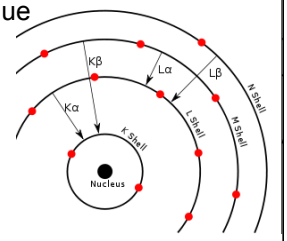
PHY132H1F Introduction to Physics II
Class 7 – **Outline:**

- Measurement Project due Dec. 1
- Vision
- Telescopes
- Microscopes
- The Hydrogen Atom
- Photons
- Quantum Physics



Quick Ch. 25 reading quiz..

What did Balmer do?

A. Developed the mathematical theory of atomic transitions.
B. Designed the first atomic spectrometer.
C. Fit the visible lines in the spectrum of hydrogen to a simple formula.
D. Discovered that x rays are diffracted by crystals.
E. Proposed a relation between the frequency of an electromagnetic wave and the energy of photons.

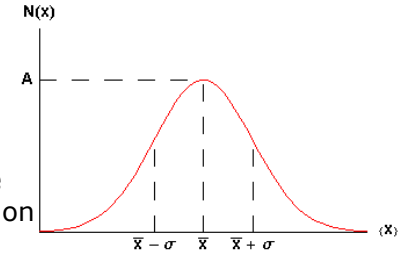
Ch. 25 quick reading quiz #2

Light consists of discrete, massless units called

A. quarks.
B. photons.
C. rotons.
D. muons.
E. phonons.

The Gaussian:

$$N(x) = A\, e^{\frac{-(x-\bar{x})^2}{2\sigma^2}}$$



68% of data between the dotted lines on the graph.

Propagation of Errors

$z = x + y$ $\quad \Delta z = \sqrt{\Delta x^2 + \Delta y^2}$

$z = x - y$

$z = x * y$ $\quad \frac{\Delta z}{z} = \sqrt{\left(\frac{\Delta x}{x}\right)^2 + \left(\frac{\Delta y}{y}\right)^2}$

$z = x / y$

$z = A\,x$ $\quad \Delta z = A\,\Delta x$

$z = x^n$ $\quad \Delta z = \left| n\, x^{n-1} \Delta x \right|$

Repeated Measurements

- Repeated **n** times
- Each individual measurement has an error of precision $\Delta \mathbf{x}$
- If $\bar{x}_{est}$ is the estimated mean, or average of the *n* measurements, then the error in the mean is:

$$\Delta \bar{x}_{est} = \frac{\Delta x}{\sqrt{n}}$$

Significant Figures

- Rules for significant figures follow from error propagation
  - Errors should be quoted to 1 or 2 significant figures. Do NOT quote errors to 3 or more significant figures – that is too precise, and it is meaningless!
  - Whatever the most precise tenths place of the quoted error is, this should also be the most precise tenths place of the value you display.
- Example: If a calculated result is (7.056 +/- 0.705) m, it is better to report (7.1 +/- 0.7) m.

You measure the slope of the stairs to have a rise of 72.3 cm for a run of exactly 1 m. You estimate your error to be 1 cm in the rise, and zero in the run. What is the slope?

A. 0.7 ± 0.1
B. 0.72 ± 1.00
C. 0.72 ± 0.01
D. 0.723 ± 0.010
E. 0.723 ± 0.001

Measurement Project: Due Dec. 1

- 2-page typed report based on measurement done as homework.
- Measurement Project may include measurements done with your team-mates from practicals (who should be listed as collaborators in your report), but your report should be written by you individually, and based primarily your own individual work.
- The Practicals mark counts toward 15% of the course mark, divided as follows:
  - **5% for first team notebook mark** (sessions 2-5),
  - **5% for second team notebook mark** (sessions 6-10) and
  - **5% for the individual Measurement Project.**

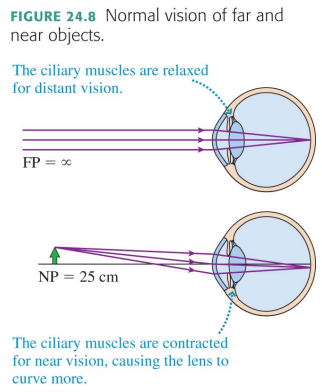


FIGURE 24.8 Normal vision of far and near objects.

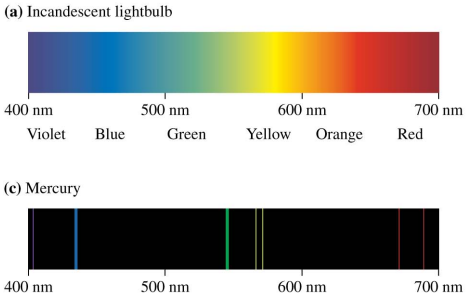


FIGURE 25.2 Examples of spectra in the visible wavelength range 400–700 nm.

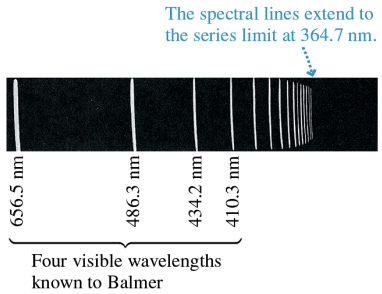


FIGURE 25.3 The Balmer series of hydrogen as seen on the photographic plate of a spectrometer.

The Spectrum of Hydrogen

- Hydrogen is the simplest atom, with one electron orbiting a proton, and it also has the simplest atomic spectrum.
- The emission lines have wavelengths which correspond to two integers, m and n.
- Every line in the hydrogen spectrum has a wavelength given by

$$\lambda = \frac{91.18\ \text{nm}}{\left(\frac{1}{m^2} - \frac{1}{n^2}\right)} \qquad \begin{cases} m = 1 & \text{Lyman series} \\ m = 2 & \text{Balmer series} \\ m = 3 & \text{Paschen series} \\ \vdots \end{cases}$$

$$n = m + 1, m + 2, \ldots$$

The Photon model of light. (and all other forms of electromagnetic waves)

Increasing light intensity

The Photon Model of Electromagnetic Waves

The **photon model** of electromagnetic waves consists of three basic postulates:

1. Electromagnetic waves consist of discrete, massless units called photons. A photon travels in vacuum at the speed of light, 3.00×10^8 m/s.
2. Each photon has energy

$$E_{\text{photon}} = hf$$

where f is the frequency of the electromagnetic waves, and h is a *universal constant* called **Planck's constant.** The value of Planck's constant is $h = 6.63 \times 10^{-34}$ J s.

3. The superposition of a sufficiently large number of photons has the characteristics of a classical electromagnetic wave.

Does a photon of red light have more energy or less energy than a photon of blue light?

A. More energy
B. Less energy

Question:

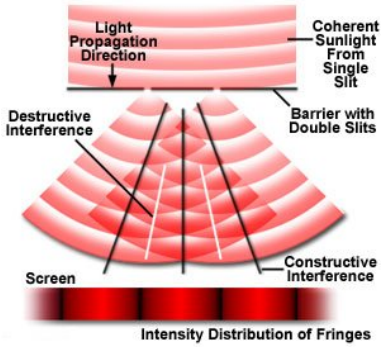
- We understand light is an electromagnetic wave. But in quantum physics, it is also like a stream of particles.
- What about the other way around? Can a stream of particles, like electrons or Helium nuclei (or even baseballs) be like a wave?
- YES!
- Matter travels from place to place as a wave. What "waves" is the probability of the particle being observed at any particular place.

The de Broglie Wavelength

De Broglie postulated that a particle of mass m and momentum $p = mv$ has a wavelength

$$\lambda = \frac{h}{p}$$

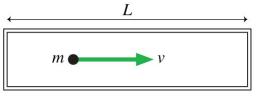
where h is Planck's constant. This wavelength for material particles is now called the **de Broglie wavelength.** It depends *inversely* on the particle's momentum, so the largest wave effects will occur for particles having the smallest momentum.



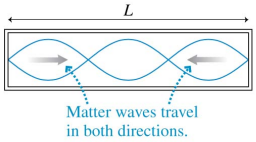
- Double slit experiment works for light or electrons (and other particles). Particles can go through one at a time and still interfere!

FIGURE 25.16 A particle of mass m confined in a box of length L.

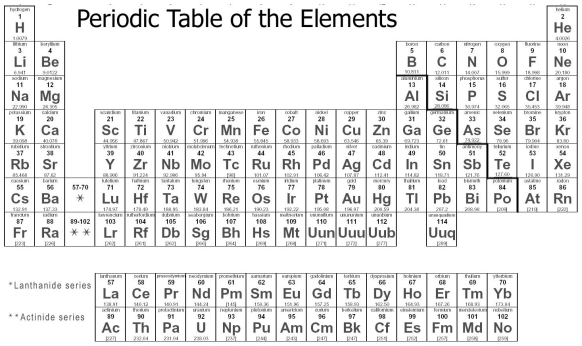
(a) A classical particle of mass m bounces back and forth between the ends.



(b) Matter waves moving in opposite directions create standing waves.



Periodic Table of the Elements



On page 1312 of Knight.

Before Next Class:

- The test on Oct. 12 will cover Chapters 20 – 25 (excluding Ch.22). Review these chapters, email questions to me if you'd like me to take up anything specific for review.

- Try the suggested end-of-chapter problems for Chapter 25

See you Wednesday!