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ENGINE DESIGN PROJECT: TWO STROKE V4 ENGINE

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Abstract. Recent advancements in fuel science and catalytic converter technology have significantly improved fuel efficiency and emission control, allowing fuel to burn more cleanly in engines, particularly those employing a two-stroke

operation. These technological improvements warrant a reanalysis of the two-stroke engine in terms of its uses and applications. This student project aims to design a high-performance 2-stroke Vee-4 engine with a cylinder displacement of 2 liters, utilizing LINKAGES software for precise modeling and simulation. The engine features a 90-degree Vee angle and a cylinder separation of 3 inches, optimizing the balance and dynamics of the engine. The primary goal of this project is to provide students with a comprehensive understanding of engine design, with a particular focus on V engines and two-stroke engines. Students will use LINKAGES software to model the individual linkages within the engine system. This software enables the precise simulation of the engine's moving parts, ensuring that the linkages are designed to withstand the dynamics of operation. The integration of LINKAGES will help in determining the engine's mechanical qualities. As part of the future direction of this project, students will employ DYNACAM to analyze and optimize the camshaft profiles, ensuring optimal valve timing and performance. This software will allow for detailed analysis of the camshaft dynamics, providing insights into the best configurations for achieving maximum power output and efficiency. Through the combination of LINKAGES and, in the future, DYNACAM software tools, students will develop a reliable engine, suitable for various applications.

The project will focus on achieving a balance between power, efficiency, and durability, making the engine ideal for use in competitive motorsports and other demanding environments. By engaging in rigorous testing and simulation, students will gain valuable insights into engine design and performance, enhancing their understanding of V engines and two-stroke engines.

Introduction. Most contemporary automotive and industrial powertrains rely on four-stroke architecture, yet a modernized two-stroke remains a compelling alternative. Our proposed 2 liter V4 two-stroke illustrates how current materials, electronic controls, and emissions hardware can unlock advantages once thought exclusive to four-stroke designs. First, the two-stroke's mechanically simple layout—no poppet valves, camshafts, or timing gear—shrinks mass and part count. Fewer components lower manufacturing cost and ease service, enabling manufacturers to offer lighter, budget-focused vehicles without sacrificing durability. Because every downward piston motion is a power stroke, a well-scavenged two-stroke delivers a higher specific power than an equally sized four-stroke according to Hilgendorf [1], eliminating the need for turbo chargers or superchargers to achieve competitive output. In a compact V-configuration, the 2-L two-stroke occupies roughly the width of a twin-cylinder four-stroke, giving designers freedom to shorten the wheelbase and streamline the front fascia—both contributors to reduced curb weight and improved fuel economy.

Historically, poor fuel economy and high hydrocarbon emissions pushed industry toward four-strokes. Today, those liabilities can be mitigated. Direct gasoline injection timed after exhaust-port closure prevents fresh charge loss, dramatically boosting thermal efficiency. Paired with variable electronic lubrication, modern low-ash oils, and stratified-charge combustion, unburned-oil emissions fall to levels on par with four-strokes. Three-way catalytic converters—now up to 99 percent effective according to Spacey [2]—further curtailing remaining pollutants, allowing compliance

with stringent Tier 3 and Euro 7 limits while retaining the two-stroke's performance density.

Market forces reinforce the case. By January 2025 the U.S. median transaction price for a new car climbed to roughly \$48 000 according to Fischer [3], up 34 percent versus 2019 according to Fischer [4]. Consumers increasingly seek affordable, efficient transportation. A lightweight, naturally aspirated two-stroke V4 can meet everyday performance expectations with fewer parts, lower assembly time, and reduced material usage, translating to a lower sticker price. Its compact footprint permits smaller, aerodynamically optimized platforms that sip fuel yet still accelerate briskly thanks to the engine's superior power-to-weight ratio.

In short, revisiting the two- strokes through the lens of twenty-first-century engineering transforms yesterday's drawbacks into today's opportunities. With direct injection, advanced lubrication control, and modern after-treatment, a clean, efficient two-stroke V4 can deliver competitive performance, lower cost, and packaging flexibility—attributes that align squarely with the modern market's demand for economical, environmentally compliant mobility.

Design Parameters. In the engine design project, several engine types were considered but the two stroke V4 engine was selected. For this engine, a piston displacement of 2 liters or 122.047 cubic inches. The stroke to crank ratio was decided to be 2, to align with industry standards as stated by Achates Power [5], which determined the stroke length and cylinder bore to be 8.535 in. and 4.267 in. respectively. This information was loaded into the LINKAGES software and the linkage was calculated. The output linkage is shown in Figure 1.

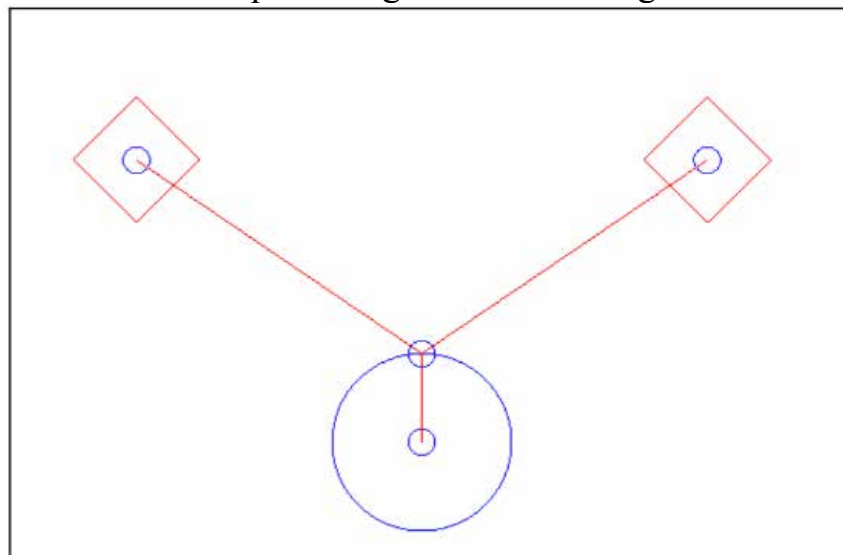


Figure 1: 2 Stroke V4 Engine Linkage Mechanism Showing Two Pistons.

Results. Based on the design of the linkage mechanism governing the output of the engine, the position, velocity, and acceleration curves were generated using Microsoft Excel. This data to populate the position, velocity, and acceleration curves was output by the LINKAGES software developed by Robert Norton. This software allowed the engine parameters to be refined and visualized. Figures 2-4 show the position, velocity, and acceleration curves needed to further design the engine to accomplish its purpose.

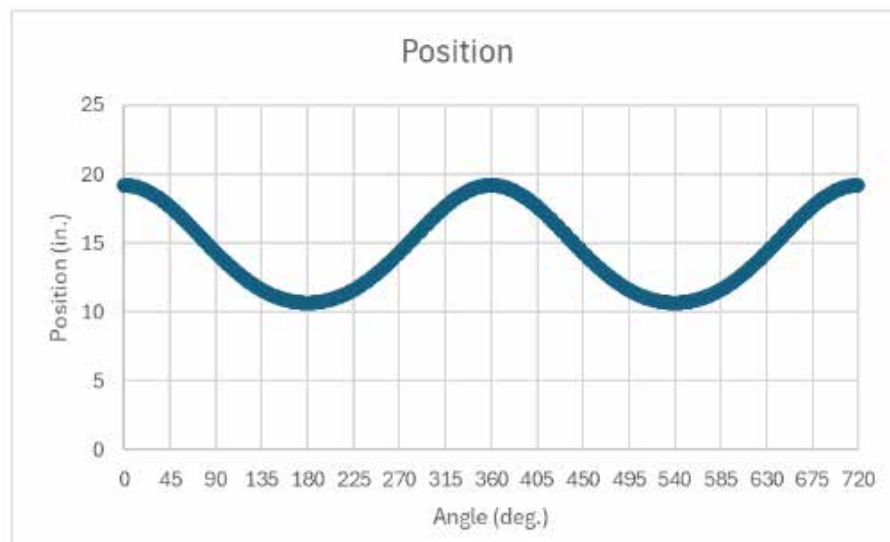
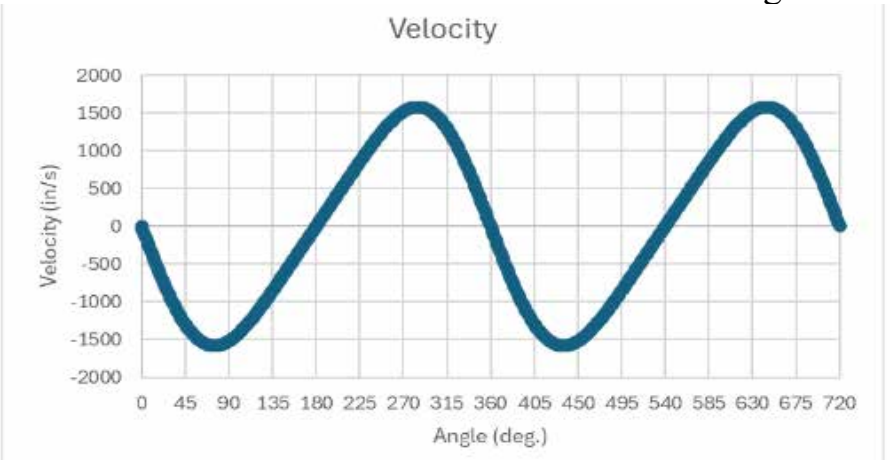


Figure 2: Piston Position at Different Positions in the Engine Stroke.



Figures 3: Piston Velocity at Different Positions in the Engine Stroke.

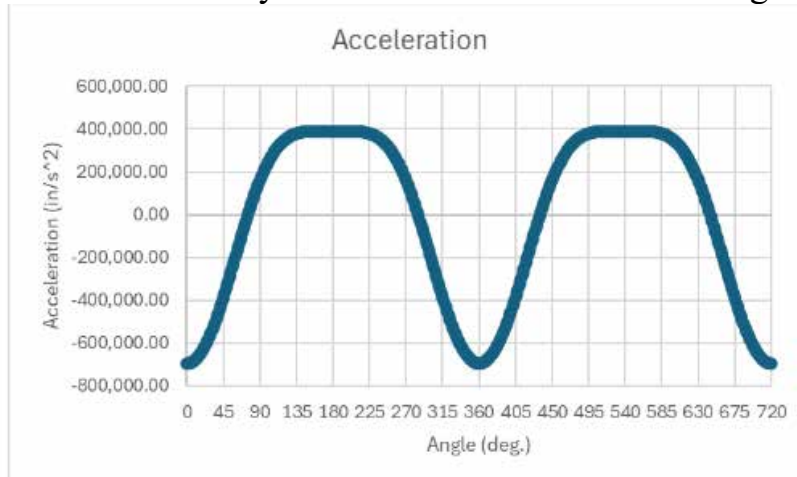


Figure 4: Piston Acceleration at Different Angles in the Engine Stroke.

The above figures show the position, velocity, and acceleration curves needed to continue designing an engine. Based on this data, the cam shaft for the engine can be generated and balancing parameters can be applied in order to allow the engine to operate with acceptable levels of vibration. Figure 5 shows the balancing of the cylinder necessary to dynamically balance the engine. This will decrease the wear and tear on the engine and allow it to run smoother and last longer.

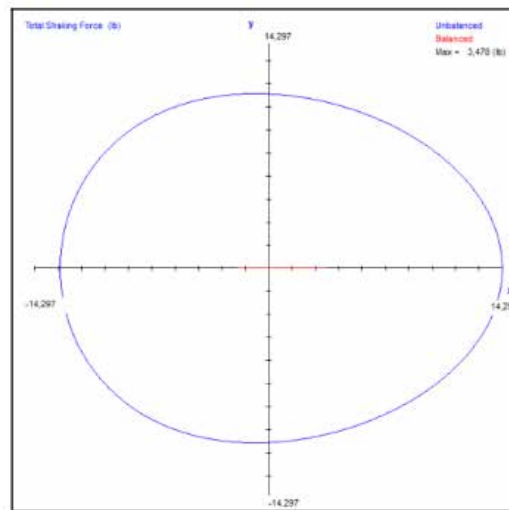


Figure 5: Balanced Cam Profile for a Single Cylinder.

For exact balance, the LINKAGES software recommends 0.02 lbs to be added at 180 degrees to balance the cylinder with a crank radius of 4.267 inches. This information is vital for designing a well balanced engine. Designing the balanced crank shaft will allow the engine to run smoother with less wear and tear.

Discussion. The design and analysis of the 2-stroke Vee-4 engine with a cylinder displacement of 2 liters, featuring a 4.267-inch cylinder bore and an 8.535-inch stroke length, provide valuable insights into the design of engines and how they operate. The stability curve, which plots the engine's performance characteristics against various operational parameters, is crucial for understanding how the engine behaves under different conditions. The stability curve also serves to explain how the engine can operate safely and more efficiently.

By analyzing the stability curve, students can determine the engine's response to changes in load and speed, which is essential for optimizing its performance. The curve also highlights the engine's ability to maintain stability under varying conditions, which is critical for high-performance applications such as competitive motorsports.

In this project, LINKAGES software was used to model the individual linkages within the engine system and aid with the ongoing design. This software enables the capability of simulation of the engine's moving parts, allowing the movement profiles to be generated to aid in the dynamic analysis of the engine. The integration of LINKAGES helps in optimizing the engine's mechanical abilities and reliability, which are crucial for maintaining stability and performance.

As part of the future direction of this project, DYNACAM will be employed to analyze and optimize the camshaft profiles. This software will allow for detailed analysis of the camshaft dynamics, providing insights into the best configurations for achieving maximum power output and efficiency. By simulating various camshaft profiles, students will identify the most effective design to enhance the engine's dynamic performance. Overall, the combination of LINKAGES and, in the future, DYNACAM software tools will enable students to design the two-stroke V4 engine.

Conclusion. Automobiles are a vital part of everyday life. They take us from one place to another and making them more affordable and dependable should be a major concern for design engineers. The engine design project is an invaluable piece of

experience for students in the process of learning about the design of engines. Designing a two-stroke, four cylinder V engine while keeping in mind the parameters that allow for the engine to function pushes students to understand why they make the decisions they do in design.

The two stroke engine has its advantages being lighter and more dependable than a four stroke engine. With the advancements in fuel science and catalytic converters, research into the efficacy of using two stroke engines, coupled with the advantages in V engines, in more situations should be conducted.

References

1. Hilgendorf D. "Two-Stroke vs. Four-Stroke Differences?," AMSOIL Blog, 24 Aug. 2022. [Online]. Available: <https://blog.amsoil.com/two-stroke-vs-four-stroke/>. [Accessed: 16 Apr. 2025].
2. Spacey T. "The Connection Between Catalytic Converters and Fuel Efficiency," Automotive Blog, 18 Oct. 2023. [Online]. Available: <https://automotiveblog.co.uk/2023/10/the-connection-between-catalytic-converters-and-fuel-efficiency/>. [Accessed: 16 Apr. 2025]. automotiveblog.co.uk
3. Fischer J. "New Car Price Trends in 2025: Average Selling Prices Hold Near Record Highs," CarEdge, 28 Feb. 2025. [Online]. Available: <https://caredge.com/guides/new-car-price-trends-in-2025>. [Accessed: 16 Apr. 2025]. CarEdge
4. Fischer J. "Car Price Inflation Is Real – These Brands Are the Worst [2025 Update]," CarEdge, 15 Apr. 2025. [Online]. Available: <https://caredge.com/guides/car-price-inflation>. [Accessed: 16 Apr. 2025]. CarEdge
5. Achates Power, "Stroke-to-Bore Ratio: A Key to Engine Efficiency," Achates Power blog, 15 Oct. 2021. [Online]. Available: <https://achatespower.com/stroke-to-bore/>. [Accessed: 16 Apr. 2025].

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