Gateway To Space

ASEN 1400 / ASTR 2500
My Name is...
\[ \frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial y^2} + \frac{\partial^2 \varphi}{\partial z^2} = 0 \]

\[ \sum_{k=1}^{n} k^2 = \frac{n(n + 1)(2n + 1)}{6} \]

\[ \frac{d}{dx} f(x) = \lim_{\Delta \to 0} \frac{f(x + \Delta) - f(x)}{\Delta} \]

\[ \cos x = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n}}{(2n)!} \]

\[ \int \tan(ax) \, dx = -\frac{1}{a} \ln |\cos(ax)| + c \]

\[ \int u \frac{dv}{dx} \, dx = uv - \int \frac{du}{dx} v \, dx \]

\[ \lim_{x \to c} \frac{f(x)}{g(x)} = \lim_{x \to c} \frac{f'(x)}{g'(x)} \]

\[ \lim_{x \to -\infty} \tan^{-1}(x) = -\frac{\pi}{2} \]
PID Control Law

- Proportional, Integral, Derivative (PID)
  - Used to control single axis
  - One PID controller for each axis

\[
\omega_{\text{err}} \quad \rightarrow \quad K_d \\
\theta_{\text{err}} \quad \rightarrow \quad K_p \\
\theta_{i\text{err}} \quad \rightarrow \quad \text{Int Att Gain}
\]

\[
\omega_{\text{err}} = \text{rate error} \\
\theta_{\text{err}} = \text{attitude error} \\
\theta_{i\text{err}} = \text{integrated attitude error}
\]
PID Control Law Response Times

- Zero Rate Gain = No Damping
- Small Rate Gain = Light Damping
- Large Rate Gain = Heavy Damping

Graph showing the response times for different damping conditions.
"If you're really successful at bullshitting, it means you're not hanging around enough people smarter than you."

Neil DeGrasse Tyson
Gateway To Space

ASEN 1400 / ASTR 2500

Class #1

Colorado Space Grant Consortium
How was the first day?
How was the second day?
Today

- Lots of stuff about the class
- What to expect from this course
- Format for this course
- “How to get an A”
- Introductions
- Pictures

First Day Checklist
So you know what you heard
Class Size
Who's Out There?
What this class takes...
Wordle from Comments 2012 Class:
Wordle from Comments 2013 Class:

- engineering
- work
- learned
- experience
- semester
- expected
- aerospace
- much
- space
- future
- made
- spacecraft
- industry
- major
- real
- still
- everything
- put
- go
- awesome
- lecturer
- working
- group
- receive
- end
- always
- went
- everyday
- problem
- major
- looking
- involved
- flight
- college
- course
- projects
- something
- day
- met
- time
- got
- many
- feel
- much
- better
- like
- going
- every
- expected
- received
- people
- surpassed
- entire
- thing
- expected
- go
- awesome
- excellent
- whole
- food
- problem
- new
- satellite
- not
- general
- well
- skill
- learn
- fun
- how
- career
- well
- think
- difficult
- found
- problem
- think
- difficult
- found
- problem
- think
- difficult
- found
- problem
- think
- difficult
- found
- problem
What to expect...
What to Expect?

- What you imagine this class will be like...
What to Expect?

- What it is like…
What to Expect?

- What it is like…
What to Expect?

- What it is like…
What to Expect?

- What it is like…
What to Expect?

- What it is like…
Speaking of History…

- What is was like…
What to Expect?

- 17th time teaching this course

- I have a unique teaching style
  - I teach like I wish I had been taught
  - Sense of humor
What to expect from this class:

- If you are not here because you want to be here, then leave…

- If you are here because you think this will be easier than GEEN 1400 (or some other class), then leave…

- If you are a slacker, then leave…

- But if you want to work hard and achieve something great…

  then please stay
The Class:

**Learn** the basics of atmospheric and space sciences, space exploration, spacecraft design, rocketry, and orbits.
The Class:

Hear about the current research in space through lectures from industry
The Class:

Launch a mini-satellite on a high altitude balloon that is designed and built by you and a team of students.
The Class:
The Class:

- Interactive
- Interesting
- Applicable
- Fun
Syllabus
Syllabus:

- 11 - Lecture
- 08 - Guest
- 10 - Teams
- 07 - Reviews
- 07 - Extra
- 10 - Attention
<table>
<thead>
<tr>
<th>Class #</th>
<th>Date</th>
<th>Day</th>
<th>DTL</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>08-26-14</td>
<td>T</td>
<td>81</td>
<td>Class Introduction and Pictures (So starts the rollercoaster)</td>
</tr>
<tr>
<td>2</td>
<td>08-28-14</td>
<td>R</td>
<td>79</td>
<td>Spacecraft Overview – (Compressed)</td>
</tr>
<tr>
<td>3</td>
<td>09-02-14</td>
<td>T</td>
<td>74</td>
<td>Guest Lecture – “Solar System Exploration Missions”</td>
</tr>
<tr>
<td>4</td>
<td>09-04-14</td>
<td>R</td>
<td>72</td>
<td>BalloonSat Overview + Request for Proposals: Functional Block Diagrams, Design Documents</td>
</tr>
<tr>
<td>5</td>
<td>09-09-14</td>
<td>T</td>
<td>67</td>
<td>HANDS-ON: Team Forming + Team Activity</td>
</tr>
<tr>
<td>6</td>
<td>09-11-14</td>
<td>R</td>
<td>65</td>
<td>HANDS-ON: Soldering 101 (Build and Blink)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*&lt;Arduino’s distributed to teams today for HW 04&gt;</td>
</tr>
<tr>
<td>7</td>
<td>09-16-14</td>
<td>T</td>
<td>60</td>
<td>HANDS-ON: Arduino – Part I (Type and Blink):</td>
</tr>
<tr>
<td>8</td>
<td>09-18-14</td>
<td>R</td>
<td>58</td>
<td>REVIEWS: Conceptual Design Review (CoDR)</td>
</tr>
<tr>
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<td></td>
<td>*&lt;4 minute presentations &amp; 5 minutes of Q/A&gt;</td>
</tr>
<tr>
<td>x1</td>
<td>09-22-14</td>
<td>M</td>
<td>54</td>
<td>PROPOSALS DUE 8:00 AM</td>
</tr>
<tr>
<td>9</td>
<td>09-23-14</td>
<td>T</td>
<td>53</td>
<td>HANDS-ON: Arduino – Part II (Analog Sensors):</td>
</tr>
<tr>
<td></td>
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<td></td>
<td><em>After lecture intro, some team members may leave to work on other aspects of the project but must report back to room at end of class</em></td>
</tr>
<tr>
<td>10</td>
<td>09-25-14</td>
<td>R</td>
<td>51</td>
<td>HANDS-ON: Arduino – Part III (Digital Sensors):</td>
</tr>
<tr>
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<td><em>After lecture intro, some team members may leave to work on other aspects of the project but must report back to room at end of class</em></td>
</tr>
<tr>
<td>x2</td>
<td>09-25-14</td>
<td>R</td>
<td>51</td>
<td>HANDS-ON: Arduino – Part IV (Memory):</td>
</tr>
<tr>
<td></td>
<td>6 – 9 PM</td>
<td></td>
<td></td>
<td><em>Team representatives required to attend</em></td>
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<tr>
<td>x3</td>
<td>09-26-14</td>
<td>F</td>
<td>50</td>
<td>&gt;&gt;&gt;&gt; Authority To Proceed (ATP) by appointment with Chris &lt;&lt;&lt;</td>
</tr>
<tr>
<td>Date</td>
<td>Day</td>
<td>Time</td>
<td>Topic</td>
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<tr>
<td>09-30-14</td>
<td>T</td>
<td>46</td>
<td>Requirements Flow Down Process + HASP 2014 Team</td>
<td></td>
</tr>
<tr>
<td>10-02-14</td>
<td>R</td>
<td>44</td>
<td>Guest Lecture – “Systems Engineering”</td>
<td></td>
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<tr>
<td>10-07-14</td>
<td>T</td>
<td>39</td>
<td>Guest Lecture – “Spacecraft Structures”</td>
<td></td>
</tr>
<tr>
<td>10-09-14</td>
<td>R</td>
<td>37</td>
<td>Guest Lecture – “Spacecraft Propulsion”</td>
<td></td>
</tr>
<tr>
<td>10-14-14</td>
<td>T</td>
<td>32</td>
<td>REVIEWS: Preliminary Design Review (PDR)</td>
<td></td>
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<td></td>
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<td></td>
<td>&lt;6 minute presentations &amp; 1 minute of Q/A&gt;</td>
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</tr>
<tr>
<td>10-16-14</td>
<td>R</td>
<td>30</td>
<td>Rocket History</td>
<td></td>
</tr>
<tr>
<td>10-21-14</td>
<td>T</td>
<td>25</td>
<td>Launch Vehicles</td>
<td></td>
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<tr>
<td>10-23-14</td>
<td>R</td>
<td>23</td>
<td>Orbits and Mission Design – Part I</td>
<td></td>
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<tr>
<td>10-28-14</td>
<td>T</td>
<td>18</td>
<td>Orbits and Mission Design – Part II</td>
<td></td>
</tr>
<tr>
<td>10-30-14</td>
<td>R</td>
<td>16</td>
<td>HANDS-ON: In-Class Team Time – Bring hardware and questions.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Chris will be walking the room and inspecting payloads</td>
<td></td>
</tr>
<tr>
<td>11-04-14</td>
<td>T</td>
<td>11</td>
<td>HANDS-ON - In-Class Mission Simulation Test (ON for the whole class)</td>
<td></td>
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<td></td>
<td>If Time = Spider</td>
<td></td>
</tr>
<tr>
<td>11-06-14</td>
<td>T</td>
<td>32</td>
<td>Guest Lecture – “Spacecraft Power” and Career Advice</td>
<td></td>
</tr>
<tr>
<td>11-11-14</td>
<td>T</td>
<td>04</td>
<td>REVIEWS: Launch Readiness Review (LRR)</td>
<td></td>
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<td></td>
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<td>&lt;4 minute presentations &amp; 4 minutes of Q/A&gt;</td>
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<tr>
<td>11-13-14</td>
<td>R</td>
<td>02</td>
<td>Launch Logistics</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Day</td>
<td>Time</td>
<td>Event Description</td>
<td></td>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>11-14-14</td>
<td>F</td>
<td>01</td>
<td>Final BalloonSat Weigh-in and TURN IN By appointment 8:00 AM to 2:00 PM @ Chris’s Office DLC 270A</td>
<td></td>
</tr>
<tr>
<td>11-15-14</td>
<td>SAT</td>
<td>00</td>
<td>Launch Day @ 6:50 AM @ Windsor, Colorado (Leave Boulder at 4:45 AM!)</td>
<td></td>
</tr>
<tr>
<td>11-18-14</td>
<td>T</td>
<td>+3</td>
<td>Guest Lecture – “Spacecraft Attitude Determination and Control” + Launch Recap and Report and Data Analysis Guidance</td>
<td></td>
</tr>
<tr>
<td>11-20-14</td>
<td>R</td>
<td>+5</td>
<td>REVIEWS: Quick Look Post Launch Presentation</td>
<td></td>
</tr>
<tr>
<td>11-25-14</td>
<td>T-R</td>
<td>+10</td>
<td>Fall Break – NO CLASSES – Fall Break</td>
<td></td>
</tr>
<tr>
<td>12-02-14</td>
<td>T</td>
<td>+17</td>
<td>Guest Lecture – “Have You Been To Mars?”</td>
<td></td>
</tr>
<tr>
<td>12-04-14</td>
<td>R</td>
<td>+19</td>
<td>Guest Lecture – “The Future of Space Exploration – The Next Big Thing”</td>
<td></td>
</tr>
<tr>
<td>12-06-14</td>
<td>SAT</td>
<td>+21</td>
<td>REVIEWS: ITLL Design Expo (9:00 AM – 4:00 PM) Open to the general public from 12:30 to 3:00 PM</td>
<td></td>
</tr>
<tr>
<td>12-09-14</td>
<td>T</td>
<td>+24</td>
<td>Space Grant Opportunities, Class Survey, and Team Videos</td>
<td></td>
</tr>
<tr>
<td>12-09-14</td>
<td>T</td>
<td>+24</td>
<td>REVIEWS: Final Presentations &lt;8 minute presentations &amp; 7 minutes of Q/A&gt;</td>
<td></td>
</tr>
<tr>
<td>12-11-14</td>
<td>R</td>
<td>+26</td>
<td>Final Class – Review and Discussion + Final Team Evaluations Bring all hardware</td>
<td></td>
</tr>
<tr>
<td>12-15-14</td>
<td>M</td>
<td>+30</td>
<td>REVIEWS: Community Service Activity Presentations + Extra Credit Final Exam (time permitting)</td>
<td></td>
</tr>
</tbody>
</table>
NOTES: All “DUE” items are due electronically via email at Prof.Koehler@gmail.com by class time unless otherwise stated above. Items submitted after class begins or past the specified time, will be late and subject to grade penalty. Files must be emailable or brought to Chris on USB driver before time due.

All Subject lines of each email submitted for this class must follow the naming convention below:

- Homework = “HW XX Lastname Firstinitial” Example = HW 01 Armstrong N (Attachments shall be in MS Word)
- Team Documents = “DD rev Team Number” Example = DD C Team 04 (Attachments shall be in MS Word)
- Team Presentations = “Review Team Number” Example = CDR Team 04 (Attachments shall be in MS PowerPoint)

Failure to use this naming convention will result in your email be deleted by a SPAM filter and may result in no credit or late penalties.

1 Minute Reports are DUE each day at the end of class. Please use your assigned number and printed form for proper credit. Attendance will be taken during each lecture. It is your responsibility to find and sign the attendance sheet before the end of class. If you need anything, please send an email with the word “HELP” in the subject. Email will be routed to the top of my email inbox.

Gateway to Space grades are based on a 100-point scale (1 point = 1% of total grade) and there is no curve. 50% of the points are based on individual contributions and 50% are based on team contributions. Grades will be posted to the website 5 to 7 times throughout the semester. A password will be given to each student to look up their grades on the website. You graded is earned not deserved. Points are divided as follows:

<table>
<thead>
<tr>
<th>Individual Points/Grade Percentage</th>
<th>Team Points/Grade Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>15% Attendance (30) &amp; 1 Minute Reports (30)</td>
<td>10% Team Proposal</td>
</tr>
<tr>
<td>10% Homework (1-8,10)</td>
<td>13% Team Presentations (4)</td>
</tr>
<tr>
<td>05% Book Assignment (Homework 9)</td>
<td>10% Team Design Document (2 Revs)</td>
</tr>
<tr>
<td>05% Community Service and Presentation</td>
<td>02% Design Expo</td>
</tr>
<tr>
<td>15% Individual Contributions &amp; Participation on Team</td>
<td>15% Final Presentation and Final Report</td>
</tr>
<tr>
<td>50% Subtotal (You)</td>
<td>50% Subtotal (Team)</td>
</tr>
</tbody>
</table>

50% + 50% = 100%
How to get an A?
How to get an A:

“Everyone starts out with an A”

You have to try really hard to get anything lower than C-

Not in the business of giving bad grades…

…but you get the grade you earn

Please, Please, Don’t Cheat
How to get an A:

Grades are based on a normal 100 point scale

No curve

Team project and participation are based on your team evaluation and instructor evaluation

Feedback may be slow

Grader – Crawford Leeds
Fall 2011
How to get an A:
How to get an A:

Grade Breakdown

<table>
<thead>
<tr>
<th>Individual Points</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance (30) &amp; 1 Minute Reports (30)</td>
<td>15%</td>
</tr>
<tr>
<td>Homework (1-8,10)</td>
<td>10%</td>
</tr>
<tr>
<td>Book Assignment (Homework 9)</td>
<td>05%</td>
</tr>
<tr>
<td>Community Service and Presentation</td>
<td>05%</td>
</tr>
<tr>
<td>Individual Contributions &amp; Participation on Team</td>
<td>15%</td>
</tr>
<tr>
<td>Subtotal (YOU)</td>
<td>50%</td>
</tr>
</tbody>
</table>
### How to get an A:

#### Grade Breakdown

<table>
<thead>
<tr>
<th>Team Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Team Proposal</td>
</tr>
<tr>
<td>13% Team Presentations (4)</td>
</tr>
<tr>
<td>10% Team Design Documents (2 Revs)</td>
</tr>
<tr>
<td>02% Design Expo</td>
</tr>
<tr>
<td>15% Final Presentation and Final Report</td>
</tr>
<tr>
<td>50% Subtotal (TEAM)</td>
</tr>
</tbody>
</table>
How to get an A:

Grade Breakdown

50% You + 50% Team = 100%
Homework
Homework:

Submit via email

- Subject should be in this format “HW XX Lastname Firstinitial”

- Send all items to Prof.Koehler@gmail.com

- Get from Website

First Homework is…
ASEN 1400 / ASTR 2500

Taught as part of the Colorado Space Grant student experience and funded by the Department of Aerospace Engineering Sciences at the University of Colorado at Boulder.
The Book(s)
Miscellaneous:

Book(s) for course

- Typical engineering book cost $100, $90, $80, $70

This Book…
- $10.86
- Rocket Boys
  Homer Hickam

Also…Set aside $25 for batteries and dry ice
Miscellaneous:

Book(s) for course

This Book...
- $14.69
- Moon Lander – How we developed the Apollo Lunar Lander
- Thomas J. Kelly

Also…Set aside $25 for batteries
Attendance & 1 Minute Report
Attendance:

- Your responsibility to sign the attendance sheet every class

- Don’t sign for friends

- Sick, stay away but send email

- Gone for other reasons, must get approved before event, not after

- Be on-time

- Plan on being here for the full class (75 minutes)
1 Minute Reports:

- Everyone has a unique number

- Use your uniquely numbered sheet each class

- Turn in at end of class

- Must be this format and not your own “I forget my forms” paper

Please Print/Write clearly

- I read each of them clearly

- Great feedback as the class goes forward
1 Minute Report:

Name: 
Date: 
Lecture Title:

1. Key points of today’s lecture?

2. What wasn’t clear and/or what questions do you wish you had asked?

3. What personal contributions have you made to your team this week?

4. What grade would you give today’s lecture?

5. Other comments, concerns, or suggestions?
Community Service:

- Everyone must do a community service activity

- Not something you are doing for any other class/club/organization (i.e. NEW)

- Preferred if it is related to this class, your college major, or your interest in space

- Activity must last a minimum of 2 hours

- Form is on the class website and must be approved before completed
Community Service:

- Assigned 08-26-14
- Approval Due 11-06-14
- Completed 12-11-14
- Form Submit 12-15-14
- Presentation Due 12-15-14 @ 12 PM

90 second presentation that summarizes your service project by using the template on the website. Presentations will be given at the Final Exam
Community Service:

Community Service Approval (must be completed and signed before activity)
Description of planned activity:

Proposed date and location of activity: ___________________________ Date ___________________________ Location

Approved by ___________________________ on ___________________________

(Chris Koehler)
Community Service Completion
Description of how the actual activity went:

Actual date ______________ and location ________________________ of activity:

Number of those affected through your activity? ____________________________

Point of Contact of the activity: ________________________________

Point of Contact signature: ________________________________

Point of Contact email and/or phone number: ________________________________

Signature of student performing the activity: ________________________________

Attach picture(s) of you doing the actual activity: ________________________________
Guest Speakers
Guest Speakers:

- Be attentive and present
- Applaud
- Thank you letters
- Ask questions
Miscellaneous
Miscellaneous:

- Respectful class participation
  - Phones, laptops, noises, footprint (stuff), etc.

- Notes – Take them

- Communications via email and this class

- Office hours 10:45-11:45 T & Th and by appointment

- I am busy but always approachable

- Where to Find Me… DLC 270A
Questions?
Introductions
Who is this Guy?
- Who has not seen Star Wars, Episode IV (1977)?
Who is this Guy?
What Experience Do You Have?

Intern at Ball
summer of 1991

Worked with
Bob Poley

Worked on
RADARSAT
Who is this Guy?

Graduated from CU in December 1992 with B.S. in Aerospace Engineering

Graduated from CU in December 1994 with M.S. in Mechanical Engineering
What Did You Do After College?

Worked at Lockheed Martin from March 1995 until May 2000
What Did You Do At Martin?

- Classified satellite
- 1,000 people on program
- Youngest
- Reaction Control System
  Mechanical Design Lead
- Design done in IDEAS
- Released over 100 engineering drawings

- Supervised manufacture, assembly, integration and test for 5 satellite builds
- Last two years, Mechanical Design Lead for the Antenna systems
What Did You Do At Martin?

- Also worked on Stardust and Genesis
- Worked with many different disciplines and people
Why Did You Leave?

- Many reasons

1. Coming back here was a great opportunity

2. Pictures on the wall

3. Mentor

4. Change
Students Statewide:
Vision:

Providing a diverse group of Colorado students with experiences in space to prepare them for our Nation’s future space programs

COSGC = Workforce Development
Start Here…

Student Training and Management
RocketSat IV:
- Highest greenhouse gas measurement
- The tubing is vacated at apogee
- Air is forced into the tube, compresses, and remains in the order that it was sampled
- Sample is analyzed using laser analyzer after the flight
Who is this Guy?

I love space…

And with the help of students…
- 10 large satellites
- 8 small satellites
- 166 rocket payloads
- 1040 BalloonSats
Who is this Guy?

I love to laugh

DEATH

The world’s leading cause of death
Who is this Guy?

I love to laugh
Who is this Guy?

I do crazy things
Who is this Guy?

I love to read
Who is this Guy?
I love to write
Who is this Guy?

I brew Kombucha

How the contents develop during the course of the fermentation process is very clearly seen in the results of Dr Jürgen Reise’s investigations. (From Deutsche Lebensmittelrundschau (German Food Review), 83rd year, No.9, 1987, with kind permission of the publisher and author.)

Substances contained in Kombucha made from black tea:

- lactic acid
- gluconic acid
- acetic acid
- ethanol
- glucose
- pH value
Who is this Guy?

I love to play video games
Who is this Guy?

I love to play guitar
Why Did You Leave?

Al Worden, Apollo 15

Al Worden, Apollo 15
Why Did You Leave?

Harrison Schmitt, Apollo 17
Why Did You Leave?
Who is this Guy?

44  My age
33  The age I feel
7   Hours I get to sleep a night
40  Hours I get to sleep a week
55  Average number hours I work a week
6   Hours per week I am paid to teach this course
17  Average hours per week I actually spend on class
17  Times I have taught this course
134 Emails I get each day
30  Emails I respond to each day
1   Me
64  You
So why are you here?
Why You Are Here:

- You want to get a good job after college
- Good School
- Good Grades
- Good Experience
- This course and Space Grant gets you all three
- Unique point in your life
Space in Colorado:

- 142,500 Coloradoans
- Expected to double in the next few years
- “Graying of the workforce”
Final Word

You’ll Never...
Space Grant Info Sessions
Aug 26th 3:00pm
Aug 28th 9:30am
Aug 29th 3:00pm
Next Time:

Spacecraft Overview
Pictures?