ME 4053: Fall 2025
Project 1
Stirling Engine Analysis & Flywheel Design

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As the theme for this modeling course this term is energy conversion and storage, a Stirling engine is being developed that is intended to drive a generator and charge a battery bank for energy storage purposes. In driving a generator, it is important to minimize speed fluctuations. Stirling engines naturally speed up and slow down during the compression and expansion processes, and that fact necessitates the use of a flywheel to even out the fluctuations in speed.

Figure 1: Example coffee cup powered Stirling engine demonstration shown in ME4053 lecture

For this project a simple beta-type engine will be analyzed with crank-slider mechanisms for both the displacer and power pistons. The connecting rods for this design are driven by a single crankshaft, as demonstrated in Figure 2.

In order to properly size the flywheel, we will need to know the amount of energy that must be delivered by the flywheel during compression, and how much rotary inertia it must have to provide an acceptable maximum allowable fluctuation in speed. By knowing the amount of kinetic energy needed, and also knowing the permissible fluctuation in speed, the designer can properly size a flywheel in order to meet the design requirements.

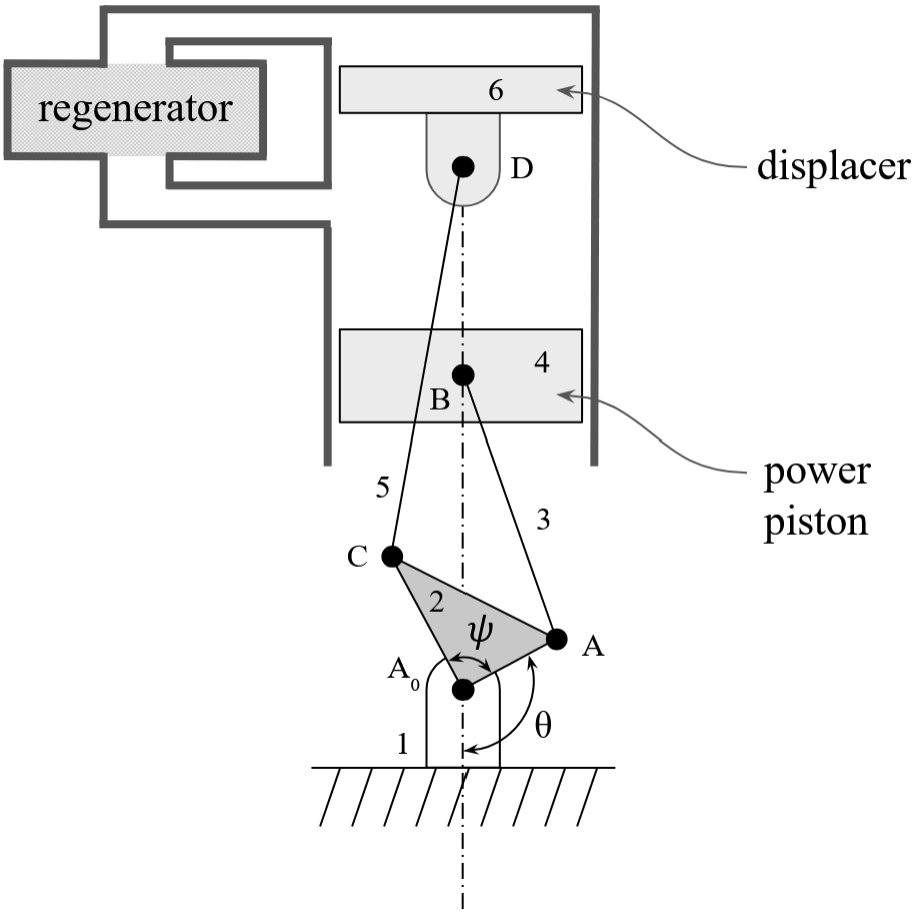

Figure 2: Labeled engine components & linkage design for the Stirling engine analysis

The flywheel that is to be used will be made up of a single material and will take the shape of an uniform cross-section annulus, such that mass is placed where it has the largest effect. A simple schematic is shown below to highlight the geometry.

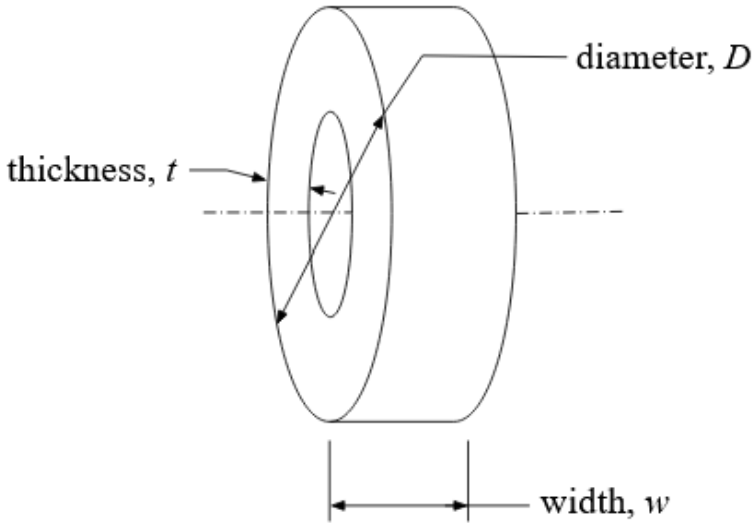

Figure 3: Labeled sketch of simplified flywheel geometry to be used in this analysis

A summary set of design specifications for the Stirling engine is provided in Appendix B. In short, your challenge is to design a flywheel that can be used on a Stirling engine that can meet these specifications. You are expected to demonstrate that your design meets the specifications, without actually building the engine, using modeling, simulation and analysis.

This, being the first analysis for this Stirling engine, the following assumptions are allowed when determining the flywheel design:

- Frictional losses can be neglected
- ˆAll components are massless (except the flywheel)
- ˆThe working fluid is behaving as an ideal gas
- ˆIsothermal expansion and compression
- ˆIdeal regenerator
- ˆLumped, 3-body
    - Constant pressure throughout the gas
    - Constant temperature in each body