A large tank contains 0.7 MPa, 27 °C air. The tank feeds a converging-diverging nozzle with a throat area of $6.45*10^{-4}$ m^2. At a particular point in the nozzle, the Mach number is 2.

a. What is the area at that point?
b. What is the mass flow rate at that point?

SOLUTION:

Use the isentropic relations to determine the downstream Mach number.

$$\frac{A}{A^*} = \frac{1}{\mathrm{Ma}}\left(\frac{1+\frac{k-1}{2}\mathrm{Ma}^2}{1+\frac{k-1}{2}}\right)^{\frac{k+1}{2(k-1)}} \quad \Rightarrow \boxed{A = 1.09*10^{-3}\ \mathrm{m}^2} \tag{1}$$

where k = 1.4, Ma = 2, and A^* = 6.45*10^{-4} m^2 (the throat must be at sonic conditions since the flow goes from stagnation conditions to supersonic conditions).

Since the flow is sonic at the throat, the mass flow rate is choked:

$$\dot{m}_{\mathrm{choked}} = \left(1+\frac{k-1}{2}\right)^{\frac{k+1}{2(1-k)}} p_0\sqrt{\frac{k}{RT_0}}A^* \quad \Rightarrow \boxed{\dot{m} = 1.05\ \mathrm{kg/s}} \tag{2}$$

where R = 287 J/(kg.K).