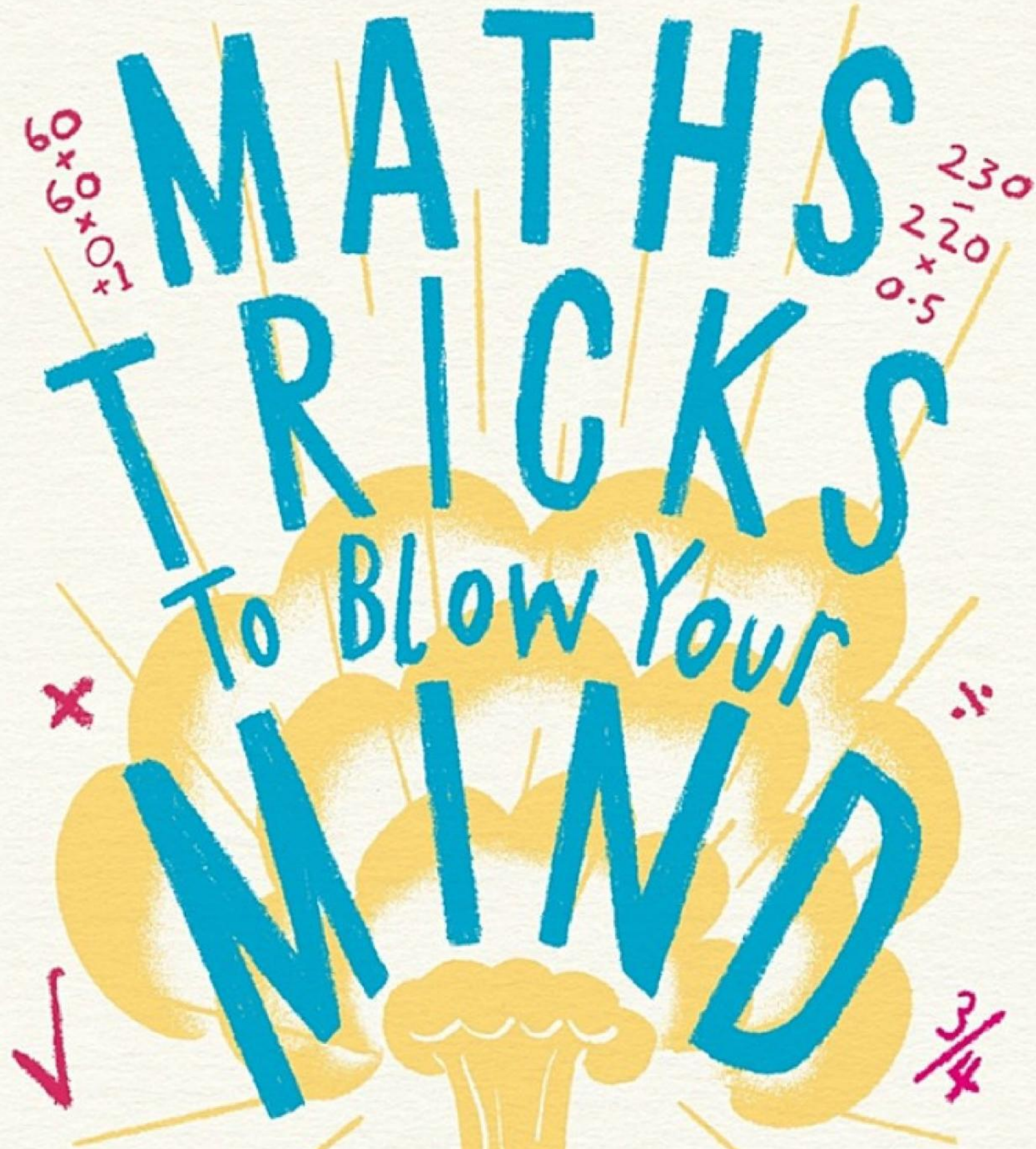
MATHS TRICKS TO BLOW YOUR MIND



A Journey Through Viral Maths

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For Edwin and Juno, and all the emergency homeschooling parents.

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INTRODUCTION

My smartphone lights up with the familiar red blob: I have a Facebook notification. I can see that it's from an old school friend I haven't seen for 20 years; they're probably just inviting all their contacts to 'like' their new business venture. Or, even worse, they could have found an old photo from the class of 2000, when my nickname was 'Spud' because my head looked like a potato. I'm definitely going to ignore it.

But… what's the worst that could happen? Hey, I'm a sucker for that dopamine hit, and, besides, I'm just sitting here doing nothing while my kids watch *Moana* for the third time today. What the hell, I'll have a look:

> Maths trick: A% of B = B% of A.
> So 8% of 25 is equal to 25% of 8.
> 25% of 8 = 2.
>
> Spud! You're into maths right? How did I never know this?!

Yes, I suppose it would be fair to say that I'm 'into maths', spending most of my working life teaching maths in a sixth-form college, then on weekends changing costume in a phone booth to perform live maths shows for children and adults. Yet the number of people I have ever taught or performed to pales in comparison to the number of people who engage with viral social media maths puzzles and 'life hacks' like the above.

It is quite amazing, isn't it? Did you know that 8% of 25 is the same as 25% of 8? I think of this as a wonderful example of the good side of 'viral' maths: something that everyone who's been through school can relate to, and is obvious once you've seen it, but the majority of people seem to go through their entire education without knowing about. What better use of social media? Raising the mathematical literacy of millions of people – who could be cynical about that?*

On the other hand, we have the dark side of viral maths: the provocative, binary choice strand of social media problems that are designed to provoke polarization and division (not that type):

> Let's see who's dumb.
>
> 60 + 60 × 0 + 1 = ?

```
1
61
121
```

This type of problem seems to be the most popular of all viral maths questions, probably because it is intentionally divisive. If we've learnt anything since the invention of the internet, it's that people just can't resist (virtually) screaming at any old stranger on the other side of the world who is naive enough to think that the answer is 1 when it's *obviously* 61!

Either way, I'm fascinated by what makes things go viral, and being a jack of all mathematical trades I'm especially interested in why certain maths problems take off while others flounder.

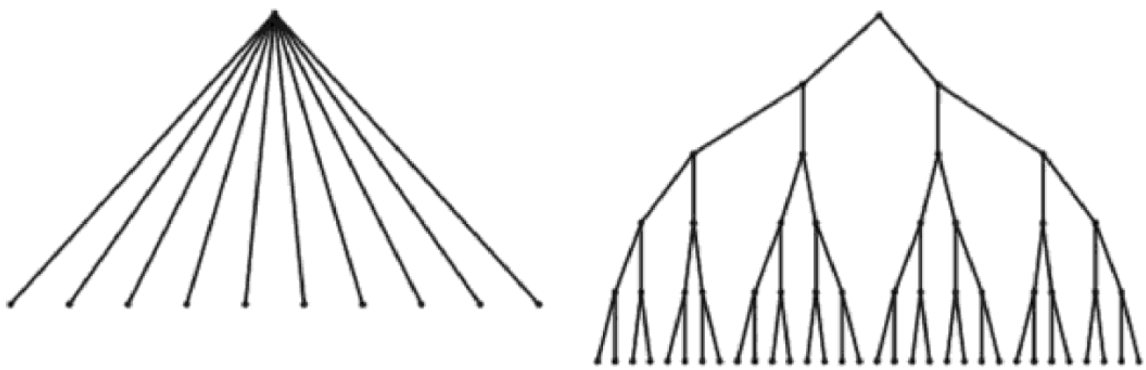
I feel it's important to mention up front that this is a book entirely about 'viral' social media maths, and absolutely in no way about the mathematics of virus transmission. There are many great books about that particular topic and I am barely fit to lace the boots of the good people working in this area. What exactly do we mean when we say something has 'gone viral' though? When did the language of viruses and epidemics start being used to describe popular videos, graphics or even just ideas?

Richard Dawkins is the godfather of the word 'meme', first using it in his 1976 bestseller *The Selfish Gene*, meaning an idea, behaviour or style that spreads from person to person within a culture.* But the online etymology dictionary actually dates the use of 'viral' outside of medicine even earlier, with Jeffrey Rayport of Harvard Business School first using the term 'viral marketing' in 1972. Scratch a little deeper (on Wikipedia) and you'll find the philosopher Marshall McLuhan describing technology as being 'virulent in nature' as far back as 1964. But despite this there can be no doubt that 'viral' has only really taken off as a term separate from actual diseases since the age of social media.

Interestingly, when I asked friends and family across various generations to name what they thought of as the all-time epitome of a viral video, tweet, image or meme, the most popular response to come back was the 'Ellen Oscars selfie'. This was a photograph taken by the television presenter Ellen DeGeneres at the 2014 Oscars, featuring A-listers such as Brad Pitt, Julia Roberts, Meryl Streep, Lupita Nyong'o and, fantastically, Lupita's opportunistic non-acting plus-one, her brother Peter. This image was for some time the most retweeted post in Twitter history, though it has since been surpassed by four tweets: two by Japanese billionaire Yusaku Maezawa in which he promised to give away vast sums of money to retweeters, one commemorating the passing of the actor Chadwick Boseman, and one by an American teenager begging the fast-food outlet Wendy's for free chicken nuggets. That was not a paragraph I ever expected I'd type.

Crucially though, I would *not* classify any of the above as truly viral in nature, other than perhaps Carter Wilkerson, the nuggets guy. All the others were broadcast by accounts with an extremely high following, from which almost all shares directly followed. Wilkerson's plea for free 'nuggs', on the other hand, picked up gradual momentum over the course of a month as more and more people saw the humorous story – the David vs Goliath angle of a man attempting to achieve a truly impossible goal* – and began to talk about the story and share it. That's what we all mean by a virus, isn't it? Something that starts slowly and builds remarkably quickly due to fertile conditions for spreading. I'm no epidemiologist, but I don't think there has ever been a biological virus that started by being transmitted simultaneously to millions of people from the same one original source. Admittedly most of my knowledge in this area comes from watching the 2011 movie *Contagion* repeatedly, but I still think I'm correct on that one.

We could consider everything that goes viral on the internet to be on a scale of *structural virality*,[†] where at one end you have 'broadcast' 2016. posts such as the Ellen selfie, where the original poster is linked to people who have seen it largely by one direct link (as in the image on the left). At the other end of the scale (see the image on the right) you have the kind of post that I'll be dealing with in this book: posts that start from a modest source but spread rapidly from person to person, via shares, comments or even word of mouth. Think of recent viral sensations such as the dress that was either white and gold or blue and black, or the sound clip that is either 'Brainstorm' or 'Green Needle'.[*] Their contentious nature made people want to share them and find out what other people thought, and this naturally drives virality.



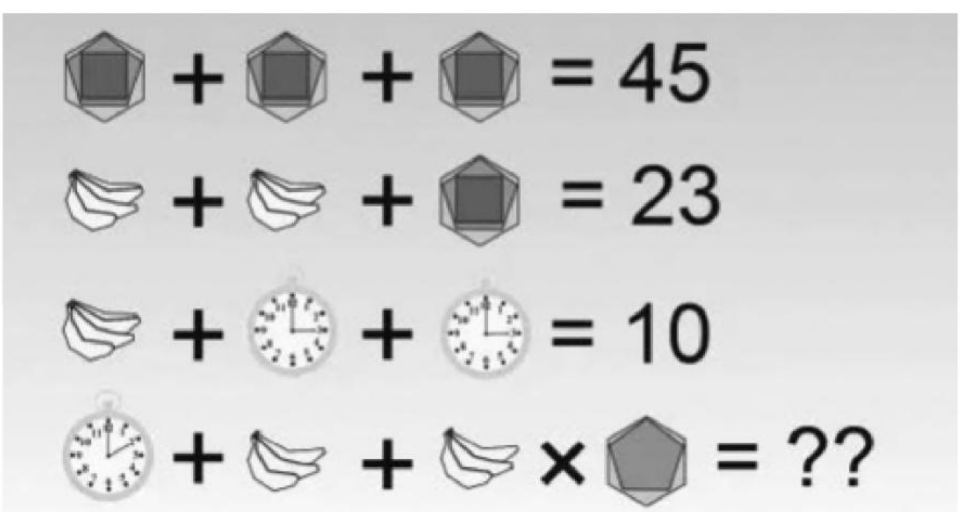
Two forms of structural virality

Source: Goel et al., 'The structural virality of online diffusion'

My own personal experience of going viral is somewhat limited, my most popular tweet being a picture of a quarter piece of cheese from Boxing Day 2018 that just happened to cost £π and weigh π-hundred grams. More than 2000 people 'liked' this post, which may say less about the hilarity of my visual humour and more about how bored the general public are after Boxing Day dinner. Either way, I can't deny how seductive the thrill was of knowing that every five minutes when I checked my phone I'd have another glut of notifications. 'What shall I tweet about next?' I thought. What other hilarious visual trigonometry puns might I have up my sleeve? Alas, like catching lightning in a bottle, it seems the audience for cheese-based maths gags had peaked, and my next attempt at Twitter humour was greeted by my usual three likes and one retweet.

(I'm aware, by the way, that not every reader might understand the cheese joke, and also that the only thing less appealing than having a joke explained is having maths explained and a joke explained simultaneously. For this reason the explanation of the cheese gag can be found at the back of the book, as can the solutions to any maths puzzles in the book that are beyond GCSE level understanding, or are just too long or fiddly that they would disrupt the flow.)

If I really wanted to gain more traction on social media, one quick way might be to regularly drop emoji equation problems like the following:



(Source unknown)

You'll have seen this kind of thing before, undoubtedly accompanied by a glut of people fighting tooth and nail over the solution. I'm endlessly fascinated that we live in a world where millions of people wear their lack of mathematical ability as a perverse badge of honour, while the same people paradoxically delight in hurling abuse at any *idiot* who would have the temerity to disagree with what they think the answer is.

As a borderline millennial I've lived both with and without the internet, first having access to the 'worldwide web' at that transformative age of 16. The whole world of information at my fingertips! Oh the possibilities! Little did I know that in 20 years I'd be scrolling through endless examples of my auntie arguing about banana emojis with a 14-year-old Texan and calling me in for back-up.

In this book I'll present 55 notable cases of viral mathematics: from maths life hacks to Facebook fruit problems, fiendish exam questions to pre-internet playground classics. The solutions to most puzzles will directly follow the question, so to avoid spoilers you might want to put the book down at regular intervals while you work out the answers for yourself. There are some blank pages at the back to save you from scribbling on receipts, bank statements or your child's latest school report. There are also some maths tricks and 'life hacks' that I will explain the workings of; again, if you are desperate not to have the magic explained but to work it out yourself, please put the book to one side or skip forward to the next section. I won't be offended – I don't know you!*

If the emoji equations above elicited a queasy feeling in your stomach, fear not: I promise there will be many moments of sublime logical illumination to sweeten the pill. If you're a real puzzle enthusiast, or just extremely online, you'll have seen lots of these puzzles before, but I hope that even the most hardened puzzler will find a few new gems here. Very few of them come from my own imagination, and I've tried my hardest to credit the puzzle creator in all cases where they deserve it. In some cases, where the puzzle is completely derivative or has no redeeming features at all, I have made no such effort.

If, after all this, we're still no closer to discovering *why* some maths goes viral, at least we will have had fun trying.

Now, without further ado, let me lead the way. These maths tricks will *blow your mind!*

* Inevitably, many people can be cynical about that: more in Chapter 1.
* It's somewhat unfortunate that Dawkins, having practically created the idea of memes and virality, now writes some of the most tone-deaf, coldest takes in all of social media.
* Wilkerson asked Wendy's how many retweets he needed to achieve for a year of free nuggets, and the reply from Wendy's was '18 million'. For context, the Ellen selfie is currently on around 3 million retweets; nothing has ever surpassed 5 million. Wendy's caved in and gave him the year's supply when he got past 3 million though.

† Goel et al., 'The structural virality of online diffusion', *Management Science*, Vol. 62,

* I regret bringing up these two viral phenomena so early in the book, as any reader who has never heard of them is bound to go and look them up and be so gobsmacked they don't come back. Please do come back!
* Unless I do, in which case: hello!

1

THIS ONE COOL MATHS TRICK WILL BLOW YOUR MIND

Maths tricks and ‘life hacks’

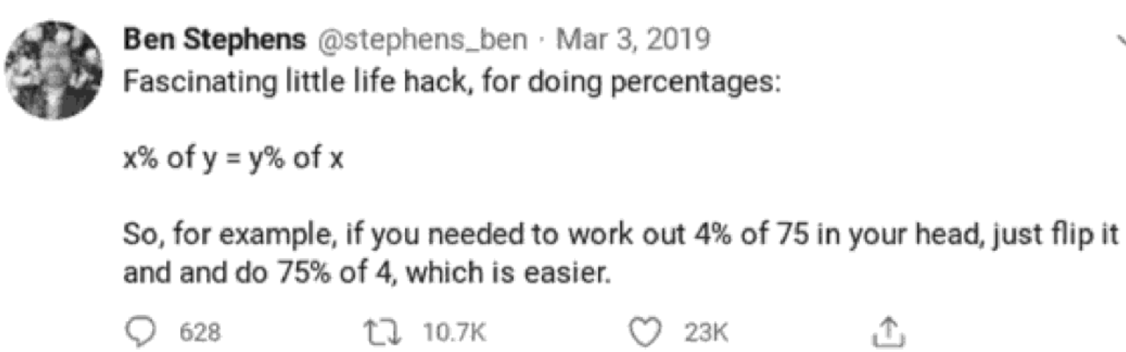
#1
Calculate 4% of 75.

Some of the most satisfying maths ‘tricks’ can be those that were under our noses for years and years but that we never noticed. Recently I was starting a lesson with an A-level maths class when one of my 17-yearold students entered, marched to the front of the room, picked up a whiteboard pen and proudly wrote in huge letters on the board:

4% of 75 is 75% of 4

The student then charismatically replaced the whiteboard pen lid (just about resisting the urge to drop the pen to the floor in the time-honoured ‘mic drop’ style) before turning to face the room to revel in the adulation of his peers. Well, half of his peers. Half of the class were as mind-blown as he was – and, perhaps, you were? – whereas the other half remained thoroughly nonplussed. They’d realized the truth of this little mathematical nugget years ago.

This, of course, is the trick mentioned in the introduction, and every few months something like this bubbles up on Facebook or Twitter, with varying levels of virality. Here is the example from 2019 that my student had seen, garnering tens of thousands of likes and retweets on Twitter:


Ben Stephens @stephens_ben · Mar 3, 2019
Fascinating little life hack, for doing percentages:

x% of y = y% of x

So, for example, if you needed to work out 4% of 75 in your head, just flip it and and do 75% of 4, which is easier.

628 10.7K 23K

Here are some suitably stunned replies:

This just broke my brain.

I used to teach maths for reporters and wish I'd had this explanation in my back pocket. I had other tricks for mathsphobes but this is far more elegant.

You have won Twitter today, Mr Stephens!

And here are some people who have no room for joy in their life:

Seriously? All you're saying is 3 × 2 = 6. As does 2 × 3. Do you really think people don't understand such a simple concept enough to know this? Good grief.

Why is this news? This is called 'propiedad conmutativa' (Commutative property) in spanish and it's taught in elementary school. Millennials discover... .

More about that '*propiedad conmutativa'* later. Let's break it down a little bit and first check that the trick definitely does work, before getting into why it works.

75% of 4

A fundamental of working with percentages is knowing their equivalent fractions and ratios: 75% is simply three-quarters, so we can very quickly see that three-quarters of 4 is **3**.

4% of 75

This is a little harder to calculate (without knowing the trick!), since 4% is not a 'nice easy' fraction. A method schoolchildren might be shown is to use 10% and 1% as starting points, using the fact that 10% of a number is ten times smaller than the original number, and 1% is ten times smaller again. In this case:

100%	of 75 = 75
10%	of 75 = 7.5
1%	of 75 = 0.75

To find 4% of 75 from here, we can put together four lots of 1%, i.e. 4 lots of 0.75 is **3**.

So if faced with the need to calculate 4% of 75, it's much easier to swap and calculate 75% of 4 instead. Don't fancy calculating 42% of 10? No problem – do 10% of 42 instead, much easier! It even works for percentages above 100. Try finding 25% of 400 – easy, right? A quarter of 400 is obviously 100. Our method says this should be the same as 400% of 25, and of course it is: 400% of 25 simply means four lots of 25: also 100. Calculations like this take us a little closer to the 'why', more of which shortly.

Try it yourself

(a) 73% of 10

(b) 12% of 25
(c) 16% of 75
(d) 44% of 5
(e) 13% of 25

I find this little mathematical trick very satisfying, not least because I still remember working it out for myself in maths class and peering around the class to see if anyone else had cottoned on. They hadn't! It seemed that only I knew this incredible secret – I'm not even sure if the teacher knew!

By the way, I don't claim to be some great genius in working the trick out for myself. Many a greater mathematician than I have gone much of their adult life without knowing this trick: in writing this book I surveyed my army of followers on social media to find out how many knew about this trick. Although they're probably slightly more maths-savvy than the average social media user, the results still showed nearly half who did *not* know that 4% of 75 was equal to 75% of 4:

Learnt it in school: 16.4%
Learnt it from social media: 25.2%
Learnt it from somewhere else: 15%
Did not know: 43.5%*

So if you had your mind blown by this, you're in good company. It was interesting that in the comments many teachers stated that they didn't know this until they began teaching, much as many people express dismay that they were never taught this in school. Now you know why: your teachers didn't know either! But that's fine; every day's a school day (especially if you work in a school). Let's zoom in a little closer to the detail of exactly *why* this works. In all of the above calculations I've shown how to find percentages of amounts using mental methods, as you would if you didn't have a calculator at hand.

Many countries – possibly most countries – implement systems where tax is added to the value of goods purchased at the point of payment. In England, where I live, this form of tax is usually applied to goods before the customer sees the price, but there are a few warehouse-style shops where VAT (value added tax) is not shown on shelf pricing, so that customers must work it out for themselves if they want to be prepared for how much they're really paying.

I still vividly remember accompanying my parents to such a shop as a child, where 'bulk buy' items were displayed without VAT, and being shown how to calculate the new price including VAT (which at the time was 17.5%) in my head. For example:

Price without VAT:	£40
10%:	£4 ('shift to the right', as we saw above)
5%:	£2 (halve it)
2.5%:	£1 (halve it again)
Price with VAT:	£40 + £4 + £2 + £1 = £47

However, in January 2011 the standard rate of VAT was changed to 20%, which it has remained since: a tragedy for maths teachers. Working out 17.5% was such a cool method: 10%, then halve it, then halve it again; in comparison, calculating 20% is a real bore. I don't know a lot about the economy, but I'd be very much in favour of seeing the 17.5% rate come back, if only to make maths lessons (even) more interesting.

Mental arithmetic is a fantastic and under-appreciated skill, but *not* using a mental shortcut actually makes it easier to see under the bonnet here. One of the ways I found 4% of 75 earlier was to find 1% of 75, and then multiply this by 4. To put it another way:

$$\frac{75}{100} \times 4 = 3$$

Similarly, I could have found 75% of 4 by finding 1% of 4, and then multiplying that by 75. This is far from the best way to do it in your head, but mathematically it works just fine:

$$\frac{4}{100} \times 75 = 3$$

Now let's put those two calculations side by side:

$$\frac{75}{100} \times 4 = 3 \qquad \frac{4}{100} \times 75 = 3$$

Notice that both calculations involve multiplying 4 by 75, and dividing by 100. All that's different is the order in which the operations are carried out. Now, strictly speaking, division is the same thing as multiplication anyway: for example, multiplying by 2 is the same as dividing by a half.*

Since division is really multiplication in disguise, we can think of our 'trick' as two multiplications, rather than a multiplication and a division. All we need now consider is: does it matter what order we multiply in? Are three 2s the same as two 3s? Of course they are the same: this is a fundamental building block of mathematics known as *commutativity* (as seen in the smug tweet earlier). Note that not all mathematical operations have the commutative property: for example, 5 minus 2 is *not* the same as 2 minus 5, so subtraction is not commutative (nor is division).*

Since multiplication is commutative, 4% of 75 and 75% of 4 are simply asking you to carry out two multiplication operations in a different order, so by definition the outcomes will be the same.

If this trick was new to you before reading this chapter, it's probably because you're proficient in calculating percentage shortcuts in your head. It's only when you lay the calculations out in seemingly unnecessary detail that the 'magic' in the trick is revealed.

#2

Think of a whole number from 1 to 9.

Multiply it by 3.

Add 3.

Multiply by 3 again.

Add the two digits of your number together.