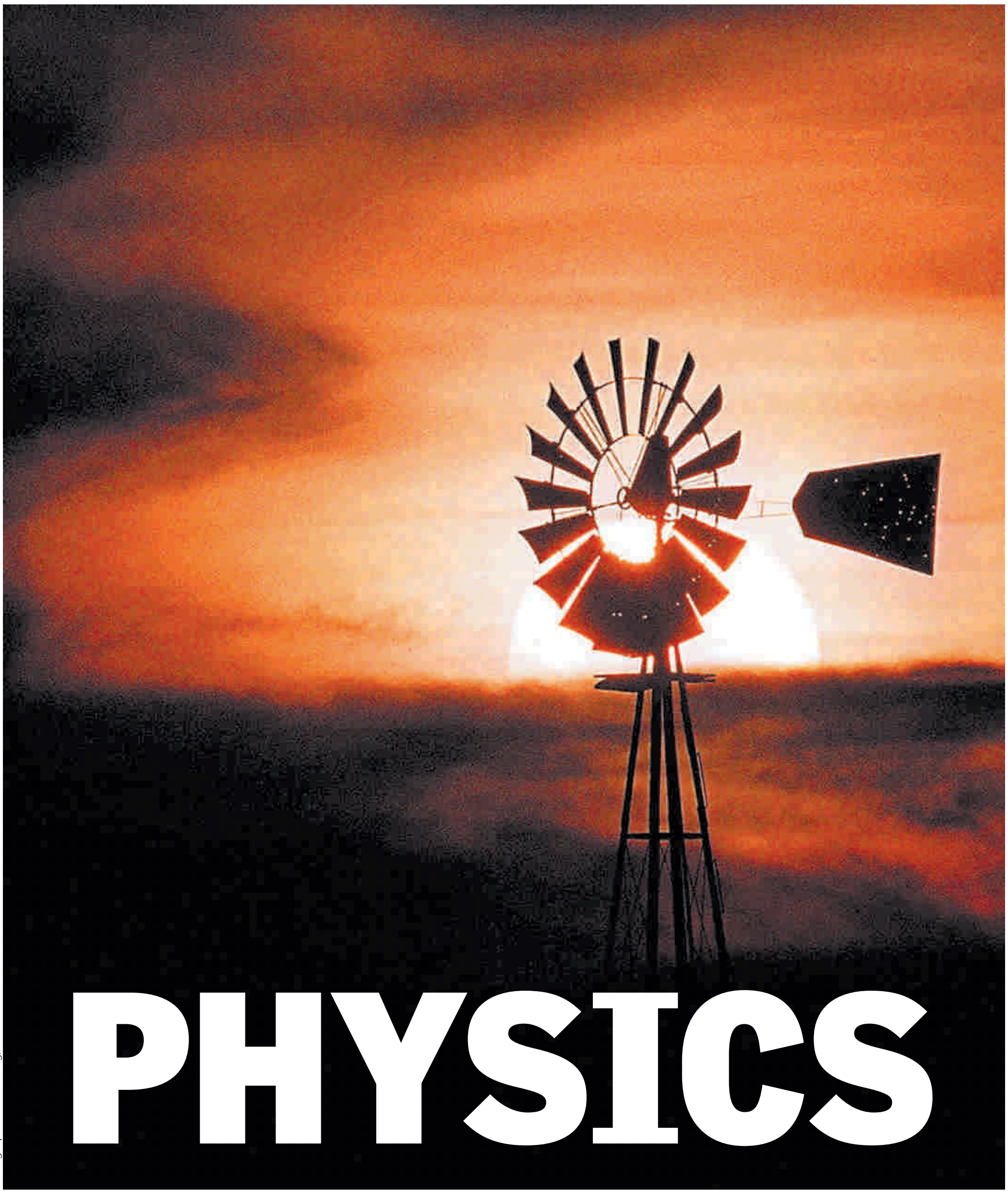

Photograph: Chris Young/AP

PHYSICS

BY JOHN O'BRIEN

John O'Brien is currently Principal teacher of Physics in Eastwood High School in East Renfrewshire. John has worked with Glasgow's advisory service helping to train teachers, was a marker and moderator for many years and is currently committed to work as a Verifier with the SQA next year. John is a teacher member of an SQA subject advisory group considering alterations to the Scottish Physics curriculum and is a Secondary representative on an East Renfrewshire Science Assessment Group.

ON Wednesday, May 17, thousands of people in Scotland will sit and will pass their Physics Standard Grade and Higher examination. This guide is aimed at helping you be part of the group which does well.

Recent changes to the arrangements for pupils sitting examinations in 2006 may make a difference to how you prepare for the Physics papers.

For the first time in the Physics exam, all candidates will have access to a booklet containing lists of equations used in the exams. It is essential that you familiarise yourselves with this booklet and are confident that you can find all the equations you need quickly. Higher candidates should note that an equation they need might be found in the Intermediate 2 or Standard Grade pages.

You need to be sure that you know what all the symbols in the equations mean if you are going to rely on them. Most teachers would advise you to learn the equations by heart and simply use the list as a safety net. You will work more quickly if you know your equations and don't have to look them up.

Another change to the exams affects the Higher Radiation and Matter Unit and the Intermediate 2 Radioactivity Unit.

In these units some terms have been changed, for example w_R (radiation weighting factor) has replaced Q (quality factor) in problems, so what was previously H = D x Q now becomes H = D x w_R.

- Intensity (I) has been changed to Irradiance (I).
- Quality factor, Q, has been changed to radiation weighting factor, w_R.
- Dose equivalent has been changed to equivalent dose.
- H = D x Q has been changed to H = D x w_R in the marking instructions.

Intermediate 2 students will have a data sheet of physical constants given out at the start of their examination, rather than data beside the questions. The data booklet will be similar to that used in Standard Grade, except that it will not have prefixes such as milli, Mega and so on. At Intermediate 2 and Higher levels you are expected to learn these prefixes off by heart. SQA plans to make an example of this data sheet available on its website prior to the exams.

Whether you are sitting Higher, Intermediate 2 or Standard Grade, your notes for this year should have been altered in school to take account of these changes. If you are using older past papers or textbooks, or if you have someone else's software or course notes from previous years, then you need to remember that the terms and definitions have changed since these were published – for example, at time of writing, the SQA website specimen Higher paper still had quality factor in use rather than its replacement w_R.

RESOURCES

Gather all your resources together – ideally you should have a wide range of materials that fit with your revision plan.

Firstly, get reading materials you can easily access or dip into to check facts or remind yourself of something. This could be summaries you have completed or made yourself, or commercial summaries you have bought. You will also need to have your own Physics notes from school. If these are handwritten or copied from a friend, make sure they are accurate copies.

If you are comfortable with a particular textbook then obtain an up-to-date version of it. This should have worked examples and problems with solutions or answers for you to check. Be careful with older textbooks since course arrangements change – some books may have extra materials you do not need, or even worse, might not cover all the content of a course. For Highers, a rule of thumb would be to look for the MOSFET in a Higher book and a modern date of publication in other texts if you want to check suitability, although most NQ Higher or Intermediate 2 textbooks will have the latest SQA arrangements changes built into them this year.

In a revision plan near the exam, the main use of your reading materials is to check the information you need to answer problems that you are doing from your assessment materials.

The main sources of the absolutely vital assessment materials are outlined below. Extensive use of these these materials is crucial to passing the exam.

Get a hold of official SQA Leckie & Leckie past paper questions and solutions (these are available from most bookstores). You can also download specimen papers free from the SQA website. Buy and use commercially published, structured and revision questions like those by Campbell Robertson in the P&N series and Lynn Robinson in the Chemcord series.

You need your own school's assessment materials, especially examples of integrative questions to try out – your school may have given you course questions which cover work from different units. It's important that you use these materials properly.

Higher candidates should try to get

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hundreds of multi-choice questions (with answers) to practise with. All students should check their pace of work by allowing time limits for questions; this also allows you to plan breaks.

If you are sitting Standard Grade, make sure you have materials for both General and Credit level. Sometimes pupils who know a lot can be sidetracked into writing too much in a General paper and can run out of time, so don't forget to pace yourself using the marks allocations on the questions to help you allocate your time.

Computer software and the internet flash learning have excellent software that covers all Scottish S3 to S6 Physics at **www.jsharkey.oneuk.com**.

Your school will need to hold a licence before you can buy student copies to use at home. It is worth asking what your school department has, because many will allow students access to computers and software for planned and structured revision between examinations. Other companies, such as Sure Q, also offer similar fairly inexpensive packages for students' home-use discs, so do check at school.

Standard Grade students can often get lots of help from packages designed for Intermediate 1 and Intermediate 2.

Some of you will have access to online support packages set up by your school or authority. Higher and Advanced Higher students may have Scholar online access from Heriot-Watt University. (If you do have this then your school will have a password entry for you.) Sometimes a Google-type search can reveal resources on other school websites which can be of great help to you.

This close to exams, you should be using the internet as an alternative source of information or problems, or as something to break your routine, not as your main study method. Get specimen papers or do exercises online through BBC Bitesize.

Specimen papers are available from the SQA online at **www.sqa.org.uk**.

At time of writing, Intermediate 1 and 2, Higher and Advanced Higher were available to download or print. To access them, navigate through the "who are you?" window, choosing "pupil", then through the "subject choice" window, choosing "Physics".

Another good resource is BBC Bitesize Physics Scotland **www.bbc.co.uk/scotland/education/**. Click on "bitesize" and choose the appropriate subject.

One or two schools have their own specific site; if your school has one, then it might be appropriate to use it to save time searching out the good from the bad.

Don't forget that friends and family can be a great resource. Sometimes it is a good idea to work in a little group, but beware of it degenerating into a chat session and simply wasting time. However, having telephone numbers, e-mail or MSN addresses can give you virtually instant support from friends when you need it most.

If you are planning to use friends and relatives or tutors outside school for extra help, then check that they will be available when you need them. Tutors especially will be in heavy demand up to Tuesday evening of May 16. If networking with friends, set up rules about how late it is appropriate to call each other and for how long.

You should take advantage of any extra supported study, weekend or holiday classes offered by your school, local colleges or universities.

EXAM TOOLS

All candidates need to gather tools of the exam trade. In your exam you may need the items listed below. You will need to practise using some of them before the test and take all of them with you to the external examination.

- A pen and spare pen that is comfortable to hold and use for most things you write.
- A copy of the examination data booklet, which contains the formulae that you may want to use during the examination.
- A pencil for graphs, scale drawings, sketching ray paths and most diagrams.
- A rubber for correction – don't use correcting fluid, it takes too long to dry and time is precious.
- A 30cm ruler, which is transparent with a clear scale so you can measure and "curve fit" graphs and see the plotted points as you are setting up the ruler to draw the line.
- A calculator of the type allowed in the examination. Check this in school in advance so you don't have yours removed at the last minute. Make sure you do not rely on a solar-powered calculator in case Wednesday May 17, turns out to be a bright sunny day. If it is, curtains may be drawn during the exam and solar-powered calculators that were fine in winter or spring-light conditions may not work in the darker rooms or halls used for the SQA exams.
- No mobile phones will be allowed in case they ring or people start texting or photographing answers. If exam supervisors find people doing this sort of thing they will be withdrawn from the examination.

At Higher Or Intermediate 2

- A protractor or angle measurer for optics or vector use and a watch or timer.

WHAT TO REVISE

At Standard grade, your study plan should cover:

- Telecommunications
- Health Physics
- Understanding Electricity
- Electronics
- Transport
- Energy
- Space Physics

For Higher grade, you should revise:

- Mechanics and properties of matter
- Kinematics
- Dynamics
- Electricity
- Circuits
- AC theory and Capacitance
- Analogue electronics

STANDARD GRADE TIPS

Don't panic if you don't have access to all of the exam tools listed, just gather what you have and use them properly. No matter which course you are sitting, it makes sense to lay out a study plan.

- Calculate realistically the number of days you have left that you are going to devote to Physics, decide what tasks you have to carry out and lay out a calendar with work planned for each day.
- Set short-term targets. For example: Monday night, 1 hour. Read, and highlight an Electricity Unit Summary. Write down the equations from the Unit and practise one past paper problem involving each equation.
- Try to include a variety of tasks in your plan, for example, draw a mind map for the unit or list all the keywords in a piece of theory.

During your revision of third year work you will still be learning new materials, so you need to keep a balance between old and new work.

In a perfect world, your plan for revision will include rereading summaries of all the sections from telecommunications to space physics and learning off-by-heart all Physics equations, and the meaning of the symbols used in the equations, or at least becoming familiar with where the equations are laid out in the data booklet.

You would also want to memorise all physics measurement units, such as, one length in metres (m) and be able to use your knowledge to check estimate answers; for example, you should spot a car travelling at $300ms^{-1}$ is going too fast for that to be a likely answer to a question.

Equally, a lamp drawing a current of 3000 amps would be silly.

Make sure you focus your time very heavily on learning how to use equations, theory, and doing past papers and problems where you can check your answers with proper solutions.

If you are stuck, find help from within your own organised resources or ask advice from your teacher. If your school no longer has a Head of Physics, because of management restructuring, then find out who the faculty manager in charge of Physics is. She or he will be able to direct you to the resources available to you in your school or local authority.

Once you have your Physics-specific plan, stick to it as well as you can but remember, all schedules have to be a bit flexible. If something puts you off schedule, don't give up. Thousands of people pass Physics every year, so can you.

HIGHER GRADE TIPS

Don't panic if you don't have access to all of the exam tools listed, just gather what you have and use them properly. Using resources properly means you need to lay out a study plan which covers the following Units:

- Mechanics and properties of matter.
- Kinematics and vectors, for example, equations of motion and projectiles.
- Dynamics, for example, acceleration, forces, momentum and impulse.
- Properties of matter, for example, density, pressure, the gas laws, kinetic theory of gases and uncertainties.
- Electricity, including circuits, series and parallel equations, internal resistance, potential dividers and Wheatstone bridges.
- AC theory and capacitance, peak and rms, voltage, frequency measurement, capacitor charge and discharge, AC theory and capacitors, capacitor applications.
- Analogue electronics, ideal operational amplifiers definitions, inverting circuits applications, gain equation, phase inversion, square wave production, differential mode circuits and equations.
- Radiation and matter, including wave theory and wave optics, wave equation, interference theory, wave effects, diffraction and spectra, refraction and Snell's law, critical angle and prism spectra, optoelectronics semiconductor theory, inverse square law, p-n junction theory, recombination energy, electron hole theory, the MOSFET, transistor switches.
- Fission, fusion, and dosimetry, $E = mc^2$, inverse square law for gamma radiation, half-life, half-thickness, absorbed dose, dose equivalent, safe practice in using radiation.

You need to practise integrated questions involving information or ideas from more than one unit.

Learning And Equations

At Higher you still need to focus very heavily on learning and using the equations. You must learn theory and show you can reproduce it by working through past papers and problems from which you can check your answers with proper solutions. Make sure you are working fast enough and can use the new data booklet properly.

Once you have your physics specific plan, stick to it as well as you can but remember you have to be a bit flexible in practice, if something puts you off schedule do not give up, thousands of people pass Higher Physics every year, so can you.

STUDY TECHNIQUES

No matter which course you are taking, it makes sense to lay out a study plan for your revision. Calculate realistically the number of days you have left that you are going to devote to Physics. Then decide what tasks you have to carry out and thus lay out a calendar with work planned for each day. Set short-term targets and include a variety of tasks to keep your mind fresh. Stick to your timetable as much as you can.

Focus on learning how to use equations, theory, and doing past papers and problems where you can check your answers with proper solutions.

There is a range of study techniques you can use to help you learn Physics.

EQUATIONS, UNITS LISTS, MIND MAPS

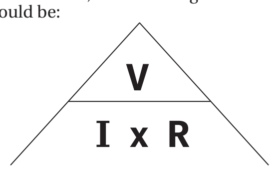
In the Physics exams, you will be given equations lists in a data booklet, but it helps to learn equations off by heart because it improves your pace of work.

You should go through your notes and summaries and write down all the equations with their units and a brief reminder note about when to use them.

You should then check where these are in your copy of the data booklet, so you can find them easily during the exam if you have a mental block.

If you prefer to use the triangle format for equations, then learn it in a form that puts the left hand side of the equation at the top of the triangle.

Using Ohms law: In Standard Grade and Intermediate 2 courses, the basic equation is V = I x R, so in triangle format this would be:



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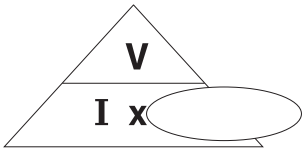
To use the triangle, you cover the symbol you want to find with your finger. To find R, for example, cover over the R on the triangle. You are left with V on top and I below, so the equation is R = $^V/_I$



Remember, you get no marks for simply writing down the triangle. You must write down the equation separately.

The good news for Intermediate 1 students is that you should only have to learn the equation one way round; you will not normally be expected to rearrange equations.

People who are visual thinkers often prefer to start with the triangle format. During revision, visual thinkers may benefit most from using a concept map or mind map (pictured right) as a summary learning tool or as a way to link ideas together.

WORK TO TIME LIMITS.
At Standard Grade – as in all exams – when you do past papers you should time yourself, both in revision and in the exam.

At Credit level there are 105 minutes for 100 marks, which gives 63 seconds per mark, so a 10-mark question at Credit level should take up 10.5 minutes.

At General level there are 90 minutes for 80 marks, which gives 67.5 seconds per mark, so an eight-mark question should take 9 minutes.

Work it out for your own exam questions when you practise pacing yourself.

MNEMONICS AND MEMORY TRICKS
Mnemonics and memory tricks can be nonsensical, as long as they help you remember the correct Physics.

ROYGBIV is familiar to many students as an easy way to remember the colours of the visible spectrum – red, orange, yellow, green, blue, indigo and violet are the colours in order from long wavelength to short wavelength.

Using colour when writing information or facts can also help you to memorise them, as can chanting them.

STUDY TECHNIQUES FOR HIGHER GRADE
Use the techniques you have developed already when you studied for Standard Grade or Intermediate 2.

However, multiple choice questions are much more important than at Credit level, so you need to study lots of them. There also seem to be a higher proportion of problem-solving questions demanding complex descriptive answers, or multi-stage answers, so practise them. You will probably have to allocate much more revision time for Higher than you did for Standard Grade.

STANDARD GRADE EXAMS

First remind yourself that the exam can be passed. Last year, 16,917 students sat Standard Grade Physics: 58.2% passed at Credit level and a further 31.5% achieved a General level pass.

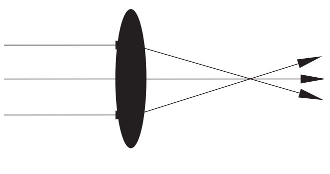
The actual pass mark at each grade was:

Credit KU out of 50 General KU out of 40
Grade one: 30 Grade three: 17
Grade two: 21 Grade four: 10

Credit PS out of 50 General PS out of 40
Grade one: 33 Grade three: 22
Grade two: 22 Grade four: 19

So if your exam in May is about the same level of difficulty as last year, then you can see what marks you need to aim for in each grade as a minimum. Last year's Knowledge pass marks were at a lower level than normal because of the difficulty of the exam.

TIPS FOR THE EXAM
- The first and most obvious rule is turn up on time for the exam.
- Do all the paper, or as much of it as you can in the time.
- Try to check every answer, if you have time.
- Never score out any answer until you have written its replacement. You can circle the wrong answer and write "ignore this please" if you want rid of something – that way if you change your mind again all you have to rub out is "ignore this please". Never, never leave both answers – the examiner will ignore both!
- Use diagrams to help with your answers. You can reduce descriptive answers considerably with a neat, good-sized drawing. For example, at Standard Grade the answer to a question on focussing rays by a lens is much better drawn than described:



MISTAKES TO AVOID
Every year candidates make mistakes that could be avoided. Here are some examples of things to watch for.
- Always put units in answers.
- Think about the prefixes in questions or in your answers – mixing up milli amps with Mega amps means the answer is wrong by a thousand million times. (If you use a thousand million times too much power you might be roasted).
- Lots of people used phrases such as "a bigger resistor" when they meant "a bigger resistance". This sort of mistake can be easily corrected.

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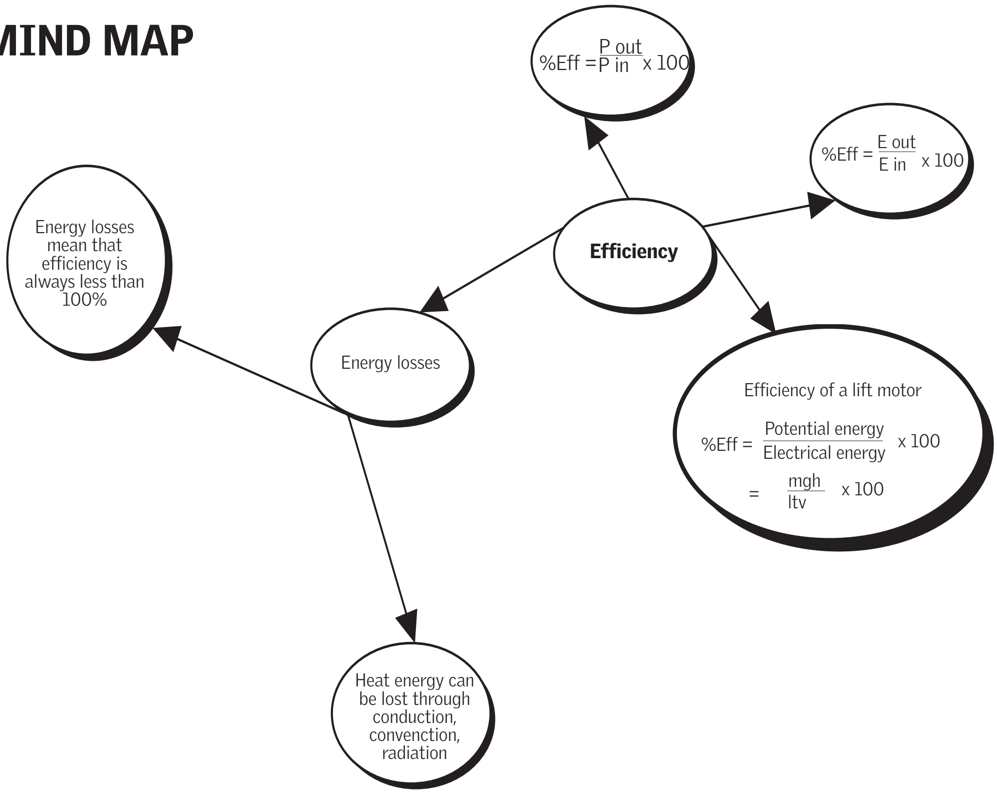
MIND MAP



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PHYSICS

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HIGHER GRADE EXAMS

Again, remember that the exam can be passed – last year 83.2% of candidates achieved an award from A to D.

In Higher Physics you have 150 minutes for 90 marks, which is about one minute and 40 seconds per mark. This means you should take about 33-34 minutes to do 20 multiple choice questions.

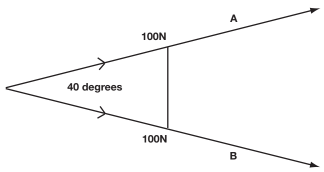
Students make similar mistakes every year, according to SQA principal examiners. Make sure you avoid these mistakes:

- Forgetting direction in vector questions.
- Using gravity as a label instead of gravitational force or weight.
- In internal resistance questions, forgetting that changes in external resistance cause changes to current which also change "lost volts".
- Confusing the name of an object with the physical quantity – for example, writing "increase the size of the resistor" instead of "increase the resistance".
- In optoelectronics, being unable to describe how a laser works or how light is produced in an LED.
- Mixing up chemical reactions with nuclear reactions.
- Do not use arrow symbols in descriptive questions. In a gas laws question, for example, write "as the temperature increases, the kinetic energy increases", rather than "as the temperature ↑ the kinetic energy ↑"
- Forgetting basic definitions like emf.
- Candidates should use SI units – 0.016 seconds is the same as 0.016s, but it would be incorrect to write as 0.016 secs.
- Always put a zero at the origin of a graph, if appropriate to do so.
- When two or more attempts have been made for the same part of a question, candidates must score through the part they do not wish to be considered.

DRAWINGS AND DIAGRAMS

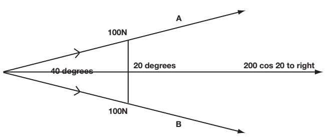
In Higher Physics, projectiles and vector questions can be made very much easier with drawings helping to specify the directions of movement or forces.

Question:



When two vectors are symmetrically positioned (above), simply resolve each vector in to the same direction – in this case the horizontal component:

Vector A has a horizontal component = 100 Cos 20 to the right and Vector B has a horizontal component = 100 Cos 20 to the right so the resultant = 2 x 100 Cos 20º to the right = 187. 94 N to right



The most common calculation problems are found in what teachers call the standard 2-marker format

Question:
Find the voltage across a four ohm resistor when a current of three amperes flows through it.

Write the equation: V = I x R (1/2 mark).
Substitute in the numbers for the things you know: V = 3 x 4 (1/2 mark)
Calculate the answer and write it down with a unit: V = 12 volts (1 mark) (Usually, a 1/2 mark is deducted if there is no unit.)

This type of question can become a 3-marker if you have to take information from another source, such as a table in the data sheet.

Question:
Calculate how long it takes for sound to travel 30cm through body tissue.

Write equation:
Speed (v) = distance/time
Substitute known numbers:
v = 0.3m/t

At this stage it looks as we have two unknown variables, v and t. However, in the data sheet the value of the speed of sound in body tissue would be found and should be substituted into the equation for an extra mark, so:
v = 1500 = 0.3/t and therefore
t = 0.3/1500 = 2 x 10^{-4}s

KEY WORDS

Look out for words that are key to understanding how marks are allocated to a question.

- **Find** usually means do a calculation to work something out numerically.
- **Describe** means write down what you would actually see or do.
- **Explain why** means give an answer based on Physics theory to clarify what is happening. For example: Explain why microwaves are detected behind a metal barrier. Expected answer: "The microwaves are diffracted round the barrier edge."
- **Explain how** usually means give practical steps in an experiment or process to illustrate what is happening. For example: Explain how microwaves are detected behind a metal barrier. Expected answer: "An aerial is placed behind the barrier and is used to detect the microwave signal."
- **State** means write down a statement or a list for the answer; no explanation is required.
- **Estimate** means make an educated guess based on reasonable interpretation of information. Example: if asked to estimate the time for a car to go a fixed distance in town, it would be reasonable to use times which gave speeds less than the urban speed limit (about 13 ms^{-1}) or close to that value. If you estimated times in milli seconds that gave speeds of hundreds of metres per second – possibly faster than sound – that would be unreasonable.
- **Give two answers** means give two, there are no marks for extra ones – if you give extra wrong answers they can sometimes cancel out correct answers.
- Highlighted words in **bold** or in *italics* are important.

LAYOUT OF ANSWERS

Always write as clearly and as neatly as you can, it makes life easier for the marker and they can give you all the marks you deserve.

Try to use directional words and phrases, such as increases, decreases, stays the same, not vague words and phrases such as changes, alters size and so on.

If you can use an equation to back up a written answer do so, but do not use too many significant figures in an answer. For example: 10/3 = 3.33 is reasonable; 3.333333 would lose marks.

As a rule of thumb, look at the data in the question. If it is to three significant figures, you will probably lose marks for using three or more figures too many, or two or more figures too few, in your answer.

In Intermediate 1 and Standard Grade General level, problems should have exact solutions so you don't have to worry about significant figures.

Also remember that spelling of some words is important – diffraction and refraction, fission and fusion, for example.

If you have a multi-stage descriptive answer to write, break it down into a set of bullet points. Try to do this in a logical order, especially when explaining something like the switching action of a transistor in electronics:

- Start by explaining how the input voltages change with the input conditions.
- Secondly, explain the changes or values of voltage needed to operate the switch.
- Lastly, explain what happens at the output of the system.

MULTIPLE CHOICE QUESTIONS

- Practise lots of them and make sure you are getting them right by checking answer banks for General level. You rarely find multiple choice in the Credit level paper. Do every past paper multi-choice you can, sometimes similar questions reappear.
- When puzzled, try to eliminate answers that are clearly wrong. Often multi-choice can be reduced to true or false by this method.
- Read the first part of the question and try to work out the solution before looking at the responses.
- Always include working out – you can do rough work on the question in the paper right beside the question. This makes it much easier to check if you have time.

HIGHER GRADE QUESTIONS

The most common calculation problems are based on the standard 2-marker format – read the Standard Grade notes above for more information.

At Higher, you will need to consider the greater likelihood of more complex, multi-stage questions. Sometimes you will have to lay out your equations and data clearly before you know how to do the question.

Data sheets will be found in the Higher and Advanced Higher exams.

KEY POINTS

- Look out for words that are key to understanding how marks are allocated to a question. See the Standard Grade notes above for information.
- Estimate means make an educated guess based on reasonable interpretation of information. These questions only have correct answers based on the estimate used.
- You only get marks for equations at Higher if a substitution is made into them as part of the answer, or if the equation represents a principle, such as conservation of momentum.

LAYOUT OF ANSWERS

You will write the answers for this exam in a separate booklet, not on the answer paper itself. This makes it even more important to always write clearly. Leave space between answers so you can change them or add information later.

It is vital to clearly identify which question (and which part of a multi-stage question) you are answering.

If you have a multi-stage descriptive answer to write, it can be a good idea to break it down into bullet points. Try to do this in a logical order. For example, when explaining the pressure increase in a gas of fixed mass and at constant volume:

- Start by explaining how temperature affects kinetic energy of the particles and the speed and motion of the particles.
- Secondly, explain the effects of these changes or impulse per collision, force per collision and number of collisions per second.
- Next, explain how force and gas pressure are affected.

MULTIPLE CHOICE QUESTIONS

Again, practise lots of them and check answer banks. When stuck, try to eliminate rubbish – often multi-choice can be reduced to true or false by this method. Always read the first part of the question and try to work out the solution before looking at the responses. Put rough working in the paper beside the question so you can check your answers later if you have time.

If you run out of time in the multiple choice, make educated guesses. Do not leave grid boxes empty.

You should consider the order you do the paper in carefully. Some people suggest doing the multi-choice Higher questions last, after doing the written questions, but you should always do what you feel most comfortable with.

When relationships in questions get complicated, use substitution methods – put numbers into equations and then rearrange the numbers instead of the equation to see what happens.

In questions with graphs, when a graph is a straight line through the origin, whatever is on the upright axis is directly proportional to the variable on the horizontal axis.

INTERMEDIATE 2

Both the Standard Grade and Higher advice will apply to your exam preparation.

In Intermediate 2 Physics, the specimen paper shows 100 marks in 120 minutes, which is 1.2 minutes per mark or one minute 12 seconds per mark, so a 5-mark question should take six minutes maximum to answer.

PHYSICS EXAM TIMETABLE

Level/Paper	Time
Wednesday May 17	
General	9am-10.30am
Credit	10.50am-12.35pm
Intermediate 1	1pm-2.30pm
Intermediate 2	1pm-3pm
Higher	1pm-3pm
Higher	1pm-3.30pm
Advanced Higher	1pm-3.30pm

Exams below are on the same day as Physics. Make sure you have made proper arrangements with your school if you have two exams at the same time

Science, Credit
Science, Foundation
Science, General
Economics Intermediate 1
Economics Intermediate 2
Economics Higher
Economics Advanced Higher
Music Higher Listening (Core)
Music Higher Listening (Extension)
Music Advanced Higher Listening (Core)

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WORKED EXAMPLES

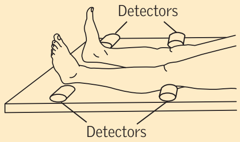
STANDARD GRADE

Making questions relevant to the real world allows situations unfamiliar to students to be used. The application considered in the following question would at best have been covered in an internet search or video by Standard Grade Physics students. Most students would be unfamiliar with the context in which familiar theory is being applied.

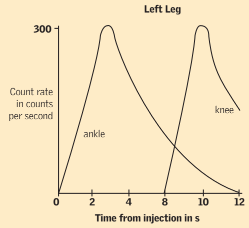
However, questions like this reflect the body of knowledge our future medics and medical engineering graduates will need to know.

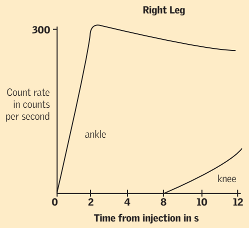
Question

A radioactive tracer is injected into a patient to investigate the rate at which blood flows in the veins of the legs. The tracer is injected into veins in the feet, and detectors are placed beside both ankles and knees of each leg as shown in the diagram.



The graphs show how the count rates at the detectors vary for each leg.





(a) The graph obtained for the left leg indicates that the blood flow in that leg is normal. How long does it take blood to travel from the ankle to the knee in the left leg?

Answer

Eight seconds (taken from graph!)

(b) Explain why the graph obtained for the right leg indicates that there could be a blockage in a vein in the right leg.

Answer

The count rate shown in the graph remains high in the right ankle showing that the blood had not flowed very quickly to the knee.

OR The count rate in the knee is not high enough showing not enough blood had flowed to the knee.

(c) The hospital keeps three radioactive isotopes for different uses. These are shown in the table below.

Isotope	Half-life	Radiation
Na-24	15.1 hours	gamma
Y-86	14.7 hours	beta
Tc-96	4.3 days	gamma

(d)(i) Which isotope should be selected for the blood flow investigation?

Answer

Na –24 should be chosen because its gamma rays will penetrate the body to reach the detectors outside the legs and because it has a reasonably short half life so the patient will not remain radioactive for long.

(d)(ii) Why are each of the other two isotopes not suitable?

Answer

Isotope: The Y-86 is a beta source and beta particles will be absorbed by the body and will not reach the detectors.

Isotope: The Tc-96 has a half life of 4.3 days so the person will remain radioactive for several days after the procedure is completed.

(e) The patient could also be given an injection of another isotope Au-79 with an activity of 10kBq. This isotope has a half life of 2.7 days. The patient must be kept under observation until the activity falls to 1.25kBq.

Calculate how long this will take.

Answer

The answer is found by halving the activity until it reaches the specified level and therefore finding the number of half lives and total time. A table like the one below is often the preferred layout for working.

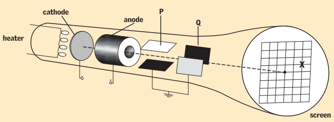
Activity at start	Number of half lives	Number of days passed
10kBq	0	0
5kBq	1	2.7
2.5kBq	2	2.7 + 2.7 = 5.4

HIGHER GRADE

Here is an example of a Higher Grade Integrative question. These are regarded as more difficult because these questions combine ideas from different units. If you are serious about gaining an A then you will need to answer some of these questions correctly to gain enough marks.

Higher Physics 1998 Question

The diagram below shows a cathode ray tube used in an oscilloscope.



The electrons which are emitted from the cathode start from rest and reach the anode with a speed of 4.2×10^7 ms^{-1}

(a)(i) Calculate the kinetic energy in joules of each electron just before it reaches the anode.

Answer

The kinetic energy is found using the equation $E_k = 1/2\ mv^2$ – where m is the mass of the electron found in the data sheet at the start of the examination and v is the velocity of the electron reaching the anode.

$E_k = 0.5 \times 9.11 \times 10^{-31} \times (4.2 \times 10^7)^2$

$= 8.04 \times 10^{-16}$ J

(b)(ii) Calculate the pd between the anode and the cathode.

Answer

The change in kinetic energy 8.04×10^{-15}J is equal to the electrical energy E_e gained by the electron so we can use the equation $E_k = E_e = q \times V$ where q is the charge on the electron and V is the required pd.

$8.04 \times 10^{-16}J = 1.6 \times 10^{-19} \times V$ so that

$V = 8.04 \times 10^{-16}J / 1.6 \times 10^{-19}$

= 5.03 kV

(b) Describe how the spot at the centre of the screen produced by the electrons can be moved to position X. Your answer must make reference to the relative sizes and polarity (signs) of the voltages applied to plates P and Q.

Answer

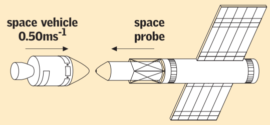
To move the electron beam upwards by one grid square apply a positive voltage V to plate P.

To move the beam to the right two grid squares apply a positive voltage of 2V to plate Q.

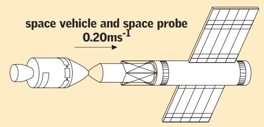
This Higher question might be regarded as difficult because the basic physics in the question is set in an unfamiliar context for most students. Not many Higher candidates will have been in space or be old enough to remember much of the televised material from earlier space exploration. Students taking part in the Scottish Space School modules run jointly by Nasa and Scottish Enterprise (organised by Careers Scotland) might be exceptions to this unfamiliarity with space.

Question

A space vehicle of mass 2500kg is moving with a constant speed of $0.50ms^{-1}$ in the direction shown. It is about to dock with a space probe of mass 1500kg which is moving with a constant speed in the opposite direction.



After docking, the space vehicle and space probe move off together at $0.20ms^{-1}$ in the original direction in which the space vehicle was moving



(a) Calculate the speed of the space probe just before it docked with the space vehicle.

Answer

This is a conservation of momentum question. We solve it by using the fact that total momentum before and after the collision are the same when no external force is acting.

Momentum before is the vector momentum of the probe and vehicle added together.

So we write a suitable equation and substitute values into it, as shown below.

momentum before = $(m \times v)_{vehicle} + (m \times v)_{probe}$

momentum before = momentum after

momentum after = $(m_p + m_v) \times v$

(the masses are added because the space probe and space vehicle stick together after the collision)

So, writing the equation for conservation of momentum:

$(m \times v)_{vehicle} + (m \times v)_{probe} = (m_p + m_v) \times v$

We then substitute the data into the equations:

(2500 x 0.5) + (1500 x v) = (2500 + 1500) x 0.2

So 1250 + (1500 x v) = 4000 x 0.2 = 800

So 1250 - 800 + (1500 x v) = 0

So 450 = -1500 x v

and $v = {}^{450}/_{-1500} = -0.3\ ms^{-1}$ where the negative sign tells us that the direction of the space probe was opposite to the direction of the vehicle.

(b) The space vehicle has a rocket engine which produces a constant thrust of 1000N. The space probe has a rocket engine which produces a constant thrust of 500N.

The space vehicle and space probe are now brought to rest from their combined speed of $0.20ms^{-1}$.

(b)(i) Which rocket engine was switched on to bring the vehicle and probe to rest?

Answer

The space probe engine was switched on (since it exerted a thrust opposite in direction to the motion of the two space ships).

(b)(ii) Calculate the time for which this rocket engine was switched on. You may assume that a negligible mass of fuel was used during this time.

Answer

One way to solve this question is find the acceleration of the pair of spaceships using F = m x a

then use v = u + at to find the time.

We need to remember that the accelerating force acts opposite to the velocity and therefore acceleration has a negative sign compared to the velocity.

So the magnitude of

${}^{F}/_{m} = {}^{500}/_{4000} = 0.125\ ms^{-2}$

and the acceleration is $-0.125ms^{-2}$

substituting into v = u + at

we get 0 = 0.2 + (-0.125t)

0 = 0.2 + (-0.125t)

So -0.2 = -0.125t

So t = 0.2/0.125 = 1.6 seconds to come to rest

Another way is to assume the rocket engines apply an impulse to the spacecraft to change their momentum.

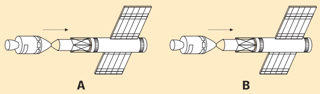
Change in momentum = average force x time for force to act

So, 4000 x 0.2 = 500 x t

and $\frac{(4000 \times 0.2)}{500} = t$

so $t = {}^{800}/_{500} = 1.6$ seconds

(c) The space vehicle and space probe are to be moved from their stationary position at A and brought to rest at position B, as shown.



Explain clearly how the rocket engines of the space vehicle and the space probe are used to complete this manoeuvre. Your explanation must include an indication of the relative time for which each rocket engine must be fired.

You may assume that a negligible mass of fuel is used during this manoeuvre.

Answer

The engines of the space vehicle which exert a thrust (force) of 1000N would be switched on for a set time which would accelerate the vehicles towards B, then switched off. With the engines off, the vehicles would then move with constant velocity towards B since no unbalanced force would be acting on them.

In order to decelerate the vehicles back to rest at B the space probe engines would have to exert a decelerating force. They would have to switched on for twice as long as the original "burn" of the space vehicle engines since they only exert half the thrust of them.

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