

Alice and Bob

Alice and Bob were deeply in love. They were first-year students at university and they fell in love in the front row of the algebra lectures. It wasn't love at first sight—it began as a competition to see who could answer the professor's questions quickest. You see, the professor had a habit of asking the students how they thought the algebra would go, before telling them how *she* thought it should go. Most of the students thought these were rhetorical questions, but not Alice and Bob. More often than not, one or other of them answered the question. And more often than not, they were right.

After a while, they found that they were no longer trying to impress the professor: they were trying to impress each other. And I don't think either Alice or Bob could tell you when they first realised this competition had turned into flirting. Perhaps it was when the professor asked “What is 5 times 7 modulo 12?” and Alice answered, quick as a flash, “Coffee time!” The whole class erupted into laughter, but you can be fairly sure most of them had not understood the joke. (At the risk of patronising most of my readers, let me explain that arithmetic modulo 12 is just what a clock does—so that $5 \times 7 = 35 = 12 + 12 + 11$ and 35 o'clock is the same as 11 o'clock tomorrow.) Bob took advantage of the diversion to invite Alice for coffee in the Students' Union after the lecture, and Alice, mightily pleased with her joke, forgot to say no. I mean, she forgot that she didn't drink coffee.

But when Bob put a frothing paper cup of capuccino in front of her she accepted the challenge to try something new. The warm rich liquid was a revelation to her, and she fell in love with it straight away. “Where have you been all my life?” she apostrophised the coffee. I think Bob thought she was talking to him, and he blushed while trying unsuccessfully to think of a suitable answer. That didn't matter to Alice, who was in a world of her own with her first capuccino. It was an almost sexual experience, and she did not want to be interrupted. So Bob just sat there, having finished his double

espresso, in a state of extreme nervousness, made worse by the caffeine hit, considering and rejecting a thousand conversational gambits in a row.

Still, Alice seemed to be enjoying herself, judging by the smile on her face, and the faraway look in her eyes, so he reasoned he couldn't have done everything wrong. Then she stood up and said "That was lovely, Bob. Let's do the same again tomorrow." And that was it.

Bob spent the rest of the day day-dreaming about the encounter and wondering what it meant. On the one hand she'd asked him where he'd been all her life; on the other, she rushed off as soon as she'd finished her coffee. On the one hand she'd suggested a second date; but on the other she'd hardly said a word to him on the first. In the end, he gave up, and put it down to the unfathomable nature of women. He went back to studying mathematics. At least you knew where you were with mathematics. It was either right or wrong. No room for contradictory signals there.

I am sure you can imagine how Alice and Bob's affair got going after that. They met for coffee every day at 11 (except when they had a lecture) and gradually got talking, about mathematics, about themselves, about their friends, about each other, and ultimately about everything under the sun and quite a few things above it. So, to cut a long story short, by the end of their first year they were practically inseparable, and everybody knew they were an item.

Not that everyone was happy for them, by any means. A couple like that evokes plenty of jealousy in the hearts of those whose search for love has been less successful. Take Eve, for example. She had a secret crush on Bob and was insanely jealous of Alice. She was one of those students who used to sit in the middle of the lecture room, trying to look inconspicuous, copying down the notes off the blackboard diligently, but never daring to answer any of the professors' questions in any of her lectures. That is why she admired Bob, who always seemed to know the answers, and was not afraid to speak out. Actually, Eve knew most of the answers too, but she was too shy or lacking in confidence to show it. Over the weeks, she started moving further forward in the class, until she would sit in the second or third row, behind and a little to one side of Bob.

From this vantage point she tried to eavesdrop on Alice and Bob. But of course Alice and Bob didn't talk during lectures—they were far too polite for that—so Eve didn't get much that way! Then Eve noticed that they were passing notes to each other. And she desperately wanted to read these notes. When she looked over Bob's shoulder she thought they must be written in a

foreign language. She couldn't read any of them. After the lecture she found one of these notes screwed up on the floor. It said

JPJJFUFYLF~~AVM~~MVBWHKVIEXFAAVKRUBAVMSPKBSPYFOESH~~PV~~WRAFJRJH

Well, that didn't make much sense, did it? There were a few words in it: 'RUB' appears about half way through, and then 'SPY FOES'. That was worrying—had Alice or Bob noticed she was trying to listen to their conversations? But if so, what did the rest of the message mean? Perhaps it was just a coincidence that these words appeared? Eve looked for some more clues in the message. She spotted AVM occurring twice—perhaps that could be a common word like 'the' or 'and'?

Eve jumped to the conclusion that it was a substitution cipher, with each letter standing for a different letter of the alphabet. To test her assumption, she counted the numbers of each of the letters. F and V were the most common, with 6 occurrences each, followed by A and J with 5, and P with four. M only occurred three times, as did B, G, K, R, and S. Since e is the most common letter in English by far, and t is the next most common, she guessed that AVM was more likely to stand for 'and' than 'the'. She tried this out, writing small letters for the ones she'd guessed, and capital letters for the ones still in code.

JPJJFUFYLF~~andnd~~BWHKnIEXFaanKRUBandSPKBSPYFOESH~~Pn~~WRaFJRJH

Well that didn't look very promising, what with the 'ndnd' and the 'aan', so she tried 'the' instead.

JPJJFUFYLF~~thehe~~BWHKhIEXF~~tth~~KRUB~~the~~SPKBSPYFOESH~~Ph~~WR~~t~~FJRJH

Now F~~tth~~K suggested that F and K were both vowels, most likely a, i, or o. Or maybe F was n? She tried F=a and K=i, which she thought was the most likely option.

JPJJ~~Ja~~UaY~~Lathehe~~BWHKhIEX~~atthi~~RUB~~the~~SPiBSPYaOESH~~Ph~~WR~~ta~~JRJH

On second thoughts, that doesn't look too good.

Then Eve had a brainwave: the pattern of the first five letters JPJJF was the same as 'Bobby'! What if Alice was writing Bobby's name at the beginning of the message?!

bobbyUyY~~Lythehe~~BWHKhIEXy~~tth~~KRUB~~the~~SPKBSPYyOESH~~oh~~WR~~ty~~RbH

Now look at the end of the message: ybRbH. That must say ‘babe’ so R=a and H=e. But that contradicts M=e. So maybe H=y? But then that contradicts F=y! So let’s try F=i instead:

bobbiUiYLithMhMBWHKhIEXitthKaUBtheMSPKBSPYioESyPhWatibaby

Now it was becoming clear—obviously it should say ‘alibaby’ at the end, and maybe ‘bobbikins’ at the beginning? So A is not t after all, it’s l. And U=k, Y=n, L=s. Here we go:

bobbikinsilVMVBWHKVIEXillVKakBlVMSPKBSPniOESyPVWalibaby

Now what is the beginning of the message? ‘ilVMVM’. You’d think it would say ‘I love you’ but that doesn’t fit. Eve however knew better. The correct spelling was obviously ‘I luv u’ which fits perfectly. How’s that?!

bobbikinsiluvuvBWyKuIEXilluKakBluvSPKBSPniOESyPuWalibaby

So we carry on with ‘vBWYKuIEXillu’. Surely this starts ‘very much’, so B=e, W=r, K=m, I=c, E=h, and the message reads

bobbikinsiluvuverymuchXillumakeluvSPmeSPniOhSyPuralibaby

And now Eve could read the whole message:

bobbikinsiluvuverymuchwillumakeluvtometonightyouralibaby

Of course Eve felt a great deal of satisfaction at having worked out what Alice’s supposedly secret message said, but she also felt really sick at the thought of Alice and Bob making love.

But what could she do about it? She brooded for a long time and thought up all sorts of devious plans for trying to split Alice and Bob up. She read lots of Alice and Bob’s messages: once she knew that they were likely to start and end with Alibaby or Bobbikins, it was a piece of cake, even though Alice and Bob changed their alphabetic substitution almost every day. Before long she knew more than was healthy about Alice and Bob’s love life, and she began turning up in all the places where Alice and Bob had agreed to go on their dates. Two or three times you could call a coincidence, but every day for a week—that was spooky. Alice and Bob got suspicious. They guessed that Eve had somehow managed to read their secret messages.

They decided to change their method of encoding their messages. Suddenly Eve couldn’t read them any more, and Alice and Bob had a bit of

privacy once in a while. In the meantime, Eve had got friendly with Fred, who also used to sit in the second row behind Alice and Bob. It seemed that Fred had a crush on Alice just as Eve had a crush on Bob. So maybe they could join forces to split up Alice and Bob, and both be winners! But how? First they had to break Alice and Bob's new method of encryption. Here is a message that Bob sent to Alice:

LZDFLPTQPCOQPWIXSSMIOZDSYOOITUCXZQGSNYSBILSFZPWC

Eve was pretty sure it wasn't a substitution cipher, because the letter patterns didn't look right, and Alice and Bob seemed to have stopped using substitution ciphers after they realised their messages were being read. Fred thought it might be a Vigenère cipher so they worked on that assumption for a while. If you don't know what a Vigenère cipher is, read on, and all will be revealed in due course.

Eve and Fred spotted the pair ZD occurring twice, one of them shifted 20 places on from the other one. They also spotted QP, one shifted 4 places from the other. So they guessed the keyword had just 4 letters (because this was the largest number which divides exactly into both 20 and 4). So the first two 'L's both encrypt the same letter—consistent with the possibility that Bob has started his message with 'Alibaby'. So Eve and Fred write down the coded message and the guessed plain message, together, like this:

ALIBABY

LZDFLPTQPCOQ...

and they count how many letters there are between the letters in the first row and the letters in the second: from A to L inclusive is 12 letters; from L to Z is 15; from I to D we have to count up to Z and then start again from A to D, making 22 altogether. And so on.

A	L	I	B	A	B	Y
12	15	22	5	12	15	22
L	Z	D	F	L	P	T

Aha! Do you see the pattern? Fred certainly did and so he repeated the pattern 12, 15, 22, 5, over and over again. Then he counted backwards through the alphabet to reconstruct the message, which came out as

ALIBABYMEETMEINTHEREDLIONATEIGHTOCCLOCKXXXXXBOBBY

So they hatched their plan. They'd write a message to Bob, apparently from Alice, changing the plan to meeting in the White Horse instead. So Bob would go to the White Horse, thinking Alice would meet him there, while Alice would go to the Red Lion, thinking Bob would meet her there. Meanwhile, Eve could go to the White Horse to meet Bob on his own, and Fred could go to the Red Lion to meet up with Alice. Seemed like a foolproof plan. So Fred forged the message

MCWFJRVVWIKYCOXSSMIOZDSYHCHVDPVJVDSKPPONIILSEWWEMM

and promised to deliver it to Bob in good time.

Fred knocked on Bob's door, and gave him the piece of paper, saying it was a secret message from Alice, who had a late class so she could not come herself. Bob took the message and deciphered it, and then asked Fred to tell Alice, yes, that would be OK. Fred agreed to do that, but of course you know as well as I do that he did nothing of the kind.

So eight o'clock came, and where do you think everybody was? Well, Eve was in the White Horse waiting for Bob, as you'd expect. She was anxiously watching the door to see when he came in. After a few minutes the door opened, and in walked Alice. What?! How did Alice know Bob was coming here instead of going to the Red Lion? Her mind worked feverishly to work out what had gone wrong with her plan. "Dirty, rotten, double-crossing bastard!" she said aloud—meaning Fred, of course. Fortunately the music was loud enough so that Alice could not hear her. She downed her double vodka and orange and sat quietly seething in the corner, trying to keep out of sight of Alice.

Where was Bob, anyway? He should have been here ages ago. And where was Fred? Fred was supposed to be meeting Alice, so was Fred on his way to the White Horse also? And had he failed to deliver the message to Bob, so that Bob went to the Red Lion after all? Eve was in a quandary. Should she go to the Red Lion, where she now thought Bob would be sitting on his own? Or should she wait in the White Horse for Fred, where he would soon come to meet Alice, and give him a piece of her mind?

Fred, of course, had no intention of going anywhere near where he thought Eve might be, so he wasn't going to go to either the White Horse or the Red Lion. He was at the bar in the Jolly Roger, well into his second pint of bitter, by the time Bob turned up. Bob looked around for Alice, and when he didn't see her, he bought himself a pint of bitter, and stood at the bar waiting. He nodded to Fred. Fred enquired, "Date with Alice?" Bob nodded. "Bloody

women, always late,” said Fred. Bob agreed, although he’d been quite late himself.

They fell into conversation, mostly on the subject of the fickleness of women, while Bob kept a wary eye on the door. Several people came in, one or two left, but no sign of Alice. Fred emptied his glass, and offered Bob another beer. Bob accepted, and they sat at a table where he could still see the door, and carried on talking.

We know, and Fred knew, that Alice wasn’t going to turn up, because she was expecting Bob to meet her in the White Horse. But since Bob wasn’t there, she bought herself a drink, and sat down. After a while she spotted Eve in the opposite corner of the pub, and began to smell a rat. Eve noticed that Alice had seen her, so she hurriedly got up and left. She headed for the Red Lion, where she thought Bob would be. Now it was Alice’s turn to try and work out what was going on. It didn’t take her long to realise that the message she thought had come from Bob, re-arranging their date for the White Horse, must have actually come from Eve. So Bob was in the Red Lion, and Eve was going to meet him there, having first checked that Alice had been fooled by the message Eve had sent.

Right! That did it. She downed her drink in one gulp and stormed out of the pub, making a beeline for the Red Lion. Her poor darling Bobbikins was innocent, but Eve the scheming bitch was going to pay for this. Or was Bobby so innocent? Perhaps he really had written the message, so he could go out with Eve? After all, how did Eve know the secret to the code, unless Bob had told her? Perhaps she should give them both a good talking-to.

We know of course what she found in the Red Lion. No Bobby. But also no Eve. That made her even more furious, especially as she now had no-one to vent her anger on. And she didn’t know where to look next for Bobby. Or for Eve. Eve couldn’t have gone far. She didn’t have much of a head start. But let us leave this little cat-and-mouse game to play out for a while while we catch up on the scene in the Jolly Roger.

Bob and Fred had had quite a few drinks by this time, and had become very friendly. They had progressed to the philosophical stage of damning the entire female half of the human race, and professing the brotherhood of man, or men. Little matter that this brotherhood seemed to consist of little more than drinking beer and slapping each other on the back. Until, that is, the question came up as to what they would do for sex if there were no girls around. Fred said to Bob, “No problem! We can do it with each other!” Bob admitted he hadn’t thought of that.

Alice's search for Eve had been unsuccessful, so she retired to the Red Lion to lick her wounds over a pint of lager, as the chase had made her very thirsty. "YOU!" she screamed, as she caught sight of Eve at a corner table. Eve put her hands up and said quickly "It wasn't me! It was Fred!"

"This had better be good," said Alice, "or you're not going to live to tell the tale."

So Eve began to tell the story, slightly edited from the true version that I've been telling you. When I say slightly edited, what I mean is, it was completely unrecognisable. According to Eve, Fred had been reading Alice and Bob's messages, and once he had figured out the code he thought it would be fun to forge some coded messages and see what he could get Alice and Bob to do. So he forged a message from Bob to Alice telling her to meet him in the White Horse instead of the Red Lion. And then he had sent Eve along to the White Horse to see if the deception had worked. At the same time he had forged a message from Alice to Bob telling him to meet her in the Sly Fox, and he would go there himself to see if Bob had been fooled also.

And clearly they had both been fooled. Alice had gone to the White Horse, and Bob was not in the Red Lion. Alice was all for going straight to the Sly Fox to meet Bob. And to confront Fred. Eve was worried for a moment that if Alice went to the Sly Fox, and found neither Bob nor Fred there, she would discover that Eve had duped her, and all hell would break loose again. So she pointed out that Bob and Fred were unlikely to be still there after all this time—"after all, we're not still in the White Horse, are we?"

Alice saw the reason in that, and they decided to stay in the Red Lion for another drink. Alice was mollified: she was no longer angry with Eve, she was angry with Fred, and cursed him roundly. She cursed Bob, too: why had he been fooled by such an obvious deception? (She conveniently forgot that she had also been fooled by a similar deception.) In fact, the whole good-for-nothing male half of the human race could go to hell as far as she was concerned. And Eve whole-heartedly agreed. They had another drink. And another.

Anyway, let us leave the girls getting drunk in the Red Lion, and the boys getting drunk in the Jolly Roger, and catch up with them the next morning.

Actually, none of them was seen the next morning. Around one o'clock in the afternoon, Eve was seen sneaking out of Alice's room, and an hour or so later Bob emerged from Fred's room. We do not know what had been

happening in the meantime, but we do know that in their second year, Bob sat next to Fred at one end of the front row, and Alice sat next to Eve at the other end. And there were no more coded messages between Alice and Bob.