# Work Breakdown Structure

## Masters Project

1. **Software**

All code written and FEM models constructed for the project.

* 1. **Generative Design**
     1. **L-Systems**

L-systems may be implemented to generate the internal geometries of the grids.

* + 1. **CPPNs**

CPPNs may be implemented to generate complete bodies constructed from multiple grids.

* 1. **Design Objective**

Design objectives to measure bodies’ performance need to be determined, i.e. grasping a solid object.

* 1. **FEM**
     1. **Grid Construction**

Code is written to construct a grid of square elements with appropriate boundary and load conditions, as well as the removal of any desired or random internal elements. Free floating internal clusters are detected and removed. Grids can be constructed at any desired size.

Tessellation of multiple grids will be implemented later.

* + 1. **Non-linear hyper-elastic material**

A placeholder Mooney-Rivlin material model for rubber is used for preliminary tests.

A final Ogden material model will be implemented.

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| --- | --- | --- | --- | --- | --- |
| **Work** | **Resource** | **Maximum** | **Minimum** | **Average** | **Spent** |
| L-Systems | Time | 30 | 15 | 22,5 |  |
| CPPNs | Time | 50 | 25 | 37,5 |  |
| Design Objectives | Time | 40 | 20 | 30 |  |
| Grid Construction | Time | 50 | 25 | 37,5 | 50 |
| Non-linear hyper-elastic material | Time | 20 | 5 | 12,5 |  |

1. **Material Testing**

Material testing done to obtain accurate material models for the project.

* 1. **Specimen Preparation**
     1. **Material Mixing**

Silicon-based materials are mixed from two components according to manufacturer’s instructions.

* + 1. **Material Degassing**

Mixed materials are degassed to remove any internal bubbles to ensure purity of samples.

* + 1. **Material Setting**

Mixed and degassed materials are smoothed to ensure an even surface and left to set in the moulds for the recommended amount of time.

* 1. **Tensile Testing**

Tensile testing is done to determine the tensile properties of the materials according to ISO 37 standards.

* + 1. **Long Travel Extensometer**

A long travel extensometer will be used with an Instron machine to measure the extension of the material specimens.

* + 1. **DIC**

If the long travel extensometer results prove to be inaccurate, DIC will be used with the MTS machine to measure the extension of the material specimens.

* 1. **Compression Testing**

Compression testing is done to determine the compressive properties of the materials according to ISO 7743 standards.

* + 1. **Design Compression Grip**

A compression grip for the material specimens is designed and manufactured for the purposes of compressive testing, as available grips allow for simple improvements.

* + 1. **DIC**

DIC will be used with the MTS machine to measure the compression of the material specimens.

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| --- | --- | --- | --- | --- | --- |
| **Work** | **Resource** | **Maximum** | **Minimum** | **Average** | **Spent** |
| Material Mixing | Time | 6 | 3 | 4,5 | 3 |
| Material Mixing | Money | R 1 000,00 | R 500,00 | R 750,00 | R 943,60 |
| Material Degassing | Time | 1 | 1 | 1 | 1 |
| Material Setting | Time | 12 | 8 | 10 | 10 |
| Material Setting | Money | R 100,00 | R 50,00 | R 75,00 | R 97,39 |
| Tensile Testing | Time | 30 | 20 | 25 |  |
| Compression Testing | Time | 30 | 20 | 25 |  |
| Design Compression Grip | Time | 3 | 1 | 2 | 2 |
| Design Compression Grip | Money | R 400,00 | R 300,00 | R 350,00 | R 341,02 |

1. **Thesis**

The document written describing all relevant parts of the project.

* 1. **Introduction**
  2. **Literature Review**
  3. **Material Testing**
  4. **Software**
  5. **Results**
  6. **Conclusion**

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| --- | --- | --- | --- | --- | --- |
| **Work** | **Resource** | **Maximum** | **Minimum** | **Average** | **Spent** |
| Introduction | Time | 5 | 2 | 3,5 |  |
| Literature Review | Time | 100 | 50 | 75 | 50 |
| Material Testing | Time | 20 | 10 | 15 | 2 |
| Software | Time | 50 | 25 | 37,5 | 2 |
| Results | Time | 25 | 20 | 22,5 |  |
| Conclusion | Time | 5 | 2 | 3,5 |  |

**Safety Report**

A safety report is required for any testing done within any laboratory settings.

A safety report detailing the experimental processes required was written up and approved by the required personnel.

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| **Work** | **Resource** | **Maximum** | **Minimum** | **Average** | **Spent** |
| Safety Report | Time | 5 | 2 | 3,5 | 3 |

**Material Model**

An Ogden non-linear hyper-elastic material model is required to accurately model the behaviour of the material. Material testing is done to obtain data on the behaviour of the material.

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| --- | --- | --- | --- | --- | --- |
| **Work** | **Resource** | **Maximum** | **Minimum** | **Average** | **Spent** |
| Material Model | Time | 20 | 10 | 15 |  |