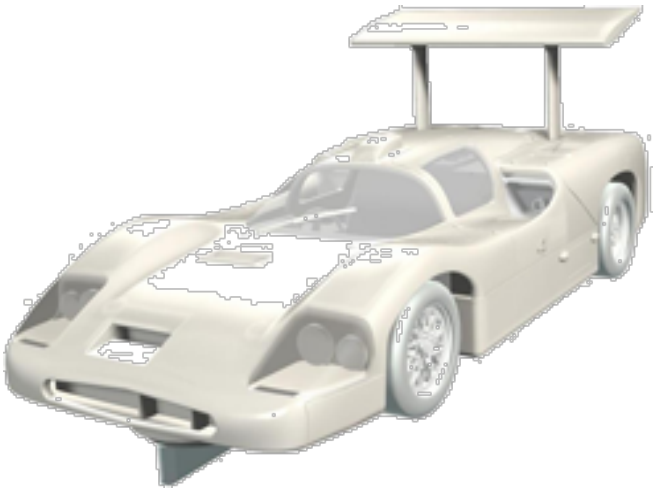
SCALEXTRIC 4SCHOOLS



S4S - Design Guide

PTC® | ACADEMIC PROGRAM

C2-SCA-L1-0202-1.0

Written by
Tim Brotherhood

Conditions of use

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Feedback

In order to ensure these materials are of the highest quality, users are asked to report errors to the author.

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Suggestions for improvements and other activities would also be very welcome.

Product code

C2-SCA-L1-0202-1.0

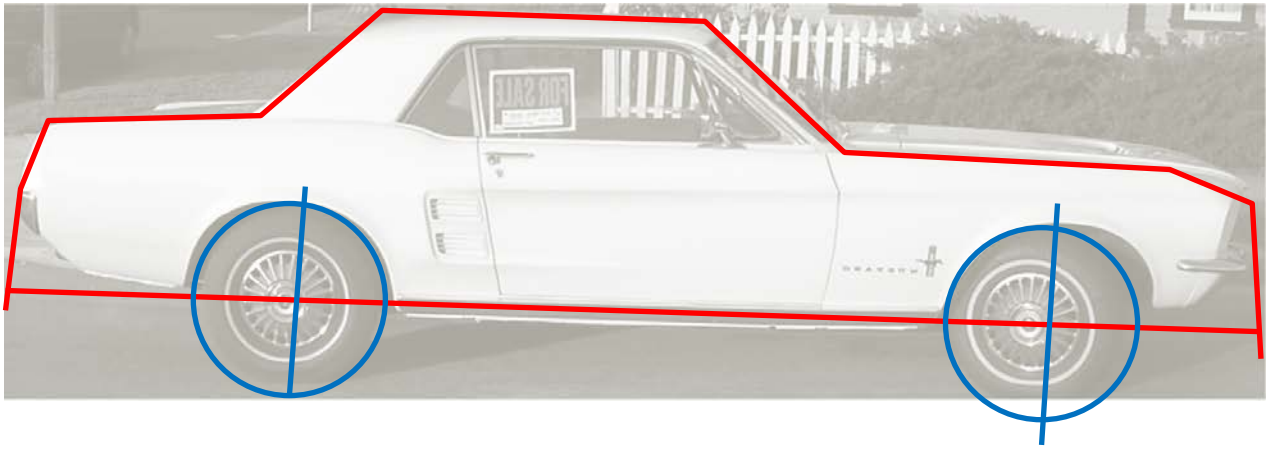
The following organisations share a common goal of promoting STEM subjects and endorse the PTC Academic Program.

Contents

Design – Car profiles – Session one

The fundamental shape of all cars is determined by the side profile of the body. In order to design your own car you will need to capture the shape you want with as few lines as possible. A good way of learning how to do this is by tracing over pictures of classic cars. You will be surprised how few lines you need! The internet is a great source of car photos to practice on.

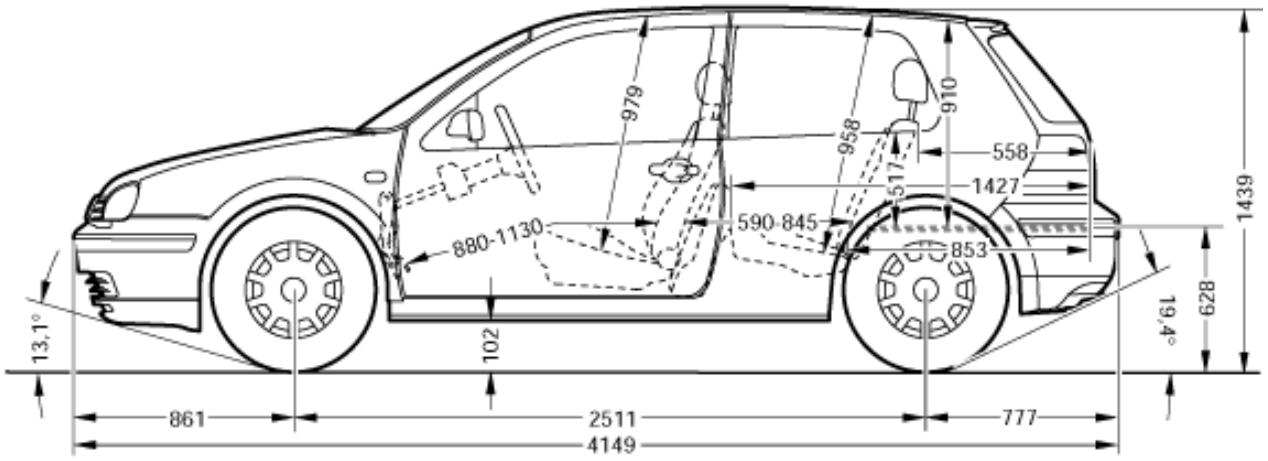
The side profile of the classic Ford Mustang below has been captured with just a few straight lines. Curves joining each straight line will be added later using rounds.



Modeling to scale

Another excellent source of side profiles are the blueprints in the specifications section of car owner's manuals. These have the added advantage of listing dimensions for the full size car which will be very useful when working out the size of your 1/32 scale model.

Example one



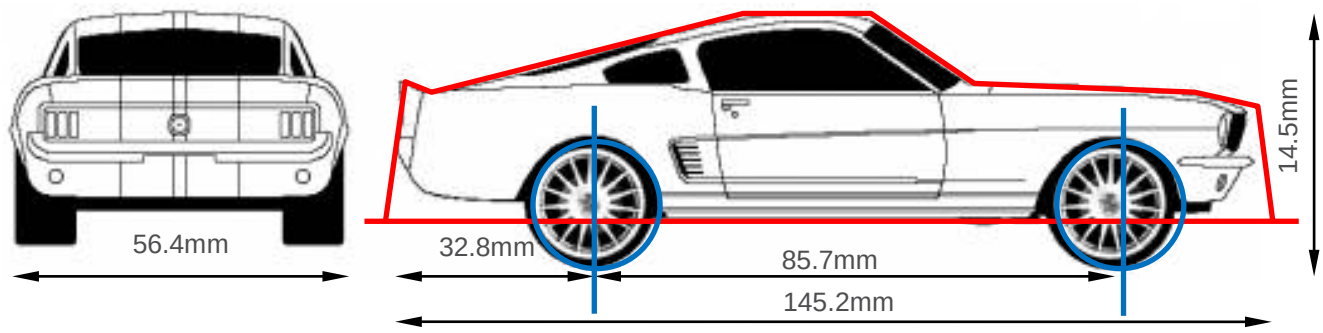
Scalextric cars use 1/32 scale which means:

Metric	ANSI
a car that is 4.149 metres long will be: $\frac{4.149}{32}$ = 0.130 (metres) or **130** mm long.	a car that is 15 feet long will be: $\frac{15}{32}$ = 0.47 feet = 5.625 inches or **5.625** inches long.

Example two

The data for a 1968 Ford Mustang is: Length = 4.648 metres (183”), Wheelbase = 2.743 metres (108”), Width = 1.8 metres (70.9”).

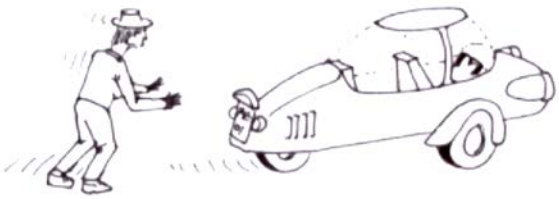
Use the same method to convert these dimensions for your chosen design.

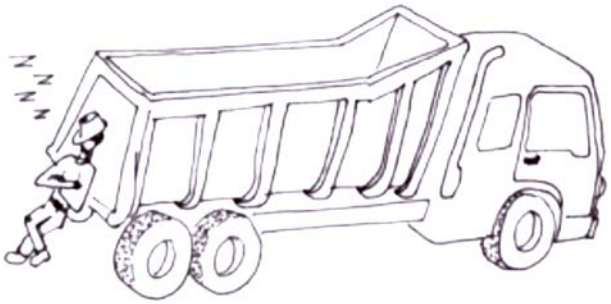


Car performance – Homework one

Mass - Small is beautiful

Resistance to movement is called inertia. Big heavy objects are difficult to get moving.





From your physics lessons you should already know the formula that governs how fast a car will accelerate:

force = mass x acceleration

If we re-arrange this we get:

Because the mass is on the bottom of the formula, any reduction in mass will increase the acceleration.

$\frac{\text{force}}{\text{mass}}$ = acceleration

- Test a standard car on track for acceleration and lap time.
- How will you measure these accurately?
- Add ballast to car such as poster tack then retest. (It can be inside the body!)
- What was the effect?
- Try different amounts
- Draw a graph of performance against added mass.

A term 'power to weight ratio' is used to indicate how quickly a car can accelerate.

Using SI units of watts for power and Kg for weight:

$$\frac{\text{Engine power}}{\text{Vehicle mass}} = \text{Acceleration}$$

Lotus Exige

206 W/Kg

Triumph Speed Triple

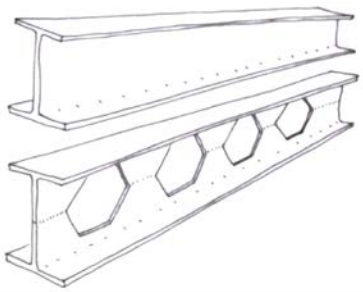
513 W/Kg

The force pushing the car comes from the motor driving the wheels and in Scalextric4Schools you must use a standard 12v electric motor with fixed power output so the only other variable you have control over is mass.

Engineers sometimes remove material where it is not needed for strength.

Beware, go too far and strength will be lost!

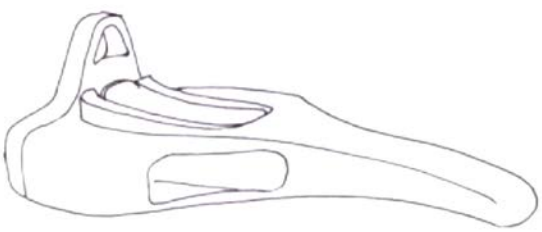
Can you find examples where engineers have removed material in this way?



You may be able to substitute a lighter material.

Thinner material could be substituted. Will the thinner material be strong or stiff enough?

A light material may work if the shape is



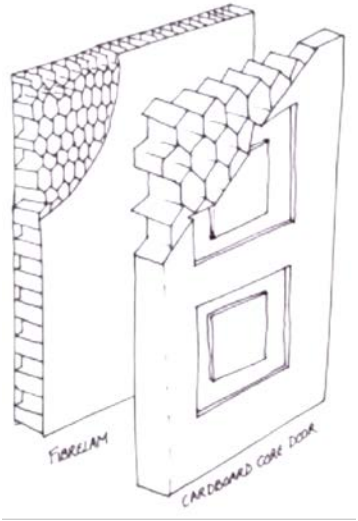
strong The cockpit of a single seat racing car works like the shell of a bird's egg.

Combining materials can make a material that is both light and strong. These are called composites.

Composites can be expensive but why not make your own? Paper mâché is a type of composite. Could you make the car body from this material?

Fibrelam is aluminium honeycomb bonded between two thin sheets of glass fibre and used extensively in aerospace because of its high strength to weight ratio.

Some internal doors are made of hardboard skins with a cardboard honeycomb between.



Centre of gravity – How low can you get?

Although centre of gravity (c of g) can affect acceleration and breaking, the greatest impact is going round corners.

Putting as much of the car as low as possible is the aim.

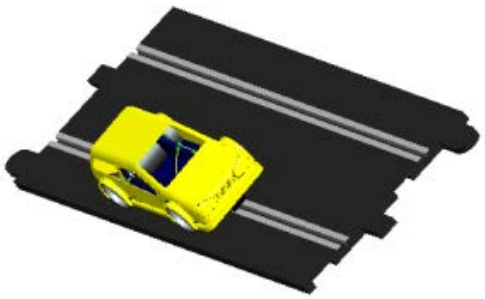
Creo Parametric has a simulation module called 'Mechanism Dynamics' that can simulate the behaviour of models when gravity is applied.

Ask your teacher about the online multimedia PTC University tutorials for **Creo Parametric**.

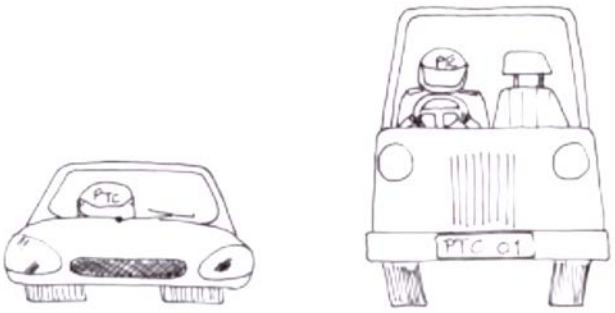
An assembly has been created for you.

- The car is assembled on to a piece of track which is gradually tilted until the car slides off or falls over.
- Measure and note the angle of the track at the point the car moved. Try the same test with other types of slot car.
- Create a table of your results.

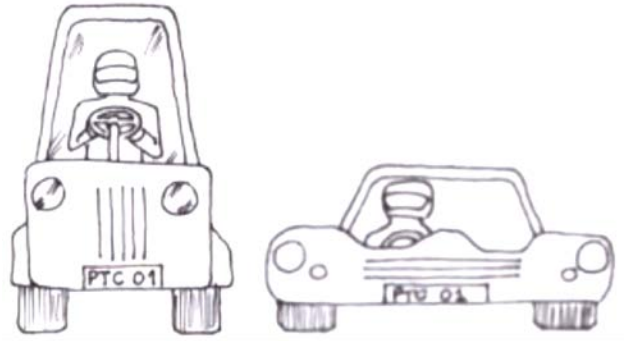
You could do this activity for real with your model car on a spare piece of track.



A lower c of g will help prevent the car toppling over when cornering.



Making the car wider will also help resist toppling.



Friction

Friction occurs wherever two surfaces rub together and can be a good thing or bad thing.

Friction we don't want is found in the motor, axle bearings. Slot guide and gears.

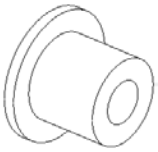
Making sure the 'fit' of axles is free running but not sloppy is very important.

Lubricating bearings can help but thick oil can slow things down. Is there a better alternative to oil for lubrication?

The basic car has axles running in holes in the chassis. Whenever materials rub against each other there is friction. Changing the materials may help.

Using proper bearings might also reduce friction but may add extra weight. You would need to find out if any

Needle roller bearing



Sleeve bearing

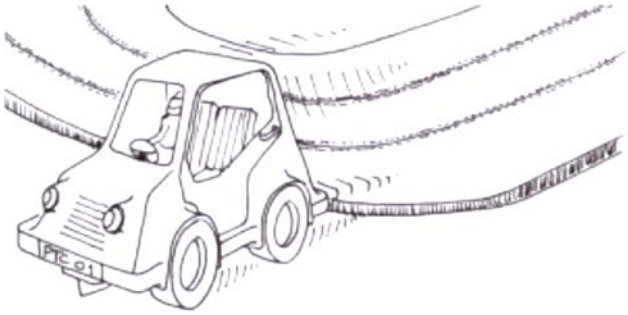
improvement was worth the extra weight.

The one place we do want friction is between the wheels and track.

Without this the car wouldn't get away at the start of a race!

With no friction between the tyres and track cornering would also be difficult!

Standard Scalextric track and tires will be used so you have little room for design development here.



Aerodynamics – Don't get the wind up

As a slot car moves along it has to force a path through the air.

We cannot see the air and it doesn't seem to stop us walking around so what's the big deal?

The damage done by strong winds is a clue to the forces the wind can have on objects.

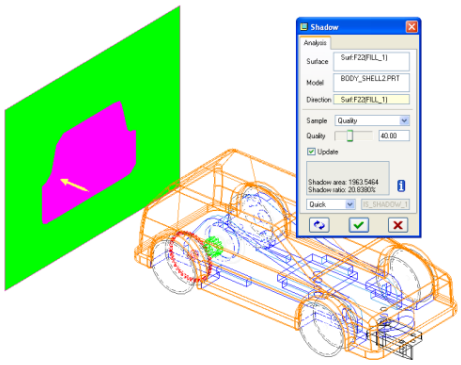
Cycling into a head wind or trying to run holding a sheet of plywood in front of you will allow you to feel the effect of trying to move through air.

There are two main things you can do to reduce the effects of air slowing the car.

- Reduce the frontal area

Creo Parametric will cast a shadow on to a surface.

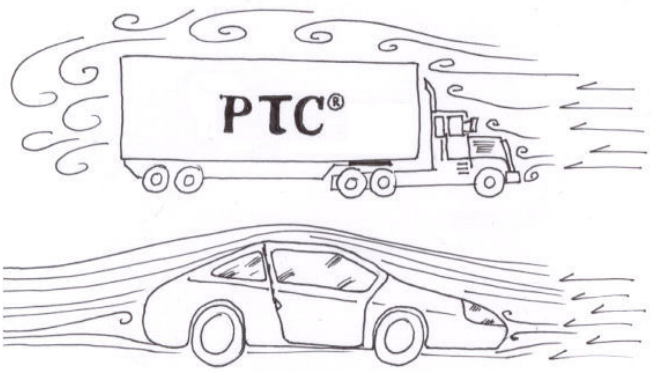
This is a great way to measure the frontal area of your car design.



- Reduce drag.

The term drag is most often used to describe the resistance created by the air when a car travels along.

The smoother and sleeker you can make your car the quicker it should be.



Car manufacturers use the term ‘coefficient of drag’ to show how streamlined a car is.

The smaller the number the more streamlined a car is.

Which of these is the most streamlined?

Which one does your design most look like?

Toyota Prius
C_d = 0.26

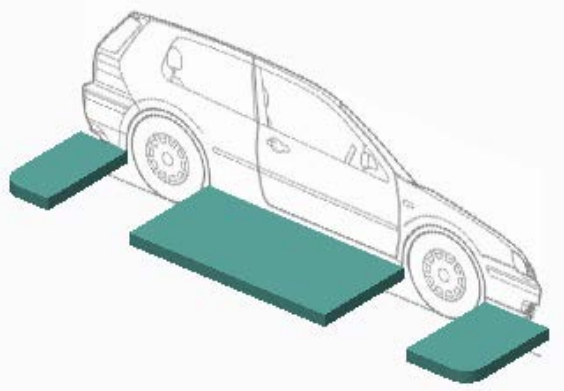
Hummer H2
C_d = 0.57

Own design – Homework two

Sketching

Sketching skills are vitally important when designing to communicate your ideas and thoughts to others. As you have seen, your body design must accommodate the standard chassis and internal components.

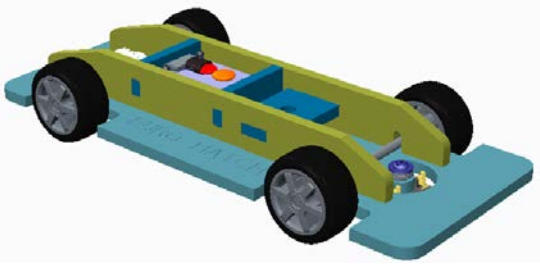
The starting point for the CAD modeling is a part called BODY.PRT



The shape was based on a saloon car to a scale of 1:32. This is the same scale as Scalextric cars and track.

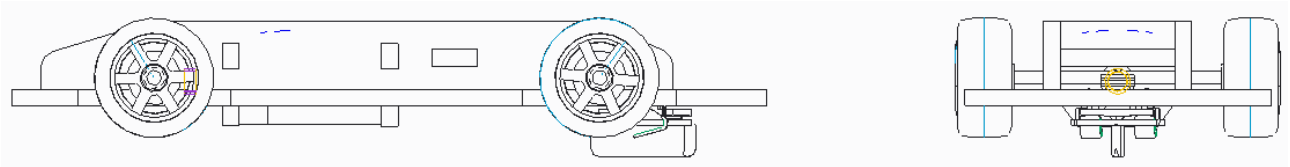
The base feature covers the 3mm acrylic chassis component while the wheel arches provide clearance around the wheels and axles.

A number of other components in the assembly will need to be enclosed inside your car body including; chassis components, motor, pick-up, gears, etc.



Your teacher will provide you with copies of the template from the end of this document (Appendix three).

Building on the practice tracing classic designs, you should now be able to sketch your own designs using the templates.



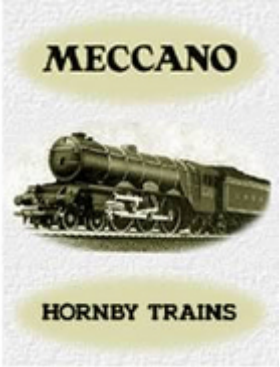
Note:

- Do not use the diagrams above as they are not ‘faded out’ and may not be to scale.
- At all stages check your designs conform to the competition rules.
- Bring your design sketches to future lessons.

The software booklet shows how to import scanned copies of your sketches into **Creo Parametric** making it easier to trace your designs.

Hornby the company – Homework two

Hornby is a household name and is famous as the UK brand leader in the model railway hobby. www.hornby.com

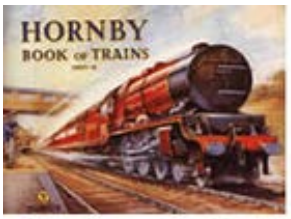


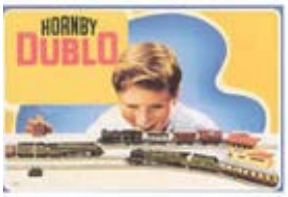
Meccano Production

The company's founder was Frank Hornby (1863 - 1936) who applied for a patent in 1901 to protect an invention he called 'Improvements in Toy or Educational Devices for Children and Young People'.

Meccano production continued during the First World War and Hornby took the opportunity to introduce toy trains in 1920.

Hornby Trains





The original Hornby trains were powered by a high quality clockwork motor, made of metal pressings held together by Meccano nuts and bolts, and '0' gauge in size.

Hornby Trains were an instant success and the company was quick to introduce more engines and accessories. In 1925 the first Hornby electric train was produced, operating from a mains supply of 100-250 volts. By 1929, Hornby had evolved a much safer system and electric models worked from a six volt DC source.

Hornby launched the first commercially produced '00' gauge live steam locomotive in September 2003, paving the way for another product line consisting of more than 650 current items.

Now simply called "Hornby", the company justifiably retains the position it has held for more than 50 years as Britain's leading model railway manufacturer.

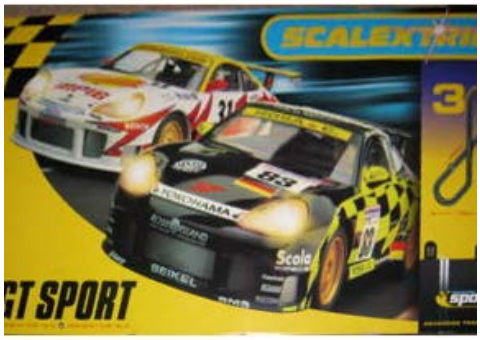
Scalextric slot cars

Scalextric came from the *Scalex* brand of Minimodels Ltd, which was a clockwork powered race car system that first appeared in 1952. Their inventor, Mr B. Francis, showed Scalextric ("Scalex" plus "electric") cars at the annual Harrogate Toy Fair in 1957. In 1958, unable to meet demand for their popular range, the parent company was sold to Lines Bros Ltd, who operated as "Tri-ang".

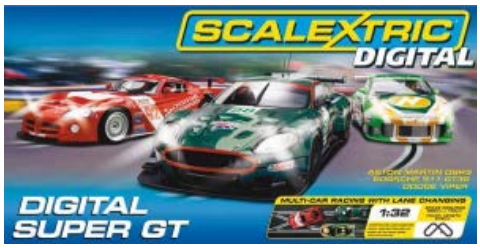
www.scalemodels.co.uk/admin/scalextric.html

Their subsidiary Rovex, which specialised in plastic, then developed Scalextric, converting the metal cars to the easier and cheaper to mould plastic. The track, which was originally a rubber compound, became moulded plastic at a later date. Production continued at Mini-models in Havant until 1967, when it moved to Rovex's own site. When Lines Bros collapsed, their subsidiary Rovex-Triang, which handled Scalextric and the Hornby railway brand, was sold off, eventually becoming Hornby Railways.

Scalextric remains based in the UK.
www.scalextric.com

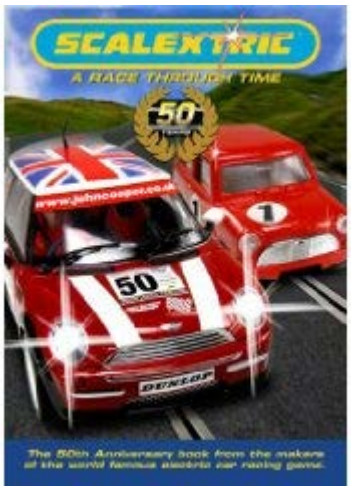


At the beginning of the 21st century Scalextric did a major redesign to make the track easier to assemble. The new design is known as Scalextric Sport. Scalextric Sport track can be connected to the classic design of track using adaptor pieces.



Also introduced in 2004 is Scalextric Sport Digital, in which up to 6 digital cars can be raced in a single slot. The cars can change from one slot to another using special lane change tracks controlled by a button on the throttle.

The Scalextric web site includes a members club offering discounts, limited edition cars and accessories. www.scalextric.com



In 2007 Hornby celebrated the 50th anniversary of Scalextric with special anniversary sets and cars.

The name Scalextric is synonymous with slot racing worldwide.

Scalextric car design – Session five homework

How cool would it be to spend your working day recreating the latest dream cars as Scalextric models?

Name: Darren Nye **Age**: 28

Occupation: Product Designer

Job Description: Using **Creo Parametric**, reverse engineer cars to 1:32 scale to accept electrical and mechanical components for a working Scalextric car. All body and chassis parts must be suitable for quantity manufacture.

Darren has been working for Scalextric for 5 years now. His job takes him all round the world sourcing photographs of the cars he then models using **Creo Parametric**.

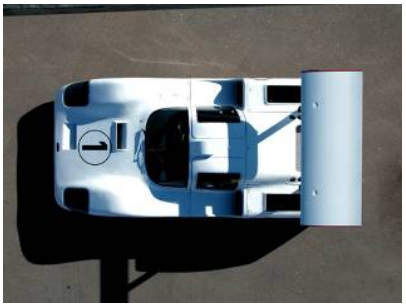
Darren has kindly agreed to show us the step by step process how he creates exact 1:32 scale replica cars for Scalextric to be manufactured into racing slot cars sold in shops around the world.

Darren normally starts a new project by travelling out to where the car he is going to model is being manufactured.

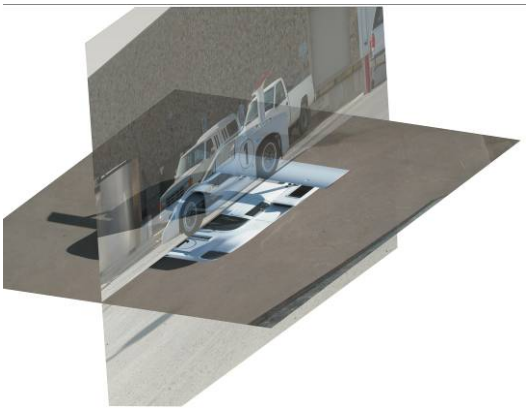
He then takes hundreds of photos and measurements of the car. Lots of photos are taken close up so that the Darren can fully understand and see all the detail within the car.

Next, five shots are taken to show the overall shape. Much like an engineering drawing, photos are taken in the front, side, back and top views of the car.

Getting a photo of the top of a car can be tricky as you need to be really high up to avoid parallax distortion due to perspective.

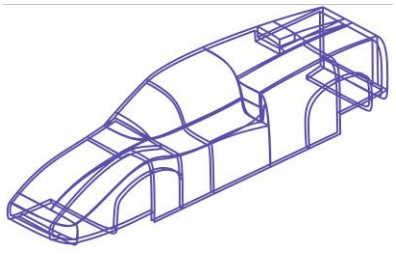


Here we can see Darren being lifted over 20 feet in the air standing on a fork lift, just to get that all important plan view shot!



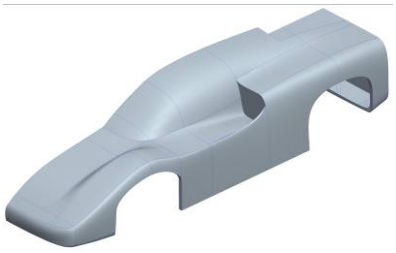
The photographs are scaled down to 1:32, the size of Scalextric car and imported into sketches on datum planes in **Creo Parametric**.

The photographs are aligned so that Darren can see the car in the correct positions so he can trace over these images to get very accurate profiles of the car.



Using curves and splines, Darren painstakingly traces over the images to build up a wire frame of half of the car.

Before you read further can you guess why Darren only models half the car?



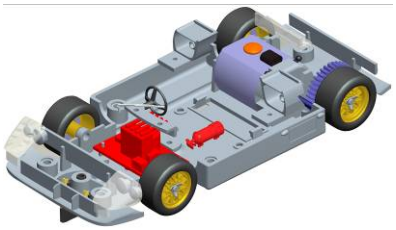
Next Darren creates what are known as surfaces from the wire frame geometry. When Darren is happy with the look of the model he will use tools in **Creo Parametric** to thicken the surfaces turning them into solid features.

Now that Darren has a physical object for half the car on his screen he mirrors the image to create the other half, completing the entire shell of the car.

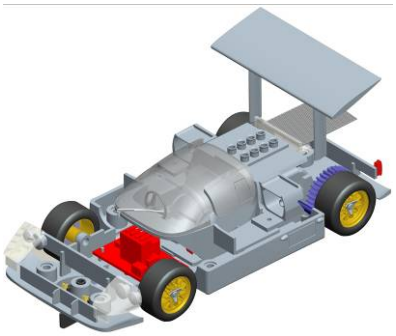
This process allows him to work much quicker as he only needed to model half of the car as it is symmetrical.

Once Darren has the basic shell he can then begin adding all the details. Everything from vents to windscreens are accurately modelled into the car.

After Darren has finished making the shell of the car he turns his attention to the chassis which provides the fixings for the motor, gears, axles, slot guide and printed circuit boards.



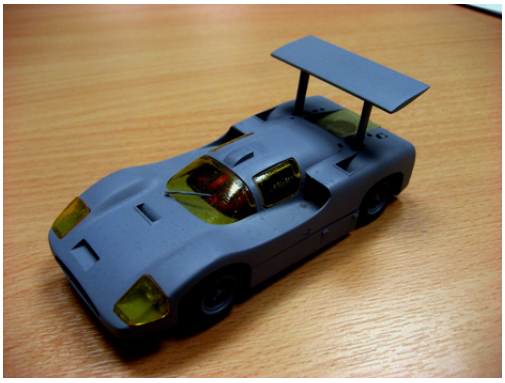
Once the chassis has been modelled, Darren uses **Creo Parametric** to assemble all the standard components from a library. These are the same **Creo Parametric** models you are provided with and include; wheels, tires, electric motor, axles, gears, … everything for a complete car!



After all the components are fitted together Darren can finally add the top shell of the car to complete the finished virtual model.

At this stage, Darren can produce CAD renderings of the car to give him, clients and manufacturers a feel of what the final product should look like.

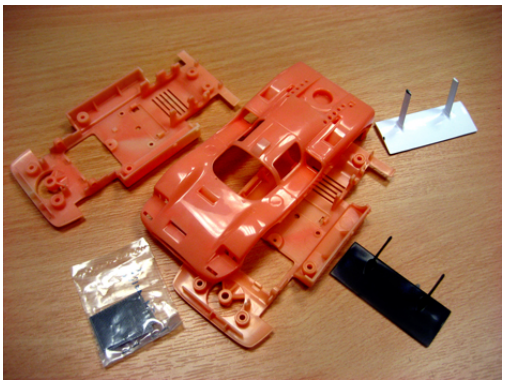
Although 2D images give an impression of the final car a 3D prototype is the only way to check the look, feel, strength and how everything fits together. In the past this would have been the job of a model maker and take weeks



Darren saves the **Creo Parametric** parts as STL files which are sent electronically to a rapid prototyping bureau.

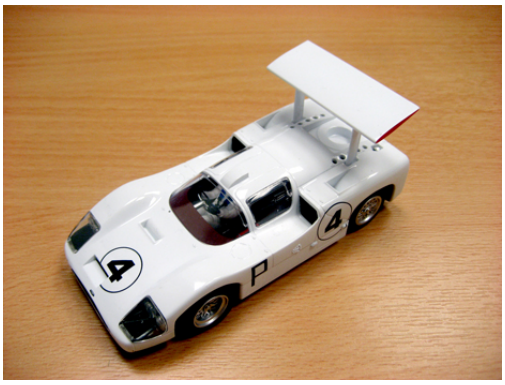
They create an accurate prototype of the Scalextric car by fusing very fine layers of material together. Prototyped parts arrive back at Hornby in about a week.

This is a great opportunity to find any obvious errors with the model before being sent out to the manufacture.



Once the car works properly and accurately represents the real car, it is sent off to the manufacturers to begin tooling for the car. After about 8 weeks the first sample injection mouldings are sent back to Darren where he can check over the quality.

Darren is often asked to make changes to the components to make them easier or cheaper to mould. These requests may change the way the car will look and if so Darren must balance the quest for accuracy against the cost benefits.



Any changes to the car are now made and altered data is sent back to the manufactures so that the car can begin mass manufacture.

After only a few weeks the finished cars begin arriving back ready to be boxed and shipped to shops around the world.

The finished production model

Career guide – Industrial Designer – Session seven homework

If you are thinking of becoming an industrial designer you may be interested in the story of Victoria, one of the Scalextric designers.

Name: Victoria

Age: 24

Occupation: Industrial Designer

Job Description: Using **Creo Parametric** to reverse engineer full size cars to 1:32 scale to accept electrical and mechanical components for a working Scalextric car. All body and chassis parts must be suitable for manufacture in large quantities.

Victoria has a very similar role to Darren, turning full size cars into 1:32 scale Scalextric models. She has been at Hornby for two years and completed many designs, some you can see on her desk.

Schools

At the age of 11, Victoria attended the Southlands Comprehensive School (Now The Marsh Academy) having missed 11+ exams due to illness. A very bright pupil, Victoria had the opportunity to move to Folkestone Grammar School during year 9 (age 14).

The Grammar school offered a wide range of courses including Design and Technology which Victoria studied at GCSE (14-16) as well as a short course GCSE in Electronics. A keen interest in how things work was probably inherited from her father who was a Design &Technology teacher.

In the first AS level year (age 16/17) Victoria studied Physics, Chemistry, D&T and History and continued with Physics, Chemistry and D&T to final A2 (age 17/18) exams.

For her A level projects, Victoria designed and constructed a teaching aid to demonstrate household wiring systems as well as a full size water feature designed to combat stress in the workplace, which was sponsored by the local company SAGA.

University

After school, Victoria attended Loughborough University studying Industrial Design and Technology BSc. Modules during the first year included Mechanics, Electronics and Material Science, which provided a solid grounding for later project work.

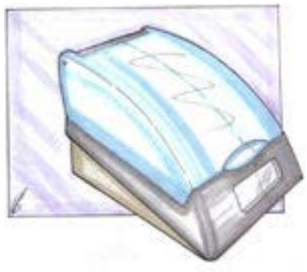
The second year at Loughborough added Materials Processing and more Electronics as well as a range of design based modules. Integrating the creative with the scientific side of design has always interested Victoria.

After the second year Victoria took a year's work experience which she arranged at Integrated Technologies Ltd located in Ashford in Kent.

Industrial placement year

Victoria worked with a local company, Integrated Technologies Ltd, a leading manufacturer of medical instruments, as an Industrial Designer within their Research & Development Department.

During this year Victoria worked on several projects including redesigning a part of the company's new web site to ease site navigation



www.itl.co.uk/vtl/msr.htm

Another project she assisted on was the ergonomics of instrument enclosures.

The pictures here are one of Victoria's initial design sketches and the final product, a Magnetic Sample Rotator. The innovative clam shell design which the team came up with allows each half to work independently for small or large batches.

This is a manual heat sealer redesigned to solve a major problem for operators.

The design included a handle so that operators of the machine were unlikely to come into contact with the hot plate reducing the risk of burns.

Not only were the ergonomics of the clamping mechanism improved to reduce RSI, but at the same time positioning the handle for carrying reduced the risk of injury.

Back at University for her third year, Victoria was introduced to programmable interface devices (PIC) and printed circuit board (PCB) manufacture. This helped Victoria with her major project, the redesign of the traditional chip and pin handset.

Always an innovator, Victoria created a device where the numbers on the keys are electronic so each time a PIN code has to be entered the numbers are in a different position. This helps guard against people and surveillance cameras spotting the pattern of key presses and therefore identifying the users pin code.

The redesign also focused on improving the usability/ ergonomics and aesthetics of the product.

Victoria recalls the pressure during her final year including a dissertation on the 'Health & Safety of Industrial Lighting', clear evidence of the need for Industrial Designers to be flexible!

Graduating with a first class honours degree, and armed with a portfolio of work, Victoria searched for a job that interested her and offered the challenge and variety she values.

Hornby offered this and Victoria gets great job satisfaction designing the latest Scalextric cars, providing pleasure to millions of people worldwide.

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Appendix one – Car profiles

Appendix Two – Car design template