Thermodynamic Processes (All Equations are Mass-Specific, Simplifications for Perfect Gas, Reversible Process)

Isentropic $s = \text{const}$ $dq = 0$ $(n = \gamma)$	Isothermal T = const (n = 1)	Isobaric P = const (n = 0)	Isochoric v = const $(n = \infty, \text{i.e.}$ $p^{1/n}v$ = const	$\left(pv^n = const\right)$	TD Process
P 1 1 T1 T2 T1	T ₁₂ 1 w _{1/2} 2	$\begin{array}{c c} p \\ \hline 1 & 2 & T_1 \\ \hline \hline & W_{12} & T_2 \\ \hline & V \end{array}$	p T ₁ T ₂ T ₂ V	<i>pv-</i> diagram	Work- Diagram
T V ₁ 1 V ₂ 2 V ₂ P ₃ 8	T V ₁ V ₂ V ₃ +q ₁₂ P ₂ P ₂	T p ₁₂ V ₁ 2 1 +q ₁₂ 5	T VI=42	Ts-diagram	Heat- Diagram
$= \left(\frac{v_1}{v_2}\right)^{\gamma-1}$ $= \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}$	<u>"</u>	$=\frac{\nu_2}{\nu_1}$	$=\frac{p_2}{p_1}$	$rac{T_2}{T_1}$	Th St
$= \left(\frac{v_1}{v_2}\right)^{\gamma-1}$ $= \left(\frac{v_1}{v_2}\right)^{\gamma}$ $= \left(\frac{T_2}{T_1}\right)^{\gamma-1}$	$=\frac{v_1}{v_2}$	=_	$=\frac{T_2}{T_1}$	$\frac{p_2}{p_1}$	Thermodynamic State Quantities
$= \left(\frac{T_1}{T_2}\right)^{\frac{1}{\gamma-1}}$ $= \left(\frac{p_1}{p_2}\right)^{\frac{1}{\gamma}}$	$=\frac{p_1}{p_2}$	$=\frac{T_2}{T_1}$	<u>II</u>	$\frac{v_2}{v_1}$	iic es
= 0	$= w_{12}$ $= RT \ln \frac{p_1}{p_2}$ $= RT \ln \frac{v_2}{v_1}$ $(RT = p_1 v_1 = p_2 v_2)$	$= h_{2} - h_{1}$ $= c_{p} (T_{2} - T_{1})$ $= c_{r} (T_{2} - T_{1})$ $+ p(v_{2} - v_{1})$	$= u_{2} - u_{1} = \int_{T_{1}}^{T_{2}} c_{v} dT$ $= c_{v} (T_{2} - T_{1})$ $= c_{p} (T_{2} - T_{1})$ $- v(p_{2} - p_{1})$	$\Delta q = q_{12}$ $\left(= \int du + \int p dv$ $= \int dh - \int v dp\right)$	Heat Transfer
$= -(u_2 - u_1)$ $= c_{\nu}(T_1 - T_2)$	$= q_{12}$ $= RT \ln \frac{p_1}{p_2}$ $= RT \ln \frac{v_2}{v_1}$ $\left(RT = p_1 v_1 = p_2 v_2\right)$	$= p(\nu_2 - \nu_1)$ $= R(T_2 - T_1)$	= 0	$w_{m12} = \int_{1}^{2} p dv$	Thermodynamic Heat (Expansion) Work Work State Quantities Transfer (Closed System) (Open System)
$= -(h_2 - h_1)$ $= -\gamma \cdot w_{12}$ $= -\gamma \cdot c_{\nu} (T_2 - T_1)$ $= -c_{p} (T_2 - T_1)$	= -W ₁₂	= 0	$=-v(p_2-p_1)$	$w_{i12} = -\int_{1}^{2} v dp$	Technical Work (Open System)
= 0	$= R \ln \frac{v_2}{v_1}$ $= R \ln \frac{p_1}{p_2}$ $= -R \ln \frac{p_2}{p_1}$	$= c_p \ln \frac{T_2}{T_1}$ $= c_p \ln \frac{v_2}{v_1}$	$= c_v \ln \frac{T_2}{T_1}$ $= c_v \ln \frac{p_2}{p_1}$	$\Delta S_{12} = S_2 - S_1$ $= \int_1^2 \frac{dq}{T}$	Change in Entropy
$du = c_{\nu}dT$ $= -w_{12}$ $\Delta u = c_{\nu}(T_{2} - T_{1})$ $= \frac{R}{\gamma - 1}(T_{2} - T_{1})$	$du = 0$ $\Delta u = 0$	$du = c_{\nu}dT$ $\Delta u = c_{\nu}(T_2 - T_1)$	$du = c_{v}dT$ $\Delta u = c_{v}(T_{2} - T_{1})$	$du = c_{\nu}dT$	Change in Internal Energy

TD Process Work- Ho	Heat- TI Diagram St	Thermodynamic State Quantities	Heat Transfer	Mechanical (Expansion) Work (Closed System)	Mechanical Work (Open System)	Change in Entropy	Change in Internal Energy
(pv'' = const) pv -diagram Ts -di	Ts -diagram $\dfrac{T_2}{T_1}$	$\frac{p_2}{p_1}$ $\frac{v_2}{v_1}$	$\Delta q = q_{12}$ $\left(= \int de + \int p dv\right)$ $= \int dh - \int v dp$	$w_{12} = \int_{1}^{2} p dv$	$w_{t12} = -\int_{1}^{2} v dp$	$\Delta S_{12} = S_2 - S_1$ $= \int_1^2 \frac{dq}{T}$	$du = c_{\nu}dT$
Polytropic $(n = n;$ typically $1 < n < \gamma$) $1 < n < \gamma$	Vi pi Vz proce	Identical to isentropic process, replace γ by <i>n</i> .	$= c_{\nu} \frac{n - \gamma}{n - 1} (T_2 - T_1)$ $= c_n (T_2 - T_1)$	$= -(e_2 - e_1) \frac{\gamma - 1}{n - 1}$ $= c_{\gamma} \frac{\gamma - 1}{n - 1} (T_1 - T_2)$ $= \frac{1}{n - 1} (p_1 v_1 - p_2 v_2)$ $= \frac{p_1 v_1}{n - 1} \left(1 - \frac{T_2}{T_1} \right)$ $= \frac{p_1 v_1}{n - 1} \left[1 - \left(\frac{p_2}{p_1} \right)^{\frac{n - 1}{n}} \right]$ $= \frac{p_1 v_1}{n - 1} \left[1 - \left(\frac{v_1}{p_1} \right)^{\frac{n - 1}{n}} \right]$ $= \frac{p_1 v_1}{n - 1} \left[1 - \left(\frac{v_1}{v_2} \right)^{\frac{n - 1}{n}} \right]$ $(p_1 v_1 = RT_1)$	$= -(h_2 - h_1 - q_{12})$ $= -n \cdot w_{12}$	$= c_{v} \ln \frac{T_{2}}{T_{1}} + R \ln \frac{v_{2}}{v_{1}}$ $= c_{v} \frac{n - v}{n - 1} \ln \frac{T_{2}}{T_{1}}$ $= c_{n} \ln \frac{T_{2}}{T_{1}}$ $= c_{p} \ln \frac{T_{2}}{T_{1}} - R \ln \frac{p_{2}}{p_{1}}$ $= c_{v} \ln \frac{p_{2}}{p_{1}} + c_{p} \ln \frac{v_{2}}{v_{1}}$	$du = c_{v}dT$ $\Delta u = c_{v} (T_{2} - T_{1})$
1 st Law of Thermodynamics: Closed System: $du = \delta q - \delta w = \delta q - p dv$; $w_{m12} = \int_{1}^{2} p dv$	$-pdv;w_{m12} =$	$\int_{1}^{2} p dv$					
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