You will need to download and compile the Haptic-Lab-Template to complete this homework. Much of this assignment involves looking through the code and exploring it which is much easier with a compiled version.

1. (5 pts.) Describe the main differences between an impedance-based and an admittance-based haptic device in terms of the physical device and how they are controlled.

2. (5 pts.) What is the workspace size and maximum force that a Falcon can apply? Given that max. force, if you assumed that they used a 12-bit DAC on the Falcon design, what should the force resolution then be?

3. (5 pts.) Describe the basic principles of a proxy-based haptic rendering method (e.g. what is done to render a virtual wall using the proxy method).

4. (25 pts.) Chai3d provides a nice vector class for us labeled cVector3d.
   a. Look through the template code and find an instance of this variable type. What is the name of that variable?
   b. What operator is used to access the variables or methods of any class? (aka. what do you type to access say the x or y component of the cVector3d class?)
   c. The vector's methods also contain useful functions such as the dot and cross product. Say we have 3 cVector3d variables (A, B, and C) and you want to use the dot and cross product on these to compute the volume of a parallelepiped. Write the code you would use to compute the volume = |A·(B x C)|. You will need to explore the vector class' methods to find these functions.
   d. How would you add or subtract vectors? How about scaling them? These are all used in the template code already.

5. (10 pts.) Chai3d also provides a 3x3 matrix class.
   a. What the name of this class? It can be found in the math section of chai with the vector class.
   b. How would you add and subtract matrices? What about scaling and multiplication?
6. (15 pts.) Within each environment file there is a method named device().
   a. What variable type does this method return?
   b. This variable is also a class like cVector3d. Why do we use a different
      operator to access its methods? (aka. What is different about the returned
      variable than our instances of cVector3d?)

7. (10 pts.) Identify the following
   a. What variable is the Falcon's position stored in within your environments?
   b. What variable is used to store the computed force output of the Falcon?
   c. Where is the camera positioned?
   d. What point is the camera looking at?
   e. Why do I clear the rendering color and depth buffers?
   f. What is the difference between public, protected, and private in classes?

8. (20 pts.) Write an openGL code snippet to do the following. Create a red solid cube at
   coordinates <1,2,1> that has each side 0.5 units long. Make sure this code will not
   affect any later lines of code.

9. (5 pts.) Open the Virtual Device found in chai's bin folder (not the bin folder in
   LabFiles). This device can be used instead of a Falcon if it opened before your haptic
   code. How do you move the virtual device around?

Hints:

Google is your friend use it.

http://nehe.gamedev.net/ provides some really good openGL resources and tutorials for just
about everything you could want.

http://www.cplusplus.com/ has definitions and examples of basically every standard function in
the C++ language. If you are using Google to search for functions this will likely show hits in the
top few links.