

Consider the following gas process, which cycles through a rectangle on a  $pV$  diagram.

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Figure 1: Gas engine path

Make a table, like the one below, and find  $W_{\text{net}}$ .

| Time period | Description (in words) | Work done by gas in this time period |
|-------------|------------------------|--------------------------------------|
| 0-10s       |                        |                                      |
| 10-20s      |                        |                                      |
| 20-30s      |                        |                                      |
| 30-40s      |                        |                                      |

**Solution** We can begin with the first step. Since the volume did not change, no work was done. The pressure is changing while the volume is being held fixed. The only way this could be happening (without changing the number of molecules in the gas) would be for the temperature of the gas to be changing. To raise the pressure of the gas, the temperature must be increasing.

In the second step, the pressure is constant, so we can find the work from

$$W = - \int p dV \quad (1)$$

$$= -p \int dV \quad (2)$$

$$= -p \Delta V \quad (3)$$

$$= -(2 \text{ atm})(0.5 \text{ L}) \quad (4)$$

$$= \text{FIXME unit conversions} \quad (5)$$

**FIXME, expand this to show the rest of the work**

| Time period | Description (in words)              | Work done by gas in this time period |
|-------------|-------------------------------------|--------------------------------------|
| 0-10s       | gas is heated at fixed volume       | 0, no volume change                  |
| 10-20s      | gas expands at fixed pressure       | -100 J                               |
| 20-30s      | gas is cooled at fixed volume       | 0, no volume change                  |
| 30-40s      | gas is compressed at fixed pressure | 50 J                                 |

The net work done is

$$W_{\text{net}} = -100 \text{ J} + 50 \text{ J} = 50 \text{ J} \quad (6)$$

Since we compress the gas at lower pressure than when it expands, it's easier to compress, and we can get net work out of the gas.