METR4810 MECHATRONICS TEAM PROJECT 2

Paul Pounds 1 March 2016



5:56 am: Rotenzimmer Mine, NE Queensland





6:02 am:

Geoscience Australia records an earthquake measuring 7.8 on the Richter scale, centred on Northeast QLD.

6:37 am:

Rotenzimmer Subterranean Mine reports substantial damage, rock falls, and loss of communication with lower galleries.

7:05 am:

Review of records indicates that several miners were below ground when the quake struck, and may be trapped.

11:17 am:

Sonographs in exploratory boreholes record coded tapping sounds from deep underground.

12:01 pm: Rescue operations commence.

MECHXTRONICS TP2



Down the Borehole

or "Journey to the Centre of the Mine"

Paul Pounds

1 March 2016 University of Queensland

Snuh?

So....

Where is Paul?

Louisville, KY HAI Heli Expo



- World's premier helicopter trade show
 - Kind of a big deal
 - Accounts for 50% of all helicopter sales
 - After 5 years in development, we are launching Olaeris' groundbreaking aircraft





1 March 2016

Have to be there. :'(



But I still love you all!!!

Ahem

But anyway, on to business...

METR4810

- What: Mechatronics team project course
- When: Starting now, going until week 13
- Where: Hawken 50-c404 (mostly)
- Who: Cast of thousands
- How: Lots of work
- Why: Get experience developing complex mechatronic and robotic systems... and *because it's awesome*

Specific class objectives

- Explore the trade-offs involved in complex mechatronic/robotic systems
- Gain experience in multi-variable analytical design synthesis
- Exercise practical cyber-electromechanical integration and trouble-shooting techniques
- Build interpersonal skills working in teams

1 March 2016

A quick note on objectives

Your objective: 7/7 grade My objective: 5/5 SECaT

Shared priorities:

- Meet course objectives
- Reduce unnecessary work
- Have fun!

This course breaks eggs

 You are probably going to find this course technically or socially challenging (or both!)
 This is intentional



What this class is

- Taking the safeties off
- Unconstrained design
- Broad horizons no hand-holding
- Focus on communication, design process, teamwork

What this class is not

- Not about the project (not really)
 - It's about how you go about solving it
- Not teaching you technical engineering
 You already know how to do math, solder, etc.
- Not giving you one single, clear path

 It's scary out there, and much is unknown

The Ghost of Projects Past

2013: Autonomous sailing and navigation







The Ghost of Projects Past

2014: Autonomous race car challenge



The Ghost of Projects Past

2015: Autonomous Carrier Operations



Assessment results

• Atypical mark spread: not a real bell curve



Assessment results



Assessment results

• Mark clusters move over time:



Assessment results

• Increasing performance, but more failures



Assessment results

• Or, put another way:

	Percentage of class					
	≤3	4	5	6	7	Avg
2011	0	19	26	22	33	5.69
2013	0	25	24	19	32	5.58
2014	6	14	8	28	44	5.90
2015	7	16	10	30	37	5.66

Typical student outcomes

Student tend to fall into two broad groups: The **Gets-its** and the **Don't-Gets-its**

- The Gets-its work as a team, deconstruct the task rationally, try to understand the real problem, and implement a solution well
- The Don't-Gets-its... don't

How to pass this course

- Work as a team
- Deconstruct the task logically
- Understand the *real* problem
- Implement a solution well

How to fail this course

- Don't contribute to your team
- Don't play nice with others
- Fixate on the first approach that comes into your head
- Do lazy, effortless hacking

Enough about other people...

Now it's your turn

PART 1

The Project

The task

Build a system for entering a miniature subterranean mine via a narrow borehole to locate and rescue trapped miners

1220 mm

The mine

Two levels of random passageways, connected via a ramp



16° ramp to lower level

130 mm

130 mm

1220 mm
The mine

- The mine is laid out on a 75 mm grid
 - The floor sections can be rotated and flipped for 32 possible ramp configurations



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Hazards

- With the mine damaged by the earthquake, expect obstructions and debris:
 - Rock falls, with boulders up to 100 μ Tons
 - Rubble piles and gravel
 - Toppled mining equipment

The miners

- The miners are represented by LEGOTM minifigures scattered through the mine*
 - You must locate the miners, report their health status, and return them to the surface



Miner health status appearance guide

Standing	Green label	Healthy
Sitting	Yellow label	Injured
Lying down	Red label	Dead

* Any resemblance of minifigures to staff or students is *purely* coincidental

Seismograph readings

- Seismograph monitors are scattered throughout the mine
 - Scan the readouts (in the form of QR codes) to assess mine safety condition



Key points

- Unlike previous years, you are not being asked to build something fully autonomous
 - Much like an open-book exam, the expectations will be correspondingly higher
- This task may seem easy, but it isn't
 - Don't underestimate the effects of variability
 - Focus on getting readily achievable marks first

Here are some numbers

There are a few parameters:

- Rescue time available: 25 minutes
- Borehole diameter: 100 150 mm
- Onboard lipo battery energy: <15 kJ
- Lego minifigure weight: <10 g

Full details on restrictions and constraints are in the task specification document

Scoring

- Performance will be measured with a point system for demonstrated functionality
- Points will be awarded during scheduled demonstration sessions in week 13
 - 30 minute total time for set up and test
 - Last 5 minutes reserved for packdown/marking

See rules and description document for full details

Functionality and scoring

Basic Functionality	25/25 Points
Rescue system enters the mine	10
Images of mine interior returned to surface	5
Rescue system reaches second level	10

Protip: Passing the class pretty much requires up to here

Locating miners	30/30 Points
Miner visually identified	2
Miner's sector location noted	1
Miner's health status reported	2
All miners located	5

Miner rescue	35/35 Points
Healthy miner rescued	5
Injured miner rescued	6
Deceased miner recovered	4
All miners returned to surface	10

Bonus Functionality	10/10 Points
Each sector stability status reported	2

The low energy solution

- There is often a simple, elegant low-energy solution to an engineering challenge
 - There is no 'right' way to solve any problem
 - Some people spend much energy on a complex solution, only to get frustrated when someone else finds a much simpler way
 - The simpler way is more correct; if you are struggling with your approach, maybe you need to rethink your assumptions?

Paul Pounds

PART 2

Assessment

My philosophy

- Engineering is the highest, purest and most noble pursuit of the human experience
 All else is artifice or drudgery
- 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

What to expect

• Expect to learn new things on your own

You need will need to know *more* than just what you've been taught at university thus far

- Expect to apply real effort
 - This course **actively** punishes freeloaders
- Expect to be involved

– Lots of peer assessment; PAFs can be *vicious*

• Expect change

- The specifications will change (intentionally)

A common theme

- Present analysis to justify design decisions
 - Motor torque/power calculations
 - Chassis structural load simulations
 - Clearance and tolerance of components
 - Microcontroller control cycle overhead
 - Decision matrices... and such!

If you can't back up it up with numbers, you're really just **guessing**

Deliverables

- Problem analysis
- Progress Review 1
- Progress Seminar*
- Progress Review 2
- Preliminary Report
- Final Product Demo*
- Final Project Report –

- 10%
- pass/fail[†]
- 10%
- pass/fail[†]
- pass/fail[†]
- 60%
- -20%
- * Team assessment with peer and tutor weightings† More on this later

Problem analysis

Due March $11^{\text{th}} - 10\%$ (2 pages max)

- Break down the design problem, determine its scope, requirements and constraints.
- Describe the key underlying engineering design challenges what makes this hard?
- Present a candidate solution, and explain how your approach will overcome them.

– Analysis is golden.

Progress Reviews 1 and 2

Due 22 - 25 March and 9 May - 13 May

- Tutor-mediated meetings
- Demonstrate your progress in the preceding period with tangible **evidence** of your contributions eg. prototypes, code, etc
- Pass/fail mark based on quality of work and relative progress towards the goal

EXPECT NO MERCY.

Progress Seminar

Due 14 – 18 April (team assessment) – 10%

- Provide a 10 minute seminar outlining progress towards developing a solution to the problem.
 - Focus on the progress, not the approach
 - Each student present for roughly equal time
- Assessed by course coordinator and tutors

Preliminary Report

Due 20 May

- Describes the methodical analytical approach to solving the subtask, how it relates to the other subsystems within the project and the analytical process that was used in developing the solution.
- Show the formal, <u>disciplined</u>, <u>quantitative</u> engineering <u>process</u> followed, demonstrating the feasibility of the approach taken.

Final Product Demo

Due week 13 (team assessment) -60%

- The Main Event show your system works!
- Marks awarded for <u>functionality</u>, <u>achievements</u> and <u>build quality</u>.
- Hand in everything needed to make your system work, including documentation and printouts of design schematics.

Above all: Convince me you can *engineer*.

Final Report

Due 5 June – 20 %

- Identical to the preliminary report, but incorporating corrections and reflecting any changes from the final two weeks.
- Preliminary report will be returned with comments so that you have an opportunity to revise your work and improve upon it,

Just like in real life!

Incremental demos

- Spontaneous night-before failure of hardware systems is brutal and unfair*. *Just like real life!*
- If your system is sort-of working early, you can have it tested in an incremental demo.
 - If the final demo mark is less than what was scored in an incremental demo, you will be awarded the incremental demo mark.

Incremental demos

- Scored just like the final demo, but the mark is capped according to time left in semester
 - Week 7: 25%
 - Week 9: 50%
 - Week 11: 75%
- Incremental demos are by appointment only*
 * Do not attempt a demo with an obviously non-functional system or you may forfeit future incremental demo privileges

Pass/fail penalties

- Subpar (or absent) pass/fail submissions incur a <u>deduction</u> from your final grade
 - Project reviews: 5% each
 - Preliminary report: 10%
- These deductions are *cumulative*

If you were to fail all of them, your maximum achievable grade for the course would be 80%

PAF and TAF

- A substantial fraction of assessment is peermoderated; others are tutor-moderated
 – Regularly adjusts results by up to 2 grades
- It's vital your team recognises your efforts
 A bitter or frustrated team means a low PAF!
- Ultimately, peer and tutor weighting is mediated by the course coordinator

Peer assessment

- At progress reviews, progress seminar and final demo, you will fill out PAFs
- Your demo mark will be scaled by all of the PAFs, according to a weighting scheme:
 - Progress review 1: 10%
 - Progress seminar: 20%
 - Progress review 2: 30%
 - Final demo: 40%

Calendar at a glance

You are	Week	Dates	Lecture	Reviews	Demos	Assessment submissions	_ Paul at
here 7	1	29/2 - 4/3	Introduction				-helí expo
	2	7/3 – 11/3	Principles of Mechatronic Systems design			Problem analysis	week 1
Teams	3	14/3 - 18/3	Professional Engineering Topics				
assigned	4	22/3 - 25/3	Your soldering is (probably) terrible	Progress review 1			
here	Break	28/3 - 1/4				L L	True
	5	4/4 - 8/4					g to work
	6	11/4 - 15/4					
	7	18/4 - 22/4		Progress seminar	25% demo		
	8	25/4 - 29/4	Swítch to				
	9	2/5 - 6/5	Q and A		50% demo		
	10	9/5 - 13/5	sessions	Progress review			
	11	16/5 - 20/5			75% demo	Preliminary report	Maduecc
	12	23/5 - 27/5				7	week
	13	30/5 - 3/6	Closing lecture		Final testing	Final report and reflection	WCCR

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PART 3

Class Organisation

Blackboard and splashy website

- This class has a Blackboard page and a "splashy" outwards-facing website
 - If the two ever differ (which they won't), the Blackboard page is considered authoritative

Blackboard: learn.uq.edu.au/ Splashy: robotics.itee.uq.edu.au/~metr4810/

Weekly schedule

- Lectures 2 hours once per week
 Professional topics and Q&A sessions
- Practicals 2 hours twice per week
 Tutors available in lab (but 24/7 access)
- "Contact" 2 hours twice per week

– Time set aside for meetings, demos, etc.

Altium notes and soldering tutorials will be made available online

Class clashes

I am aware of some clashes with other classes

- Most notably METR4900

 This will ruin your life plan accordingly
- Any others I've missed?

All lecture content will be online Major announcements go out via Blackboard ... but you'll hear it first in class

Lectures

• Boring, useless lectures help *nobody*

• I will endeavour to provide lectures that are educational, useful and (sort of) entertaining

• Lectures will be student-driven: you tell me what you want to learn about and I'll teach it

Lectures

- Lecture 1: Introduction to the project
- Lecture 2: Principles of mechatronics system design
- Lecture 3: Professional engineering topics
- Lecture 4: Your soldering is terrible (probably)
- Lecture 5: ???

Topics may be nominated by emailing me, and then voted for on a doodle poll

Lectures

- No, you don't *have* to attend lectures, but if you don't you're really missing out
 - Protip: Students who attend lectures historically do better than those who don't!
- Lectures are the first and most immediate way of hearing about what's happening and getting your questions answered

– Note: recordings aren't interactive

Some suggested topics

- Principles of teleoperation control
- Vehicle dynamics
- Digital control
- Electromechanical devices
- Computer vision
- Sensor-fusion and filtering
- Localisation
- Schopenhauer and philosophical pessimism

Teams

- Teams will each consist of four people
 Except for when they don't
- Teams will each be assigned a tool kit
 Complete kit must be returned *or else*

• Work together! Contact sessions are set aside for team meetings and collaboration

Teams

- You will have to work with people you hate* Just like in real life!
- You may email me and request one person with whom you do not want to work

– Exclusion requests must be in by Friday

Otherwise, teams will be allocated by magic
 Teams will be assigned in week 2

*If you don't hate them now, you will by the time you're done
- More students this year (more new friends!)
 - Space not so terrible yet ... I think
- Consequence: be neighbourly
 - Lockers for project work under desks
 - Share space and resources
 - Get started early; consider how you can work most effectively in the final two crunch weeks

<eyeofsauron>

Hey, about that lab ...

- The laboratories are governed by the UQ risk management policy
- To work in the lab:
 - You **MUST** have completed the induction
 - You **MUST** have read the lab risk assessment
 - You MUST wear appropriate footwear
 - You **MUST** abide by all safety requirements
- If you do not follow the guidelines you will be barred from the lab

- Just in case you forgot:
 - No eating/drinking in the lab
 - No sleeping in the lab
 - No non-METR4810 students in the lab
 - The lab is not for facebook/tindr/gaming/ socialising/having a life etc.
 - <u>I am held personally responsible for the safety</u> and condition of the lab and I get *very* grumpy.

So don't say you weren't told.

- Keep the lab clean and orderly
- Cleanliness "warning light" system in effect
 - Status noted on Blackboard/class website

Green: Full speed ahead Yellow: Clean up needed Red: Danger Will Robinson!* Black: "Uh oh."**

*Lab will go to limited hours until cleaned. **Lab will be locked until further notice.

</eyeofsauron>

Keeping the lab tidy makes for a nicer place to work and makes it easier to get stuff done

Resources

- Website
 - Everything will be posted on the Blackboard class website: (learn.uq.edu.au)
 - Better-looking class website will mirror course materials: (robotics.itee.uq.edu.au/metr4810)
- Textbook
 - "Introduction to Mechatronic Design"
 by Carryer, Ohline and Kenny



(recommended but not required)

Knowledgeable people

- Course Coordinator and Chief Conspirator:
 – Paul Pounds
- Technical Staff
 - Peter Bleakley
 - Ray White
 - Dejan Subaric
 - Keith Lane
 - Doug Malcolm

- Tutors:
 - Alex Macintosh
 - Kit Ham
 - William Deer
- Emergency Auxiliary Temporary Back-Up Replacement Stand-in Teaching Faculty
 - Dr. Surya Singh
 - Dr. Michael Kearny

Contact info

If anything is bothering you, bring it up *early*

- Rules questions
- Technical issues

- Assessments
- Group problems

• Ordering

- Enrolment
- Disenfranchisment with the sociopolitical gestalt

Serious? Email first to arrange a meeting
No? Just stop on by! (but email is good too)

Contact info

Who: Me!

Why: Questions, issues, concerns, ennui!
Where: GPS 78-529 or Wordsmiths
When: 10 to 4 – by appointment (or drop in)
What: Coffee or coke (either kind)
How: paul.pounds@uq.edu.au

On that topic...

- I often get comments in the SECaTs about things that *could* have been addressed during the semester if I'd been told about it
- Don't wait until you're angry in week 13
 Tell me about it as soon as it comes up so I can
 - explain it/solve it/fix it/find it/sort it right away
- I'm always happy to help! ③

What happens next?

- Send me group exclusion requests
 - Email me ASAP!
 - Groups will be posted next week
- Attend the afternoon practical session in Hawken c404 Thursday 10th March
 - Toolbox handouts
 - Room induction, 3D printer induction

And start thinking about solutions!

Tune-in next time for...

Principles of Mechatronic Systems Design

or

"Striking a Balance is Making Everybody Equally Unhappy"

Fun fact: The survivors of the 2010 Chilean Mine Collapse hold the record for the longest time spent underground: 69 days.

Questions?

