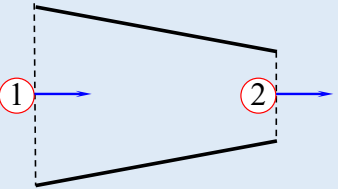
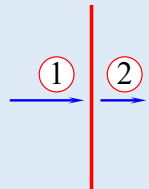
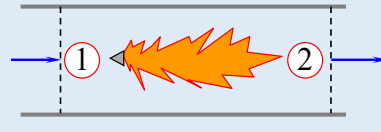
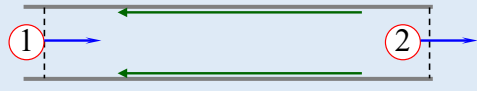


Qualitative Comparison: Property Changes in Various One-Dimensional Compressible Flows

Prepared by Professor John M. Cimbala, Penn State University. Latest revision: 13 November 2019

	Converging duct		Normal shock		Rayleigh flow (with heat addition)		Fanno flow	
Flow →								
Change →	Area change		Shock		Heat added, \dot{Q}		Friction on walls	
Cons. Eqns.								
Mass	$\rho_1 V_1 A_1 = \rho_2 V_2 A_2$		$\rho_1 V_1 = \rho_2 V_2$		$\rho_1 V_1 = \rho_2 V_2$		$\rho_1 V_1 = \rho_2 V_2$	
Momentum	Used only if need to know force on duct		$P_1 + \rho_1 V_1^2 = P_2 + \rho_2 V_2^2$		$P_1 + \rho_1 V_1^2 = P_2 + \rho_2 V_2^2$		$P_1 + \rho_1 V_1^2 = P_2 + \rho_2 V_2^2 + \frac{F_{\text{friction}}}{A}$	
Energy	$T_{01} = T_{02}$		$T_{01} = T_{02}$		$q = \frac{\dot{Q}}{\dot{m}} = c_p (T_{02} - T_{01})$		$T_{01} = T_{02}$	
Property ↓	Subsonic	Supersonic	Subsonic	Supersonic	Subsonic	Supersonic	Subsonic	Supersonic
V	↑	↓	Not Applicable	↓	↑	↓	↑	↓
M	↑	↓		↓	↑	↓	↑	↓
s	No change	No change		↑	↑	↑	↑	↑
T	↓	↑		↑	↑ then ↓	↑	↓	↑
ρ	↓	↑		↑	↓	↑	↓	↑
P	↓	↑		↑	↓	↑	↓	↑
P_0	No change	No change		↓	↓	↓	↓	↓
T_0	No change	No change		No change	↑	↑	No change	No change