Laws of Thermodynamics

Conservation of Mass – The Continuity Equation

$$\sum_i \dot{m}_i - \sum_e \dot{m}_e = \frac{dm_{sys}}{dt}$$

Conservation of Energy – The First Law of Thermodynamics

$$\dot{Q} - \dot{W} + \sum_i \dot{m}_i \left(h_i + \frac{V_i^2}{2g_c} + \frac{g}{g_c} z_i \right) - \sum_e \dot{m}_e \left(h_e + \frac{V_e^2}{2g_c} + \frac{g}{g_c} z_e \right) = \frac{dE_{sys}}{dt}$$

The Entropy Balance – The Second Law of Thermodynamics

$$\sum_k \frac{\dot{Q}_k}{T_k} + \sum_i \dot{m}_i s_i - \sum_e \dot{m}_e s_e + \dot{S}_P = \frac{dS_{sys}}{dt}$$

Alternate Forms: 1st Law for Closed Systems

The First Law over a finite period of time is (making a movie),

$$Q - W = \left(U_2 - U_1\right) + \frac{m}{2g_c}\left(V_2^2 - V_1^2\right) + \frac{mg}{g_c}\left(z_2 - z_1\right)$$

$$q - w = \left(u_2 - u_1\right) + \frac{\left(V_2^2 - V_1^2\right)}{2g_c} + \frac{g\left(z_2 - z_1\right)}{g_c}$$

The First Law at an instant in time is (taking a picture),

$$\dot{E}_T = \dot{E}_G = \frac{dE_{sys}}{dt}$$

$$\dot{Q} - \dot{W} = \frac{dE_{sys}}{dt} = \frac{d}{dt}\left[U + \frac{mV^2}{2g_c} + \frac{mgz}{g_c}\right]$$