# Toys and Games in Mechanics Education

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***Extended summary***

Toys and games have considerable educational potential. In some fields of mathematics, such as combinatorics, probability and statistics, the use of examples involving playing cards and dice is well established and these examples reflect portions of the early history of development of those subjects. The field of game theory is, intrinsically, all about strategies for winning games. In mechanics certain toys and games that particularly lend themselves to analysis have been afforded comprehensive scholarly treatment. The monumental treatise on the motion of the top by Sommerfeld and Klein, and the monograph on billiards by Coriolis may be cited as two key examples. It follows already from these examples that a comprehensive analysis of a simple toy or game is often not at all simple and may challenge even advanced students and scholars.

In this paper a number of toys and games that rest on and illustrate basic mechanical principles are described. Some of the smaller toys will be brought to the presentation. The author's (admittedly limited) experience in using toys and games for project work with undergraduates is recounted, and some ideas on how to expand the use of toys and games in an educational setting are presented.

Fig.1: Pauli and Bohr fascinated by the Tippe Top

Fig.2: Commercially available rattlebacks

There are several good reasons for exploring mechanical toys. First, they are fun. Students of all ages find them intriguing and engaging. Who can forget the picture of Wolfgang Pauli and Niels Bohr enthralled by the counter-intuitive, angular-momentum-reversing behavior of the Tippe Top (Fig.1)? Second, they are (typically) quite cheap. The rattlebacks shown in Fig.2, for example, are available for pennies. Third, toys are often surprisingly complicated. It follows that they hold fascination for even seasoned researchers, an important consideration when taking on the supervision of an independent project by a student. It follows, fourth, that many illustrious mechanicians have studied them to the point of publishing articles or monographs (besides Coriolis, Klein and Sommerfeld, we may mention Bondi, Synge and Stewartson; see the references given below). They continue to do so, *cf.* recent papers by Hinch & Saint-Jean on "Newton's cradle", the study by Berry on the "Levitron™" and the work by Moffatt on the "Euler disk" (vividly demonstrated during his closing lecture at ICTAM2000). Toys and games have great motivational value at all levels, from school children to mature researchers. Finally, they are part of our cultural heritage, a fact illustrated, for example, by the inclusion of the "Slinky" in a series of US postage stamps entitled "Celebrate the Century" (Fig.3). The introduction of this flexible spring in 1945 created a fad that has lasted to this day.


Fig.3 US postage stamp featuring "Slinky"

Fig.4: Shoot the Moon game/toy

Examples of mechanical toys and games with relatively simple mechanical principles underlying them include the "Sand Wand", the "Ooze Tube", and "Shoot the Moon" game/toy (Fig.4). More complicated dynamics is displayed in toys such as "Newton's cradle", "Slinky", the "Euler disk", the "Tippe Top", and the rattleback (celt or wobblestone). Numerous articles exist on the "Tippe Top" and the rattleback. Three-dimensional dynamics of rigid bodies in contact with a rough surface continues to hold many challenges!

I will describe two independent study projects done with the "Ooze Tube" and "Shoot the Moon". In the former case it was possible to touch on the topic of fluid flow instability with which a US undergraduate student will typically have little familiarity. (This included studying the paper by G. I. Taylor presented at the 12th ICTAM in 1968.). The project with "Shoot the Moon" involved relatively intricate, albeit two-dimensional dynamics of a rigid body, and simple ideas about control of a dynamical system.

Apart from analytical mechanics projects the world of mechanical toys opens up a number of "softer" questions that may be used to attract students into the field of mechanics. One can, for example, pursue issues of materials selection, assembly of bibliographic material, or construction of websites on toys. It is cheap and relatively simple to construct prototypes of novel toys (often variations on existing toys). Diagnostic experiments are relatively cheap since the length and time scales involved are typically macroscopic. Finally, demonstrations involving toys tend to be great "crowd pleasers" (particularly for crowds including children) at various outreach events.

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