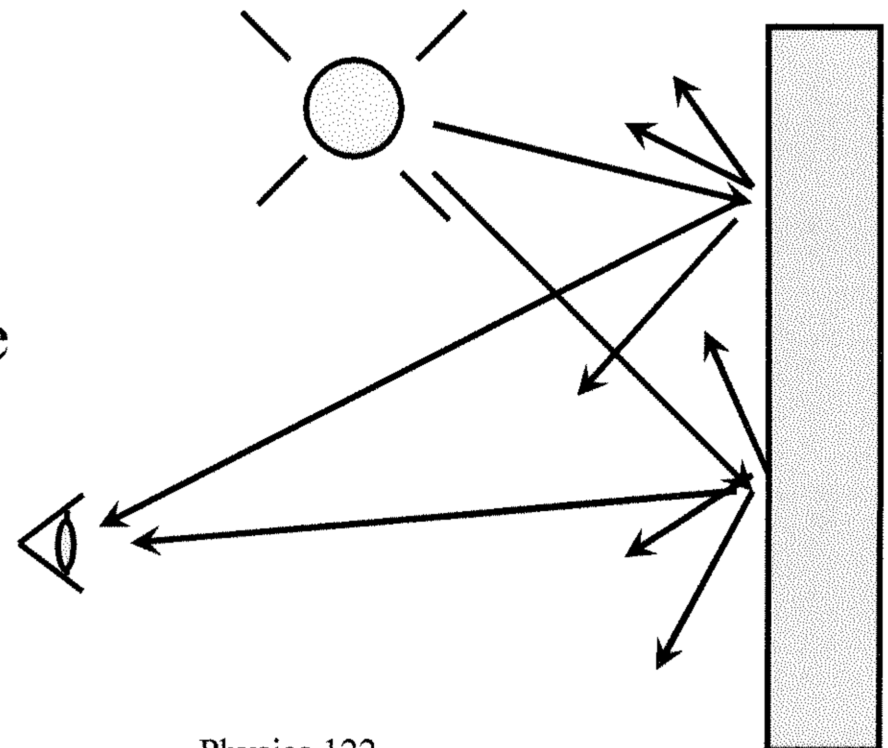




Light and Shadow

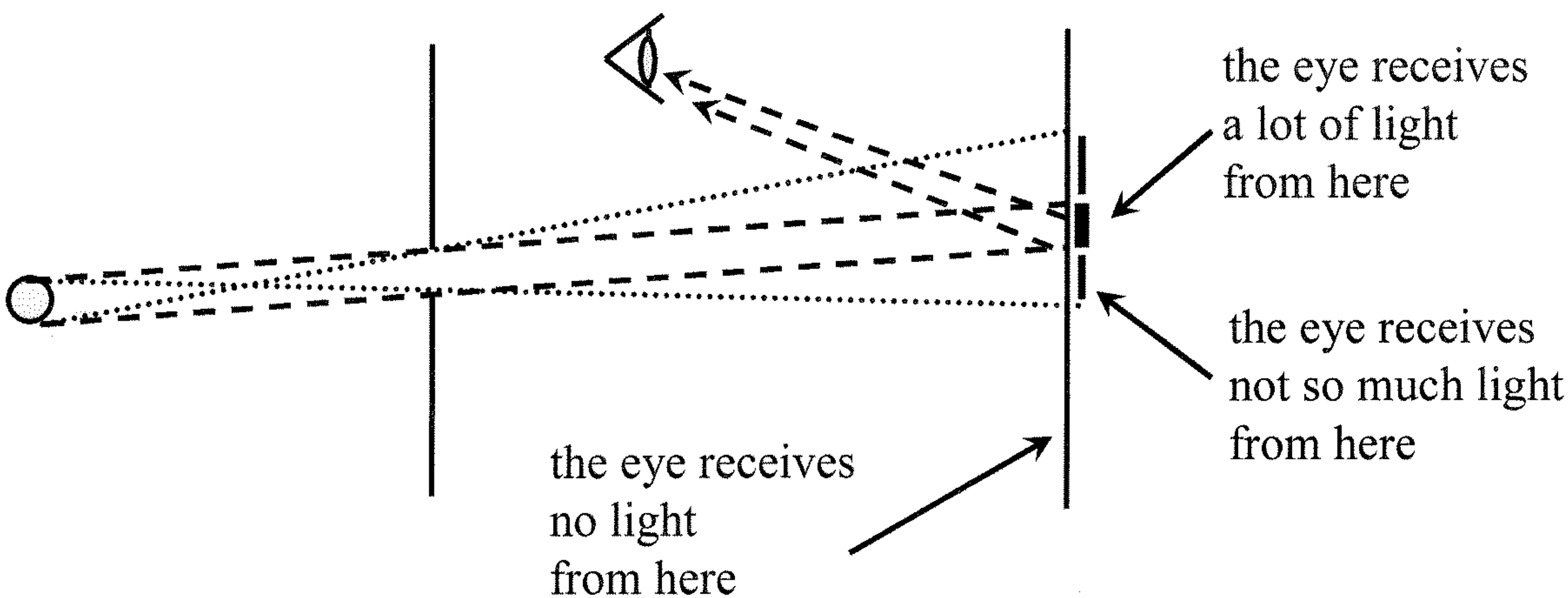
- If we shine a light on a uniform (rough – not mirrored) screen, what will we see?

Since light hitting the surface at each point scatters in all directions our eye will receive some light from each point.
The entire object can be seen.



Partial lighting

- Consider a small bulb ("point source") lighting a screen through a hole in a mask.

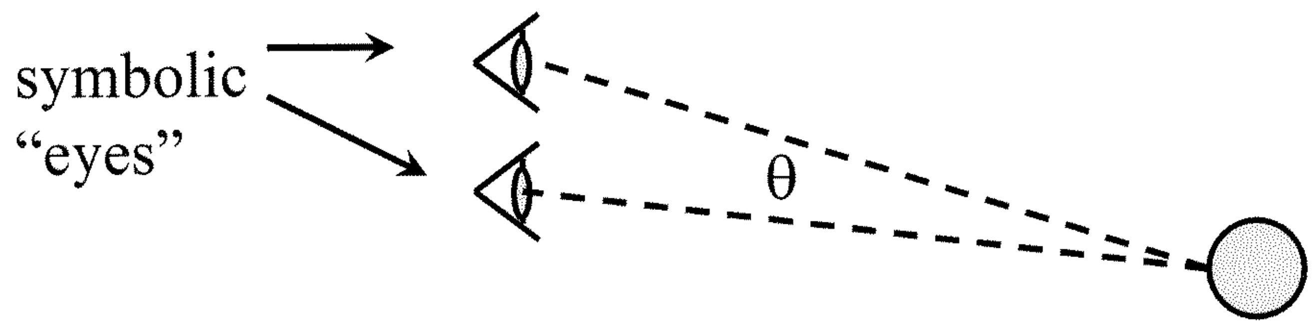


How do we decide how far away something is?

- There are actually many mechanisms.
  - Parallax
  - Assumed constancy of size
  - Haziness
  - Relative size to a known object
- Misleading one or another of these mechanisms leads to interesting optical illusions such as
  - the moon on the horizon
  - distant mountains in the desert
  - Stereopticon pictures
  - "Magic Eye" pictures

Parallax

- Parallax (the angle between the lines each eye has to point to be directed at the object) tends to be the dominant mechanism for nearby objects.



- Our eyes identify a point as being on an object when rays traced back converge at that point.