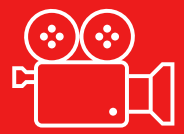
IMAGINE

Driven to Inspire: The science of going fast!

KS2

Learning outcomes

- I will be able to understand the scientific factors of racing
- I will be able to explain what makes racing cars successful or unsuccessful
- I will know the role environments can play when driving
- I will be able to analyse, measure and optimise scientific factors to make the car perform better
- I will be able to evaluate the work of my peers and give helpful scientific critique
- I will be able to work as part of a team to a shared goal
- I will know how to test my ideas in a virtual setting



https://www.youtube.com/watch?v=dW52igWrBTc

LESSON 1

Car racing

- What type of racing cars can you think of**?**
- Have you seen any racing cars**?**
- Present your answers to the class, can you remember any of the car's key features**?**

Formula 1

- **Tarmac**
- **Dry weather**
- **Light rain**

A single-seater car race made up of 20 drivers and 10 teams all racing for first place. These cars cannot go on the main roads as they are modified for racing, not driving.

Rally

- **Tarmac/ gravel**
- **Rough roads**
- **Grass**
- **Suitable for all weather conditions**

Rally racing sees two people; one driver and a co-driver, drive a road-legal car to complete a timed stage. These stages tend to be short in length with the driver completing several stages per round.

Did you know?
Going first at the start of a rally stage can actually be a bad thing, as it means drivers clear the grit on the road for those behind them!

Rally raid

- **Rough roads**
- **No roads**
- **Deep mud/ water**
- **Steep inclines**
- **Suitable for all weather conditions**

A form of racing taking place off-road in 4X4 vehicles over a number of days; it can take place on different types of terrain as the cars are specially designed to drive in extreme conditions.

One of the most famous events for this type of racing is the Dakar Rally.

Go-karting

- **Tarmac**
- **Dry weather**
- **Light rain**

One of the most affordable options in motorsport, this type of racing is also available to children and has different speed karts ranging from 50cc to 250cc.

You may also know about Go-karting thanks to Nintendo's video game, Mario Kart.

Did you know?
Go-karting is seen as the starting point for children who one day want to go into F1 racing. The official starting age is eight years old.

Drag racing

- **Tarmac**
- **Dry weather only**

Usually a short, simple race that two vehicles, motorbike or car, compete in (think Fast and Furious!).

What skills do you think are needed for a car racing team?

Did you notice any other skills mentioned in the video at the beginning of the lesson?

The importance of working as a team

Working as a team is important in all walks of life, especially in motorsport where a group of highly-skilled individuals work together to create a winning car.

- Being respectful and kind
- Listening to each other's opinions
- Using everyone's skills to the team's advantage
- Everyone having a role that is important to the overall outcome
- Being honest and able to disagree if it means creating something better
- Learning together to improve
- Working well together to get the job done faster and better

More brains means more new and exciting ideas!

It’s time to meet some of the team at PDC!

Gavin Johnson

Gavin was nine when he received a radio-controlled buggy as a present and built it with his Dad, who would occasionally take him to a racetrack to watch the racing. He began modifying his car and testing it in different weather conditions in order to gain a better understanding of how it worked and how he could improve its performance. Outside of PDC, Gavin's professional life sees him controlling railway engineering projects, which allows him to develop transferable skills for his racing and vice versa. He believes that the team at PDC have really enhanced his engineering knowledge by exposing him to car builds and educating him on how different setups in the car change how the car performs.

Racing bio:

Years racing: 6
Formats: Sprint/ endurance
Races complete: 92
No. of circuits visited: 16
Race cars raced: 8
Cars built: 0

Racing highlights:

- 2018 champion
- 4 lap records
- Racing a Porsche at Spa-Francorchamps

Skillsets:

- Motivation
- Planning
- Management
- Driving
- Analysis

Since meeting the team in 2016, Gavin now has multiple roles at PDC, with his main one being to drive fast!

Roles:

- STEM ambassador
- Driver
- Instructor
- Marketing
- Public relations
- Management

Dr Esther Quaintmere

Esther was heavily involved in the creation of PDC racing by setting up the website, the social media and capturing all the footage, all while still doing her self-funded PhD and having part time jobs. As well as being behind the wheel, she's also been in charge of the pit crew and communicating with drivers during endurance races. During her time at PDC, she has been diagnosed with Tourette's Syndrome but continues to work hard and race when she can to prove it doesn't stop her being able to do the things her teammates do.

Esther's interest in racing all began when she helped her uncle build a 2cv kit car. She transferred those skills into her education and years later found herself as both a mechanic with the team and testing cars as a way of improving her understanding of what the drivers wanted the cars to do, leading to her racing debut in 2017!

Outside of PDC, Esther's professional life sees her as an innovation/ design engineer specialising in computational fluid dynamists; stimulating fluid flow to make better designs. She is also a mechanical engineer with a whopping three degrees (BEng, MSc, PhD)! The mind of an engineer - wanting to learn how things work, how to tackle a difficult problem - is directly transferable to her roles in the team; analysing data and graphs can also help and are useful ways to optimise the performance and reliability of the cars.

Racing bio:

Years racing: 3
Formats: Sprint/ endurance
Races complete: 5
No. of circuits visited: 4
Race cars raced: 2
Cars built:

- 1 full car
- 5 engines
- Liveried multiple cars including the Boxster the team used in 2019

Skillsets:

- Designing
- Creative maker
- Web design
- Car diagnostics
- Pitstops

Racing highlights:

- 2nd in class at Cadwell Park in the Roadsports in 2018
- Surviving the 2cv 24hour race in 2019 and scoring fastest lap for her team

Esther has multiple roles at PDC, with her main one being to build engines and race when she can!

Roles:

- Driver
- Mechanic
- Video editor

Pip Hammond

Pip was introduced to racing through his father who used to race in the early 2000's and was a 4x4 off-road trialling champion in 2003. Pip started racing in off-road trials in 2002 – first as the navigator and from 2005 as the driver. When his dad stopped racing, Pip moved to racing cars mid-season in July 2008, aged 21; winning his first championship in his first full season in 2009, then again in 2011 after a year off. He started with PDC Racing in 2016.

Pip's professional life sees him as an apprentice electrician installing electrical equipment at Power Distribution Control Ltd, while going to college to learn his trade. He didn't know much about how cars worked when he began racing, but now people come to him for advice about their car or driving, which led to his role as racing instructor to help other racers! While his role (outside of driving) is more mechanic than engineer,

Pip is learning from his teammates and certain tasks like setting up the geometry or 'balancing' cars requires a nice blend of practical skills, mathematics and critical thinking!

Racing bio:

Years racing: 12
Formats: Sprint/ endurance/ oval racing/ hill climb
Races complete: 125
No. of circuits visited: 14
Race cars raced: 16
Cars built: 5

Racing highlights:

- Championships won in 2009, 2011, 2017
- 8 lap records

Skillsets:

- Driving
- Fixing things
- Car set-up

Pip has multiple roles at PDC, with his main one being to build and race cars.

Roles:

- STEM ambassador
- Driver
- Instructor
- Mechanic
- Apprentice electrician
- Develop race cars

What kind of environments do cars race in?

Are there any others you can think of?

Weather conditions:
- Wet
- Dry
- Windy
- Snow/ ice

Terrain:
- Off-road (mud, grass, water, steep inclines etc.)
- Tarmac
- Gravel

Track:
- Strip
- Circuit (both small, built circuits and large, off-road, planned-out tracks)
- Winding cities

Think back to the types of racing if you're struggling!

Driving conditions

Wet conditions make driving hard, as it affects the tyre/ road grip. You need the right tyres for this condition, otherwise you will struggle to control the vehicle!

Dry/ hot conditions can be great for steering control, however, especially in F1, it can cause problems with the engine and tyres getting too hot.

Wind can also affect driving conditions by causing handling issues. (Think about how difficult it is to walk forward when it's really windy!)

Off-road conditions (grass, dirt tracks etc.) work best with 4x4 and rally vehicles as they are designed to work well in different weather conditions.

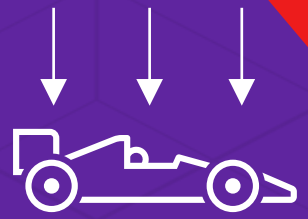
Tarmac is great when dry as it's more forgiving when a driver makes a mistake and allows for better control of the brakes. When wet, the track becomes slippery and can be hard to navigate safely.

Gravel, even when dry, can cause grip issues between the tyres and the surface because it tends to be loose. This means special tyres are needed to keep the car in control.

What factors affect the car's performance?

Drag (air resistance): A force that slows a moving object down, i.e. as the car speeds up, the air resistance works against this.

Gravity: A force that keeps the car (and us!) on the ground; the centre of gravity being as low as possible improves the car's performance, primarily via stable grip.



Mass: Gravity's effect on the weight of the car; this changes how fast the car is, but also holds the car to the track when going around corners.

Friction: The movement of tyres against the track creates friction which makes the car easier to control, but also creates heat which burns out the tyres when high speeds are maintained.

Torque: The force that causes the wheels to turn.

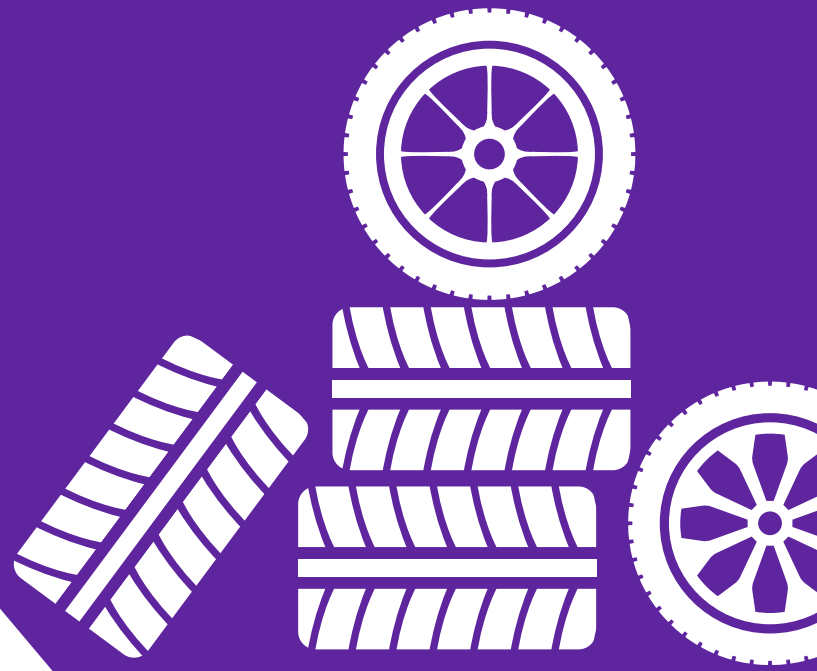
IMAGINE

Group activity

Get into groups and learn the performance factor you have been assigned. Once you understand this, send one member from the group to the other groups to learn about each factor and report back. Write down what you learn on the **Motorsport Cheat Sheet.**

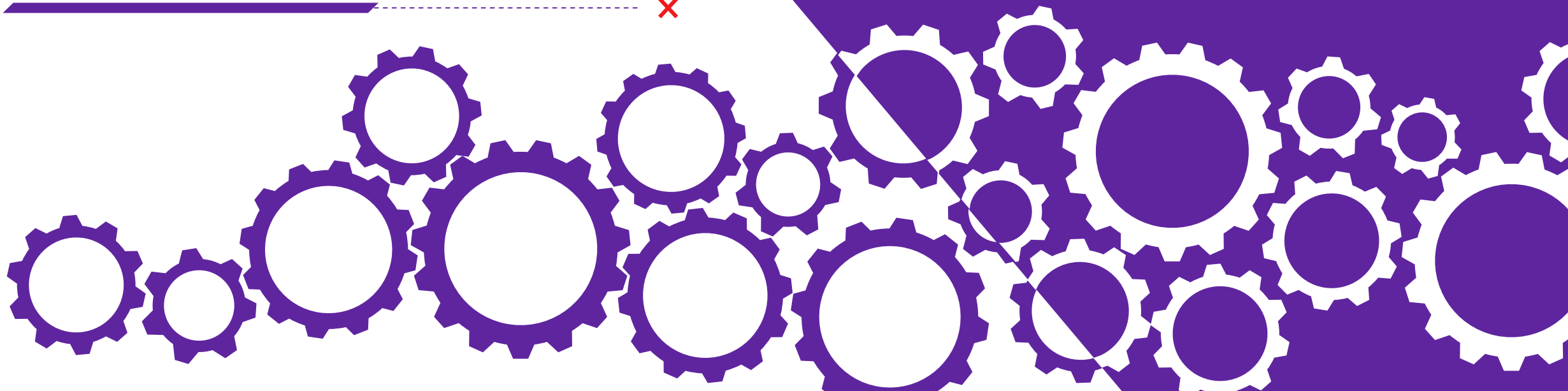
Tyres

- Your choice of tyre will make a huge difference to your vehicle and speed
- There are many different types of tyres to suit dry weather, wet weather and off-roading



Engines

- An engine is a machine with moving parts that uses fuel to turn power into movement
- Many motorsport championships have rules on the weight and power of an engine to keep the race eco-friendly, safe and fair



Vehicle body features

Vehicle design is very important to ensure a car can go fast - but is also safe.

- At fast speeds, air resistance can lift the car up (F1 cars are designed with a low centre of gravity to stop this)
- Rally raid cars are quite big and bulky as they absorb shock when travelling off-road
- Go-karts are quite light but also low to the ground and can travel quite fast

Did you know?

Spoilers, wings, diffusers, splitters and dive panes are all features that can be added to your car to help battle the issues caused by drag.

Overall mass

The mass of the car can greatly affect speed and fuel consumption. Many championships set power to weight classes to keep racing safe and fair.

The mass of the car generally indicates the size of the engine. While a heavy car can hold a larger engine for more power, a lighter car can get around corners quicker and brake in a much shorter time.

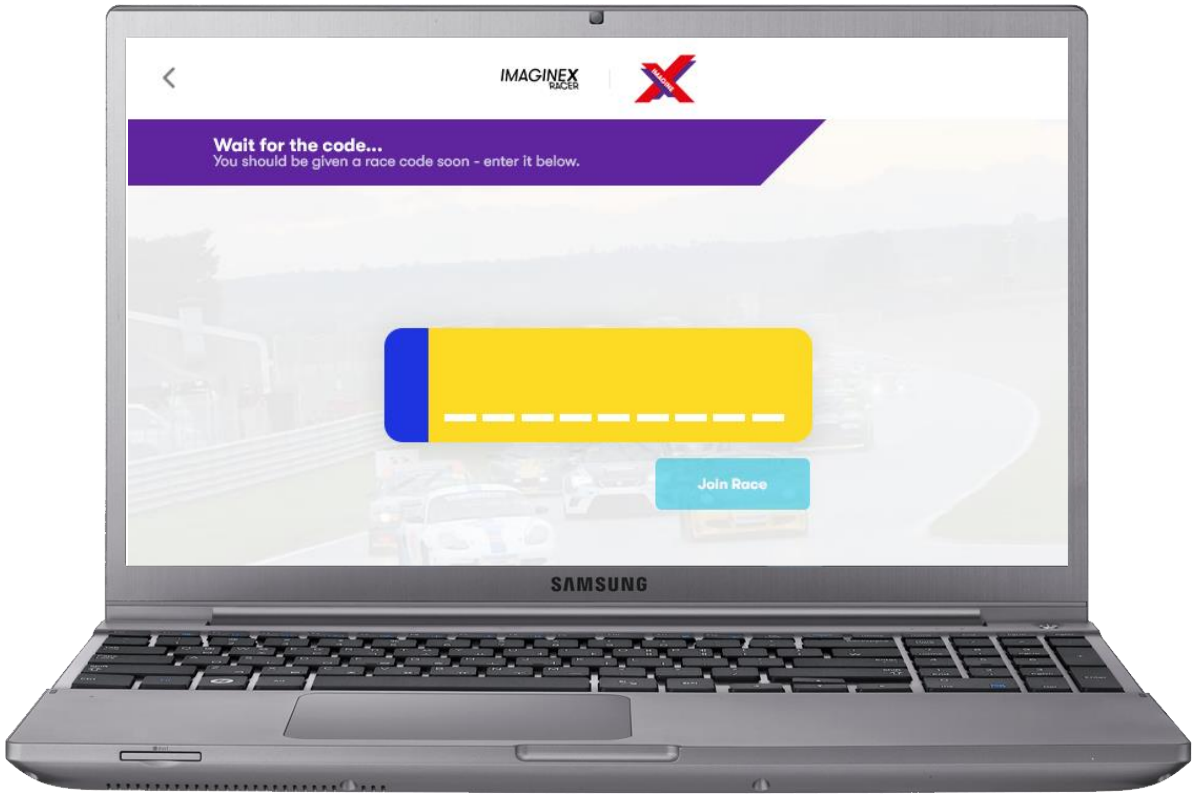
Certain tracks favour heavy cars with power and certain circuits favour smaller, lighter cars.

Group activity

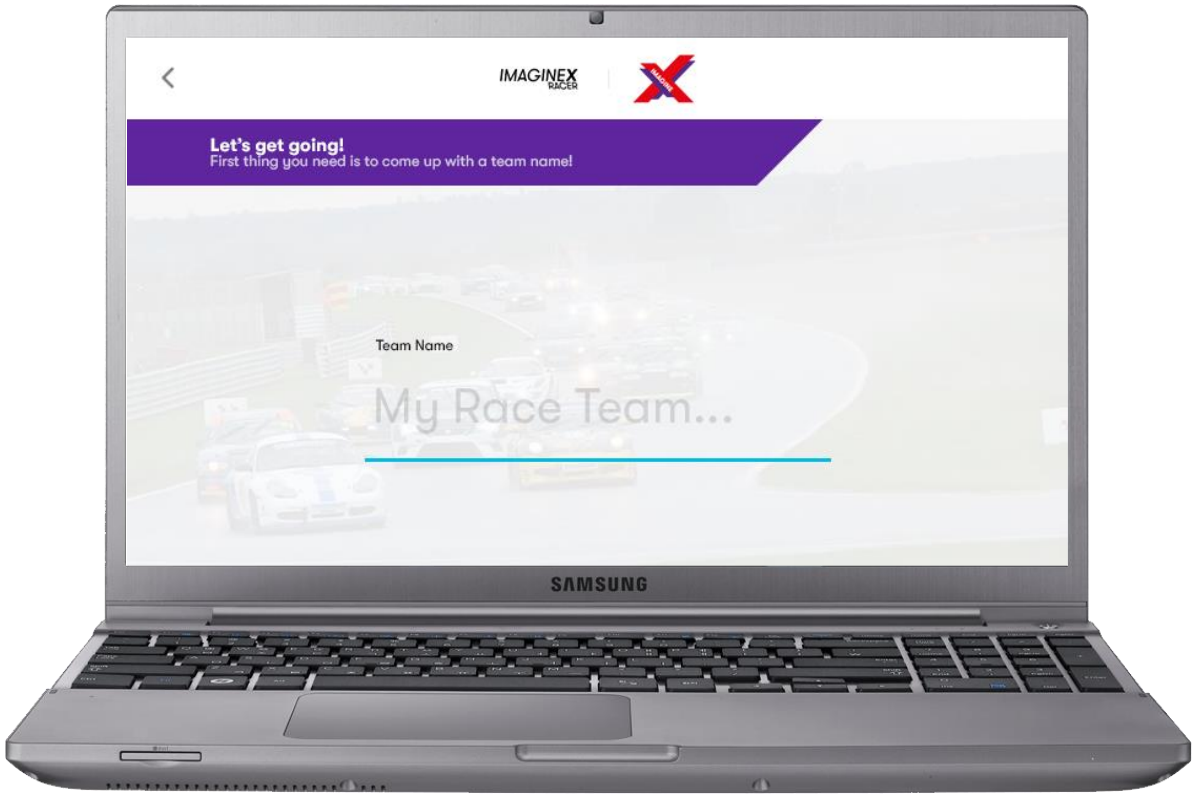
Get into groups and learn the vehicle attribute that you have been assigned. Once you understand this, send one member of your group to the other groups to learn about each attribute and report back. Write down what you learn on the **Motorsport Cheat Sheet.**

Time to get into your teams and put on your racing caps!

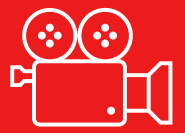
How to access the race



Enter the simple code to join your class game.



Choose a fun team name.
Please remember to be respectful of others and no bad words allowed!



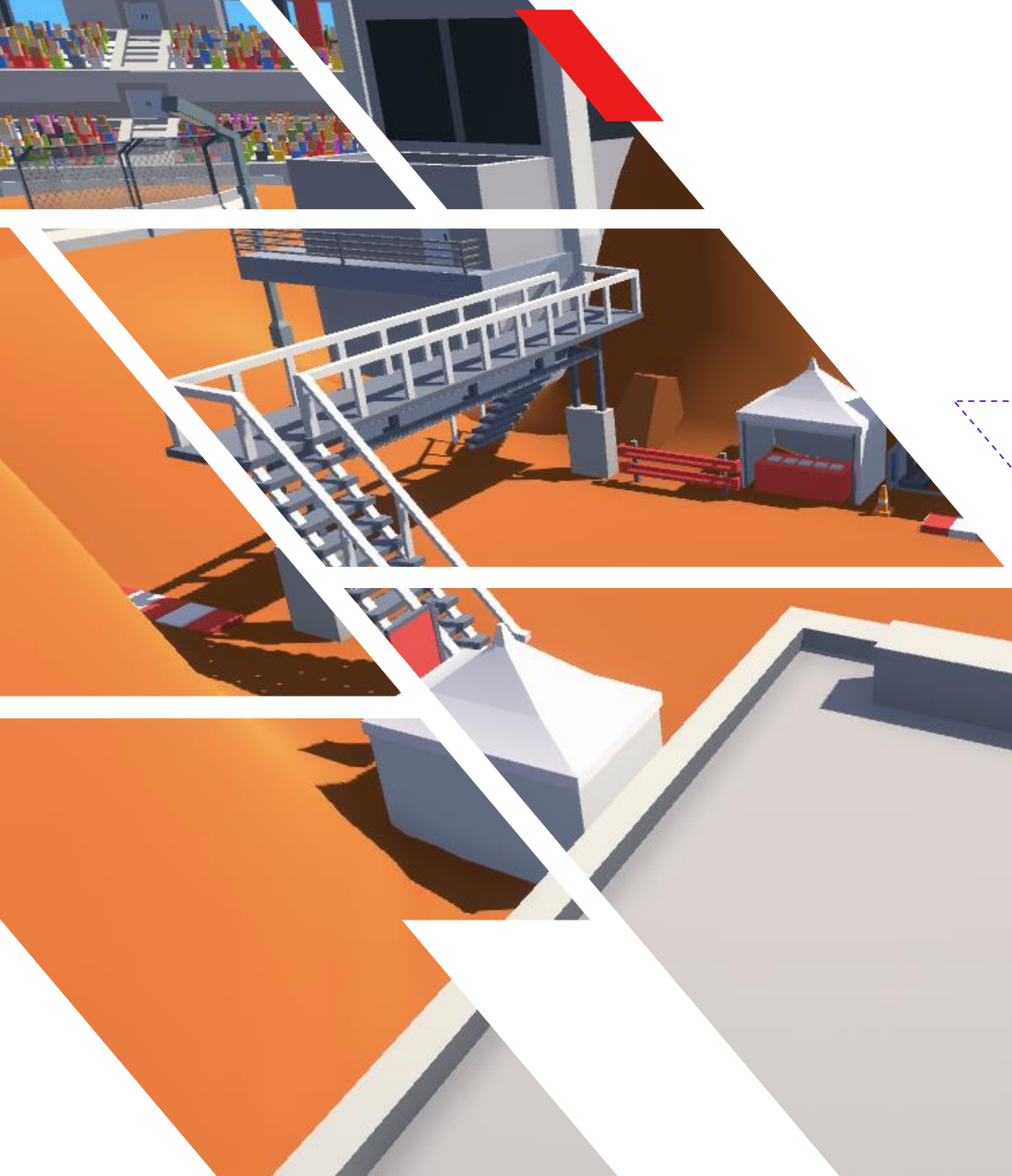
https://www.youtube.com/watch?v=vu5DKh8rAXc&feature=youtu.be

TRACK 1

Dry conditions on a standard tarmac track.

TRACK 2

Wet conditions on a standard tarmac track.

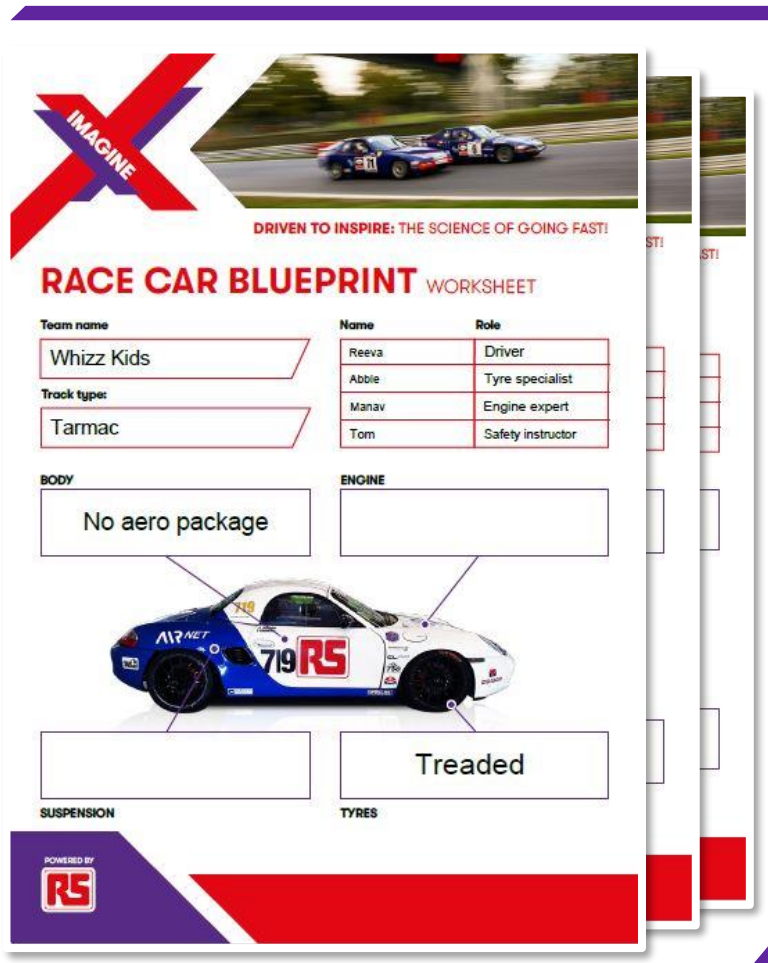


TRACK 3

A track which boasts rough and uneven terrain in dry weather conditions.

How will the conditions **impact** the performance of your car in a race

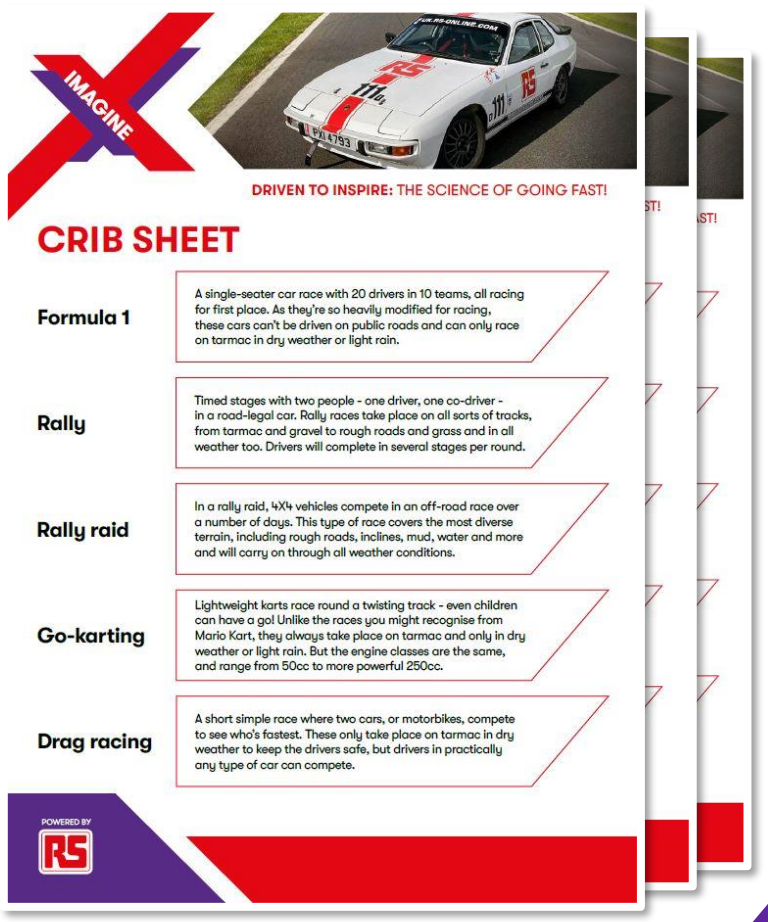
Think about the type of tyre that works best with your track; will your car need to be of a heavier mass to deal with all the lumps and bumps of off-roading?


IMAGINE
DRIVEN TO INSPIRE: THE SCIENCE OF GOING FAST!
RACE CAR BLUEPRINT WORKSHEET
Team name
Whizz Kids
Track type:
Tarmac
Name
Role
Reeva
Driver
Abbie
Tyre specialist
Manav
Engine expert
Tom
Safety instructor
BODY
No aero package
ENGINE
SUSPENSION
TYRES
Treaded
POWERED BY
RS


P ZERO
TAG HEUER
PayVoo


RAUCH


Mobil 1


IMAGINE
DRIVEN TO INSPIRE: THE SCIENCE OF GOING FAST!
CRIB SHEET
Formula 1
A single-seater car race with 20 drivers in 10 teams, all racing for first place. As they're so heavily modified for racing, these cars can't be driven on public roads and can only race on tarmac in dry weather or light rain.
Rally
Timed stages with two people - one driver, one co-driver - in a road-legal car. Rally races take place on all sorts of tracks, from tarmac and gravel to rough roads and grass and in all weather too. Drivers will complete in several stages per round.
Rally raid
In a rally raid, 4X4 vehicles compete in an off-road race over a number of days. This type of race covers the most diverse terrain, including rough roads, inclines, mud, water and more and will carry on through all weather conditions.
Go-karting
Lightweight karts race round a twisting track - even children can have a go! Unlike the races you might recognise from Mario Kart, they always take place on tarmac and only in dry weather or light rain. But the engine classes are the same, and range from 50cc to more powerful 250cc.
Drag racing
A short simple race where two cars, or motorbikes, compete to see who's fastest. These only take place on tarmac in dry weather to keep the drivers safe, but drivers in practically any type of car can compete.
POWERED BY
RS


P ZERO
TAG HEUER
PayVoo


RAUCH


Mobil 1

Let's get designing!

Feedback time

Look at the designs made by other teams, is there anything you like about them or think would work better?

Make sure to explain your thoughts to help your peers better understand what you're saying!

Stretch & challenge

Thinking about the feedback your team has received, can you link any of it to the physics terms you have just learned?

While you're thinking about this, also have a think about how you will fix these issues.

Time to reflect

Individually, think about how you worked together in your teams.

Did how you worked together affect the overall design of the car?

Next lesson

In the next lesson, you will be testing out your designs to see which team produced the fastest car!

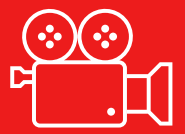
Good luck everyone!

Autonomous vehicles

Driverless cars are known as autonomous vehicles. They use sensors and software to control, navigate and drive the car, while you just sit there and relax!

They're not quite ready to go out into the world just yet, but when they do, it'll make getting to places a whole lot easier.

At this current moment, there are **five** different levels to the autonomous vehicle.



https://youtu.be/6592pKyQfyE

The five key levels of autonomy:

1. Driver assistance - Small amount of automation, i.e. parking sensors, cameras etc.
2. Partial automation – Using data sources for advanced cruise control (being able to lock in the speed on long strips of road etc.); this is the current level for most automated vehicles.
3. Conditional automation – Vehicle can drive itself, but the driver must be active to respond to issues and alerts.
4. High automation – Ability to drive without human interaction, however, only businesses and certain locations can use them; this car is unlikely to be owned by individuals.
5. Full automation – The car is able to drive itself in most (if not all) areas, without any help from a human, and anyone can own or access one.

Car or human?

The autonomous vehicle shows similarities to how we, as humans, move around.

Like a car's sensors, which can sense surrounding objects and produce readings of the car's performance, we use our **senses** (sight, smell, touch and sound) to make sure we don't bump into someone else; we also use sound to alert someone we're there, just like a car horn!

Can you think of other ways our senses are similar to autonomous vehicles?

Who could benefit from autonomous vehicles and why?

Think about:

- Different age groups
- How it could help those with disabilities
- Where different people live
- Could it help you**?**

Situational awareness

Situational awareness has three stages:

1. Looking and noting the basic information of what is happening around you
2. Thinking about these surroundings and understanding this information
3. Using the first two stages to understand what will happen next

For example:

The PDC Karting World Champion 2020 race has just begun.

Driver two is currently in second place. Looking ahead at the car in front, they notice a sharp turn up ahead, which Driver one has just taken too fast, causing the car to go wide across the outer area of the track.

Driver two begins to slow down and take the turn. They use the inner corner of the track to keep out of the way of the car in front that has significantly slowed down while turning, and manage to take the lead. Driver two and the other drivers will remember to slow down earlier on the next lap to make sure that no one is harmed.

Being aware

The driver has to be aware of their surroundings. Making sure they don't crash into objects on the track (especially when off-roading) or even into other cars is important, as the smallest object can cause a lot of damage to the car and the driver when going at fast speeds.

What parts of a racing car can help the driver to stay aware of their surroundings

Autonomous motorsport

Situational awareness plays an important part in the development of autonomous vehicles too!

It is replicated through the use of sensors and readings, but also through the help of the driver/ passenger who can take control if needed. These factors can alert the driver to any potential issues that occur, such as a closed road or an object that isn't visible to the driver, but is detected by the parking sensors.

Autonomous motorsport

Using autonomous vehicles in motorsport would mean the safety of the driver would no longer be a worry.

Some of the safety features could be removed if there was no longer a driver in the car, meaning the racing cars would be lighter and could go even faster.

Some questions to think about

- Do you think autonomous racing would still be fun?
- Would you watch it?
- Is speed the only thing that makes motorsport exciting?
- Do you think that it is fair to remove the driver from the sport?
- What elements of autonomous vehicles could be used in motorsport to improve the cars, without removing the driver?

Homework

Now that you've spent some time working as a team, for the next lesson, think about the **top three** things that make a good motorsport team. Be ready to put these into practice next lesson!

See you

In lesson 2

LESSON 2

Lesson 1 recap

The next few slides will be going over the things we learned last lesson.

Get ready to be tested on your memory!

What makes a good team?

- Being respectful and kind
- Listening to each other's opinions
- Using everyone's skills to the team's advantage
- Everyone having a role in the team that is important to the overall outcome
- Being honest and able to disagree if it means creating something better
- Learning together to improve
- Working well together to get the job done faster and better
- More brains means more new and exciting thoughts!

Can you think of anything else that makes a good team? (Think back to the PDC video!)

Types of car racing

Formula 1:
A single-seater car race with 20 drivers in 10 teams, all racing for first place.

Rally:
Timed stages with two people – one driver, one co-driver, in a road-legal car.

Rally raid:
4X4 vehicles compete in an off-road race over a number of days.

Go-karting:
Lightweight karts race round a twisting track – even children can have a go!

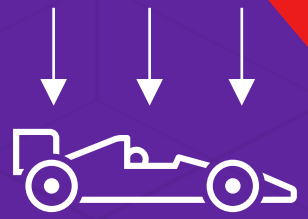
Drag racing:
A short simple race where two cars, or motorbikes, compete to see who's fastest.

- **Which races take place on tarmac?**
- **Which can still go ahead in the rain?**
- **Which race doesn't need any roads at all?**

What factors affect the car's performance?

Drag (air resistance): A force that slows a moving object down, i.e. as the car speeds up, the air resistance works against this.

Gravity: A force that keeps the car (and us!) on the ground; the centre of gravity being as low as possible improves the car's performance, primarily via stable grip.



Mass: Gravity's effect on the weight of the car; this changes how fast the car is, but also holds the car to the track when going around corners.

Friction: The movement of tyres against the track creates friction which makes the car easier to control, but also creates heat which burns out the tyres when high speeds are maintained.

Torque: The force that causes the wheels to turn.

IMAGINE

You're all caught up!

Time to get down to business

Simple changes make big differences

Jessie started off the go-karting race using slick tyres suitable for tarmac, meaning they don't have a tread pattern on them to create grip between the tyres and the ground. The weather at the start of the race was dry, however, half way through it begins to rain. Jessie begins to lose some of her grip on the track and steering becomes quite difficult.

Because of this, Jessie has to slow down to gain some control back over the steering and she goes from first place to fifth.

She makes her way to the pit stop, where the team quickly work together to change her slick tyres for wet tyres, which have deep treads in them to create grip.

Simple changes make big differences

She quickly gets back on the track, feeling a lot safer and in control of the kart, and speeds her way to victory!

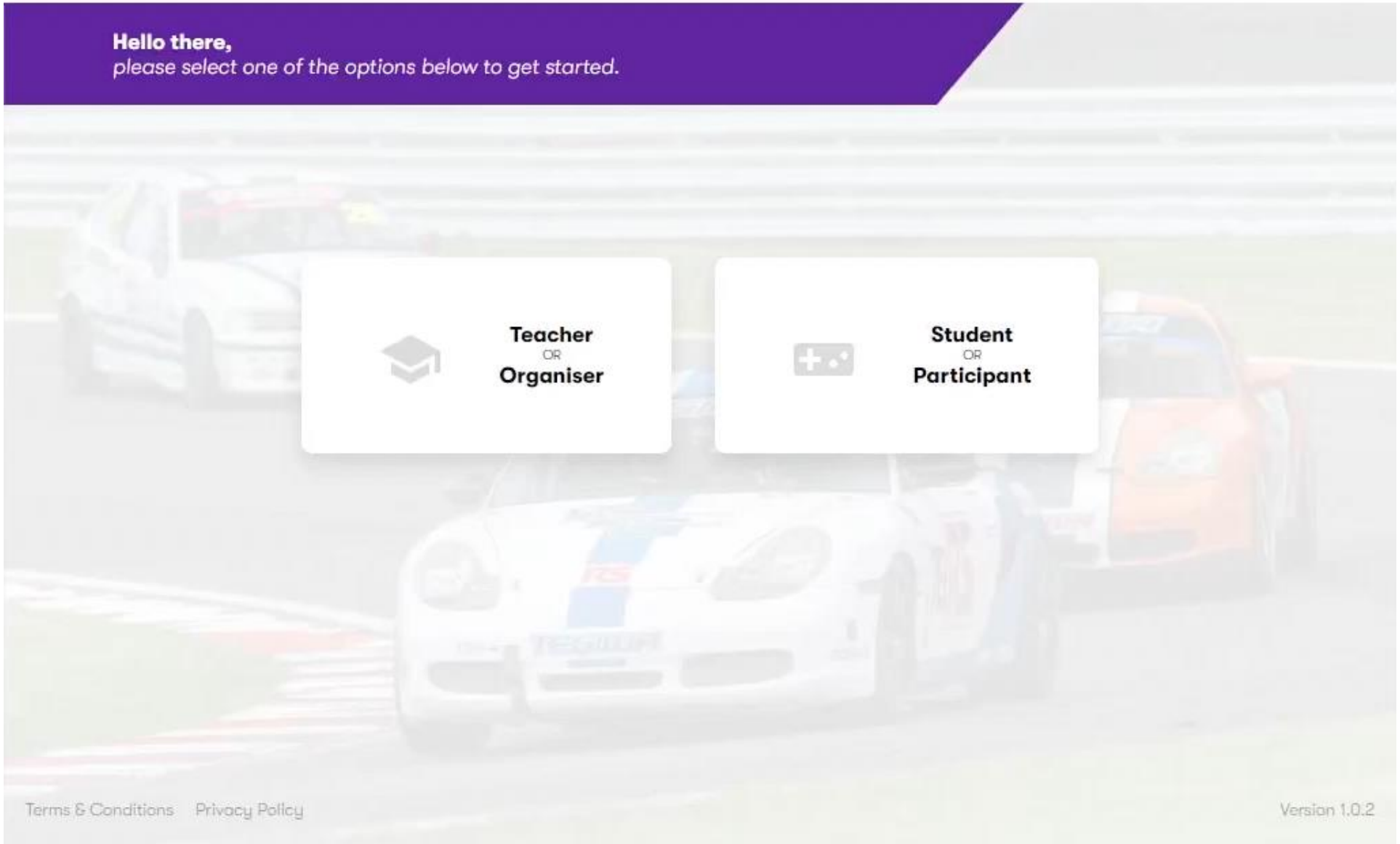
Can you think of ways that this could affect your car design?

Is the affect these simple changes have a good thing, or a bad thing?

IMAGINEX RACER

In association with

Hello there,
please select one of the options below to get started.



Teacher
OR
Organiser

Student
OR
Participant

Creating your cars

You will be using the materials available in the classroom; each tyre, body and other features will resemble the types of motorsport features on offer (F1, go-kart, rally etc.)

While creating these, think about how they will work on the track you have chosen to use.

Remember: Be respectful of the other teams and those around you and don't put others in harms way!

Time to get back into your teams!

Using your **Racing Car Blueprint** worksheet, **Motorsport Cheat Sheet and Racing Car Crib Sheet** from the last lesson, start creating your racing cars!

Don't be afraid to change features of your car to make it work better on your chosen track!

Let’s race!!!

Leaderboard

1st .....

2nd .....

3rd .....

Room for improvement

Look at your team's results - what could you have done to improve?

To conclude

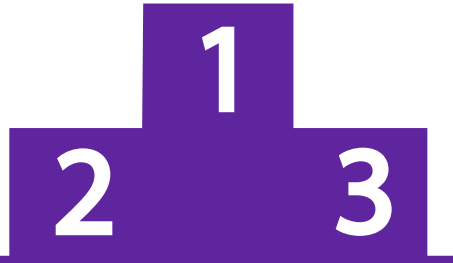
Driving conditions can range from wet, dry, off-road, tarmac, gravel etc. and all have different effects on the car's performance.

Physics plays an important role in motorsport, especially friction, drag, mass and torque.

The smallest change can make the biggest difference.

Motorsport teams need good teamwork in order to successfully create and maintain a winning car that can be used by anybody.

Let’s talk about inclusivity



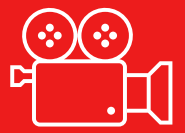
THE HAMILTON COMMISSION

Six-Time Formula One™ World Champion, Lewis Hamilton MBE HonFREng and the Royal Academy of Engineering have partnered up to create **The Hamilton Commission:** a research project that will work to identify the key barriers to recruitment and progression of Black people in UK motorsport, and provide actionable recommendations to overcome them. While The Hamilton Commission's research is focused on the experiences of Black people, we hope the findings will help to improve diversity across minority ethnic groups in UK motorsport.

The importance of inclusive racing

Inclusivity is the practice of everyone having equal access to opportunities and resources.

For those with disabilities that need the aid of a wheelchair, even entering a car can be difficult. However, motorsport is becoming more inclusive, thanks to the teams making scientific and mechanical progress in creating new and exciting features for racing cars – hooray for teamwork!



https://www.youtube.com/watch?v=jov89bJ0mBs

Nathalie McGloin

The first female with a spinal injury to be granted a racing licence in the UK and, four years later, she became the **first ever** female disabled rally driver!

Nathalie's car has been altered so that it can be hand-controlled so she doesn't need to use the pedals with her feet.

Can you remember what sense she uses to understand the car's movements?

How would you alter your racing car to make it easier to enter and use for those who have disabilities?

IMAGINE

Driven to Inspire: The science of going fast!

KS2