Project 2
Hydrodynamics of Hard Disk Drive Heads
Due March 12

You are free to establish your own 3 or 4 person groups.

Background on the topic of head flight can be gained by reading the six linked subtopics listed under the "Head-Disk Interface" heading on the right side of the web page http://www.hgst.com/hdd/research/storage/hdi/index.html . These six linked pages lay out a wealth of information about the design of the air-bearing surface used to "fly" hard-disk drive heads over their magnetic platters. Details include quantitative data on the current and historical evolution of the air-bearing surface shape, dimensions, load, pressure distribution, and physical spacing from the spinning platter.

Introduction

After reading the cited web pages, your group should formulate a FEM-based project that probes the behavior of head flight and seeks to predict at least one of the pieces of experimental performance data given on the web pages. For example, can you predict the fly-height for a certain type of head at a given load, can you get a pressure distributions and flight properties like that seen for a negative pressure head, etc.. Your introduction should clear layout the background and objectives of your project. Try to make it sound interesting and relevant to HD operation.

Governing Equations, Boundary Conditions, and Formulation of a Lubrication Theory Problem

You are likely to be performing mostly, if not entirely, 2-D simulations to represent 3-D problems. Describe the equations you solved and discuss the anticipated reasonableness of your 2-D simulation vis-à-vis the actual physical system. Additionally, I ask that you formulate a lubrication problem that can be solved analytically. If the geometry you plan to use for the FEM analysis can't be tackled analytically, do the analytics using a closely-related geometry that is soluble.

Results and Discussion

I. Compare analytical lubrication theory solutions to numerical solutions. This can be used to assess the numerics and/or to test how well the geometric and dynamic constraints of lubrication theory hold for your geometry.

II. Present the simulation results that are supposed to mimic data or data trends shown in the web pages. Discuss the results and give plausible reasons for the agreement/disagreement with data.

III. Kinetic theory says that the mean distance a molecule travels between collisions in a gas (called the mean-free path) is given by

$$\lambda = k\,T/(\sqrt{2}\,\sigma\,p)$$

where k is Boltzmann's constant, T is temperature (K), σ is the molecular collision cross-section (take $\sigma = 0.31\ \text{nm}^2$ for N_2), and p is pressure. The discrete molecular nature of a fluid becomes evident when the characteristic geometric length scale for a problem (ℓ) is comparable to, or smaller than, the fluid's mean free path. Alternatively, one can say that fluids only behave like a continuum if $\ell / \lambda \gg 1$. Discuss the implications of these facts on your results.

Concluding Remarks