Physics Factsheet

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How to Avoid Losing Marks – Calculations

Improving your performance in Physics Exams… That's easy. Just get more marks; but what if that's easier said than done? Time to figure out why you're losing marks.

Where Are Your Marks Going?

Look at mark schemes (and do it honestly – never say "I pretty much got that"). Are there any patterns you can do something about?

i) I didn't know the answer
ii) I misinterpreted some, or all, of the question
iii) I didn't put enough information down to get all the marks
iv) I made a (daft) mistake somewhere despite knowing what I was doing
v) I never did this in lessons.

Figure out which of these is you!

This Factsheet concentrates on losing marks in answers to calculation questions. Other Factsheets deal with other aspects such as interpreting the question and giving the correct depth of response.

Practice! We shall look at specific examples, but practice is the way to get more familiar with the requirements. Make sure you are clear on exactly what the question wants you to calculate.

Use the mark scheme! Figure out what you missed out. Give your answers, being mindful of the chunks of information worth a mark.

Example 1

A 1.5V cell has an internal resistance of 0.45Ω. Using three 10.0Ω resistors, calculate the largest possible current that could pass through each resistor. [3 marks]

First attempt

0.45 [0 marks]

What's wrong with this answer?

- *No workings.*
- *No plan of information given.*
- *No equations listed or used properly.*
- *No unit on answer (though this is usually given for you in the exam).*

Improved Answer

I = V/R = 1.5/(30) = 0.05 A [0 marks]

Better. Still no marks though. What's wrong now?

- *Initial information not noted, so wrong equation used.*
- *Two stages needed, calculation done in one go so two mistakes made.*

Much Improved Answer

R=10Ω, 3 resistors

Highest current lowest resistance, so place in parallel.

(The diagram is not essential to the answer but might help clarify your thoughts).

R_T: $1/R_T$ = 1/10 + 1/10 + 1/10 = 3/10.

R_T = 10/3 = 3.3Ω

Find I through each resistor.

r = 0.45Ω, V=1.5V, E = I(R_T +r)

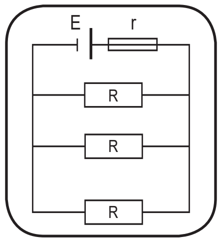
I = E/(R_T+r) = 1.5/(3.3+0.45) = 0.4A

[2 marks]

Still not quite there though!

- *Total resistance was rounded too much and used to find the final answer.*
- *Final answer given to too few significant figures.*

Figure 1



Now we've got the right answer, well almost. We just need to fine tune the way we deliver it.

Correct Answer

R=10Ω, 3 resistors

Highest current lowest resistance, so place in parallel.

R_T: $1/R_T$ = 1/10 + 1/10 + 1/10 = 3/10. R_T = 10/3 = 3.3333Ω (or leave as 10/3)

I = E/(R_T+r) = 1.5/(3.3333+0.45) = 0.3964758A

I = 0.40 A [3 marks]

What's the difference between this and the last answer?

- *Significant figures in answer are correct.*

Example 2

Calculate the drift velocity of electrons in a wire of diameter 1.2mm and n = 8.5 × 10^{28} m^{-3} if it is carrying a current of 1.28A. [2 marks]

Incorrect Answer

I= nAve, so v=I/(nAe)

$$v = \frac{1.28}{1.2 \times 8.5 \times 10^{28} \times 1.6 \times 10^{-19}} = 2.75 \times 10^{25}\ m\ s^{-1}\ [0\ marks]$$

Can you find all the mistakes made here?

- *A simple check tells us this is faster than the speed of light – this can't be true.*
- *These answers are usually mms^{-1} or less.*
- *First check put the numbers into the calculator again: 1.72×10^{-12} m s^{-1}*
- *Mistyped into the calculator the first time. This still isn't right. Go back to the calculation, check all the numbers for typical mistakes.*
- *Diameter in mm and area not calculated.*
- *1.2mm = 0.0012m*
- *Area = πd^2 / 4 (remember it is diameter which is given, so d/2 for radius, then r^2 is d^2 /4).*
- *A = 1.131×10^{-6} m^2*

Correct answer

$$v = \frac{1.28}{1.131 \times 10^{-6} \times 8.5 \times 10^{28} \times 1.6 \times 10^{-19}} = 1.82 \times 10^{-5}\ m\ s^{-1}$$

Example 3

A gas of volume 3.27dm³ is heated and expands to 4.50dm³. If the gas starts in a room temperature lab at 22°C, calculate the end temperature. Give your answer in °C

Information given:

$V_1 = 3.27dm^3$, $V_2 = 4.50dm^3$, $T_1 = 22.0°C$, $T_2 = ?$.

Use: $V_1/T_1 = V_2/T_2$

What are the potential pitfalls in this question?

- *Rearranging the equation correctly.*
- *Remembering to convert temperature to Kelvin.*
- *Wasting time converting the volumes to m³. It is not needed, provided they are in the same unit, the units will cancel out (temperature in °C is not an absolute scale so the same does not apply to it).*
- *Giving the final answer in Kelvin and forgetting to convert it back to °C.*

Incorrect answer

- $22°C + 273 = 295K$ (T_1)
- $T_2 = T_1 \times V_1/V_2 = 295 \times 3.27/ 4.50 = 214K$
- $214-273 = -58.6°C$

How can you tell this isn't correct?

- *The temperature would go up if the gas has expanded, not down.*

Can you see the mistake?

- *The equation is not rearranged properly. Be really careful with fractions like this.*

Correct Answer

$T_2 = V_2 \times T_1/V_1 = 4.50 \times 295 / 3.27 = 406K$

$406 - 273 = 133°C$ *[3 marks]*

Example 4

The lift, L, of an aircraft is given by the equation:

$L = \frac{1}{2} \rho v^2 AC_l$

ρ = density of air, v = relative velocity of air, A = surface area of wings, C_l *is the coefficient of lift (no units)*

Show that this equation is homogenous.

Firstly, don't panic. You probably haven't ever seen this equation before. The exam board know this. Just figure out what to do. What would you do with an equation you did know?

- *See if the units are the same on both sides.*

Incorrect answer

$N = kgms^{-2} = kgm^{-3}\, m^2s^{-2}m^2 = kgms^{-2} = N$

It is inappropriate to write a statement like N = N, and this does not show how you arrived at your answer.

Correct answer

Lift is a force in Newtons:

Left hand side $N = kgms^{-2}$ *(Get this using F=ma,* $N=kgms^{-2}$*)*

Right hand side: (you might not know the equation but you know all the quantities, so you can put the units in and see what you get).

$(\rho)kgm^{-3}\ (v^2)m^2s^{-2}(A)\ m^2 = kg\ m^{-3}m^2m^2s^{-2} = kgms^{-2})$

The equation is homogenous.

"Show That" Questions

These questions give you the answer, so you get marks only for showing the working.

Example 5

Light with an initial frequency f is incident on a metal plate, electrons are ejected via the photoelectric effect with a maximum kinetic energy of E.

The work function of the metal = 2E.

The frequency of incident light is doubled. Show that the new maximum kinetic energy is 4E. [3 marks]

Incorrect answer

If the frequency is doubled, the energy is doubled.

No explanation. No marks

Correct answer

Using the equation:

$E = hf - \varphi$ *If* $\varphi = 2E$ *Then* $E = hf - 2E$ $E = \frac{hf}{3}$

If the frequency doubles

$E_2 = h(2f) - \varphi$ $E_2 = 6\frac{hf}{3} - 2E$

$E_2 = 6E - 2E = 4E$

Calculations Using Previous Answers

Answers that rely on previous answers are becoming less common. Quite often the first part is a "show that", so you can always do part b.

If you can't answer part a, you can put any answer and will get "error carried forwards" in part b, potentially getting all the marks, PROVIDED there is not another way to do part b).

If you can answer part b without using your answer to a, then there is a chance you get no error carried forwards marks. If you can see another way to do it that doesn't need your first answer, use that method, just in case.

Example 6

An electric motor is used to launch gliders along a horizontal runway to reach a take-off speed of $32.5ms^{-1}$.

The glider has mass 655kg.

a) If the glider can reach take-off speed in 11.2 s, calculate the average power output of the motor.

b) The force delivered by the motor can be assumed to be constant. Calculate the magnitude of the force delivered by the motor.

Correct answer

a) Power = Work done by motor/time = $\frac{1}{2}mv^2/t = 1/2 \times 655 \times 32.5^2/11.2 = 30\,900W$

b) Power = Force × velocity (using average velocity from 0 to $32.5ms^{-1}$ *of* $16.25ms^{-1}$

Force = 30 900 ÷ 16.25 = 1900N

That is all fine. But what if you couldn't do part a?

You can't put any number as your answer to a, and use it in part b as there is another way to get answer b:

Force = Δmomentum/Δtime = (655×32.5)/11.2 = 1900N

Some mark schemes might give you some credit for an error carried forwards, but some would expect you to see the other way to do this and you would get no error-carried-forward mark.

General Principles

From these examples, some general principles emerge:

Approach to Calculations

1) Be clear about what the question is asking you to find.
2) Collect all the information from the question and write it down. Put it on a diagram if possible. Don't forget the 'hidden number' like start velocities being zero if you start at rest, or that the Earth´s period of rotation is 24 hours. Not all numbers are given in the question.
3) Make a note of any equations that come to mind and might help.
4) Write down the workings in stages, and show your workings clearly. Students try to cut corners with this. They make mistakes and lose marks. It also takes longer as they try to mentally keep track of what they've done. Don't bother. Write it down. Get it right. Move on.
5) Note down units for every number you know. Convert them to standard units at the start, unless you can clearly see the question doesn't need you to. That way it won't distract you half-way through the problem solving bit.
6) Underline numbers in lengthy text to make it easier to find when you look back.

Use the mark scheme

- Do the whole question before you look at the mark scheme, then check your answer. Don't look at it because you're stuck, to get tips.
- Look at typical breakdowns of marks on mark schemes. Pay attention to 'evidence of' or 'workings seen' or 'use of equation' to see what the examiner might allow - useful for questions you could start but maybe not finish. You know what things to try in order to hit a couple of method marks.
- ECF – error carried forwards, where you are allowed to use a previous answer even if incorrect.
- OWTTE – or words to that effect, allows marks for the correct idea. Look out for things <u>underlined</u> or in **bold** which means they need to be present to get a mark.

Use of R_T = 1/10+1/10+1/10	1	Allow 10/3
I = EMF/(R+r) or substitution	1	Correct answer scores 3
I=0.40A (2 sig figs)	1	Allow 0.396A

This tells us a correct answer automatically gets full marks without workings.

This is often but not always the case. If you don't show workings and get it wrong you get nothing. If you haven't written workings you are quite likely to get it wrong.

Know the Equations

- Don't rely on your formula book, not everything you need is in there.
- Know which equations are in the formula book and where they are. Always use them when practicing questions.
- Know the rules that apply to equations, for example:
  - You can get marked down for using equations in the wrong context even if the answer comes out correctly, or if you are asked to use a particular approach.
  - You can only use the equations of motion (suvat) for constant acceleration.
  - In "work done" calculations the force used must be in the direction travelled.
  - Vectors require positive or negative signs, based on direction.
  - Force and distance to pivot are perpendicular for moments.
  - Use the resultant force for F in Newton's 2nd Law equations: F=ma or F=Δp/Δt.
  - Use the accepted quantities, for instance, f is frequency while F is force.

Significant Figures

- Look at how many significant figures the information in the question is given to.
- Give your answer to the least number of significant figures you see.
- Remember that 0.8 to two significant figures is 0.80.
- Rounding errors are easily made, look out for them:
  - 0.8968 to two significant figures is 0.90
- You are often allowed one extra significant figure in your final answer.

Check your answers

- If it's complicated, do a simple version of the calculation to see if your answer is roughly as expected.
- Think logically how big or small the number should be. Does your answer match? Is it realistic?
- Does what you've done seem worth the number of marks available? If not you've possibly missed something (don't cross anything out unless you've already written a replacement!)

Check for typical mistakes:

- Converting units – make sure you spot where the question has units that need to be converted and you know how to convert between all prefixes.
- Remembering to convert units properly for areas and volumes (there are 100cm in a m, 100^2 cm^2 in $1m^2$ and 100^3 cm^3 in $1m^3$, apply that logic to any area or volume conversions).
- Rounding errors.
- Forgetting initial velocities, times or energies, etc. that need to be added to your answer.
- Not actually answering the full question after a calculation.
- Correct number of significant figures in an answer.
- Confusing diameter and radius.
- Incorrectly rearranging an equation.
- Calculator error – check you typed it in correctly and used brackets in the right places.

Practicing

What does practicing look like?

The main way to cut down on mistakes and get used to understanding exam questions is to practice. But what does this look like?

Just to be clear, it is **not** reading a text book or revision guide and highlighting key points (sorry if you thought this works. It doesn't. No matter how bright/colourful/scented your highlighters are).

- Print off your syllabus so you can tick off what you know and what you need to work on.
- Make a list of the equations (and symbols and units for quantities if you need it). This makes it easier to look them up and learn them until you don't need to look them up any more. Make sure you know what equations you are given in the exam.
- Do exam questions until you're sick of seeing them. Then you're really ready for the exam.

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