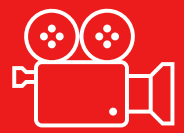
Driven to Inspire: The science of going fast!

KS3

Learning outcomes

- I will have gained knowledge on the scientific factors affecting motorsport
- I will be able to explain what makes racing cars successful or unsuccessful
- I will know the role driving conditions can play when driving a vehicle
- I will have developed the skills needed to analyse, measure and optimise scientific factors to make the racing car perform better
- I will be able to evaluate the work of my peers and give helpful, scientific feedback
- 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
- I will be able to explain the different types of driverless cars and driverless technology



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

LESSON 1

The different types of motorsport

- Formula 1
- Rally
- Rally raid
- Go-karting
- Drag racing

Motorsport Cheat Sheet

Group activity

One person from each group must find out about the different types of racing by asking other groups about the race-type they have been given.

Feed this back to your team who will complete the **Motorsport Cheat Sheet.**

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**

Also known as a rally raid, this is a form of racing that takes place off-road in 4X4 vehicles over a number of days; it is the most versatile in terms of terrain availability.

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, with the karts having different speeds ranging from 50cc to 250cc. It has also been popularised virtually by the Nintendo franchise with the famed series, 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**

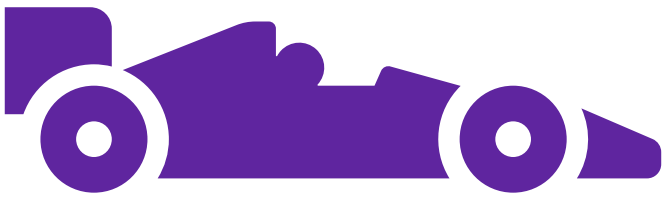
Usually a short, simple race that two vehicles, motorbike or car, compete in (think Fast and Furious!).

Driving conditions

What do we need to consider?

Do we need to think about the weather?

What about the track type?



What do you know about **motorsport** so far ???

What can happen during the race?

Some things to think about when designing your race cars…

Let's take a look at some of the factors that can severely impact the vehicle's performance.

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.

F1:
Wide and smooth tyres are designed to ensure a perfect performance. Tyres are designed to withstand the heat generated by friction on the track.

Rally:
The tread patterns in tyres are designed to suit use on gravel and tarmac. Tyres need to maintain grip in wet and slippery conditions and are usually of a specific size and measurement.

Rally raid:
Large, reinforced tyres with deep treads to help with grip, protection and control while off-roading.

Go-karting:
Karting uses two main tyre types: slick or wet. Slick are most common for dry conditions and are wide and smooth; wet tyres have deep treads to maintain grip in the wet through water displacement.

Drag racing:
These tyres have to pass Department of Transportation (DOT) regulations, focused on tread depth and hydroplane resistance to ensure safety in wet and slippery weather conditions.

Engines

An engine is a machine with moving parts that uses the chemical energy in fuel to turn power into movement (kinetic energy).

Many motorsport championships have rules on the weight and power of an engine to keep the race eco-friendly, safe and fair.

F1:
Since 2014, cars in F1 use 1.6 litre, double-overhead camshaft (DOHC) reciprocating engines, which have high power while using 40% less fuel than previous engines. They achieve this via a hybrid system and the use of KERS (Kinetic Energy Recovery System).

Rally:
There are a variety of engines used in rallying. Turbocharged engines are common. A turbocharger is a system that reuses hot exhaust gases kicked out by a car's engine. The gases are rerouted via a turbine in the turbo and the air is squashed down to give the driver more boost, torque and power.

Rally raid:
Because of their weight, 4x4s tend to be less fuel-efficient and tend to use 8-cylinder petrol engines.

Go-karting:
There's a range of karts to suit all ages who can then in-turn race the most appropriate sized kart with the safest engine for their age and cup class.

Drag racing:
Engines are customised for maximum performance and speed over a short distance.

Vehicle body features

A car is designed to perform its best in the safest way possible.

- F1 cars are designed with speed and air resistance in mind, as air resistance can lift the front of the car up; this is why the front tends to slope downwards and is positioned close to the floor to reduce the flow of air underneath
- Rally raid cars tend to be quite bulky, acting as a shock-absorber when off-roading, as well as a safety net that can handle more impact in comparison to a rally car, which tends to be built quite low depending on the suspension and driving conditions
- Go-karts are also designed to be as light as possible so that they can perform at maximum speed

Suspension choice

F1: The suspension is vital as it maximises the time that the wheels are actually on the ground, as the slightest change can greatly affect the aerodynamics of the car.

Rally: Suspension choice vary depending on driving conditions. Tarmac requires harder, stiffer suspension, with the car lowered for better handling, while gravel sees softer suspension for impact on landings after the jump.

Rally raid: Suspension is vital with this car, especially for off-roading as the large amounts of vertical acceleration, caused by quick-changing surfaces, need to absorb the shock. Springs, both air and coil, are utilised for this.

Go-karting: A go-kart doesn't have an obvious suspension system. The go-karts suspension comes from the flex in its chassis and axle. A soft chassis and axle will flex more than a hard one.

Drag racing: Suspension systems in drag racing relies on the terrain. If the cars are racing on a straight line with little-to-no terrain issues, then it will only need simple suspension design. However, if the terrain is uneven, it may mirror something similar to Rally cars.

Race suspension has two main roles. The first is to control the weight transfer of the car both laterally and longitudinally to improve cornering ability, while the second is to control the impacts from bumps or kerbs to maintain constant contact between the tyre and the road surface.

Rally cars drive off road so need longer and more capable suspension to help manage the uneven surfaces they travel over.

Good suspension helps to maximise friction and improves the car's grip.

Overall mass

F1: Designed to be as light as possible. F1 cars currently weigh 745kg, however, due to more crash testing measures being implemented, this will increase to 768kg by 2021.

Rally: Depending on their engine size and stage class, rally cars can weigh anything between 1000-1350kg. To put this into perspective a black rhino weighs between 800 – 1400kg!

Rally raid: There are no restrictions for vehicle mass. These cars tend to be extremely heavy in order to succeed in safely driving across various terrains.

Go-karting: One of the lightest vehicles in motorsport, weighing between 72-74kg for an adult kart. This is roughly the weight of a female sheep, which can range between 45-100kg!

Drag racing: There are minimum weights in drag racing, usually ranging from 453kg to 612kg, depending on sizes and class. A male polar bear, on average, weighs 450kg!

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, i.e. 300 BHP per ton.

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

Certain circuits favour heavy cars with power and certain circuits favour lighter more nimble cars.

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, 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 its really windy!)

Off-road conditions (grass, dirt tracks etc.) work best with 4x4 and rally vehicles as they're 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 hard to navigate safely.

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

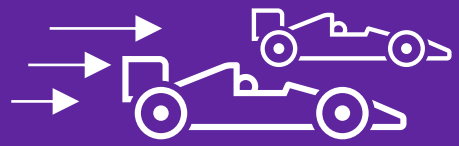
How the car works

Aerodynamics: Moving through the air with the least amount of resistance and generating forces to help stay on the track.

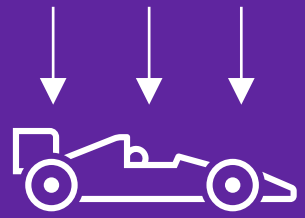
Grip: Ability to stay on the track in dry, wet or rough conditions.

Safety features : Additions that ensure the safety of the driver, such as protective gear, roll cage installation, harnesses, belts and car parts designed to absorb impact.

Acceleration: Ability to get away from the start quickly and get past other racing cars.



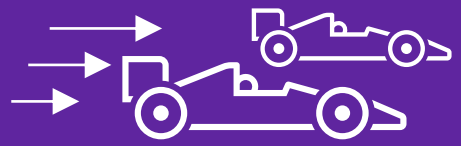
Weight: Altering the weight of the vehicle will drastically affect the speed and control of the car.



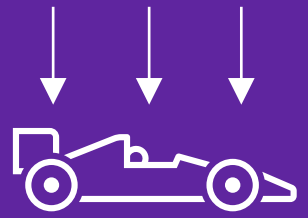
How it relates to physics

Friction: Contact between the tyre, the surface and air resistance (drag) between the racing car body shape and the air it is moving through.

Power: Rate at which the chemical energy stored in the fuel can be transferred to the engine to create kinetic energy that moves the car forward.



Mass: Gravity's effect on the weight of the car; this impacts the rate of acceleration, but also holds the car to the track when cornering.



Material design and composition:
Materials play a key part in the efficiency of a car's performance, with specialised scientists designing the most cutting-edge materials and processing techniques to support this sport.

For example:

- Carbon fibre is light but strong and is great for aerodynamics (hence why it is used on the car and the helmet)
- Iron based alloys are very strong and are used to make the crankshaft and camshafts
- Magnesium alloys are required by the FIA to be used in wheels

Group activity

One person from each group must find out about the different factors that can affect the performance of a race car by asking other groups to explain their given factor.

Feed this back to your team who will complete the **Motorsport Cheat Sheet.**

What impacts a vehicle's performance???

Discuss your findings with the class.

We have looked at the types of motorsport and what can impact performance, but what makes a successful race winner in motorsport?

Discuss your answers with the class.

The driver?

The driver is the person in control behind the steering wheel. They must perform well, even under extreme pressure.

They need to be experienced in:

- Driving at high velocity/ fast speeds
- Performing well under pressure
- Being physically fit to deal with G-forces and pressure fluctuations (especially F1 drivers!)
- Handling weather and terrain variations using ultra-fast reactions
- Understanding how the car is performing in order to get the best response out of it

Did you know?

Jamie Chadwick, born 1998, is a British racing driver who has worked her way up to become the current test driver for the Williams team. In 2021, she hopes to be the first woman since 1976 to race in Formula 1 Grand Prix.

The racing car?

A car is designed to perform its best in the safest way possible. Different race types require modifications to suit the race style. The smallest design feature can make a huge difference in how the car performs best on the track; from choosing a specific tyre to suit the weather, to the position of a spoiler to tackle air resistance.

Use of technology can also help give the most accurate performance readings during the action. These and many more features, paired with a team of highly skilled professionals, ensure the car is designed to suit its purpose and its race.

Money?

Making all those alterations to the car isn't cheap; neither is the car itself! But don't let this put you off racing – that's what sponsors are for! Pricing varies depending on the type of motorsport, as some are more high-maintenance than others. If you win the race, or come in the top three, you might even win a cash prize!

Research has shown that F1 racing car teams spend roughly around £223M annually, with a new budget cap of £119M being introduced in 2021. In addition to the car, there are the people who make and maintain them, that are experts in their fields. There is also the driver, all the fuel and extra tyres the car needs to survive countless laps.

Go-karting is perhaps one of the cheapest motorsport options, as prices range from £300-£3,000 for the kart, which is designed with the bare essentials to keep it light. However, don't forget about maintenance costs, competition costs, training costs, outfit/ protective gear costs – **it all adds up!**

Being the fastest?

Perhaps this is the most obvious one, but being the fastest is a large factor in reaching the finish line first. But it's not just the car that needs to be speedy. Some cars, like in F1, need the pit stop crew to be just as fast in making sure everything's in check!

Did you know?

The pit stop time in the 2019 F1 season averaged between 2-4 seconds. Red Bull held the record that year at a speedy 1.8 seconds!

Reliability?

The driver and the team have to think about how they can avoid personal injury or car damage by ensuring that they communicate and do a great job in solving issues as they arise at any point throughout the race, without wasting precious seconds.

Did you know?

Lewis Hamilton, a British racing driver, crossed the finish line with only three tyres in the 2020 British Grand Prix and still won first place!

Did you also know that Tyrell designed a formula 1 car, the Tyrell P34, that had **SIX** wheels**?** It even won a Grand Prix!

Why do you think that the designers thought six wheels would work better**?**

To tackle air resistance!

The designer, **Derek Gardner,** believed that more (smaller) wheels could reduce the amount of lift generated with normal front wheels - and he was right!

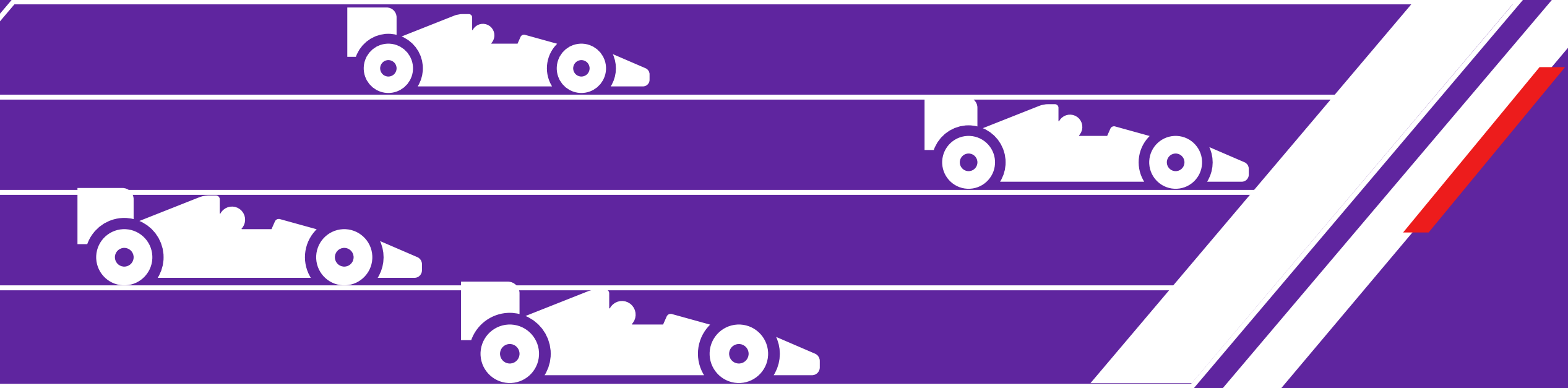
Group activity

One person from each group must find out about the different attributes of a successful race winner by asking other groups to explain their given factor.

Feed this back to your team who will complete the **Key Features of Success worksheet.**

So which one do you think it is?

Is there a particular reason for your answer?



Could it be a team effort?

Priceless skills

A combination of technical skills working together in a team are priceless.

Every member of the team has the ability to make a difference in each race with their knowledge, passion and ability.

Let's meet some of the PDC team!

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

Lets take a look at some of the different roles in the motorsport industry

One person from each group must find out about the different roles in motorsport by asking other groups about the role they have been given.

Feed this back to your team who will complete the **Motorsport Cheat Sheet.**

There are a multitude of engineers involved in motorsport supporting different roles. They can analyse data, study computational fluid dynamics, calculate the stress in suspensions and decide which tyres to use.

Engineer

The engineer oversees and takes on the responsibility for multiple areas, including pre-race data insight, vehicle mechanics and regulation compliance.

Software engineer

Software engineers are in charge of creating and improving software, both for use in vehicles and for outside software elements, i.e. testing sites, applications and servicing tools.

They must be able to:

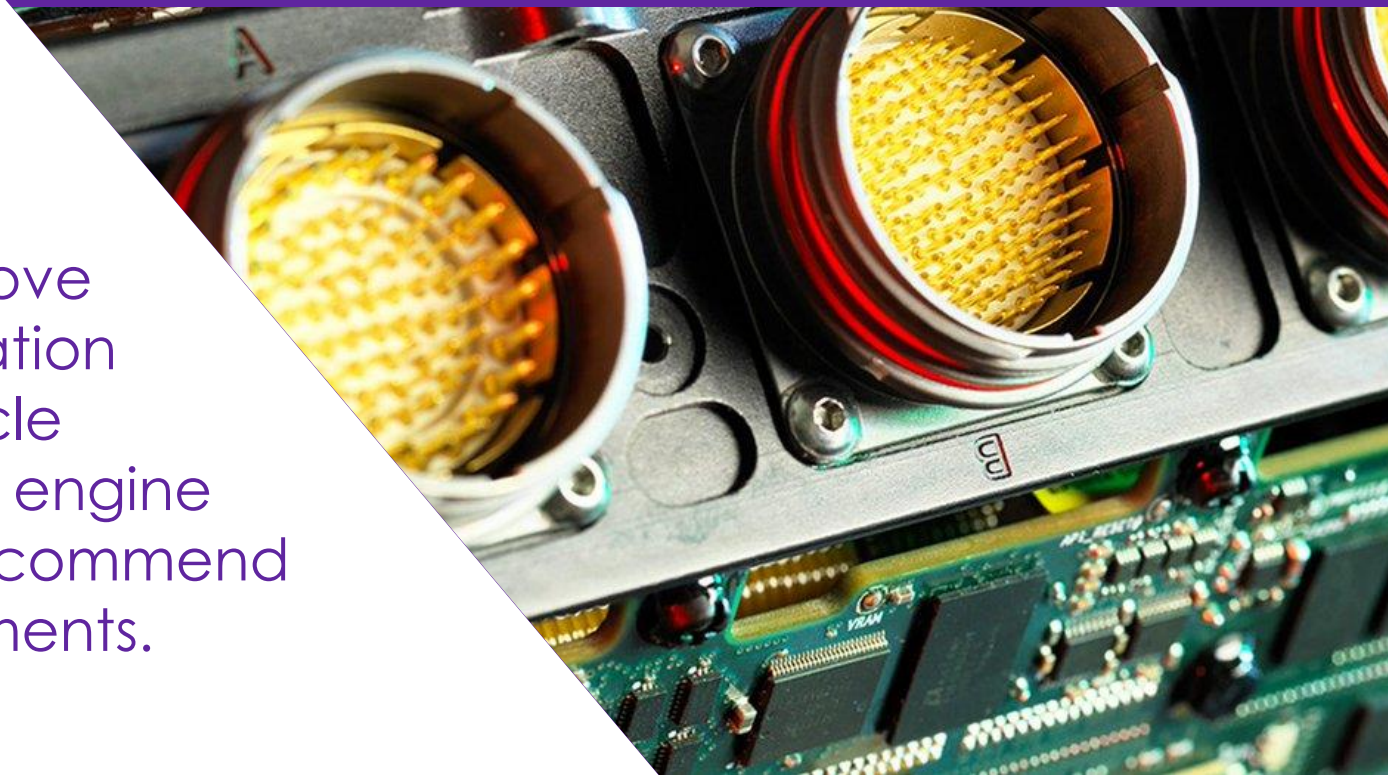
- Design, develop and code software
- Understand and analyse the data for improvement and errors
- Find new and promising solutions to improve existing and future software

Electronics expert

They must be able to:

- Spot errors
- Understand data
- Find quick and promising solutions

Electronics experts analyse and improve the engineering data through evaluation of all aspects that can alter the vehicle performance and safety (i.e. sensors, engine data etc.), which they then use to recommend and produce solutions and improvements.



Marshals

A grid marshal is in charge of the grid area at the start of the race. They will ensure all cars are in their correct positions and are safe and ready to race.

A pit marshal ensures the safety of everyone, such as the driver, pit crew and spectators within the pit by guiding the traffic.

Flag marshals have a front row seat to the race, communicating via various methods to the drivers when conditions change or issues arise.

Course marshals help with clean ups and removing failed/ broken race cars from the track when conditions have caused issues to arise. They also help with removing the driver from the car following a breakdown or incident and get them to safety.

Pit crew

Pit crews are comprised of a number of team personnel dependant on the championship/ race.

In Formula 1 a pit crew will have a team for changing tyres, a team for jacking the car up, a team for releasing the car and a team to check for any issues. F1 pit stops are very quick so large numbers and a coordinated approach is needed.

In an endurance championship the pit crew will include engineers, team managers, mechanics and others. This race is generally completed over a longer time period and drivers will swap out and take turns so that they do not tire out. Information can also be shared between the team if time allows for this.

It is paramount that the team works well during a pit stop. There are vital seconds to be gained by being efficient. Many motorsport teams practice pit stops regularly.

Did you know?

Refuelling mid-race has been banned in F1 since 2010!

Group activity

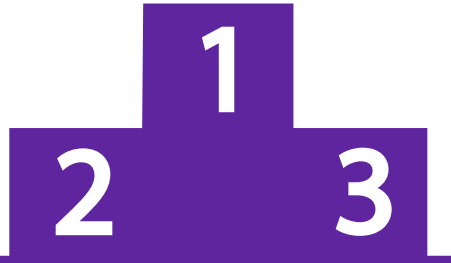
One person from each group must find out about the different roles in motorsport by asking other groups to explain their given role.

Feed this back to your team who will complete the **Motorsport Cheat Sheet.**

Time to pick your roles!

Split into groups of two to four and pick your team roles. Remember to think about what makes for a good motorsport team!

Let’s talk about inclusivity in motorsport



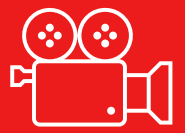
THE HAMILTON COMMISSION

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 license in the UK and, four years later, she became the **first ever** female disabled rally driver!

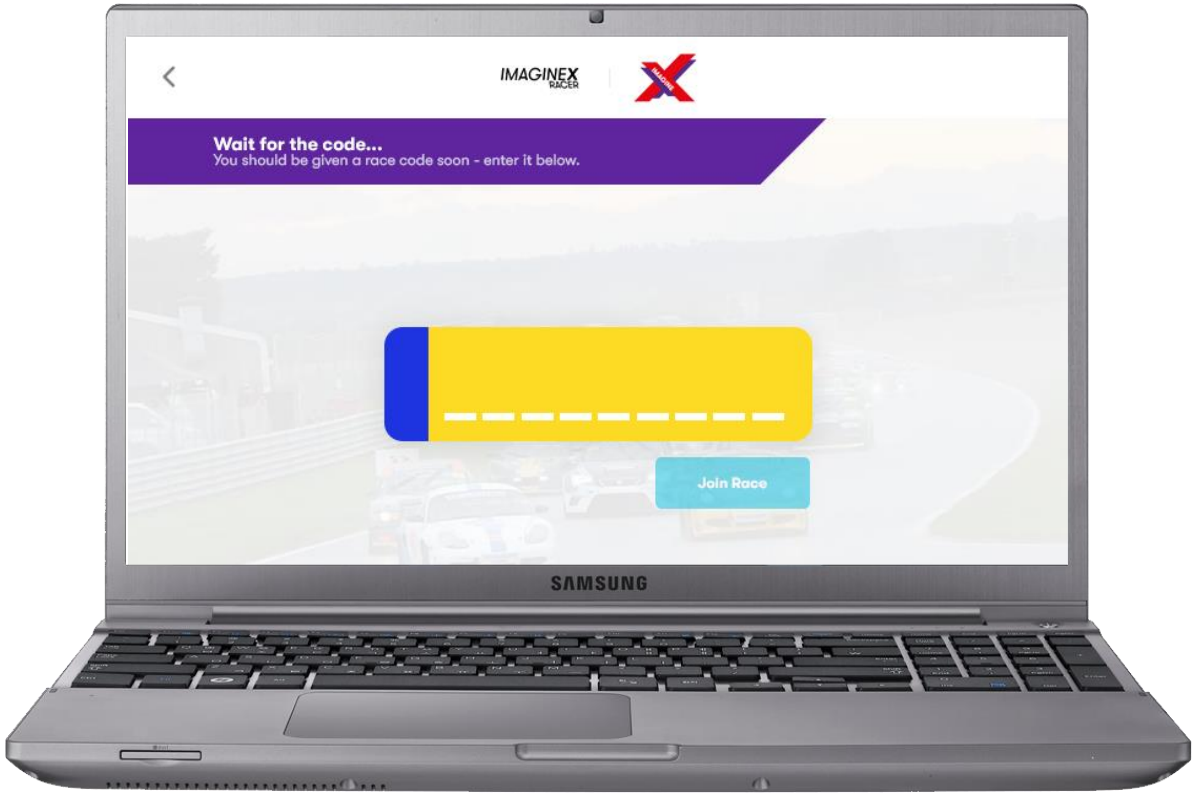
Nathalie's car has been altered so that it can be hand-controlled so she doesn't need to use the pedals with her feet.

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

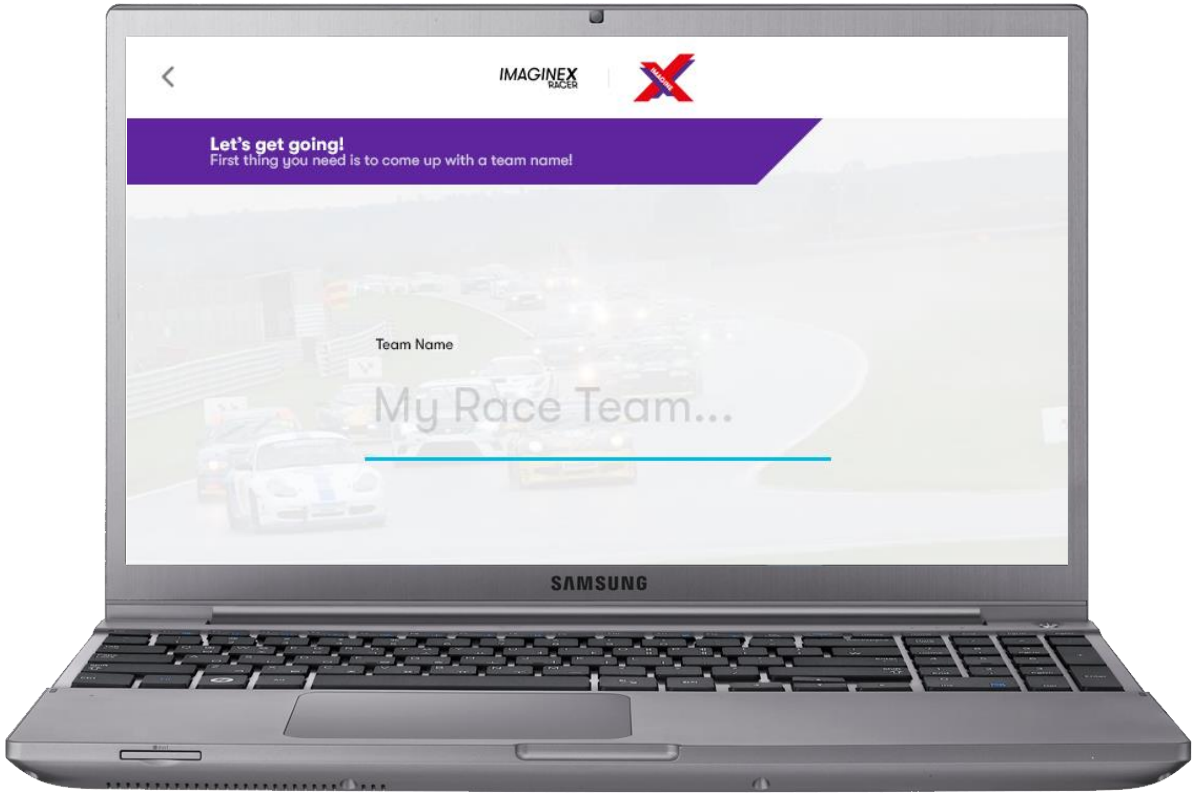
Can you think of ways you could make your car accessible

Discuss your answers with the class.

How to access the race

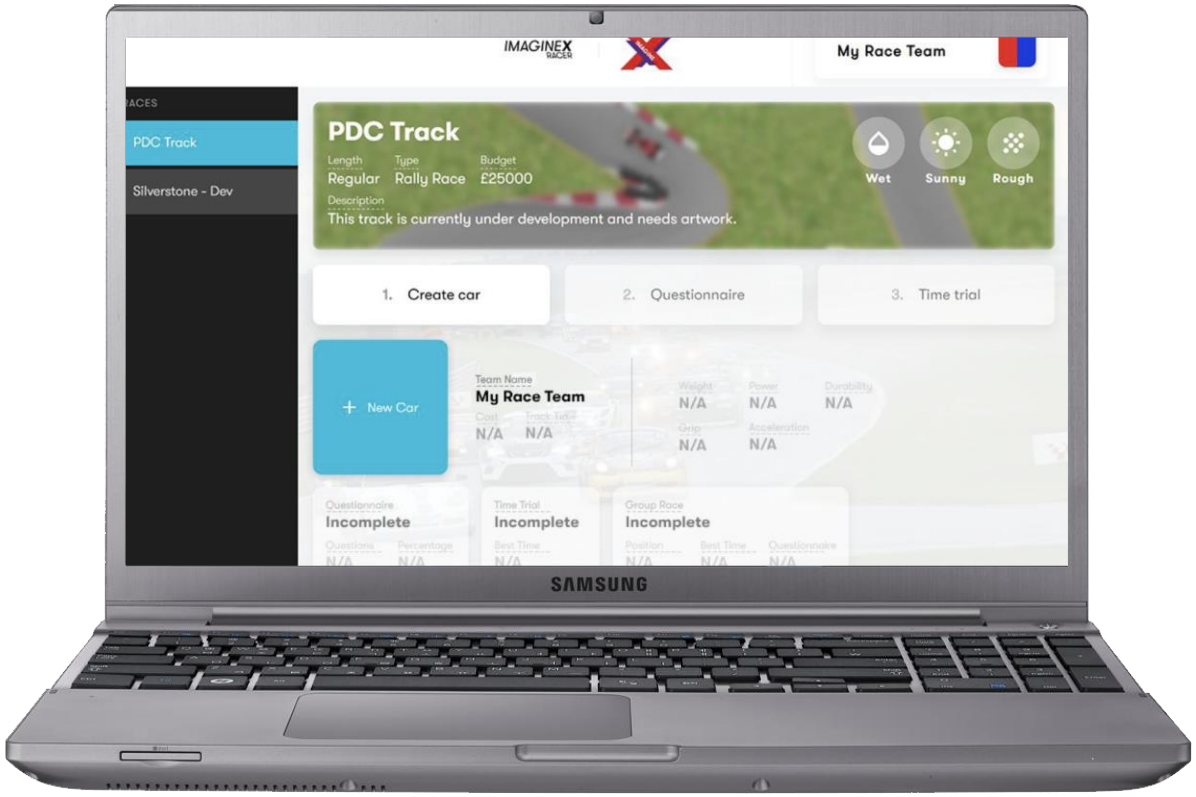


Enter the simple code to join your class game.

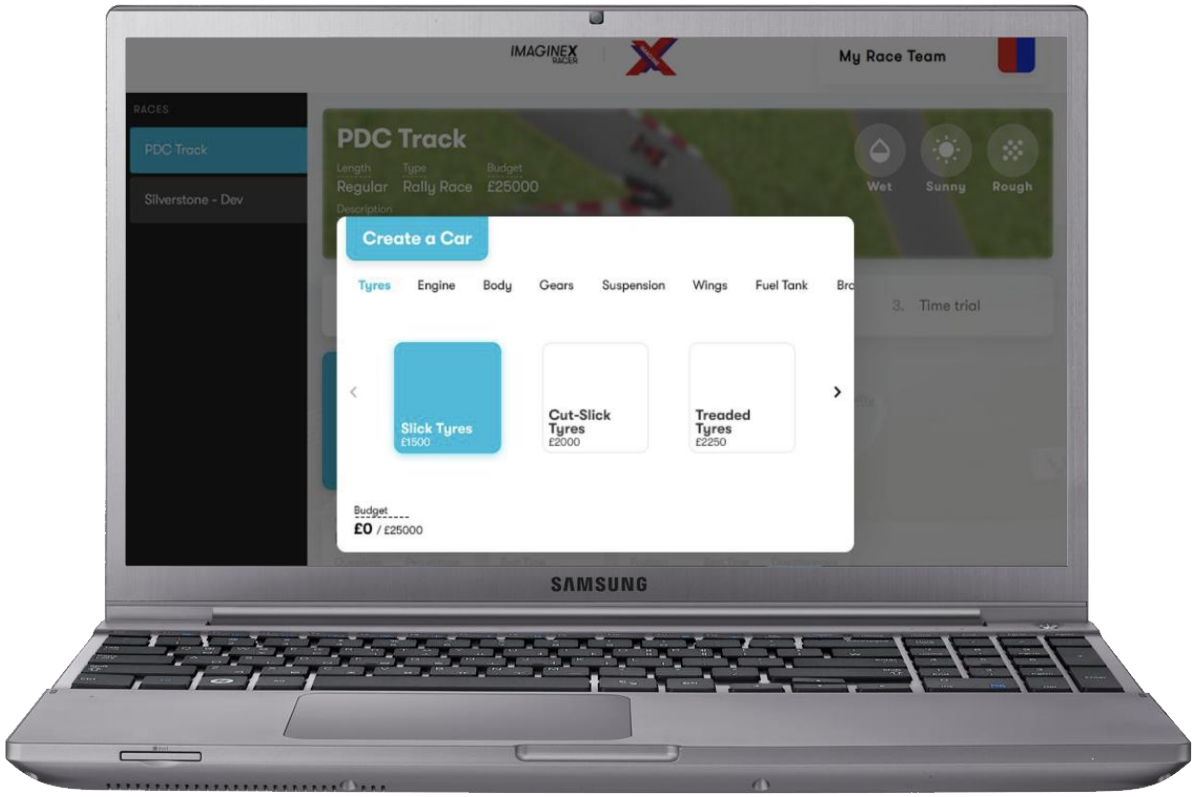


Choose a fun team name.
Please remember to be respectful of others and no bad words allowed!

Creating your vehicle



Select your chosen track and create a new car using the ‘New Car’ button.



Create your car by selecting the appropriate vehicle features from the options menu - keep an eye out for the price!

Before we start designing, there's just some key information that we're missing…

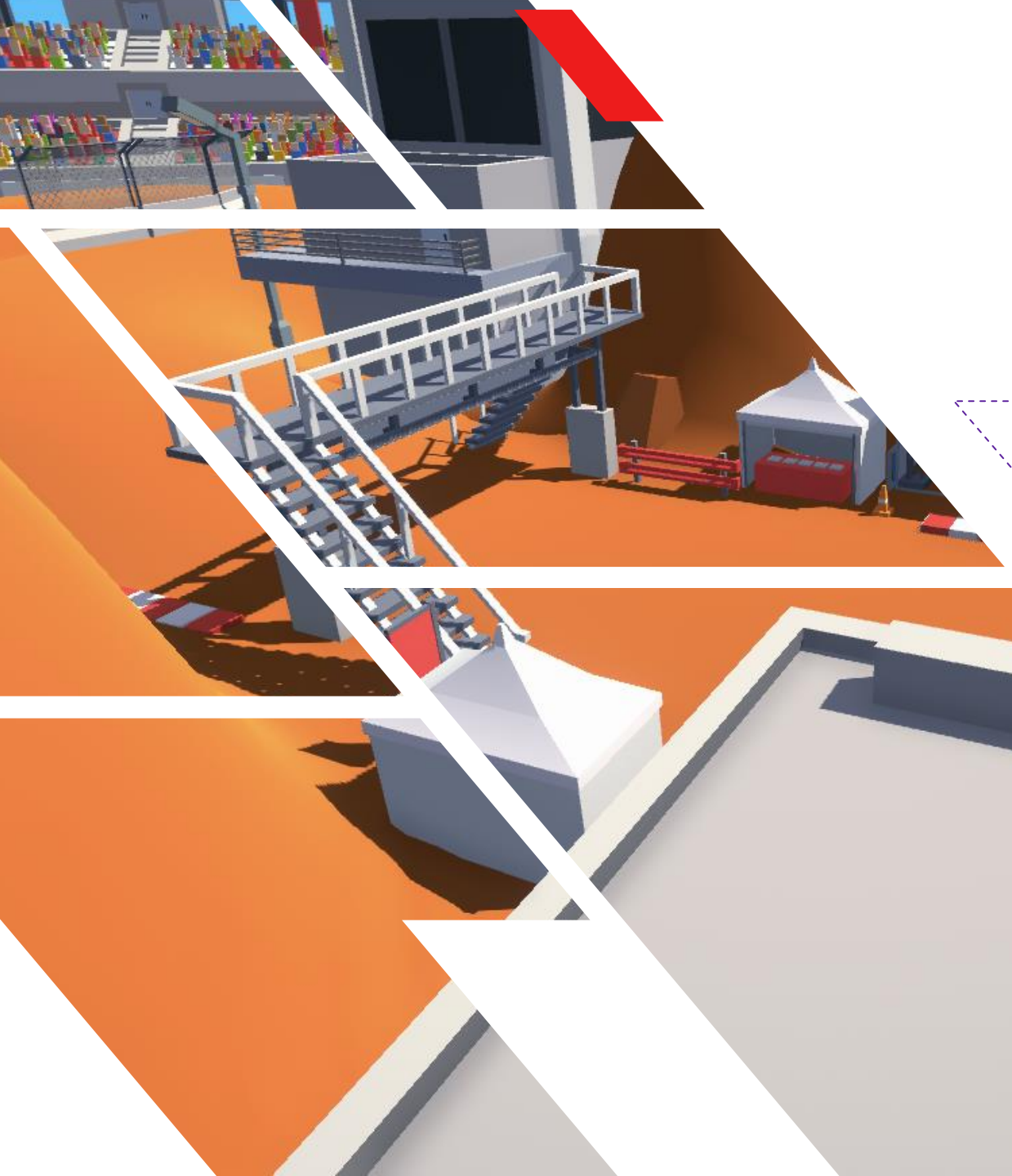
The track you will be racing on!

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.

Option 1

In teams, design a racing car for the track type given to you.

Remember to think about:

- Weather conditions
- How different car parts affect safety and speed
- The best way to win!

Option 2

Vote for the track type you want to design a racing car for – time to be as speedy as your car in order to win your chosen track!

×

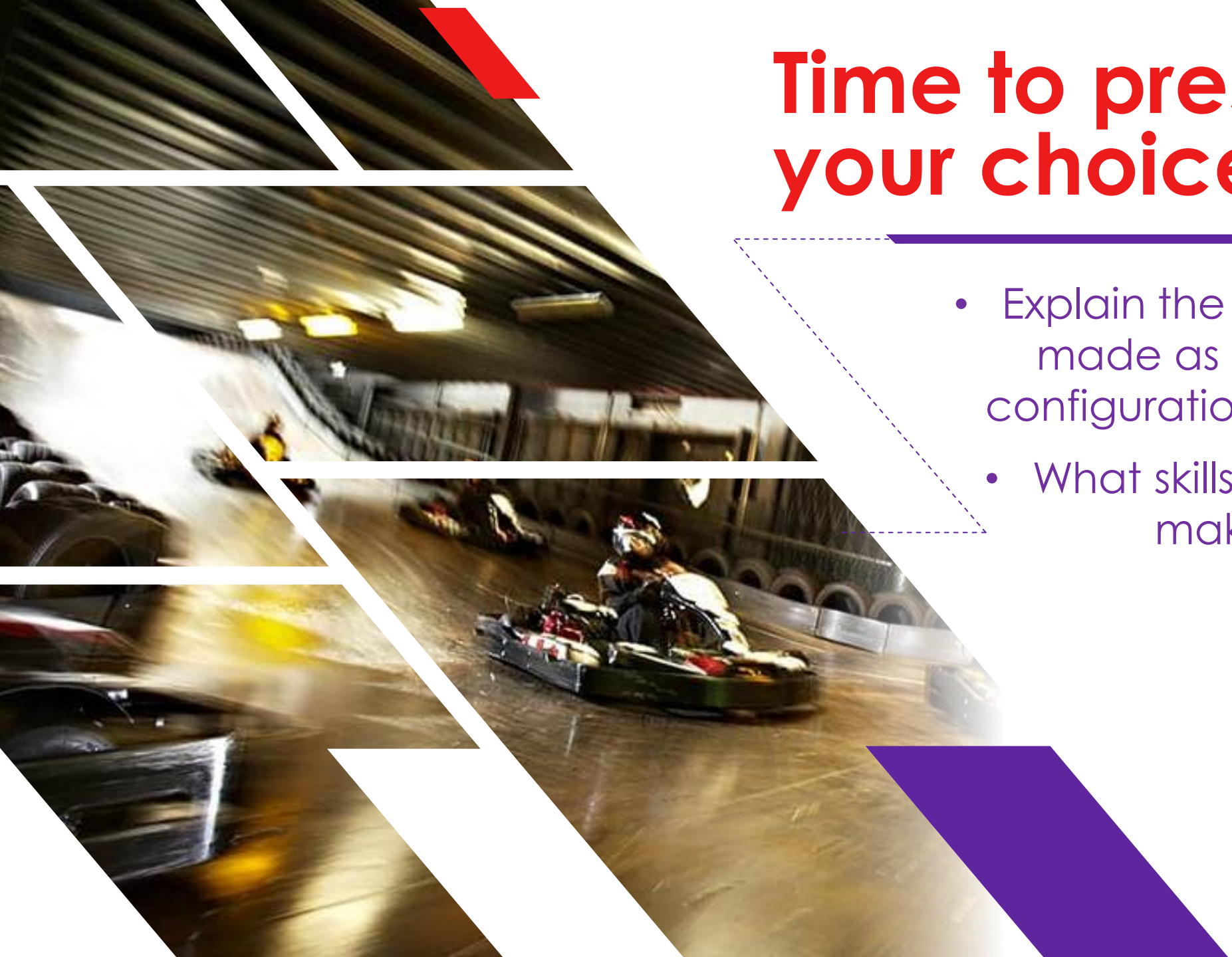
Remember to think about:

- Weather conditions
- How different car parts affect safety and speed
- The best way to win!

Remember:

Use the supporting **Key Features of Physics** worksheet and your **Motorsport Cheat Sheet** to help complete your **Design Team** worksheet.

Let's get designing!



Time to present your choices:

- Explain the choices you have made as a team during the configuration of your race car
- What skills have you used to make your team work well together**?**

Thinking back to our discussion on inclusivity, how would you alter your racing car to make it easier to enter and use for those who have disabilities?

To conclude:

- Driving conditions can range from wet to dry, off-road, tarmac, gravel and more; all of which have different effects on the car's performance
- Physics plays an important role in motorsport, especially friction, power, mass and materials
- Motorsport teams need good teamwork in order to successfully create and maintain a winning car; hopefully, you have demonstrated this in the design phase and will carry this over to the next lesson where we're putting these cars to the test

Homework

Using the worksheet provided, think about how the mechanics need to work as a safe and efficient team for a pit stop:

- What roles need to be performed in the pit stop**?**
- What order do activities need to occur during the pit stop**?**
- What makes a quick pit stop**?**
- What makes a successful pit stop**?**
- What role would you pick in the pitstop and why**?**

See you

In lesson 2

Stretch & challenge

In 2004, the USA's military research team, DARPA, started the Grand Challenge for driverless vehicles to cover 132 miles of rough desert terrain. The challenge laid the foundations for the latest driverless car technologies being investigated.

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.

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.

Think about…

…how these levels might be applied or modified to what a human does when walking around the classroom.

Some examples:

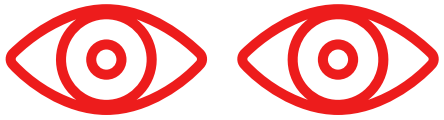
- How do you know where you're going?
- How do you use your senses?
- How do you know you're moving at a safe speed?

The future

- How might autonomous vehicles change motorsport**?**
- What aspects do you think people might be interested in with driverless motorsport**?**

Discuss your ideas with those in your group.

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 anticipate 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 coming up which driver one has just taken too fast, causing them to go wide across the outer corner of the track.

Driver two begins to slow down and take the turn. Using the inner corner of the track, they keep out of the way of the car in front which 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.

For example…

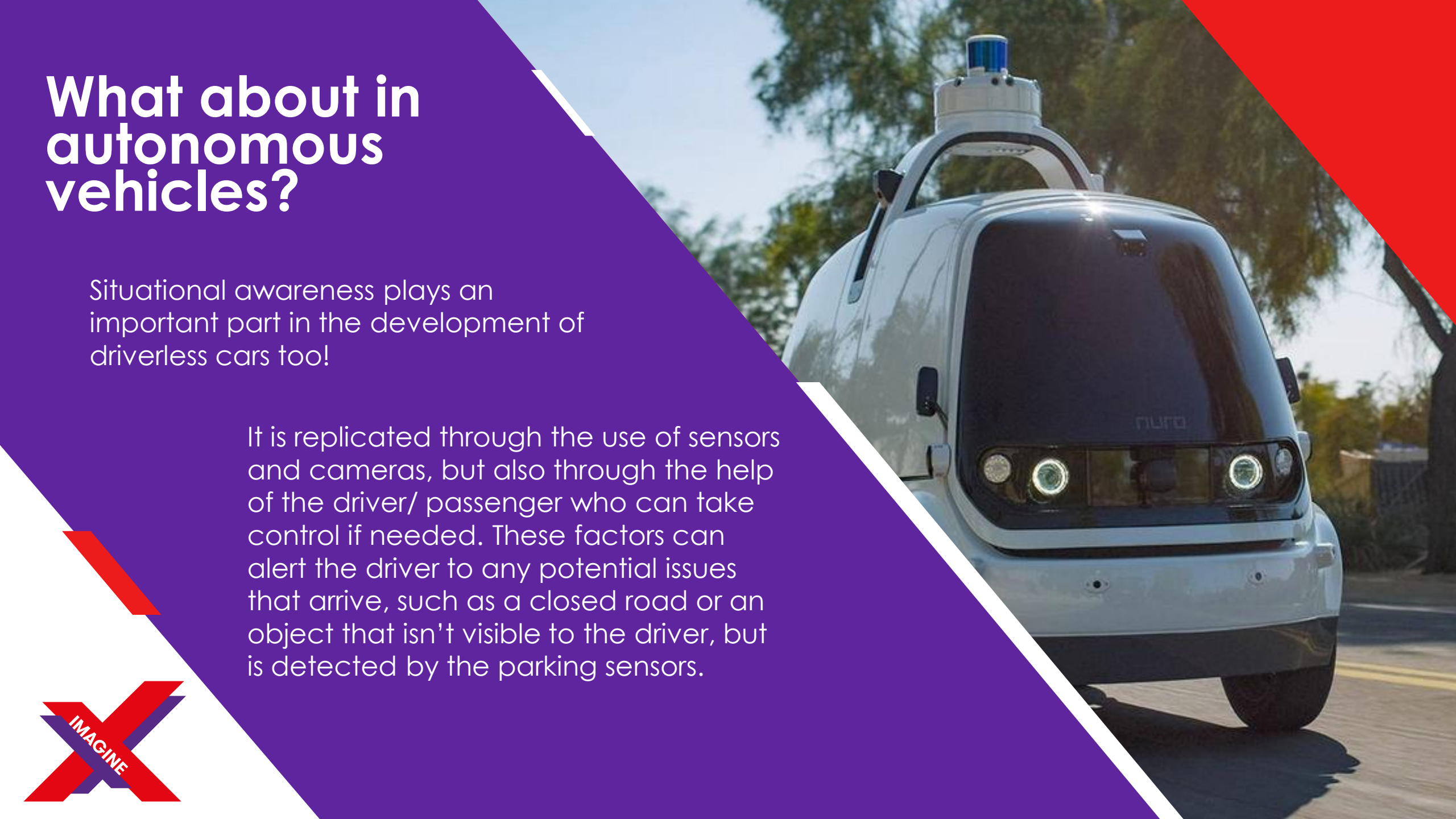
The driver has to be aware of their surroundings. Making sure you don't crash into objects on the track (especially when off-roading) or even into other cars is vital, as the smallest object can cause severe damage to a car and the driver, especially when going at fast speeds.

What elements of a racing car can help the driver to stay aware of their surroundings**?**

What about in autonomous vehicles?

Situational awareness plays an important part in the development of driverless cars too!

It is replicated through the use of sensors and cameras, 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 arrive, 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 could go even faster.

Some questions to think about:

- Do you think autonomous racing would still be fun?
- Would you watch it?
- Do you think that it is fair to remove the driver from the sport?

- Is speed the only thing that makes motorsport exciting?
- What elements of autonomous vehicles could be capitalised upon to improve motorsport while still including the driver?

LESSON 2

Lesson 1 recap

What did we look at last lesson?

- **Teamwork**
- **How the car works**

The importance of teamwork

If a team isn't working well together, there's a good chance that something could go wrong, the overall finish time is increased and health and safety issues may arise.

What were your findings from the homework given at the end of lesson 1**?**

Thinking back to lesson 1, what did you think made a winning race car**?** Do you still think the same**?**

What can you remember ? how the race car works

How the car works

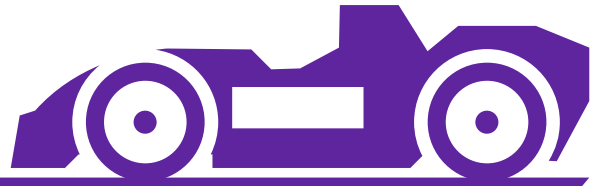
Grip: Ability to stay on the track in dry, wet or rough conditions. This is achieved by increasing friction between the tyre and the surface.

Acceleration: Ability to get away from the start quickly. This is determined by the car's power – that's the rate at which the chemical energy stored in fuel can be transformed into kinetic energy which moves the car forward.

Weight: Altering this will affect the speed and control of the car; Gravity's effect on the weight of the car determines its mass.

Safety features: Elements of the car are designed with the driver's safety at the forefront. Material design and composition play a key role in keeping the driver safe, but also ensuring the efficiency of a car's performance.

You're all caught up!

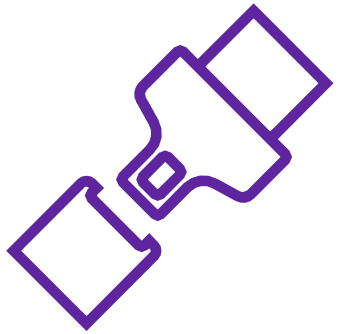


Time to get down to business.

Today we will be looking at:

- Safety
- Variables
- Testing and amending

Keeping safe

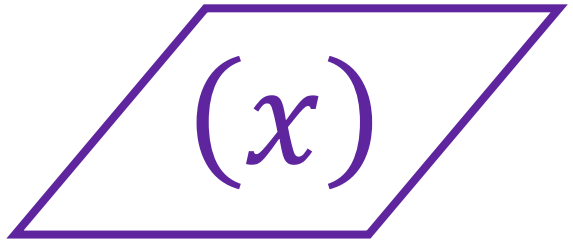


Some ways that drivers stay safe inside their vehicles include:

- Safety cage and structure
- Advanced braking systems (ABS)
- Using the correct tyres for the right conditions
- Suspension for stability
- Six-point harness seat belts or similar high-tech belts

Can you think of any other ways drivers are kept safe**?**

Think about variables



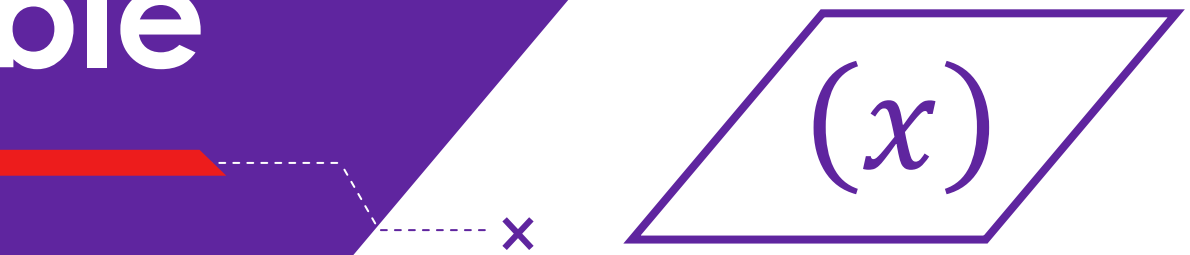
A variable is something that can be changed or adapted. In motorsport, variables can make a huge difference to the performance of the car.

The relationship of changing the driving conditions can be seen via the tyre choice, while keeping the same control over the car.

Which variable is:

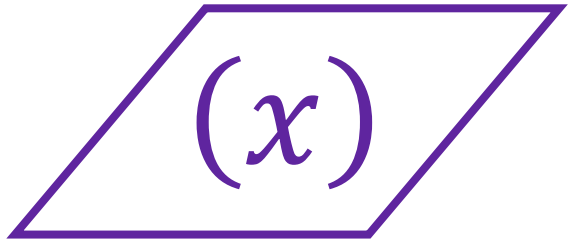
- Independent**?**
- Dependant**?**
- Controllable**?**

Independent variable



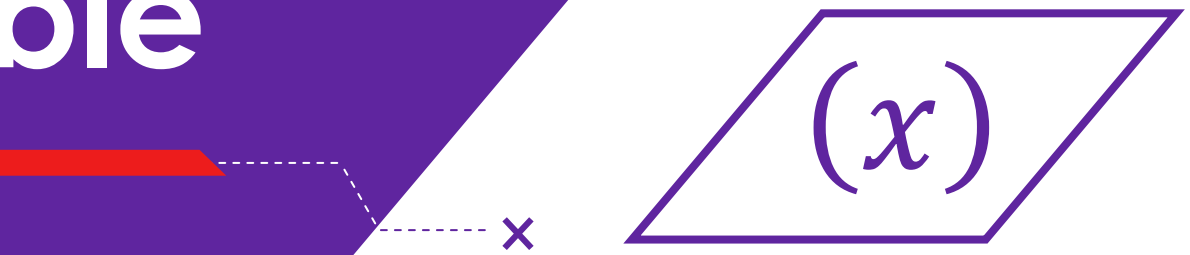
The independent variable stands alone and isn't affected by other variables. In this case, the independent variable is the weather, as no matter what changes you make, it won't affect the weather conditions.

Dependant variable



This variable depends on other factors.
In this case, it would be the tyres, as they are chosen and amended based on track and weather conditions.

Controllable variable

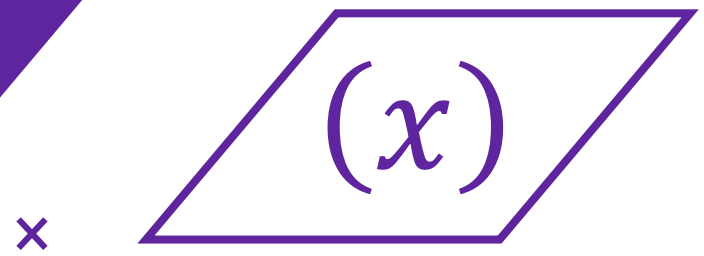


This is the variable that can be controlled. In this instance, it is the control over the car, which is maintained through the dependant variable in conjunction with the independent variable!

What could we change when designing our cars ???

Discuss the possibilities with your team.
Each team must present one variable
to the rest of the class.

Think about variables



Take a look at the following case study.
What are the variables in this instance**?**

Write your answers down and share with the class.

Speed vs Safety

In both 2017 and 2018, the PDC racing team won the Porsche Championship with an incredibly light Porsche 924 fitted with a fibreglass bonnet and Perspex windows. Pip Hammond, the team's fastest driver, recorded an impressive lap time of **1 minute 44 seconds** in the Porsche.

The changes

New rules for the 2020 championship meant the PDC team had to add **100kg** to the car. They added a steel bonnet and glass windows to make up the weight and had to swap their tyres for narrower ones to meet regulations.

The outcome

The car was safer through corners with its increased mass but took longer to speed up and slow down. The thinner wheels also meant less grip on the track's surface. With these changes, Pip's best time was **1 minute 48 seconds;** four seconds slower than before.

Did you spot the variables?

Did you notice ???

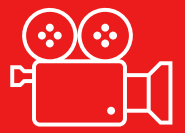
Were there any trends you noticed from this**?**

Looking for trends and performance differences is a vital job for the racing team. It allows them to see what works well and what needs changing to win the race; noting even the slightest change to weight, suspension, tyres etc. can make a huge difference to the overall race time!

Testing the variables will be an important aspect in ensuring your cars succeed!

When analysing the performance of your car, it is encouraged that you record your findings on the back of your **Design Team** worksheet. Here is an example of how you may do this:

Test number	Text description	Prediction	Outcome
1	Reducing the engine size	Car will be lighter and use less fuel	A lighter car is usually easier to control in corners unless it has a lot of power



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

Time to take the wheel!

Don’t forget to select the track you were given in lesson 1 and remember, there is a time limit with this, just like a rally race. So don’t miss out on making it to the starting line!

Remember:

It's okay if you change your original design to improve the performance of your car, but be sure to use the back of your **Design Team** worksheets to record what key feature you have decided to change.

Make sure to note the impact it has made on the finishing time and record your final race configuration!

Feedback time

What key feature made the most difference to your finishing time?

How does this link to physics?

What about **fuel** usage

What is the worst thing that could happen in relation to the fuel usage**?**

Fuel types

- The two most common types of fuel for road cars are Unleaded and Diesel
- The fuel used in Formula 1 is similar to the sort of premium Unleaded you can buy at a petrol station. Samples are requested during race weekends to make sure the octane is within the permitted level
- As of 2019 F1 cars were allowed to use up to 110KG of fuel per race. That's around the same weight as a Panda!
- Refuelling is now banned in Formula 1 for safety reasons, so all cars must make it to the end on one tank of fuel. This requires testing to find the right strategy for different circuits based on fuel usage. A circuits surface, weather, layout and other factors can all influence how much fuel the car burns
- In other areas of motorsport fuel strategy can be a big decision that impacts success. Low fuel makes the car lighter and quicker but it has to stop sooner to refuel. Lots of fuel means the car could run longer into the race but would weigh more. Teams have to consider weather, the particular track and many other things when deciding on their fuel strategy

Fuel strategies

PDC raced in Belgium at the legendary Spa-Franchorchamps in 2019. Their car could only hold so much fuel so it had to run for 20 minutes as a minimum before pitting in order to allow the car to be refuelled to get to the end of the race. The team put enough fuel in for 45 minutes to allow themselves the flexibility to stop in reaction to incidents on the track. This meant the car wasn't as light nor as heavy as it could be but there was a lot of flexibility for strategy. The team pitted the car after 40 minutes when a safety car came out (safety cars slow down other cars). This meant they gained five places and a lap on others despite not being the fastest car in the early stages. They filled the car up in this pit stop and ran till the end of the race with no further stops required.

One more thing…

…the amount of fuel your car uses will also be an important factor in deciding the winner!

Think about how the engine size, distance and the overall performance of the car can determine the fuel usage.

Ready, Set, GO!

It's time for the final race.

Using your final race configuration, run the race on your decided track to obtain your final finish time.

Good luck!

On a budget

Each team will be given a budget ranging from **£30,000** to **£80,000** depending on how well you did in the race.

Adapt and amend

Take a look at the **Cost of Value** worksheet. Each team will now have a budget to adhere to when configuring the race cars.

Calculate the cost of your final race configuration and adjust the vehicle to meet the budget conditions.

Worked Example - Cost of Value

1st place: **£250,000**
2nd place: **£100,000**
3rd place: **£50,000**

DRIVEN TO INSPIRE: THE SCIENCE OF GOING FAST!

COST OF VALUE WORKSHEET

Team name: Whizz Kids

Budget: £50,000

Finish time:

Fuel usage:

Vehicle Features

TYRES	BODY	ENGINE	SUSPENSION
SLICK TYRES	FULL AERO PACKAGE		
Cost £2,500	Cost £7,500	Cost	Cost

Total

Budget left over:

New finish time:

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TYRES	Slick tyres £2,500	High grip on smooth, dry tracks. Very good over a short number of laps. Wear out quickly, poor performance on rough or wet surfaces.
	Treaded tyres £2,000	Good allrounder, average performance in wet or dry conditions.
	Off road/ durable tyres £1,500	High grip on off road. Good performance on loose or wet surfaces, long lasting. Poor grip on track.
BODY	Full aero package £7,500	Big wings/ Body kit/ Diffuser/ Splitter - Increased downforce, increased drag. Lightweight.
	Medium aero package £4,000	Small wings/ Diffuser/ Splitter - Slightly increased downforce, small amount of drag. A good compromise between all types of track.
	No aero package £0	No generated downforce, no drag.
ENGINE	Large capacity engine £20,000	Increased power, higher top speed and greater acceleration. Increased fuel consumption.
	Mid-size capacity engine £15,000	Decent all-round, with no major advantages or drawbacks.
	Small capacity engine £8,000	Less power, lower top speed, reduced fuel consumption.
SUSPENSION	Soft suspension £3,000	Good for preserving tyres.
	Medium suspension £7,000	Decent all round with no major advantages or drawbacks.
	Hard suspension £8,000	Good for rapid change of direction.
GEARS	Gears in a racing car affect acceleration. Long ratio gears support higher top speeds and slow acceleration whereas short ratio allow for faster acceleration. Short ratio gears are more likely to be used in a rally car as they scrabble for grip.	
WINGS	Aerodynamics are key to a car's performance. Increased aerodynamics increases the weight of the vehicle; this can improve lap times on certain tracks as by pushing the car down into the ground it produces more grip.	
FUEL TANK	Vehicles needs fuel to run the engine. More fuel means your car will run for longer but will increase the weight. Less fuel means the car will be lighter but won't go as far.	
BRAKES	Brakes are a piece of equipment that slows the vehicle down. More robust brakes do this much quicker at the cost of more weight; lighter brakes aren't as strong or durable but can save weight in lower powered cars.	

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Time to reflect

Now that you've amended your configurations to your budgets, what does your final race configuration look like and what was the thought process behind your decisions**?**

Think about:

- Science
- Technology
- Engineering
- Mathematics

It's time to announce the winners!

Stretch & challenge:
Using the virtual prize money your team has won, use your **Cost of Value** worksheets to work out whether or not you have made a profit!

Everyday impact

What impact does motorsport have on normal cars**?**

Going green

How does forcing motorsport to be fuel-efficient help normal cars that we purchase**?**

Think about

- Engine innovation
- Fuel utilisation
- Vehicle design

Driven to Inspire: The science of going fast!

KS3