The dictionary defines SCIENCE as systematized knowledge derived from observation, study and experimentation carried on in order to determine the nature or principles of what is being studied. PHYSICS is defined as the science dealing with the properties, changes, interactions, etc. of matter and energy in which energy is considered as continuous (classical physics), including electricity, heat, optics, mechanics, etc., and now also is considered to be discrete (quantum physics), including such branches as atomic, nuclear and solid state physics.

The Language of Physics is the quantified discussion and description of the specific system’s phenomena being observed, studied and/or experimented upon. The quantified language which describes these activities is known as Mathematics. The strong point of mathematics is that while one can manipulate and count specific activities or objects; the numerical and algebraic relationships between these objects remain the same if the specific object is removed. Namely, if one has 10 apples, the concept 10 stands independent of the apples and can be applied to the counting of 10 oranges – in this sense; apples and oranges do mix.

Similarly if one has a system for which you can develop a physical and thus an algebraic model, the mathematics of this model can be separated from the specific system being modeled and applied to similar systems which have analogously mathematically equivalent responses to those of the original system and/or model.

This tool is especially powerful when one is trying to describe a complex system or segments of a complex system. The power of mathematics is that with appropriate approximations and assumptions, complex systems separated in proper segments that then can be modeled by simpler analogous models, for which you have possible algebraic solutions.

The ability to take a complex phenomena and separate it into an expanded concentric set of systems surrounding by their environment, that themselves become a new larger system again surrounded by a new larger environment, which now becomes a new still larger system, etc., until a complete complex physical system is approximated, described and/or modeled. This methodology that allows a complex physical system to be described by appropriate simpler physical models applied to these subsystems provides one of the most powerful problem solving and design tools available to the scientist and/or engineer.

When these physical models, with appropriate approximations and be mathematically modeled, quantitative solutions are possible. Dynamically manipulating and varying the model (with assumptions) provides specific solutions to the questions being asked about the system’s response to specific situations and values of the independent input variables.
Depending on the modeling, the initial and/or the boundary conditions, one can get the following types of information:

1. Approximate "Back-of-the-Envelope" calculations and values [+ or – 20%].
2. Upper or Lower Bounds [ceilings or floors] on the expected values of the dependent variable(s) output depending on the independent variable(s) input.
3. First order or by iterative applications, higher order approximations of needed, expected and/or predicted results.
4. Ranges, Limits, Regions of valid and non-valid results.

You will be doing these Projects/Activities in order to learn the methodology as well as to provide you with a tool box of simple models that can be used to solve a broad base of applications in many areas of physics and engineering.

1. Develop an understanding of the basic physics of the specified fundamental system being modeled. Learning the characteristics of the mathematical descriptions of this physical model. Assumptions made and/or possible and the consequences of using these, both positive and negative will be studied.
2. Manipulate the model within physical system constraints and determine responses, limits and capabilities. Dynamic analysis of the model will be done to determine responses based on the various possible assumptions.
3. Learn the characteristics of the mathematical model that can be applied to any number of systems. Also, the constraints and approximations necessary for application too similar or other systems. This will include costs of the approximations and assumptions, namely both losses and gains with respect to information and system design specifics. These will include reliability, response change and possible changes in limits, ranges of validity and sensitivity to changes in input types and values.
4. Chose a more general physical system, including the environment, that can be described and modeled, with appropriate approximations and limits placed on the Physical/Mathematical Model developed, studied and analyzed in (1) above. **You must get approval for choosing the specific physical system or object; you want to model from your Recitation Instructor.**
5. Do the dynamic physical modeling, including algebraic and mathematical analysis on the system and surrounding actions/interactions using appropriate trend lines, qualitative and quantitative analysis, tabular and graphic analysis, and/or computer software and programming analysis.
6. The results of the Project/Activity is presented in a short complete formal report and submitted in finished copy. Report details will be stated later.

You may work in a group of up to 4 persons, or as an individual. All students in the class as a whole will be responsible for the same work in parts (1), (2), and (3). Each group or individual will be responsible for their analysis of the approved application example and carrying out the activities of parts (4), (5) and (6).

NOTE: Each group independent of size, one or up to four in number, submits one Report per Special Problem/Project/Activity.

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