MECH20422 Applied Thermodynamics Formula Sheet

1 Basic Thermodynamics

$\delta W = P\,dV$	Boundary Work	(1)
$h = u + pv$	Specific Enthalpy	(2)
$E = U + \mathrm{KE} + \mathrm{PE} = U + m\dfrac{V^2}{2} + mgz$	Total Energy of a System	(3)
$Q_{\mathrm{net}} - W_{\mathrm{net}} = \Delta E_{\mathrm{system}} = \Delta U + \Delta\mathrm{KE} + \Delta\mathrm{PE}$	General Energy Balance	(4)
$q - w = \Delta u$	Stationary System (Per Unit-Mass)	(5)
$\delta q - \delta w = du$	Stationary System (Differential Form)	(6)
$\sum_{\mathrm{in}} \dot{m} = \sum_{\mathrm{out}} \dot{m}$	Mass Balance (Steady Flow)	(7)
$\dot{m}_1 = \dot{m}_2 \quad \rightarrow \quad \rho_1 V_1 A_1 = \rho_2 V_2 A_2$	Mass Balance (Single Stream)	(8)
$\dot{Q} - \dot{W} = \sum_{\mathrm{out}} \dot{m}\left(h + \dfrac{V^2}{2} + gz\right) - \sum_{\mathrm{in}} \dot{m}\left(h + \dfrac{V^2}{2} + gz\right)$	General Steady-Flow Energy Equation	(9)
$\dot{Q} - \dot{W} = \dot{m}\left[h_2 - h_1 + \dfrac{V_2^2 - V_1^2}{2} + g(z_2 - z_1)\right]$	Single-Stream Energy Balance	(10)
$q - w = h_2 - h_1 + \dfrac{V_2^2 - V_1^2}{2} + g(z_2 - z_1)$	Unit-Mass Energy Balance	(11)
$\delta q - \delta w = dh + d\mathrm{KE} + d\mathrm{PE}$	Differential Form (Open System)	(12)
$c = \dfrac{Q}{m\Delta T}$	Specific Heat Capacity	(13)
$c_v = \left(\dfrac{\partial u}{\partial T}\right)_v$	Specific Heat at Constant Volume	(14)
$c_p = \left(\dfrac{\partial h}{\partial T}\right)_p$	Specific Heat at Constant Pressure	(15)
$\Delta u = u_2 - u_1 = \int_1^2 c_v(T)\,dT$	Internal Energy Change (Ideal Gas)	(16)
$\Delta h = h_2 - h_1 = \int_1^2 c_p(T)\,dT$	Enthalpy Change (Ideal Gas)	(17)
$q = c_v(T_2 - T_1) = c_p(T_2 - T_1)$	Heat Transfer (Perfect Gas)	(18)
$\eta_{th} = \dfrac{W_{\mathrm{net,out}}}{Q_{\mathrm{in}}} = \dfrac{Q_{\mathrm{in}} - Q_{\mathrm{out}}}{Q_{\mathrm{in}}} = 1 - \dfrac{Q_{\mathrm{out}}}{Q_{\mathrm{in}}} = 1 - \dfrac{Q_L}{Q_H}$	Thermal Efficiency	(19)
$COP_R = \dfrac{Q_L}{W_{\mathrm{net,in}}}$	COP (Refrigerator)	(20)

$$COP_{HP} = \frac{Q_H}{W_{\text{net,in}}} = \frac{Q_H}{Q_H - Q_L} \quad \text{COP (Heat Pump)} \tag{21}$$

$$COP_{HP} = COP_R + 1 \quad \text{COP Relationship} \tag{22}$$