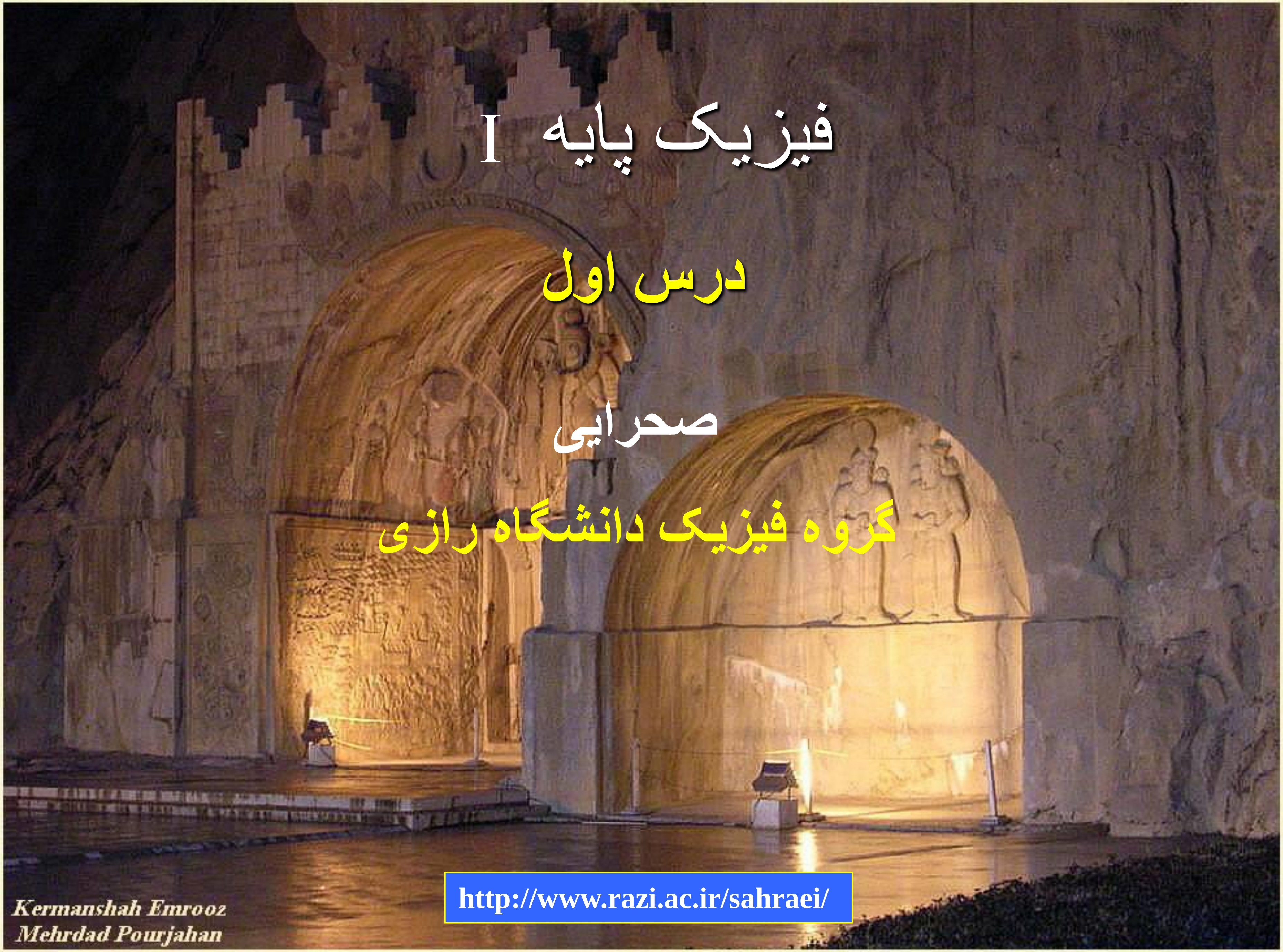
فیزیک پایه I

درس اول

صحرایی

گروه فیزیک دانشگاه رازی



http://www.razi.ac.ir/sahraei/

References: منابع:

- Physics, Volume 1, Resnick, Halliday, Krane, 1992.

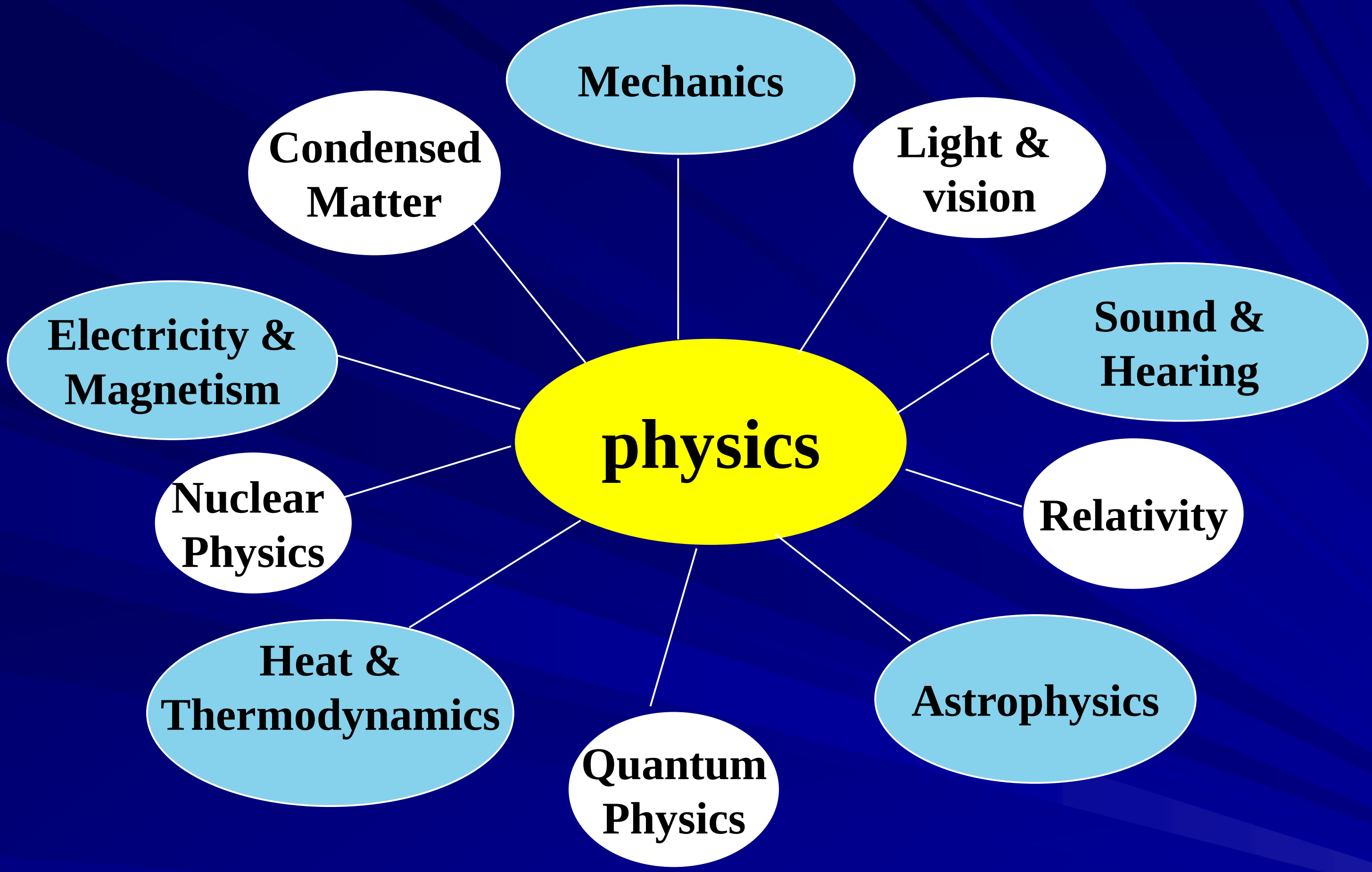
فیزیک ، جلد اول ، ترجمه پاشایی راد ، خرمی ، بهاری، انتشارات مرکز نشر دانشگاهی

- Fundamentals of Physics, Volume 1, Resnick, Halliday, Walker, 1997.

- Internet

Assessment

- Quiz (Including mathematical methods, Physical concepts): 20%
- Mid semester exam (Mon. 4 Azzar): 30%
- Final exam: 50%



Mechanics
Condensed Matter
Light & vision
Electricity & Magnetism
Sound & Hearing
physics
Nuclear Physics
Relativity
Heat & Thermodynamics
Astrophysics
Quantum Physics

Course Outline

Kinematics – Chapters 1 – 4

- **Measurement**
- **Motion in 1 Dimension**
- **Vectors**
- **Motion in 2 & 3 Dimensions)**

Newton's Laws – Chapters 5 – 6

- **Force & Motion – I**
- **Force & Motion – II**

Conservation Laws – Chapters 7 – 10

- **Kinetic Energy & Work**
- **Potential Energy & Conservation of Energy**
- **Systems of Particles**
- **Collisions**

Rotation & Equilibrium – Chapters 11 – 14

Rotation

Rolling, Torque & Angular Momentum

Equilibrium & Elasticity

Measurement

- Physics is based on measurement.
- All physical quantities are measured in their own special units and compared against "standards".
- Some things we measure are in "base units" – others are in "derived units"

The International System of Units

- The International System of Units (the *metric system*) was established in 1971. (Le **Système International d'Unités**, abbreviated **SI)**.
- Seven fundamental (base) quantities were picked – we will look more closely at three of them starting today:
  - Length (meter)
  - Time (second)
  - Mass (kilogram)

Base units: only seven for all of physics!

Table 1. SI base units

Base quantity	SI base unit Name	SI base unit Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Physical Units

Mechanics is the branch of physics in which the basic physical units are developed.

The basic mechanical units are those of

MASS, LENGTH, & TIME

All mechanical quantities can be expressed in terms of these three quantities.

Units…

- **SI (Systèm International) Units:**

mks: L = meters (m), M = kilograms (kg), T = seconds (s)

cgs: L = centimeters (cm), M = grams (gm), T = seconds (s)

- **British Units:**
  - Inches, miles, feet, pounds, seconds, slugs…

- We will use mostly SI units, but you may run across some problems using British units. You should know how to convert back & forth.

Prefixes for SI Units

- To make the use of SI units a little easier, prefixes have been established for certain powers of 10

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10^1	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

SI Prefixes and Unit Conversion

Unit Conversions

- **To convert the units of a measured value, the value is multiplied by a conversion factor to produce a result with the desired units.**

1mi = 1609 m; 1 kg = 1000 g; 1 cm = 10 mm; 12 in. =1 ft.

- When converting units use the following formula.

$$\text{Number in original units}\left[\frac{\text{new unit}}{\text{original unit}}\right] = \text{new number in new unit}$$

Quantity to express in new units

Conversion Factor

Quantity now expressed in new units

1 min =60 s

1= 60s / 1min

1 mi = 1609 m

1=1609 m / 1 mi

55 mi/h =? m/s

55 mi/h =55 mi/h *(1609 m/1 mi) * (1 h/3600 s) = 25 m/s

Converting between different systems of units

- **Useful Conversion factors:**
  - 1 inch = 2.54 cm
  - 1 m = 3.28 ft
  - 1 mile = 5280 ft
  - 1 mile = 1.609 km

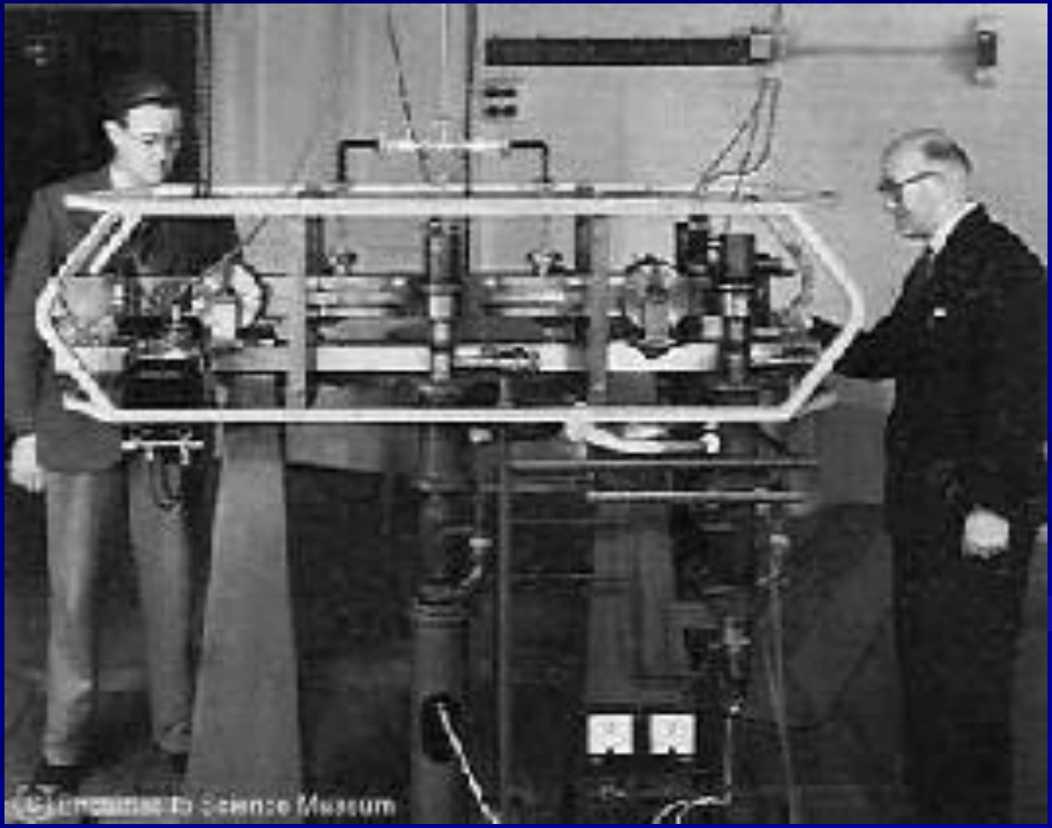
- **Example: convert miles per hour to meters per second:**

$$1\frac{\text{mi}}{\text{hr}} = 1\frac{\text{mi}}{\text{hr}} \times \left(5280\frac{\text{ft}}{\text{mi}}\right) \times \left(\frac{1}{3.28}\frac{\text{m}}{\text{ft}}\right) \times \left(\frac{1}{3600}\frac{\text{hr}}{\text{s}}\right) = 0.447\frac{\text{m}}{\text{s}}$$

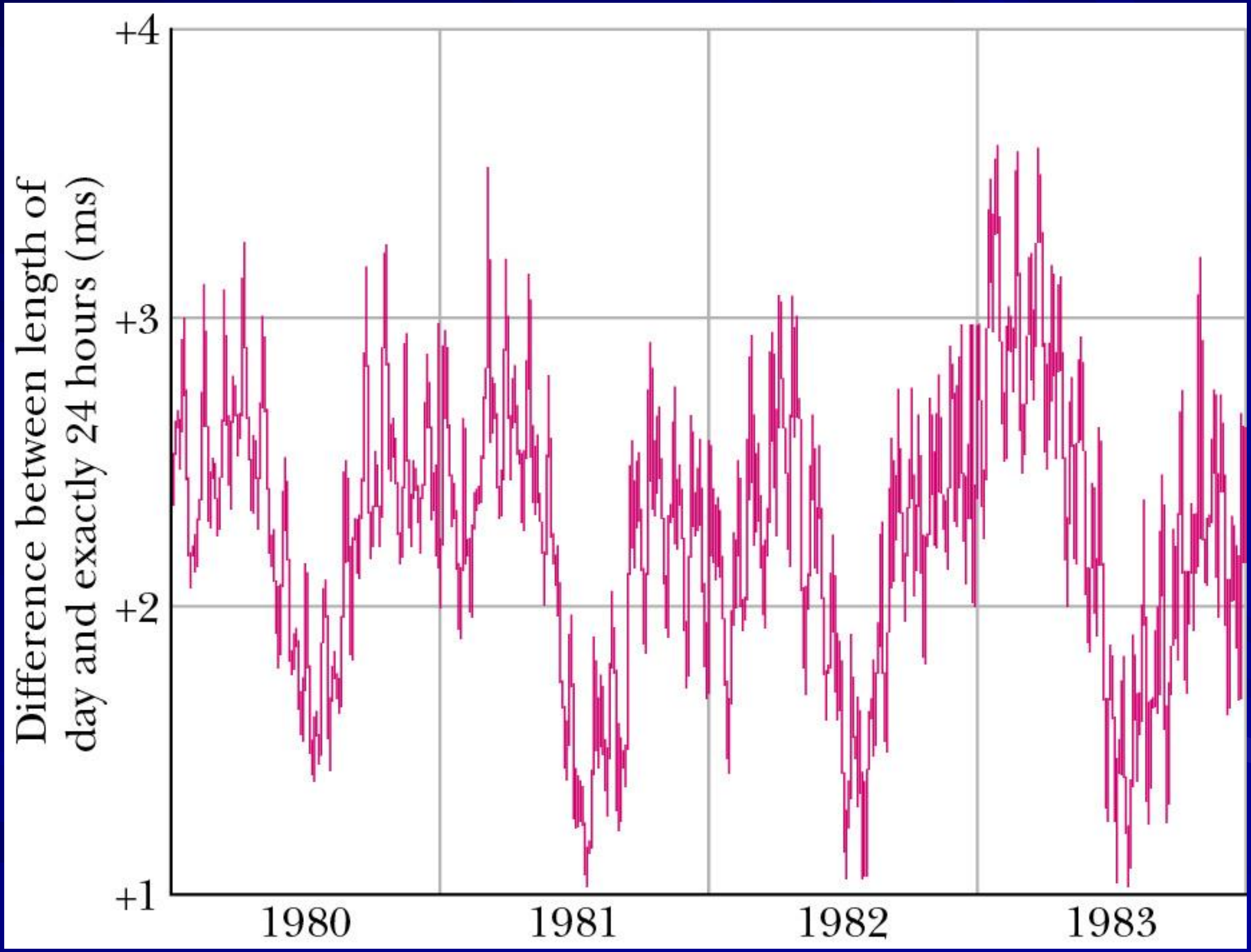
Time

- The standard unit of time is of course the *second* and it is now defined to be the length of time it takes for 9,192,631,770 oscillations of light (of a particular wavelength) emitted by cesium-130 atoms
- The mechanism for detecting and counting these oscillations is called an atomic clock
- The accuracy of a cesium-based atomic clock is such that it would take 300,000 years for two such clocks to differ by 1 second

ساعت اتمی : که بر اساس فرکانس دقیق تابش میکروموجی است که از اتمهای عنصر سزیم گسیل می شود.



Time



+4
+3
+2
+1
Difference between length of day and exactly 24 hours (ms)
1980
1981
1982
1983

Quartz Clocks

Quartz clock operation is based on a property of quartz crystals. If you apply an electric field to the crystal, it changes shape, and if you squeeze or bend it, it generates an electric field. When put in a suitable electronic circuit, the crystal can vibrate and generate an electric signal that can be used to operate an electronic clock display.

Quartz crystal clocks were better because they had no gears. Such quartz clocks continue to dominate the market in numbers because their performance is excellent and they are inexpensive.

- (*solid-state physics*) Having the ability to generate a voltage when mechanical force is applied, or to produce a mechanical force when a voltage is applied, as in a piezoelectric crystal.

Length

- Specifically, a meter is now defined to be the distance light travels (in a vacuum) during a time interval of 1/299,792,458 second
- Consequently, the speed of light is also now defined to be exactly 299,792,458 m/s

A light-year is a unit of distance.
It is the distance that light can travel in one year.

1 light year = 9.4605284×10^{15} meters

1 light year = $5.87849981 \times 10^{12}$ miles

Mass

- The standard unit for mass is a physical object – a platinum-iridium cylinder kept at the International Bureau of Weights and Measures near Paris
- By international agreement, that cylinder of metal has been assigned a mass of exactly 1 kilogram (1 kg)

Mass

- Because we need to measure the mass of very small objects (atoms or even smaller) the physical cylinder in Paris (or copies of it) may not be very convenient

- So a second standard has also been adopted – one for use at the atomic level

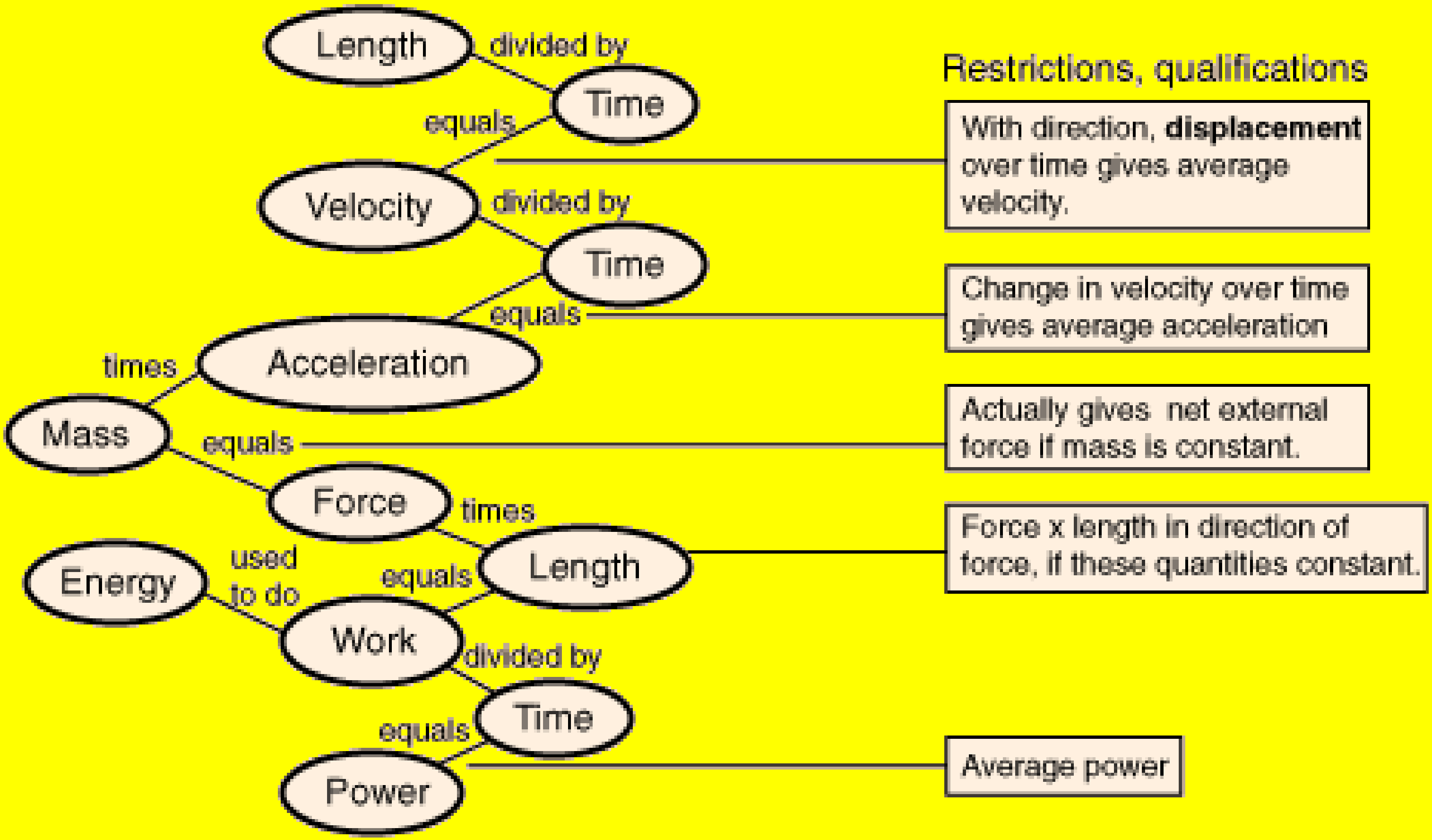
Mass

An atomic mass unit (symbolized AMU or amu) is defined as precisely 1/12 the mass of an atom of carbon-12.
The carbon-12 (C-12) atom has six protons and six neutrons in its nucleus.

The relationship between the two mass standards is:

1 atomic mass unit (1 u)= 1.661 × 10^{-27} kilograms

The Chain of Mechanical Quantities



Accuracy and Significant Figures
دقت و رقمهای با معنی

- Measurements are inherently <u>approximate</u> and <u>variable</u>
- Terms associated with measurements
  - accuracy
  - precision

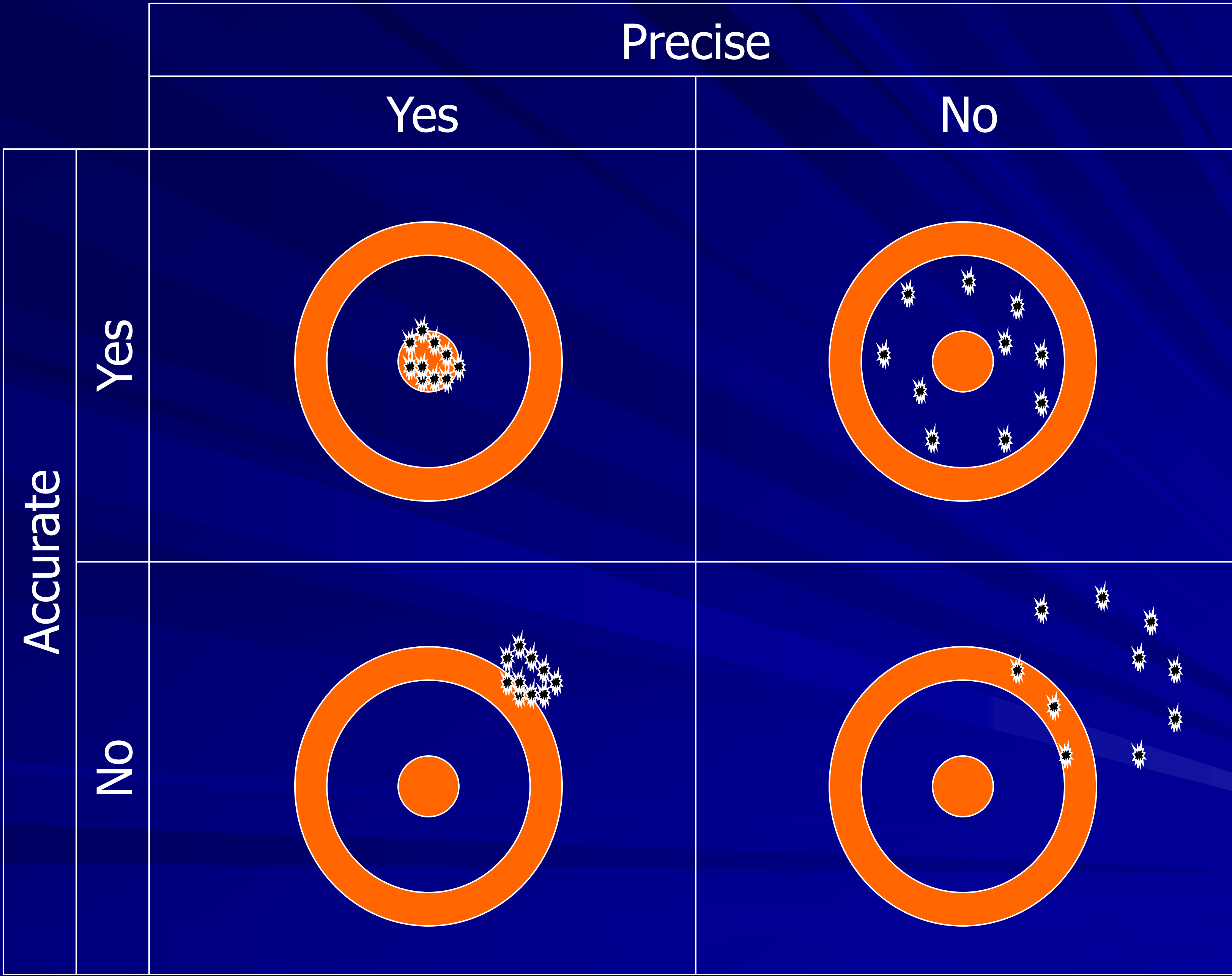
- Accuracy - The degree of conformity of a measured or calculated value to some recognized standard or specified value.

- Precision - The degree of mutual agreement between individual measurements, namely repeatability and reproducibility.

Example: Precision vs. Accuracy

- *An easy way to remember the difference between precision and accuracy is to consider patterns shot on a target.*
- *Consider the table shown on the next slide…*

Target Practice


Precise
Yes
No
Accurate
Yes
No

Italics means that students do not need to write it down.

Thought Problem

- *If we measure the weight of a calculator and get values of 3.001 N, 3.000 N, 2.999 N, 3.000 N*
- *These numbers are precise enough for us to believe that if we measure in again we would get 3.000 ± .001 N.*
- *What if the actual weight is 2.5 N?*
  - *our scale is precise, but not accurate!*

A. **Precision** - the reproducibility of a series of measurements.

Poor Precision

Good Precision

Standard Deviation

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

Where:

x_i = experimental result

$\bar{x}$ = average result

n = number of results

B. <u>Accuracy</u> - the agreement of a measurement with the accepted value of the quantity.

Good Accuracy

Good Precision

Poor Accuracy

Error

$$E_a = x_i - \mu$$

Where:

x_i = experimental result

m = accepted value

Percent Error

$$\%E = \frac{x_i - \mu}{\mu} \times 100\%$$

A digression on the length of a day. . .

- A *solar day* is the amount of time when the sun is directly overhead until it is again directly overhead
- This is nominally taken to be 24 hours (86,400 seconds)
- A *sidereal day* is the amount of time it takes the earth to rotate 360º w.r.t. a distant star, e.g., a star we are <u>not</u> orbiting

The *sidereal day* is defined to be the length of time for the vernal equinox to return to your celestial meridian. The *solar day* is defined to be the length of time for the Sun to return to your celestial meridian.
The two are not the same, as illustrated in the following animation.

Animation illustrating that a solar day is about 4 minutes longer than a sidereal day because of the Earth's motion on its orbit

http://csep10.phys.utk.edu/astr161/lect/time/timekeeping.html