

Problem 1

Po 100 psia
To 560 R
Amin 1.778 in²
Ae 3.000 in²

For a shock in the exit area:

$A^*x = A_{min}$

$A_x = A_e$

$A_x / A^*x = 1.6873$ * You can use 1.6875 0.012% error

$M_x = 2$

$P_x / P_{ox} = 0.1278$

$P_x = 12.78$ psia

$P_y / P_x = 4.5$

$P_y = 57.51$ psia

For a shock in the exit, $P_b = P_y$

$P_b = 57.51$ psia

Pressure just before the shock is $P_x = 12.78$ psi

Pressure immediately after the shock is $P_y = 57.51$ psia

For a supersonic shock-free flow, $P_b = P_x = 12.78$ psia

$m^* = .5317 P_o A^* / T_o^{.5}$

$m^* = 3.995$ lbm/sec

Problem 2

Pox,1	100 psi	Mmin,2?
To	525 R	Shock in nozzle 2?
Amin,1	1.25 in ²	Where is the shock, if there is?
Ax,1	1.914 in ²	
Ae,1	3.258 in ²	
Amin,2	1.610 in ²	
Ae,2	2.239 in ²	
Pb,2	62.73 psi	

In nozzle 1, Amin,1 = A*x

Ax,1/A*x,1	1.5312	* You can use 1.5308	0.026% error
Mx,1	1.88		
Poy,1/Pox,1	0.77656		
Poy,1	77.656 psi		
A*x,1/A*y,1	0.77656		
A*y,1	1.610 in ²		

We use Amin,2 = A*y,1. We generally need a large difference to say there isn't

Amin,2 = A*x,2

Ae,2/A*x,2	1.3907		
Pe,2/Po,2	0.8568	For subsonic, This is a check, not necessarily a fact	
Pe,2	66.54 psi	But Pb < Pe,2 so we might have a shock, need to check supersonic	
Pe,2/Po,2	0.1867	For supersonic, again this is a check	
Pe,2	14.50 psi	We know there is a shock, Pe,super < Pb < Pe,sub	

Because there is a shock, Amin,2 = A*x,2 and so M=1 at Amin

We know that Pe,2 must equal Pb at steady state

Pe,2	62.73
Ae,2	2.239 in ²

$$(Pox,2)(A*x,2) = (Poy,2)(A*y,2)$$

Poy,2 A*y,2	125
PA / Po A* y,2	1.12362
Pe,2/Poy,2	0.8416

Poy,2	74.54 psi
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Poy,2/Pox,2	0.95983	1.67738 A*x,2
Mx,2	1.3932	

Ax,2/A*x,2	1.1112	
Ax,2	1.7887 in²	This is the location of shock 2

*We should check that Ax,2 is not greater than Ae,2 as this would indicate a different exit condition

Problem 3

Vx	1227.6 ft/sec
Px	39.06 psi
Pe	86.94 psi
Ae	2.161 in ²
To	540 R
cp	0.24 Btu/lbm-F
1	32.17 lbm-ft/lbf-sec ²
1	778.17 lbf-ft/Btu

$$T_o = T_x + (V_x^2)/2c_p$$

Tx	414.6 R
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$$M_x = V_x / (49.02 * T_x^{0.5})$$

Mx	1.230
Ax/A*x	1.03983
Px/Po	0.39645
Po	98.52 psi

Using B3

My	0.8240
Poy/Pox	0.9895
Poy	97.49 psi

Pe/Poy	0.8918
Me	0.4078 B2
Ae/A*y	1.5657
A*y	1.3802

$$m^* = .5317(Poy)(A*y)/(To^{.5})$$

m*	3.0788 lbm/sec
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A*x/A*y	0.9895
A*x	1.3657

Ax	1.4201 in²
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$$A_{min} = A^*x$$

Amin	1.3657 in²
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