

UNIVERSITY OF  
**WATERLOO**



FACULTY OF ENGINEERING  
**Department of Mechanical  
and Mechatronics Engineering**

## **MTE 322 Project 1**

Prepared for:

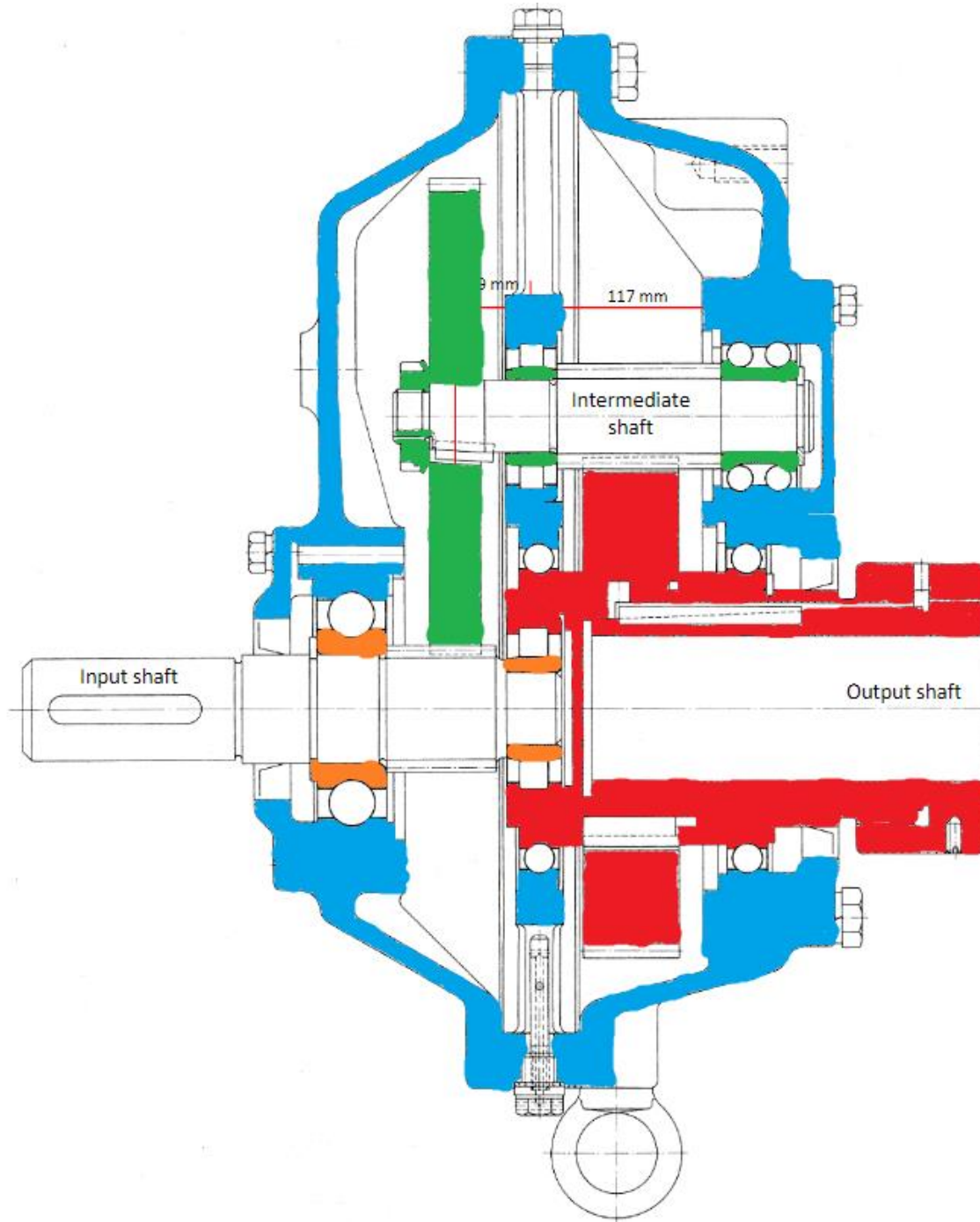
MTE 322 – Electromechanical Machine Design

By:

Paolo Torres – 20656027

## 1 Coloring Page

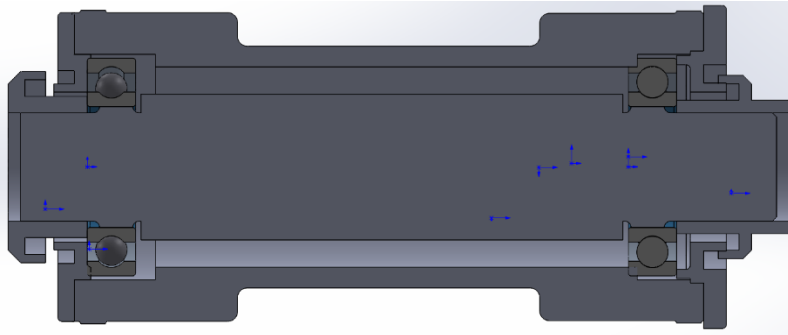
The gear train in **Figure 1.1** is colored in with four different colors: blue, green, red, and orange. Each color represents a different speed that the part is rotating at, with blue being the housing of the gear train, thus being stationary.



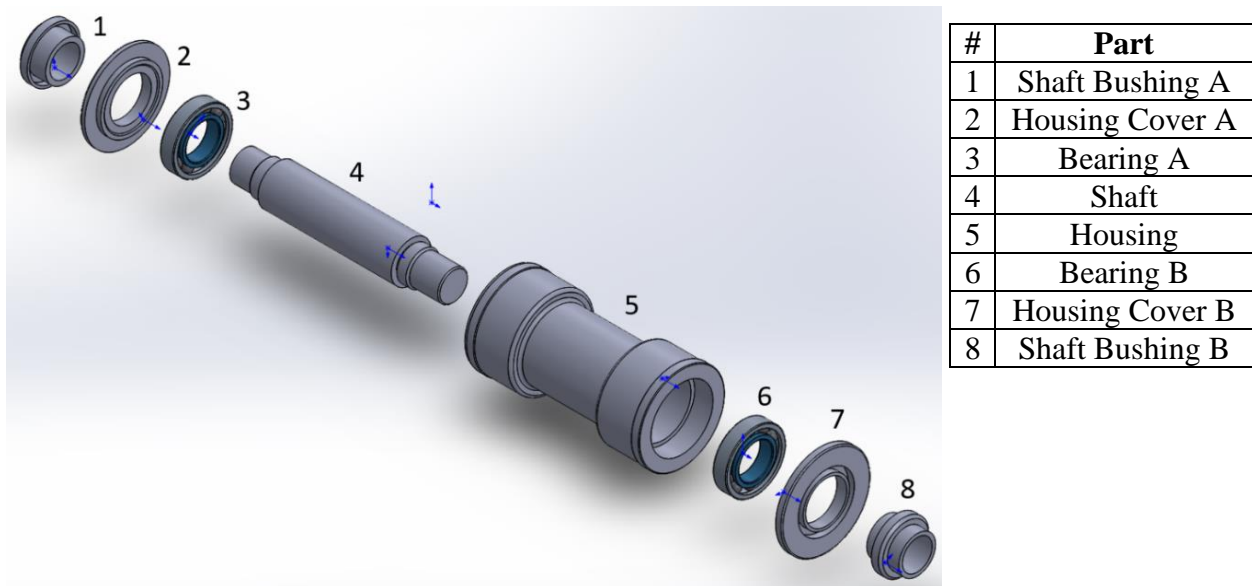
**Figure 1.1:** Gear train with colors representing different speeds (blue is stationary)

## 2 Assembly Model and Procedure

### 2.1 Cross Section and Model



**Figure 2.1:** Cross section of the shaft and housing



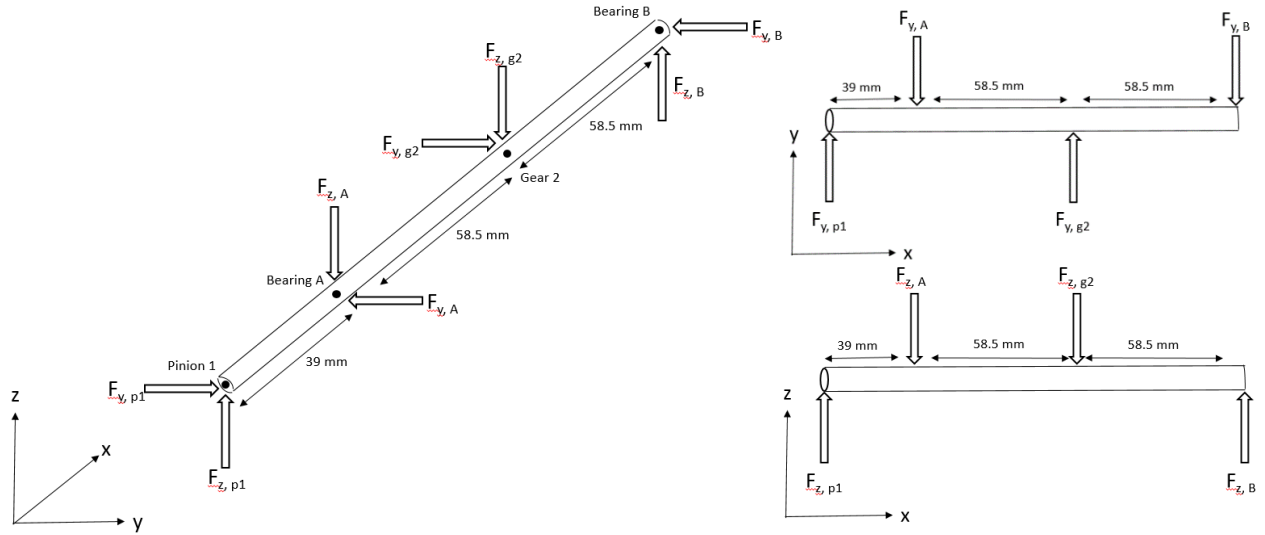
**Figure 2.2:** Exploded view of the shaft and housing with labelled parts

### 2.2 Procedure

1. Press-fit bearing A [3] onto the left side of the shaft [4]
2. Mount the housing [5] onto the shaft [4]
3. Slide in housing cover A [2] into the housing [5] and around the shaft [4] on the left
4. Slide in shaft bushing A [1] into the housing [5] and around the shaft [4] on the left
5. Slide in bearing B [6] onto the right side of the shaft [4]
6. Slide in housing cover B [7] into the housing [5] and around the shaft [4] on the right
7. Slide in shaft bushing B [8] into the housing [5] and around the shaft [4] on the right

### 3 Free Body Diagram and Calculations

#### 3.1 Free Body Diagram



#### 3.2 Calculations

The reduction ratio is:

$$N = \frac{D_{g1}}{D_{p1}} \frac{D_{g2}}{D_{p1}} = 19.216$$

The input and output torques are:

$$T_{in} = \frac{P}{n \times \eta} = 35.368 \text{ N} \cdot \text{m} \quad T_{out} = T_{in} \cdot N \cdot \eta = 611.655 \text{ N}$$

The pinion and gear forces applied on the intermediate shaft are:

$$F_{z,p1} = \frac{T_{in}}{D_{p1}/2} = 1178.926 \text{ N} \quad F_{y,p1} = F_{z,p1} \cdot \tan(20^\circ) = 429.094 \text{ N}$$

$$F_{z,g2} = \frac{T_{out}}{D_{g2}/2} = 4993.105 \text{ N} \quad F_{y,g2} = F_{z,g2} \cdot \tan(20^\circ) = 1817.342 \text{ N}$$

On the x-y plane, the forces applied in the y-direction are:

$$F_{y,p1} + F_{y,g2} = F_{y,A} + F_{y,B}$$

$$-F_{y,p1} \cdot 0.156 + F_{y,A} \cdot 0.117 - F_{y,g2} \cdot 0.0585 = 0$$

$$F_{y,A} = 1480.796 \text{ N} \quad F_{y,B} = 765.640 \text{ N}$$

On the x-z plane, the forces applied in the z-direction are:

$$F_{z,p1} - F_{z,g2} = F_{z,A} - F_{z,B}$$

$$-F_{z,p1} \cdot 0.039 - F_{z,g2} \cdot 0.0585 + F_{z,B} \cdot 0.117 = 0$$

$$F_{z,A} = 924.652 \text{ N} \quad F_{z,B} = 2889.243 \text{ N}$$