From Intuitive Physics to Star Trek:
Large Context Problems (LCP) to enrich the teaching of physics

LCP 1: INTUITIVE PHYSICS AND MOTION

All of us have common sense (intuitive) ideas about motion and forces around us. These ideas can be called personal "theories" of motion based on familiar experiences. We then try to explain motion around us based on these theories. We could refer to this understanding as pre-scientific, intuitive, "personal knowledge". In this LCP we will test and challenge students
conceptual understanding of motion.

LCP 2: PENDULUM AND MOTION

The pendulum did not only play a central role in the development of the kinematics and dynamics in the seventeenth century, but served as a research instrument in the 18^{th} and 19^{th} centuries. We can look at the pendulum as the most successful research instrument to test intuitive understanding of the physics of motion and develop our understanding of the physics of kinematics and dynamics. Its ubiquity is attested to by the modern application of the pendulum to the study chaos and non-linear motion.

This context is based largely on Galileo's ideas, the recent special issues of *Science & Education*"The Pendulum: Scientific, Historical, Philosophical, & Educational Perspectives", and the work of the author and Don Metz (The Ubiquitous Pendulum, *The Physics Teacher*, (2003*)*. Almost all elementary kinematics and dynamics can be taught and/or reinforced.

LCP 3: GALILEO, NEWTON, AND ROBOTICS

The elementary physics of materials and of mechanics determine the limits of structures and the motion bodies are capable of. The physical principles of strengths of materials goes back to Galileo, and the dynamics of motion we need to apply is based on an elementary understanding of Newtonian mechanics, and the mathematics of scaling required depends only on an elementary understanding of ratio and proportionality. The physics of micro, meso, and macrorobots will be discussed. Finally, the main ideas developed here are intimately connected to architecture, robotics and biology and will be used in the later chapters. It is hard to imagine a more motivating large context to teach the foundations of statics and dynamics with a strong link to the world around us.

This context is based on three sources: Galileo's "Two New Sciences", first published in 1640, G.B.S. Haldane's celebrated article "On Being the Right Size", published in 1928; Mel Siegel's (a robotics research professor) recent comprehensive summary of robotics "When Physics Rules Robotics"; and the author's updated version of the article "Physics and the Bionic Man" published 25 years ago in *The Physics Teacher* and *New Scientist.* This context provides an excellent opportunity to learn to think in proportionality statements, and become familiar with scaling.

LCP 4: MACROROBOTS FOR ENERGY PRODUCTION

We hear a great deal about microrobots and nanotechnology but not about macrorobots. Good examples of macrorobots are radio telescopes, oil tankers and the International Space Station. These are all beyond human scale. The macrorobots we will discuss are the Giant Wind Turbines (GWT) and th giant solar furnace in Souther France. GSF. The GWT produce 1 or more megawatts of electric power, and the GSF is represented by the largest one in the world, the Louis Pyrenees solar furnace in France, . The GWT is truly a viable energy production machine but the GSF is really a giant research instrument. However, the physics and the technology in discussing this giant research instrument can be used to design solar collectors for household and the design of robots on the human scale. We can also discuss the physics of voltaic cells and solar energy collection on the meso and macro scales.

We will also discuss the physics of a GSF. This context is based on a 1972 Time magazine's Science section that described the world's largest solar furnace in sufficient technical detail to allow the setting for an investigation that involves a great deal of students' knowledge of physics and, with some guidance, can lead to an asking of a series of questions that lead to problems and exprimentation that go beyond the textbook. The Mont-Louis solar furnace in the Pyrenees is still the largest in the world**.** The background information for the GWT is taken from the Internet and articles from journals like *The Physics Teacher* and *Physics Education*. A research article written by the author, "Solar Power for Northern Latitudes", published in the *The Physics Teacher* in 1978 will also be consulted..

The questions generated by these two LCPs lead to the discussion of electricity, magnetism, mechanical energy, radiation, optics, wave motion, thermodynamcs, solar energy, thermonuclear reactions, and BB radiation, and those generated by the GWT lead to a discussion of the physics of wind energy, electric power production, electric storage and electric circuits.

LCP 5: THE ULTIMATE MACROROBOT: A ROTATING SPACE STATION

The design and the physics of a rotating space station is presented. Description and the physics of the RSS, a la *2001: Space Odyssey*. A tear-level system for training astronauts to go to the Moon and Mars will be discussed..This context is based on NASA information from the Internet, and the author's original unpublished LCP that he designed and uses in his physics education methods classes. The physics that is part of this context is dynamics and gravitational theory.

LCP 6: PHYSICS ON THE MOON:
The physics of low gravity environment is investigated and the physics of living on the Moon discussed. Structures, mobility, astronomic observations, Olympic games, etc are topics investigated. Robots for the low gravity environment are suggested and the physics omotion
This context is based on NASA information from the Internet, and the author's unpublished LCP that he uses in his physics education methods classes. The physics involved is elementary kinematics and dynamics, the strength of materials.

LCP 7 : JOURNEY TO MARS: THE PHYSICS OF TRAVELLING TO THE RED PLANET

The history of the importance of Mars to the understanding the solar system. Several scenarios to travel to the red planet will be described and the physics of the journey explained. An interactive computer program will allow students to plan their own journey.

LCP 8: THE AGE OF THE EARTH AND THE SUN
We will review the main attempts made to calculate the age of the earth and the sun, beginning with Newton's thought experiment and ending with Hans Bethe's thermonuclear model
of the sun's energy. In Part One special attention is paid to the protracted debate about the age of the earth in the second half of the nineteenth century that involved Kelvin and Helmholtz. Part I will terminate with a brief mention of the radioactive / nuclear theories being developed just prior to the death of Kelvin in 1907. Part II will look into 20^{th} century explanations and dating techniques, paying special attention to the thermonuclear model first proposed by Hans Bethe in the late 1930s.

For both parts the results of the calculations are given in the main text but details can be found in the boxes that will allow teachers and students to solve novel problems and generate interesting questions for discussion. SI units will be used throughout, but sometimes it may be expedient to mention the original units used (as in the case of Kelvin's calculations in his celebrated paper of 1862 "On the Secular Cooling of the Earth").

LCP 9: ASTEROID/EARTH COLLISIONS
The physics of asteroid/Earth collisions will be discussed. The physics of a simple computer model for "impact scenarios" will be developed and several famous collisions (Tunguska, Yucatan) presented in detail. The energy of the recent Tsunami will be compared to an asteroid collision of average size.

LCP 10: THE PHYSICS OF STAR TREK
The study of motion in the three regions of physics: speed of less than 10% the speed of light (Newtonian), speeds greater than 10% but less than the speed of light (Einsteinian), and speeds greater than the speed of light (superluminal, or tachyon-like). Several historical calculations of the age of the Earth and the Sun, from Bishop Usher, Newton, Helmholtz, Lord Kelvin to using modern radioactive dating will be discussed.

The background to this context is based on the research done for the article "Physics of Star Trek", and published by *New Scientist* in 1981. The article was written by the author and Ian Winchester. The physics for this context involves Newtonian dynamics and gravitation theory and the well known consequences of the special theory of relativity.