# **First law of thermodynamics** (for AP Physics 2)

$$KE_i + U_{\mathrm{G},i} + U_{\mathrm{S},i} + U_{\mathrm{E},i} + \Delta W_{\mathrm{EXT}} = KE_f + U_{\mathrm{G},f} + U_{\mathrm{S},f} + U_{\mathrm{E},f} + \Delta U_{\mathrm{INT}}$$

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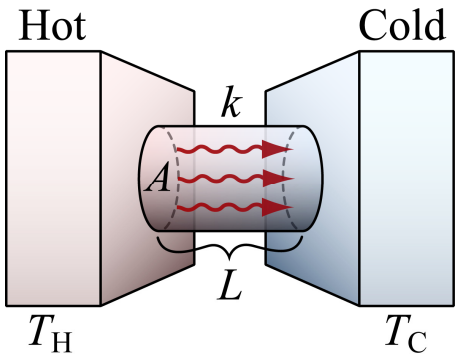
**Heat conduction**

$$\Delta Q = \frac{kA}{L}\Delta T \Delta t$$

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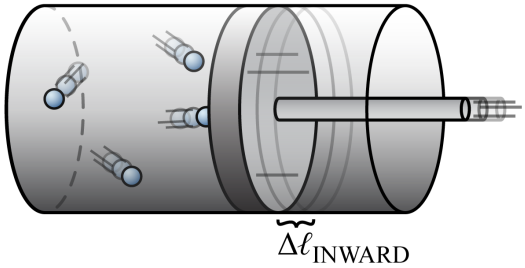
**Work**

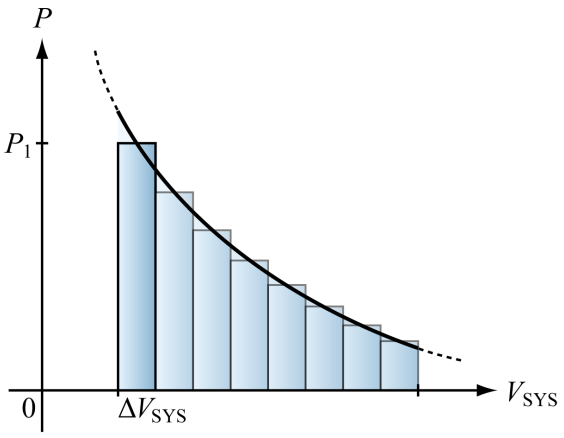
$$\Delta W_{\substack{\mathrm{OUTSIDE}\\ \mathrm{ON\ SYS}}} = F_{\mathrm{INWARD,AVG}}\,\Delta \ell_{\mathrm{INWARD}}$$
$$= P_{\mathrm{AVG}}\,A\,\Delta \ell_{\mathrm{INWARD}}$$

$$\Delta W_{\substack{\mathrm{OUTSIDE}\\ \mathrm{ON\ SYS}}} = P_{\mathrm{AVG}}\,(-\Delta V_{\mathrm{SYS}})$$




$$\Delta W_{\mathrm{BY\ SYS}} = P_{\mathrm{AVG}}\,\Delta V_{\mathrm{SYS}}$$

$\Delta W_{\mathrm{BY\ SYS}}$ = Signed area under graph of $P$ vs. $V_{\mathrm{SYS}}$

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**First law of thermodynamics**

$$\Delta U_{\mathrm{SYS}} = \Delta Q_{\substack{\mathrm{OUTSIDE}\\ \mathrm{INTO\ SYS}}} + \Delta W_{\substack{\mathrm{OUTSIDE}\\ \mathrm{ON\ SYS}}}$$

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**Types of thermodynamic processes**

**isovolumetric** – at constant volume
**isothermal** – at constant temperature
**isobaric** – at constant pressure
**adiabatic** – without transfer of heat