In the year 20X4...
METR4810
Mechatronics Team Project 2
2014
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*
A quick note on objectives

Your objective: 7/7
My objective: 5/5

Shared priorities:
• Meet course objectives
• Reduce unnecessary work
• Have fun!
Last year’s results

• The 2013 class fell into three broad groups:
  • **Group Capable**
    – Average but motivated, or smart but lazy, and a few less-capable students who gave it 150%
  • **Group Excelsior**
    – Smart, dedicated – top notch proto-engineers
  • **Group Other**
    – Really have no business being in this class
Assessment results

- This is reflected by mark clusters:

![Chart showing mark distribution and an "Awesome peak"]
SECaT results

• Good course result last year: **4.78/5**

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.58</td>
<td>4.96</td>
<td>4.50</td>
<td>4.50</td>
<td>4.58</td>
<td>4.79</td>
<td>4.92</td>
<td>4.78</td>
</tr>
<tr>
<td>% Agree</td>
<td>88%</td>
<td>100%</td>
<td>88%</td>
<td>83%</td>
<td>88%</td>
<td>96%</td>
<td>100%</td>
<td>96%</td>
</tr>
</tbody>
</table>

Q1  I had a clear understanding of the aims and goals of the course
Q2  The course was intellectually stimulating
Q3  The course was well structured
Q4  The learning materials assisted me in this course
Q5  Assessment requirements were made clear to me
Q6  I received helpful feedback on how I was going in the course
Q7  I learned a lot in this course
Q8  Overall, how would you rate this course?
SECaT results

- Excellent teacher result last year: **4.92/5**

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.71</td>
<td>4.88</td>
<td>4.96</td>
<td>4.88</td>
<td>4.92</td>
<td>4.96</td>
<td>4.92</td>
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<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>96%</td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Q1  … was well organised
Q2  … was good at explaining things
Q3  … was approachable
Q4  … stimulated my interest in the field of study
Q5  … inspired me to learn
Q6  … encouraged student input
Q7  … treated students with respect
Q8  Overall, how would you rate this teacher?
PART 1

The Project
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
The Goal

Build a miniature race car to autonomously drive around racetracks as quickly as possible.
Key points

• Time-trial for marks, exhibition race for fun

• Points are awarded based on functionality:
  – E.g. driving, turning, avoiding obstacles
  – Additional points for certain ‘achievements’
  – No marks awarded for actual lap-time
The Rules*

• Construct one car per team of four
• All driving must be completely autonomous
• Pit stops required during race and time trials
• Off-board computation is permitted.
• Limited to $150 in parts/materials
• ALL purchases through ETSG – reimbursements will NOT be made

*Brief synopsis only – see Description, Rules and Regulations document for complete official rules
Challenges

• Many challenges to force you to think
  – Obstacles on the track (eg. tiny cows)
  – Soft road edges, grit
  – Camera occlusion – mountain, tunnel or flyover
• Strictly limited 3D printing budget – 0.5 kg
  – At least one component must be machined
• Pit stops require you to remove a random component from the car and replace it
  – Encourage modular design and interfaces
The car

- Electric motor drive only – no ICE/fuel cell
- Size limitations:
  - Top surface must have room for a 70mm wide optical marker
- Must have 1+ custom PCB
- Must have 1+ machined metal components
  - Milled, lathed, water-jet cut, etc. ok
  - Drill press and/or bandsaw don’t count
Track modules

- The track is divided into a variety of tiles
Starting grid

- Single double-length starting grid/pit lane

- All tile geometry will be published online
Practice tracks

- Tutors will set up practice tracks of increasing complexity over the semester

Wk 4 - Scumbag Speedway
Wk 6 - Gumball Rocket
Wk 8 - California Hairpin
Wk 10 - Mount Sushiyama
Wk 12 - Terminal Junction
Wk 13 - St. Lucia Gran Prix
Testing arena

≈ 2 m

≈ 1.5 m

≈ 4 m

COMING SOON!
(End of March)
Tracking marker

- Tracking markers are used for other teams (and the judges) to detect your car
- You must have room to mount one flat on the top surface of your car
- Inner area may have an ID shape to differentiate your car from others
- You may mount additional optical markers as desired
Scoring

• Performance will be measured with a points system for demonstrated functionality
• Points are awarded during individual time-trials on demo day – multiple attempts ok
• Three tiers: basic, intermediate, advanced
  – To get points for intermediate functionality, all basic functions must be demonstrated first
  – Similarly, advanced functionality requires all intermediate functions must be demonstrated
# Functionality and Scoring

<table>
<thead>
<tr>
<th>Basic Functionality</th>
<th>30/30 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car moves upon activation</td>
<td>3</td>
</tr>
<tr>
<td>Car drives in a straight line</td>
<td>4</td>
</tr>
<tr>
<td>Car executes turns</td>
<td>5</td>
</tr>
<tr>
<td>System detects raceway</td>
<td>8</td>
</tr>
<tr>
<td>Car follows track over two whole tiles</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intermediate Functionality</th>
<th>40/40 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car starts automatically on GO signal</td>
<td>3</td>
</tr>
<tr>
<td>Detects obstacles</td>
<td>6</td>
</tr>
<tr>
<td>Car avoids an obstacle</td>
<td>6</td>
</tr>
<tr>
<td>Car never leaves track</td>
<td>7</td>
</tr>
<tr>
<td>Car enters and exits pit-lane autonomously</td>
<td>8</td>
</tr>
<tr>
<td>Car completes whole lap</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advanced Functionality</th>
<th>40/30 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car never contacts obstacles</td>
<td>7</td>
</tr>
<tr>
<td>Complete pit-stop inside 15 seconds</td>
<td>7</td>
</tr>
<tr>
<td>Car drives behind occlusions, through tunnels</td>
<td>8</td>
</tr>
<tr>
<td>Detects and overtakes pace car</td>
<td>8</td>
</tr>
<tr>
<td>No offboard processing*</td>
<td>10</td>
</tr>
</tbody>
</table>

*THIS IS A TRAP

Qualified for exhibition race

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**Basic Functionality**

- Car moves upon activation
- Car drives in a straight line
- Car executes turns
- System detects raceway
- Car follows track over two whole tiles

**Intermediate Functionality**

- Car starts automatically on GO signal
- Detects obstacles
- Car avoids an obstacle
- Car never leaves track
- Car enters and exits pit-lane autonomously
- Car completes whole lap

**Advanced Functionality**

- Car never contacts obstacles
- Complete pit-stop inside 15 seconds
- Car drives behind occlusions, through tunnels
- Detects and overtakes pace car
- No offboard processing

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Must do all this

to attempt this

Qualified for exhibition race
St. Lucia Gran Prix

• Demonstrating all intermediate functionality qualifies the car for the St. Lucia Gran Prix!

• Exhibition race is for glory, not marks
  – No points will be rewarded, no matter how good or badly you do

Podium finish teams will receive trophies hand-cast from semi-precious metals*

*Subject to availability
St. Lucia Gran Prix

Podium finish teams will receive trophies hand-cast from semi-precious metals*

*Bismuth-Tin-Indium alloy
Subject to availability
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**
  – Need to know more than what’s covered in class

• **Expect to apply real effort**
  – This course *actively* punishes freeloaders

• **Expect to be involved**
  – PAFs can be *vicious*

• **Expect change**
  – The specifications **WILL** change (intentionally)
Deliverables

• Design Brief – 10%
• Progress Review 1 – pass/fail†
• Progress Seminar* – 10%
• Progress Review 2 – pass/fail†
• Preliminary Report – pass/fail†
• Final Product Demo* – 60%
• Final Project Report – 20%

* Team assessment with peer and tutor weightings
† More on this later
But most of all…

• Expect to present technical analysis to justify your design decisions.
  – Motor torque/power calculations
  – Chassis structural loads
  – Clearance and tolerance of components
  – Microcontroller control cycle overhead

If you can’t back up it up with numbers, you’re really just guessing
Design Brief

Due March 21\textsuperscript{th} – 10%

- Show you have understood the problem, its scope, and its requirements and developed insights into how it may be solved.
- Detail your part of the project, the key challenges you will face and how it fits into the overall solution.
- Analysis is golden.
Progress Reviews 1 and 2

Due 31 March – 4 April and 5 May – 9 May

• Tutor-mediated meetings

• Demonstrate your progress in the preceding period with physical evidence of your contribution to the team – eg. prototypes

• 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 your approach and progress towards developing a solution to the problem.

• Each student should present for roughly equal time.
Due 23 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, disciplined, quantitative engineering process followed demonstrating the feasibility of the approach taken.
Final Product Demo

Due week 13 (team assessment) – 60%

• Show your system works!
• Marks awarded for functionality, achievements and build quality.
• 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 6 June – 20 %

• Identical to the preliminary report, but incorporating corrections and reflecting any changes from the last 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 final demo, but final 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 attempts
Pass/fail penalties

• Subpar (or missing) pass/fail submissions incur a **deduction** from your final grade
  – Project reviews: 10% each
  – Preliminary report: 20%

• These deductions are **cumulative**
  – If you were to fail all of them, your maximum achievable grade for the course would be 60% and you will almost certainly fail the course.
# 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>3/3 – 7/3</td>
<td>Introduction</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>10/3 – 15/3</td>
<td>Principles of Mechatronic Systems design</td>
<td></td>
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<tr>
<td>3</td>
<td>17/3 – 21/3</td>
<td>Professional Engineering Topics</td>
<td></td>
<td></td>
<td>Design brief</td>
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<tr>
<td>4</td>
<td>24/3 – 28/3</td>
<td>Your soldering is (probably) terrible</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>31/3 – 4/3</td>
<td>By request</td>
<td>Progress review 1</td>
<td></td>
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<tr>
<td>6</td>
<td>7/4 – 11/4</td>
<td>By request</td>
<td></td>
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<tr>
<td>7</td>
<td>14/4 – 18/4</td>
<td>By request</td>
<td>Progress seminar</td>
<td>25% demo</td>
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<tr>
<td></td>
<td>Break</td>
<td>21/4 – 25/4</td>
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<td></td>
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<tr>
<td>8</td>
<td>28/4 – 3/5</td>
<td>By request</td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>5/5 – 9/5</td>
<td>By request</td>
<td>Progress review</td>
<td>50% demo</td>
<td></td>
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<tr>
<td>10</td>
<td>12/5 – 16/5</td>
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<td></td>
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<tr>
<td>11</td>
<td>19/5 – 23/5</td>
<td></td>
<td></td>
<td>75% demo</td>
<td>Preliminary report</td>
</tr>
<tr>
<td>12</td>
<td>26/5 – 30/5</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>2/6 – 6/6</td>
<td>Closing lecture</td>
<td>Final testing</td>
<td></td>
<td>Final report and addendum</td>
</tr>
</tbody>
</table>

Try to work Paul’s Tenure review! 😞

Madness week

Paul’s European Junket

You are here
PART 3

Class Organisation
Blackboard and website

• This class has both a Blackboard page and “splashy” outwards-facing website
  – If the two ever differ (which they won’t), the Blackboard page is considered authoritative

• Blackboard page:
  https://learn.uq.edu.au/

• Class page:
  http://robotics.itee.uq.edu.au/~metr4810/
Weekly schedule

• Lectures – 2 hours once per week
  – Technical topics driven by student requests

• 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 tutes will be made available (details TBA)
Class clashes

I am aware of some clashes with other classes

- **ELEC3300**
  - Should not affect anyone too badly

- **METR4900**
  - Will ruin your life – plan accordingly

- Any others I’ve missed?

All lecture content will be online; major announcements will go out via Blackboard
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
Some suggested topics

- Vehicle dynamics
- Modular design
- Projective geometry
- Computer vision
- Navigation and path-planning
- 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

• Otherwise, teams will be allocated by magic

*If you don’t hate them now, you will by the time you’re done
Laboratory space

• Fewer students this year (Why? No idea!)
  – Space not so terrible for once

• Consequence: (still) 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
Laboratory space

- 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 will be barred from the lab if you do not follow the guidelines
Laboratory space

• 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.
  – I am held personally responsible for the safety and condition of the lab and I get *very* grumpy.

So don’t say you weren’t told.
Laboratory space

• 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: “Ruh roh!”**

*Lab will go to limited hours until cleaned.
**Lab will be locked until further notice.
Keeping the lab tidy makes for a nicer place to work and makes it easier to get stuff done
The testing arena

• Cars will be tested on an actual miniature race course with an actual modular track
  – Still under construction – hopefully will be fully armed and operation by mid-late March

• Politics and geometry have decreed that the testing arena cannot be in c403 or c404
  – Instead, it will be stored outside the ELCX
Working with the track

- The track equipment will be available during scheduled practical sessions
  - Available other times by request

- Some simple rules:
  - You must wear rubber-soled, closed footwear
  - Do not walk on the track
  - Do not lean against the supports or rail
  - Do not eat the tiny cows
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)
  – FAQ document will be updated periodically

• 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:
  – John Geddes
  – Reuben Strydom
  – Marty Papamanolis

• Emergency Auxiliary Temporary Back-Up Replacement Stand-in Teaching Faculty
  – Prof. Steve Wilson
  – Dr. Michael Kearny
Contact info

If anything is bothering you, bring it up early

• Rules questions
• Technical issues
• Ordering
• 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
What happens next?

• You will be assigned groups
  – Groups posted on class site by next Monday
  – If you have exclusion requests, email me ASAP!

• Attend the afternoon practical session in Hawken c404 Thursday 13th March (next week)
  – Toolbox handouts
  – Room induction, 3D printer induction

  And start thinking about solutions!
Questions?
Tune-in next time for...

Principles of Mechatronic Systems Design

or

“Striking a Balance is Making Everybody Equally Unhappy”

Fun fact: There are 4.8539 Septendecillion (10e+54) possible race track tile combinations. Most of them don’t make any sense.