

STUDENT ENGINEERING HANDBOOK



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KEY TEAM INFO

Team Name:

School or Organisation:

Preferred method of communication within team (eg. WhatsApp, Email, Text, Messenger):

Contact Information

Query Type	Person	Contact info
Admin	Theresa Gale-Mancer Jo Morgan	theresa@evolocity.co.nz jo.morgan@evolocity.co.nz
Technical	Keith Anderson Josh Burrows Joella Tomkins	keith@evolocity.co.nz josh@evolocity.co.nz joella@evolocity.co.nz
CEO	Jason Maraku	jason@evolocity.co.nz

KEY TEAM INFO

Team Member 1

Name:

Phone:

Email:

Team Member 2

Name:

Phone:

Email:

Team Member 3

Name:

Phone:

Email:

KEY TEAM INFO

Team Member 4

Name:

Phone:

Email:

Team Member 5

Name:

Phone:

Email:

Team Member 6

Name:

Phone:

Email:

KEY TEAM INFO

Team Member 7

Name:

Phone:

Email:

Team Member 8

Name:

Phone:

Email:

Team Member 9

Name:

Phone:

Email:

RUNNING YOUR TEAM

A suggested team structure

Team Leader (usually your teacher)

- Creates team spirit
- Sets deadlines and ensures team stays on track
- Ensures all team members are involved and supported
- Resolves team conflicts

Financing/Resources

- Records all money that is received and spent
- Calculates expenses
- Manages the budget
- Sources materials
- Connects with and finds sponsors

Manufacturing Engineer

- Creates manufacturing plan
- Sources equipment/facilities
- Delegates manufacturing tasks
- Ensures manufactured components meet design requirements

Design Engineer

- Develops the design of the vehicle
- Decides on the materials
- Creates prototypes of the vehicle
- Ensures parts have been designed with manufacturing in mind

Electronics Engineer

- Creates circuit diagrams
- Designs programs
- Creates wiring plan
- Cable management
- Ensures electrical safety

Testing/Quality Assurance

- Creates testing plan
- Checks vehicle against WOF sheet
- Ensures rules are adhered to
- Ensures driver safety at all times
- Has final say in safety-critical items

PLANNING

Keeping an up to date project plan is important to ensure you allocate enough time to complete your build on schedule. Below is a calendar for you to use to note down key dates described below, as well as any important team dates such as holidays away, exams, major assessment due, sports games etc.

Why go to a Build Day?

Build days are a great experience with teams from all across your region gathering to build their vehicles. This is an entirely practical and hands-on event - you bring your materials and you build your vehicle. There will be tools and equipment on-hand as well as mentors with engineering expertise. Even if you have a workshop at school we recommend coming along to a build day, especially if you are struggling to get motivated or you are falling behind.

A build day can get you a substantial way through your build, with some teams building their vehicles at only 3-4 build days.

Why go to a Workshop?

Workshops are targeted skills events. The focus of the session is to teach you skills that you can use in your design and build, such as programming Arduinos, learning to weld, and using CAD.

Why go to Pre-Scrutineering?

Pre-scrutineering is usually one month before Race Day. Our scrutineers will check your vehicle to ensure that it meets our WOF requirements. If there are issues found then you have time to fix them, which increases your likelihood of being able to race on the day. It takes between 15min and 30mins per vehicle and your vehicle doesn't actually have to be finished - your vehicle will be checked as-is. However, we do recommend that you aim to have your vehicles finished by the pre-scrutineering date, rather than Race Day, as this allows a buffer period and means the feedback you receive more accurately reflects your final build.

RECOMMENDED TIMELINE

We know you are all eager to get straight into the building stage of your vehicle, however there's a lot of ground work that needs to be done in any project before you can start cutting up materials or assembling.

We've put together a recommended timeline of how your project should progress throughout the year.

MONTH	FOCUS	TASKS
March	Team organisation	• Assigning roles and responsibilities • Choosing a team leader • Planning a meeting schedule • Officially registering your team
April	Concepts & design	• Familiarise yourself with Competition Rules and WOF Sheet • Brainstorm ideas, identify wants and needs, have at least 3-5 different concepts • Decide on a concept • Create parts list • Plan budget and timeline
May	Sourcing money & materials	• Fundraise • Source materials • Create manufacturing plans • Begin building
June	Building	

RECOMMENDED TIMELINE

MONTH	FOCUS	TASKS
July	Building	
August	Testing & revising	• First test drive
September	Finishing touches	• Attend pre-scrutineering • Make recommended changes • Add vehicle race numbers and any aesthetics • More test driving and practicing race events • Register vehicle race number and provide co-ordinator with full vehicle details
October	Racing	• Final check against WOF Sheet and Rules • Ensure you have appropriate PPE for racing • Ensure you have completed Driver Responsibility Agreement • Invite whanau and friends to your Regional Finals

KEY DATES

Check out and subscribe to the events calendar online for Build Days, Workshops, Pre-Scrutineering, and Race Day in your region at evolocity.co.nz/calendar

Keep an eye on our socials for event updates Facebook.com/EvolocityNZ or [@evolocity_nz](https://twitter.com/evolocity_nz)

FUNDRAISING

When it comes to materials and tools for your vehicle, there's sure to be plenty you can borrow, up-cycle and recycle. Though chances are you'll still need to fund-raise for any needed cash. There are plenty of ways to help fund your project: sausage sizzles, garage sales, bake stalls, mufti days, and sponsorship requests, for example.

Tips for a great Sausage Sizzle

What you'll need:

- Sausages
- Onions (you can often buy them pre-sliced from the supermarket or butcher)
- Serviettes, wipes, spray n wipe, disposable gloves
- BBQ tools, rubbish bins/bags - for customers and chefs
- Chillybin and ice (or refrigerator if available)
- BBQ, plenty of gas, gazebo
- Signage
- Cash box and a float (coins and small notes for giving change) of around \$100

Things to consider:

- Venue - location is key! Stores such as The Warehouse, Bunnings, Mitre10 Mega and some supermarkets offer sausage sizzle spots, and some can even provide the BBQ. Be sure to book early to avoid missing out. Events such as school galas and sport events can be great too. Chat to your city council to check if you need permission on public property.
- Price - Keep your pricing affordable and simple. Consider your audience when choosing what level of quality sausage to sell.
- Product - you might consider extras alongside sausages, such as drinks or juices. Be sure to check with store managers for any restrictions.
- Promotion - set up signage to state your products and price, but also what you are fundraising for - people are more likely to support a good cause.

FUNDRAISING

Sample Letter - Sponsorship Request

This letter contains some ideas and information that may be helpful in your fundraising efforts. You can amend or build on it to suit your requirements.

Date

ABC Company Ltd
Address

Dear Manager

Our school would like to offer your company the exciting opportunity to be a positive part of a brighter future for New Zealand youth and our environment. We invite you to become a sponsor of our team in the EVelocity programme where our challenge is to conceive of, design, and build an electric kart or bike. Along the way we are going to learn some awesome skills.

EVelocity's mission is to develop New Zealand's next generation of engineers, technology innovators and entrepreneurs, to accelerate the transition to electric vehicles, clean transportation, and a more sustainable future. Their vision is to provide young people with a practical learning programme which stimulates and embraces innovation, inspires them to pursue subjects and careers in STEM, and leads New Zealand towards electric vehicle uptake. EVelocity's tertiary and trade related partners are keen to engage with participants offering STEM related education or work placement opportunities. Learn more at evelocity.co.nz

Ways you can support our team:

- Financial sponsorship for materials e.g. electric motor kit (kits are purchased through EVelocity for \$600 +GST), wheels, framework etc
- Sponsorship of materials e.g. wood, metal, steering systems, bike parts etc
- Sponsorship of services e.g. welding, mentoring etc

In appreciation of your support, we can offer you:

- Your logo/branding on our vehicle
- Social media opportunities following our progress
- An introduction to EVelocity management to explore a more significant, mutually beneficial partnership
- Certificate of support

We look forward to hearing from you soon.

Kind regards

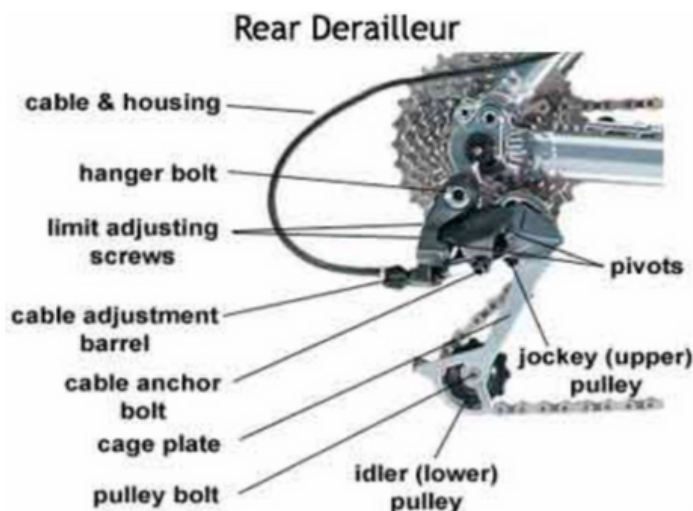
GEARING - KEY INFO

The need for gearing is the same as with a pushbike. Starting out on a pushbike, you stand on your pedals and produce large turning forces, but once underway in a low gear you end up pedalling so fast you can't get the same pressure on the pedals and the speed ultimately stops increasing. On most bikes you fix the problem by switching up to a higher gear, which slows your pedaling but makes your back wheel rotate faster (greater road speed). Starting off in this gear would be very hard, so the gears we use for slower speeds need to be different to the ones we use for top speed.

Three build requirements that are absolutely critical are:

- 1) Ensure your sprockets are accurately aligned – otherwise the chain could break.
- 2) Tension the chain to make sure it cannot jump teeth or jump off.
- 3) Make sure the mount is very sturdy, otherwise the motor's torque will break it from its mounts as it gets the vehicle going. It is MUCH stronger than it looks.

Bikes use a two step chain drive to transmit the power through the gearing system. In our case, the electric motor drives what would be the pedal crank which transmits through the bike chain and gears to the back wheel. Teams should identify what gearing they need in order to optimise performance for each event. The Drag Race needs the vehicle to get off the mark quickly but also have a high top speed, so you may start with a low gear and transition through an intermediate gear to reach the gear needed for highest speed. The stopping and starting of the Gymkhana won't require as high a top speed, so may be better with a lower low gear and only one higher one. Good performance in the Economy Run requires that the vehicle last as long as possible for the lowest energy draw from the battery. Try testing different gear arrangements to see which works best for each event.



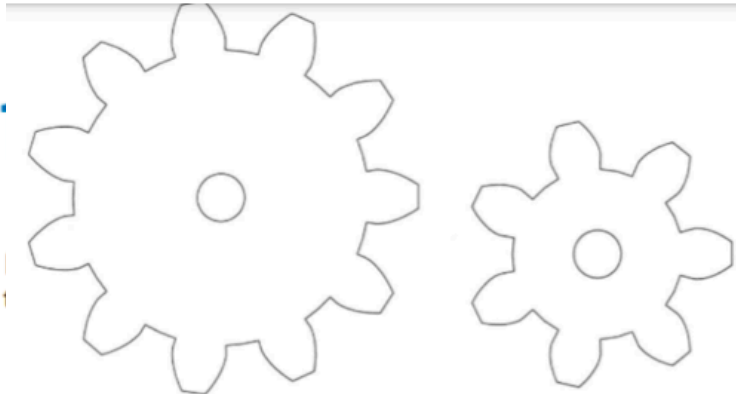
A standard bike gear-change mechanism is appropriate for Standard Kit motors. This system pushes or pulls the chain across to select smaller or larger sprockets and hence changes the gear. A similar system often controls 3 sprockets on the front pedal cluster too. With 3 choices on the front and 7 on the back you can then achieve 21 gears.

From <<http://bikesonrobson.com/wp-content/uploads/2012/12/06-131-rear-derailleur.jpg>>

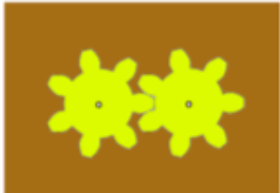
GEARING ACTIVITY

PLAYING WITH GEARS

1. Print 2 copies the gears on the right into stiff card
2. Cut them out and colour the small ones yellow, big ones blue
3. We will get them to mesh and put a drawing pin through the centre and into a stiff cardboard backing
4. Now let's see the difference between gear combinations.

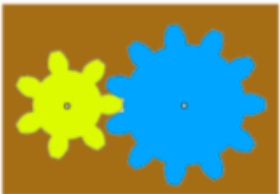


Driver gear Driven gear



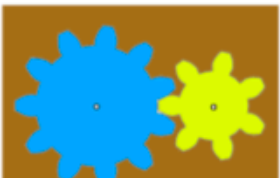
Turn the Driver gear one full turn. How much does the Driven gear turn?

$$\text{Gear ratio} = \frac{\text{Driver turns}}{\text{Driven turns}} = \frac{\text{Teeth on Driver}}{\text{Teeth on Driven}} = \frac{\quad}{\quad}$$



Repeat the above

$$\text{Gear ratio} = \frac{\text{Driver turns}}{\text{Driven turns}} = \frac{\text{Teeth on Driver}}{\text{Teeth on Driven}} = \frac{\quad}{\quad}$$



Repeat the above

$$\text{Gear ratio} = \frac{\text{Driver turns}}{\text{Driven turns}} = \frac{\text{Teeth on Driver}}{\text{Teeth on Driven}} = \frac{\quad}{\quad}$$

Which gives the highest gearing Small to Large or Large to Small?

Which is the fast gearing _____

Which would you use for going slowly up hill? _____

Which gearing would you engage if you were pushing off from a standing start? _____

Why? _____

We will have ensure our motor can get the vehicle underway and then decide on which gearing we can use to get the highest speed.

While these are gears and not a sprocket and chain system like a bike it still has the same principles. When a link of the chain comes off the driver sprocket a link turns onto the driven sprocket. The big difference with a chain and sprockets though is both sprockets turn in the same direction.

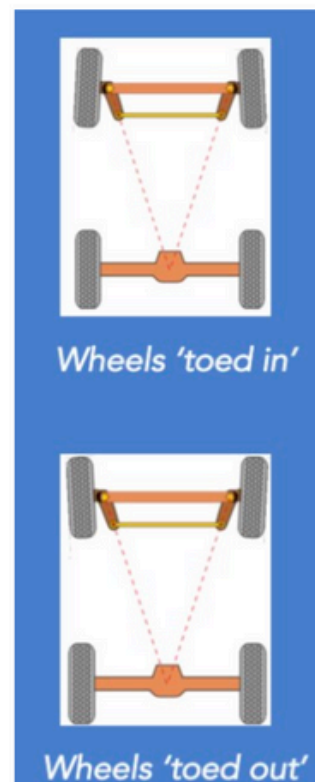
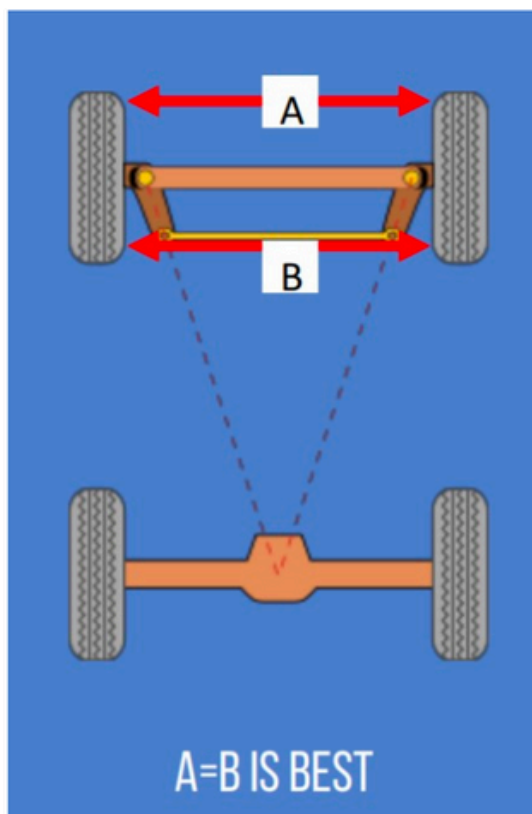
WORKING WITH WOOD

You don't have to make your vehicle entirely out of metal. Wood is a low cost, environmentally friendly alternative. With only needing to screw parts together your build will come together quickly, and if you make a mistake you just unscrew and rescrew.

We recommend wood as the main framing material for beginner and junior teams, as it's more forgiving, reduces the reliance on welding, and reduces build times.

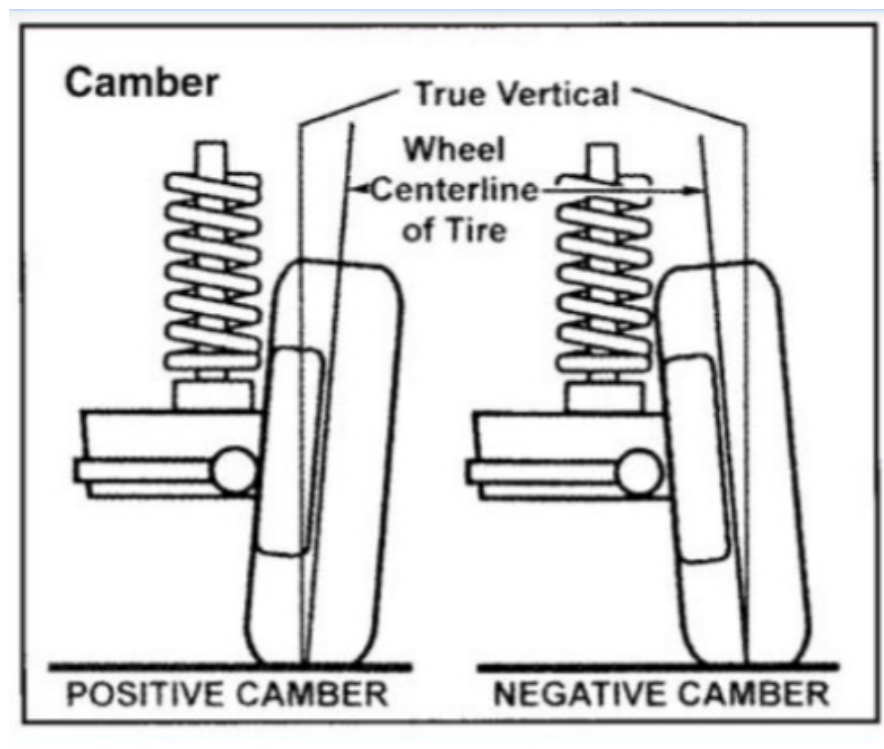
STEERING - KEY INFO

Wheel alignment: for the two front wheels to roll freely without scrubbing along, the distances A and B must be equal. This can be checked using a simple tape measure taking care to measure distances from equivalent points on the front and rear of each wheel (as shown). The tie rod coloured yellow should have an adjustment on it so that it can be shortened or lengthened (as it does in a car) to correct this problem.



STEERING - KEY INFO

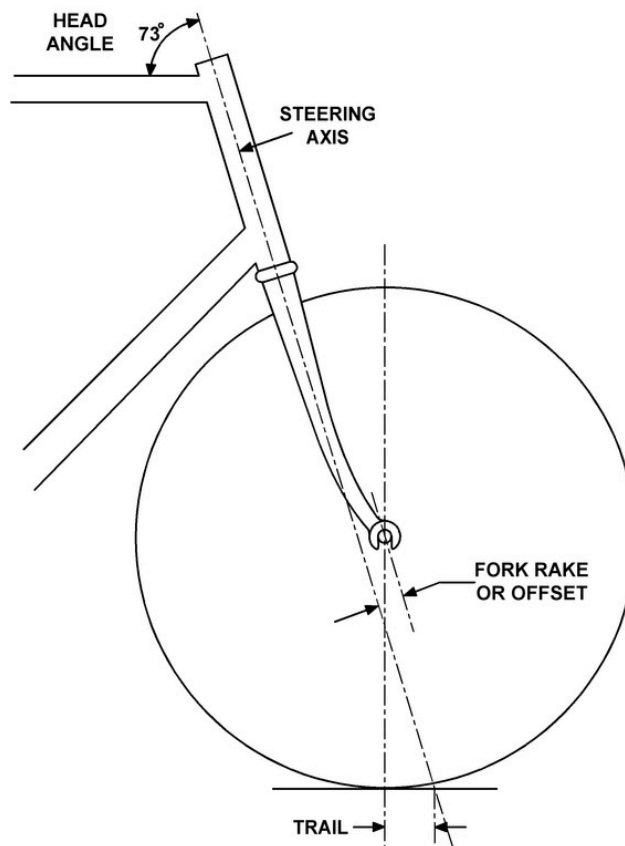
For a vehicle to move easily and achieve the best speed the motor can deliver, it must have low rolling friction and drag. Wheels should have good bearings and low weight in order to reduce rolling resistance and allow it to accelerate quickly. Tyre pressure and tread are also important considerations. Teams often choose to use bike wheels, as they are ideal for straight line speed for the above reasons, but on a cart they do not handle the stresses of cornering. When you go around a corner in a car you feel as though you are being pushed to the outside of the turn. This is no different in a cart, and the force you feel is applied to the outside wheel. A spoked bike wheel isn't designed to have the axle push at 90 degrees to the wheel (called an axial load) and will blow the spokes out if the force is big enough (when cart speed rises). On a bike the wheel can withstand this as the rider leans the bike into the turn and the force is transferred lengthwise through the spokes. The trick is to have the key bike wheel in a similar position when a cart corners.



ENOTOCILIA

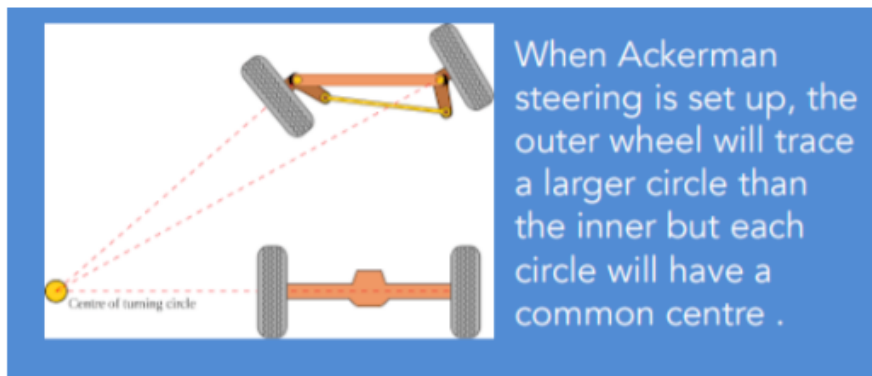
STEERING - KEY INFO

Ideally a vertical line through the wheel axle should be slightly behind the line through the steering axle. This is called *caster*, and caster improves steering and stability. Bikes will already have this optimised, though too small a head angle will mean at low speed the vehicle will be prone to flopping over and oversteering, since the weight of the vehicle forces more turning than intended. A bit of trail makes the steering heavier and less responsive.



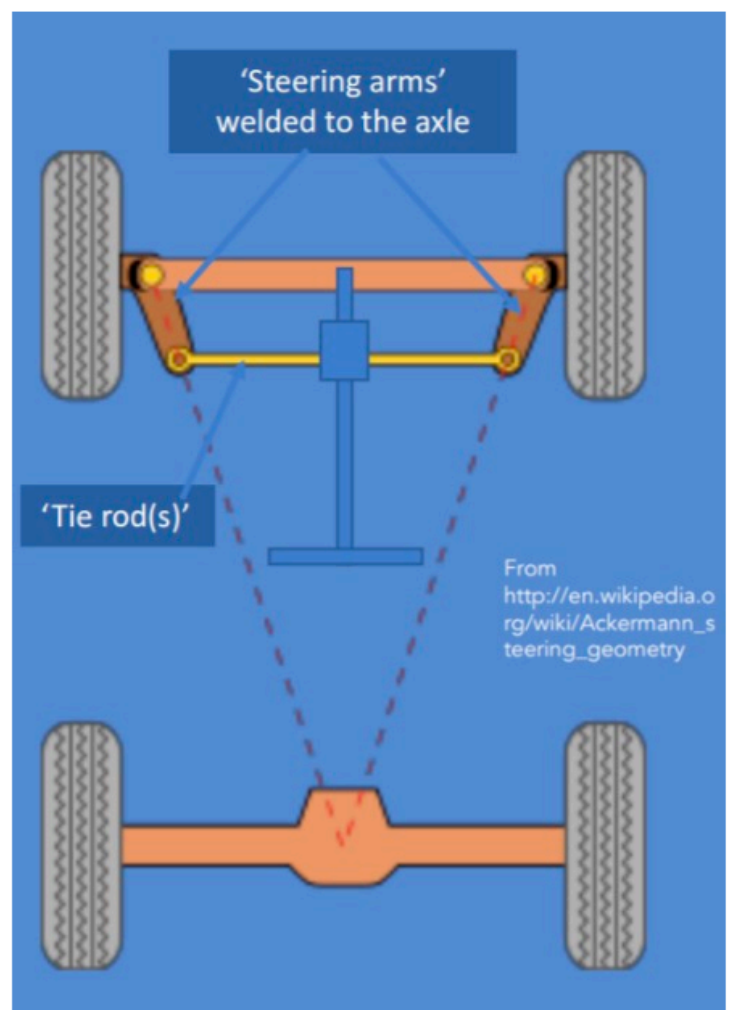
STEERING - KEY INFO

When cornering, the outer wheel traces a larger circle than the inner wheel. This means that the wheels have to turn different amounts to trace out these circles, otherwise the inner one will scrub across the ground when cornering and weight is placed on the outer wheel.



Setting up Ackermann Steering geometry

The lines through the steering arms should intersect at the mid point of the back axle, shown by the red dotted line. This will ensure the tie rod length is shorter than the axle length, and the inner wheel will turn more when cornering. If the tie rod is in front of the axle, the tie rod will have to be correspondingly longer to have the same effect. See the effect in action at [Wikipedia - Ackermann Steering](http://en.wikipedia.org/wiki/Ackermann_steering_geometry).



KEY MATERIALS

Key materials you will need that are not included in the motor kit:

- Full-face helmet
- Extra wire/cable
- Spare fuses
- Chain - you may need a longer one than is in the box

Key tools you may find useful:

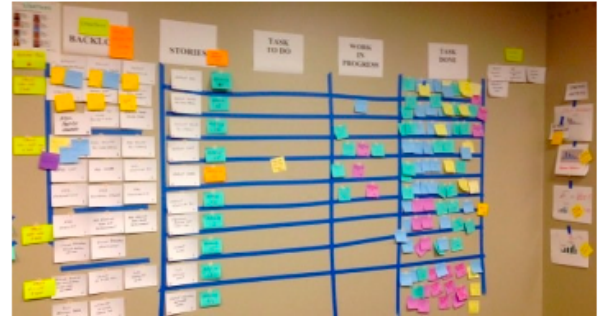
- Wire stripper
- Crimp tool
- Craft knife
- Screwdriver (Philips head, flathead)
- Drill and bits - metal and wood bits depending on your build, plus screwdriver heads
- Pliers
- Circular saw - if working in wood
- Allen keys
- Wire cutters
- Grinder
- Hacksaw
- Jigsaw (metal and wood blades depending on your build)
- Multi-tool
- Soldering iron
- Staple gun
- Metal bender

Key building materials you may find useful:

- Rod ends
- Plywood (7mm, 12mm, 20mm)
- Steel box section (25mm)
- Steel pipe (25mm)
- Threaded rod
- Wooden skirting
- Bicycles, forks, wheels
- Steering and gearing systems
- A range of screws, nuts and bolts, including high tensile (consider size and length)
- A range of washers to fit your nuts and bolts
- Nyloc nuts
- Pillow inner or pool noodles

SCRUM

SCRUM is a way of managing a project that breaks the project down into small chunks to be completed in a Sprint – usually a two week period. A SCRUM Master (the teacher) keeps the teams on track with their timing, supports regular meetings and helps teams to develop the SCRUM culture.



SCRUM Board

Scrum starts with a SCRUM board. The SCRUM board has five main columns: the backlog, to do, doing, done and impediments (or stuck).

The **backlog** is a wish list of all the big things that need to get done. For example in a short film involving robotic cars: code the robots, build the set, make the props, come up with a story, and practice the story.

The **to do** column lists the more specific tasks that make up the big task. For example: the big task of “make the props” becomes:

- Decide what props we need
- Sketch out the props
- Make the 5 trees
- Make the pizza building
- Make the street façade
- Make the villain’s house
- Paint the pizza building
- Paint the street façade
- Paint the villain’s house

Each of these tasks needs to go on a separate post-it note (or equivalent).

The **doing** column should contain the tasks that each person will do during the sprint. Students will need help to manage their workload effectively. However, as they work through the process they will get an idea for how much they can do during a sprint.

A **sprint** is usually two weeks long but you can determine the length of a sprint based on your time availability and the age of the students. In class I have used a sprint as four 1 hour sessions or two weeks of 1 hour sessions.

The **done** column is where completed tasks go. Students will need help to determine what *done* means. It may pay to make a note of the one or two conditions that make an item done, especially if there is potential for argument. For example; “paint the pizza building” means that anyone can tell it is a pizza building, it should have a pizza sign, it should have three windows and a door and the whole box should be painted.

The **impediments** column is for when students get stuck. I would recommend that they use this for when they need help from the teacher, and use their Scrum meetings to ask for help from their team mates. If you continue to recommend to students to put their task in the impediment section, you can quickly see who needs help and with what, rather than being inundated with random “help please”.

Sprint Planning (15 mins max)

Sprint planning is the first meeting in the Sprint:

- Quickly read through all the to do list items.
- Each person select two items that they will work on – add their names to the items and move them into the doing section.
- Ask: does anyone need anything (resources, devices, internet access, library time, an expert, paper etc.). Team leader should take note and communicate these needs to the teacher.
- Ask: is anyone concerned about anything or have something that may affect our timing this sprint (like trips out of school, feeling sick etc.). Team leader should take note and suggest a solution.
- End meeting



Daily SCRUM meeting (10 mins max)

The Daily Scrum should happen every time the team meets. This could be daily, or every time you work on the project. You may rotate the person who runs the meeting each time.

Ask each person:

1. What task are you working on? (Should be a 10 second reply)
2. Do you need anything?
3. Is there anything that will stop you finishing things?
4. Do you have anything to celebrate? (Finished a tricky task, found out something cool, someone else helped you out)
5. Any other questions?

End meeting – make sure everyone has moved tasks into **doing** and **done** and have their name on them.

Sprint Review and Retrospective (10 mins max)

The Sprint Review and Retrospective are about understanding how to improve for next time. While the Scrum method usually has these as two as separate meetings, here they have been combined for efficiency.

Quickly read through the **done** items.

Is there anything outstanding? If so, move these tasks into the next Sprint

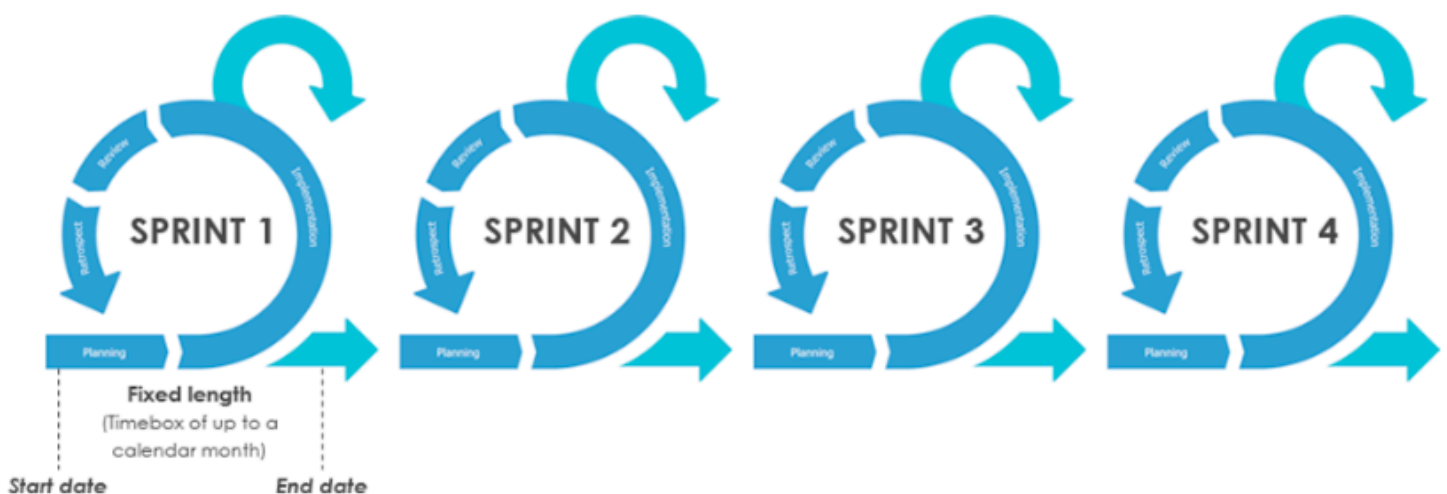
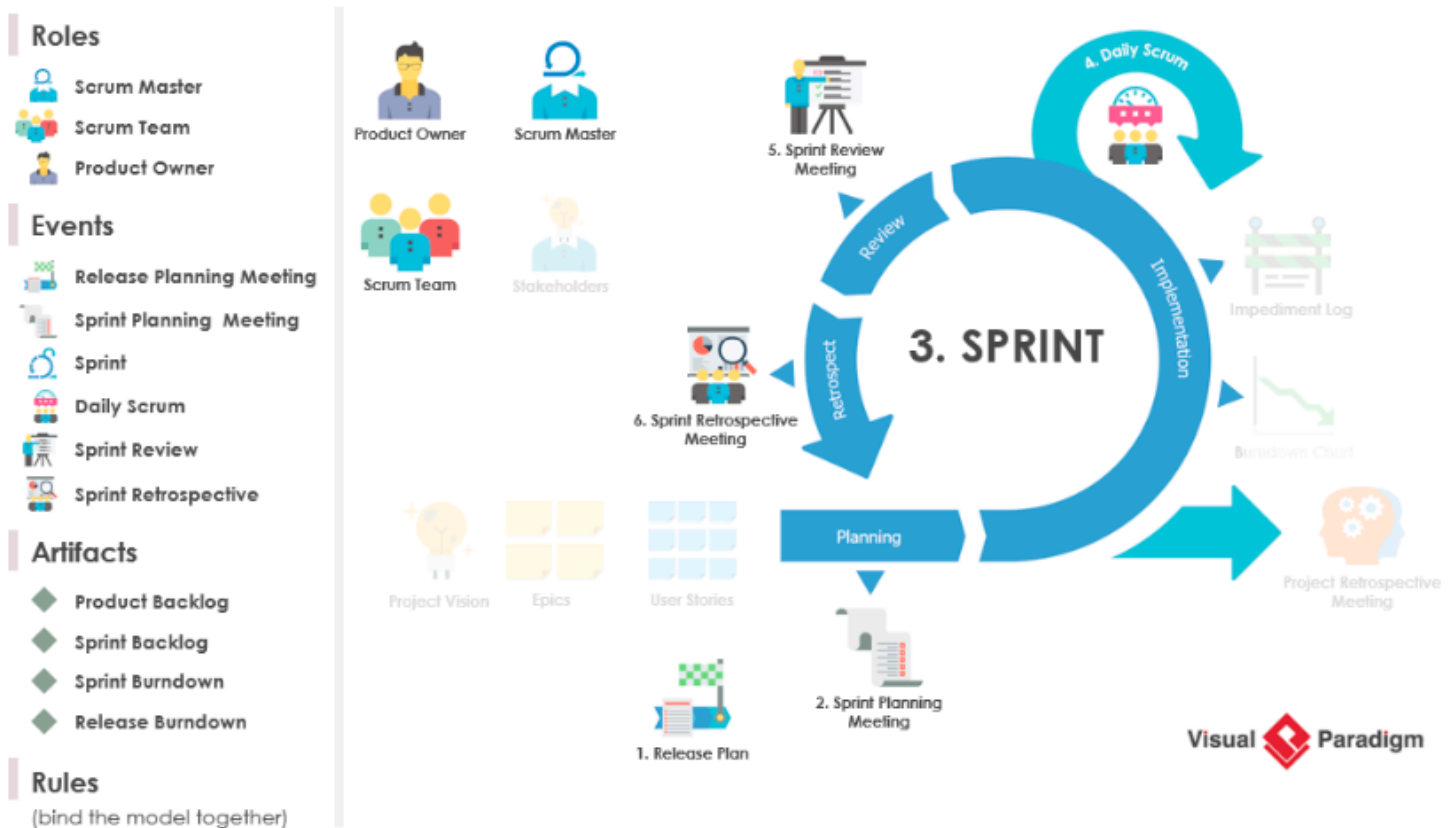
Ask:

1. What helped us get things done on time? (Headphones in so I can't get distracted, working in 10 min blocks etc.)
2. What stopped us getting things done on time? (Talking too much, too much arguing, someone was sick)
3. (If behind schedule) What can we do to catch up? (Someone who finishes early help out the others, do extra time if away etc.)

End meeting

Students will need to be guided through this process as it is very different from most group work they have done. For the first few Sprints ask the questions yourself and have the teams discuss. For the next few sprints rotate through the groups each day as they do their meetings, starting with the teams who need more guidance.

There are three key SCRUM meetings. The **Sprint planning** (1st meeting), the **Daily Scrum** and the **Scrum Review / Retrospective**.



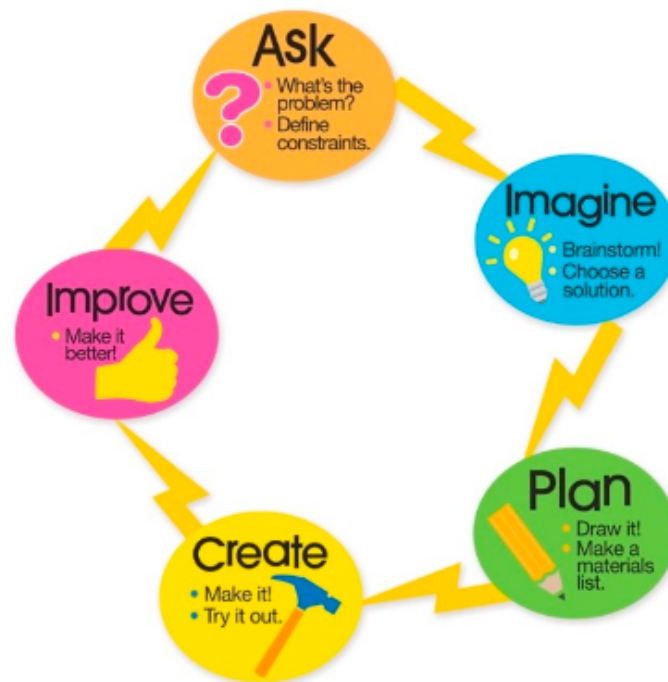
TO DO

If you're looking for some ideas on what should be on your 'to do' list, here is a start (not in any particular order):

- Brainstorm desired vehicle components (solar panels, wheels, speed monitor etc.)
- Generate first sketch and design
- Evaluate design against WOF and rules
- Amend design
- Agree on design
- Put measurements on the design (wheel sizes, width, height)
- Decide on materials
- Create a list of measurements for materials e.g. length of steering rods
- Locate, order/purchase materials
- Mount wheels
- Cut tie rods for steering
- Create steering column
- Test steering circle
- Mount motor
- Place batteries and secure
- Measure lengths for exterior
- Put together exterior
- Design a seat
- Tidy up wiring
- Detailed design of steering
- Determine where to mount motor
- Determine where to locate batteries
- Determine where to locate controller
- Take parts of bikes as needed e.g. wheels, brakes, forks
- Measure lengths for chassis
- Cut lengths for chassis
- Weld or put chassis together
- Cut lengths for steering
- Create brackets for steering
- Put steering together
- Amend steering as needed
- Add chain to motor
- Wire up your motor
- Cut lengths for exterior
- Paint, stain or otherwise make it look classy
- Make the seat
- Check WOF

DESIGN PROCESS

The design process is a way of thinking that people like engineers and programmers use to solve a problem. Everything in our lives can be defined as a problem, whether it's making life better or fixing an issue. The design process gives guidelines so that we can move from a problem to a solution. The design process is a circle because we can always make things better.



Ask

The first step is to define the problem. Here you need to review the different challenges. What does your vehicle have to do? What are the constraints? This means the rules that you have to operate in. For example, if your vehicle is in Standard Class, you must use the standard motor and batteries. That is a constraint.

- Read through the rules, challenges and marking rubrics.
- Summarise these and explain them to someone else.

DESIGN PROCESS

Imagine

Now that you know what you are aiming for, you need to come up with a range and variety of ways that you could complete the competition events. To start with put *all* of your ideas on paper.

Now review these ideas, which are realistic, what materials might you need to make it happen, which ones would be the most effective and why?

Select two or three of the best ideas and use these in the next step.

Plan

Create a list of what materials you need – do you need wire, mesh, plastic, metal? Perhaps collect a couple of different material options so that you can have different choices to test.

Sketch out what your steering and chassis might look like – put measurements and labels on the sketch. If you don't know your measurements yet, make an estimate.

Use TinkerCAD to create a 3D model of your vehicle – you might be able to 3D print this.

Create

Make your vehicle. Test out the steering, set up and try some of the competition events. Get a feel for your vehicle.

Create different versions of your vehicle using the different materials and the different ideas you had.

Improve

Once you have tested your vehicle, improve it. Consider making it from a different material, positioning things differently, swapping parts for more suitable ones.

Finally, if it doesn't work, go back and **imagine, plan and create** again!



Team Name		School Name	
Team Members			

Design Activity 1

Brainstorm some theme ideas for your team and vehicle here:

- Choose a team theme
- Decide which events you are designing for e.g. drag, gymkhana, earth care, mixed or all
- Decide on vehicle class and wheel layout

Team Theme:
Vehicle Class: Standard/Open

Wheel Layout:
Design Priorities:



Design Activity 2

Now that you’ve chosen a vehicle and team theme, brainstorm some things you might want and need in your electric vehicle.

NEEDS	WANTS



Design Activity 3

Using your brainstorming from earlier, draw 3 different vehicle designs and select the team favourite.



Use these pages to get started on designing your vehicle. Don't worry about if it's too hard, drawing isn't your thing or whether it's practical yet. Just get your ideas down to get started.











The next pages are blank for your team to use as you need to. We recommend that each time your come together you start by noting what you plan to do and who is doing it. Then take pictures, make notes and otherwise describe what you did. Describe any challenges and successes, and finally conclude with what you achieved at the end of your time.

This process will help you to see your progress, highlight issues, and will be extremely useful when it comes to writing the report.

Good luck!

