5.12

a) ratio is part of finding F/ṁ taking ratios through engine core

$$\frac{u_9}{u_0} = \sqrt{\frac{T_9}{T_0}\,\frac{M_9}{M_0}}$$

or:

$$\frac{T_{t9}}{T_9} = 1 + \frac{\gamma-1}{2}M_9^2 = \cancel{\frac{T_{t9}}{T_{t5}}}^{\,1}\,\frac{T_{t5}}{T_{t4b}}\,\frac{T_{t4b}}{T_0}\,\frac{T_0}{T_9}$$

$$1 + \frac{\gamma-1}{2}M_9^2 = \tau_{tb}\,\tau_{\lambda b}\,\frac{T_0}{T_9}$$

$$\frac{T_9}{T_0} = \tau_{tb}\,\tau_{\lambda b}\left(1 + \frac{\gamma-1}{2}M_9^2\right)^{-1}$$

and

$$\frac{P_{t9}}{P_9} = \left(\frac{T_{t9}}{T_9}\right)^{\frac{\gamma}{\gamma-1}} = \left(1 + \frac{\gamma-1}{2}M_9^2\right)^{\frac{\gamma}{\gamma-1}} = \cancel{\frac{P_{t9}}{P_{t5}}}^{\,1}\,\frac{P_{t5}}{P_{t4b}}$$

$$\times \cancel{\frac{P_{t4b}}{P_{t4a}}}^{\,1}\,\frac{P_{t4a}}{P_{t4}}\,\cancel{\frac{P_{t4}}{P_{t3}}}^{\,1}\,\frac{P_{t3}}{P_{t2}}\,\cancel{\frac{P_{t2}}{P_{t0}}}^{\,1}\,\frac{P_{t0}}{P_0}\,\cancel{\frac{P_0}{P_9}}^{\,1}$$

$$\left(1 + \frac{\gamma-1}{2}M_9^2\right)^{\frac{\gamma}{\gamma-1}} = \pi_{tb}\,\pi_{ta}\,\pi_c\,\pi_r$$

$$= \left(\tau_{tb}\,\tau_{ta}\,\tau_c\,\tau_r\right)^{\frac{\gamma}{\gamma-1}}$$