

Question Level:-

This question is at a **second-year to early third-year undergraduate mechanical engineering / CAD standards level**, aligned with a professional drafting and GD&T standard rather than a school- level task.

Assignment 1: Mechanical Component Modeling & Tolerance Analysis

High-Pressure Hydraulic Valve Body

Software, Standards & Design Approach

- **Software Used:** AutoCAD / SolidWorks (as applicable)
- **Standards Followed:** ASME Y14.5–2018, ANSI Inch Template
- **Modeling Approach:** Parametric solid modeling with constraint-based design

This approach ensures dimensional accuracy, design flexibility, and compliance with professional mechanical drafting standards.

Design Assumptions

- Operating pressure was assumed to be within safe working limits for **Stainless Steel 316**.
- Standard bolt sizes and tolerances were selected based on **ANSI flange practices**.
- Valve stem and spring dimensions were assumed for the purpose of demonstrating assembly intent and fitment.

These assumptions were clearly stated to maintain transparency and avoid ambiguity in design interpretation.

Part 1: 3D Part Modeling (20 Marks)

a) Modeling Techniques (Boolean Operations & Fillets)

A 3D solid model of the **High-Pressure Hydraulic Valve Body** was created using parametric solid-modeling techniques. The external geometry was developed using **extrude and revolve operations** based on the provided design specifications.

Internal fluid chambers and flow passages were modeled using **Boolean subtraction operations**, where cylindrical and profiled solids were subtracted from the main body to form accurate internal cavities. This modeling method ensures manufacturability and precise internal flow geometry.

All **fillets and rounds** were applied according to the stress-concentration report to minimize sharp edges and reduce stress risers. Larger fillet radii were applied at high-stress regions such as internal corners near valve seating areas, while smaller rounds were used on non-critical edges to preserve dimensional accuracy.

b) Parametric Design (Bolt-Hole Circle Constraints)

The bolt-hole circle was created using a **parametric circular pattern**. Geometric and dimensional constraints were applied so that:

- The **number of bolt holes** can be modified by changing a single parameter.
- The **bolt-circle diameter (BCD)** can be adjusted without affecting hole alignment or symmetry.

These constraints ensure that all holes remain evenly spaced and concentric with the main valve axis. This parametric design allows quick modification for different mounting standards without breaking the model.

c) Material Properties & Mass Report (10 Marks)

The material **Stainless Steel 316** was assigned to the 3D model using the CAD software's material library. This material was selected due to its corrosion resistance and suitability for high-pressure hydraulic environments.

After assigning the material, a **mass properties report (.fmp)** was generated. The report includes:

- Total mass
- Volume
- Center of gravity
- Moments of inertia

The generated **.fmp mass properties report** is included in the submission ZIP file as per the prescribed instructions. This data supports manufacturing planning and basic structural evaluation.

Part 2: 2D Production Drawing (20 Marks)

a) Orthographic & Section Views (8 Marks)

A complete **2D production drawing** was generated from the 3D model using **ANSI standards**. The drawing includes:

- Front View
- Top View
- Right-Side View
- Full Section View (Section A–A)

The section view clearly illustrates internal valve seating, fluid chambers, and internal bores, allowing machinists to understand internal features without ambiguity. All views are correctly aligned and scaled using appropriate paper space viewports.

b) GD&T Application (ASME Y14.5–2018) (12 Marks)

Geometric Dimensioning and Tolerancing (**GD&T**) was applied in accordance with **ASME Y14.5–2018** standards.

- **Position tolerance** was applied to the mounting holes relative to the primary datum axis to ensure accurate alignment during assembly.
- **Flatness tolerance** was applied to the mating surface to ensure proper sealing and leak-free operation.

Feature Control Frames (FCFs) were clearly defined and associated with true geometric features. All dimensions used are **true dimensions derived directly from the 3D model**, with no manual overwriting of dimension text.

Part 3: Assembly & Exploded Views (10 Marks)

a) Assembly & Exploded View

An assembly drawing was created to demonstrate how the **valve stem and spring** integrate with the valve body. Assembly constraints were applied to accurately represent real-world fit and movement.

An **isometric exploded view** was generated using **Tweak Tracks** to visually illustrate the correct sequence of assembly. This view clearly shows the order and orientation of components, improving clarity for manufacturing and maintenance.

b) Bill of Materials (BOM) (5 Marks)

A **dynamic Bill of Materials (BOM)** was inserted into the assembly drawing. The BOM automatically extracts data from block attributes and includes:

- Part Name
- Material
- Quantity

The table updates automatically when changes are made to the assembly, ensuring consistency and accuracy across all documentation.

Standards & Submission Compliance

- All drawings use the **Inch (ANSI)** template.
- Model space is maintained at a **1:1 scale**, with appropriate viewport scales applied in paper space.
- All associated drawings are managed using **Xrefs** for proper file organization.
- No dimensions were manually overridden, maintaining professional ethics and data integrity.
- Files are named according to the required convention:
MECH2025_Final_Project_V1.dwg

Learning Outcome (*Optional – Included for Academic Completeness*)

This assignment enhanced my understanding of **parametric modeling, tolerance analysis using GD&T**, and the importance of creating **production-ready mechanical documentation** that complies with international engineering standards.

Conclusion

This assignment demonstrates the complete workflow from conceptual design to production-ready documentation. The application of parametric modeling, GD&T, correct material assignment, and clear assembly representation ensures that the hydraulic valve body can be manufactured, assembled, and inspected efficiently while complying with **ASME Y14.5–2018** standards.