Design and Analysis of Gear Box Shaft

- Course: Strength of Materials (ME2303)
- Batch: E-3Guide: Dr. Dinesh Washimkar

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Abstract

- Project focuses on structural and torsional behavior of a differential gearbox shaft.
- Model created using Fusion 360 and analyzed in ANSYS 2025 R2.
- Results: Max Stress ≈ 1.5223+008 Pa, Max Deformation ≈ 1.1106e-004 m.
- Analytical, programming, and simulation results matched within ±5%,
- confirming design safety under the given load conditions.

Introduction

- Gearbox shafts transmit power and experience bending, torsion, and shear.
- Goal: Ensure strength and stiffness under combined loading.
- Methods used: CAD modeling, analytical calculations, and FEA validation in ANSYS.
- Results confirmed safe and reliable design performance.

Problem Statement

- To design and analyze a differential gearbox shaft subjected to torque and bending due to gear forces, and to verify stresses and deformation using analytical methods, programming, and FEA.

Objectives

1. Model gearbox shaft accurately using Fusion 360.

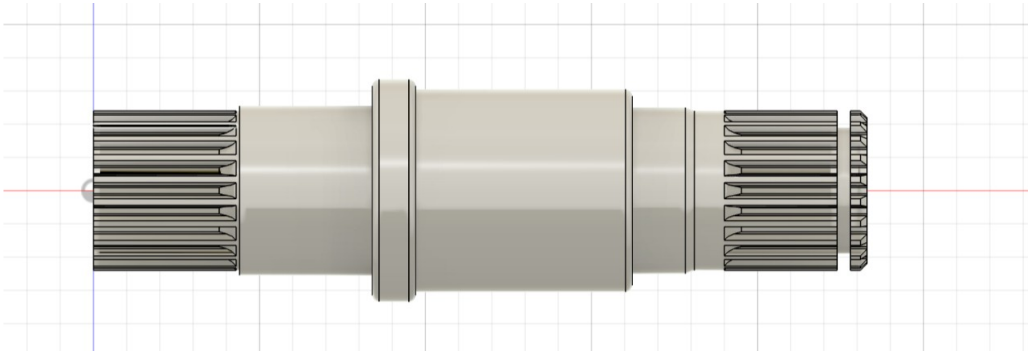
2. Perform FEA in ANSYS under applied load.

3. Calculate deformation & stress; check material suitability.

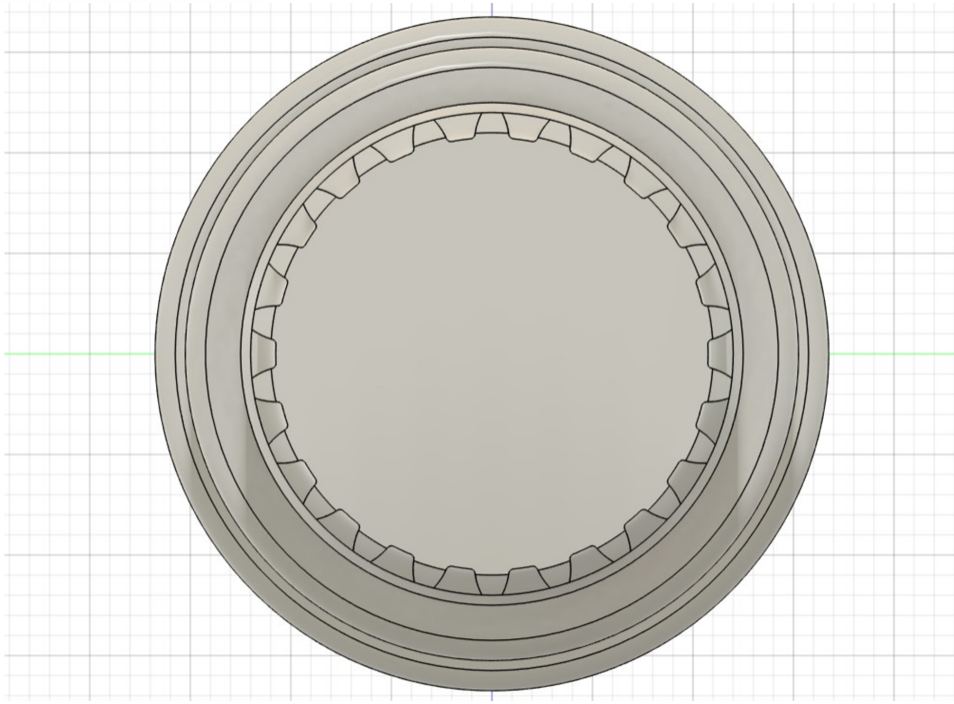
4. Validate results using programming (Python/Excel/C++).

5. Apply SOM concepts: stress, torsion, bending, deformation.

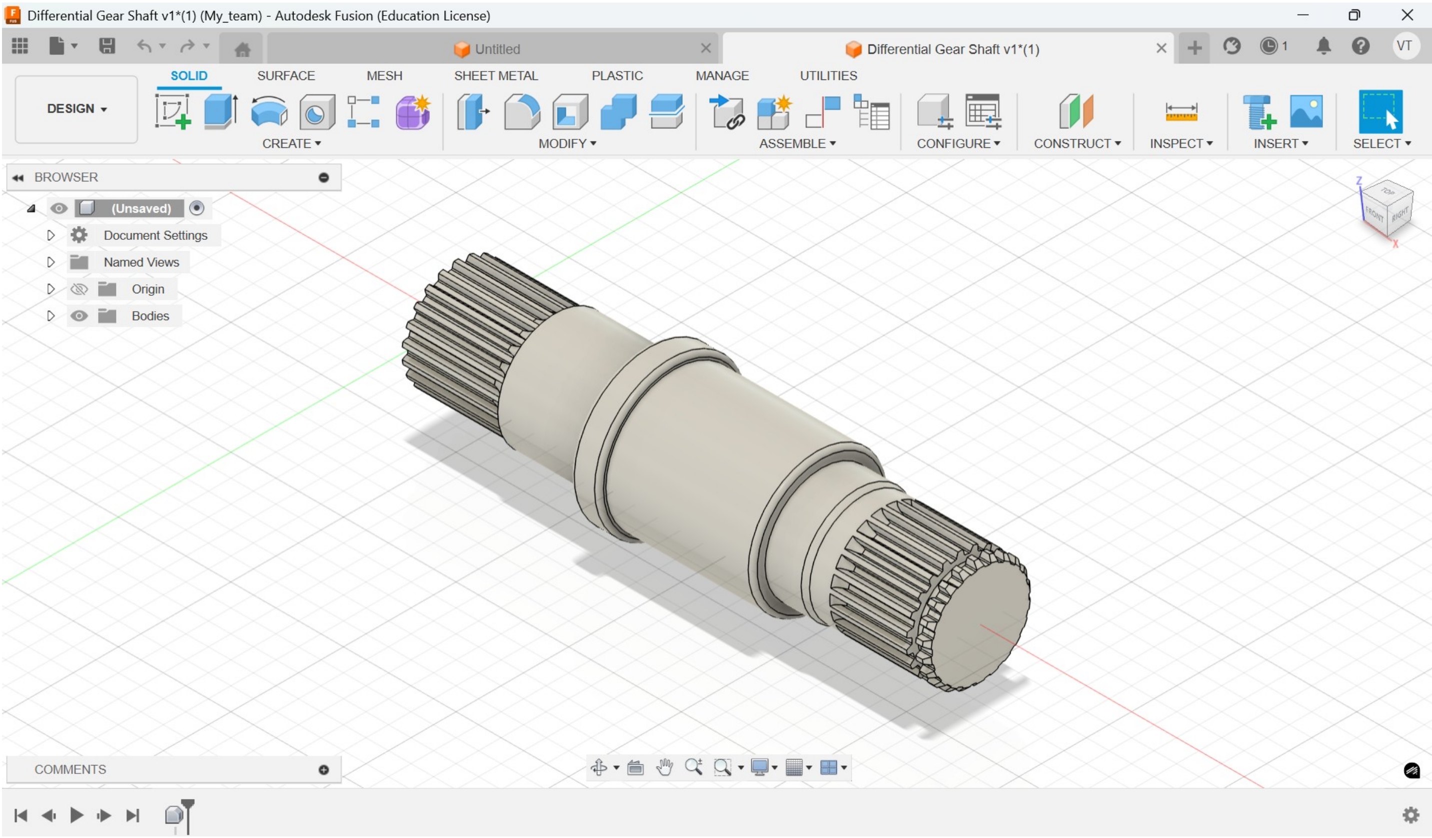
CAD Modeling



- Geometry modelled usingFusion 360.
- Steps:
- 1. Revolve base sketch to form shaft.
- 2. Apply circular pattern (22 splines).
- 3. Mirror operation for symmetry.



In this project, the gearbox shaft was designed using Autodesk Fusion 360.
We first created a 2D sketch based on actual dimensions, including total shaft length, diameters, spline width, keyway depth, and fillet radius.
After fully constraining the sketch, we used the revolve tool to generate a 3D solid shaft.
The splines were created using extruded cuts and then patterned using the circular pattern feature with 22 repetitions.
A mirror operation was used to maintain symmetry.
Chamfers and 1 mm fillets were added to remove sharp edges and reduce stress concentration, which is important from a Strength of Materials perspective.
The final model was exported as a STEP/STL file for FEA analysis in ANSYS.



Here are the key SOM-based decisions for my differential shaft:

• Fillets: Used to reduce stress concentration and prevent fatigue.

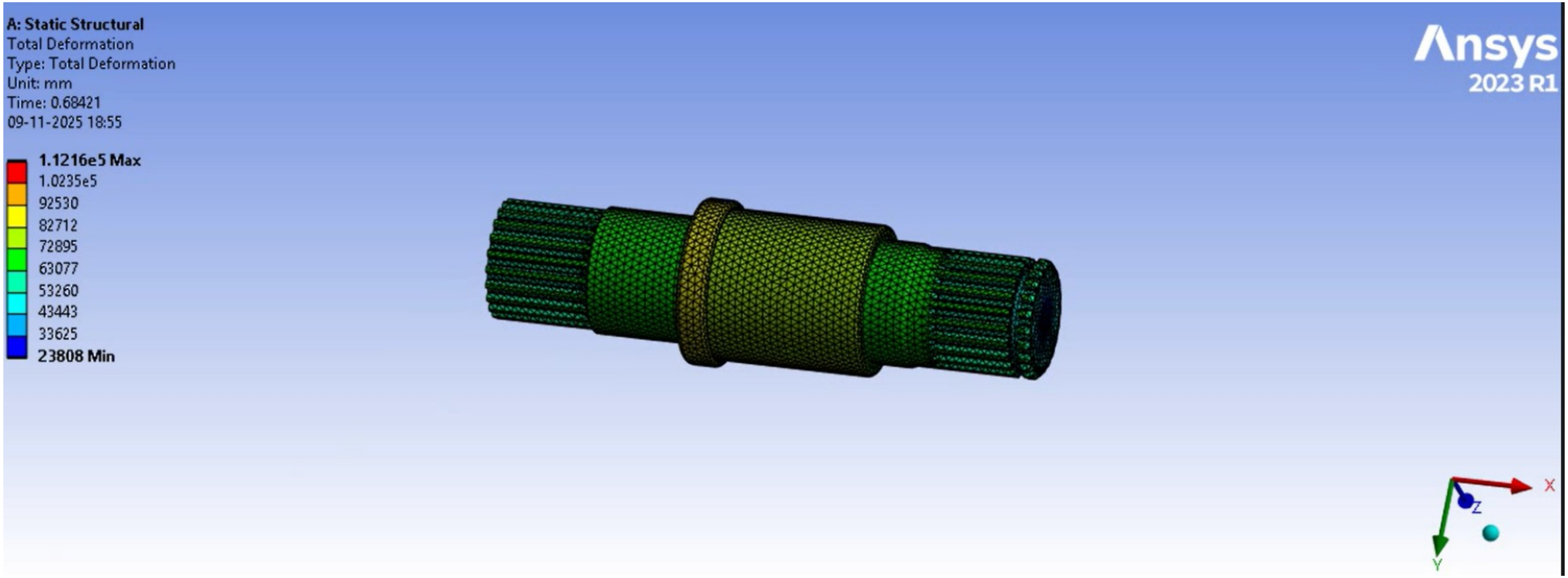
• Diameter: Calculated to get the right polar moment of inertia (J) for handling torsion.

• Splines: Added to maximize torque transmission capacity.

• Chamfering: Applied to the ends to avoid crack initiation.

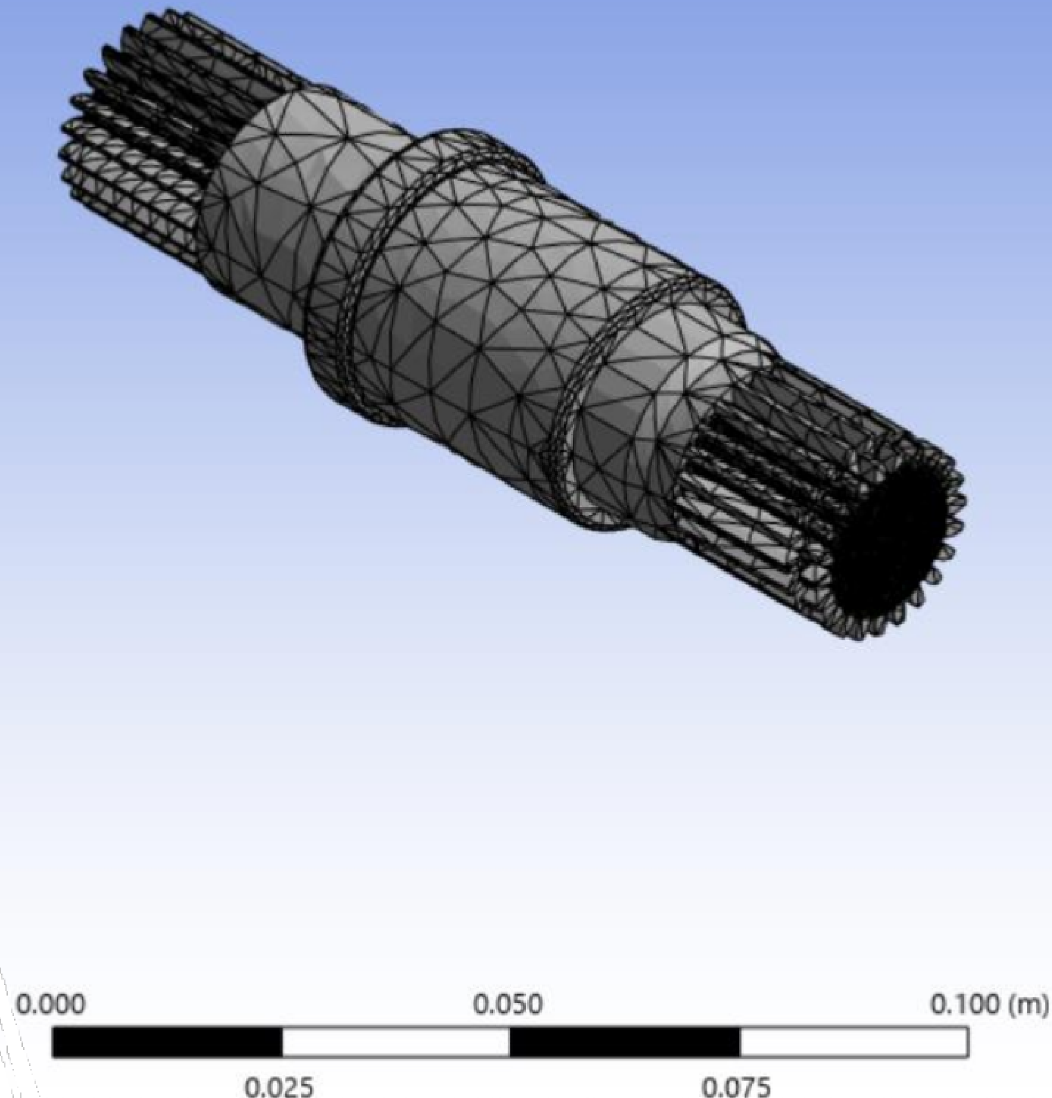
• Length/Thickness: Balanced to ensure rigidity and control deflection.

• Material: I used Structural Steel, selected for its high stiffness (210 GPa Young's Modulus) and reliable yield strength (250 MPa).



ANALYSIS

- Fillet applied to reduce stress concentration.
- Final 3D model ready for analysis and exported to ANSYS.

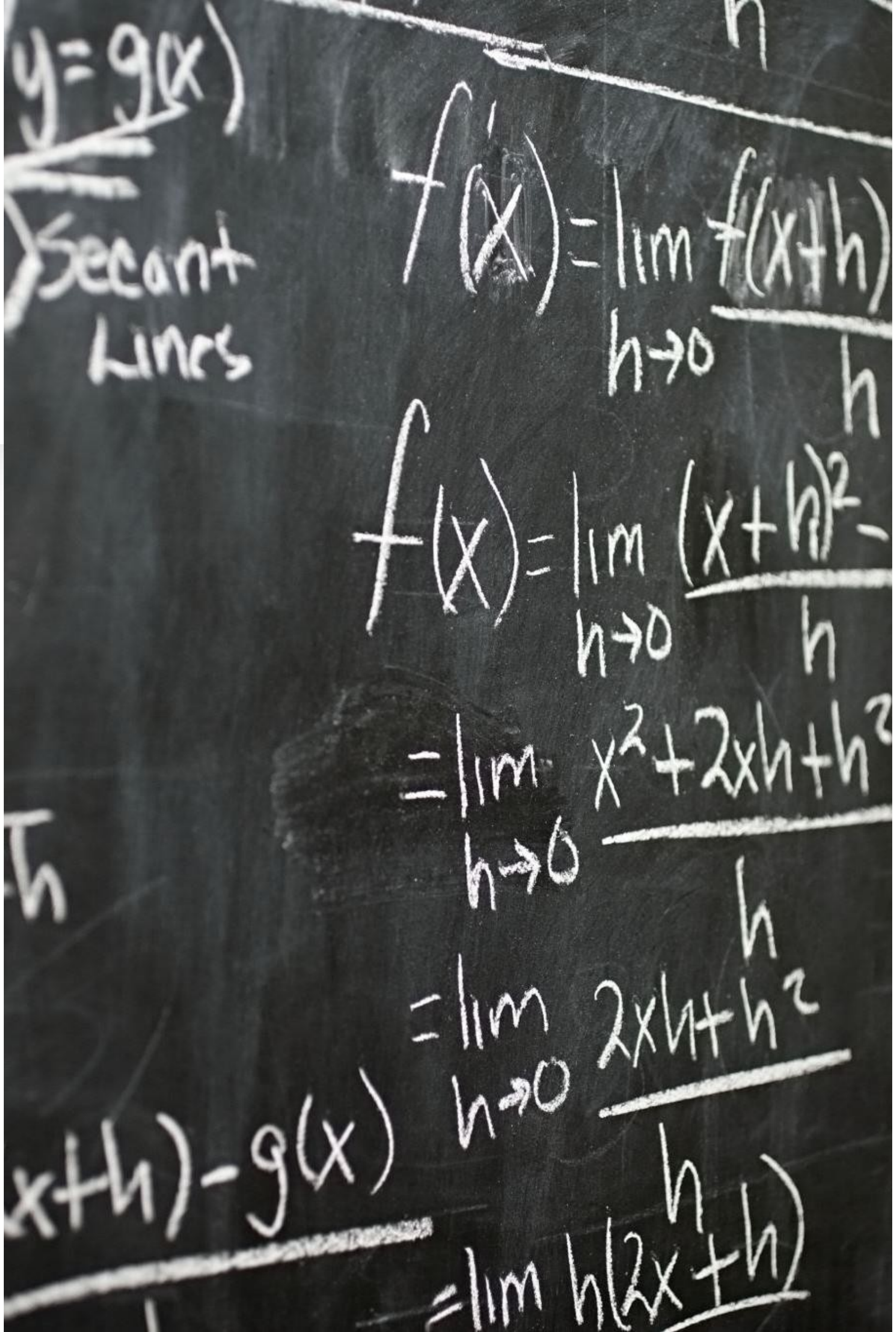


Material Selection

- Material: Structural Steel
- $E = 2 \times 10^5$ MPa | $G = 7.7 \times 10^4$ MPa | σ_γ = 250 MPa
- Reason: High strength, easy availability, machinability, suitable for power transmission shafts.

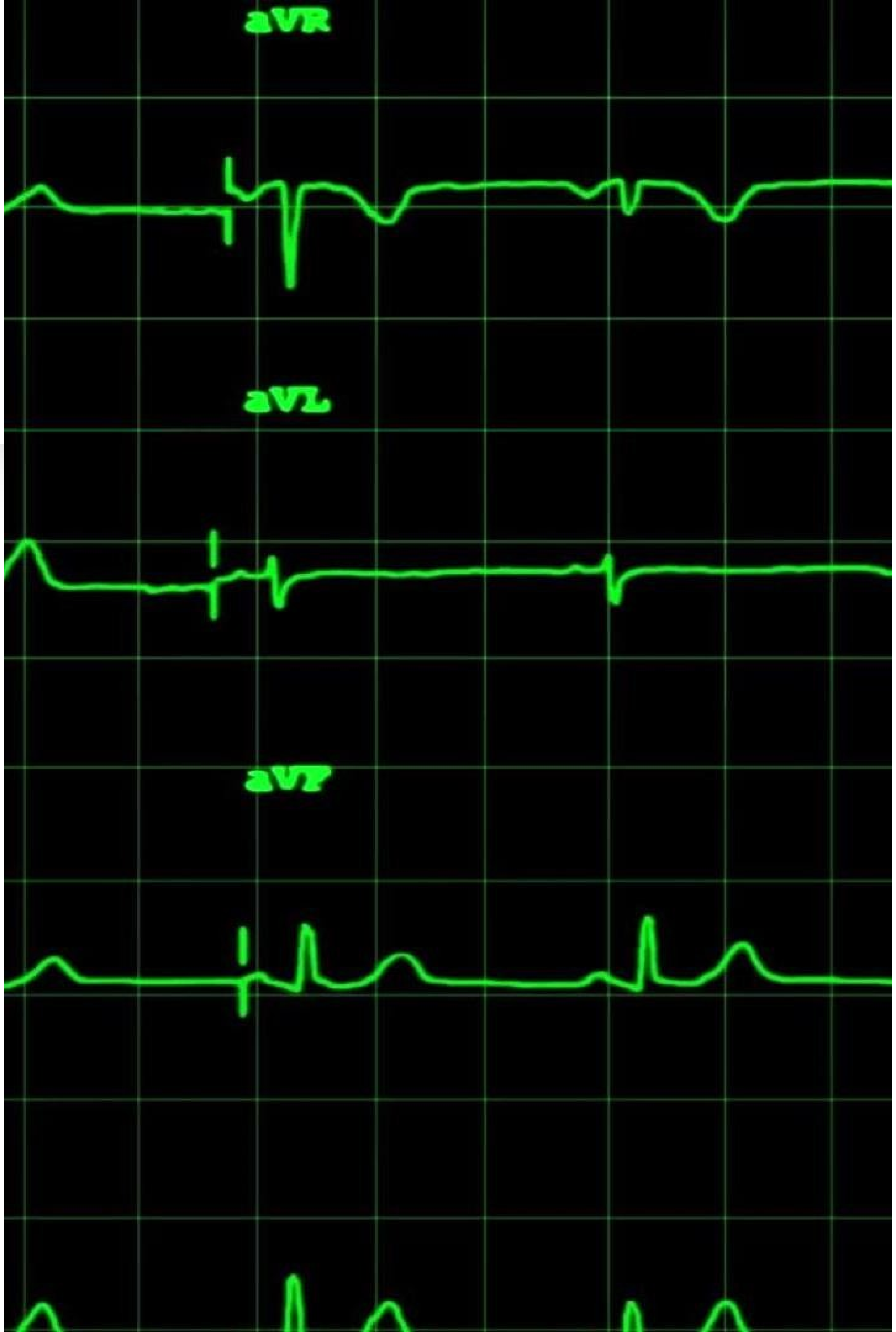
Programming Support

- Calculated torsional shear stress, bending stress, and angle of twist.
- Results matched with ANSYS (±5% error), validating theoretical equations.



FEA Analysis Results

- Solver: Static Structural (ANSYS 2025 R2)
- Max Equivalent Stress: 1.5223e+008 Pa | Max Deformation: 1.1106e-004 m
- Stress concentrated near spline ends; design safe under given torque.



Discussion

- Max stress occurs at spline region due to stress concentration.
- Deformation maximum at mid-span.
- Analytical and FEA results consistent; redesign or stronger material suggested for safety.

Conclusion

- Gearbox shaft successfully designed and analyzed.
- FEA results show stress near yield limit.
- Confirms theoretical behavior of bending and torsion.
- Further material or design improvements recommended.

Thank You