

**THER103**  
**(INTRODUCTION TO THERMO-FLUIDS)**  
**KEY FORMULAE**

Non-Flow Energy Equation:  $Q + W = \Delta U$

Steady Flow Energy Equation:  $\dot{Q} + \dot{W} = \dot{m} \Delta \left( \frac{v^2}{2} + gz + h \right)$

**Reversible Non-Flow Processes for Perfect Gases**

	<b>Constant Pressure (Isobaric)</b>	<b>Constant Volume (Isochoric)</b>	<b>Constant Temperature (Isothermal)</b>	<b>Polytropic</b>	<b>Adiabatic</b>
Equation defining the Process	$p = \text{const.}$	$V = \text{const.}$	$T = \text{const.}$	$pV^n = \text{const.}$	$pV^\gamma = \text{const.}$
$Q_{12}$	$mc_p(T_2 - T_1)$	$mc_v(T_2 - T_1)$	$-W_{12}$	$\Delta U - W_{12}$	zero
$W_{12} = - \int_{V_1}^{V_2} p dV$	$-p(V_2 - V_1)$ $-mR(T_2 - T_1)$	zero	$p_1 V_1 \ln \frac{V_1}{V_2}$ $mRT_1 \ln \frac{V_1}{V_2}$	$\frac{p_2 V_2 - p_1 V_1}{n-1}$ $\frac{mR(T_2 - T_1)}{n-1}$	$\frac{p_2 V_2 - p_1 V_1}{\gamma-1}$ $\frac{mR(T_2 - T_1)}{\gamma-1}$
$\Delta U$	$mc_v(T_2 - T_1)$	$mc_v(T_2 - T_1)$	zero	$mc_v(T_2 - T_1)$	$mc_v(T_2 - T_1)$
Other formulae	$\frac{V_1}{V_2} = \frac{T_1}{T_2}$ $Q_{12} = m(h_2 - h_1)$	$\frac{p_1}{p_2} = \frac{T_1}{T_2}$ $Q_{12} = m(u_2 - u_1)$	$pV = \text{const.}$	$\frac{T_2}{T_1} = \left( \frac{p_2}{p_1} \right)^{\frac{n-1}{n}}$ $\frac{T_2}{T_1} = \left( \frac{V_1}{V_2} \right)^{n-1}$	$\frac{T_2}{T_1} = \left( \frac{p_2}{p_1} \right)^{\frac{\gamma-1}{\gamma}}$ $\frac{T_2}{T_1} = \left( \frac{V_1}{V_2} \right)^{\gamma-1}$

**Property Relationships for Perfect gases**

Universal Gas Equation:  $pV = n\bar{R}T$

Perfect Gas Equation:  $pV = mRT$

$$R = \frac{\bar{R}}{M} \quad n = \frac{m}{M}$$

$$c_p - c_v = R$$

$$\frac{c_p}{c_v} = \gamma$$

$$\Delta u = c_v \Delta T$$

$$\Delta h = c_p \Delta T$$

$$h = u + pv$$

## FLUID DYNAMICS

Continuity:  $\dot{m} = \rho_1 \dot{V}_1 = \rho_2 \dot{V}_2 = \rho_1 A_1 v_1 = \rho_2 A_2 v_2$

Momentum:  $\sum \vec{F} = \dot{M}_{out} - \dot{M}_{in}; \quad \dot{M} = \dot{m} v = \rho A v^2$

Energy:  $\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$  (Bernoulli's Equation – no losses)

## PIPE FLOW LOSSES

Pipe Friction:  $h_f = 4f \frac{L}{d} \frac{v^2}{2g}$       Minor Losses:  $h_L = k \frac{v^2}{2g}$

## FLUID STATICS

$$p + \rho g z = \text{const}$$

$$F_{net} = \rho g Z A \sin \theta$$

$Z$  is the distance from the datum to the centroid of the shape

$$h - Z = \frac{I_c}{AZ}$$

where :

$h$  is the distance from the datum to the centre of pressure;

$I_c$  is the second moment of area of the shape about its centroid