Available online at www.sciencedirect.com
ScienceDirect
Procedia IUTAM 20 (2017) 183 – 188
Procedia IUTAM
www.elsevier.com/locate/procedia

24th International Congress of Theoretical and Applied Mechanics

Mechanics for liberal arts students

Yutaka Shimomura*

Department of Physics, Hiyoshi Campus, Keio University, Yokohama 223-8521, Japan

Abstract

From my quarter-century experience of educating liberal arts students of Keio University in Japan, who are generally not good at mathematics, I believe that mechanics is a very effective subject for them to learn scientific approaches through observations and experiments on mechanical phenomena: they develop a study skill of how to find a problem, form a hypothesis for the solution, validate it, and finally solve the problem. This is because many phenomena in mechanics are comparatively simple but attractive, ubiquitous, easily observable, sometimes intuitively understandable and sometimes mysterious.

Peer-review under responsibility of organizing committee of the 24th International Congress of Theoretical and Applied Mechanics

Keywords: mechanics; liberal arts students; Keio Univesrity; swings; Japanese swords

1. Introduction

I am a professor of physics in the faculty of law, Keio University [1], Japan, which was established in 1858 by Yukichi Fukuzawa, whose face is printed on a ten-thousand yen bill. The founder Fukuzawa was one of the pioneers of modern Japan, who noticed the importance of learning that is based on “jitsugaku”, or science. It was the demonstrational feature of science that he thought important, as is compactly expressed in the Royal Society's motto 'Nullius in verba' [2]. In fact, he incorporated physics in curriculum at early days of Keio as a basic preparatory subject for all students to learn before other subjects. In 1886, as the first introductory book on science in Japan, he published “Kinmou Kyuuri Zukai” with many Japanese illustrations, which introduces phenomena explained by thermal, solid, fluid mechanics and geoscience.

Succeeding the founder’s spirit of science, I have been teaching physics with experiments in Keio University for 25 years to the liberal arts students who belong to the faculties of letters, economics, law, or business and commerce. Most of them are not strong at mathematics, and some are even allergic to mathematical formulae, so that in my physics class I try to avoid using mathematics as much as possible and explain theories in physics with ordinary words.

* Corresponding author. Tel.: +81-45-566-1322; fax: +81-45-566-1322.
E-mail address: yutaka@keio.jp

Peer-review under responsibility of organizing committee of the 24th International Congress of Theoretical and Applied Mechanics
doi:10.1016/j.piutam.2017.03.025

Since 2006, I also have been teaching a small study group of three- or four-year level students belonging to the faculty of law, who physically research natural phenomena in the class. Up to now, I have been taking up phenomena mainly in solid and fluid mechanics for this study class.

Here, I review how my liberal arts students in both classes learnt scientific approaches through their experiments and observations of natural phenomena in mechanics to see whether mechanics is effective for their learning.

Nomenclature

l	length of the swing chain
m	total mass of a swing rider and its pedestal
h	variation length of the rider's knee height
ϕ	angle between the vertical line and the swing's chain
α	maximum angle between the vertical line and the swing's chain
g	gravity acceleration
v	magnitude of the velocity at an angle ϕ
v_0	magnitude of the velocity at the angle ϕ =0
P	critical point on a arc wire
θ	half of center angle of the wire's arc
x	x-coordinate of P
y	y-coordinate of P

2. Physics Class

In the physics class, I call into question the mechanics of swings in playgrounds, which are simple amusing rides so familiar to them. First, I give students some background knowledge about the definition of mechanical energy (1) and forces acting on a rider as shown in Fig. 1 (a):

$$E=K+U=1/2mv^2+mgl(1-\cos\phi). \tag{1}$$

Then I ask them why they can swing just by the repeat of flexing and extending their legs, though the repeat of up-down motions does not seem to generate any mechanical energy. Most liberal arts students can't answer this question at once, and I let them think and discuss in a small group. I demonstrate that the amplitude of a pendulum oscillation can be amplified by changing the length of its string if the timing is right, and they notice the timing of up-down motions is important and start remembering how they actually move when riding on a swing. So, I require them to draw a trajectory of their navels on a swing, and some groups propose a few types of trajectories that can generate a positive energy to the swing. I explain the ideal trajectory, which is different from the actual one and give the swing the most mechanical energy, is the red curve shown in Fig. 1 (b): the riders should extend their legs when the swing is in the lowest position and flex them when it is in the highest position.