UNIVERSITY OF WOLLONGONG IN DUBAI

# TEAM ASSIGNMENT COVER SHEET

| Student Name | Student Number | Student submitting work |
|---|---|---|
| Asad Rizwan Shaikh | 8113257 | Discussion |
| Mark Joy Binsu | 8197088 | Discussion |
| Taha Yaseen Parker | 8243578 | Results, Polishing Discussion |

| | |
|---|---|
| Subject number and name | ENGG103 – Materials in Design |
| Subject coordinator | Mr. Mohammad Yousuf |
| Title of Assignment | Experiment 4 – Tensile Test |
| Date and time due | November 26, 2023, 23:59:59 |
| Lab Number | 4 |

Student declaration and acknowledgement (must be read by all students)

By submitting this assignment online, the submitting student declares on behalf of the team that:

1. All team members have read the subject outline for this subject, and this assessment item meets the requirements of the subject detailed therein.
2. This assessment is entirely our own work, except where we have included fully documented references to the work of others. The material contained in this assessment item has not previously been submitted for assessment.
3. Acknowledgement of source information is in accordance with the guidelines or referencing style specified in the subject outline.
4. All team members are aware of the late submission policy and penalty.
5. The submitting student undertakes to communicate all feedback with the other team members.

# Results

## A. Graphs

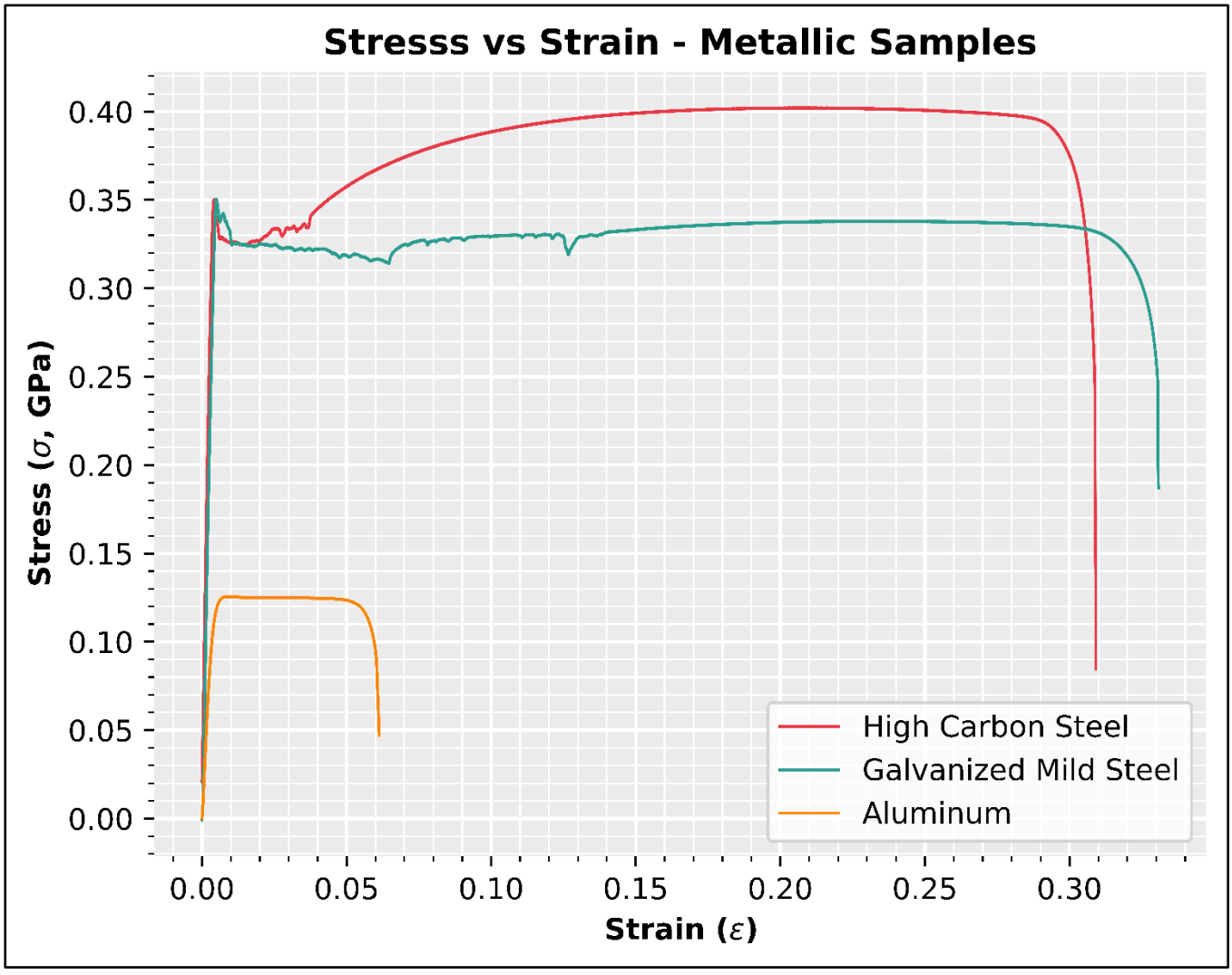


*Figure 1 – Engineering Stress vs Strain for all metallic samples*

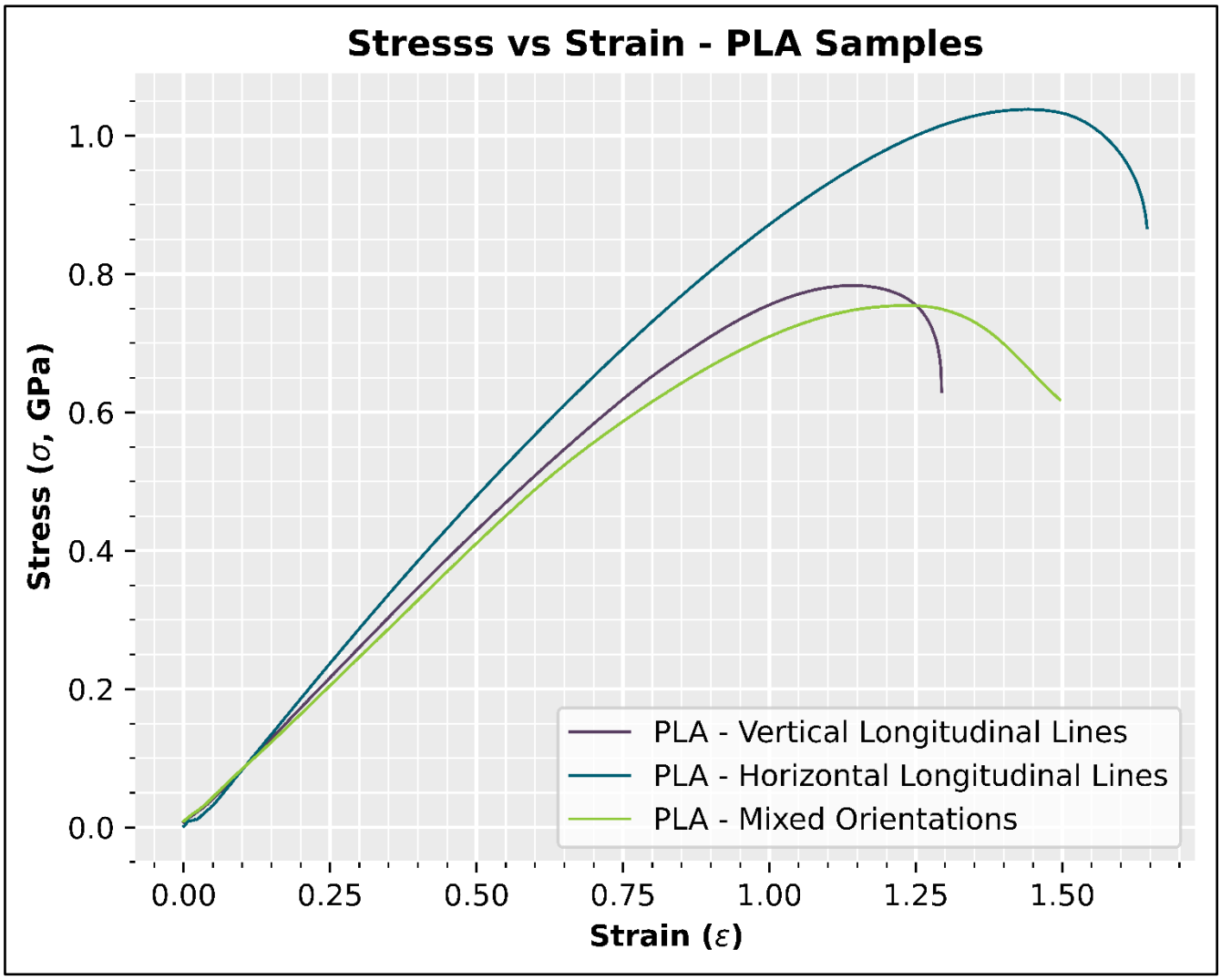


*Figure 2 – Engineering Stress vs Strain for all 3D Printed samples*

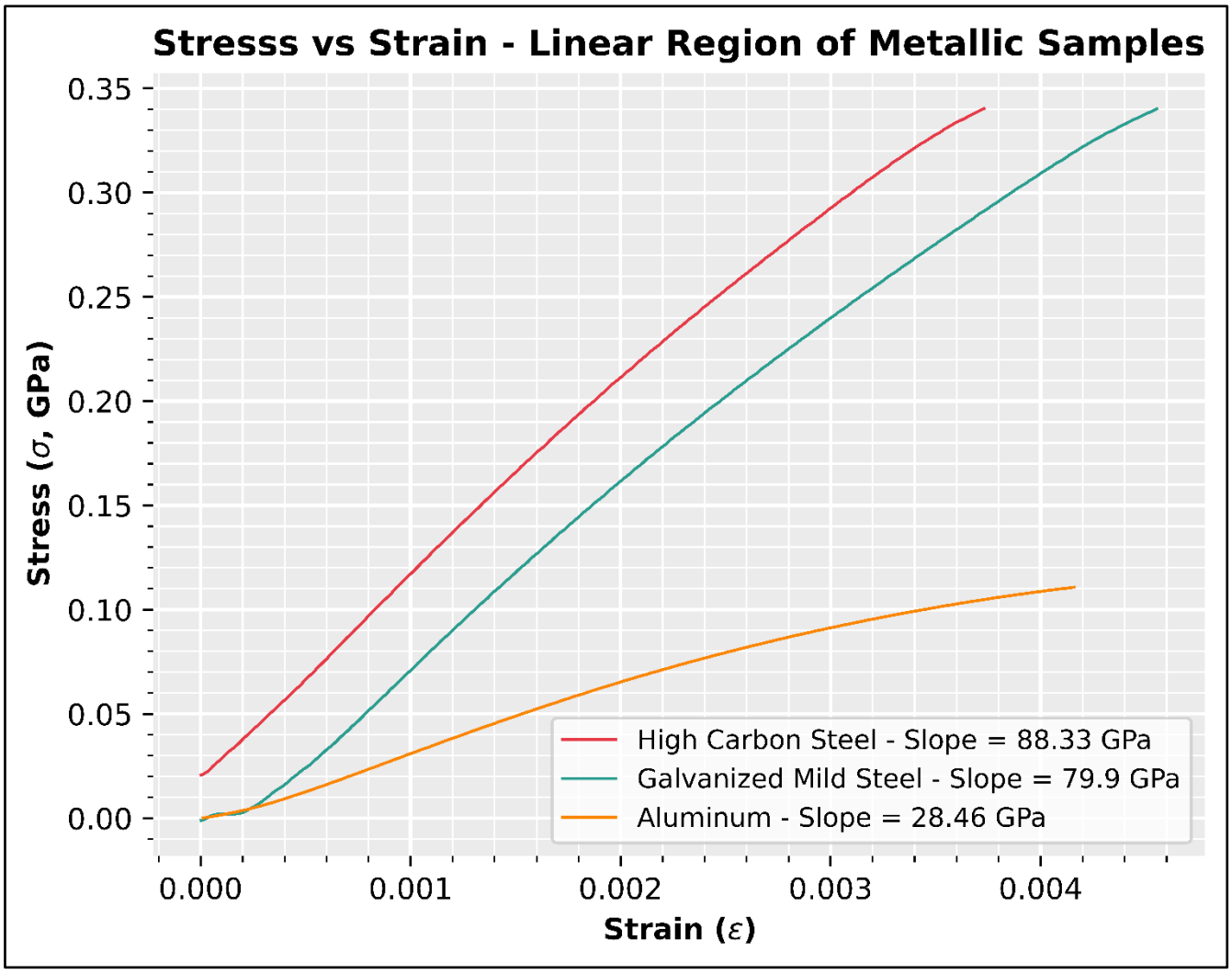


*Figure 3 – Linear region of all metallic samples with slope*

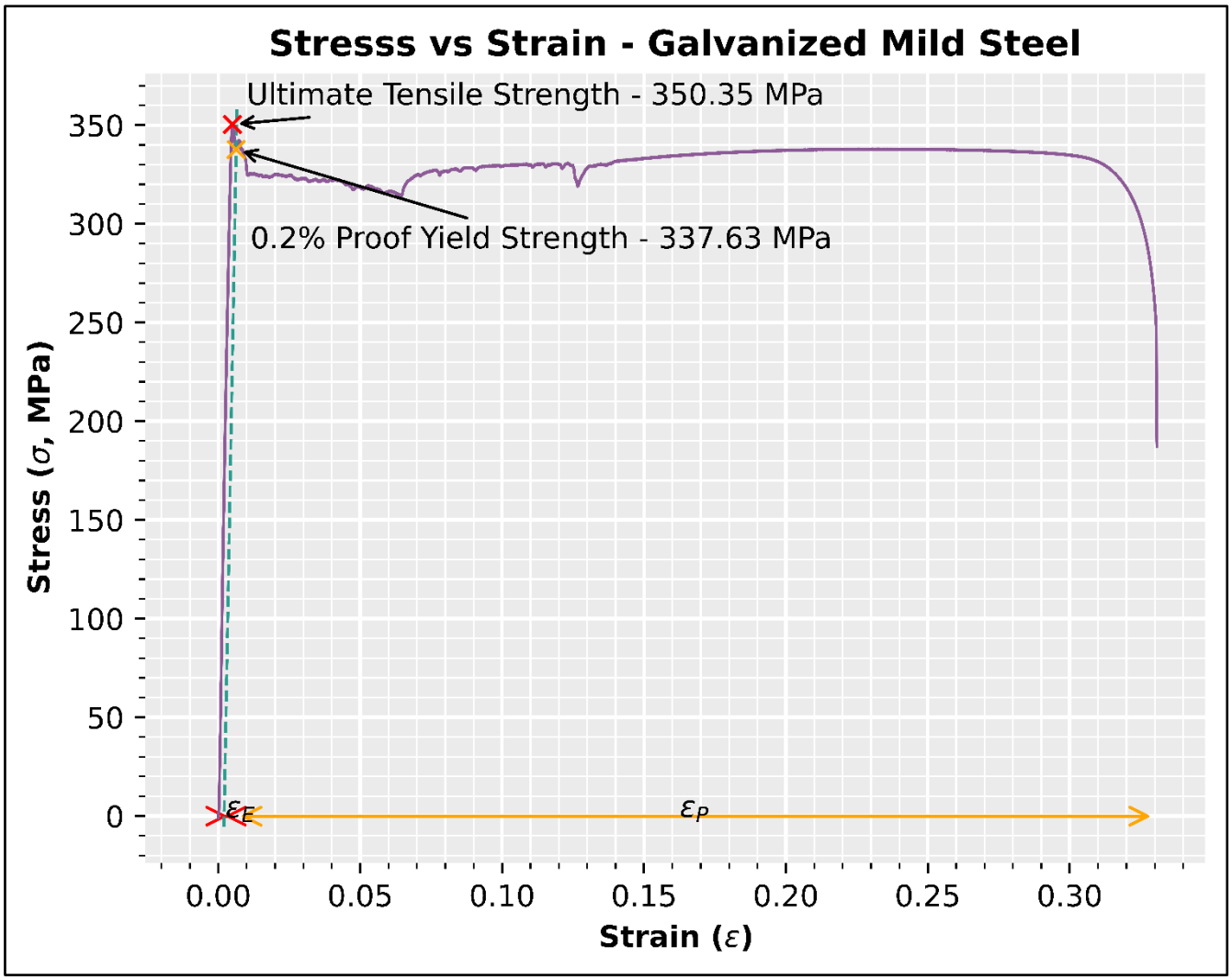


*Figure 4.1 – Stress vs Strain graph of Galvanized Mild Steel with various annotations*

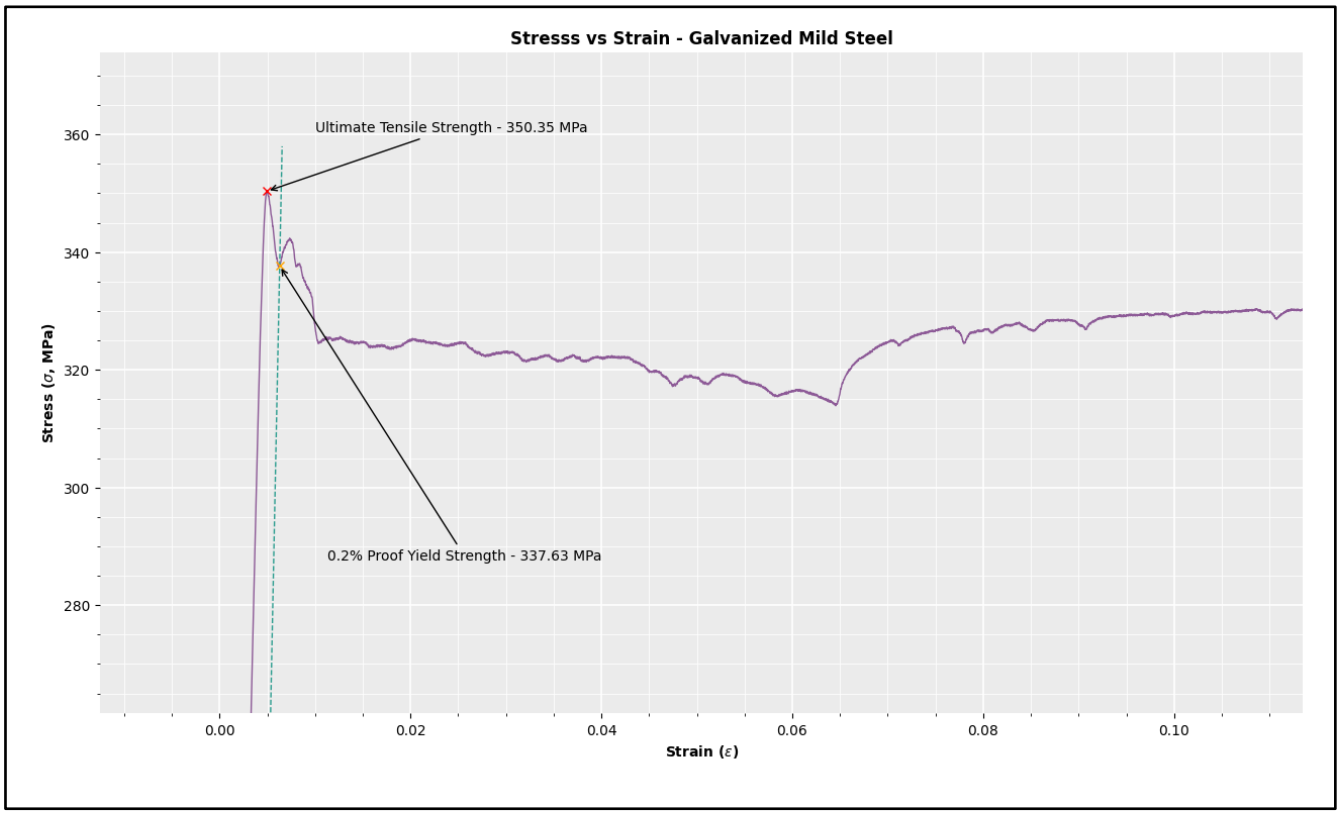


*Figure 4.2 – Close-up view of Ultimate Tensile Strength and 0.2% Proof Yield Strength of Galvanized Mild Steel sample*

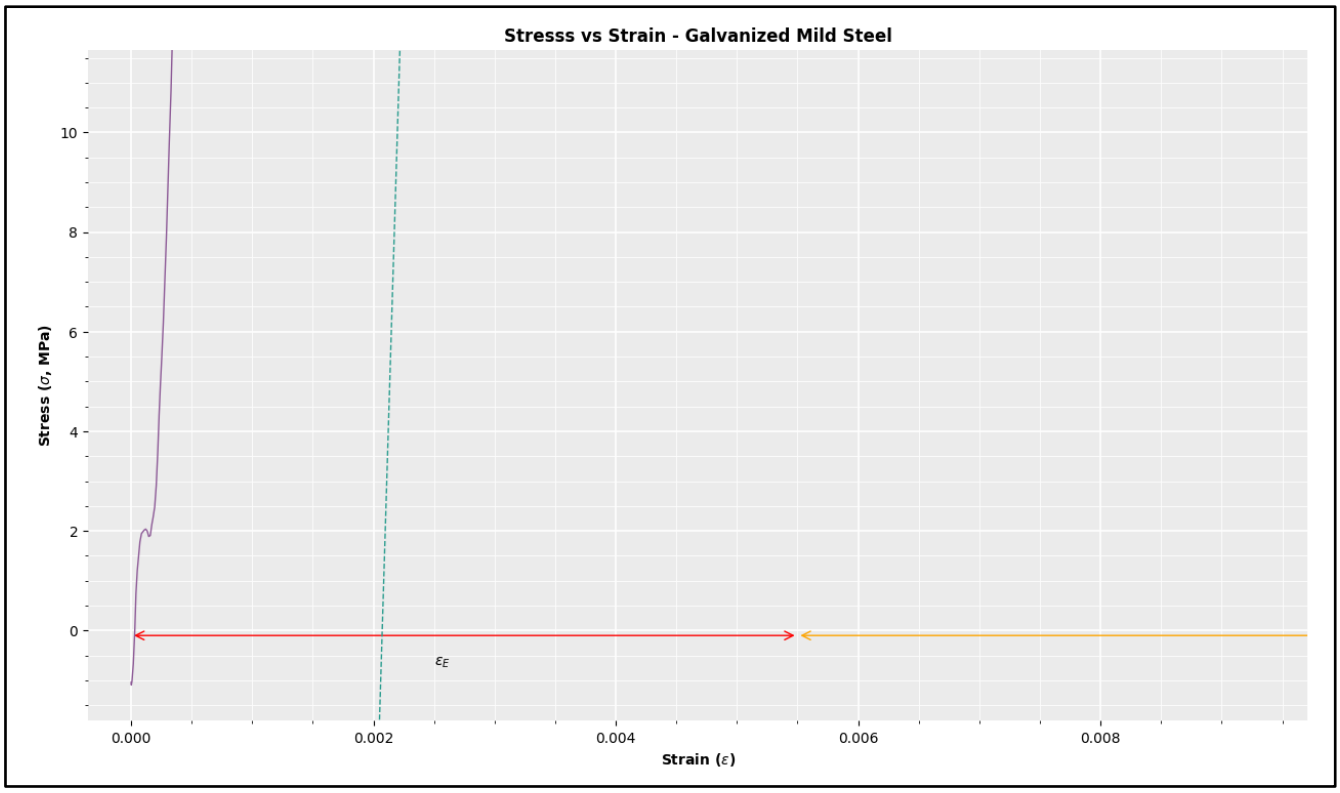


*Figure 4.3 – Close-up view of Linear Elastic Region of Galvanized Mild Steel sample*

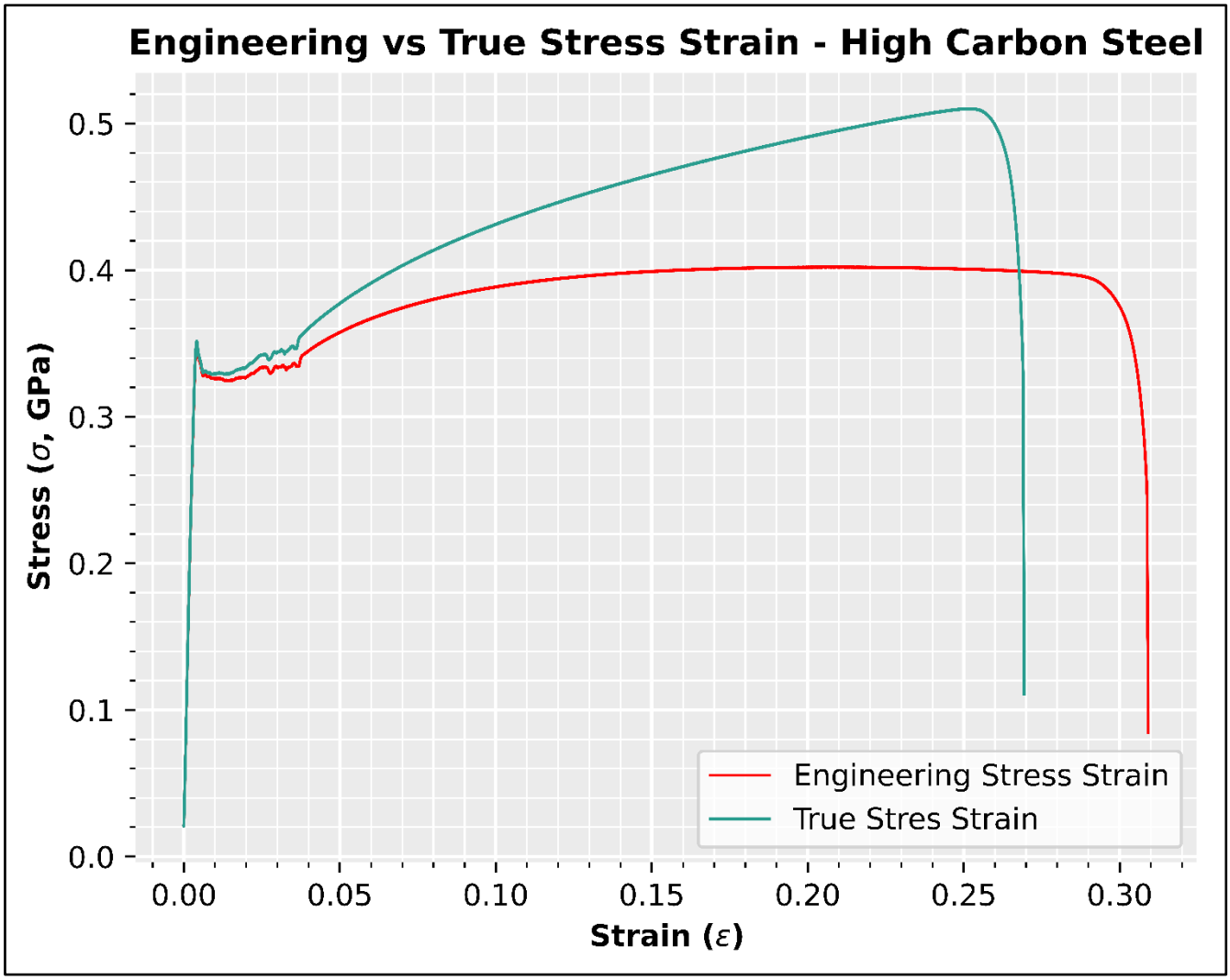


*Figure 5 – True Stress vs Strain and Engineering Stress vs Strain of High Carbon Steel sample*

## B. Summary of Properties

### Metallic Samples

| Material | Young's Modulus (Experimental) | Young's Modulus (Theoretical) | 0.2% Yield Strength | Ultimate Tensile Strength | Total Elongation | Ductility |
|---|---|---|---|---|---|---|
| | GPa | GPa | MPa | MPa | m | % |
| High Carbon Steel | 88.326 | 200 | 334.9644 | 402.13 | 0.309116 | 30.9116 |
| Galvanized Mild Steel | 79.895 | 200 | 337.6292 | 350.35 | 0.330783 | 33.0783 |
| Aluminum | 28.465 | 69 | 123.5926 | 125.57 | 0.061311 | 6.1311 |

### 3D Printed Samples

| Material | Young's Modulus (Experimental) | Ultimate Tensile Strength | Ductility |
|---|---|---|---|
| | GPa | MPa | % |
| PLA 1 – Vertical Lines | 0.972354 | 39.175 | 4.313 |
| PLA 2 – Horizontal Lines | 1.001242 | 51.905 | 5.482 |
| PLA 3 – Mixed Orientations | 0.762793 | 37.725 | 4.986 |

# Discussion

**Question 1**

**Write a paragraph concluding the experiment objectives, procedure and outcomes.**

To summarize, the goal of the tensile testing experiment was to provide practical experience using a Universal Testing Machine (UTM) to conduct tensile tests and examine stress-strain curves for different kinds of materials. The samples/materials were axially aligned and securely held on vertically by the jaws of the UTM. Then after zeroing the force and displacement readings to eliminate any initial offset, the machine would start pulling and applying tension to the material and the force applied and displacement values would be recorded.
In addition to metallic specimens such as high carbon steel, galvanized mild steel and aluminum, the investigation also focused on 3D printed PLA test specimens with various infill patterns (vertical lines, horizontal lines, and mixed orientations). Important mechanical characteristics like Young's modulus, yield strength, ultimate tensile strength, percentage elongation, and percentage area reduction were all assessed using the tensile test. As the study delved into the field of 3D printing, examining the impact of infill patterns on mechanical characteristics allowed for comparisons between the metallic and 3D samples. This gave a more comprehensive understanding in this investigation of material behavior under tension and the subtle effects of manufacturing parameters on mechanical performance.

**Question 2**

**Compare the properties of the three metallic materials using the table you created in the Results section.**

From our experiment, we can conclude that Aluminum is the material with the least yield and tensile strength. From our experiment, our theoretical values for Young's modulus differ greatly from the experimental values. This is due to not considering minute impurities, instantaneous surface area and other such quantities when performing our calculations. High carbon steel has the highest experimental values for Young's modulus and Ultimate Tensile strength at 88.326 GPa and 402.13 MPa. Mild steel comes in second in terms of Young's modulus and Ultimate tensile strength but has greater 0.2% Yield strength (337.629 MPa), elongation (0.330783m) and Ductility (33.0783%) than High Carbon Steel.

**Question 3**

**High carbon steel is superior to mild steel in terms of strength due to the higher carbon content. Was this evident according to the results you obtained from the experiment? Search the internet and provide a comprehensive and scientific explanation on how carbon content influences the strength of steel.**

As we know the presence of carbon in steel influences the strength of the material. The influence is due to different microstructures that form when carbon is introduced to the material. Adding carbon to the material influences the grain size of the material and creates more fine-grained structures. This method is called grain size reduction and is one of the main ways to increase strength of a material but in turn reduces the ductility of the material. The number of fine grains increases with an increase in carbon content. This was proven from our experiment where high carbon steel had higher overall strength and lower ductility than mild steel.

**Question 4**

**Compare the properties of the three 3D printed samples using the table you created in the Results section.**

The three 3D printed materials only differ by their 3D printing direction/pattern. Each of the three infill patterns (Vertical Lines, Horizontal Lines, and Mixed Orientations) display unique mechanical properties when the results of the 3D printed PLA samples are examined. PLA 2 with Horizontal Lines exhibits the greatest Young's Modulus (stiffness) at 1.001242 GPa, with PLA 1 with Vertical Lines coming in second at 0.972354 GPa and PLA 3 with Mixed Orientations third at 0.762793 GPa. When it comes to Ultimate Tensile Strength, PLA 2 is in the lead once more with 51.905 MPa, followed by PLA 1 with 39.175 MPa, and PLA 3 with 37.725 MPa. The percentage of elongation, which is used to quantify ductility, shows a similar pattern. PLA 2 has the highest ductility at 5.482%, followed by PLA 3 at 4.986% and PLA 1 at 4.313%.

**Question 5**

**From your results, which 3D printed sample had the highest strength? Why would an engineer select the sample with the mixed orientations over the one with vertical lines, although the sample with vertical lines will statistically show higher strength?**

From our experiment, we can see that 3D printed sample with horizontal lines has the highest values for Young's Modulus (1.001242 GPa), Ultimate tensile strength (51.905 MPa) and ductility (5.482%). The choice of 3D material that an engineer would choose would mainly depend on the specific goals of the engineer's project. For example, in some applications, the material would be subjected to multi axial stress simultaneously, so making use of the sample with mixed orientations can provide a better performance compared to uni-axial 3D samples.