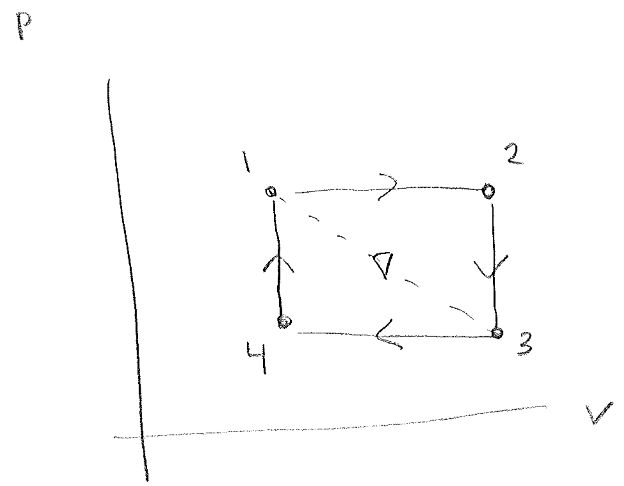

① work $1 \to 2 \to 3 \to 4 \to 1$

$$W = -(P_{high} - P_{low})(V_{high} - V_{low})$$

$\boxed{\text{negative of area enclosed by path}}$

② work $1 \to 2 \to 3 \to 1$

$$W_{1\to 2} = -\int P\,dV = -P_{high}(V_{high} - V_{low})$$

$$W_{2\to 3} = -\int dV = 0$$

$$W_{3\to 1} = ?$$

$$W_{3\to 1} = -\int_{V_{high}}^{V_{low}} P\,dV$$

$$= -\int_{V_{high}}^{V_{low}} (-aV + b)\,dV$$

$$= \frac{a}{2}\left(V_{low}^2 - V_{high}^2\right) - b\left(V_{low} - V_{high}\right)$$

$$= \left(V_{low} - V_{high}\right)\left(\frac{a}{2}\left(V_{low} + V_{high}\right) - b\right)$$

$$P = -aV + b$$

$$a = \frac{P_{high} - P_{low}}{V_{high} - V_{low}} > 0$$

$b = ?$ want $P = P_{low}$ when $V = V_{high}$

$$P_{low} = -aV_{high} + b$$

$$\Rightarrow b = P_{low} + aV_{high}$$

$$= \left(V_{low} - V_{high}\right)\left(\frac{a}{2}\left(V_{low} + V_{high}\right) - P_{low} - aV_{high}\right)$$

$$= \left(V_{low} - V_{high}\right)\left(\frac{a}{2}\left(V_{low} - V_{high}\right) - P_{low}\right)$$

$$= \left(V_{low} - V_{high}\right)\left(\frac{1}{2}\,\frac{P_{high} - P_{low}}{V_{high} - V_{low}}\left(V_{low} - V_{high}\right) - P_{low}\right)$$

$$= \left(V_{low} - V_{high}\right)\left(-\frac{1}{2}\left(P_{high} - P_{low}\right) - P_{low}\right)$$

$$= -\frac{1}{2}\left(V_{low} - V_{high}\right)\left(P_{low} - P_{high}\right)$$

$$W_{net} = -P_{high}\left(V_{high} - V_{low}\right) - \frac{1}{2}\left(V_{low} - V_{high}\right)\left(P_{low} + P_{high}\right)$$

$$= \frac{1}{2}\left(V_{high} - V_{low}\right)\left(P_{high} - P_{low}\right)$$