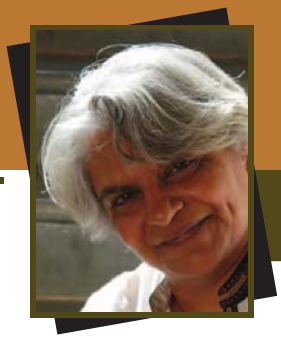


19 Ganesha gives back to Physics

Jyoti Thyagarajan

For many years now, I have taught Physics to the Grades 11 and 12 and it has been the most energizing experience for half the time and almost deathly dull for some of the time.

Most of the physics curricula which I have taught, IB or A Level or ISC, all of which I have taught in equal measures of time, always start with mechanics. So the first thing the students hear is Units, then they hear Vectors, then they hear Speed, Velocity and Acceleration, then they hear Newton's Laws, then they hear Newton's equations of Motion, then they hear Newton's free body diagrams, then they hear Newton's treatment of free fall, then they lose interest. Then, I am left with having to manfully push through energy and power, rotational motion, elasticity, heat transfer and linear expansion in heat before we hit wave mechanics.

Actually, I must confess to trying to paint a dramatically doleful picture. The truth is not so bad. Students managed to keep their interest up through the topics at the big picture level. Occasional days were "full of dole", which was the phrase we made up to keep our spirits up on those days. So, come early the following year, I would set a project to coincide with Ganesh Chathurthi. It counted for 10% for the second year's grade. If nothing, it gave me the chance to link all of basic mechanics together in one elegant package, the elegance being supplied by Ganesha, the package being slapped together by me.

The project needed Ganesha idols. The school I taught in was walking distance from a potters' village and the people at this village made Ganeshas for the northern part of the city. This was fortuitous, because for a class size of ten, I need three unfired and unpainted clay Ganeshas. Also for each Ganesha, I need two or three "clay slicers", which is a 40 cm length of resistance wire, each end of the wire is twisted around a short stub of a pencil and the pencil acts as a handle. If the wire is placed along a section of the Ganesh and pulled through gradually, it slices the idol in a neat section.

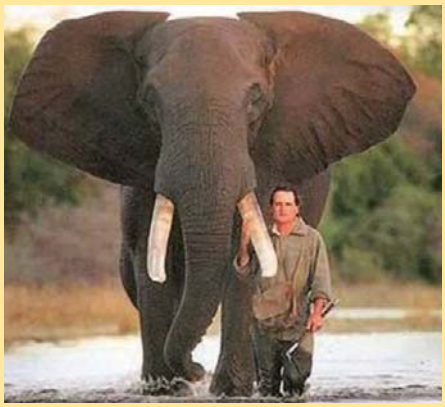
The lab is set with all the usual measuring instruments that is commonly available in a lab, vernier calipers, screw gauge, ruler, weights, force meter, thread, travelling microscope, torque meter and so on. I was happy to supply any of the equipment that the students had used in the lab before, as and when they had the need for it in their experiment.

Each student got the following project prompt on a sheet of paper as well as in my blog:

> Before you is an idol of Ganesha. The story of his genesis is interesting and dramatic and can be found at: http://hinduism.about.com/od/lordganesha/a/ganesha.html

> You can also find this image, which I have attached, at: http://treadinggrain.com/2011/made-me-smile/a-elephant-and-man/

Use this picture to gather data from.



You may use the clay cutter to slice through the idol. I ask that you save all the pieces in the same order that you cut them, so that at the end of this exercise, we can respectfully dissolve the pieces and return the idols to the earth that they came from.

By researching some values of mass, breadth, length, crush-factor of bone material etc, (no more hints!) analyse the physical form of Ganesha and conclude if he is a viable living form. Your conclusion should be supported by numerical data and accurate calculations, as far as possible.

Good luck. You have the rest of this week and the weekend that follows to produce the lab report.

On Friday, we will put all the pieces into a bucket full of water to let the Ganeshas dissolve. If you do not have the readings before Friday, you will not be able to take the readings you need for your project. So, may I suggest that you err on the side of generous when you are taking readings?

So the students got to work and I had a great spectrum of experiments done and many hypotheses proved.

The grading criteria is as per the chart below:

Category	4	3	2	1
Experimental Hypothesis	Hypothesized relationship between the variables and the predicted result is clear and reasonable based on what has been studied.	Hypothesized relationship between the variables and the predicted result is reasonable based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted result has been stated, but appears to be based on flawed logic.	No hypothesis has been stated.
Scientific Concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.
Experimental Design	Experimental design is a well-constructed test of the stated hypothesis.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is not relevant to the hypothesis.

Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
Data	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in written form. No graphs or tables are presented.	Data are not shown OR are inaccurate.
Analysis	The relationship between the variables is discussed and trends/ patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/ patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends or predictions are made based on the data.	The relationship between the variables is not discussed.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.

(Thanks to Rubistar (http://rubistar.4teachers.org/) for help in creating the above rubric for the Ganesha project)

One student did a comparison of the size of a man and the size of an elephant head and produced a result that was earth-shattering for me. I had always imagined Ganesha to be knee-high, but not true! He would have to be as tall as an elephant to be able to carry that head to the proportion to which we have become accustomed. I accepted this project, although it was almost all math and very little physics.

I do not have a record of actual measurements that the students took. They were almost all students from other countries and at the end of the course went back to their countries. But I remember rough sizes. For example, Ganesha's backbone would have to be of a diameter of about 20 centimeters, it turned out, to avoid being impacted by the head. The weight of the head forced his legs to be about four times as thick in cross-sectional area if he walked on his hands and legs, or six times as thick if he walked on two legs.

One student looked into the elasticity of the veins and arteries, but ran aground because he did not have access to base figures from the internet. Another student ingeniously realised that the turning momentum necessary to turn the elephantine head would cause a problem, but the linear force to stop the turn could tear the muscles on the neck. He was thinking rotational momentum. He also suggested that if Ganesha ever looked down, the muscles on the back of his neck did not have the bulk to ever lift his head again. This was not supported by data or calculation, and it was not for want of trying in medical data banks. Seemingly,

medical researchers do not test tear limits of bundles of muscles in the human neck. If they do, it was difficult to find at short notice. Students thought that medical sites that handled whiplash wounds should have had the data, but it was not available.

There was a comment on micro-surgery being necessary on one script that I wrote, "This is a little facetious!" against. But my favourite comment was from a German student, who noted that while his research showed that Ganesha was an unviable physical form, as a spiritual form there were few religious figures that could compete with him!

Did the students learn from this exercise? Yes, I would say that they did learn how all of science is interconnected. They also learned that the investigations in real science are sometimes elegantly simple. Did they demonstrate their knowledge of mechanics? I would say some did, and some did not. But is that not the way with term tests, as well? Would I do it again, in another classroom in the future? I would respond with a resounding, "YES!"

JYOTI has taught Mathematics and Physics for thirty years, on both sides of the Arabian Sea. She started teaching in Lusaka, Zambia. Then ten years later, she moved to Liverpool to do a second Masters in High Energy Physics and Education. She returned to Bangalore to work at Mallya Aditi International School for ten years. Then, just to break the ten-year repeating pattern, she moved to Kenya for six years to teach at International School of Kenya. She re-returned to India to work at Aditi again for a short while and "retired" from her formal teaching career after four years at Stonehill International School. Now Jyoti is involved with a dizzying number of initiatives in a mind-numbing number of NGOs. One day, in the distant future, Jyoti promises to really retire. She can be contacted at jyoti.thyagu@gmail.com