A single tube heat exchanger is used to heat a tank filled with m_g = 20 kg of glycol. The glycol is initially at a temperature of T_{gi} = 10°C. At time t = 0 valves are opened for a mass flow rate of 0.05 kg/s of hot water with a constant inlet temperature of T_{wi} = 90°C to flow through the tube passing through the tank. Assume that the glycol in the container is well mixed and maintains a uniform temperature (although changing with time). Use the lumped capacitance method with appropriate assumptions to analyze this problem to determine the temperature history of the glycol in the tank and how long it takes to heat the glycol to 80°C. Assume that the tank is well insulated. The thin-walled tube has a diameter of d = 0.01 m with a length in the tank of L = 2.5 m. You may assume that the mass of water in the tube at any time is small compared to the glycol in the tank. Although the outlet water temperature and the glycol temperature change with time, the following ratio of temperatures remains constant

$$\frac{T_{wo} - T_{wi}}{T_g - T_{wi}} = 0.5$$

a. (20) Determine an algebraic expression for the heat transfer from the water to the glycol in terms of the given constants and variables.

q =

b. (10) Sketch the glycol temperature in the tank versus time, with the limiting temperatures labeled.

c. (20) Sketch the heat transfer q from the water to the glycol with the limiting values labelled (beginning and end of time)

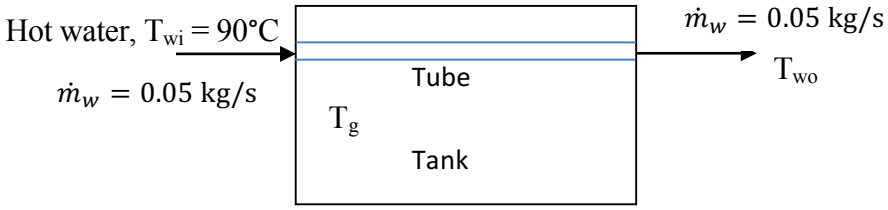
d. (20) Write down the transient energy balance equation for the glycol in the tank.

e. (15) Determine the solution for the tank glycol temperature as a function of time, T_g =

f. (10) Determine the time constant, τ =

g. (5) Determine the time for the water in the tank to reach 80°C, t =

<u>water properties</u>
k = 0.63 W/m·K
μ = 6.4 x 10^{-4} N-s/m^2
Pr = 4.2
c_p = 4180 J/kg-K
ρ = 990 kg/m^3
h_{fg} = 2400 kJ/kg



<u>glycol properties</u>
k = 0.25 W/m-K
c_p = 2400 J/kg-K
ρ = 1100 kg/m^3
Pr = 150