

# 12R021 - HOW TO DO RESEARCH

1-APR-12

Aim - to describe what I have learnt about research approaches during my academic career to give hints to new researchers

## 1. INTRODUCTION

Whether it is a final-year undergraduate project or a PhD, starting research can be overwhelming. In research there are long timelines, goals are often not well-defined and the expectations may be unclear.

Research involves firstly learning something yourself, then secondly passing this knowledge on to others.

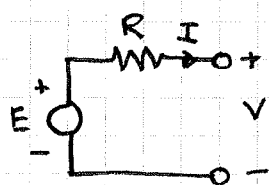
Thus research is about learning. Learning is about gaining understanding and insight. Not just a surface level of understanding, but a deep, in-depth knowledge of the topic.

Research is <sup>generally</sup> a step-by-step approach. Like running a marathon, it is one step at a time. Sometimes the steps <sup>may</sup> seem to be going backwards, but they still grow your understanding.

Research is like building a house... it needs solid foundations, which are a deep understanding of the fundamental principles of the topic.

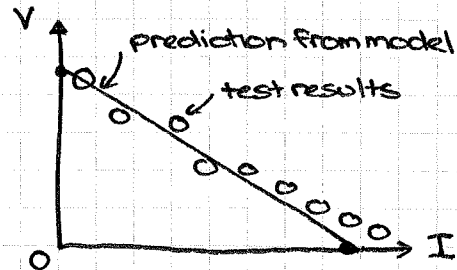
## 2. A RESEARCH MODEL

Science and engineering is based on developing models for phenomena, for instance, that to first approximation, a 1.5V battery can be modelled as a voltage source  $E$  and series resistance,  $R$ .



We can do tests on the battery to determine the two model parameters,

$E$  and  $R$ . With this we can then predict the performance characteristics of the battery at any value of output current,  $I$ . (within the accuracy of the model). The accuracy of the model can be tested by comparing the predictions with test results.



A useful research approach is to identify the fundamental theory related to the topic. This can then be used to develop simple models. The models can be tested under simulation or experiment to check their accuracy. Second-order refinements can then be added to the model and their effect checked/investigated via simulation and experiment.

Parametric analysis using dimensionless parameters is a powerful approach to gain physical insights. More details on this approach is described in PEBN #11 available on the website at the top of this page.

Research methods:

- a) analytical equations - generally requires simplifying approximations but can provide powerful insights into underlying physical processes
- b) simulations - allows investigation of more complex/non-linear models over a wide range of operating conditions
- c) experiment - important for verification of results, usually only limited operating conditions available, includes all practical effects