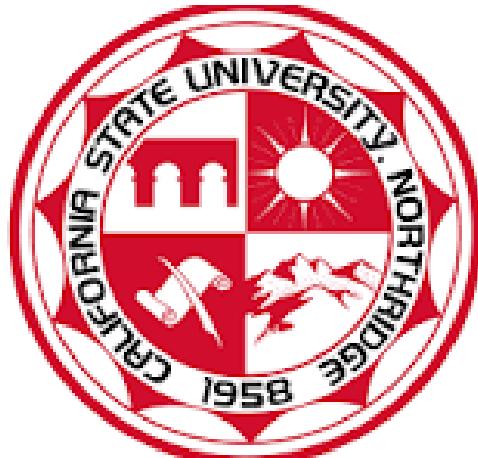


CALIFORNIA STATE UNIVERSITY, NORTHRIDGE  
Department of Mechanical Engineering



**CSUN** | Engineering and  
Computer Science

BRAKE ASSEMBLY DESIGN: MATERIALS, MANUFACTURING, AND COST ANALYSIS

ME 286 - Mechanical Engineering Design II  
Fall 2025

Submitted to:  
**Professor Mohab Shalaby, Ph.D. P.Eng.**

Prepared by:  
Rodrigo Cervantes  
Emily Skipworth  
Arturo Orozco  
Gavin Dion  
Vincent Seip  
Jovanny Perez-Giron

December 18, 2025

## ABSTRACT

High-performance automotive braking systems operate under extreme mechanical loads and severe thermal conditions, requiring careful integration of geometry, material properties, manufacturing feasibility, and economic constraints. As vehicle speeds, power output, and mass continue to increase, braking systems must safely dissipate large amounts of kinetic energy while maintaining consistent frictional performance and structural reliability. The design of such systems therefore represents a multidisciplinary engineering challenge involving solid mechanics, heat transfer, manufacturing science, and cost optimization.

The focus of this project is on design choices, material selection, manufacturing process selection and cost analysis of a high-performance automotive braking system. Modern braking systems must undergo high mechanical and thermal stresses while providing responsiveness, reliability, and durability. The objective of this project is to design and develop a braking assembly that is capable of withstanding the operating and service conditions of a high-performance automotive.

To accomplish this objective, the braking system was evaluated as an integrated mechanical and thermal energy conversion device. Design considerations included the transfer of hydraulic pressure into clamping force, the transformation of kinetic energy into heat at the rotor–pad interface, and the subsequent dissipation of that heat through conduction and convection. These operating principles guided all design, material, and manufacturing decisions.

The scope of the components considered in this project includes the rotor, brake pads, calipers, pistons and other relevant supporting components of the assembly. Each component was analyzed based on their functionality, anticipated mechanical and thermal loads, and geometry. CAD modeling, calculations, and other general engineering analysis aided us in the reasoning behind each design decision.

Each component was evaluated using fundamental engineering principles including stress analysis, heat transfer behavior, and manufacturability considerations. Tradeoffs between performance and cost were assessed by comparing conventional production materials and methods with higher-performance alternatives typically used in motorsports and premium automotive applications.

The report is broken into four chapters. Chapter 1 is the introduction. Chapter 2 focuses on design choices, such as geometry, assembly design, and cooling features. Chapter 3 discusses material selection. This includes an analysis of each material's mechanical and thermal properties, performance, manufacturability, and cost . Chapter 4 presents the manufacturing techniques and processes selection, with a focus on feasibility, scalability, and product efficiency. Chapter 5 is our final cost analysis estimations based on how each design process selection affected the system c

## TABLE OF CONTENTS

<b>Abstract</b>	2
<b>Table of Contents</b>	3
<b>References</b>	30
<b>Appendix</b>	32
<b>Chapter 1 - Introduction</b>	
1.1 Historical Development and Automotive Braking Systems	5
1.2 Performance and Thermal Motivation for High-Performance Braking Systems	5
1.3 Design for Manufacturing and Cost Drivers In Brake Systems	6
1.4 Project Objective	6
1.5 Project Scope and System Overview	6
<b>Chapter 2 - Design Choices</b>	
2.1 Introduction	8
2.2 System Level Braking Operations	8
2.3 Rotor Design and Geometry	9
2.4 Caliper Configuration and Layout	10
2.5 Brake Pad and Piston Interaction	10
2.6 Assembly and Serviceability (DFM/DFA)	11
2.7 Design Constraints and Tradeoffs	12
<b>Chapter 3 - Materials Selection</b>	
3.1 Introduction	13
3.2 Materials for Rotor and Brake Pads	14
3.3 Caliper Material	14
3.4 Pistons and Back Plate	15
3.5 Corrosion	15
3.6 Material Tradeoffs and Final Selection	15
<b>Chapter 4 - Manufacturing Techniques and Processes</b>	
4.1 Introduction	17
4.2 Rotor Manufacturing	17
4.2.1 Material Selection	17
4.2.2 Casting Processes	18
4.2.3 Secondary Manufacturing Operations	19
4.2.3.1 Machining Operations	20
4.2.3.2 Heat Treatment and Surface Conditioning	20
4.3 Brake Pads Manufacturing	21
4.3.1 Brake Pad Material Formulation	21
4.3.2 Powder Pressing	21
4.3.3 Sintering Process	21
4.3.4 Backing Plate Assembly	22
4.3.5 Surface Treatment	22
4.3.6 Impact on Performance, NVH, Safety, and Cost	22
4.4 Caliper, Pistons, and Hardware Manufacturing	23

4.4.1 Caliper Manufacturing	23
4.4.2 Piston Manufacturing	23
4.4.3 Hardware, Pins, and Clips	24
4.4.4 Assembly and Tolerances	24
4.5 Manufacturing Defects, Tolerances, and Quality Control	24
4.6 Design Manufacturing Integration	24
 <b>Chapter 5 - Cost Analysis and Design Optimization</b>	
5.1 Introduction	25
5.2 Cost Breakdown Approach	25
5.3 Material Costs	26
5.3.1 Rotor Material Cost	26
5.3.2 Brake Pad Material Cost	26
5.3.3 Caliper, Pistons, and Hardware Cost	26
5.4 Labor Costs	27
5.5 Overhead Costs	27
5.6 Cost Optimization	27
 <b>Chapter 6 - Conclusion</b>	28