Chapter 1

Solutions

1.1 Depending on the available library resources and the previous preparation of the students, the instructor may have to give some initial guidance as to specific journal titles that might be good sources for this kind of information. The instructor may also wish to "steer" the students to certain topical areas (fluid flow, machine design, manufacturing, etc.) if the course has a certain focus, rather than being of a general measurement nature.

1.2 As in problem 1, the instructor can use hints to tailor this question to the needs of the particular course or lab.

1.3 a. While biomechanics has had some success in using theoretical models for the human body, this problem would require an experimental approach. Students might raise ethical questions about the use of human subjects, but in this case its seems unavoidable. Astronauts and test pilots regularly risk their lives as part of their jobs; so as long as "informed consent" is obtained, such research satisfies ethical considerations.

b. A theoretical approach to this problem is certainly possible and in fact found in most machine design texts. This problem is simple enough that students with only the usual physics (or perhaps engineering mechanics) preparation could deal with it. The theoretical approach brings out useful relations involving lever lengths, friction coefficient, and applied force. However, the normal force and friction force are actually distributed pressures rather than concentrated forces, thus assumptions about where the concentrated forces used in the analysis are sources of error. Also, the actual friction coefficient would not be the same as a "handbook" value used in the analysis, and might change with wear, temperature, sliding speed, etc. An experimental study woul yield information on such questions.

c. This is a thoroughly practical problem encountered often in all vehicle dynamics studies, not just rockets. When we have not yet built any prototypes and have to work from drawings, it is really impossible to theoretically compute inertial properties such as total mass, location of center of mass, moments of inertia, etc. There are just too many individual parts, complex shapes, and different materials. Some finite element software will compute inertial properties of individual odd-shaped parts from the CAD drawings, but this is not practical for an entire automobile or aircraft. The experimental approach requires only some weighing scales to locate the center of

mass. Moments of inertia usually are found by creating a vibrating system by connecting the inertia to springs and measuring the natural frequency.[1]

d. The simplest version of this problem neglects air resistance and considers only the gravity effects. Many students will have encountered it as an example of maximization in a calculus course. This theoretical approach is quite quick and easy and gives a specific result. When air resistance is added, it can become quite complex, depending on the model used. For example, the air resistance depends on altitude, not just projectile speed. The experimental approach could become quite complex and expensive but would allow study of the air resistance model.

1. E.O. Doebelin, System Dynamics, Marcel Dekker, New York, 1998, pg. 80.