Reprinted from

**SCHOOL SCIENCE REVIEW**

(A journal of the Association for Science Education)

Science notes SSR, Jun 1989, **70 (253)**

# Relativity is kids' stuff

## A `Noddy's Guide' to Special Relativity (with apologies to Enid Blyton)

N Vivian Pope

Noddy and Big Ears in Noddy's bright new yellow boat, were sailing steadily north across an east-flowing tide. Now quite grown-up and with nothing strenuous to do, Noddy was waxing philosophical. 'I wonder, Big Ears', he asked, after gazing abstractedly into the water, 'Can you explain to me Einstein's theory of relativity?'

'That's easy!' replied Big Ears sitting at the tiller. (Noddy had been surprised at how much wiser Big Ears had become as he, Noddy, had grown older). 'Here is a chance to practise your A-level geometry, Noddy. In the last hour we have been sailing some miles north while the tide has taken us some miles east. Let's say we know those two distances. How would you calculate the number of miles covered altogether?'

Noddy was keen to exercise his new knowledge. 'Let's see' he said, 'If we draw the distance the tide takes us east, call it *t*, across the page like this... and our sailing-distance north, *s*, up the page like this... and then join the endpoint and starting point... like so... then we have a right-angled triangle!' And Figure 1 is the triangle Noddy drew.

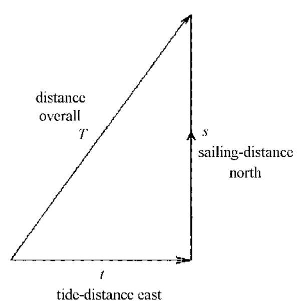


Figure 1 The triangle Noddy drew

'There!' he exclaimed, 'The total distance *T* is given by the hypotenuse of this right-angled triangle.'

'Indeed it is!' cried Big Ears. 'And what formula do you use for expressing that total distance?'

Noddy thought for a moment and then, on his drawing he wrote the Theorem of Pythagoras:

$$T = \sqrt{(t^2 + s^2)} \qquad (1)$$

'There!' he said, 'that's easy!'; and then, after a pause, 'But what's that got to with relativity?'

'Well, now; said Big Ears, 'if you know Pythagoras' Theorem then you know all that's necessary to understand relativity. All you need, apart from that, is a little imagination. Imagine that the tide in your drawing is "the river of time" and that your up-down dimension is distance in astronomical space. This makes *t* in your drawing a measure of time and *s* any distance travelled in space – by a space-ship, say.

'Now astronomers, as you know, measure space in light-years, which is a measure of time. So with your up-down dimension measured in years and your across-dimension measured also in years your triangle becomes a geometrical time-triangle, with all its sides measured in years. Your formula now expresses the hypotenuse-time *T* to which the base-time *t* is stretched. In relativity this is called time-dilation. And that, in a nutshell, is relativity theory.'

'Is that all it is?' asked Noddy, surprised.

'Basically, yes; Big Ears replied. 'In the same way that our sailing-course is stretched by the components of wind and tide, this shows how the "time drift" of a body is stretched when it travels in space .

'But I thought relativity was supposed to be highly mathematical and very difficult to understand,' said Noddy. 'That's easy! So why is it thought to be so difficult?'

'Ah; said Big Ears, looking very wise, 'That's different. It is because the way it was discovered was so complicated that it took the mind of a genius to work it out. And because that genius became so revered, students were forced to follow, from then on, the same complicated procedure he used originally'.

'So how was it discovered?' asked Noddy. 'By scientists experimenting with what is called "light-velocity in moving reference frames, " replied Big Ears. 'In those complicated terms, your "theorem of Pythagoras" looks like this' – and handing the tiller to Noddy he wrote in Noddy's book:

$$T = t / \sqrt{} \, [1 - (v/c)^2] \quad (2)$$

'That doesn't look like Pythagoras' theorem!' said Noddy.

'No it doesn't,' replied Big Ears. 'That's because it uses "velocities" instead of times – or mechanics instead of geometry. This is what disguised it for so long and made relativity so difficult to understand'.

'But how can that be Pythagoras' theorem?' asked Noddy.

'Well,' said Big Ears, 'once we remove its disguise you may see for yourself. Here's a chance for you, Noddy, to practise your A-level algebra. Suppose I tell you that v in this second formula, the Einstein formula, is the distance s in your formula divided by the stretched time T. What would that tell you?'

'That I may substitute *s/T* for *v* in the Einstein formula; replied Noddy, `like this...' and he wrote:

$$T = t / [1 - (s/cT)2] \quad (3)$$

'Clever boy!' exclaimed Big Ears. 'So now, Noddy, where do you go from there?'

'First; said clever Noddy, writing it down, 'square everything to get rid of the square root'. And Noddy wrote

$$T^2 = t^2 / [1 - (s/cT)^2] \quad (4)$$

'Now what?' enquired Noddy, after he had written it down.

'Divide throughout by $T^2$ and cancel,' said Big Ears; which Noddy did:

$$1 = t^2 /[T^2 - (s/c)^2] \quad (5)$$

'Now multiply through by the expression in the square brackets; instructed Big Ears:

$$T^2 - (s/c)^2 = t^2 \quad (6)$$

'Now swap $(s/c)^2$ over to the other side,' said Big Ears, 'and don't forget to change the sign. Then square-root the equation to get rid of the square':

$$T=\sqrt{(t^2+ (s/c)^2)} \quad (7)$$

'There, you see!' said Big Ears triumphantly, 'Your theorem of Pythagoras, which is what Einstein's equation was, all along!'

'So it is!' exclaimed Noddy, amazed – and then, frowning, 'But why do we now have (*s/c*) in place of *s*?'

'That', said Big Ears, 'is because distance is usually measured in metres and time in seconds, which means that a constant, *c*, has to be included for converting metres into seconds. If you measure both in years, as you have done, or in seconds or whatever, then *c* becomes one and disappears.'

'So *that's* relativity', said Noddy thoughtfully, 'as simple as that?'

'Yes,' replied Big Ears, 'so long as you dump all the old assumptions about "light-velocity" and think instead of *c* as just a constant for inter-converting units of observational distance and time'.*

'Well, fancy that!' mused Noddy. 'Thanks for explaining, Big Ears. Now let's fish!'

* * *

*For a fuller explanation of this observer-centred no light approach to relativity see N.V. Pope and A.D. Osborne, 'A new approach to special relativity', *International Journal of Math Educ in Sci and Tech,* 1987, 18, 2, 191-8. See also N.V. Pope, 'The overdue revolution', *MENSA*, April 1987, 28-9.