METR4810 MECHATRONICS TEAM PROJECT 2

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ROBORROE: GREED FOR SPEED

SPEEDWAY 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:
- <u>Group Capable</u>
 - 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:



SECaT results

• Good course result last year: 4.78/5

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Mean	4.58	4.96	4.50	4.50	4.58	4.79	4.92	4.78
% Agree	88%	100%	88%	83%	88%	96%	100%	96%

- 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

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Mean	4.71	4.88	4.96	4.88	4.92	4.96	4.92	4.92
% Agree	92%	100%	100%	100%	100%	100%	96%	100%

- 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

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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

m66

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 50 mm
- 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



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 timetrials 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

(Basic Functionality	30/30 Points	
Must do all thís	Car moves upon activation	3	
	Car drives in a straight line	4	
	Car executes turns	5	
	System detects raceway	8	
	Car follows track over two whole tiles	10	
to ottomot (Intermediate Functionality	40/40 Points	
this	Car starts automatically on GO signal	3	
	Detects obstacles	6	
Must do all thís	Car avoids an obstacle	6	
	Car never leaves track	7	
	Car enters and exits pit-lane autonomously	8	
	Car completes whole lap	10	
(Advanced Functionality	40/30 Points	ું નું
to attempt thís	Car never contacts obstacles	7	- da
	Complete pit-stop inside 15 seconds	7	2 red
	Car drives behind occlusions, through tunnels	8	jt j
	Detects and overtakes pace car	8	ibí
	No offboard processing*	10	& Ž

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 <u>WILL</u> change (intentionally)

Deliverables

- Design Brief
- 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

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 $21^{\text{th}} - 10\%$

- 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.

Preliminary Report

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 <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 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 <u>deduction</u> 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

You are	Week	Dates	Lecture	Reviews	Demos	Assessment submissions	
here 🤄	1	3/3 - 7/3	Introduction				
	2	10/3 - 15/3	Principles of Mechatronic Systems design				
	3	17/3 – 21/3	Professional Engineering Topics			Design brief	
	4	24/3 - 28/3	Your soldering is (probably) terrible				WOYR
	5	31/3 -4/3	By request	Progress review 1			Tryt
	6	7/4 - 11/4	By request				Paul's
	7	14/4 - 18/4	By request	Progress seminar	25% demo		Tenure
	Break	21/4 - 25/4				Ŵ	review! 8
	8	28/4 - 3/5	By request				R
	9	5/5 - 9/5	By request	Progress review	50% demo		
	10	12/5 - 16/5					
	11	19/5 - 23/5			75% demo	Preliminary report	Maduecc
	12	26/5 - 30/5				7	weeb
	13	2/6-6/6	Closing lecture		Final testing	Final report and addendum	WCCR

Paul's European Junket

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 authourative
- 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

• 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

- 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

- 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: "Ruh roh!"**

*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

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

- 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

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.