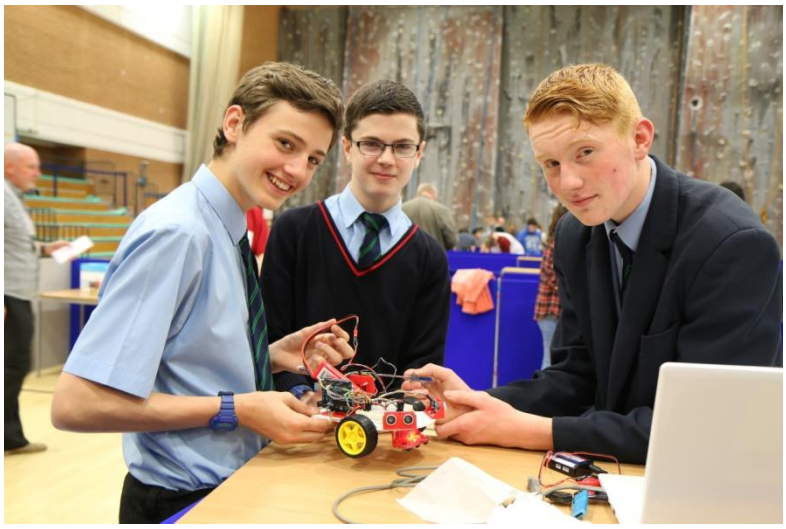
University of South Wales
Prifysgol De Cymru

Engineering Olympics

28 June 2017



School of Engineering

Faculty of Computing, Engineering & Science
University of South Wales

Summary and Introduction

The Engineering Olympics is an exciting competition where your students will be able to compete as part of a team to complete one of six engineering challenges. Please see below for descriptions of each challenge.

Teams should comprise of up to 10 students from Year 10 and/ or Year 12 (or college equivalent). Schools/ colleges may enter more than one team for the different challenges, but no more than one team in each challenge. There will be prizes for the winning teams in each challenge.

If applicable, we will send you the necessary equipment for each challenge around 6 weeks prior to the event. Our engineering lecturers are able offer assistance and advice on the development of each challenge, if required.

If you would like to enter a team from your school/ college in the Engineering Olympics, e-mail **schoolsandcolleges@southwales.ac.uk** or call **01443 654 408** by **Friday, 17th March**. Please note that all students must be accompanied by a member of staff from your school/ college for the duration of the event. Please also note that lunch will be provided as part of the event. We reserve the right to charge £5 per person if you cancel within 48 hours of the event, and reclaim the full cost of the challenge kit(s) (if applicable).

Engineering Olympics Challenges

1. **Electrical Engineering:** Robo-Rally Challenge

Teams will assemble and programme a two-wheeled robot in advance of the day which will intelligently navigate an obstacle course, making use of the on-board photo and ultrasonic sensors. The robot will be controlled by an Arduino microprocessor-based board. You will be provided with a Robo kit complete with instructions.

Please see page 4 for the complete brief.

2. **Aeronautical Engineering**: Paper Glider Challenge

Teams will design a paper aircraft, which is to be launched by a powered launcher which will be supplied by the University on the day of the Engineering Olympics. Teams should design and optimise a paper aircraft plane to achieve longest glide distance (straight flight) and longest glide time.

Please see page 5 for the complete brief.

3. **Aircraft Maintenance Engineering**: Platform Ejector Seat Challenge

Your team will need to design and build an ejection platform system that will help Teddy Pilot to escape from his aircraft during an emergency. You should also produce a portfolio showing your prototype and design work. We will provide teams with the Teddy Pilot and seat. Your team will need to design his ejection platform.

Please see page 6 for the complete brief.

4. Robotics: Robot Programming

This competition is based around programming a Mindstorm Robot. Please see www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com for information. Teams will programme the robot so it is able to navigate through a hazardous road layout with sloes, turns and bumps. The Mindstorm robot kit, including instructions will be provided, in addition to the course specification and layout.

Please see page 9 for the complete brief.

5. Civil Engineering: Bridge Design Challenge

The Bridge Design Challenge will require participants to design, fabricate and test a model bridge to failure.

Only certain materials are available for construction, as detailed below. The University will supply each team with a kit containing all the necessary materials.

- 40 no. plastic straws
- Sellotape
- 1m of string
- 1 sheet of A4 card
- 1 standard aluminium bar – this bar must be placed at the middle of the bridge, in the lower section, to enable weights to be suspended from the structure

Please see page 14 for the complete brief.

6. Mechanical Engineering: Rat Trap Racer Challenge

Teams will build a racing vehicle powered by a mousetrap. The faster and more reliable the vehicle is, the better the score will be. There will be two races and the score will be given according to the total time taken to complete them.

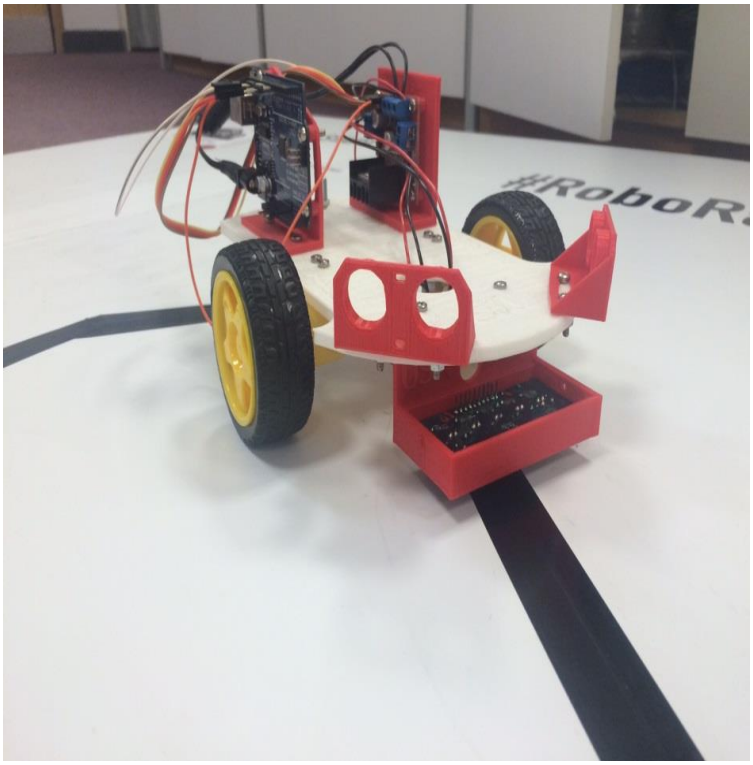
Please see page 15 for the complete brief.

Robo-Rally Challenge

The competition will require participants to assemble and programme a two-wheeled robot controlled by an Arduino programming board from a kit designed and 3D printed at the university. The aim is for the robot to in intelligently navigate a race track using on board sensors to follow a black line.

The finished product will be demonstrated in the Engineering Olympics, with a prize for the team with the quickest completion time. Each Team will have a few trial runs on the track before completing any pre-time trial tweaks to software or hardware. The University will supply each team with the robot kit which will require assembly, detailed in a supplied work manual. The fully-assembled product will need to be programmed to control the motor's speed and direction along with reading the sensors' values to help with the robot's navigation. The robot will be required to complete a course following a 2m curving black line, using the line follower sensor on the underside of the robot. There will be numerous algorithms which may be adopted to complete this task; the most efficient, well-thought out solution will navigate the course in the quickest time.

You can keep us posted of your progress throughout the build by tweeting pictures of the robot construction and programming, and using #USWEngOlympics and by tagging @USW_SCL and @USWEngineering.



Paper Glider Challenge

Your team will design a paper aircraft, which is to be launched by a powered launcher which will be supplied by the University on the day of the Olympics. Teams will need to design and optimise a paper aircraft plane to achieve longest glide distance (straight flight) and longest glide time (design will need to have control surfaces to achieve a circular flight due to the size of the Olympics venue). Teams may submit two different designs for the two challenges. A portfolio must be submitted on the day showing the design and build process.

Your design should be original, mostly made from paper and be able to be launched safely from the supplied launcher by a single person. The teams must incorporate a coupling for the launch mechanism into their design and build.

Points will be awarded in 3 categories:

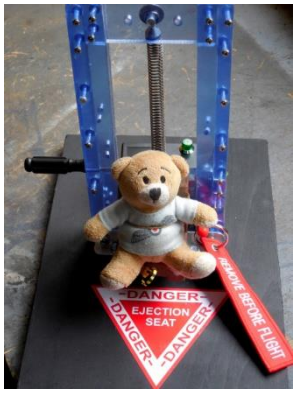
- Place in the distance and/or flight time challenge
- Quality and depth of the team's portfolio design
- Build quality and originality

Platform Ejector Seat Challenge

BACKGROUND

The first bungee-assisted escape from an aircraft took place in 1910, and in 1916 an ejector seat using compressed air was patented. However, it was not until the Second World War when ejection seats were first fitted to operational aircraft.

As aircraft got faster during the 1940s, it became difficult for aircrew to escape from them should they become damaged, so the 'Ejector Seat' was developed. Using rockets and explosives as the propulsion force, this device literally 'shot' the aircrew out of the aircraft like a bullet from a gun, having first jettisoned the aircraft's canopy. One of the first aircraft to be fitted with an ejector seat was the Heinkel He 162, a small aircraft with its jet engine on top of the fuselage, immediately behind the cockpit. Following the Second World War, Britain soon became a world-lead leader in ejection seat design and manufacture, through the company, Martin Baker. Modern designs are called zero-zero ejection seats, which means that they can safely eject the pilot from the aircraft at zero speed, and zero altitude.



YOUR CHALLENGE

Your team will need to design and build an ejection seat system that will help Teddy Pilot to escape from his aircraft during an emergency. You should also produce a portfolio showing your prototype and design work.

MARKING CRITERIA

Engineering incorporates several differing aspects. As such the scoring will incorporate some of these. Points will be allocated for:

- **Functionality**: Does the ejector seat safely fire the pilot above the aircraft's tail? [50% of mark if functions. 0% if it does not fire Teddy Pilot above the aircraft's tail.]

- **Design Portfolio:** An A0 sized display and / or a logbook should be compiled and presented, showing photos and drawings of your prototypes, the maths or science involved and any work that led up to your final design. [15%]

- **Design Safety:** What safety ideas are incorporated into your design [15%]

- **Build Quality:** How neat is the work on the project [10%]

- **Artistic Flair:** How aesthetically pleasing is your project [10%]

SEAT SYSTEM DESIGN CRITERIA

The following criteria should be incorporated into your design.

- The device should be mounted to an A4 sized base plate. This will be fixed to the 'aircraft' on the day of the Engineering Olympics. It is recommended that for ease of fitment that the base plate is made of thick plywood or similar material. This will be drilled and bolted to fit the 'aircraft' on the morning of the competition.

- Your seat should be 'fired' by using a pull cord, which should be fitted. This should be at least one metre long.

- You should use the seat and the Teddy Pilot issued to you by the University. Teddy Pilot should be strapped to your seat prior to 'flight'. You will be issued TWO seats; one for your prototype and one for your final design. The seat may be modified to fit your design.

- Your ejector seat system should be powered by rubber or spring. Compressed gas or explosives are not allowed.

- Your seat system should be capable of launching Teddy Pilot, strapped to the seat beyond the height of the aircraft's tail, which is 600 mm tall, measured from the underside of your base plate.

- Your design should be no more than 300 mm tall, from the underside of your base plate.

- Your seat system should include an electrical safety circuit to indicate when the seat is LIVE FOR FLIGHT. This should illuminate a clearly visible light.

- A parachute for safe landing is optional

FLIGHT SAFETY

To ensure the safety of participants:

- Your seat system should include REMOVABLE SAFETY LOCKS to stop it from launching accidently. These will be removed by USW staff once the seat system has been installed in the aircraft.

- You will only be allowed to fire your seat when it has been declared safe and LIVE FOR FLIGHT by our safety inspectors.

SCORE SHEET

Team name: ……

School: ……

Team Leader / Teacher: ……..

Functionality: (0% or 50%)	Does the ejector seat safely fire the pilot above the aircraft's tai? [50% of mark if functions. 0% if it does not fire Teddy Pilot above the aircraft's tail]	
Design Portfolio: Up to 15%	An A0 sized display and / or a logbook should be compiled and presented, showing photos and drawings of your prototypes, the maths or science involved and any work that led up to your final design.	
Design Safety: Up to 15%	Which safety ideas are incorporated into your design	
Build Quality: Up to 10%	How neat is the work on the project	
Artistic Flair: Up to 10%	How aesthetically pleasing is your project	
	TOTAL	
NOTES:		

Robot Programming

BACKGROUND

Robots are machines. There are lots of types of robots. They move in different ways and do all kinds of jobs. But they only do what we tell them to do. In order to tell them what to do or to convey instructions, we have to use computer programming.

Robot software programming is a set of coded commands that tell a mechanical device and electronic system, which tasks to perform. Robot software is used to perform autonomous tasks. Many software systems and frameworks have been proposed to make programming robots easier.

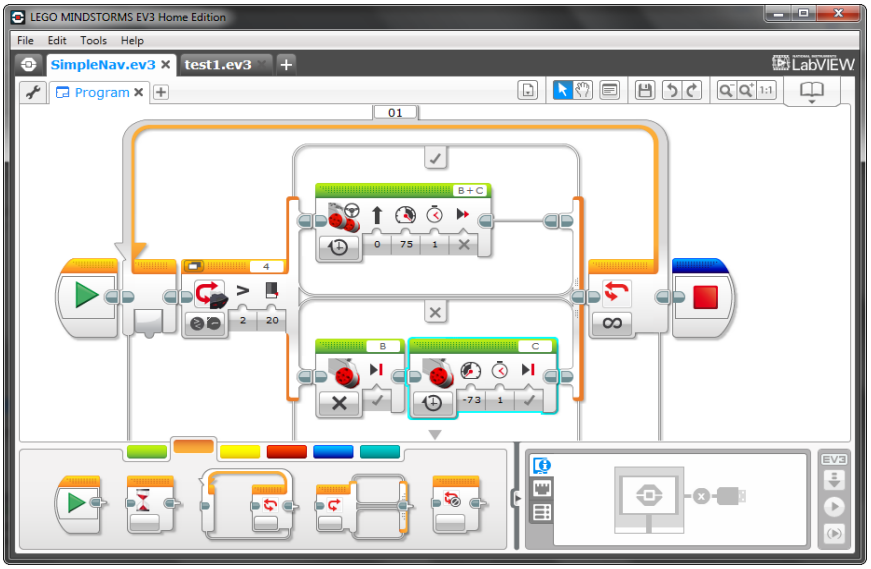
YOUR CHALLENGE

Your team will need to programme a LEGO Mindstorm EV3 robot, which will be provided by the University, to navigate through the pre-specified track (path) given. The robot that completes the course in the in the shortest time will be the winner of 2016 Olympic Robot programming challenge.

ROBOT PROGRAMMING INSTRUCTIONS

The following instructions should be incorporated into your design.

- The robot should follow the path (map) provided and complete the track within the shortest possible time.
  Your robot should stay on the path. Any deviations from the path will incur a penalty.
- You should vary the speed of your robot to navigate through bends and turns. In some cases you may have to stop the robot when it comes to sharp bends and curves.
- Please make sure your battery is fully charged before the competition - this is your responsibility. Please make sure you use only the battery charger provided to charge the unit.
- No modifications to the physical appearance of the original robot design are permitted. It is your responsibility to return the complete set as it is at the end of the competition.



ROBOT PROGRAMMING INSTRUCTIONS

The following instructions should help you to develop your robot programming skills.

- Use the USB cable provided to connect EV3 Track3R to your computer
- Download the EV3 software for PC or MAC using the following web link http://www.lego.com/en-us/mindstorms/downloads/download-software
- You can then start developing your programming skills using the following web links provided by LEGO team. http://www.lego.com/en-us/mindstorms/learn-to-program

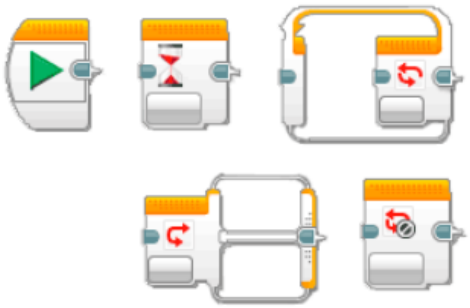
PROGRAMMING BLOCKS IN THE EV3 SOFTWARE

Combine the blocks to explore the magic of bringing your robot to life!

ACTION BLOCKS (Green)

The action blocks control the actions of the program. They control motor rotations and also image, sound and the light on the EV3 P-brick.

FLOW BLOCKS (Orange)

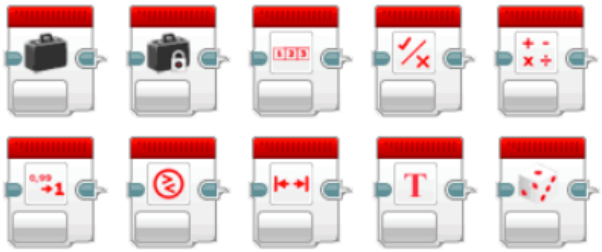


The Flow blocks control the flow of the program. All programs you create will start with the start block.

SENSOR BLOCKS (Yellow)

The Sensor blocks allows your program to read the inputs from the Color sensor, IR sensor, Touch sensor and much more.

DATA OPERATION BLOCKS (Red)



The data operation blocks let you write and read variables, compare values and much more. Please note: the red data blocks are only available in the programming software for PC/Mac and NOT in the EV3 Programmer App.

SCORING SHEET

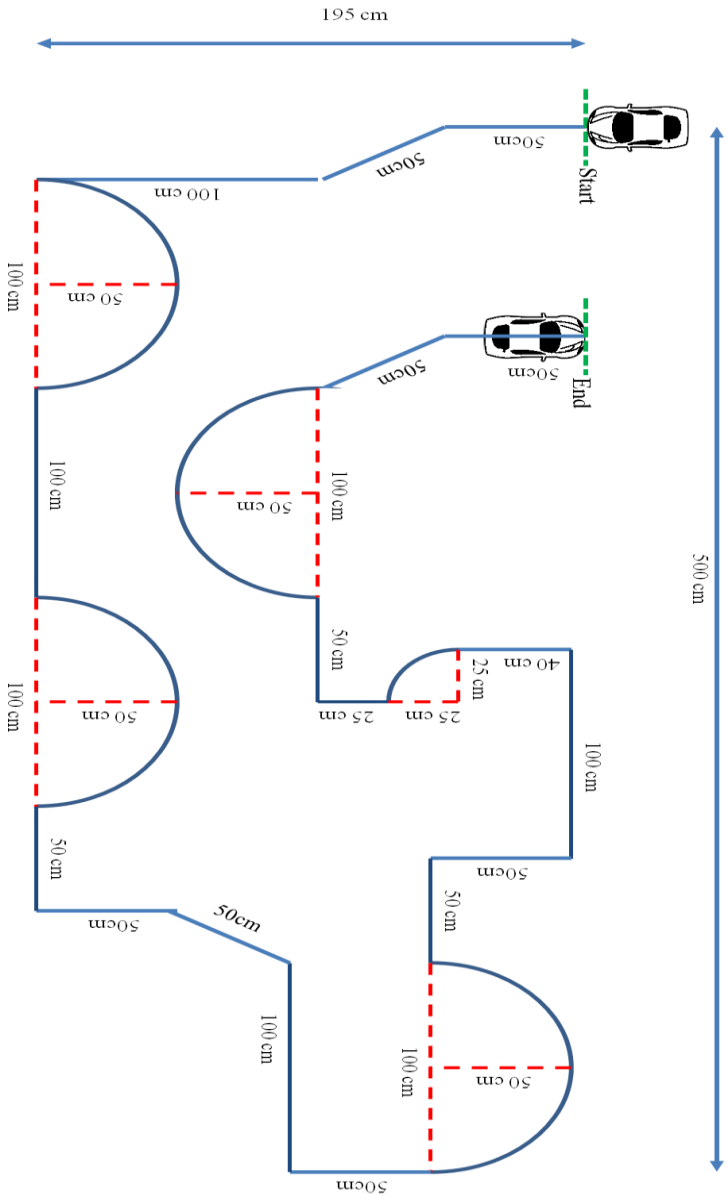
Team name: ……..

School: ……..

Team Leader / Teacher: ……..

Functionality: (0% or 40%)	Does robot complete the full track? [40% if completed in full, 20% if completed more than halfway, 0% if less than halfway)	
Programming accuracy Up to 30 %	The robot's ability to stay on the path and margins [30%]	
Control over designing: Up to 10%	Using variable speeds at the sharp edges. [10 %]	
Finish Time : Up to 20 %	The fastest will achieve the full 20%.	
	Total	
NOTES:		

ROBOT TRACK


500 cm
Start
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End
50cm
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Bridge Design Challenge

The Bridge Design Challenge will require participants to design, fabricate and test a model bridge to failure.

Only certain materials are available for construction, as detailed below. The University will supply each team with a kit containing all the necessary materials.

- 40 no. plastic straws
- Sellotape
- 1m of string
- 1 sheet of A4 card
- 1 standard aluminium bar – this bar must be placed at the middle of the bridge, in the lower section, to enable weights to be suspended from the structure

The bridge will be required to span a distance of **350mm** and carry the loads without being fixed to the supports.

The finished bridge will be tested to destruction at the Engineering Olympics

There will be three prizes available:

- A prize for the best engineered bridge.
- A prize for the bridge that is able to carry the most weight.
- A prize for the bridge that gains the most points based on the following system:
    - 100 points per 100 grammes carried
    - +25 points for every straw not used
    - +100 points for every 100mm of string not used

The competition is open to all secondary schools and all participating schools will be invited for surgery sessions, to help with the development of the bridge, if required.

The following links can be used to get more information on typical bridge structures:

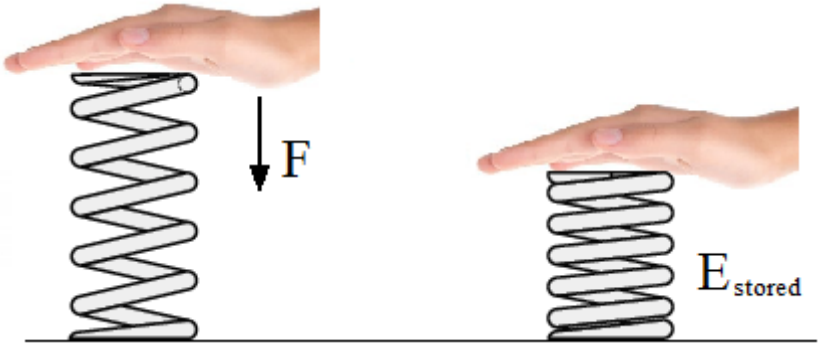
http://pghbridges.com/basics.htm http://www.technologystudent.com/struct1/struindex.htm

And there is also a FREE mobile app called **Bridge Constructor**, available from:

Rat Trap Racer Challenge

Racing can be summed up in one sentence: the fastest participant wins. Participation in races allows a group of people, aka a *team*, to show off their battle spirit and their capacity to succeed.

In this competition, participants are challenged to come up with the most daring designs they can think of, based on a common idea. In this particular race, the vehicles will be using the potential energy stored within the spring of a rat trap to propel themselves forward in a straight line.



In order to compress a spring, force needs to be applied to it. This force is released the moment the spring is set free. The rat trap allows the release of the force to be triggered by a lever.

Example Rat Trap Racers

Rat trap racers come in many shapes and sizes but the most necessary characteristic is speed!

Objective

Your team will need to build a racing vehicle powered by a mousetrap. The faster and more reliable your vehicle is, the better your score will be. There will be 2 races and the score will be given according to the total time taken to complete them.

Rules

- The vehicle will be weighted before the race.
- The vehicle has to move in a straight line.

Essential Equipment

Equipment required	Function
1x Rat Trap	Engine
4x circular objects (CDs, rubber wheels, etc)	Wheels
1x Plank of foam 30x15x2 cm	Body
1m Gift wrap ribbon tape	Transmission
1x Plastic straw	Wheel holes
4x Wooden skewers	Wheel axles
1x Black tape	To stick
4x zip ties	To secure engine to body and transmission to mousetrap

Instructions for assembly:

1. The engine is to be safely strapped to the body.
2. The wheels are connected to the wooden skewers which are in place safely secured to the body while being allowed to spin inside the plastic straw.
3. The gift wrap ribbon tape is used to connect the rat trap to the wheel axle and needs to be safely secured at both ends.
4. To start the vehicle, simply rotate the thrust wheels which will, in turn, cause the rat trap to activate and the coil to compress.

Performance Evaluation Sheet

Team name:……

School:……

Team leader/Teacher:……..

Straight-line driving: [20%]	The straightest trajectory gets the full 20% and the rest according to their respective deviation.	
Safety: [20%]	Is the vehicle safe to operate? How are accidents prevented?	
Quality of construction: [20%]	Did the vehicle survive without any maintenance throughout all the races? (-5% for every 'pit stop')	
Marketing: [10%]	Full marks given to the most impressive presentation.	
Finish Time: [30%]	The fastest vehicle will get the full 30% and the rest according to the completion time compared with the fastest.	
	Total	

NOTES: