
Overview, Dimensions, and the Scientific Method

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Why do we use special units in astronomy?

Overview, Dimensions, and the Scientific Method

Units, Symbols, and Basic Math

- ◆ **Units** (also see your text's appendices)
 - Most quantities have units, with the most common exception being ratios
 - Common system of units in science: MKS System
 - » meter-kilogram-second
 - » Other units are hybrids of these, e.g.:
 - Newton (N): kg·m/s² (Force)
 - Joule (J): N·m (Energy)
 - Watt (W): J/s (Power)
 - In astronomy, units are chosen to best fit the scale of the object(s) under study (e.g., nm, AU, ly, and Mpc)
 - For any problem you solve, treat units separately and cancel/combine appropriately (also, unit conversion)

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Units, Symbols, and Basic Math

Numbers greater than one

$10 = 10^1$

$100 = 10 \times 10 = 10^2$

$1000 = 10 \times 10 \times 10 = 10^3$

$1,000,000 = 10^6$

$1,000,000,000 = 10^9$

Numbers less than one

$0.1 = 10^{-1}$

$0.01 = 10^{-2}$

$0.001 = 10^{-3}$

$0.000001 = 10^{-6}$

$0.000000001 = 10^{-9}$

Move the decimal to the left

Move the decimal to the right

Units, Symbols, and Basic Math

◆ Scientific Notation (also see your text's appendices)

- We often express large or small numbers in terms of a number between 1 and 10 multiplied by a power of ten
- $149,600,000,000 \text{ m} = 1.496 \times 10^{11} \text{ m}$
- $0.00000000000000000000000000000167 \text{ kg} = 1.67 \times 10^{-27} \text{ kg}$
- Look at text appendix for astronomical, physical, and mathematical constants expressed in a variety of formats and units

What is Science?

◆ "The true scientific method is to test hypotheses. A good hypothesis must predict some things about nature, and if the predictions are wrong, the hypothesis must be rejected or modified. Though a hypothesis can never be proven ultimately true, if experiments keep turning up consistent results, it is considered more and more reliable and comes to be an accepted theory or law."

Hartmann

What is Science?

- ◆ Some “tools” for scientific progress
 - Error analysis
 - » How well do you know what you know?
 - Contradictory results
 - » Which results do you ignore?
 - Framing questions
 - » Creativity
 - Aesthetics
 - » How do you define simplicity, beauty?

What is Science?

- ◆ Some Common Themes in Astronomy:
 - How far is it?
 - How fast does it move and why?
 - What are its physical characteristics?
 - What allows it to be detected?
 - How are any of the above features related?
 - What created it?

What is Science?

- ◆ Hypothesis – A tentative explanation awaiting further development and testing.
- ◆ Theory – A hypothesis or set of hypotheses that have been well tested and verified.
 - Must be careful to understand the domain of spatial and temporal scales under which the theory is shown to be valid

What is Science?

◆ **Laws of Nature**

- The rules of the game played by nature
 - » Universal
- Laws cannot be suspended
 - » Good science fiction
- Laws may be modified with better understanding
 - » e.g. Kepler's Laws → Newton's Laws → Einstein's Special Relativity

What is Science?

◆ A scientific model is a theory that accounts for a set of observations in nature.

- For example, stars residing on a giant spinning celestial sphere is a model that explains the rising and setting of the stars (geocentric model).

◆ A scientific model is not necessarily a physical model.

- In the above example, the Sun's motion relative to the stars is explained as the motion of the Sun along a path on the celestial sphere, even though the "real" universe is heliocentric.

What is Science?

◆ Three modern criteria of scientific models:

- Model must fit the data
- Model must make predictions that can be tested and be of such a nature that it would be possible to disprove it
- Model should be aesthetically pleasing - simple, neat, and elegant (**Occam's razor**)
