A Brain-Friendly Guide

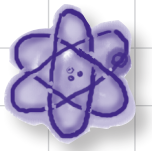
Head First Physics

Conserve your energy by spotting patterns

A learner's companion to Mechanics and Practical Physics

Think like a Physicist

Understand how stuff really works



Try experiments, and solve dozens of puzzles and exercises

Deal with pressure without being under it

O'REILLY®

Heather Lang

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5 dealing with direction

Vectors

Time, speed and distance are all well and good, but you really need DIRECTION too if you want to get on in life.

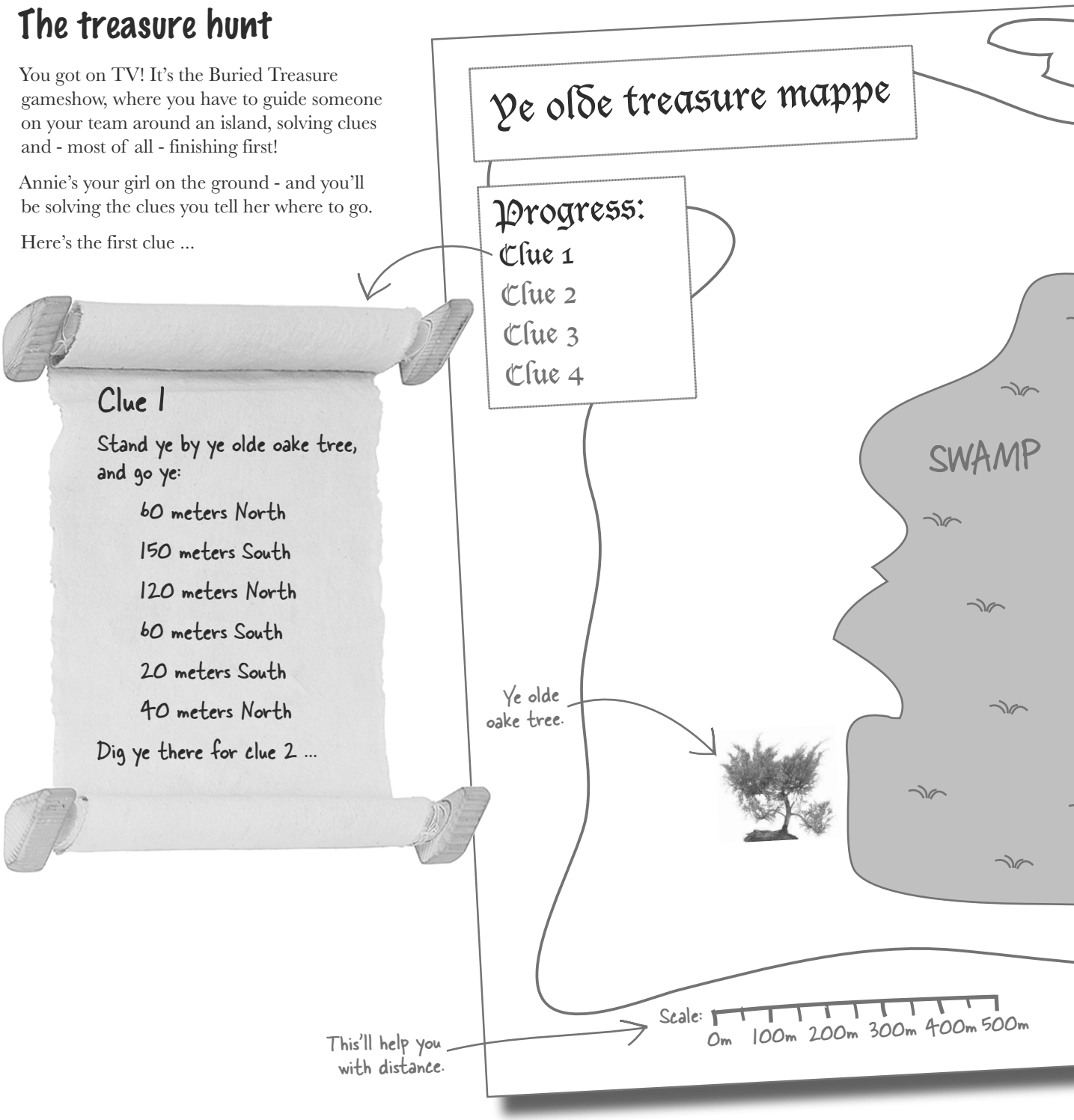
You now have multiple physics superpowers! You've mastered graphs and equations, and you can estimate how big your answer will be. But **size** isn't everything. In this chapter, you'll be learning about **vectors**, which give **direction** to your answers - and help you to find **easier shortcuts** through complicated-looking problems.

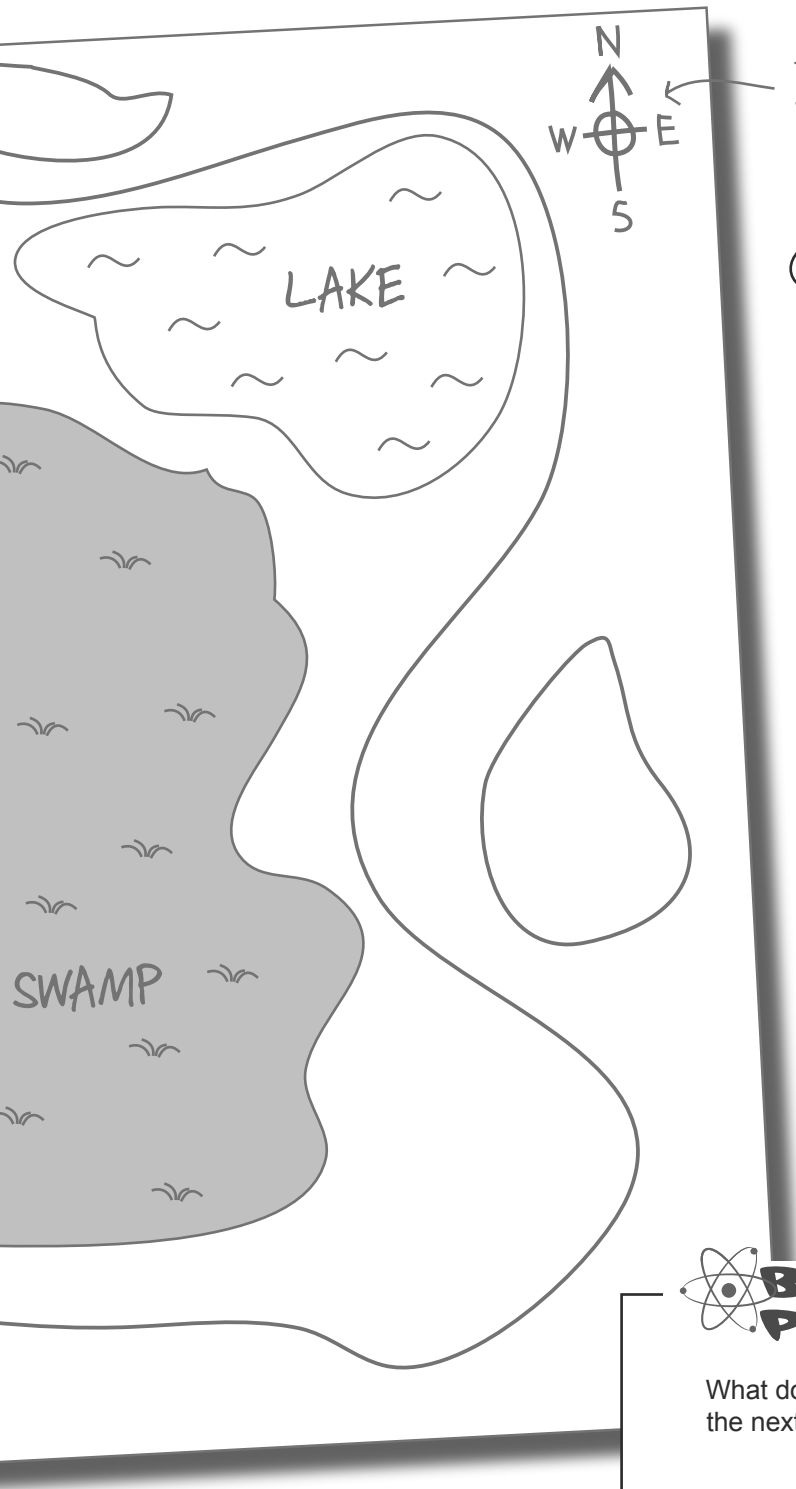
The treasure hunt

You got on TV! It's the Buried Treasure gameshow, where you have to guide someone on your team around an island, solving clues and - most of all - finishing first!

Annie's your girl on the ground - and you'll be solving the clues you tell her where to go.

Here's the first clue ...





This'll help you with direction.

I'm ready what's first?

Annie, your fortune seeker.

BRAIN POWER

What do you think is the best way to guide Annie to the next clue **as quickly as possible**?

Clue conversation

Your team gets to work on the first clue

Joe: Annie looks like the fastest runner out of all the contestants. I say we just tell her to get going and follow the directions as quickly as possible!

Mary: Hang on - what if there's some kind of shortcut?

Joe: Hmmm?

Mary: I mean - would they really make it that easy? Maybe there's a quicker way of solving the clue than mindlessly running up and down. The directions do seem to be a bit ... uh ... repetitive.

Joe: Oh yeah, I see what you mean. The first instruction sends Annie off to the North - and then the next one makes her retrace her steps back to the South again!

Mary: All of the directions in the clue are either North or South. So she'd just be running up and down the same line until she reached the end of the instructions.

Joe: I see what you mean. So it looks like getting Annie to run the whole course won't be the quickest way after all.

Mary: Yeah I think we should try to imagine the directions first - it's faster. So that's 60m North, then 150m South, then ...

Joe: Wouldn't it be better to sketch them out? It'll be much easier to see what's going on than trying to hold onto all these directions in our heads.

Mary: I guess so - let's get to work!

ALWAYS start with a sketch!

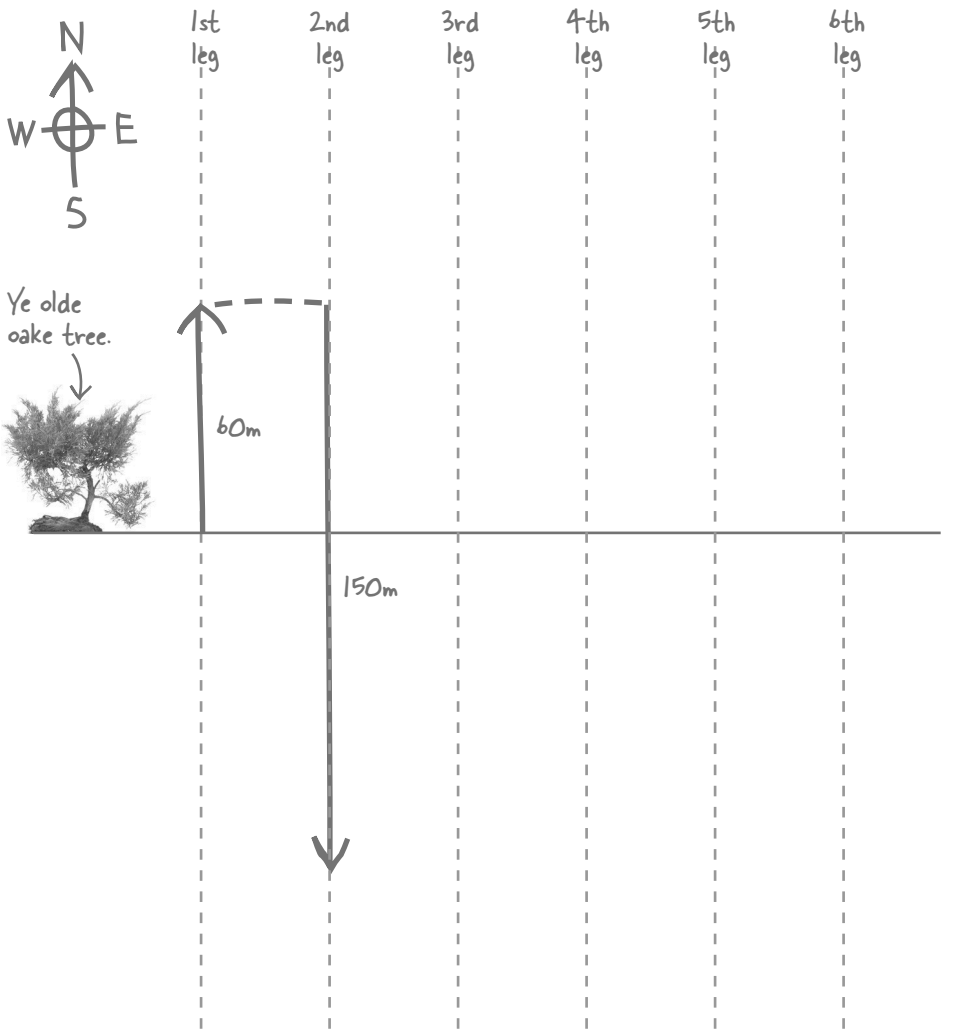
Do a sketch on paper to make room in your brain to think about physics.

Sharpen your pencil

Your team already started a sketch of the instructions in clue 1, but haven't managed to finish it off yet.

That's your job!

They've decided to represent each leg of the instructions using an arrow, so that 1cm represents 20m.

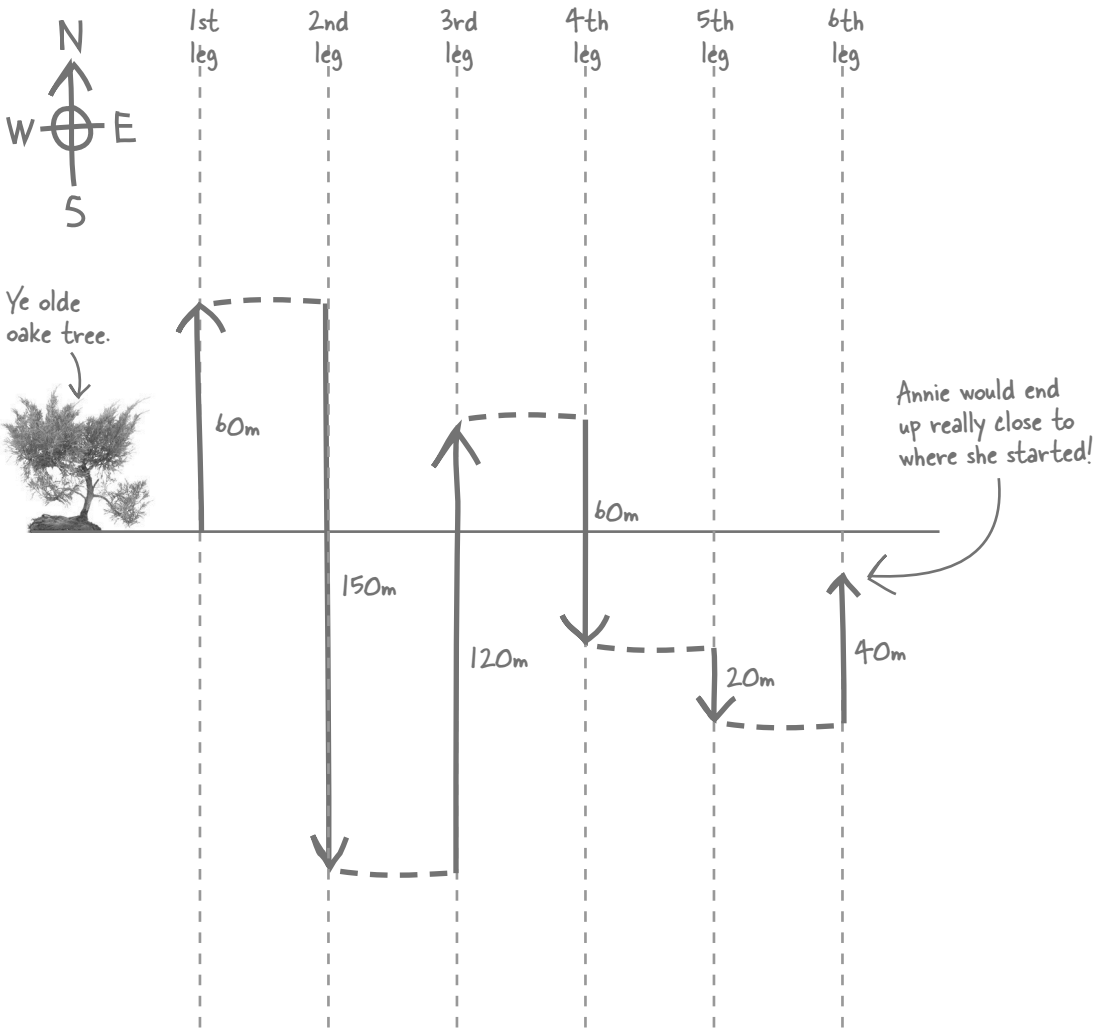


Sharpen your pencil Solution

Your team already started a sketch of the instructions in clue 1, but haven't managed to finish it off yet.

That's your job!

They've decided to represent each leg of the instructions using an arrow, so that 1cm represents 20m.



You can save Annie distance by working out her displacement

You've just worked out that Annie would end up very close to the tree after following all of the directions in the clue. You've just worked out the difference between distance and displacement.

Distance is the actual distance travelled, regardless of route or direction. A trip of 100km North then 90km South way would be a distance of 190km.

This is just a number with units – a size with no indication of direction.

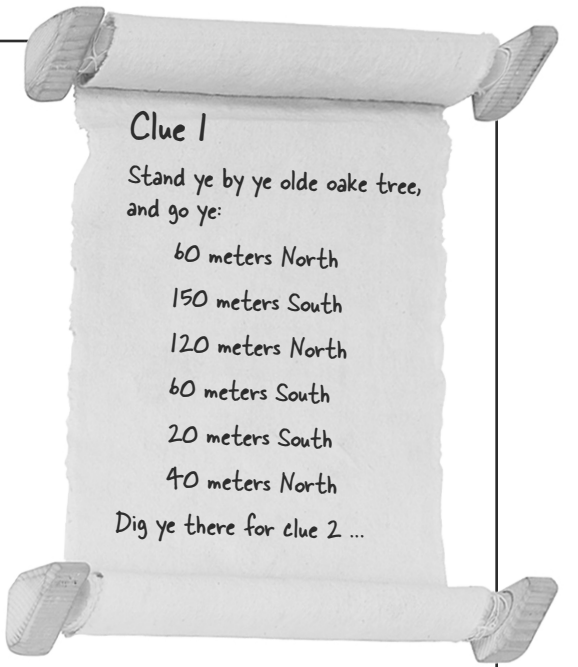
Displacement is the distance moved in a specific direction - in this case from the start point to the finish point, regardless of which route you took to get there. A trip of 100km North then 90km South would be a displacement of 10km North.

This has both a size and a direction.

Sharpen your pencil

a. Work out the **distance** Annie would travel if she followed the instructions in the clue exactly.

b. Work out Annie's **displacement** - the distance and direction from her start point to her finish point.



Sharpen your pencil Solution

a. Work out the **distance** Annie would travel if she followed the instructions in the clue exactly.

Distance = 40 + 150 + 120 + 62 + 20 + 40

= 450m

She'd travel 450m if she followed the instructions in the clue exactly.

b. Work out Annie's **displacement** - the distance and direction from her start point to her finish point.

There are a few different ways you might have done this.

Let's make North positive and South negative, then add up all the individual legs of the journey like that.

Displacement = 60 – 150 + 120 – 60 – 20 + 40

= –10m

As South is negative, –10m means a displacement of 10m to the South of where she started.

Let's add up all the individual Norths, then add up all the individual Souths, and see what happens:

North total = 60 + 120 + 40

= 220m

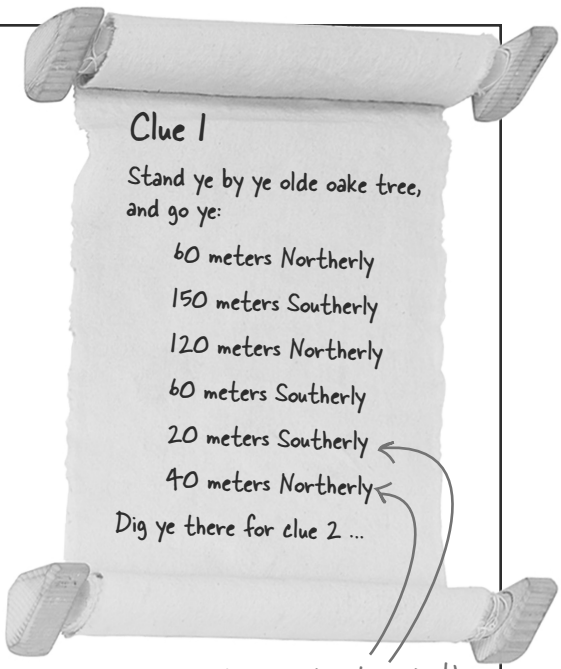
South total = 150 + 60 + 20

= 230m

If we make South positive and North negative, then:

Displacement = 230 – 220

= 10m South of where she started.



Each of the instructions in the clue is a displacement – with a SIZE and a DIRECTION.

Or maybe you got your ruler out and read the answer off the sketch on page 6!

Distance is a scalar; displacement is a vector

Distance is an example of a **scalar** quantity in physics.
Scalars only have a **size**.

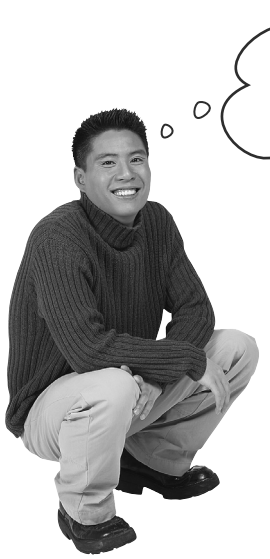
Displacement is an example of a **vector** quantity in physics.
Vectors have a **size** and a **direction**.

Scalars only have a size.

Vectors have both size and direction.

Represent vectors using ARROWS.

Length = size.
Direction = direction.

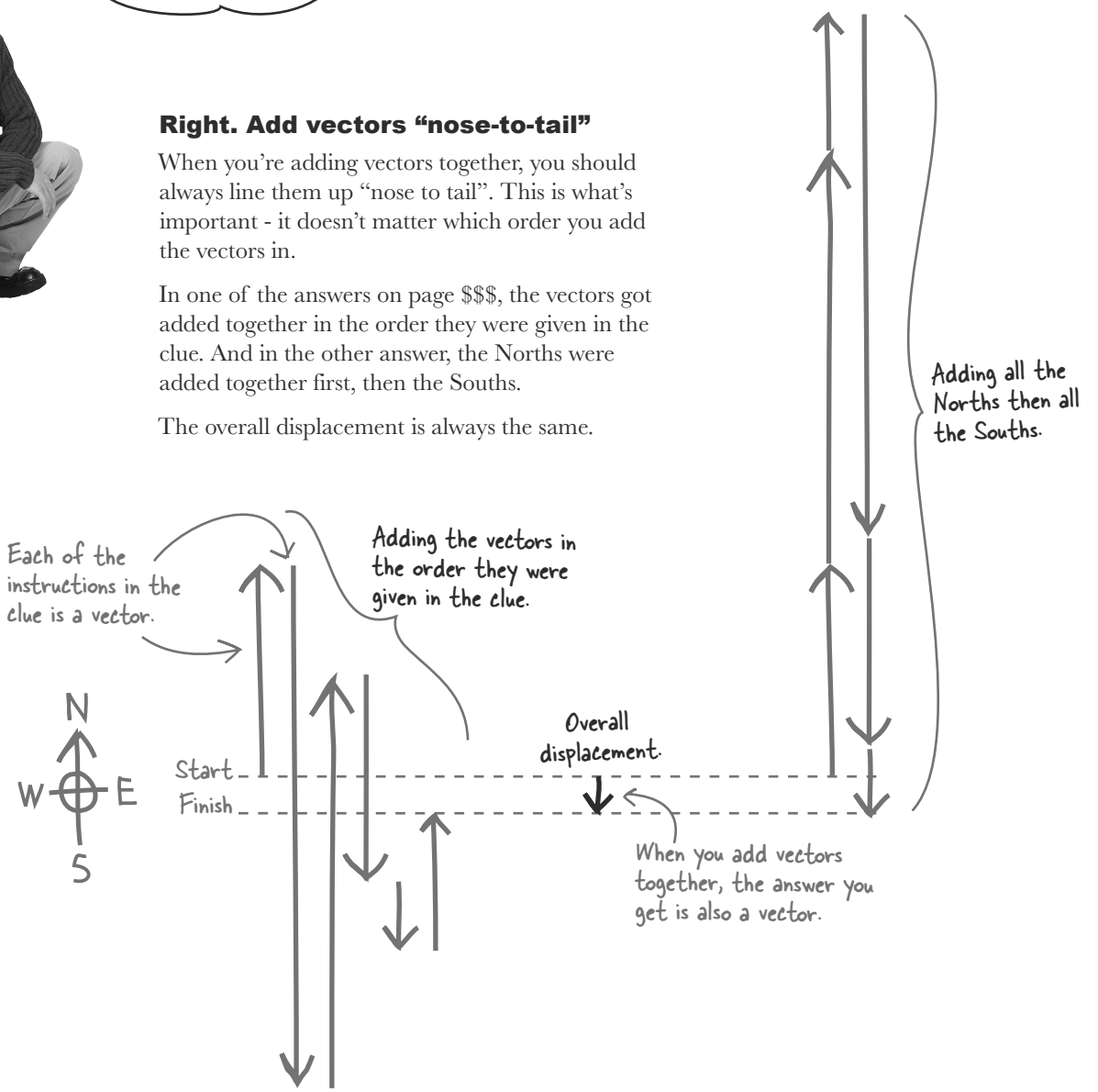


Right. Add vectors "nose-to-tail"

When you're adding vectors together, you should always line them up "nose to tail". This is what's important - it doesn't matter which order you add the vectors in.

In one of the answers on page $$$, the vectors got added together in the order they were given in the clue. And in the other answer, the Norths were added together first, then the Souths.

The overall displacement is always the same.



You can add vectors in ANY ORDER.

Let's make North positive and South negative, then add up all the individual legs of the journey like that.

Displacement = 60 – 150 + 120 – 60 – 20 + 40

= –10m

This way gave an answer of –10m.

Let's add up all the individual Norths, then add up all the individual Souths, and see what happens:

North total = 60 + 120 + 40

= 220m

South total = 150 + 60 + 20

= 230m

If we make South positive and North negative, then:

Displacement = 230 – 220

= 10m South of where she started.

But this way gave an answer of 10m!

I get the arrows over there, but I don't get how you add vectors together with **numbers**. If you do it one way you get one answer - but if you do it another way you get another answer, like on page $$!

You can use + and - signs to indicate direction

Both answers are identical - even though their signs are different.

This is because **you** get to choose which direction to make positive and which direction to make negative when all of your vectors point along a straight line (in this case, either North or South).

The first answer declared that North was positive, so the answer of "Displacement = -10m" means 10m to the South.

In the second answer, South is defined as positive, so the "Displacement = 10m" also means 10m to the South.

there are no Dumb Questions

Q: If vectors add "nose-to-tail" then how do scalars add?

A: The same way they always have - you just add the numbers together.

Q: Are there any other vector quantites apart from displacement?

A: Yes - we'll meet some others soon ...

Q: Don't you need to define a starting point before you add your vectors?

A: Yes, that's right. Sometimes (like here) there'll be an obvious starting point. Sometimes you'll need to define one - e.g. if you're describing heights, it's convential to make 0m = sea level and measure everything else in reference to that.

Q: How do you decide which way is positive and which way is negative?

A: It's up to you - as long as you choose a direction then stick with it, the math will work out the same. You just need to remember how to interpret a negative answer.