The Final Lecture

or

“All good things”

Paul Pounds

28 May 2013
University of Queensland
But first…

Some house keeping
### Calendar at a glance

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Lecture</th>
<th>Reviews</th>
<th>Demos</th>
<th>Assessment submissions</th>
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<tbody>
<tr>
<td>1</td>
<td>25/2 – 1/3</td>
<td>Introduction</td>
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<td>2</td>
<td>4/3 – 8/3</td>
<td>Principles of Mechatronic Systems design</td>
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<td>3</td>
<td>11/3 – 15/3</td>
<td>Principles of Sailing</td>
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<td>Design brief</td>
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<tr>
<td>4</td>
<td>18/3 – 22/3</td>
<td>Sensor Fusion and Filtering</td>
<td>Progress review 1</td>
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<tr>
<td>5</td>
<td>25/3 – 29/3</td>
<td>Your Soldering is Terrible</td>
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<tr>
<td></td>
<td>Break</td>
<td>1/4 – 5/4</td>
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<tr>
<td>6</td>
<td>8/4 – 12/4</td>
<td>3D printing</td>
<td>Progress seminar</td>
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<tr>
<td>7</td>
<td>15/4 – 19/4</td>
<td>Image Processing on Microcontrollers</td>
<td></td>
<td>25% demo</td>
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<tr>
<td>8</td>
<td>22/4 – 26/4</td>
<td>Fluid Mechanics</td>
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<tr>
<td>9</td>
<td>29/4 – 3/5</td>
<td>Q&amp;A</td>
<td>Progress review</td>
<td>50% demo</td>
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<tr>
<td>10</td>
<td>6/5 – 10/5</td>
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<tr>
<td>11</td>
<td>13/5 – 17/5</td>
<td>Q&amp;A</td>
<td></td>
<td>75% demo</td>
<td>Preliminary report</td>
</tr>
<tr>
<td>12</td>
<td>20/5 – 24/5</td>
<td>Q&amp;A</td>
<td></td>
<td>50% demo</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>27/5 – 31/5</td>
<td>Closing lecture</td>
<td>Final testing</td>
<td>Final report and addendum</td>
<td>Final report and addendum</td>
</tr>
</tbody>
</table>
Lab matters

• This is the last week of lab use
  – Last big push
  – Keep it tidy for one more week!

• Toolbox hand-in: c404, 2 pm, Thursday 30\textsuperscript{th}
  – Return complete toolkits in good condition
  – Your desk must be cleared/clean, locker empty
  – Don’t panic if you’re testing 2-3 pm… just show up to the lab when your testing slot is done
Lab matters

• The room will be cleaned prior to sign-off
  – Floor swept out
  – Rubbish to go in Hawken skips
  – Soldering area tidied up

• It’s a really terrific idea to clean the lab early if you can!
FAQ Roundup

• How is the final demo different from the incremental demos?
  – Aside from the mark cap? No different - just the same.

• Will it ever end?
  – Yes, on Friday. Then you are free.
Final report

• Due on Friday
  – Really, really soon now!

• Your report must have:
  – Max 5 + 1 pages of explanation/writing
  – Bibliography/math/sims/figures/budgets/etc. in the appendices
  – Analytics
  – Incorporate comments from preliminary report
Final Report

• Do not exceed 6 pages of written content
  – Go nuts with the appendices for bibliography/math/sims/figures/budgets etc.
  – There is no such thing as too many pictures
  – Don’t try to sneak written content into the appendices – *seriously?* I won’t read them.

*Exception:* you may include a short personal reflection in the appendices, if you wish.
Final report

• Also, just 2 pages and a picture won’t cut it
  – 2 pages \textit{without} a picture won’t cut it either!

~You know who you are~
Final demo

• Wednesday and Thursday this week!
  – Held at the METR3800 testing tank (duh)
  – Where most of the marks are!
  – Your chance to win the treasure of Axolotlzuma!

• Also looking for volunteer groups for a special exhibition session at 11 am on Friday 31\textsuperscript{st}
  – Interested? Email me!
## Final demo schedule

<table>
<thead>
<tr>
<th></th>
<th>Wednesday 29th</th>
<th>Thursday 30th</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9:00-9:30 Setup</td>
<td>9:00-9:30 Team 7</td>
</tr>
<tr>
<td></td>
<td>9:30-10:00 Team 15</td>
<td>9:30-10:00 Team 9</td>
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<tr>
<td></td>
<td>10:00-10:30 Team 13</td>
<td>10:00-10:30 Team 6</td>
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<tr>
<td></td>
<td>10:30-11:00 Team 3</td>
<td>10:30-11:00 Team 11</td>
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<tr>
<td></td>
<td>1:00-1:30 Team 2</td>
<td>1:00-1:30 Team 5</td>
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<tr>
<td></td>
<td>1:30-2:00 Team 12</td>
<td>1:30-2:00 Team 10</td>
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<tr>
<td></td>
<td>2:00-2:30 Team 1</td>
<td>2:00-2:30 Team 4</td>
</tr>
<tr>
<td></td>
<td>2:30-3:00 Team 8</td>
<td>2:30-3:00 Team 14</td>
</tr>
</tbody>
</table>
Marking schema

• Product demo is 60 per cent of class grade

• This is subdivided into:
  – Build quality       – 10 per cent
  – Basic functionality – 20 per cent
  – Voyage result       – 30 per cent

• All three parts will be assessed during the final demo sessions
Structure of the final demo

1. Meet at the tank at designated time
2. Hand over box with design notes + boat
3. Build quality assessment
4. Basic capabilities demonstration
5. Seaworthiness certificate
6. Three voyage attempts
7. Go to c404 to clean out lockers and gear
8. Commiserate/celebrate at Red Room
Build quality

• Marks are given for the quality of fabrication
  – Neat and tidy assembly
  – Smooth operation of moving parts
  – Clean design and professional finish

• Worth 10 per cent of course grade
  – Print outs: budget, code, drawings, etc

• This will be assessed prior to your demo
  – Detailed best-practice guidelines and marking rubric available on Blackboard
# Build quality

<table>
<thead>
<tr>
<th>Grade Band</th>
<th>Electrical (35)</th>
<th>Mechanical (35)</th>
<th>Software (20)</th>
<th>Finish(10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent (85-100%)</td>
<td>Clearly designed and well thought-out optimised construction, high-quality of manufacture and defect-free. Professional-quality work</td>
<td>Clearly designed and well thought-out optimised construction, high-quality of manufacture and defect-free. Professional-quality work</td>
<td>Tight well-structured code, useful comments, easy to read and understand without explanation</td>
<td>20</td>
</tr>
<tr>
<td>Very Good (75-85%)</td>
<td>Neatly laid out and ordered, orderly sensible circuit routing and layout, high-quality assembly with few defects</td>
<td>Solid construction with no excess or deficit of material, tightly-toleranced components, rock-solid assembly, good materials selection</td>
<td>Beautiful construction, intuitive and pleasurable to use</td>
<td>18</td>
</tr>
<tr>
<td>Good (65-75%)</td>
<td>Solid design and construction, few soldering or assembly defects, indications of methodical layout design</td>
<td>Clear indication of design and care in construction, well-fitting parts, and robust assembly, few design or fabrication problems</td>
<td>Comprehendible, organised and methodical, easy to follow with minimal effort, could be maintained without help</td>
<td>14</td>
</tr>
<tr>
<td>Satisfactory (50-65%)</td>
<td>Obtuse layout, some suboptimal design elements, construction problems or defects but serviceable</td>
<td>Chunky or weak in parts, but not fragile or bloated, inappropriate materials, rough fits, unrefined but serviceable</td>
<td>Structured and understandable with effort, unhelpful variable names or functions, difficult to make sense of without explanation</td>
<td>12</td>
</tr>
<tr>
<td>Poor (25-50%)</td>
<td>Shoddy design/construction, low-quality soldering with a high rate of defects, unlikely to be reliable</td>
<td>Rickety, rough and cobbled together; poorly fitting and shoddily assembled, unlikely to be reliable</td>
<td>Chaotic and incomprehensible, impossible to modify or maintain, even if it works</td>
<td>8</td>
</tr>
<tr>
<td>Very Poor (0-25%)</td>
<td>No attempt made</td>
<td>No attempt made</td>
<td>No attempt made</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes:
- Electrical: 35
- Mechanical: 35
- Software: 20
- Finish: 10
Basic functionality

Not the same as the seaworthiness certificate

• Worth 20 per cent of course grade
5 marks each to be awarded for demonstrating:
1. Floats in water – i.e. doesn’t sink
2. Wind propulsion – i.e. not just drifting
3. Sensing – extracts environment information
4. Intentionality – aims for specific direction
Seaworthiness certificate

Only required for bonus achievement points

• Place your boat on one side of the tank
  – Any position or orientation you like
  – Fans will blow from the opposite side

• Successful if the boat reaches the other side
  – Success may be granted if the boat makes substantial progress within tank size limitation.
The Voyage

- Worth 30 per cent of course grade!

- Three attempts
  - Start at centre of eastern edge, facing due West
  - 5 minutes for each attempt
  - Randomly placed dragon
  - As many fans as I can scrape together

Highest score of the three is the one counted
Voyage marks

“But… how are marks going to be calculated from our point score??”
Voyage marks

Non-trivial, non-linear function:

\[ \text{Voyage mark} = \min(\text{total points} \times 5, 35) \]

<table>
<thead>
<tr>
<th>Landfall location</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost at sea</td>
<td>NA</td>
</tr>
<tr>
<td>Island</td>
<td>2</td>
</tr>
<tr>
<td>Desert</td>
<td>3</td>
</tr>
<tr>
<td>Forests</td>
<td>4</td>
</tr>
<tr>
<td>River</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Achievement</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter attempt*</td>
<td>+1</td>
</tr>
<tr>
<td>Reached the Temple of Axolotlzuma</td>
<td>+2</td>
</tr>
<tr>
<td>All ships reach river delta</td>
<td>+1</td>
</tr>
<tr>
<td>No off-board computation</td>
<td>+1</td>
</tr>
<tr>
<td>$20 under budget</td>
<td>+1</td>
</tr>
<tr>
<td>Snagged ship freed by judge</td>
<td>-1</td>
</tr>
</tbody>
</table>
Maximum demo score

• Maximum of 35 out of 30? Lolwut?

• Sharp-eyed readers of the ECP will notice that that demo is listed as scored out of 65%

• Teams may score up to 5 extra marks
  – Up to 65 marks for a “perfect” score
But also…

You were promised treasure!
The Treasure of Axolotlzuma
The Treasure of Axolotlzuma

If a team’s boat successfully reaches the temple during the three final demo attempts, each member of that team will receive an Axolotlzuma trophy.
The Treasure of Axolotlzuma

If a team’s boat successfully reaches the temple during the Friday exhibition session, each team member present will receive an Axolotlzuma trophy
The exhibition session

• Just like the final demo, but not for marks
  – Will not be considered for marks, no matter how well or poorly you do

• But! A second chance to get the trophy
  – No limit on number of attempts (or boats in the water concurrently)

• Please email me if you would like to enter your boat in the session
And now…

*The tables are turned*
SECaTs

• In this class, I have been evaluating you.
  – Now is your chance to evaluate me.

• I have been asking you to show me methodical engineering design.

You should expect no less of me!
SECaTs

So, in fairness, I would like to present…
An (Abridged) Design Case-Study

The full version was 60+ slides long for parts 1 and 2 out of 7

… and probably boring.
The process

1. Specification
2. Research
3. Analysis
4. Implementation
5. Validation
Specification

What is it I’m supposed to be doing, anyway?
Design Specification

Codified in the “learning objectives”:

1. TEAMWORK
   1.1 Be an effective team player.
   1.2 Understand your responsibilities in a team situation.

2. DESIGN
   2.2 Design an electromechanical and software based product.
   2.3 Identify and break down personal and technical problems in product design.
   2.4 Implement a complete design cycle.
   2.6 Choose appropriate design strategies.

3. PROJECT
   3.2 Apply project management skills.
   3.4 Produce, implement and devise product plans.
   3.5 Deliver a product on-budget and on-time.

4. COMMUNICATION
   4.2 Use ICTs for information retrieval and dissemination.
   4.4 Write formal reports
   4.6 Chair and attend formal meetings.
   4.7 Verbally present your design ideas
The underlying goals

Read between the lines:

Get students to experience doing a real **engineering design** project…

… on a **challenging problem**…

… that requires **teamwork** to be successful…

… leading to real world **social dynamics**.
Why is this hard?

Challenging problem?  
Social dynamics?  
Team work??

This is a recipe for disaster!

And that’s before I actually try to teach design!
Research and analysis

Lessons and insights from previous classes
Prior experience

Lessons from METR team projects past:
1. Students overly familiar with old projects
   – Everyone knows Micromouse and Robocup
2. Friend-based teams can go *catastrophically* wrong 😞
3. PAFs can be unfair and brutal
   – “12 Angry Men syndrome”
Prior experience

4. Supervised team meetings don’t work
   – Results in “Potempkin Meetings”

5. Product-based courses exhibit boolean failure modes
   – Small errors on last day are lethal

6. Students *never* get started early enough
   – Even when you tell them to!
Translate into design constraints

• **Project must be awesome**
  – Easy to be motivated by intrinsic drivers
  – ie. for the joy of engineering, not just marks!

• **The project must be properly scaled**
  – Suitable to teams of four students with mechatronics backgrounds
  – Tough task, but not impossible (with teamwork!)

• **The class structure must reward hard work**
  – Don’t reward slackers; identify problems early
The idea

• Had the itch for an “astral navigation” project that used LED ‘stars’ for guidance

As seen on the Lockheed SR-71. Inertial-aided ANS could track up to 56 stars in the daytime – through a circular window in the upper fuselage – and use them to estimate both position and altitude.
Comparative analysis

There are many other candidate projects, but I won’t discuss them here, as they will likely be used for future years and are **TOP SECRET**

So… yeah… Autonomous sail boats!
Meeting the spec’

Why autonomous sailing?

- No reuse of previous project work
- Four clear, independent mechatronics tasks
  - Wind, hull, vision/planning, electronics/sensors
- Naturally motivated obstacles/disturbances
- More focus on design, less on fabrication
  - Lower time burden and better learning value
Implementation

Key design subsystems:
- Sensible assessment
- Making it challenging
- Making it fun
Sensible assessment

• Assignments as a *de facto* project plan
  – Design brief to get you thinking early
  – Regular freeform milestones every 3 weeks
  – Big milestone in the middle
  – Early submission to get you working on report

• Reports differentiate students, give chances
  – Allows good students to survive bad groups
  – No single assessment is ‘sudden death’
  – Safety net options – designed to reduce angst
Making it challenging

• Multiple competing objectives
  – Must use the synthesis step to find a solution
  – Duct-tape approach will not succeed

• Obvious approaches inferior to carefully reasoned approaches – rewards thinking

• Add hazards to test specific design skills
  – Volcano for disturbance rejection, dragon for obstacle avoidance, narrows for navigation
Making it fun

• Just what makes something ‘fun’ is ineffable
  – But years of game design experience help!

• Sense of humour and consistent style
  – Little bit quirky, little bit silly, very polished
  – A little bit of theatre!
  – ‘Look and feel’ modelled on MIT Mystery Hunt

My team, <Entire Text of Atlas Shrugged>, won this year!
Making it fun

Several key design features that elicit ‘fun’

• Well-defined objectives
  – You know what to do; clear project spec’
  – Collaborative puzzle-solving

• Multiple possible solutions

• Difficult but obviously achievable
  – Not futile; tangible reward for time put in
  – Early pay-off for effort (eg. a hull that floats)
Results

How it went down
My philosophy

• Engineering is the highest, purest and most noble pursuit of the human experience
• You are training to be engineers, and this is a chance to actually practice engineering
• You are not your grade*
• There will be second chances

* They make me assign you a grade
The good, the bad, and fun details

I did some things well,
other things not so well
What I think I did well

• Kept it real
  – Treated you like Men (or Women)

• Cared about the stuff that matters
  – No stupid nit-picking about stuff
  – Told you what to really expect from industry

• Used assessments wisely
  – Encourages thinking and keeps you on track
  – Rewards hard work and discourages freeloaders

“Let that which does not matter truly slide” – Tyler Durden
What I think I did well

• Focussed on success and learning
  – Toy problem, real analysis; no busywork
  – Second chances – no ‘cliff’ assessment

• Made time for students
  – Made myself available in the lab
  – Lots of one-on-one feedback on assessment

• Put a *crazy-astronomical* amount of effort into goshdarned near everything
What I think can be improved

Things I can’t change:

- Political bun-fight over tank location
- Needs more lab space and 3D printers
- Miserable clash with METR4900

Things I can change:

- More upfront material about report writing
- More fans! (ie. more testing of apparatus)
- More (longer) lecture content?
What you liked

• You learned lots
• Project was challenging and interesting
  – Hard, but rewarding!
• Lots of feedback on reports
• Sense of humour (?)
• Free coffee after Tuesdays Q&A!
What you didn’t like

• Project was really hard!
  – Maybe too hard?

• Collision with other classes assessments led to numerous sleepless nights

• Still nobody can tell you what “scope” is
Fun details

• The constellations are all based around Internet memes
  – Did you work them all out?

• Inscriptions are actual Latin (via Google)
  – Most are silly; some are hints about the project!
  – Markings and guides on the maps are accurate

• I blew $1500+ of my own money on this
  – If it’s worth doing, it’s worth making awesome!
Cutting-room floor

A few cool things didn’t make the cut…
Discarded challenges

Extra hazards to keep things scary:

• Some sort of kraken that would attack ships
• Whirlpool that would spin ships around
  – These were all too complex to implement and it was felt that randomness was unfair to students

Another discarded early idea:

To get the trophy, you would have to make the return journey with an added 50g cargo
Rejects and concept art

The art team came up with some awesome stuff, but not all of it was included

Some of it was also terrible
“Corsair” art style

Too web 3.0?

Ended up going with a more renaissance look
Axolotlzuma evolution

Greenstone idol
Dumbarton Oaks Collection

‘Golden Idol’
Raiders of the Lost Ark

Tribal head
Axolotlzuma concept

Final chosen
Axolotlzuma concept
Axolotlzuma evolution
Splash pic

- Had to give a quick, instantly catchy intro
Fonts and calligraphy

- Gives the website a Ye Olde style
  - Artist learned calligraphy just for this project!

**METR3800**

Mechatronics Team Project 2

2013

Voyage to the New World

Treasure of Axolotlzuma
Unused constellations

“HABET POSSEM CASEUM SANDWICO?”

“The Cat”

These went unused because they’re terrible

“The Cyclist”

“The Traitor”
Conclusion

We’ll have to wait until Friday! 😊
Take-home points

• Think about things analytically, first

• It’s rarely possible to optimise any one thing without regard for other subsystems

• You need to get along with your fellow engineers if you want to succeed
Cast of Thousands

Dozens of people helped make this a success, but a few deserve particular recognition:

The *simply amazing* workshop guys:
Keith Lane, Grant Tayles and Mark James

The *astonishingly supportive* Keith Bell

The *patience-of-saints* Eddie Platt
And now...

Vote Paul in 2013

Fun fact: If we don’t get higher than 3.5 on Q8, we don’t get paid!
Voyage to the New World

~Fin~

Treasure of AxolotlZuma
<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starring</td>
<td>Paul Pounds</td>
</tr>
<tr>
<td>Written and directed by</td>
<td>Paul Pounds</td>
</tr>
<tr>
<td>Supporting Cast</td>
<td></td>
</tr>
<tr>
<td>Paul Pounds as Royal Messenger</td>
<td></td>
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<tr>
<td>Chris “Kit” Ham as Tutor 1</td>
<td></td>
</tr>
<tr>
<td>Adam Keyes as Tutor 2</td>
<td></td>
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<tr>
<td>Jared Page as Tutor 3</td>
<td></td>
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<tr>
<td>Prof. Steve Wilson as Acting Course Coordinator</td>
<td></td>
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<tr>
<td>Dr. Michael Kearny as Backup Lecturer</td>
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<tr>
<td>Peter Bleakley as Lab Director 1</td>
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<tr>
<td>Doug Malcolm as Lab Director 2</td>
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<tr>
<td>Dr. Surya Singh as Singh the Merciless</td>
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<tr>
<td>Prof. Steve Wilson as Course Coordinator</td>
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<td>Dr. Peter Sutton as Acting Course Coordinator</td>
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<td>Dr. Surya Singh as Backup Lecturer</td>
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<tr>
<td>Peter Bleakley as Lab Director 1</td>
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<tr>
<td>Doug Malcolm as Lab Director 2</td>
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<tr>
<td>Dr. Surya Singh as Singh the Merciless</td>
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<tr>
<td>Producers</td>
<td>Paul Pounds</td>
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<td>Original music</td>
<td>Paul Pounds</td>
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<td>Camera and Cinematography</td>
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<tr>
<td>Camera 1</td>
<td>Dr. Surya Singh</td>
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<td>Camera 2</td>
<td>Michael Eastwood</td>
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<td>Key grip</td>
<td>Jared Page</td>
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<td>Adam Keyes</td>
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<td>Best Boy</td>
<td>Chris “Kit” Ham</td>
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<td>Paul Pounds</td>
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<td>Dr. Peter Sutton</td>
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<td>Production Design</td>
<td>Paul Pounds</td>
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<td>Mark James</td>
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No students were harmed in the teaching of this class.
Special thanks to
Keith Lane
Eddie Platt
Andrew Cameron
Michael Eastwood

And all the students who made this class fun and enjoyable!

In memory of Keith Bell