Giving Physics the Elbow

Gren Ireson,
Loughborough University, UK
g.p.ireson@lboro.ac.uk

Abstract

Teaching physics based courses to pre-university and undergraduate students has led the author to the belief that understanding comes with context and inquiry.

The following paper addresses the seemingly simple concept of turning moments. The approach taken is to set the learning in the context of the action of the biceps brachi or muscle of the upper arm.

A simple laboratory exercise can be used to generate data and these data can then be modelled mathematically. Real data, from muscle activity, can then be collected for comparison.

This approach develops the physics in context and allows the student to develop modelling skills, appropriate mathematics and their application of ICT.

Introduction

This exercise can be considered in three parts: the simple laboratory exercise, the mathematical model and the collection of muscle activity data.

The first part requires very basic laboratory apparatus, the second access to a spreadsheet and the third a means of taking measurements of electrical activity in the muscle, an EMG. The system used in this paper was developed in the UK as a training aid for medical students and is both relatively cheap and easy to use[3].

Part one – turning moments in the human arm

A model arm can be constructed as shown in figure 1 which models the *biceps brachii.*

Notice how, in figure 1, the *muscle* could not be attached along the horizontal line since this would result in no turning moment to return the arm from the vertical. The force in the muscle, as read by the Newton meter, can be measured over a range of angles, θ, and a suitable graph plotted. The graph will have the general shape shown in figure 2.

Students should be required to devise their own method of data collection, produce a suitable graph or graphs, including error bars where appropriate, and comment on both the accuracy and precision of their results.

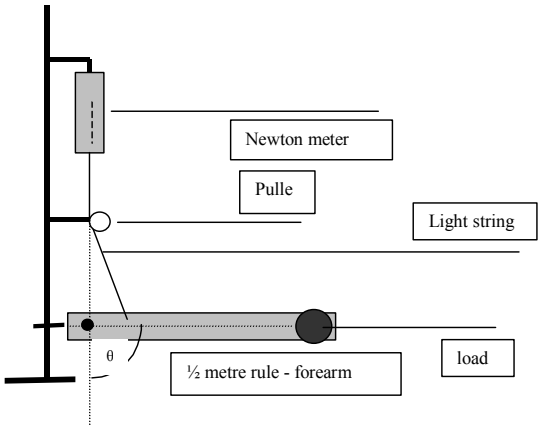

Figure 1 – practical set up

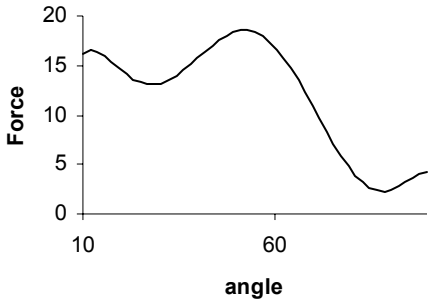

Figure 2 – general graph

Part two – developing a mathematical model

In order that students may more fully appreciate the findings a mathematical model can be developed. Students should be allowed a suitable time to develop their own model but repeated application of the cosine rule leads to an adequate solution for the single, *biceps brachii,* muscle.

The challenge for the more able students is to research, locate and then account for the contribution made by both the *brachialis* and *brachioradialis* muscles.

[3] *The Body Electric*, University of Sheffield UK

Part three – measuring muscle activity

The final part of this investigation is to allow students to collect muscle activity data which are an indication of the force being applied by the muscle. The question for the student to answer is, 'does the graph follow the same general trend as that predicted by the model?'

The data collection instrument used in this investigation was the *Body Electric* kit developed by Sheffield University and the Royal Hallamshire Hospital, UK for trainee medics.

The kit uses three electrodes to measure electrical activity that is logged in millivolt and can be exported to your usual spreadsheet package as a CSV file. The data in this investigation were exported to an *Excel* file, averaged and smoothed and graphs produced.

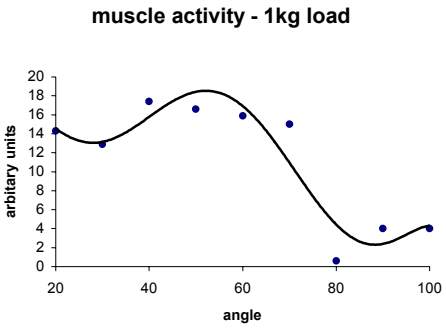

Figure 3 – muscle activity data

Conclusion

By taking a simple example, which all students can relate to, physics can be put into a meaningful context which allows the physics concept, the underlying mathematics and the appropriate use of ICT to be developed simultaneously