Welcome to PHYS 1302

Astronomy of the Solar System

Home

Everything on the screen is available to you on the class homepage:
www.sci.angelo.edu/phys1302

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What we’ll talk about today

- Introductions
- Syllabus
- Schedule of weekly reading assignments
- Define basic tenets of science

Dr. Blount

- Personal webpage:
  - www.sci.angelo.edu/grady.htm
- Attended 17 K-12 schools (Army brat)
- Stubborn:
  - Took College Algebra twice
  - Took Trig three times
  - Got a “D” in English
  - Have a Ph.D. and over $25M in grants

How about you?

- Please take out a piece of paper and share with me the following:
  - Your name?
  - Hometown?
  - Why are you in this class?
  - What is your class (frosh, soph, etc.)?
  - Do you work? How much (hrs/week)?
  - Any interesting tidbit about who you are thus far?
PHYS 1302

- This is a 3-semester credit hour course lasting 15 weeks (not 6 weeks).
- You should spend 2 hours of prep time out of class for every hour in class.
  - Distributed as → 45 hours meeting & lecture
  - 90 hours preparation
  - 9 hours/week commitment!
- Reading assignments, weekly homework assignments, study time.

PHYS1302 syllabus

- **WHAT IS A SYLLABUS?** It is an outline of the course, the instructor’s policies, and a schedule of topics, due dates, and exams. Read it thoroughly and keep it as a reference.
- **MEETING TIMES:** Mon. and Wed. 5:00-6:15, MCS #100
- **FACULTY AND STAFF COMMUNICATIONS:**
  - Instructor: Dr. Grady Price Blount, Vincent Building #175, 942-2526, grady.blount@angelo.edu
  - Staff: Ms. Gayla Trotter, Vincent Building #175, 942-2024, gayla.Trotter@angelo.edu
- **INTRODUCTION:** This course is a survey of planetary science. Major topics include the scientific method and the origin and evolution of planetary systems.
- **STUDENT LEARNING OBJECTIVES:** After successful completion of this course you will be able to describe the scientific method as applied to planetary science, list key events in the history and development of human understanding of the solar system, discuss current theories on the origin and evolution of planetary systems, and discuss the physical attributes of our planetary neighborhood. You should also be able to appreciate the impact of the Copernican revolution, and modern concepts of the time scales and distance scales of the solar system versus the rest of the universe.
  - Copies of the lecture slides are available on-line at: www.sci.angelo.edu/phys1302

- **DEMONSTRATION OF PROFICIENCY (Grading)**
  - 300 points from four lecture exams at 100 points each
    - 3 term exams plus 1 final exam @ 100 points each (lowest score from these 4 is dropped).
  - 100 points from in-class quizzes/assignments:
    - Percentage curve applied at the end of the semester!

- **On-Line Assignments**
  - Sign up for class list-serve
    - phys1302-list-request@angelo.edu
  - If you’re in lab, PHYS 1102 weekly assignments
    - www.masteringastronomy.com
      - Click on the Solar System edition
      - Course ID is "fall2009gpb"
    - Assignment 1 & 2 due on September 9th
  - Other Information on syllabus to read:
    - Activities, how this course relates to your education, and general information.

How to complete assignments

- There will be random in-class assignments or quizzes worth 10 X 10 = 100 points.
- **Show up!**
- **Listen carefully.**
- **Take notes to remind yourself.**
- **Your own work is required.** If cheating is detected, all students turning in questionable work will be assigned a grade of zero for entire quiz or assignment.
How to prepare for exams

- The exams are 60-90% multiple choice or T-F, plus 10-40 point short essay.
- Multiple choice questions will be challenging!
- Don’t wait to the last minute!
- Keep developing your notes and challenging yourself with self-tests, on-line tutorials, study groups, writing out possible essays.
- Use Mastering Astronomy resources.

How to use on-line resources

- Check the PHYS 1302 web site: www.sci.angelo.edu/phys1302
- Sign up for the PHYS1302 list-serve
- Read the list-serve messages!
- Complete the on-line tutorials under “Study Area” and “Tutorials”
- Check Weekly Notes for info on exams, grades, etc.

Contacting me

- Office is Vincent #175
- Office hours are every afternoon.
- Email me: grady.blount@angelo.edu
- I usually reply promptly.
- Try to be specific.
- Please include your name and contact information so that I can reply!

How to use the book

- The Cosmic Perspective, 4th Edition: The Solar System by Bennett et al., 2007 (or 5th)
- On-line tutorials and Study Area at masteringastronomy.com.
- Read for comprehension, not completion.
- Preface, pages xiii to xx have overview.
- How to Succeed, pages xxvi to xxvii

Major Themes Woven throughout the Book

- Using the text…pages xxvi through xxvii
  - Read the learning goals on first page of each chapter.
  - Study the illustrations and read captions.
  - Read the main chapter text for comprehension.
  - Then go back and read the boxed insets
    - Special Topics and Common Misconceptions
    - Read the Summary of Key Concepts
  - Test yourself by doing the Exercises and Problems
  - Study time, study time, study time…

Reminder about signing up for PHYS1302 list serve

This is your second 10 point in-class freebee.

To subscribe send an email from your account: phys1302-list-request@angelo.edu
Subject: subscribe

To send a message to the list: phys1302-list@angelo.edu
Observation

- Up close and personal does not mean accurate or correct
- Some things can only be understood by integrating knowledge from many sources

Doing science

- Scientists have a logical paradigm (world view)
- Scientists distinguish between truth and facts
- Scientists parse sentences
- They are very careful about what they say and how they say it (and that means you have to be very careful listening).

Parse

- **parse** (verb, parsed, parsing) - to analyze (a sentence) in terms of grammatical constituents, identifying the parts of speech, syntactic relations, etc.
- Parsing is a required element of critical thinking.
- "That depends on what the meaning of "is" is..."
- Try these:
  - "Reliable sources indicate Iraq has weapons of mass destruction"
  - "Iraq has weapons of mass destructions"
  - "Everything on sale at up to 50% off"
  - "Everything is on sale at 50% off"
  - "This item is not available in all states"
  - "This item is not available in some states"

Primero

- Let’s be clear on a few things
  - This is a science class so we’re going to use...
  - the rules of logic to reach reasonable conclusions.
  - When everyone agrees that a reasonable conclusion has been reached...a Fact arises.
  - Logical Science seeks Facts, NOT truth.
  - Scientific Truth is an oxymoron.
  - Science does not seek truth.

What is Truth?

- (1) the state of being the case (judicial sense), (2) fundamental reality (spiritual sense), (3) the property of being in accord with REALITY (common usage)
  - Where REALITY = "of or relating to fixed, permanent, and unchangeable things".
    - What is your birthdate? Who are your parents? etc.
    - The central tenets of Religion and Law are based on truth.
  - Science studies a constantly changing universe which exists across 20 orders of magnitude...
    - Birth and Death of organisms, mountain ranges, galaxies, stellar life cycles, planetary motions...
    - Therefore, Science cannot seek truth*.

Things are made of littler things that jiggle

- If you think you are living in reality (fixed, permanent, unchanging) you are not paying attention.
- "Reality" exists in the world of truth.
- The universe you live in is dynamic (changing).
- The **physical universe** and **reality** are two different things.
The Physical Universe

- Is constantly changing on all time scales and all spatial (space) scales.
- Atomic motion is so fast, all we “see” is the average.
- Erosion is so slow we don’t live long enough to “see” what is happening.
- Galactic motion is so large we cannot see what is happening.
- But the good news is...

We have facts...

- A fact is an agreed upon observation.
- A fact is a reproducible and observable state under a given set of conditions.
  — What is the temperature?
- A fact is a statement of how the natural world usually responds in a given situation. Facts describe change!
- Facts are the basis of Natural Laws.
- By definition, Facts are subject to change.

Logic

- Scientists use logic:
  - Based on the idea of testing premises *
  - State an argument, any argument. Then test it.
  - It can be valid = true, or invalid = false.
  - In mathematics, the argument is “defined”
- If $A = B$ and $B = C$, then $A = C$
- Is $A = C$ true (the state of being the case)?
- How about $A = D$?

- DEDUCTIVE ARGUMENTS
  - A deductive argument is one in which the conclusion is certain based on the premises. If the premises are correct then the conclusion is 100% certain.

- INDUCTIVE ARGUMENTS
  - An inductive argument is one in which the conclusion is probable based on the premises. In an inductive argument the conclusion goes beyond the premises.

* a proposition supporting or helping to support a conclusion

Wait a minute...

- If everything is changing, how do you know anything?
- Scientists do use one very specific form of truth (the state of being the case)
- Boolean logic: $2 + 2 = 4$, why?
- Because we said so.

I’m a policeman...

- I visit the nearby prison and notice that all the prisoners on death row have blue eyes.
- Here are some testable statements: (Deductive or Inductive)?
  - 1 – All of the people on death row have blue eyes.
  - 2 - All of the people convicted of murder have blue eyes.
  - 3 - All murderers have blue eyes.
  - 4 - All people with blue eyes are murderers.

I’m a scientist...

- I visit the nearby prison and notice that all the prisoners on death row have blue eyes.
- Here are some testable statements: (Deductive or Inductive)?
  - 1 – All of the prisoners on death row in this prison appear to have blue eyes

Only one statement can be agreed upon as a fact
Some logical rules

- You must define your criteria.
  - "Half of the test animals died. The other one lived."
- Normal variance does not negate a conclusion.
  - e.g. the 98 year old smoker
- Facts must be testable for disproval.
- You cannot prove a negative.
- Inferences about a group must be supported by evidence representing the entire group.
  - e.g. "All people with blue eyes are murderers"
- To disprove a hypothesis you must invalidate a premise which the conclusion depends upon.
- 100% agreement not necessary to establish a fact.

Order from Chaos

- The physical universe changes constantly, but...
- It changes according to rules
- We can understand those rules
- And predict the future

Lab Assignments

- Will be on-line 2 weeks prior to due date.
- Two assignments in first batch.
- Get online now.
- Get the book:
  - Read Preface, Chapters 1 & 2
- Do on-line Assignments 1 & 2 by September 9th

Getting Started

- www.masteringastronomy.com
- Go through registration screens

Getting Started

- Register with code from card
- Do not share codes
- This is how your scores are kept!
You have two assignments due by September 9th.

**PHYS 1302**
Astronomy of the Solar System

- The scientific study of the space environment in our neighborhood.
- Includes some history, some basic celestial mechanics, space flight, remote sensing, satellite communications, a little bit of rocketry, lots of planetary science, some stellar evolution & cosmochemistry, and a little exobiology.......

**Not so long ago...**

- Solar System = Everything within the heliopause (the boundary between our Sun and interstellar space).
- Space = Everything above 60 miles (100 km) altitude.
- Science = The observation, identification, description, experimental investigation, and theoretical explanation of phenomena.

**The New Solar System**

- One thermonuclear object
- Small rocky objects close-in to the middle
- Big gaseous objects farther out
- Millions of small objects
- A halo of comets really far out

**Traditional Planets**

- Jupiter
- Saturn
- Uranus
- Neptune
What do we mean?

- When we say "planet"
  - Literally wanderers
  - Objects that appear to be moving against the fixed background of stars.
  - Different, therefore, special
    - Special, therefore, important
- A 3,000 year history of sloppy thinking gets another turn at bat...the Pluto thing

How is a Solar System Created?

- Gravitational instabilities in a protostellar nursery collapse towards center.
- Heavier elements drawn to middle - lighter elements to outside.
- Localized eddies form the planets.
- Leftover debris forms cometary halo.

The Solar System is well-behaved

Almost all of the objects, big and small:
- Same age with a common origin
- Circular Orbits (pretty close anyway)
- All in the same plane
- Spin in the same direction
- Rotate around the Sun in the same direction
- Obey distance vs. density rule
  - High Density close in
  - Lower Density farther out

Terrestrial Planets

- Mercury, Venus, Earth, Mars
  - All made of rock
  - Close to the sun
  - Relatively small
  - All the same age
  - All made of the same stuff
    - Silicates (quartz, feldspar)

Gas Giants

- Jupiter, Saturn, Uranus, Neptune
  - All made of gas
  - But with rocky cores
  - Far from the Sun
  - Relatively big
  - All the same age
  - All made of gas
    - Mostly Hydrogen and Helium
  - All have moons made of ice (lots of moons)

A mini-Solar System

- Ganymede larger than Mercury or Pluto
- Io most volcanically active body in SS
- Europa has liquid water ocean beneath frozen crust
- Type cases for alternative volcanism
  - Sulfur volcanism
  - Ice volcanism
What’s missing?
- Comets
- Asteroids
  - Rocky debris between Mars and Jupiter
- Kuiper Belt Objects
  - Icy planetesimals beyond Pluto

The edge of the unknown…

Titan

Planets?

Starbirth

Extrasolar Planetary Systems
- 42 Confirmed planets
- Most are extremely large (Jupiter-sized or bigger)
- In large orbits
- Most common around sun-like stars
- All associated with disk systems

Chapter 1
Our Place in the Universe
1.1 A Modern View of the Universe

Our goals for learning:

- What is our place in the universe?
- How did we come to be?
- How can we know what the universe was like in the past?
- Can we see the entire universe?

Star

A large, glowing ball of gas that generates heat and light through nuclear fusion

Planet

A moderately large object that orbits a star; it shines by reflected light. Planets may be rocky, icy, or gaseous in composition.

Moon (or satellite)

An object that orbits a planet.

Asteroid

A relatively small and rocky object that orbits a star.
Comet
A relatively small and icy object that orbits a star.

Solar (Star) System
A star and all the material that orbits it, including its planets and moons.

Nebula
An interstellar cloud of gas and/or dust.

Galaxy
A great island of stars in space, all held together by gravity and orbiting a common center.

Universe
The sum total of all matter and energy; that is, everything within and between all galaxies.

How did we come to be?
How can we know what the universe was like in the past?

- Light travels at a finite speed (300,000 km/s).

<table>
<thead>
<tr>
<th>Destination</th>
<th>Light travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon</td>
<td>1 second</td>
</tr>
<tr>
<td>Sun</td>
<td>8 minutes</td>
</tr>
<tr>
<td>Sirius</td>
<td>3 years</td>
</tr>
<tr>
<td>Andromeda Galaxy</td>
<td>2.5 million years</td>
</tr>
</tbody>
</table>

- Thus, we see objects as they were in the past:
  The farther away we look in distance, the further back we look in time.

We see the Orion Nebula as it looked 1,500 years ago.

Example:
This photo shows the Andromeda Galaxy as it looked about 2 1/2 million years ago.
Question: When will be able to see what it looks like now?

Light-year

- The distance light can travel in one year.
- About 10 trillion km (6 trillion miles).

What have we learned?

- What is our physical place in the universe?
  - Earth is part of the Solar System, which is the Milky Way galaxy, which is a member of the Local Group of galaxies in the Local Supercluster
- How did we come to be?
  - The matter in our bodies came from the Big Bang, which produced hydrogen and helium
  - All other elements were constructed from H and He in stars and then recycled into new star systems, including our solar system
What have we learned?

- How can we know that the universe was like in the past?
  - When we look to great distances we are seeing events that happened long ago because light travels at a finite speed
- Can we see the entire universe?
  - No, the observable portion of the universe is about 14 billion light-years in radius because the universe is about 14 billion years old

1.2 The Scale of the Universe

Our goals for learning:

- How big is Earth compared to our solar system?
- How far away are the stars?
- How big is the Milky Way Galaxy?
- How big is the universe?
- How do our lifetimes compare to the age of the universe?

How big is Earth compared to our solar system?

Let’s reduce the size of the solar system by a factor of 10 billion; the Sun is now the size of a large grapefruit (14 cm diameter).

How big is Earth on this scale?

A. an atom
B. a ball point
C. a marble
D. a golf ball

How far away are the stars?

How far would you have to walk to reach Alpha Centauri?

A. 1 mile
B. 10 miles
C. 100 miles
D. the distance across the U.S. (2500 miles)

How do our lifetimes compare to the age of the Universe?

- The Cosmic Calendar: a scale on which we compress the history of the universe into 1 year.

1.3 Spaceship Earth

Our goals for learning:

- How is Earth moving in our solar system?
- How is our solar system moving in the Galaxy?
- How do galaxies move within the Universe?
- Are we ever sitting still?
How is Earth moving in our solar system?

- Contrary to our perception, we are not "sitting still."
- We are moving with the Earth in several ways, and at surprisingly fast speeds...

The Earth rotates around its axis once every day.

Earth orbits the Sun (revolves) once every year:

- at an average distance of 1 AU \( \approx 150 \) million km.
- with Earth’s axis tilted by 23.5° (pointing to Polaris)
- and rotating in the same direction it orbits, counterclockwise as viewed from above the North Pole.

Our Sun moves randomly relative to the other stars in the local Solar neighborhood...

- typical relative speeds of more than 70,000 km/hr
- but stars are so far away that we cannot easily notice their motion

... And orbits the galaxy every 230 million years.

Are we ever sitting still?

Earth rotates on axis: > 1,000 km/hr
Earth orbits Sun: > 100,000 km/hr
Solar system moves among stars: ~ 70,000 km/hr
Milky Way rotates: ~ 800,000 km/hr
Milky Way moves in Local Group
Universe expands

1.4 The Human Adventure of Astronomy

Our goals for learning:

- How has the study of astronomy affected human history?

How has the study of astronomy affected human history?

- Copernican Revolution showed that Earth was not the center of the universe (Chapter 3)
- Study of planetary motion led to Newton’s Laws of motion and gravity (Chapter 4)
- Newton’s laws laid the foundation of the industrial revolution
- Modern discoveries are continuing to expand our “cosmic perspective”
A new view of “home”