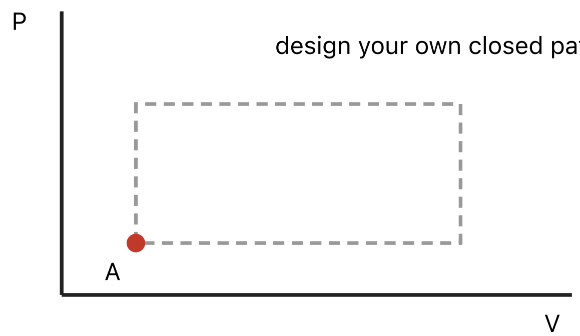
THERMO DAY 13: LAB L9.4: DESIGN A HEAT-ENGINE CYCLE

CED 9.4 · Inquiry B · FRQ: ED · artifact: student-designed P–V cycle and First-Law ledger

INVESTIGATION QUESTION

PRE-LAB **What makes a cycle an engine?**

Open the Day 13 guided experience, lock the prediction, and choose **Explore After Predicting**. Use the gas-piston model to design and run a closed P–V cycle. Keep the particle count fixed; your group chooses the temperature and volume changes, state points, and number of measurement steps. The cycle must return to its starting state and deliver positive net work.



Design constraints

- At least three distinct legs and four recorded state points.
- Include at least two process types.
- Stay within the simulation's safe P, V, and T ranges.
- Record data you generate; printed sample data does not count as today's investigation.

PLAN Sketch your proposed path, add arrows, identify each leg, and predict the sign of $W_{by,net}$.

PROCEDURE YOU DESIGN

1. Choose process legs and target state points.
2. Decide how many intermediate readings each leg needs.
3. Specify which controls change and which quantities remain fixed.
4. Run one pilot cycle; revise if it does not close.
5. Run the final cycle and retain the data table.

Point	P (kPa)	V (m^3)	T (K)	Process to next point
A				
B				
C				
D				
E				
A return				

QUALITY CHECK How will you decide whether your final point is close enough to the initial state to call the path closed?

ANALYSIS

Estimate work for each leg from the signed area under the P–V path. For horizontal legs, $W_{by} = P\Delta V$. For curved legs, use trapezoids between adjacent measurements.

Leg	W_{by} (kJ)	Q (kJ)	ΔU (kJ)	Evidence
1				
2				
3				
4				
5				
Net				

ENGINE RESULT Compute $W_{by,net}$, total positive heat input Q_H, and $e = W_{out}/Q_H$. Does $\sum \Delta U$ agree with zero within your measurement resolution?

CLAIM–EVIDENCE–REASONING

Claim: Did your cycle operate as a heat engine?

Evidence: Cite loop direction, enclosed area, net work, and efficiency.

Reasoning: Connect the closed path to $\Delta U_{cycle} = 0$ and the First Law.

Revision: Identify one design change that would increase enclosed area without exceeding the simulator limits.

Required lab record: keep the plan, raw state-point table, graph, ledger, calculations, and CER together.