Problem 1. EQUILIBRIUM OF A STATICALLY INDETERMINATE PROBLEM WITH STICK-SLIP CHARACTERISTICS.

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Working Sessions held in Room 119 Harrelson

A car is supported at four corners with springs. There are also torsion springs on two sides of the car. These are known as the anti-sway bars. The dimensions of the vehicle are known. At rest, consider the deflection of each wheel to be zero. Each spring is represented by a lookup table. This is because the stiffness of each spring are dependent on the deflection. At the initial (at rest) state, the exact location of each wheel on the lookup table is known. Now, add a point load of known mass at known location. The goal is to develop a program to determine the deflection of the four wheels of the vehicle. As an additional variable, add Stick-Slip Characteristics to each wheel. Realistically speaking, a small increase in load does not cause a deflection in any wheel. Instead, a certain threshold of additional load must be added before there is wheel deflection. This problem is to be solved with no time dependencies.
Problem 2. **MODELING COMPTON SCATTERING AND PHOTLECTRIC ABSORPTION OF X-RAYS IN MEDIA CONTAINING HEAVY ELEMENTS.**

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Battelle is investigating the detection of heavy elements embedded within supporting media with the use of X-rays. Other researchers have explored a variety of X-ray techniques such as X-ray fluorescence (Cranley 1982) for this application. To further explore various techniques, Battelle would like to model the scattering and absorption of X-rays within a volume of supporting media. The goal is to create a two dimensional (three if time warrants) mathematical model of a system consisting of a radioactive source, a volume of supporting media, and a removable volume of iodine located within the supporting media. For the radiation energy range and materials involved in this problem, the two (of four possible) phenomena that should be considered are photoelectric absorption and Compton scattering. The Nobel Prize-winning work of Klein-Nishina (1929) should be considered when modeling Compton scattering. The model output should consist of the X-ray fluence (flux area density) at various points.

Cranley, K. (1982), Investigation of Applications of X-Ray Fluorescence to Scanning of Tissue Concentrations of Iodine and Cadmium, PhD dissertation at The Queen's University of Belfast.

Problem 3. *PEUDO-STEADY-STATE INHALATION MODEL FOR SOLUBLE GASES AND VAPORS.*

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In the field of toxicology, there is concern over the rate at which gases and vapors are taken up by the body. Gas uptake occurs primarily in the alveolar region of the lung, and two of the limiting factors for uptake are the rate of respiration (amount of air inhaled per time) and the rate of blood-flow to the alveolar region. For many organic gases (hydrocarbons), for which the solubility or liquid:air equilibrium constant is low a simple ("base") model of gas exchange which depends on only these two rates adequately describes gas uptake. Specifically, the base model assumes that the concentration of the gas in the air which reaches the alveolar region of the lung is the same as the ambient concentration. For gases with high solubility, however, some of the gas is absorbed in the airway walls of the conducting airways on inhalation, and then desorbs from those walls on exhalation. The result is that the concentration in the air reaching the alveolar region is less than the ambient concentration, and the net rate of uptake is lower than one would predict with the base model. This is called the "wash-in, wash-out effect." Mathematical models have been developed previously which account for this phenomenon, but they track each separate breath, moment-to-moment, through inhalation and exhalation. These models require considerable elaboration of the base model (introducing many more state variables) and are computationally intensive. The base model uses a pseudo-steady-state approach, in which uptake is treated as a continuous processes effectively averaged over the breathing cycle. The goal of this project will be to develop a pseudo-steady-state model for uptake of soluble gases which requires minimal addition of state variables and computational time. An initial solution has been developed, but it uses fitted parameters rather than being derived from physiological data (e.g., airway diameters and lengths) and it's performance, while better than the base model, leaves considerable room for improvement. The specific goals of this project will be to derive parameters from lung physiology and to account for the effects of breathing frequency and volume on uptake.
Problem 4. PARTICLE TRAJECTORIES ON SURFACE OF ARBITRARILY SHAPED FRICTIONAL SURFACE.

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Working Sessions held in Room 136 Harrelson

Streams of powders are important in studying the behavior of filling of bins, as well as various schemes to reduce dust and/or attrition in the handling of bulk solids such as belt-belt transfers and pneumatic conveying. Applications are relevant to a wide range of problems in the pharmaceutical and food industries, large scale power plants and mining operations. The problem posed will be the formulation and solution of equations of motion of a particle sliding on a frictional surface of arbitrary curvature. The hope is that a general algorithm can be developed.
Problem 5. DOCUMENT POOLING FOR INFORMATION RETRIEVAL.

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Information retrieval is the process of evaluating a given query, or information need, against a set of documents (web pages or journal articles, for example) in order to determine which of the documents most closely satisfy the query. With the continuing growth of already massive document sets, it is difficult to quickly and accurately evaluate queries. A traditional method for handling this difficulty is to group documents by topic ("cluster" them) and evaluate a query against representatives chosen for each group. Although this method improves the speed of the information retrieval, it degrades its accuracy. While current research is focused on finding better ways to cluster documents, we will examine whether it is possible to improve information retrieval by simply pooling documents together and identifying better ways to choose representatives for the document groups. The problem is then to find a model for subsets of the larger document set so that when a query is compared to the model, it can be determined whether any of the documents are relevant to the query.
A potential uplink Radio Frequency Interference (RFI) problem occurs when the victim satellite simultaneously collects power from desired and undesired signals. If the victim satellite collects sufficient power from one or more interfering links to degrade its performance below an acceptable level, an RFI problem exists, resulting in a communication blockage. The severity of the RFI problem can be characterized by the blockage duration and rate of occurrence. These, in turn, depend on geometry considerations. We have developed a computer tool for collecting data on RFI periods. Based on databases of ground stations and satellites with circular orbits, as well as a selected victim satellite, the tool provides data on geometric conjunctions, i.e., periods during which the victim satellite is within the uplink beamwidth of an interfering ground station. During a conjunction, the range from the interfering ground station to the victim satellite can be used to calculate the interfering power, which in turn determines whether there is blockage. It is desirable to develop a mathematical model to statistically relate RFI parameters (such as RFI duration and rate of occurrence) to victim satellite parameters (such as altitude and inclination), interfering ground station parameters (such as beamwidth and transmitted power) and other parameters of interest. The model can be verified by exercising the computer tool with different parameter values for victim satellite and interfering ground stations. Initially the model is valid for the specific databases utilized, including only satellites with circular orbits. It is hoped that the mathematical model, after verification, can be extended to more complex scenarios; e.g., victim satellites with elliptical orbits as well as different satellite and ground station databases (with appropriate characterizing parameters for databases). A similar mathematical model is also needed for the downlink RFI problem.