Common Errors

1. Writing = when you mean "roughly equals".
2. Writing a list of equations with nothing to show how they're logically related.
3. Writing = to mean logical equivalence.
4. Confusing f with $f(x)$.
5. Using letters without introducing them.
6. Missing out equals signs.
7. Not using enough brackets.
8. Bad cancellation.
9. Starting an argument by stating the conclusion.
10. Using "i.e." to mean "=".

These are explained on the following pages, one Common Error per page.

Here's the story. Soon after I started teaching first year undergraduates, I realized that they were making the same errors of logic and communication in their written work week after week. In the beginning, whenever I came across such a mistake in a student's work while I was marking it, I would write out a little explanation of what was wrong. But writing out the explanations took time, and inevitably they got shorter and more cryptic, and most of the time I ended up simply circling the mistake in red, which may not have been very helpful. My efforts didn't seem to be having much effect.

So I decided that radical steps were necessary. I compiled a list of the most common errors, wrote out an explanation of each, and spent some time at the photocopier. Every time a student committed one of the errors, I would write 'Common error no. 2' (or whatever) next to it and staple to their script a copy of my little explanation of what was wrong and how to do it right. This strategy seemed to work—there was an appreciable improvement in the quality of my students' arguments—at the price of making me feel like a traffic warden issuing parking tickets.

This also explains the bizarre formatting of this document.

Common Error No. 1: writing = when you mean "roughly equals". Is it true that $\pi = 3.14159$? No, so it's false—as false as the statement that $0 = 1$. If you want to say "roughly equals", use $\approx$.

(Moreover, there's no need to give a numerical approximation unless you're asked for one. If your final answer is $\frac{6e(e^2-1)}{3+\sqrt{29}}$, that's fine: leave it there. No need to mention that this is approximately 12.427; in maths we're usually interested in the exact, not the approximate.)

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Common Error No. 2: writing a list of equations with nothing to show how they're logically related. This is like writing a novel with no punctuation: the reader has a hard time and can only sometimes guess what you mean. Suppose, for instance, that you write

$$\begin{aligned} 7x &= 7\sqrt{2} \\ x &= \sqrt{2} \\ x^2 &= 2. \end{aligned}$$

Do you mean that these three statements are logically equivalent? Or that if the first is true then so is the second, and if the second is true then so is the third? Or some combination or variation?

A respectable version is

$$\begin{aligned} 7x &= 7\sqrt{2} \\ \text{i.e.} \quad x &= \sqrt{2} \\ \text{so} \quad x^2 &= 2. \end{aligned}$$

"I.e." means "that is", or "is logically equivalent to". (In other words, if $7x = 7\sqrt{2}$ then $x = \sqrt{2}$, and if $x = \sqrt{2}$ then $7x = 7\sqrt{2}$.) I've put "so" rather than "i.e." in the last line because although $x = \sqrt{2}$ implies $x^2 = 2$, the reverse is not true: think about what happens when x is $-\sqrt{2}$.

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Common Error No. 3: writing = to mean logical equivalence. Suppose you're asked to solve $7 = 2x - 3$. If you're bad, you might write

$$\begin{aligned} 7 &= 2x - 3 \\ = x &= 5. \end{aligned}$$

What you mean is that the statements "$7 = 2x - 3$" and "$x = 5$" are logically equivalent. But the problem is that you've written $7 = \ldots = \ldots = 5$, from which it follows that $7 = 5$: nonsense.

The remedy is simple. If you want to indicate equality of numbers or quantities, use =. If you want to indicate logical equivalence of statements, use "i.e." or "iff" ("if and only if"). In our example, the second = should be "i.e." or "iff".

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Common Error No. 4: confusing f with $f(x)$. Here f is a function (let's say a real-valued function of real numbers) and x is a number. A function is a machine that takes in one number as input and produces a new number as output; a number is just a number. f is a function; x and $f(x)$ are numbers. They're simply different kinds of animal. If you write "the graph of $f(x)$", that's as bad as writing "the graph of $6\frac{1}{2}$". If you write "$f = 2$", that's like writing "$\sin = 2$".

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Common Error No. 5: using letters without introducing them. If you want to use a letter that doesn't appear in the question, you must explain what you're using it to mean. Perhaps you, your schoolteachers and your lecturer are all in the habit of using m to mean the gradient of a straight line. But this isn't a universal convention, and your reader may have no idea what you mean by "m" unless you tell them. Just say "let m be the gradient".

Just about the only exceptions to this rule are π, e and i.

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$$\begin{aligned} &x^2 - (y^2 - 2) - 2 \\ &x^2 - y^2 \\ &(x - y)(x + y), \end{aligned}$$

you're probably meaning to say that these three expressions are equal—but you're not saying it. What you want to write is

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Common Error No. 8: bad cancellation. A particularly common form of this is

$$\frac{\not{a}+b}{\not{a}+c} = \frac{b}{c}.$$

This is nonsense: try taking $a = b = 1$ and $c = 2$, for instance.

When you see it this plainly, it's more obvious that it's nonsense, but people tend to make this mistake when they're in the middle of a long calculation and "a", "b" and "c" stand for more complicated expressions. If you find yourself wanting to make a cancellation and not knowing whether you're "allowed" to, stop for a moment and try to write down the general form of the rule you're hoping to use: is it really true, or is it something like $\frac{a+b}{a+c} = \frac{b}{c}$?

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Common Error No. 9: starting an argument by stating the conclusion. Suppose the question says: "Show that $(\sec\theta - \tan\theta)(\sec\theta + \tan\theta) = 1$." It's tempting to start your answer by writing down "$(\sec\theta - \tan\theta)(\sec\theta + \tan\theta) = 1$". Don't do it!

Remember that every one of your answers should be a coherent, logical argument. If your first line is "$(\sec\theta - \tan\theta)(\sec\theta + \tan\theta) = 1$", the reader's reaction will be "Really? Why?" You haven't proved it yet.

If you want to start by writing down the conclusion, do it like this: "*To be proved:* $(\sec\theta - \tan\theta)(\sec\theta + \tan\theta) = 1$".

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Common Error No. 10: using "i.e." to mean "=". It's good that you're trying to give your answer some logical structure, but this doesn't just mean writing "i.e." everywhere!

First, appreciate the difference between *statements* and *quantities*. A statement is something that can be true or false, such as "$123 < 321$" or "$x^2 - 3x + 1 = 0$". A quantity (or number) is something like "123" or "$x^2 - 3x + 1$".

Use "i.e." to say that two *statements* are *logically equivalent*.
Use "=" to say that two *quantities* are *equal*.

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