Practical Physics

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APPENDICES

1 The object of practical physics

This book is intended to help you to do practical physics at college or university: its aim is to make the laboratory work more useful and profitable. We may start by asking what is the object of laboratory work in a university physics course. There are several possible objects. Laboratory work may serve

(a) to demonstrate *theoretical ideas* in physics,
(b) to provide a familiarity with *apparatus*,
(c) to provide a training in *how to do experiments*.

Let us consider each of these in turn.

Seeing something demonstrated in practice is often a great help in understanding it. For example, interference in light is not an intuitive concept. The idea that two beams of light can cancel each other and give darkness takes a little swallowing, and most people find it helpful to be given a visual demonstration. A demonstration is useful for another reason – it gives an idea of orders of magnitude. The interference fringes are in general close together, which indicates that the wavelength of light is small compared with everyday objects. But the demonstration is no substitute for a proper explanation, which goes into the details of geometry and phase relations. So the first object, the demonstration of theoretical ideas, has a definite but limited usefulness.

The second object is perhaps more important, but it is necessary to say exactly what is meant by 'apparatus' in this context. In any practical course you will handle a number of instruments, such as oscilloscopes, timers, thermometers, and so on, and the experience you gain from using them should prove useful. However, if you eventually do scientific work of some kind, the range of instruments you could conceivably work with is enormous. No practical course could possibly teach you to use them all. What the course should do is to train you to use instruments *in general*. There is a certain attitude of mind that an experimenter should adopt when handling any instrument, and this the course should try to instil. But this is part of the third object which is the most important of all.

The phrase 'how to do experiments' may sound vague, so let us try to be more specific. The primary object – or set of objects – of practical physics is to train you to

(a) plan an experiment whose precision is appropriate to its purpose,
(b) be aware of and take steps to eliminate systematic errors in methods and instruments,
(c) analyse the results in order to draw correct conclusions,
(d) estimate the precision of the final result,
(e) record the measurements and calculations accurately, clearly, and concisely.

All this adds up to saying that the main object of a course in practical physics is to train you to be a competent experimenter. But the course can do still more. It can show the way physics works.

Physics is one of the natural sciences, that is to say, it is part of our attempt to understand the natural world. When we are confronted by a situation in the natural world, the way we proceed in physics is to select what we think are the essential features. For example, the Greeks saw that a moving body came to rest and they therefore said that a force is necessary to keep a body moving. Galileo and Newton observed the same phenomenon, but they said that the coming to rest of the body is not an essential feature of the situation. In depends on friction; in the absence of friction a body keeps moving. If we try to do an experiment to test this view, we find that we cannot completely eliminate friction or other retarding forces, but we can make such forces small, and the smaller we make them the farther the body goes before coming to rest. So it is reasonable to believe that in the limiting case of zero friction the motion will remain unchanged as stated in Newton's first law.

This is the way physics works. We select what we think are the essential features in an actual physical situation. From them we make a generalization, or theory, and from the theory, deductions. We test a deduction by doing an experiment. But the deduction refers to an idealized or theoretically simple situation. In order to test it we have to create this simple situation in the messy, complicated, natural world, which is often a difficult thing to do.

In lectures you are taught the theory of the subject. The physical world is described in terms of the features which the current theories say are essential. These features tend to be the only ones you hear about, and you may well come to feel that they constitute the entire world, instead of a specially selected part of it. Moreover, everything fits together so smoothly that you can easily lose sight of the genius and effort that went into creating the subject. The most effective antidote to this is going into the laboratory and seeing the complications of real life.

By doing practical physics, then, you learn at first hand some of the obstacles to testing a theory, to measuring what you want to measure and not something else, and you learn how to overcome them. But above all you get an insight into physics as a whole, into the way experiment and theory interact, which is the very essence of the subject.