Please read through this document and try to do the design exercises. Please summarize your results by answering the questions and be prepared to share them in class. Also, save your loads module (zone) file and project (heat exchanger) files so that we can look at them in class if we have time.

**Exercise 1:** Vertical Design

**Objective:** Your goal is to design a vertical heat exchanger system with 300 ft deep boreholes and no space/area constraints (ie- you have flexibility in the borefield layout and bore spacing). After you have designed the system using the listed input parameters, answer the questions at the end of this exercise.

**Input Parameters:**

**Loads:** Use the CaseStudy1.xls loads data and copy/paste the data into Average Block loads module

*Hint*: Data are in metric units. Convert the Loads Module to metric units via the metric/English conversion button at the top of GLD before you copy/pasting data. After you bring the data in, switch back to English units if so desired

**Pumps:**

Choose a water to air pump (approximately 5-8 ton)

**Target *Design Day* fluid temperatures:**

87-92F for cooling

40F for heating

**Flow rate:**

3 gpm/ton

**Fluid:**

Water

**Ground Temperature:**

58F

**Soil Thermal Conductivity/Diffusivity:**

1.10 Btu/(h\*ft\*oF)

0.60 ft2/day

**Modeling Time Period:**

10-20 years

**Pipe:**

You select pipe size and type and be prepared to justify decision

**Radial Pipe Placement:**

You select and be prepared to justify decision

**U-Tube Configuration:**

Single

**Borehole Diameter:**

5.25 inches

**Grout Info:**

0.88 Btu/(h\*ft\*oF)

**Exercise 1 Questions:**

1) Now that you have completed a basic design, run a monthly simulation for 10 years. Are the calculated peak inlet cooling and heating temperatures from the monthly simulation the same as those you selected as your original Design Day inlet temperatures? If not, why do you think they are different? If they are different, how could you modify your design so that the monthly temperatures are closer to those that you originally used for the Design Day calculation?

2) Looking at your monthly results, what is the difference between a Heat Pump EER/COP and the Seasonal Heat Pump EER/COP? Which one is appropriate to use when doing lifecycle costing? Why?

3) Either reduce or increase your borehole spacing by 5 ft, run the monthly simulation again and determine the impact of this one change on the Seasonal Heat Pump EER/COP results

**Exercise 2**

**Objective:** Your goal is to transfer your heat exchanger design into the lifecycle costing module and then to determine the annual energy costs to run your system. Your secondary goal is to determine how many tons of C02 your design is excepted to result in being emitted over 10 years of operation. After you have designed the system using the listed input parameters, answer the questions at the end of this exercise.

**Input Parameters:**

**Utilities:**

Electricity costs are $0.11/kWh for summer and winter rates

**Other Costs: Emissions Costs:**

Determine the C02 emissions rate for your location. *Hint:* Use the "?" button to find a link to a website that has the information you need.

Enter your best guess C02 emissions cost based on your own research

Set the effective initiation delay to 3 years

**Exercise 2 Questions:**

1) What is the effective initiation delay?

2) How many tons of C02 did your system emit over 10 years of operations? *Hint:* On the Geothermal Tab be sure to set the time to 10 years. Then, print a report from within the Lifecycle Cost Module. Choose the Financial Analysis report to see the tonnage.

**Exercise 3**

**Objective:** Your goal is to design a single GHX module using the CFD Module. You will use the automatic wizard to build a piping system, auto design the headering, determine the recommended purge pump size and finally determine the Reynolds numbers under normal operational conditions. After you have designed the system using the listed input parameters, answer the questions at the end of this exercise.

**Input Parameters:**

* + GHX Module Builder (*hint: to access the Module Builder Wizard, on the Layout tab right click the mouse while in the big white workspace***:**
  + Reverse Return System
  + You choose # of circuits, circuit separation, one-way circuit length and circuit pipe size based on your design from exercise 1
  + Header Pipe Size- choose appropriate size based on what we learned in class
  + Supply Return Runout Length: 200 ft
  + Supply-Return Runout Pipe Size: Same as Header Pipe Size

***Hints:***

*After you have auto-built the basic design, switch to PURGE MODE and use the button that pops up next to the calculate button to select the two auto design functions. Then hit calculate/design.*

*To review the design, the display button to select appropriate results. This is how you can see the total pressure drop and flow rate, the two variables you need to know to determine the purge pump requirements.*

*After your design is done, you will want to see how the system performs under standard operating conditions. Switch from Purge to Peak Load mode first. Next, go to the FLUID tab and enter an appropriate flow rate. This can be determined from the Vertical Borehole results tab, estimated by trial and error, etc. Look at the Reynolds number results to see what they are.*

**Exercise 3 Questions:**

1) What capacity purge pump do you need to purge the system at 2 ft/s?

2) What is your overall GHX module pressure drop under Peak Load flow conditions?

3) What are your Reynolds numbers in your GHX circuits under Peak Load flow conditions?

4) Change the fluid types in the Fluid Tab and see what happens to the Reynolds number results as the fluid viscosity changes. Summarize.