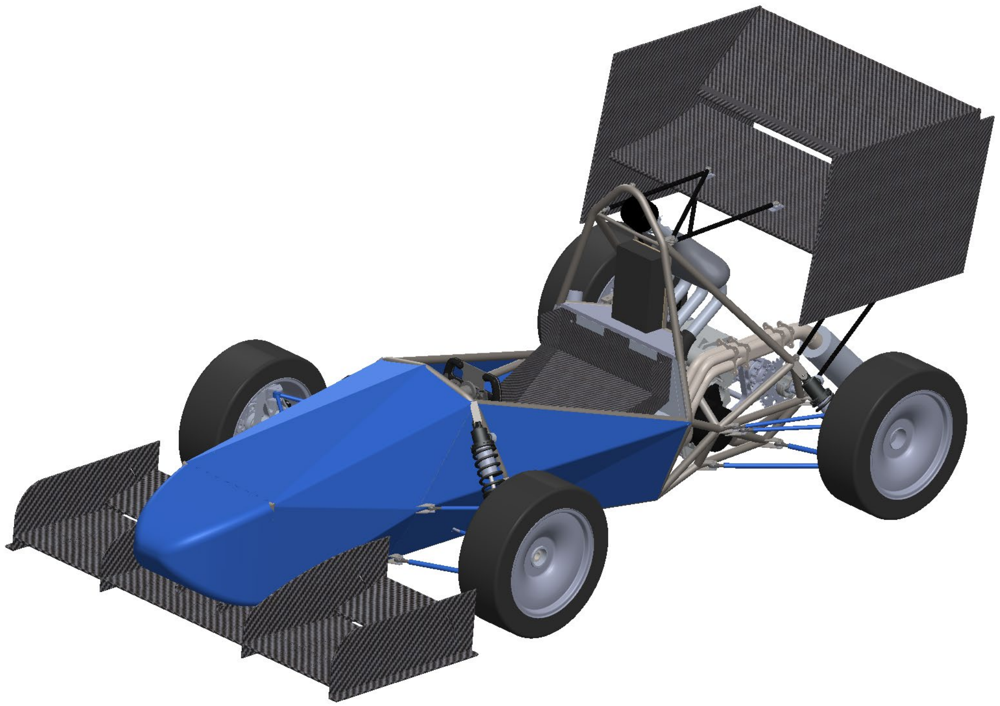


Designing and Manufacturing with Carbon Fibre Composites

VINCENT YUNG

QUEENS' COLLEGE

In partnership with Full Blue Racing (FBR)

FORMULA STUDENT
Institution of MECHANICAL ENGINEERS

What is Formula Student?

Formula Student UK is a university-level motorsport competition where students design, build, and race a single-seat, open-wheel car.

🔧 Engineering Focus

- ❑Hands-on design & manufacturing
- ❑Emphasis on innovation, cost, and performance
- ❑Industry-relevant skills under real-world constraints

🏁 Competition Format

- ❑Static Events: Design, Cost, Business
- ❑Dynamic Events: Acceleration, Endurance, Efficiency

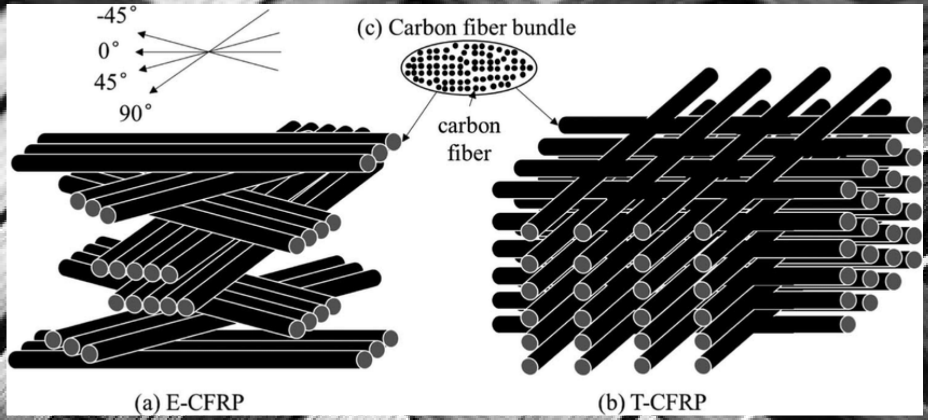
Who is Full Blues Racing?

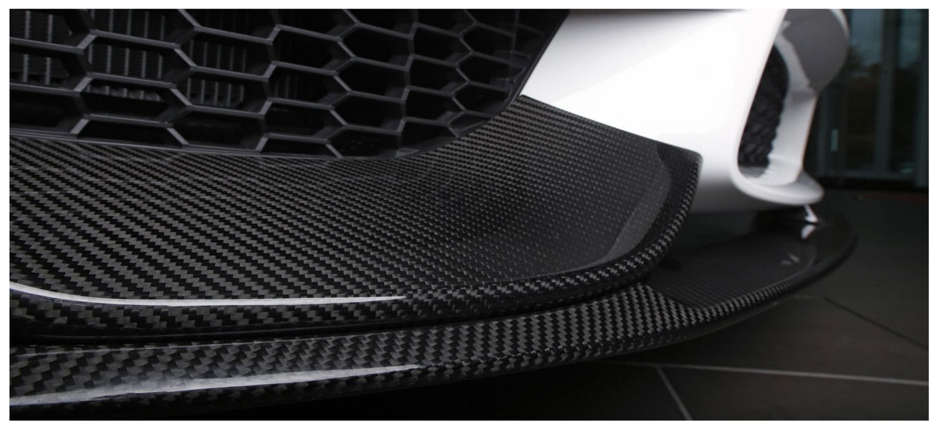
- Established student-led Formula Student team since 2006
- ~60 students design, build & race single-seater cars
- Compete in Formula Student UK, Germany, Spain, and more
- Apply engineering theory to real-world vehicle systems under time and budget constraints
- Operate through dedicated sub-teams: Chassis & Composites, Powertrain & Intake, Electronics, Suspension & Vehicle Dynamics, Aerodynamics
- Emphasise cross-team collaboration, technical communication, and design reviews

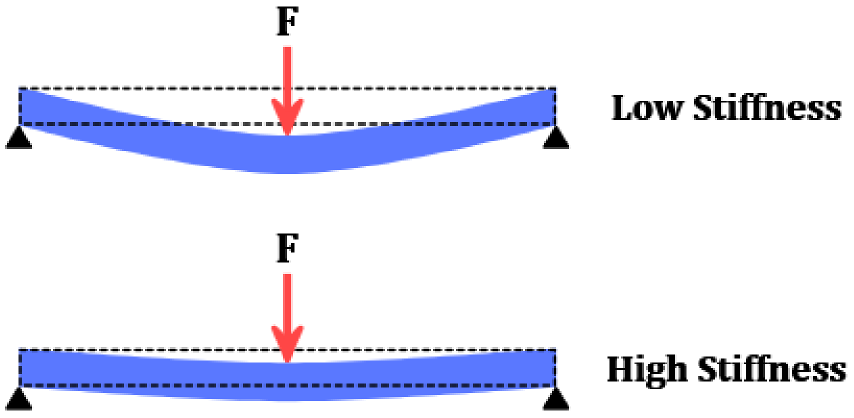
Carbon Fibre Reinforced Polymers

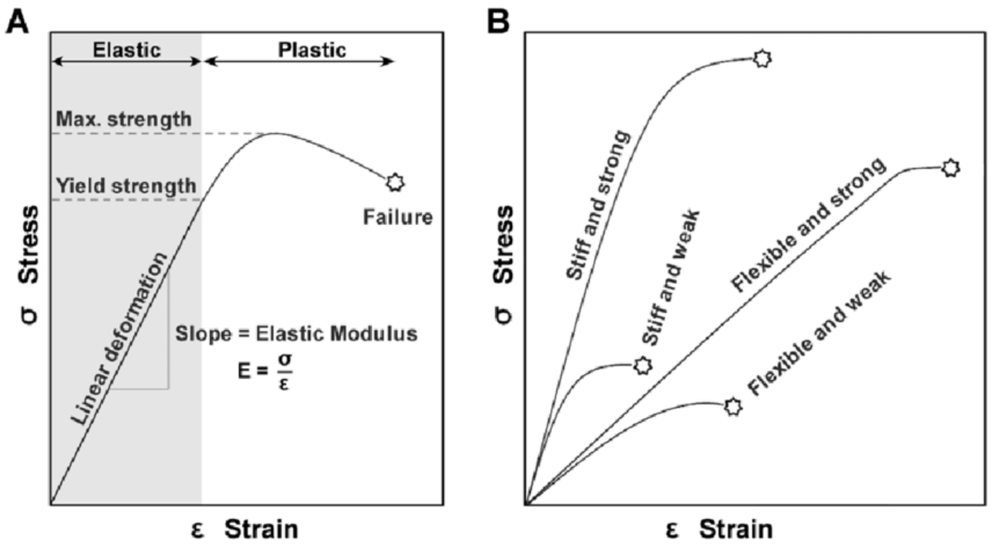
Why Use Them in Cars?

- **High Strength-to-Weight Ratio** — stronger than steel, but ~5x lighter
- **Excellent Stiffness** — crucial for handling and aerodynamic parts
- **Corrosion Resistance** — unlike metals, CFRPs don't rust
- **Customisable** — tailored stiffness via ply orientation and layup
- **Complex Shapes** — ideal for tight packaging (e.g. intake plenums, aero)









Stiffness of CFRP

- Stiffness = Resistance to Bending or Stretching
- Stiffness is quantified by the Elastic Modulus (E) — the steeper the slope of the stress-strain curve, the stiffer the material
- $\delta = F \frac{k}{Et^3}$
- CFRPs are orthotropic, meaning their stiffness and strength vary depending on direction:
  - Very stiff along the fibre direction (0°)
  - Much less stiff across fibres (90°)Intermediate properties in between

Why is CFRP Difficult to Model?

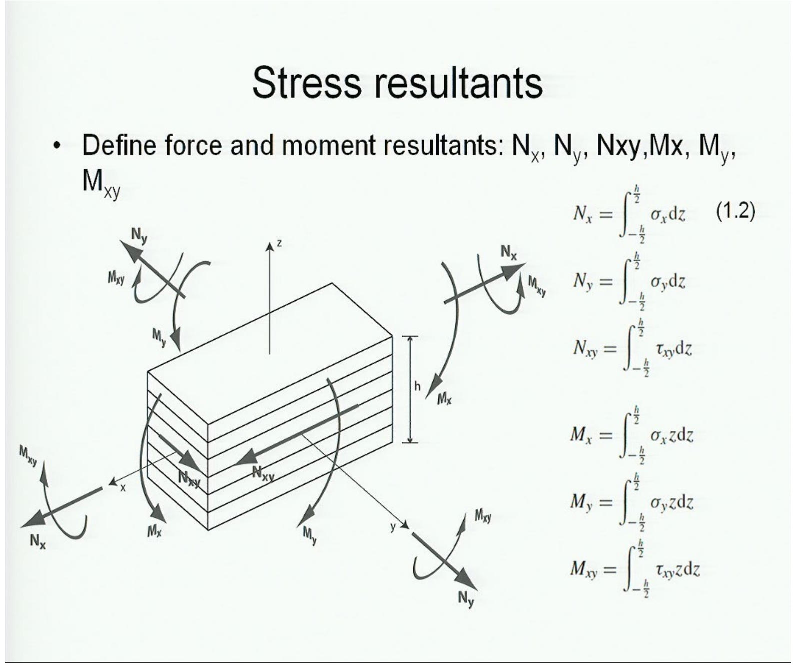
Orthotropy: can't use simple isotropic material assumptions like you would with metals.

Layered Structure: It's made of many thin layers, each with different angles — that makes calculations difficult.

Inconsistent Material: Small differences in how it's made can affect strength and stiffness.

Breaks in Complex Ways: It can crack, snap, or peel apart between layers — not just snap like metal.

Takes Lots of Testing You often need real-world experiments to check your models.



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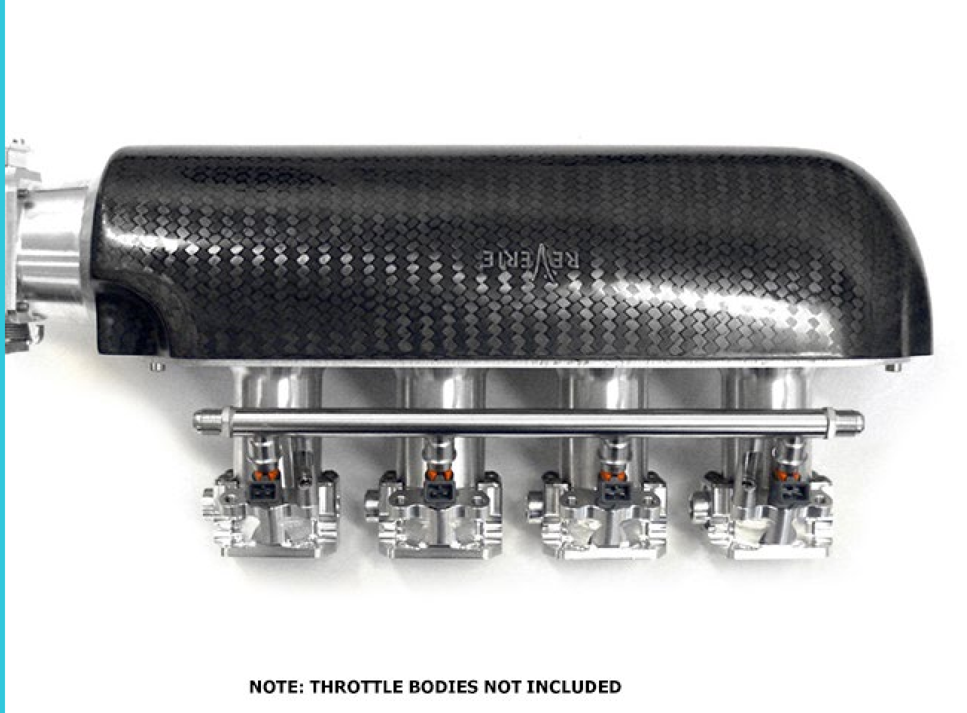
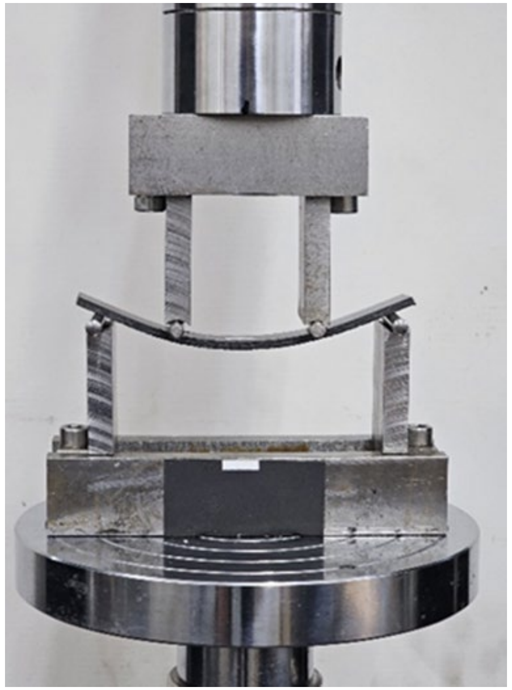
What is an Intake Plenum?

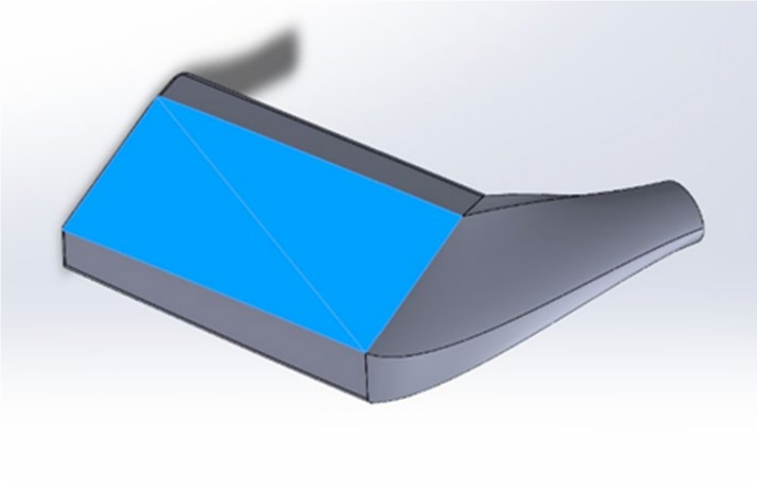
- It’s a big air box that stores and distributes air going into the engine.
- Helps each cylinder get even airflow for better performance.
- Reduces sudden changes in airflow when the throttle opens or closes.
- Shape and volume affect how much power the engine can make.
- In racing, it must be light, strong, and space-efficient — perfect for carbon fibre!



My Project

- Pressure inside plenum creates complex 3D stresses (bending + tension + compression)
- CFRP hard to model → simulations need Finite Element Analysis (complex & slow)
- My project: Create a simple equation-based model for FBR to use
- Ran 4-point bending tests on laminates with different fibre directions and thicknesses
- Used Classic Laminate Theory to decide plenum wall thickness
- More layers = less stress, $\sigma = k\frac{M}{t^2}$, but also heavier → find the balance





Manufacturing with CFRP

- Tested samples with air bubbles and layer separation, much lower stiffness/ strength
- Solved by using hand lay-up + vacuum bagging
- Made a glass fibre mould coated with wax
- Layered carbon fibre + resin inside the mould
- Used vacuum bag to suck out air and cure the part
- Result: strong, stiff, and lightweight plenum

Thank you for listening!

Questions?