TEACHING PORTFOLIO

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Lowell Observatory

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Statement of Teaching Philosophy

Ultimately, my goal as a teacher is to prepare students to be active members of society. While I am hopeful that they will retain some of the astronomical principles that are discussed in the class, the more important aspect to me is that they learn to think critically and challenge assertions in scenarios they encounter in their everyday lives. I hope that students will leave my class with a better understanding of the world around them (or in this case the universe around them!) and a willingness to think for themselves.

To this end, I approach teaching with the following aims:

- Students will learn to answer problems through reasoning rather than rote memorization. They will learn to adapt to new concepts and integrate ideas learned throughout the semester to analyze new information.
- Students will gain an appreciation for the scientific process. Lectures will relate the basic concepts of physics and astronomy to real world applications so that students will gain an understanding of their relevancy for modern astronomy and will expand their awareness of science in mainstream news and pop culture.
- Students will have an active part in class. Through group work, team games, and the chance to ask anything at the start or end of class, each student will have the opportunity to participate in the learning process. When possible, lectures will be adjusted to spend more time on concepts students find challenging.
- I will strive to incorporate all students in every class and to make the classroom a welcoming environment regardless of ability or interest.
- I hope to reduce the barrier between student and teacher, encouraging all those interested to talk or email me outside of class regarding any topic they find compelling. Students can expect a classroom where I know all of their names (this has worked well for classes of 40) and where they can feel free to express themselves without embarrassment.

Teaching Methods and Strategies

My goal as a science teacher is to convey the excitement of the scientific process to my students. I have found that my enthusiasm for astronomy can be infectious and that students are more willing and interested to learn when they share my interest.

I spend a lot of time analyzing the material I plan to cover in my upcoming lecture, and thinking about how best to present it in a cohesive, understandable manner. The extra time it takes making sure the lesson is organized and coming up with new ways of explaining topics and drawing diagrams is typically rewarded by the students' increased interest in the lesson and their greater understanding of the subject matter. Student evaluations have frequently cited my explanations as being simpler and more logical than in the professor's lectures or the explanations given by other TAs.

I have the good fortune to do scientific research that is relatively accessible to everyone, regardless of their scientific training. As such, I make it a point to discuss my research when appropriate to support course material. This elicits positive responses from students who enjoy relating the basic principles they have learned in class to real world applications. I stay abreast of the astronomical topics that are reported in the mainstream media so that I am prepared to discuss these stories in class. I encourage students to ask me about anything astronomy related at the start of every class, whether it relates to what has been covered in lectures or not. While infrequent, these discussions tend to be the most rewarding. On occasion, students ask me something about which I am unfamiliar or am unable to give a detailed enough answer. In these cases I make it a point to look up the answer and follow up with them in the subsequent class (or by email when more practical).

I try to relate to my students at an informal level, to reduce the barrier between student and teacher so that they will feel willing to engage me outside of class with questions and comments. One way of doing this is to encourage students to call me by my first name. While some students are not comfortable with this, for those who do, I feel it makes me more approachable. Similarly, I make it a point to learn the names of all the students in the class within the first few lectures, and to use them throughout the semester. This demonstrates to the students that I care about them, and makes for a more intimate classroom experience. I believe that when students know that I know their name, it makes them more likely to attend class and to feel included. I received comments semester after semester that students had never had a TA know their name before. In graduate school, I often engaged students in pre-and post-class debates about sports rivalries between my undergraduate university and the University of Maryland. By doing so, it reinforced to them that I was a part of the campus community and gave them "ice-breaker" topics to talk to me about.

It is important to keep class fresh and interesting. I try to vary the format of discussion sections from week to week to keep students engaged. Activities are designed to complement the material being presented and also to encourage student participation. I solicit feedback each semester about which activities worked well, implementing improvements in subsequent semesters.

Some of the more popular classroom activities include (examples of some of these can be found in Appendix I):

- *Group work* – I ask the class to break up into groups of 3-5 and work on activities together. I then circulate around the room and talk to every group, guiding them through difficult concepts. This gives me immediate feedback on which concepts students are having trouble with and allows me to alter class lessons accordingly. Occasionally it is necessary to change partners so that strong students can help weak students, or to encourage quieter students to talk.

- *Games* – I adapted popular game shows such as Who Wants to be a Millionaire and Jeopardy for review purposes. Rule tweaks were implemented to encourage all students to participate. I also designed a number of crossword puzzles that were extremely popular with students. Even when students couldn't get all the answers this led them to search through their books to complete them and to take them home to finish.
- Movies – I showed scenes from science fiction movies and asked the students about the depictions of science we had covered in the class.

Teaching Assistant

I was a graduate TA for ASTR 100 for four semesters at the University of Maryland, College Park. The University of Maryland is a large, public, Research I university with a diverse student body. ASTR 100 is an introductory astronomy course for non-majors to fulfill their science requirement, and typically has enrollment of 250-300 students, most of whom are freshmen or transfer students. I was responsible for leading weekly 50-minute discussion sections for about 40 students, typically teaching two or three sections per semester. The content of these discussion sections was designed entirely by me to supplement the lectures given by the professor. I also held weekly office hours where students were able to get help with concepts, ask questions, or talk about other topics of interest. Additional responsibilities included attending the lectures and helping with distribution and collection of materials and demos, grading homework assignments for students in my section, writing exam essay questions, and grading exams (typically grading one or two essay questions for all students in the course). Additionally, I voluntarily lead review sessions before each exam that were typically attended by students from all discussion sections. The time commitment for each class varied but was typically 15-25 hours per week, which included 3 hours attending lecture, 4-5 hours of preparation, 2-3 hours of teaching, 2-3 hours of office hours, and 5-15 hours of grading.

Course	Semester	Professor	Sections	Students
ASTR 100	Fall 2000	Stacy McGaugh	3	117
ASTR 100	Spring 2001	Stacy McGaugh	3	118
ASTR 100	Fall 2001	Stuart Vogel	2	76
ASTR 100	Spring 2001	Jim Stone	2	80

Navajo-Hopi Outreach Program

I taught astronomy to a class of 3rd-6th grade Talented and Gifted students at Second Mesa Day School on the Hopi Reservation (a two hour drive east of Flagstaff, AZ) during the 2009 fall semester. I taught approximately 35 students for three hours once a month. Lessons covered basic topics in astronomy and optics, and were necessarily very hands on to maintain the attention span of so many students for a long period of time. In addition to teaching in the Navajo-Hopi program, I also gave tours of the Lowell 42" telescope to numerous classes of Navajo and Hopi students as part of their annual visits to Anderson Mesa, Lowell Observatory's dark sky research site. These visits lasted 2-3 hours and involved showing them how the telescope works and talking about the research I was doing.

Towson University's Project ASTRO

I taught astronomy in a 6th grade Earth science class at Friendship Academy of Science and Technology (FAST) in inner city Baltimore, MD during the 2011-2012 and 2012-2013 school years (and am committed to teaching it again in 2013-2014). I taught 3-4 classes of approximately 75 minutes each once a week during the students' astronomy unit (typically three classroom visits). Lessons were designed in consultation with the teacher to compliment her lessons and ensure that they were sufficiently interactive to keep the students engaged (most students had disciplinary problems in their original school and transferred to FAST). I have partnered with the same teacher each year and we have refined the lessons each year to optimize the content.

Substitute teaching at the high school level

I substitute taught math and science at my high school for about six weeks over breaks during the 2000-2001 University of Maryland school year. Approximately four weeks were spent teaching algebra after the teacher was severely injured in a car accident. Since her absence was unexpected, I developed my own lesson plans (with consultation from other teachers at the school) for the month I would be teaching. At the end of my four weeks, I was offered the job permanently by the principal, however, I declined since I wanted to continue graduate school.

Evaluations
For each class that I taught at the University of Maryland, students were asked to fill out anonymous surveys at the end of the semester which were not seen by the TA until after all grades had been submitted. The surveys consist of 21 multiple-choice questions, with the opportunity for students to comment on any of the questions, and three areas for students to write additional positive or negative feedback. Evaluations from my students frequently praised my enthusiasm for astronomy, interest in teaching the class, ability to present difficult topics in an interesting and straightforward manner, and personality (friendliness, approachability, and memory of their names). An overview of my average ratings over the four semesters I taught is below (with the ratings of all introductory astronomy TA's for comparison). A collection of student responses and a more detailed overview of the ratings can be found in Appendix II.

Question	**My Rating (out of 4)**	***All ASTR TA Rating (out of 4)***
Overall quality of the course	**3.31**	*2.91*
Teaching	**3.65**	*2.95*
Organization of each class	**3.58**	*3.05*
Clarity of explanations	**3.55**	*2.76*
Knowledge of course content	**3.74**	*3.28*
Interest in teaching	**3.81**	*3.33*
Class sessions being interesting & attention-holding	**3.17**	*2.56*
Clarity and completeness in answering questions	**3.59**	*2.85*
Respect shown towards individual students	**3.81**	*3.54*

Awards
I was named the Maryland Astronomy Department's Philip E. Angerhofer Outstanding Teaching Assistant and a Center for Teaching Excellence Distinguished Teaching Assistant for both the 2000-2001 and 2001-2002 academic years. The Astronomy Department awards the Outstanding Teaching Assistant (and a $250 prize) annually to the Teaching Assistant judged by the faculty to be the most deserving. The Center for Teaching Excellence awards the Distinguished Teaching Assistant awards annually. Recipients are nominated by the chairperson of their department and represent the top 10% of the teaching assistants in their department.

Activities to Improve Teaching and Learning

A primary means of improvement for any teacher is responding to their student's needs and concerns. I surveyed my students at the beginning, middle, and end of the semester to gauge what their expectations were for the class as well as what was/was not working. After the initial survey, I would point out when topics of interest to the class would be covered and emphasized those points a bit more when they were discussed. As a result of the suggestions made in these evaluations:

- I began displaying a slide summarizing the key points from the professor's lectures the previous week at the start of each class. This allowed me time to pass back graded papers without wasting students time, and helped the students distill 3 hours of lecture into a few key points.
- In response to students' claims of being unsure how they could get a good grade in the course, I distributed a worked example of "How to get an A" in the first class. This allowed them to more easily follow their progress and calculate their expected grade.
- I began putting a list of commonly used astronomical abbreviations, conversions, and Greek letters on the back of the syllabus. This was then frequently referenced during the semester and ensured that they held on to the syllabus throughout the semester. This is included in Appendix I.

I made efforts to improve my teaching by having professors and other TA's sit in on my discussion sections and by sitting in on other TA's discussion sections. Getting feedback from my teaching peers helped me identify areas for improvement for my teaching style, and seeing others led me to reevaluate some of the techniques I used in my classroom.

I also attended the University of Maryland's TA orientation when I arrived in August 2000, as well as the Astronomy Department's annual teaching workshop each fall.

Professional Contributions

I contributed to the improvement of the teaching and curriculum in the University of Maryland Astronomy Department in several ways:

- At the start of each school year, the astronomy department holds a teaching workshop for new and returning TAs. I presented lectures for several years on topics such as "ice-breakers for the first class" and "integrating games into the classroom".
- Many introductory astronomy professors require that students attend the department observatory's "Open House" (a public lecture followed by telescope viewing) and write a paper about it. I developed a rubric for grading these essays which was given to students at the start of the semester (included in Appendix I). This ensured that students understood what was expected of them and that TA's graded consistently across sections (essay grading is the most subjective part of a science class!). This proved so successful that all subsequent professors for whom I taught incorporated it into their classes.
- I contributed electronic copies of all my teaching documents to a database of astronomy teaching materials available to TA's in the University of Maryland Astronomy Department via a web interface.

Reflections and Future Goals

I see myself as a teacher and mentor in all aspects of my life. Whether I am in front of a classroom of students, discussing research details with colleagues, or talking with a child about her daydreams, I am influencing someone else. With this in mind, my growth as a teacher, a scientist, and as human being is never-ending. While I am pleased with the abilities and experiences I have gained so far, in the short- and long-term I hope to further improve the skills necessary to be successful in all of these endeavors.

Short-term goals: While there is no official teaching component for my current position (assistant research scientist), I have voluntarily participated in outreach teaching programs in Arizona (Lowell Observatory's Navajo-Hopi Outreach Program) and Maryland (Towson University's Project ASTRO). I am also developing skills as a mentor and advisor by supervising research projects by undergraduate students: in the summer of 2009 I supervised a student through the NSF's Research Experience for Undergraduates (REU) program (this work resulted in a refereed publication); I supervised the same student when he returned to Lowell Observatory in the summer of 2010 as a research assistant (also resulting in a refereed publication); I supervised an undergraduate student for a short (3-week) "January term" research project in January 2013 (her work contributed to a refereed publication); I am currently supervising another student as a research assistant at Lowell Observatory (this has already resulted in one publication and future publications are likely); and from 2009-2011 I remotely supervised an undergraduate student at the University of Maryland who was working part-time as a research assistant (a publication from this work is in preparation). I hope to continue to grow as a teacher and mentor through continued participation in activities such as these.

Long-term goals: Ultimately I hope to be a professor at a university where I am expected to maintain active teaching and research programs. This will involve teaching large survey courses, smaller courses for advanced undergraduates or graduate students, supervising and advising undergraduate students, graduate students, and/or postdocs, writing grants to fund my research program, and publishing my research in peer-reviewed journals.

Appendix I: Teaching Materials

The following pages contain examples of teaching materials I created for ASTR 100 discussion sections.

- **Syllabus** (p.12-13) – This was given to students at the beginning of the semester. The first page is simply a summary of class policies and my contact information. To encourage students to keep this information, I included frequently used conversions and constants on the back of the page. Throughout the semester, students were referred to this sheet to look up information that would help them solve problems.

- **Open House Grading Form** (p. 14) – This was given to students at the beginning of the semester. The open house report was a mandatory assignment, which was graded by each student's TA. I developed this grading rubric to show the students what was expected of their reports and to ensure that each TA was grading on the same scale. I created it in my first semester, and in subsequent semesters it was used by all introductory astronomy professors with whom I taught.

- **Quiz** (p. 15) – This was given at the end of discussion section, and was designed to take less than 5 minutes. Students receive 2 of the 5 points just for attending section (i.e. answering their name and section number). The remaining questions cover concepts which had just been discussed in section and had previously been discussed in lecture and/or assigned as reading homework. Thus, the quiz serves more to encourage students to attend (and pay attention) in discussion section than as a diagnostic test.

- **Group Work** (p. 16-17) – This was designed to take 20-30 minutes in groups of 3-5 students. I try to make group work fairly math intensive (relative to what non-astronomy majors are accustomed to) so that the weaker students are challenged and the stronger students won't feel like they are wasting time. I circulate through the classroom to give guidance and gauge the students' understanding, then spend 10-15 minutes going over the assignment. These assignments were also intended to prepare students for the math they would encounter in their homework assignments and exams

- **Jeopardy Game** (p. 18-20) – This was a review which was given before an exam. It was designed to last 45-50 minutes, including time spent explaining certain questions. The questions were read aloud and students responded with the answer (given in bold here). Students were split into 3 teams, and everyone on the team was required to give an answer before anyone could give a second answer. This encouraged everyone to contribute and prevented the most outspoken students from dominating. Copies of all the questions were available after class if students wanted them for further review.

- **Crossword Puzzle** (p. 21-23) – This was my most popular review. It was designed to last 45-50 minutes, and students were encouraged to work together and use their books. I circulated through the class as they worked on it, helping students individually with questions they were having trouble figuring out. Solutions were available upon request.

Astronomy 100: Introduction to Astronomy

Spring 2002

Section 0104: Wednesday 9:00 – 9:50
Section 0106: Friday 12:00 – 12:50
Room CSS 2400

Teaching Assistant:	**Matthew Knight**
E-mail:	**mmk8a@astro.umd.edu**
Phone:	**(301) 405-1967**
Office:	**CSS 0204**
Office Hours:	**Wednesday 10:00 – 11:00**
	Friday 1:00 – 2:00
	or by appointment

Textbook:	***Astronomy: The Solar System and Beyond***
	by Michael A. Seeds

SECTION:

The discussions sections of Astronomy 100 are intended to reinforce the lectures and to occasionally present new material. You are responsible for all of the material covered in lectures and in the readings, so this is your chance to make sure you understand it. I will come prepared with a lesson plan each week, but discussions will not be restricted to it. Section is intended to be a less formal, more interactive learning environment. I want this to be a class you look forward to coming to each week (or at least one you don't dread attending)!

ATTENDANCE & GRADING:

Attendance in discussion section is mandatory and is highly recommended. Section accounts for 20% (150 out of 750 points) of your grade in Astronomy 100. This portion of your grade will be determined based on attendance in section as well as your performance on assignments given in section (group work, quizzes, etc…). No extra credit or makeup assignments will be given.

ABSENCES:

If you must miss a class, you should notify me ahead of time so that arrangements can be made for you to make up any assignments that you missed. Make up assignments will only be granted for acceptable absences. If you are unsure of the acceptability of an absence please contact me or consult the University's policy.

ACADEMIC HONESTY:

Although discussing homework problems with classmates may be helpful and is encouraged, you must **express your answers in your own words**. Academic dishonesty will not be tolerated. You will be expected to write the Honor Pledge on all work submitted unless stated otherwise. If you have any questions or concerns regarding the Honor Pledge, consult the University's official page: http://www.inform.umd.edu/honorpledge/

Commonly Used Abbreviations in ASTR 100:

Distance: m = meter
AU = astronomical units
ly = light-year
pc = parsec

Angles: ° = degree
arcmin = minutes of arc
arcsec = seconds of arc

Mass: kg = kilogram

Time: s (or sec) = second
yr = year

Temperature: K = Kelvin
°C = Centigrade
°F = Fahrenheit

Constants: c = speed of light
G =gravitational constant
$\pi \approx 3.14$

Prefixes: k = kilo- = 10^3 = 1000
M=mega-=10^6=1,000,000

Conversions:

Distance: 1 inch = 2.54 centimeters
1 m = 100 cm = 1000 mm
1 km = 1000 m
1 mile = 1.6 km
1 AU = $1.5*10^{11}$ m
1 ly = $9.46*10^{15}$ m
1 pc = 206,265 AU
= 3.26 ly
= $3.09*10^{16}$ m
1 kpc = 1000 pc
1 Mpc = 1,000,000 pc

Angles: 1° = 60 arcmin
= 3600 arcsec
1 arcmin = 60 arcsec

Time: 1 yr = $3.16*10^7$ sec

Constants: c = $3*10^8$ m/s
= 300,000 km/s
= 186,000 miles/s
G = $6.67*10^{-11}$ N*m^2/kg^2

Other values: Mass of Earth ≈ $6*10^{24}$ kg
Mass of Sun ≈ $2*10^{30}$ kg
Radius of Earth ≈ 6400 km
Radius of Sun ≈ 700,000 km

Commonly Used Greek Letters and Symbols:

≈ "approximately equal to"
∝ "is proportional to"
γ "gamma" (photon)
λ "lambda" (wavelength)
π "pi" (a constant)
θ "theta" (an angle)
ρ "rho" (density)

For more references (ie. conversions, distances to planets, sizes of moons, distances to stars, periodic table, etc…), see appendix A in the back of your book.

NAME: ______________________________
SECTION: ____________________________

OPEN HOUSE PAPER

Composition (15 points total):	
Spelling:	__________ / 5
Grammar:	__________ / 5
Presentation:	__________ / 5
Summary of Presentation (20 points total):	
Speaker info (name, talk title):	__________ / 5
Information:	__________ / 15
Observations (15 points total):	
What did you observe?	__________ / 10
Drawings / description of observatory & telescopes:	__________ / 5
Extra Credit:	__________
TOTAL:	__________ **/ 50**

Quiz February 22, 2002

Note: Please write out your work and make clear what your final answer is. Each question is worth 2 points (except as noted). There will be no partial credit awarded. The maximum score you can receive is a 10.

1. Your Name: ________________________________
2. Your Section: ________________________________

3. Which of the following is not one of Newton's laws of motion?
   a. A planet's orbital period squared is proportional to its average distance from the Sun cubed ($p^2 = a^3$)
   b. When a body exerts a force on a second body, the second body exerts an equal but opposite force on the first body (action-reaction)
   c. A body at rest stays at rest while a body in motion stays in motion (inertia)
   d. A body's rate of change in motion is proportional to the force (F = m*a)

4. Which location would have the best "seeing" for an optical telescope?
   a. Cornfield in Nebraska
   b. On top of Mauna Kea (an inactive volcano in Hawaii)
   c. Charlottesville, Virginia (in the Appalachian mountains)
   d. Alcatraz Island (ie The Rock), San Francisco

5. It is the year 2020, and having been inspired by your introductory astronomy course at the University of Maryland, you have become an astronaut. After riding in a space shuttle for 4 years, you are about to be the first human to step foot on Saturn (I know it's a gas planet, but bear with me). As part of all NASA funded projects, 10% of your budget must be dedicated to teaching/outreach, so you plan to demonstrate to the youth of Earth that despite the tremendous difference in size and mass, you still weigh exactly the same on Saturn that you weighed on Earth. Knowing that Saturn's radius (R_s) is about 10 times larger than Earth's radius (R_e), determine Saturn's mass (M_s) compared to Earth's mass (M_e).
   Hint: Use Newton's law of gravity: $F = GMm / R^2$

(0 points) Check: From your own knowledge, is Saturn more massive than Earth? Does your answer for question 5 agree with what you know? It should!

Extra Credit: Maryland is one of three schools involved in BIMA, the best array of millimeter wavelength telescopes in the world. What are the other two schools involved in BIMA?

GROUP WORK March 20/22, 2002

Formation of the Planets

1. In the early solar system, elements and compounds condensed (i.e. froze) out of the solar nebula when the temperature at that distance from the Sun dropped below the freezing point of the element. Consulting the table below, what elements and compounds would you expect to have condensed at each of the following positions?

Element or Compound	Freezing Point (K)
Hydrogen	14
Helium	1
Carbon	3800
Nitrogen	63
Iron	1811
Sodium	1100
Lead	600
Water	273
Ammonia	195

A. Future Mercury (1400 K)

B. Future Earth (700 K)

C. Future Jupiter (175 K)

2. The Sun is approximately 73% Hydrogen, 25% Helium, and 2% everything else (carbon, nitrogen, oxygen, etc….). If the solar nebula had the same composition that the Sun does today, why do the Jovian planets have lots of Hydrogen and Helium, while the terrestrial planets do not? *Hint: think about gravity*.

Impacts and Cratering

3. *You have probably heard that the dinosaurs were killed when a meteor crashed into the Earth. Let's decide if you should be worried about this happening again soon*. Scientists have found a 150 km wide meteor crater in the Gulf of Mexico, which corresponds exactly with the time when the dinosaurs died out. If the average meteor creates a crater that is 10 times bigger than the meteor itself, how big was the meteor which killed the dinosaurs?

Consulting the graph on the overhead, about how often do meteors this size hit Earth?

The last meteor this size to hit the Earth was the one which killed the dinosaurs, approximately 65 million years ago. Should you be worried that another one this size will hit the Earth during your lifetime?

Comets

1. Comets are known to have two tails: a dust tail, and a gas tail. Label each of these tails on the diagram of a comet below. Why do you think the dust tail follows the path the comet traveled, while the gas tail points directly away from the Sun?

Meteors

2. Why are almost all meteors small bits of icy comets, while almost all meteorites are rocky or metallic bits of asteroids? *Hint: what is the difference between meteors and meteorites?*

Fusion: The Sun's Energy Source

3. Fusion is the joining of light elements resulting in more tightly bound elements, releasing energy. The Sun is powered by the fusion of four hydrogen atoms into one helium atom:

$$^{1}H + {}^{1}H + {}^{1}H + {}^{1}H = {}^{4}He + \text{energy}$$

If one hydrogen atom has a mass of 1.008, and one helium atom has a mass of 4.003, what is the difference in mass between the left and the right side of the equation above?

This difference in mass is converted to energy using Einstein's famous equation: $E = mc^2$.

If the speed of light, $c = 3\times10^{10}$, what is the energy released in this process? *Hint: The energy of a car driving along the beltway is about* 3×10^{12} *erg. Your answer should be much larger than this value! Note: the units of energy that you calculated are called ergs.*

ASTR 100: Review for Midterm 2
May 10/12, 2002

Jeopardy Round
Question values: 100, 200, 300, 400, 500

Things that begin with the letter R

1. Cold stars appear this color. **Red**
2. The Hertzsprung-_______ diagram aids in classifying stars. **Russell**
3. While most meteoroids are icy, most meteorites are this. **Rocky**
4. When the Sun reaches this phase, it will have expanded beyond the orbit of Venus. **Red Giant**
5. This is the imaginary limit around a planet beyond which moons can survive, but inside of which they break up into smaller particles. **Roche Limit**

Stellar Evolution

1. During this, the final stage of a star's evolution, it cools gradually forever. **White Dwarf**
2. The hydrogen burning stage of a star's lifetime. **Main sequence**
3. Many beautiful images such as the Hourglass, Ring, Butterfly, and Cat's Eye have been made during this stage of a star's evolution. **Planetary Nebula**
4. This event occurs after the hydrogen in a star's core is exhausted, causing it to swell to become a giant star. **Helium flash**
5. This element is the end state of fusion in a star's core. **Iron**

Jovian Planets

1. The planet most famous for its majestic rings. **Saturn**
2. The Great Red Spot on this planet is a storm twice the diameter of Earth which has been raging for at least 300 years. **Jupiter**
3. A large impact likely caused the very large (98°) axial tilt of this planet. **Uranus**
4. From January 21, 1979 until March 14, 1999, this planet was the farthest from the Sun. **Neptune**
5. This is the "most mooned" planet in our solar system. **Uranus**

Impacts

1. The so called K-T impact 65 million years ago caused the extinction of these massive reptiles. **Dinosaurs**
2. There is evidence for a 30 million year old crater under this body of water, which separates Maryland from its Eastern Shore. **Chesapeake Bay**
3. 1998 movie about a meteor the size of Texas on a collision course with the Earth, starring Bruce Willis, Ben Affleck, and Liv Tyler. **Armageddon**
4. Within a factor of 10, on average, how many people per million die each year from meteor impacts? **0.5**
5. A meteor exploded over this part of Russia in 1908, leveling trees for 100 square miles and causing widespread belief that a UFO crash-landed. **Tunguska**

The Sun

1. Short-lived, cool, dark regions on the Sun's surface, which vary on an 11 year cycle. **Sunspots**
2. The joining of light elements resulting in more tightly bound elements and releasing energy, it is the Sun's main energy source. **Nuclear fusion**
3. Einstein's most famous equation, relating the conversion of mass to energy. **$E = mc^2$**
4. The part of the Sun which we see, it radiates most of the Sun's energy. **Photosphere**
5. The sun is approximately this many Earths across. **100**

Small Bodies

1. Icy bodies known for their beautiful tails, thought to originate in the Oort Cloud or the Kuiper Belt. **Comets**
2. This belt is located between Mars and Jupiter. **Asteroid**
3. A small bit of matter which glows as it travels though the Earth's atmosphere. **Meteor**
4. Many astronomers now consider this to be the largest member of the Kuiper Belt, rather than the most distant planet in our solar system. **Pluto**
5. Chicxulub crater, which is believed to be the remnant of the impact that killed the dinosaurs is located here. **Yucatan**

Double Jeopardy Round
Question values: 200, 400, 600, 800, 1000

"Satellites"

1. "Satellite" was a radio hit for this Virginia band in 1995, from their album Under the Table and Dreaming. **Dave Matthews Band**
2. NASA's space based optical telescope, it has taken the most distant images ever. **Hubble**
3. This two-letter satellite of Jupiter is the most geologically active world known. **Io**
4. These satellites confine the rings of planets. **Shepherd satellites**
5. NASA's telescope for looking directly at the Sun; it is the satellite that takes the data I am currently studying for my second year project. **SOHO**

Things that begin with the letter M

1. A meteoroid which is found on the ground. **Meteorite**
2. Early observers thought they saw canals on this planet, triggering the idea of "little green men". **Mars**
3. This was believed to have formed when a large body collided with the young Earth. **Moon**
4. My middle name, this is also the last name of the quarterback for the Indianapolis Colts. **Manning**
5. Approximately 1 km across and formed by an impact 50,000 years ago, this is a popular tourist attraction in Arizona. **Meteor Crater**

Comets

1. The most well known comet, its most recent visit was in 1985. **Halley**
2. The nucleus of a comet is thought to be a dirty _________. **Snowball**

3. Contrary to popular belief, comets have not one but this many tails. **2**
4. This comet's passage in 1997 incited 39 members of the Heaven's Gate cult to commit suicide. **Hale-Bopp**
5. The University of Maryland is leading this $60 million NASA mission to smash a probe into a comet on July 4, 2005. **Deep Impact**

H-R diagram

1. The H-R diagram is a diagram of luminosity versus this. **Temperature (or spectral type)**
2. The spectral sequence O B A F G K M can be remembered using this pneumonic. **Oh Be A Fine Girl/Guy Kiss Me**
3. Hot stars appear this color. **Blue**
4. Spell Hertzsprung.
5. Stars on the main sequence which live the longest can be found here. **Bottom right**

The Sun II

1. Also the name of a beer, this is the hot, tenuous layer of the Sun, visible only during an eclipse. **Corona**
2. Hydrostatic equilibrium is the balance between gas pressure and this, first understood by Newton. **Gravity**
3. The Sun is approximately this many light minutes away from the Earth. **8**
4. The Sun contains 99.9% of this in the solar system. **Mass**
5. Buried under a mountain, the Super Kamiokande detector in Japan collects these particles, which are created during nuclear fusion at the center of the sun. **Neutrinos**

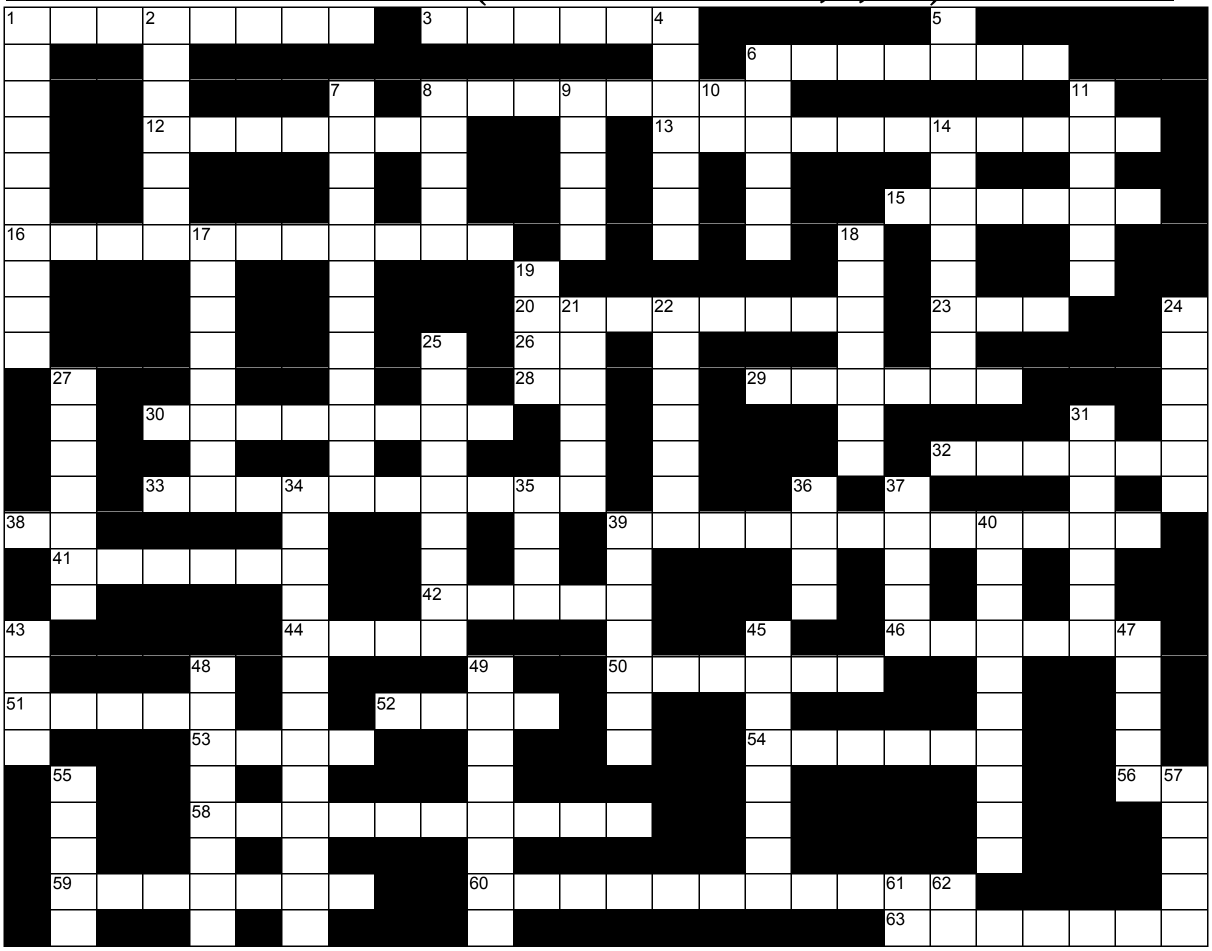
Potpourri

1. 1 parsec is approximately this many light years. **3**
2. This phenomenon occurs when an object appears to shift position relative to more distant objects and is used to measure the distance to stars. **Parallax**
3. Total energy per second (Watts), this is proportional to R^2T^4, and is a common measure of light bulbs. **Luminosity**
4. This star forming region is one of the most famous images taken by the Hubble Space Telescope. **Eagle Nebula (picture on p.277)**
5. The first extrasolar planet discovered was orbiting this star, in the constellation Pegasus. **51 Peg**

Final Jeopardy Category: The Atom

These are atoms that have the same number of protons but a different number of neutrons, such as Hydrogen and Deuterium. **Isotopes**

CROSSWORD PUZZLE (CHAPTERS Intro, 1, 2 5) 10.1.01



ACROSS

1. The spin of the Earth around its axis, taking 24 hours.
3. Small bits of dust and rock falling into Earth's atmosphere leaving momentary streaks of light, commonly referred to as "shooting stars". *Note: spell this backwards!*
6. Greek philosopher who improved **#25 down**'s geocentric model of the universe by adding **#17 down**'s.
8. Contains everything in existence. The largest structure possible, much bigger than **#60 across** or **#29 across**.
12. **#6 across** said that all the planets traveled with ___________ circular motion.
13. Stars which never set are said to be _______ (ie. they are always visible).
15. Seventh planet from the Sun.
16. The inner four planets. They are small, dense, rocky, and have less atmospheres than Jovian planets.
20. The farthest point from the Sun in a planet's orbit; the opposite of perihelion.
23. **#41 across**'s $F = GMm/r^2$ is an example of an inverse square ________.
26. Right Ascension (abr.)
28. Strontium (abr.)
29. Bigger than **#60 across**, but smaller than **#8 across**. Ours is called the #**45 down**.
30. The apparent path of the sun around the sky.

32. The solar ______ theory explains that the planets formed from the same cloud of gas and dust that formed the Sun.
33. Earth-centered cosmology advocated by **#6 across** and **#25 down**.
38. The distance from the Earth to the Sun (abr.)
39. Sun-centered cosmology introduced by Copernicus.
41. English physicist who discovered the fundamental laws of motion, such as $F = GMm/r^2$.
42. Type of eclipse which can only occur during a full moon.
44. These are created by the Moon's pull on the Earth's oceans. (singular)
46. The Celestial _______. (An imaginary sphere of very large radius surrounding Earth and to which the planets, stars, sun, and moon seem to be attached)
50. The point in the sky directly above the observer.
51. Combined with **#43 down**, these are the time required for half of the atoms in a radioactive sample to decay.
52. A measure of the amount of material in an object.
53. The Earth's ______ causes the seasons.
54. German astronomer who discovered the laws of planetary motion, such as $p^2 = a^3$.
56. Hewlett-Packard (abr.)
58. The apparent backward (westward) motion of planets as seen against the background of stars.
59. Day when there is exactly 12 hours of sunlight and 12 hours of darkness. Occurs twice a year (3/22 & 9/22).
60. Made up of the Sun, the nine planets, plus comets, and asteroids. (2 words)
63. Italian astronomer whose observations conclusively disproved the geocentric model of the solar system.

DOWN

1. The motion of the Earth around the Sun, taking 365 days.
2. Type of solar eclipse in which just the rim of the Sun is visible around the moon.
4. Closest planet to the Sun.
5. Helium (abr.)
6. In $p^2 = a^3$, the time for a planet to complete one orbit around the sun, p.
7. Occurs when the Sun, Moon, and Earth are perfect aligned (in that order); very rare. (2 words)
8. The region of a shadow that is totally shaded. The Earth must pass through the moon's ________ for a solar eclipse to occur.
9. Second planet from the Sun.
10. Silicon (abr.)
11. Sixth planet from the Sun.
14. Apparent change in position of an object due to a change in the location of the observer.
17. The small circle followed by a planet in **#6 across**'s system to account for **#58 across** motion.
18. Oops…The same as #2 down.
19. Fourth planet from the Sun.
21. Unit of distance, approximately equal to 3 light-years.

22. Shape of the Earth's orbit around the Sun.
24. The band around the sky centered on the ecliptic within which the planets move.
25. Greek astronomer who advocated the geocentric model of the solar system.
27. Eighth planet from the Sun.
31. Fifth planet from the Sun.
34. One of the stellar patterns identified by name, usually of mythological gods, people, a nimals, or objects. Also, the region of the sky containing that star pattern.
35. One of the elements common in the core of terrestrial planets. Chemical symbol: Fe.
36. The object which orbits Earth approximately every 29 days.
37. Oops…the same as #9.
39. The line that marks the apparent intersection of the Earth and the sky.
40. Danish astronomer who measured the positions of stars with great accuracy. (full name)
43. Combined with **#51 across**, the time required for half of the atoms in a radioactive sample to decay.
45. The galaxy in which we live.
47. The planet on which we live.
48. Small rocky worlds, most of which orbit the sun between Mars and Jupiter. (singular)
49. A named grouping of stars that is not one of the recognized constellations, such as the Big Dipper.
55. Small, icy body that orbits the Sun and produces a tail of gas and dust when it approaches the Sun.
57. Farthest planet from the Sun.
61. For example.
62. F = _______.

Appendix II: Teaching Evaluations

For each class that I taught at the University of Maryland, students were asked to fill out anonymous surveys at the end of the semester would not be seen by the TA until after all grades had been submitted. The surveys consisted of 21 multiple-choice questions, with the opportunity for students to comment on any of these questions, and three areas for students to write additional positive or negative feedback. These surveys were designed by the College of Mathematical and Physical Sciences to evaluate a wide range of courses. As such, some of the questions are not relevant in evaluating my teaching abilities and have been omitted.

Each semester's results are calculated from 59-88 student responses, with the average score calculated out of a possible 4.0. For comparison, I have listed the average score for all TAs who taught introductory level astronomy courses during this time (a total of about 456 evaluations per semester). Hard copies of all evaluations are available upon request.

Question	**Spring 2002**	**Fall 2001**	**Spring 2001**	**Fall 2000**	***All TAs***
Number of responses	64	59	84	88	*1825*
The overall quality of the course was	3.42	3.30	3.25	3.28	*2.91*
In general, the instructor's teaching was	3.71	3.64	3.62	3.63	*2.95*
In general, evaluative grading techniques were	3.55	3.32	3.39	3.47	*2.99*
The instructor's written communication of the upcoming course content was	3.61	3.57	3.57	3.43	*3.01*
The instructor's organization of each class was	3.67	3.54	3.59	3.52	*3.05*
The clarity of explanations were	3.56	3.59	3.51	3.54	*2.76*
The instructor's knowledge of the course content was	3.89	3.73	3.76	3.62	*3.28*
The instructor's interest in teaching the course was	3.92	3.75	3.82	3.75	*3.33*
The class sessions, as far as being interesting & attention-holding were	3.25	3.15	3.06	3.25	*2.56*
Instructor's clarity & completeness in answering questions was	3.71	3.49	3.61	3.54	*2.85*
The respect the instructor showed toward individual students was	3.89	3.68	3.82	3.82	*3.54*
Constructiveness of the instructor's feedback on your work was	3.36	3.37	3.29	3.30	*2.88*
The instructor's using the board was	3.83	3.66	3.63	3.56	*3.13*
The instructor's writing legibility was	3.67	3.49	3.49	3.36	*3.02*
The instructor's out of class help was	3.22	3.41	3.38	3.21	*3.00*

Selected responses by students:
I include below selected responses by students. These have been grouped by topic. A collection of every written response from all students who filled out a survey (295 evaluations) as well as hardcopy photocopies of all evaluations are available upon request (hardcopy originals were retained by the University of Maryland).

Enthusiasm/interest in teaching

- He is very energetic about astronomy and very knowledgeable on the topic. He cares very much about making the students understand the topics at hand, and does everything he can to help.
- He was excellent. Best TA I've had at UMCP. He put a lot of effort into making the class fun, interesting, and informative. I had a great time, even if it was at 9 AM Monday morning.
- He shows a good amount of interest in the course. He also keeps me interested in the subject material as well.
- I am thoroughly impressed with the enthusiasm and knowledge evident from this TA. He did a wonderful job in supplementing the astronomy lecture course.
- Very enthusiastic about course material. It helps me get interested in it too.
- He was very energetic this early in the morning which kept me awake and focused. He explained answers clearly and concisely.
- Matthew Knight seems very energetic about teaching this class and that helps the students get involved. Also, he came well prepared to class to give us [the] best use of the student's time.

Ability to make class time interesting and useful

- This TA's teaching style and knowledge of course material is excellent. He did a very good job of coming up with new ways to help convey material.
- He uses a clear method of communication of the material, able to give good examples, and uses things like crossword puzzles to get the knowledge integrated into our lives.
- When explaining problems, he always picks the best approach and they are always the easiest method. That's something that I noticed in comparison to other TA's at review session. Though his approaches are easier, they are appropriate in preparation for our exams.
- The TA was the most informative and helpful TA I have had for core classes. He was willing to answer all of my questions and explained concepts in a way that was understandable.
- He did a good job varying what we did each week with Q&A, crosswords, etc…
- He was very eager to help us out and teach us in the most clear way possible. He used the board effectively and I left discussion feeling a lot more confident about the course.

Interactions with students

- I really felt like he read everything and graded fairly with supportive comments
- Matt is the most dedicated and thoughtful TA I've had in three years. He truly cares about the material and the students.
- He's the only TA I've ever had that actually knows my name
- You knew everyone's name even if they did not speak a lot
- Thanks for learning my name

Appendix III: Pictures from Project ASTRO

The following photos were taken by my partner teacher, Karen Watson, during the 2011-2012 school year at Friendship Academy of Science and Technology in Baltimore, MD.

Figure 1: Students look at a model comet nucleus I made in class using dry ice, ammonia, dirt, and chocolate sauce.

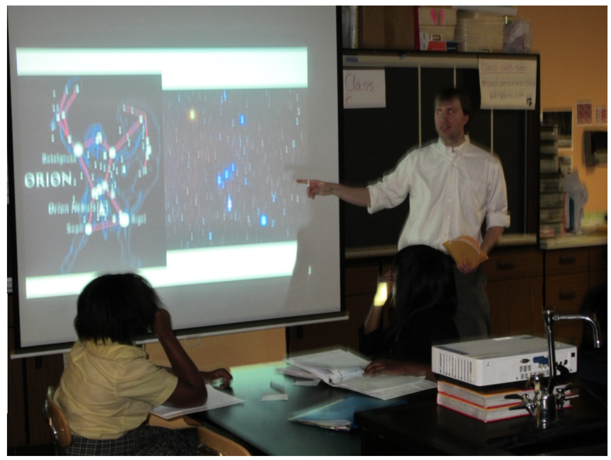


Figure 2: I discuss the origin of horoscopes and their relation to constellations.

Figure 3: Students create star charts they can take home to use to find constellations.

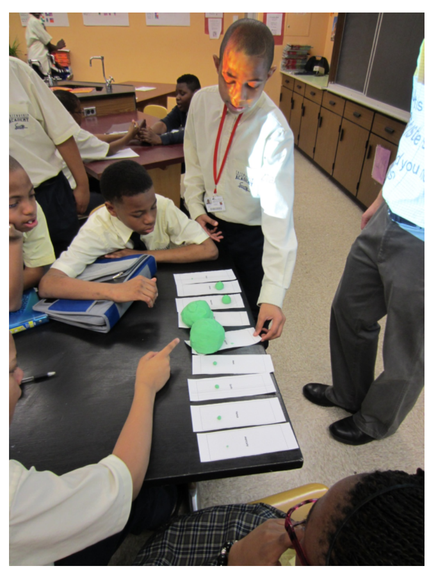


Figure 4: Students create a scale model of the solar system out of play-dough.