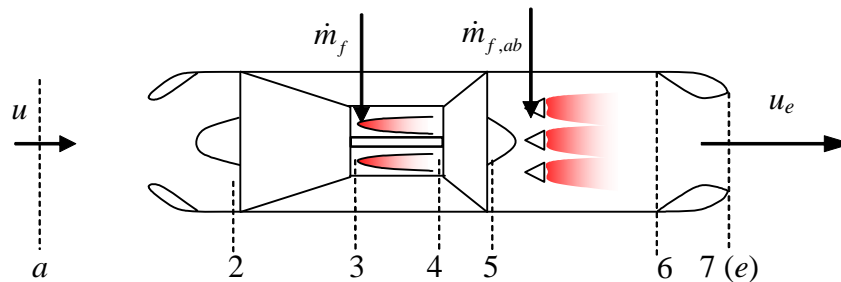


Problems: 2-3 and 2-10 from Hill & Peterson, and supplementary problem below.

S-1 An afterburner is a device used to increase the thrust of a jet engine for short periods of time. Additional fuel is burned in the gas leaving the turbine so that the gas entering the nozzle is much hotter than it would be otherwise. The following state designations are used for a turbojet engine equipped with afterburner:



0	Ambient air	5	Turbine outlet, afterburner inlet
2	Compressor inlet	6	Afterburner outlet, nozzle inlet
3	Compressor outlet, combustor inlet	7	Nozzle outlet
4	Combustor outlet, turbine inlet		

The data below have been computed in the simplified analysis of a turbojet being run on a test stand in ambient air  $T = 300 \text{ K}$ ,  $p = 100 \text{ kPa}$  assuming  $\gamma = 1.4$ . For convenience we choose  $s_{ref} = 0 \text{ J/kg-K}$  at  $T_{ref} = 300 \text{ K}$ ,  $p_{ref} = 100 \text{ kPa}$ . The stagnation state corresponding to a given state is indicated with a prefix  $o$ , e.g.  $o7$  is the stagnation state corresponding to state 7, i.e.  $T_{o7}$ ,  $p_{o7}$  are the stagnation temperature and pressure for state 7 that has static temperature and pressure of  $T_7$  and  $p_7$  respectively. In the table the stagnation pressure and temperature are specified for every state, and in addition the static temperature and pressure are given for the nozzle outlet.

State	$s \text{ (J/kg-K)}$	$T \text{ (K)}$	$p \text{ (kPa)}$
$o2$	0.0	300.0	100.0
$o3$	76.6	772.7	2100.0
$o4$	819.4	1600.0	2016.0
$o5$	857.8	1136.2	532.4
$o6$	1655.7	2500.0	521.7
$o7$	1667.7	2500.0	500.3
7	1667.7	1578.2	100.0

- a. Plot these data on a  $T$ - $s$  diagram (use a graphing program, do not do a freehand sketch). On the diagram plot the constant pressure lines  $p_{o2}$ ,  $p_{o3}$ ,  $p_{o4}$ ,  $p_{o5}$ ,  $p_{o6}$ , and  $p_{o7}$ . Recall that a constant pressure line in a  $T$ - $s$  diagram is specified by

$$\frac{T}{T_{ref}} = \left( \frac{p}{p_{ref}} \right)^{\frac{\gamma-1}{\gamma}} \exp \left[ \frac{s - s_{ref}}{c_p} \right].$$

- b. Calculate the gas velocity at the nozzle exit, assuming that  $R=287 \text{ J/kg-K}$ .