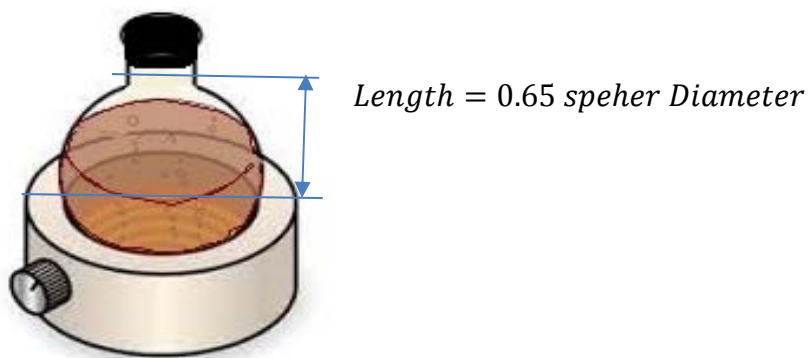




In an experimental study, a mixture containing Water and Ethanol is poured in a metallic heated spherical bulb (whose schematic is shown in Figure1). The bulb is heated uniformly at a rate equal to one tenth of mixture initial heat of vaporization per hour. Under following assumptions, write a program to obtain the instantaneous temperature and concentration distributions of liquid and vapor phases that exist in the bulb (i.e., transient behavior of temperature and concentration profiles of various phases). The heater covers almost 35% of the bulb diameter.



The initial condition of the liquid phase in the flask is given in Table 1; you may ignore the induced velocity fields both in liquid and vapor phases to simplify the system model. However, if you do not use such an assumption it can lead to a maximum of 25% bonus in the problem (**of course, if you can come up with the rationale results** 😊). All the thermo-physical properties of the mixture at various conditions both in liquid and vapor phases can be estimated based on the methods mentioned in “Properties Of Gases & Liquids” book, or any other reference which represents thermos-physical as functions of temperature, pressure, composition and phase of the mixture. You can neglect the temperature distribution throughout the bulb wall. You can also neglect the cylindrical portion of the bulb (due to its short height). The bulb volume is  $250 \text{ cm}^3$ . There is no material exchange between the bulb and the environment. It is assumed that the bulb can withstand very large pressures and you should not have any concern about bulb breakage.



Table1- System Initial Condition<sup>§</sup>

| Student Minor                        | Admission<br>Year | Ethanol<br>Weight %<br>In Mixture | Ambient<br>Temp.<br>[°c] | Initial<br>Temp.<br>[°c] | Initial<br>Liquid<br>Level |
|--------------------------------------|-------------------|-----------------------------------|--------------------------|--------------------------|----------------------------|
| Separation. & Transport<br>Phenomena | 1401              | 70                                | 20                       | 40                       | 55%                        |
|                                      | 1402              | 80                                | 30                       | 30                       | 65%                        |
| Process Design                       | 1401              | 75                                | 45                       | 25                       | 45%                        |
|                                      | 1402              | 85                                | 25                       | 35                       | 70%                        |
| Simulation & Control                 | 1401              | 90                                | 30                       | 30                       | 85%                        |
|                                      | 1402              | 98                                | 40                       | 30                       | 40%                        |

**§: Note that for groups with two members are free to choose either one of requested properties based on group members.**

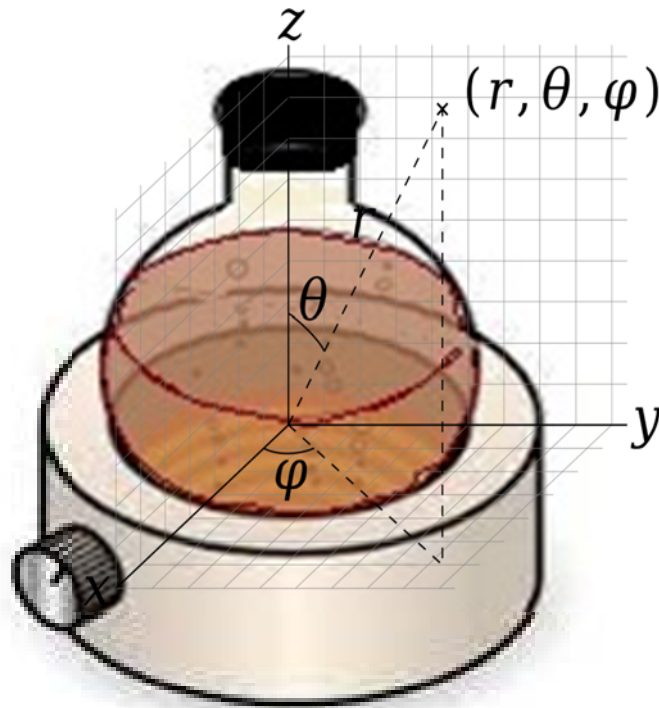
Your report should contain the following items:

- All the assumptions that your obtained model for the system is based on and their corresponding rationales.
- All the equations conforming the model of the system with all aspects of each equation both governing equations and boundary conditions of various parts of the system
- The method that you have used to discretize both geometry and all constituting equations of your model.
- The solution method used to solve the obtained equations and its corresponding results compared against the results obtained based on the lumped dynamic model of the system
- The results of the Spatiotemporal model (i.e., dynamic model with three dimensions) should be reported as follows:
  - Liquid level at various times



- Temperature and composition of various points of the system as contour of Temperature and Ethanol composition at the vapor liquid interface, and three contours for each variable (i.e., Temperature and composition) three distinct values of  $\theta$  for each phase, as  $TEmperature(r, \varphi)$ ,  $MoleFraction_{ethanol}(r, \varphi)$  according to the following notation:

○



Good luck