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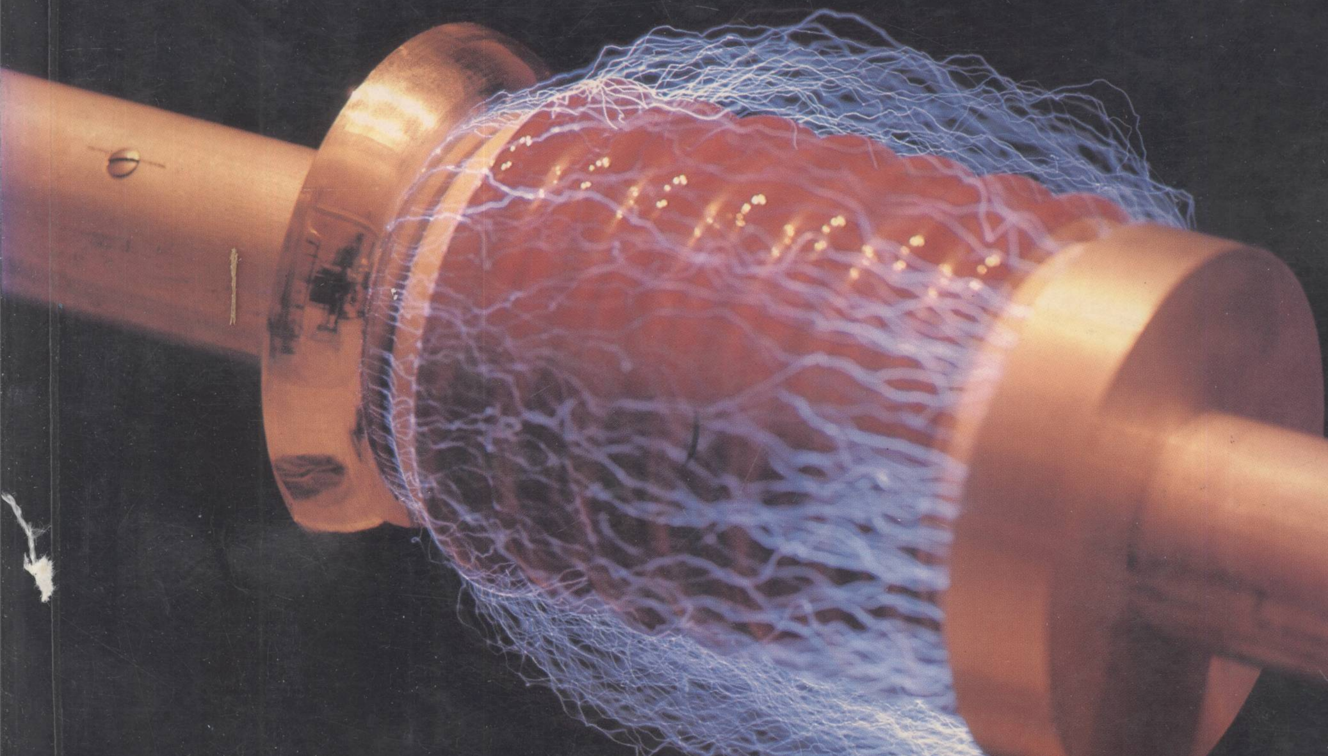

Tim Akrill and Stephen Osmond

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Work Out Physics A-Level

华南理工大学图书馆藏书

Tim Akrill
and
Stephen Osmond

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Introduction

How to Use this Book

This book is not designed to replace a textbook – indeed it will be of most effect if used alongside one. It aims to give you the opportunity to practise your physics by giving examples and questions on topics that form the core of all 'A' Level syllabuses.

Each chapter begins with sections telling you:

- What you should recognise.
- What you should be able to use.
- About the most important ideas in that chapter.

These will help you prepare for the work on that chapter. If you have a textbook you should make yourself familiar with its contents and index so that you can follow up the ideas you are finding troublesome.

Your examination board has extra things in its syllabus that are not common to all the boards, so you must also at this stage look at your syllabus. Syllabuses can be obtained from the boards whose addresses are at the front of the book on pages vii-viii.

Once you have an idea of what you should have covered in any topic area you can start on the questions. There are two types:

- *Worked examples*. The answer follows immediately after the question, with additional comments.
- *Questions*. The numerical answers and hints are to be found later in the book.

The examples and questions either are from real examination papers or are specially devised to fill in gaps and avoid unnecessary repetition. They are all of 'A' Level standard, but some are of course easier than others.

The answers to the worked examples are written out a little more fully than those we would expect from a good candidate. This is to ensure clarity. The additional comments in **bold type** are written in the light of the authors' experience of both teaching and examining at 'A' Level. They would not be part of a real answer.

The examples can be used in a variety of ways, but a suggested routine is:

- Read the question carefully. So many marks are lost by careless reading that practice here is essential.
- Without looking at the answer, have a go at answering it in note form with sketch diagrams where necessary. Consult the start of the chapter and your textbook at this stage. Try the numerical problems.
- Consult the answer. Find out if and where you have gone wrong and go through it very carefully. Follow any algebra through stage by stage and beware if your answer is much longer than the model. But do not just find your mistakes – learn from them!

With each example you should gain confidence and improve your technique. Once you have studied the examples, try the questions – first without the hints, and then if necessary with their help.

The following section on revision will emphasise further the value of doing physics and not just reading textbooks and notes.

The introductions to the chapters will also help you sort out some of the problems that confuse lots of 'A' Level students:

- *Units*. The SI system is clearly laid down and used almost the world over. (See in particular page 7.) When reading the answers, look at the units carefully and use them in your own answers.
- *Abbreviations*. Physicists the world over use a consistent set of abbreviations. Even the Russians with their different alphabet use Roman and Greek letters in their formulas. A few Greek letters crop up more than most. These are α (alpha), β (beta), γ (gamma), ϵ (epsilon), λ (lambda), μ (mu – this is also used for micro, 10^{-6}, not to be confused with m for milli, 10^{-3}), θ (theta), ϕ (phi), ρ (rho) and the very familiar π (pi). Two letters δ, Δ (delta) and ω, Ω (omega) crop up in both small and capital forms. Even with the Roman letters, be sure about whether you are meant to use the small or capital form. For instance, C is used to represent a capacitance, but c represents the speed of waves.

Another couple of questions that 'A' Level students might ask are:

- What do I need to remember from GCSE?

Since one piece of physics builds on another, there is not normally a great problem; you will have been using your earlier physics all through the 'A' Level course. It is, however, worth having a quick look through what you did before, just in case there are areas in which you are very rusty. Though questions are unlikely to ask specifically about them, you may find that it is easier to do an answer if you are still familiar with them. Examiners tend to assume you still remember GCSE.

- What if my mathematics is not strong?

If you had a good understanding of mathematics before 'A' Level you will know most of the things necessary for 'A' Level physics. But there are a few mathematical results necessary for physics that only come up in 'A' Level mathematics. The examination boards list these in their syllabuses and some physics textbooks cover them in an appendix. Time spent on these results is time well spent because the same result is used many times over in different physics topics. For instance, exponential decay formulas crop up in work on capacitors and in work on radioactive decay.

If you are having trouble with the mathematics, read through the working very carefully and ask someone to explain the steps you do not understand. If you consult a mathematics textbook remember that it may go into much more detail than you need. But do not worry too much since the boards are aware of the problem that not all candidates do both subjects at 'A' Level and try to make sure that they are testing mainly your physics and not your mathematics.

Revision

Literally, revision means 'seeing again' and it is a vital part of learning, though the word often gets used simply to mean preparation for an examination or test.

The process of learning has been studied and it has been found that the amount that can be recalled drops dramatically unless the new ideas are revised or reviewed. The graph opposite shows what happens: if an idea is reviewed after 10 minutes, then after a day and so on, it is possible to get to the stage where nearly 100% recall is achievable long after the last review. The explanation for the graph lies in the changes that take place in the cells of the brain and in the connections between them.

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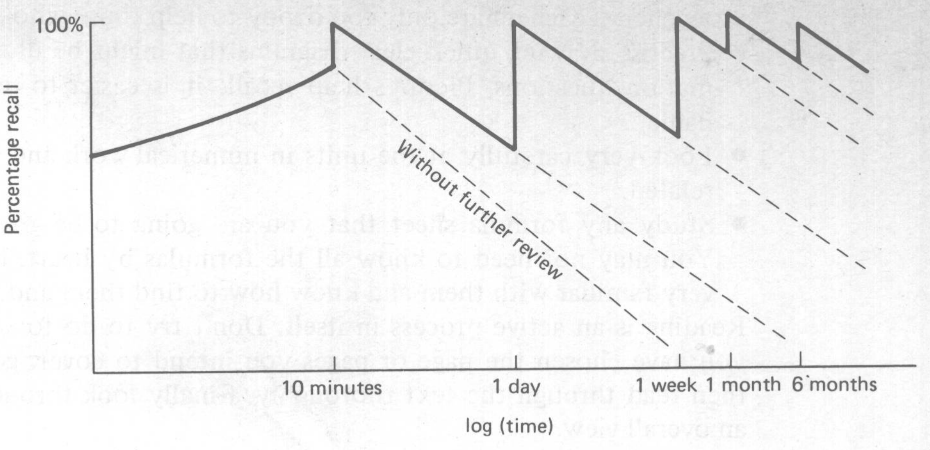

The keys to effective preparation for examinations are:

- Planning a timetable that includes time for review.
- Making revision an active process.
- Finding a suitable time and environment for study.

Let us look at these in turn.

'I haven't got time to work just now, but I'll revise all day for the last week of the holidays.'

Revision for summer examinations should aim at short but regular sessions. Little but often is the key. In a subject like physics that involves understanding concepts more than absorbing information, the early start is particularly important. A little time spent planning in advance, and at the start of each session, saves hours. Write down your plan after thinking about the following:

- What syllabus have I got to cover?
- What notes and textbooks do I have available?
- What questions have I got to practice with?
- How much time do I have available during term and during the holidays?
- Am I being over-ambitious?

You should never sit down to study without a clear idea of what you intend to do. If you finish your set tasks a little early, treat yourself to some free time.

Another hint is to plan just a very small amount of work for your first session, but make absolutely sure you get it done. You will feel you are under way and the rest of your revision will seem much less intimidating.

'It's such lovely weather that I'll take my notes outside and revise in the sunshine.'

Better to study properly for half an hour and sunbathe for two rather than pretend to revise all afternoon. Study needs to be active, and browsing through notes has little value. Things to try and do are:

- Find what the textbook has to say about what you have just read in your notes and maybe add to them or put down page references for later review.
- Do short questions to check your understanding.
- Prepare answers to longer questions in note form.
- Mark up the most important parts of your notes with underlinings or a fluorescent pen.
- Make a note of things to review at the end of the session and at the beginning of the next day's session.

- List the things that you have not quite sorted out, so that you can ask your teacher. Teachers are only too happy to help those who are helping themselves.
- Practise drawing quick clear diagrams that might be useful in answering examination questions. Pictures help recall: it is easier to remember a face than a name.
- Look very carefully at the units in numerical work and see how they are interrelated.
- Study any formula sheet that you are going to be given in the examination. You may not need to know all the formulas by heart, but you do need to be very familiar with them and know how to find them and use them.

Reading is an active process in itself. Don't try to do too much at a time. When you have chosen the page or pages you intend to cover, go through quickly and then read through the text thoroughly. Finally look through again quickly to get an overall view.

'I work much better with music on.'

This is often true when we do what are basically mechanical or boring tasks, but efficient study needs good conditions. Things to aim for are:

- A comfortable chair at a big table.
- Bright but diffuse lighting.
- No visual distractions such as a window with a view.
- Few sounds that distract.
- A temperature of about 20°C (68°F). It is better to wear a jumper than sit in too warm a room since the brain is at its sharpest at the slightly lower temperatures.
- Planned breaks, but don't let the time for every cup of coffee spin out to a half hour or so.

When you are not actually studying, get a reasonable amount of exercise and a good night's sleep.

Preparing for an important examination should not stop you doing the things you really want to do. If you plan well and avoid wasting time, you will be able to continue with most of your favourite activities. Those who talk most about the revision they need to do are generally those who are not actually doing it. Those who really are revising find it satisfying and feel they are getting somewhere as they work through their plan and find plenty of time for relaxation too.

The Examination Itself

'Didn't you say the exam started at half-past nine?'

Always make sure that you know in good time exactly where and when the examination is going to be held so that you can arrive in good time, but not too early. In a subject such as physics it is best to plan the end of your revision a day or so before the examination and relax. A good night's rest is far more valuable than a couple of extra hours of work. Literally last minute revision tends to make people panicky by reminding them of things they do not know or understand well. Have all the things you will need ready the day before so you have a chance to do something about it, if for instance your calculator is not working. A few suggestions for things you will find useful are:

- A tried and trusted pen which you have filled or for which you have refills. Many find a fountain pen more comfortable for long periods of writing.
- Spare ball points of various colours. A diagram will often get a point across more quickly and more simply if a second colour is used.
- Calculator with spare batteries or better still two calculators.

- Pencils, ruler, rubber and compasses. But remember, don't rule lines when freehand diagrams are sufficient. Almost all the diagrams in the answers to examples in this book are in fact freehand. However bad your drawing, electrical circuit diagrams will be as clear freehand as when ruled.
- A watch or small clock.
- Don't bother with Tipp-Ex. Simple crossings out are much quicker and the marker will ignore them. He has enough to do without reading anything with a line through it.

'But you told me we only had to do four questions.'

Arrive fully prepared having eaten something. Talking about the examination with other candidates does no good at all. You only make each other nervous. Once you are given the printed question paper, read the instructions carefully. You should be familiar with the type of paper you are sitting but it is as well to be sure about how long you have and how many questions you must answer. What happens then depends on the type of paper. The common types are:

- Coded answer or multiple choice.
- Short structured questions.
- Longer questions often including descriptions and a numerical problem or analysis of data.
- Long questions of an essay answer type.
- Comprehension questions.
- Practical examinations, which will be covered in Chapter 8.

'It's only the multiple guess today.'

Though some candidates nickname multiple choice questions 'multiple guess', these papers require a high degree of mental effort. There is a certain amount of technique to help you get the highest mark you deserve.

- Don't rush because you have between two and three minutes per question. It is better not quite to finish than to do all the paper carelessly. Check each answer as you go, but do not leave time to check at the end. A correct answer arrived at after a minute or two's careful thought is often altered in a ten second 'check'. If a question is taking too long or you are unsure about the answer, note down its number and come back to it at the end.
- Read the questions very carefully and read each answer thoroughly even if you think you have already spotted the correct one. Be active: sketch a diagram, write down a relationship, do anything that helps you think clearly.
- In numerical questions, don't look at the answer until you have worked it out using rough paper. The wrong answers are often very plausible.
- Scribble on the question paper and rough paper as much as you like, even though you will have been told not to on old papers that have been lent to you.
- Expect questions that are trying to catch you out, sometimes by appearing too simple or by giving data you do not need.
- Do not be worried by too many of one letter since they are random.
- Be absolutely sure to get the easier questions right, by not rushing them. The questions all carry the same marks.
- Finally if in doubt guess, but remember if you have removed patently wrong answers you improve your chances. If you can whittle the choice down to two you have a 50% chance of being right.

A certain amount of practice with old papers is vital, but technique will not improve indefinitely and make up for not having learnt the physics.

There is normally no choice of questions in coded answer papers, but a choice is common in other papers and so it is vital to know how many you must do and whether they must be chosen from particular sections. Doing, say, four questions instead of five can be disastrous because you have thrown away all chance of getting 20% of the marks. Doing too many wastes time, but is not quite so serious. Keep to your time allocation for each question even if it is tempting to do otherwise.

The model answers in this book show how to answer questions, but a few hints can be summarised:

- Use simple straightforward English.
- Use clear labelled diagrams.
- Leave space so you can add things that occur to you later.
- Explain all your working and put in correct units.
- Round off your final answers to a sensible number of significant figures.
- Check your working as you go.
- Look at the marks to gauge how much detail is likely to be expected and, in the case of papers where you answer on the question paper, look at the space available. Six marks probably means six ideas are needed in the answer.

In the case of longer and more open-ended questions be sure to plan your answer first. This will avoid waffle and ensure that every sentence says something relevant and is worthy of a mark. Remember no candidate will have time to write the perfect answer, so just make sure you put down plenty of physics.

In comprehension questions read the passage quickly, look at all the questions and then read it carefully. Finally start answering the questions, referring to the passage as necessary.

If you have time at the end, check all your numerical working first, paying special attention to units and significant figures. Then go through the rest of your answers checking wording and that you really have answered the question asked. You may be able to add some extra detail.

Finally do not discuss the paper with the other candidates and do a post mortem. Some papers may suit you better than others, but whether everyone thinks the examination was hard or easy is of no interest since the pass marks are decided after the papers are marked and the difficulty of the paper is taken into account. Forget all about it and relax so as to be fresh for your next examination.

There is one piece of advice that cannot be repeated often enough to candidates in every range of ability:

- **READ THE QUESTION.**

1 Quantities and Units

1.1 You Should Recognise

(a) The Basic Quantities and Units of the SI System

Quantity	*Symbol*	*Unit*
mass	m	kilogram, kg
length	l	metre, m
time	t	second, s
current	I	ampere, A
temperature interval	T	kelvin, K
amount of substance	n	mole, mol
angle	θ	radian, rad

These units are the basic units from which all other units can be obtained. Lists of derived units, e.g. newton, N, which is a name for kg m s^{-2}, or coulomb, C, which is a name for A s, can be found on the first page of the chapter in which it is widely used: see pages 13 and 73 for example.

The only definition you are usually asked for is that of the ampere. The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.

(b) Multiple and Submultiple Prefixes

Multiple	*Prefix*	*Symbol*	*Submultiple*	*Prefix*	*Symbol*
10^3	kilo	k	10^{-3}	milli	m
10^6	mega	M	10^{-6}	micro	μ
10^9	giga	G	10^{-9}	nano	n
10^{12}	tera	T	10^{-12}	pico	p

You will find these crop up regularly with certain units: e.g. μF, microfarad or 10^{-6} F, is very common when describing a capacitor; nm, nanometre or 10^{-9} m, when giving an optical wavelength; kPa, kilopascal or 10^3 Pa (10^3 N m^{-2}), when quoting a gas pressure.

1.2 You Should be Able to Use

(a) Equations to Define Physical Quantities

Any quantity, other than those listed in section 1.1(a) above, can be defined by using a word equation, e.g.

$$\text{density} = \frac{\text{mass}}{\text{volume}}, \qquad \rho = \frac{m}{V}$$

$$\text{momentum} = (\text{mass})\,(\text{velocity}), \qquad p = mv$$

$$\text{resistivity} = \frac{(\text{resistance})\,(\text{cross-sectional area})}{\text{length}}, \qquad \rho = \frac{RA}{l}$$

These defining equations, which are given at the beginning of the chapters in which they are used frequently, also fix the unit for the derived quantity. You should appreciate that the unit for density must be kg m^{-3}, for momentum kg m s^{-1} (which is equivalent to N s) and for resistivity $\Omega\ m^2\ m^{-1}$ or simply Ω m.

(b) Units or Dimensions to Test Possible Relationships

As any equation in physics must have the same units on each side, it is possible to detect an impossible relationship by considering only its units. For example, suppose you seem to remember that the drag force, F, on a tennis ball moving at a speed v through air of density ρ is given by $F = \frac{1}{2}\rho v$.

As ρ has the unit kg m^{-3} and v the unit m s^{-1}, the right-hand side has units

$$\frac{\text{kg}}{\text{m}^3} \times \frac{\text{m}}{\text{s}} = \frac{\text{kg}}{\text{m}^2\,\text{s}} = \text{kg m}^{-2}\ \text{s}^{-1}$$

while the left-hand side has units

$$\text{N} = \text{kg m s}^{-2}$$

so the equation you have tried to remember *must be wrong*. ($F = \frac{1}{2}\rho v^2$ has the correct units; but note that the $\frac{1}{2}$ could be wrong – we can never be sure a formula is right by this method.) If you use dimensional symbols M, L and T rather than units kg, m and s to check equations in this way, be careful not to muddle M for mass with m for metre, i.e. length.

The contents of ( ) in ln( ), $\log_{10}$( ) and exp( ) must be dimensionless, that is they are simply numbers. Trigonometric functions such as sine or cosine are also numbers.

(c) Conventions for Labelling Graph Axes and Heading Tables of Data

The important thing to remember here is that a quantity in physics is always represented by a number *and* its unit. A pressure might be

$$p = 6.4 \times 10^5\ \text{N m}^{-2} \quad \text{or} \quad 640\ \text{kN m}^{-2} \quad \text{or} \quad 640\ \text{kPa}$$

A graph of p against something would have (i) $p/10^5$ N m^{-2} or (ii) p/kPa on its axis and the number plotted would be (i) 6.4 or (ii) 640. Similarly if a time period T = 0.74 s is measured then $T^2 = 0.55\ s^2$ and you would have graph axes of (i) T/s or (ii) T^2/s^2 and plot the numbers (i) 0.74 or 0.55.

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