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Freeze-dried Strawberries (Deliverable I)

- ## Background
  - ### Drying Process
    Drying is a common technology used in food processing for removing the majority of the original water content, without removing any nutrition in the fruits. Dried fruit is much easier for transporting and it has a much longer shelf life as well. Drying is the oldest method preserving food, and it has a very long history that can even back date to fourth millennium BC. The sun and the wind are the first methods that we used to dry out the water from the fruits. Some people also use smoky fire to dry the fruits and also adding smoky favor to them. However, simply use heat to evaporate the water from the fruit would cause the shrinkage of the sharp and discoloration of the fruit, due to the destruction of the structure of the fruit cells.
  - ### Freeze-drying Process
    In order to full fill the insufficiency of traditional heat-dry, freeze-drying is discovered. There are two main steps to freeze-dry. Begin with fresh fruit at room temperature and atmospheric pressure. First, we low the temperature to freeze the water in the fresh fruit to ice. Fresh fruits are now at frozen state. Then, we low the pressure to sublimate the ice to gas, in order to dry the frozen fruits.
  - ### Freeze-dried Strawberries
    We can find freeze-dried strawberries easily in different kind of food product. They are prized for the retention of the nutrition and the bright red color from the fresh strawberries.

- ## About This Model
  - ### Output parameters:
    m_f : total mass of the final product, freeze-dried strawberries, in kg
    $x_{w,f}$: composition of the final product, freeze-dried strawberries, in percentage. (Since only the amount of water in the strawberries is changing during the freeze-drying process, only consider the percentage of water in the final product.)
  - ### Input parameters:
    m_o : total mass of the starting material, fresh strawberries, in kg
    $x_{w,o}$: composition of the starting material, fresh strawberries, in percentage. (Since only the amount of water in the strawberries is changing during the freeze-drying process, only consider the percentage of water in starting material.)
    V_o : volume of the starting material, fresh strawberries, in m^3
    T_o : initial temperature of the starting environment, in K
    P_o : initial pressure of the starting environment, in Pa
    t : time, in s
  - ### Relationships of the parameters:
    m_f, $x_{w,f}$ is changing with time, processing temperature, and processing pressure.
    The mass of solids in the strawberries is constant. Therefore,
    $$m_o*(1-x_{w,o}) = m_f*(1-x_{w,f})$$
  - ### Fundamental principles:
    Law of conversation of energy, Law of mass conversation, Laws of thermodynamics, Mechanism of heat transfer, and Newton's law of cooling.

- o This Model will be useful in freeze-dried strawberries manufacturing. This model is able to predict the total mass of the product at certain initial conditions. This would help the company know how much they are going to get after freeze-drying, and the weight that they need to transport. This model is also able to predict the water composition in the final product. This would help company know what kind of package they need, what kind of environment is required for keeping the final products, and what kind of secondary product can be developed.