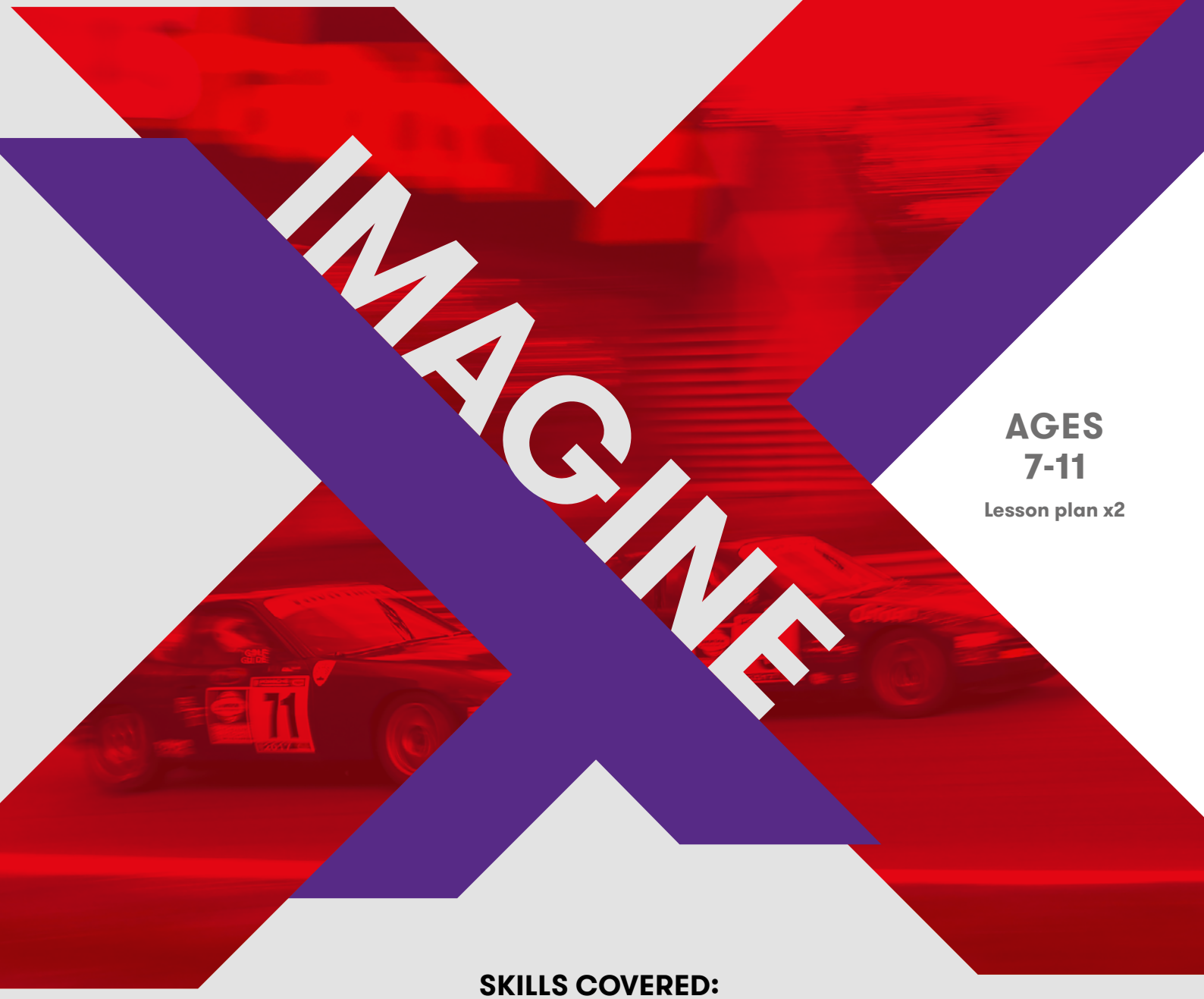
POWERED BY RS

DRIVEN TO INSPIRE: THE SCIENCE OF GOING FAST!

Combining physics, motorsports, design, teamwork and evaluation

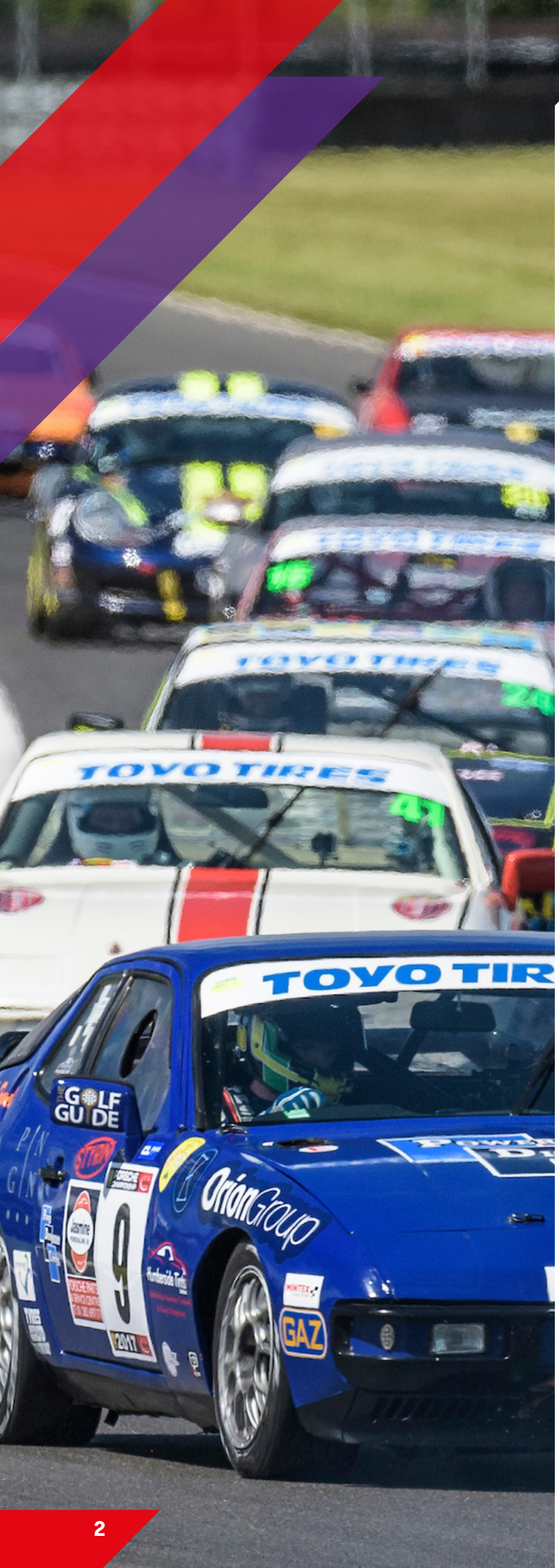


AGES 7-11

Lesson plan x2

SKILLS COVERED:

- Identifying racing track conditions and the appropriate car parts
- Working as part of a team
- Racing car design and engineering
- Applying technical physics, computational thinking and engineering knowledge to the design process
- Testing and evaluating racing car performance
- Thinking creatively while adapting and amending designs
- Understanding autonomous technologies and the importance of accessibility in motorsports
- Using and understanding computer software



LESSON 1 (informative)

- What an effective racing team looks like
- Introduction to PDC team
- Key physics terminology in relation to motorsports
- Situational awareness and vehicle optimisation
- Benefits of computer technology for designing vehicles
- Driverless cars

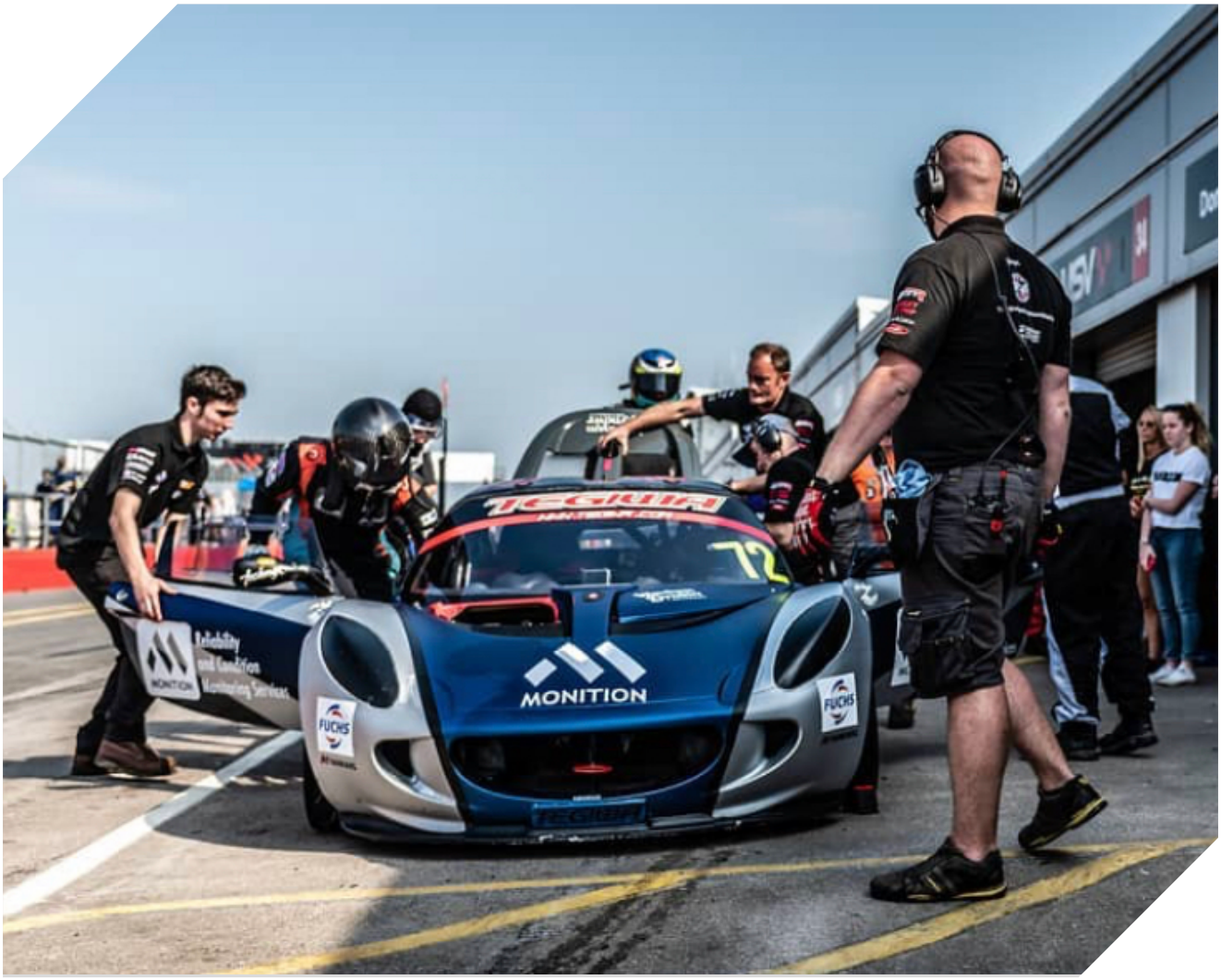
LESSON 2 (practical)

- Assembling a vehicle using software
- Identifying, evaluating and adapting vehicles for improvement
- Testing ideas using software
- Analysing findings and planning future improvements
- Inclusivity in motorsports

DESIRED PUPIL OUTCOMES (lessons 1 & 2)

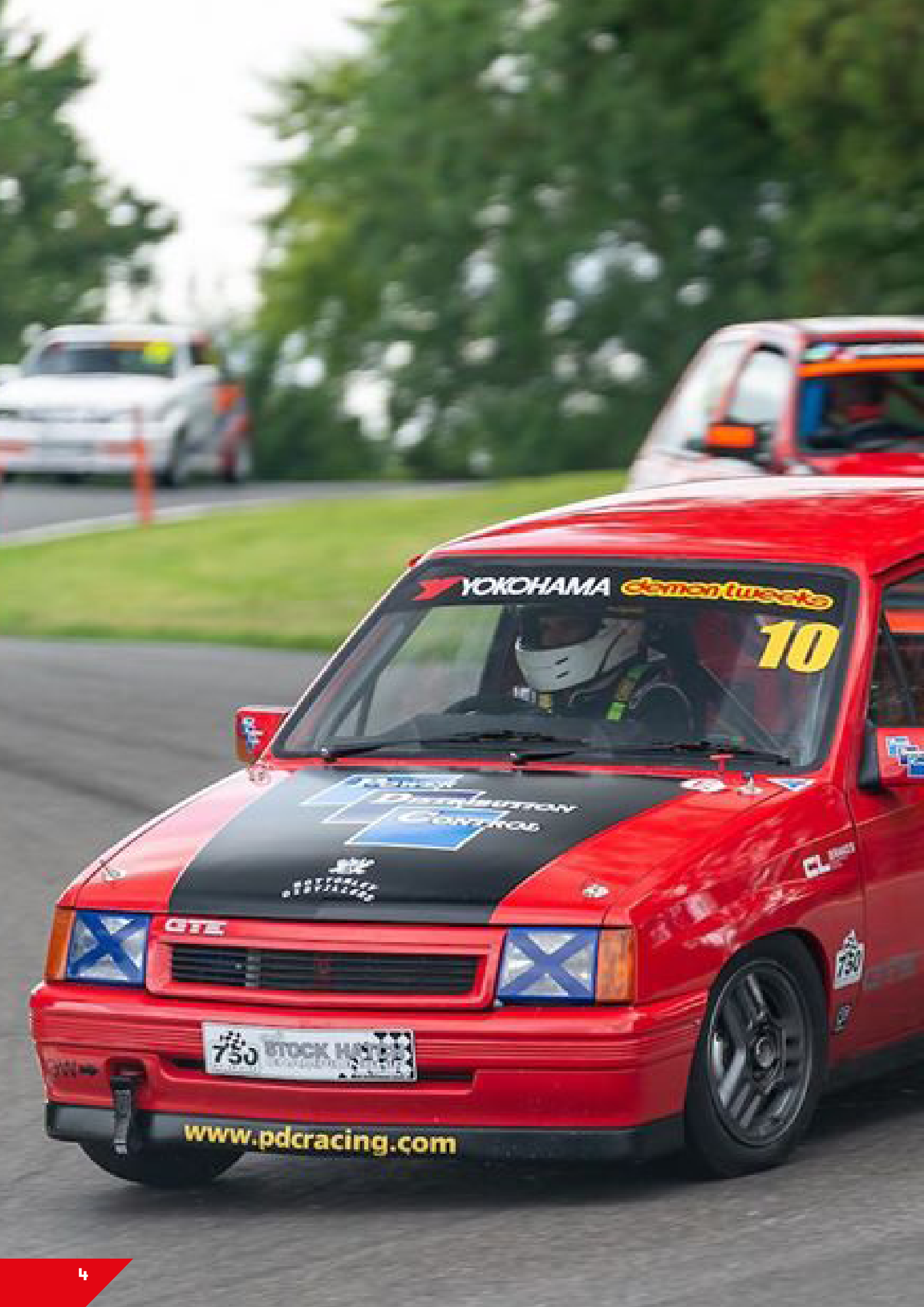
- I can now understand the scientific factors of racing
- I can explain what makes racing cars successful or unsuccessful
- I know the role environments can play when driving
- I can analyse, measure and optimise scientific factors to make the car perform better
- I can evaluate the work of my peers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

Overview



The combination of outstanding teamwork and brilliant engineering create a winning motorsport racing team. Technology, physics, scientific research and critical thinking all play a key role in what makes them so successful.

This lesson looks into the fundamental principles of physics that keeps a racing car at the top of the leader board and the importance of the teamwork needed to keep it there.


YOKOHAMA
demon tweeks
10
GTE
www.pdcracing.com

Lesson 1

REMEMBER...

The material in this lesson plan is rich and immersive. While it is possible to cover in two lessons, we advise its deployment over a 'Science Day' whereby maximum value can be had, allowing for students of all abilities to gain value from its usage. For lower or mixed ability classes, we advise extending lesson 1 over two sessions in order to a) grasp the scientific concepts and b) fully understand the worksheet ask, before moving on to lesson 2.

LESSON STRUCTURE:

1. Types of motorsports	**Slides 5-10**
2. Team	**Slides 11-20**
3. Cars	**Slides 21-29**
4. Design	**Slides 30-39**
5. Reflection	**Slides 40-43**
6. Stretch & challenge	**Slides 44-54**
a. Autonomous vehicles	
b. Situational awareness	
7. Homework	**Slide 55**

1. Intro activity - PPT led 20 minutes (slides 3-10)

SHOW

- The PDC video introducing the racing challenge

ACTIVITY

ASK

- What type of racing cars can students think of?
- Have they seen any racing cars?

Have students present their answers to the class, thinking of any of the car's key features that they can remember.

EXPLAIN

The types of motorsports using the slides as guidance:

- F1 – Tarmac – Dry and light rain
- Rally – Tarmac/ gravel/ rough road/ grass – All weathers
- Rally raid – Rough road/ no road/ deep mud/ deep water/ steep inclines – All weathers
- Go-karting – Tarmac – Dry and light rain
- Drag racing – Tarmac – Dry only

2. ASK (slides 11-20)

The following questions and have students record their thoughts on whiteboards or paper to discuss with the class;

- What different skills are needed in a motorsports team?
- Did the class pick up any skills from the video?

DISCUSS

- The importance of working as a team and the key benefits listed on the slide

INTRODUCE

- The three PDC team members using their slide bios

3. ASK (slides 21-29)

The following questions, having students present their answers to the class and encourage them to think of any key features of the cars that they can remember:

- What kind of environments do cars race in?
- What physics factors can you think of that may affect the performance of cars?

ACTIVITY

Have students get into groups of <5 and give each group a performance factor to learn. Once they understand this, they must have one member from the group go to the other groups and understand each factor to report back to their group to write down on the **Motorsports Cheat Sheet**.

EXPLAIN

The elements that affect the performance of the racing car:

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

EXPLAIN

The key factors students need to consider with their racing car design using the slides as a guide (for extra support, you can use the Imagine-X Racing Game to showcase the different options:

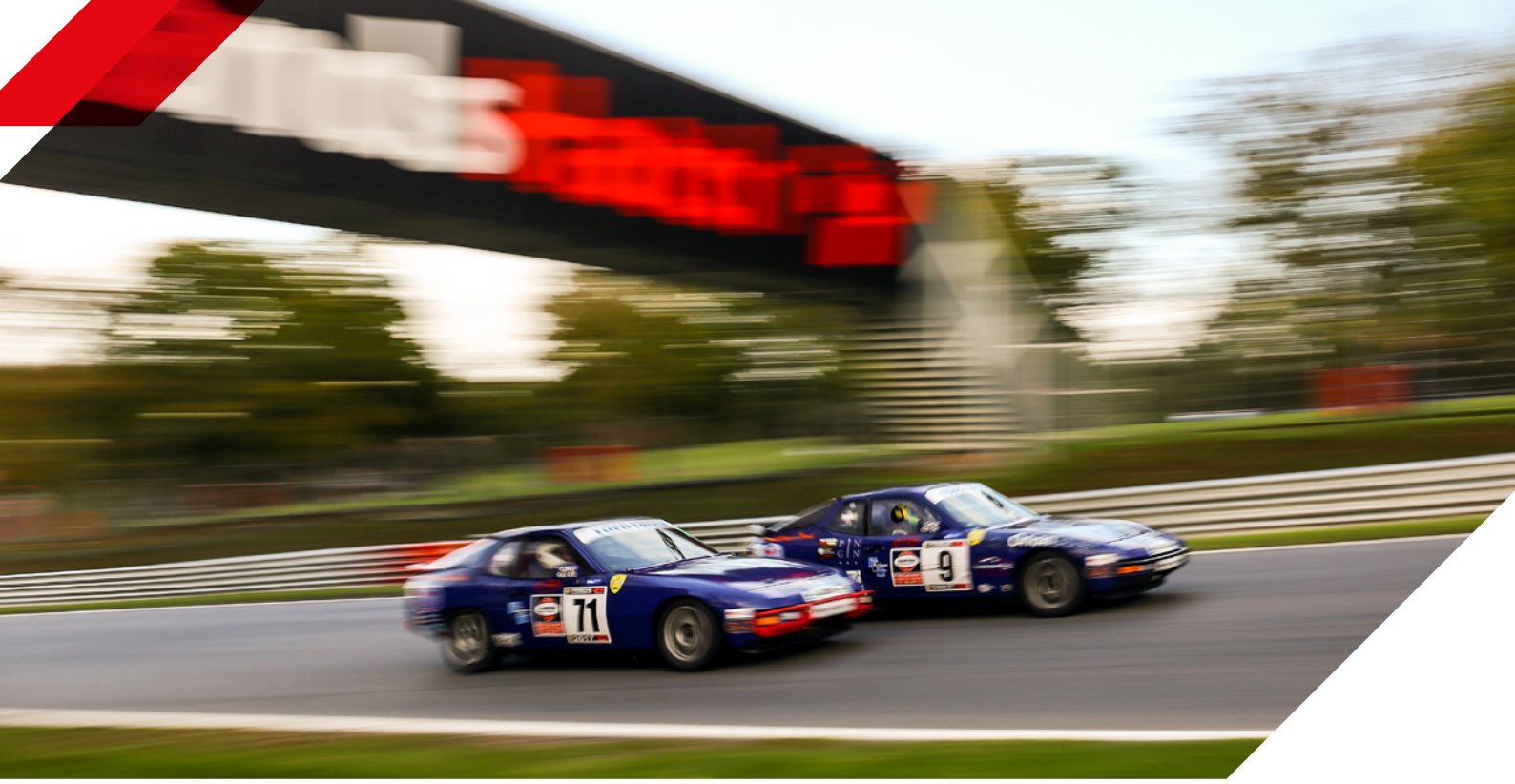
- Tyre choice – speed and grip
- Engine choice – power and size
- Vehicle body features – air resistance and shock absorption
- Overall mass – weight, acceleration and cornering

ACTIVITY

Get into groups of <5 and learn the vehicle attribute that you have been assigned. Once you understand this, have one member from the group go to the other groups and learn each attribute to report back to your group to write down on the **Motorsports Cheat Sheet**.

NOTE

If you are under time constraints, the first lesson could finish here with a recap of what the students have learned about racing cars.



1. Main activity – 30 minutes (slides 30-39)

Form the class into teams of <5.

SHOW

- The class the video of the game mechanics and the slides detailing the team code they will need to access the game for lesson 2, the team name screen and the three track options

ASK

- What conditions will they need to consider in order to race their cars in the best way?

EXPLAIN

- That teams must fill out a **Racing Car Blueprint** worksheet with their design that will produce the best result when racing in their chosen environment
- Teams also have their **Racing Car Crib Sheet** and **Motorsports Cheat Sheet** to help them

5. **ASK** (slides 40-43)

- Teams to critique and review the worksheet of other teams and explain their feedback

Collect their Racing Car Blueprint worksheets ready for lesson 2.

Stretch & challenge

ASK

- Teams to discuss the feedback and criticism they have received, linking this to the physics terminology they have learned and whether they can use this knowledge to fix these design issues

Plenary – 10 minutes

ASK

- Your students to reflect on how they worked as a team
- Did this affect the overall design of the car?

EXPLAIN

- In the next lesson, they will be testing out their designs to see which team has produced the fastest car

6. Stretch & challenge - recommended 45 minutes (slides 44-54)

EXPLAIN

- The idea of autonomous vehicles

SHOW

- The video explaining the five levels of autonomous vehicles

LINK

- The idea of human senses to car senses (sight, sound, touch etc.)

ASK

- Who could benefit from autonomous vehicles and why (elderly, young, disabled, rural or socially excluded)?

EXPLAIN

- Situational awareness using slides to guide you

ASK

- What elements of a racing car can help with situational awareness? (i.e. mirrors, sensors, pit crew reporting via headset etc.)

EXPLAIN

- How situational awareness helps autonomous vehicles to work better

ASK

- How do students use situational awareness in everyday situations? (i.e. crossing the road, going to their next classroom, how they will create their cars etc.)

EXPLAIN

- How autonomous vehicles could change the future of motorsports

ASK

- Whether the removal of the driver from the sport is fair?
- Would they still watch the sport?
- Would the sport still be fun to watch?
- Is speed the only thing that makes motorsports exciting?
- What elements of autonomous vehicles could be used in motorsports to improve the cars, without removing the driver?

7. OPTIONAL HOMEWORK (slide 56)

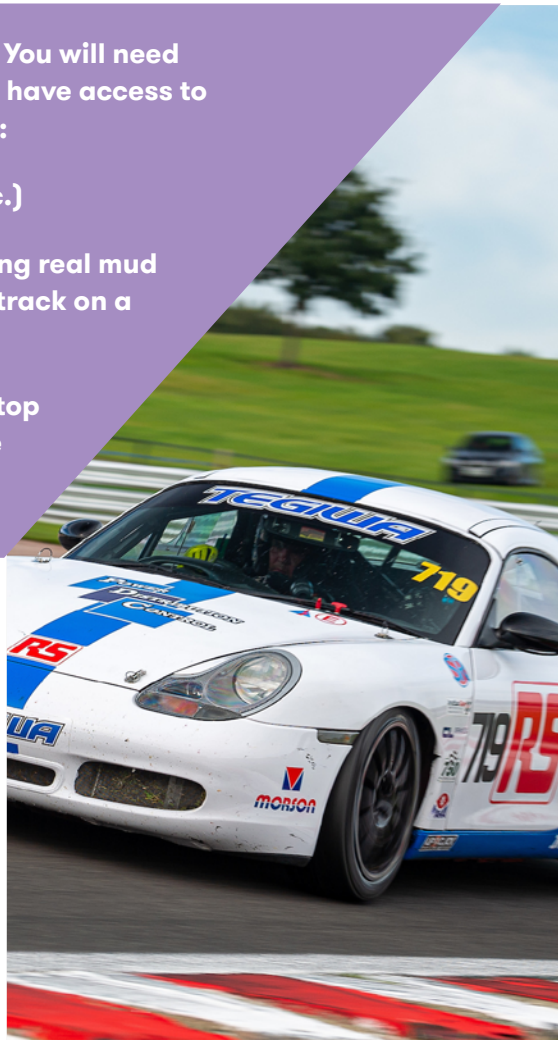
Instruct the class to go away and think about the top three characteristics that make a good motorsports team

Lesson 2

REMEMBER...

This lesson will rely heavily on the accompanying virtual game. You will need access to a computer in order to be able to play it. If you do not have access to a computer, the lesson can be adapted to a physical setting via:

- **Simple Lego/ KNEX cars (with various types of tyre, body etc.)**
- **A table-top racing track with a plastic top sheet if you're using real mud to simulate rally conditions, or safely mapping out a racing track on a tarmac or grassy surface if possible**
- **In a physical version, you will rely on pupil's observations, stop watches and the use of everyday objects available to create cars and different tracks**



LESSON STRUCTURE:

1.	**Lesson 1 recap**	**Slides 58-62**
2.	**Variants**	**Slides 63-65**
3.	**Practical**	**Slides 66-70**
4.	**Reflection**	**Slides 71-72**
5.	**Stretch & challenge**	**Slides 73-78**
	a. Inclusivity in motorsports	

1. Intro activity – 15 minutes (slides 58-62)

Use the slide material to recap on the previous lesson:

- How the team work together to produce a winning car
- Types of car racing
- How physics affects the performance of the car

2. **EXPLAIN** (slides 63-65)

- How changing parts of the car design can alter the end results using the example on the slides

ASK

- Can the class think of ways that this could affect their car designs?
- Is the affect these simple changes have a good thing, or a bad thing?

3. Main activity – 30 minutes (slides 66-70)

SHOW

- The class how to use the provided software
- If you're doing the physical version, show them the materials you have on offer and what they represent (i.e. wheel type, car type, body type etc.) and go through the health and safety regulations if needed

ASK

- Students to form their teams from the previous lesson and give them their **Racing Car Blueprint** worksheet
- To begin assembling their cars suitable for a tarmac drag strip, a muddy rally track or a racing circuit
- To alter factors such as weight, body material, tyre type etc. to suit the environment using their scientific knowledge

Once everyone has completed their racing cars, put their ideas to the test by having teams race against each other.

Optional: Write the results down on a leader board and crown 1st, 2nd and 3rd place.

4. Plenary – 10 minutes (slides 71-72)

ASK

- Teams to analyse their results and think about how to improve them

SUMMARISE

- The driving conditions, key elements of physics used in motorsports and the importance of teamwork using the slide as guidance

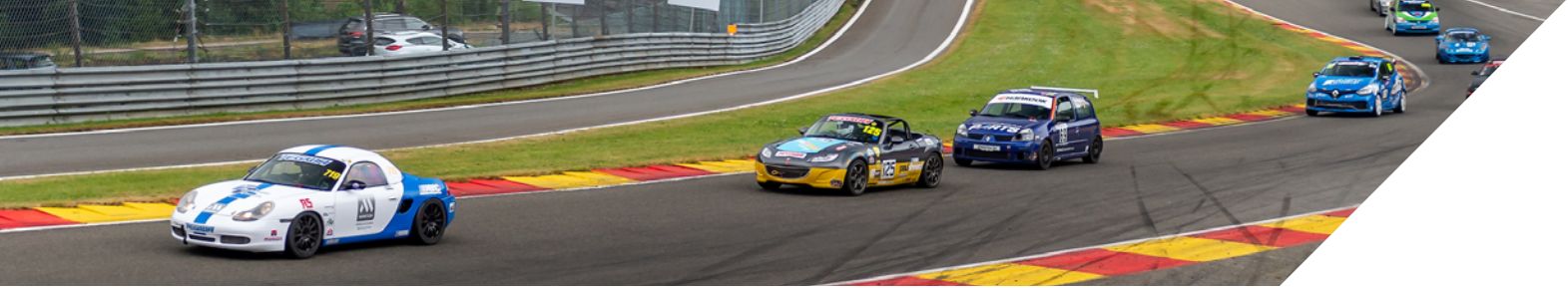
5. Stretch & challenge (slides 73-78)

EXPLAIN

- Inclusive racing and why it's important; use the Hamilton Commission and Nathalie McGloin case study slides (74-77) as guidance

ASK

- If students can remember what sense Nathalie uses to understand the car's movements from the YouTube video provided on slide 76
- How students would build extra features to make the vehicles easier to enter and operate for people with diverse ability needs



Teaching notes

Key science principles

Power= energy/ time	The more energy the engine can output in a short space of time, the larger the force the engine can apply to the tyre contact area.
Work done (energy) = force x distance	Energy from the power equation and the distance the wheel turns through, allows force to be calculated.
Force = mass x acceleration	Speed at which your vehicle can move forward depends on its mass and the force the engine can put out. The lower the vehicle mass the higher the acceleration from the force.
Weight = mass x gravitational field strength	However, a low mass doesn't help you go around corners fast because the vehicle weight isn't enough to generate the downward pressure, which in turn generates friction to stop you sliding off the track.
Pressure = force/ area	The bigger the tyre contact area the more force you can put into pushing the car forward without spinning the wheels or sticking to the road to go around a corner, but the bigger the tyre contact area the larger the rolling friction which slows the vehicle down.
Force = spring constant x extension	A soft spring allows for lots of movement to keep the shocks from the road from damaging the vehicle but makes the vehicle more difficult to drive fast. A stiff spring allows for very little movement and allows the vehicle to drive fast and change direction rapidly.
Front facing surface area and smoothness	Small, forward-facing surface area and smooth surfaces reduce drag to go fast but doesn't generate much down force to help increase contact pressure at the tyre contact area when going around corners. Adding aerofoils to generate downward thrust increases drag which slows the car down. This means a low mass vehicle can accelerate quickly but generate enough downward force to go around a corner fast.
Force = mass x velocity/ impact time	If you can lengthen the impact time during a crash, you reduce the force a driver will experience. So a race car reduces its mass by falling apart in a crash and has materials that have a soft spring constant to increase the impact time. The roll cage is made of materials with a very high spring constant to create a safety area which the driver doesn't get squashed inside.

Teaching notes

Word bank:

Car modification
The definition of a car modification is a change made to a vehicle so that it differs from the manufacturer's original factory specification (Burrows Motor Company).

Road-legal car
A road-legal car is a vehicle which meets the legal requirements to be driven on roads. Features that make a car illegal on regular roads include:

- Neon light fittings
- Overly-tinted windows
- Engine modifications such as removal of catalytic converter

Information on what makes a car road-legal can be found here: https://www.hg.org/legal-articles/what-makes-for-a-street-legalvehicle-31563

G-Force
The force of gravity, also known as a unit of acceleration.

Water displacement
In wet conditions a grooved tyre is used. The grooves allow the tyre to quickly displace the water into the grooves. This ensures as much rubber as possible is in contact with the ground and ensures there is grip. An F1 tyre can disperse up to 60 litres of water per second.

Lesson delivery and timings:

This plan should serve as a guide but can easily be adapted to suit your teaching schedule by expanding or cutting short whichever sections you feel appropriate. You don't need to include every aspect of this plan and presentation if it is not beneficial to your students.

We recommend group activities are limited to a maximum of 15 minutes. Focus should remain on content learning in lesson one while more practical learning is the focus of lesson two.

Progress and assessment:

Measure progress by asking your class to reflect on content and explain what they've learnt. This is prompted throughout each lesson with suggested questions in the presentation and further suggested activities which encourage students to put their new knowledge into practice.

Teaching notes

Imagine-X Racing: Game questions

Below is a list of the questions and their respective answers that are listed within the Imagine-X Racing game. They can be used in the practical version of the main activity at the start of the race to determine the placement of each car, and during the pit stop to ensure that students have understood the lesson content. They must correctly answer the questions as fast as possible to continue with the race.

The correct answer for each question is in **bold**.

What racing car works best on hills and in deep mud?

- Go-kart
- Rally car
- **Rally Raid (4X4)**

What energy does the engine produce?

- Chemical
- Nuclear
- **Kinetic**

What is the term for being aware of your surroundings?

- Mirror awareness
- **Situational awareness**
- Driver safety

Which of these factors refers to the vehicle weight?

- **Mass**
- Friction
- Drag

What is the purpose of situational awareness in motorsport?

- To make sure your car's sensors are working
- To make sure you're using your mirrors correctly
- **To be aware of and understand your surroundings and act upon any potential risks**

Which of these is a key benefit of working in a team? (TRICK QUESTION)

- **Inclusivity**
- **Better ideas**
- **Respecting each other**

Which force works against aerodynamics and slows down a moving vehicle?

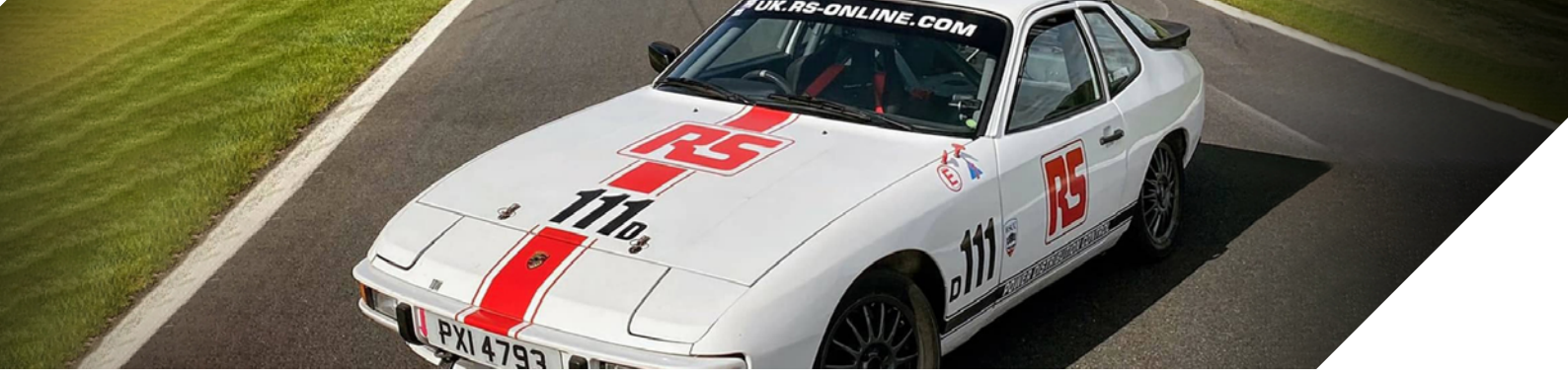
- Gravity
- Mass
- **Drag**

How many levels are there to vehicle autonomy?

- 8
- **5**
- 3

Why are Rally Raid cars built with heavy parts? (TRICK QUESTION)

- **For reliability on rough terrain**
- **For safety**
- **To help absorb shock**



Bonus Q (hard q's)

What is the current level of vehicle automation for most cars?

- **Partial automation**
- Driver assistance
- High automation

What is torque?

- **The force that causes the wheels to turn**
- The force that keeps the car on the track
- The energy that the engine creates

What is the second stage of situational awareness?

- Reacting to the information
- Viewing the surroundings
- **Processing the surroundings**

Pit stop q's:

How many tyres are there on a normal racing car?

- 3
- 8
- **4**

Who works in the pit stop?

- **Pit crew**
- The driver
- Marshals

Which tyres work best in wet conditions?

- Go-karting tyres
- Drag racing tyres
- **Rally tyres**

If you are the first car out onto a rally stage, are you at an advantage?

- Yes
- **No**

Which of the following is affected when the track is wet?

- Drag
- **Friction**
- Mass

How will a car behave on a wet surface compared to a dry one?

- More grip
- **Less grip**
- No change

Teaching notes

Curriculum links

KS1 - Years 1 to 2 – age 5 - 7

Science

Working scientifically

- Asking simple questions and recognising that they can be answered in different ways
- Observing closely, using simple equipment
- Performing simple tests
- Identifying and classifying
- Using their observations and ideas to suggest answers to questions
- Gathering and recording data to help in answering questions

Computing

- Using logical reasoning to predict the behaviour of simple programmes

Mathematics

Comparing, describing and solving practical problems for:

- Mass/ weight (for example, heavy/ light, heavier than, lighter than)
- Time (for example, quicker, slower, earlier, later)

Statistics

- Asking and answering questions about totalling and comparing categorical data

Design & technology

Design

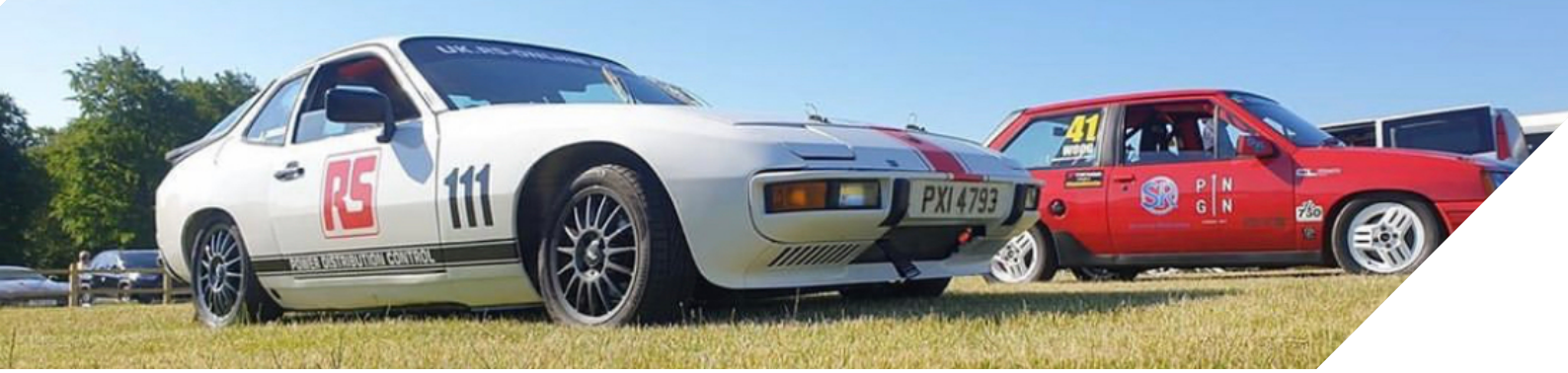
- Designing purposeful, functional, appealing products for themselves and other users based on design criteria
- Generating, developing, modelling and communicating their ideas through talking, drawing, templates, mock-ups and, where appropriate, information and communication technology

Make

- Selecting from and using a wide range of materials and components, including construction materials, textiles and ingredients, according to their characteristics

Evaluate

- Evaluating their ideas and products against design criteria



Teaching notes

Curriculum links

KS2 - Years 3 to 6 – age 7 - 11

Science

Working scientifically

- Asking relevant questions and using different types of scientific enquiries to answer them
- Setting up simple practical enquiries, comparative and fair tests
- Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, with a range of equipment, including thermometers and data loggers
- Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions
- Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables
- Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions
- Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions
- Identifying differences, similarities or changes related to simple scientific ideas and processes
- Using straightforward scientific evidence to answer questions or to support their findings
- Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary
- Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
- Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
- Using test results to make predictions to set up further comparative and fair tests
- Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of, and a degree of trust in results, using oral and written forms such as displays and other presentations
- Identifying scientific evidence that has been used to support or refute ideas or arguments

Teaching notes

Curriculum links

KS2 - Years 3 to 6 – age 7 - 11

Forces and magnets

- Comparing how things move on different surfaces
- Identifying the effects of air resistance, water resistance and friction that act between moving surfaces

Computing

- Using sequence, selection and repetition in programmes; work with variables and various forms of input and output

Design & technology

Design

- Using research and developing design criteria to inform the design of innovative, functional, appealing products that are fit for purpose, aimed at particular individuals or groups
- Generating, developing, modelling and communicating their ideas through discussion, annotated sketches, cross-sectional and exploded diagrams, prototypes, pattern pieces and computer-aided design

Make

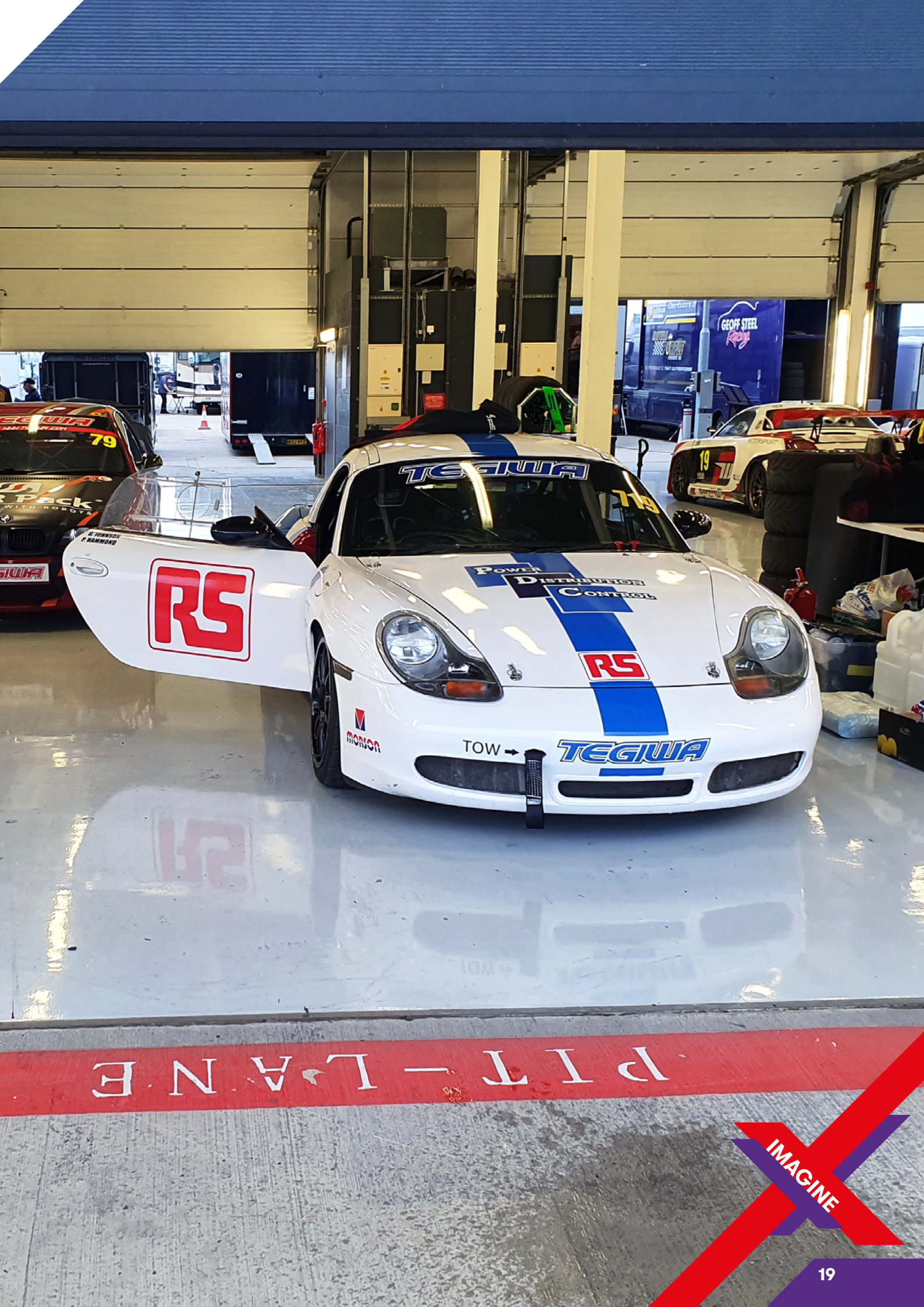
- Selecting from and using a wider range of tools and equipment to perform practical tasks (for example, cutting, shaping, joining and finishing) accurately
- Select from and use a wider range of materials and components, including construction materials, textiles and ingredients, according to their functional properties and aesthetic qualities

Evaluate

- Evaluating their ideas and products against their own design criteria and considering the views of others to improve their work
- Understanding how key events and individuals in design and technology have helped shape the world

Technical knowledge

- Applying their understanding of how to strengthen, stiffen and reinforce more complex structures
- Applying their understanding of computing to programme, monitor and control their products


TEGIWA
79
RS
POWER
DISTRIBUTION
CONTROL
TOW
TEGIWA
PIT - LANE
GEOFF STEEL
Racing

Instructions for teachers

Lesson 1

Before you start

- Make the classroom ready to show a presentation (video and audio needed)
- Download the slides from the resource packs
- Set to the beginning slide 1 – Lesson 1
- Check access to the internet and specifically that the online activities are not blocked by any network security policies, so you can show the software and watch the YouTube videos

Resources

- **DRIVEN TO INSPIRE: THE SCIENCE OF GOING FAST!** Presentation slides
- Teacher notes
- Screen and projector
- White boards
- Activity worksheets:
  Racing Car Blueprint
  Motorsports Cheat Sheet
- Information worksheet:
  Racing Car Crib Sheet
- Coinciding printouts

Lesson 2

Before you start

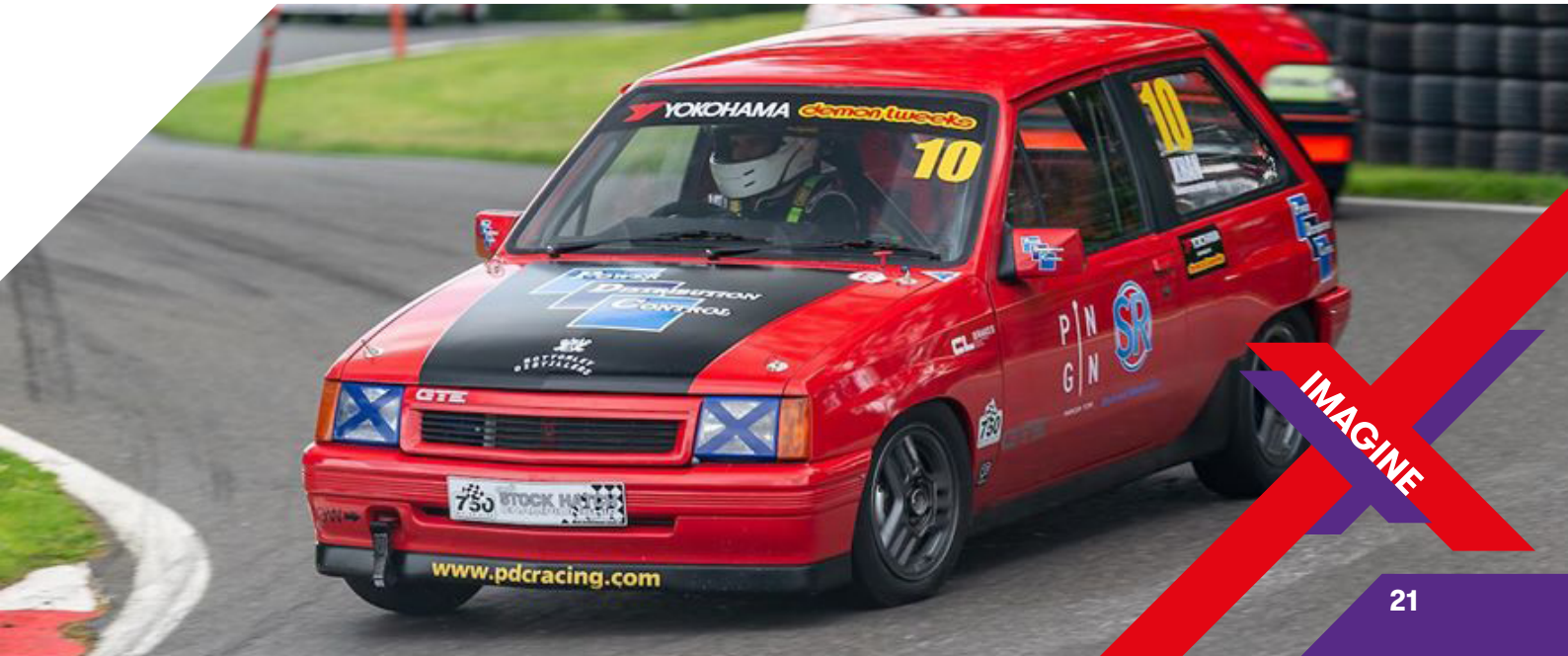
- Set to the beginning slide 57 – Lesson 2
- Check access to the internet and specifically that the online activities are not blocked by any network security policies, so students can access the software
- Ensure computers or tablets that can operate the software are available for students to use
- If you have opted to do the physical version of the task, make sure you have all the materials and equipment available

Resources

- **DRIVEN TO INSPIRE: THE SCIENCE OF GOING FAST!** Presentation slides
- Teacher notes
- Screen and projector
- Coinciding printouts
- Activity worksheets:
  Racing Car Blueprint
  Motorsports Cheat Sheet
- Information worksheet:
  Racing Car Crib Sheet
- Lego, timer, plastic sheets, mud, chalk, board and any other materials deemed appropriate for the physical version of the main activity to take place

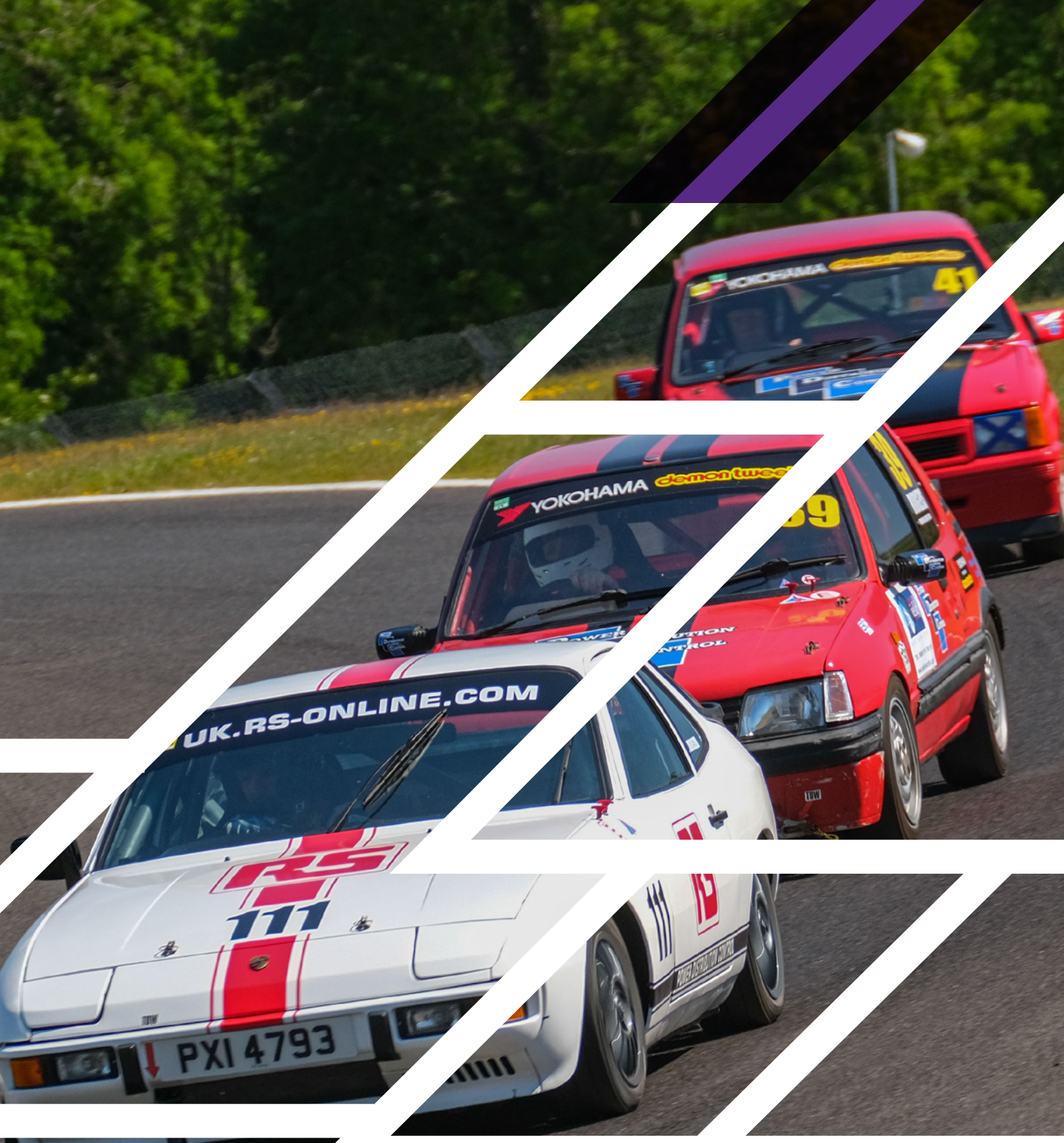
Safety and risk

Risk	Impact	Mitigation	Probability of occurrence
Transmission of disease.	Loss of student educational time.	Ensure to register all students (and staff) involved in the lessons for contact tracing and testing. Keep a list of which students are in each team.	Low to high, dependent on transmission rates within local area.
	Risk of serious health conditions for students and staff.	Clean all surfaces, equipment, keyboards and mice used by students during the lessons or leave equipment un-touched for 48 hours. Ensure current guidance is followed on social distancing.	Low to high, dependent on transmission rates within local area.



NOTES...

NOTES...



uk.rs-online.com/stem