The Geometry of Movement

Abi Bown and Jo Sibley

MEI®
Because maths matters!

Turning our hobbies into KS4 geometry

Bands and weights – some geometry in small movements

Martial arts – geometry for a winning advantage!

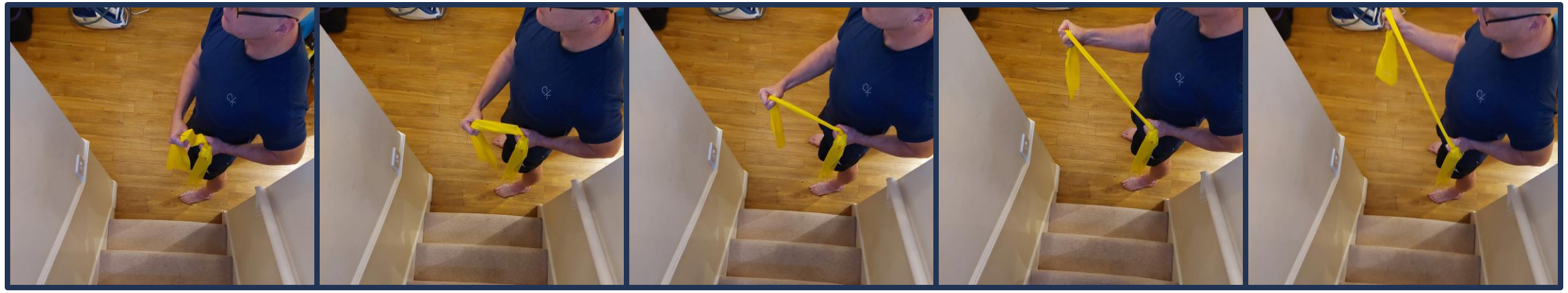
Canoeing – essential geometry

What can we do with maps? – the hills are alive… with geometry!

Please be careful taking part in the activities!

Bands and weights

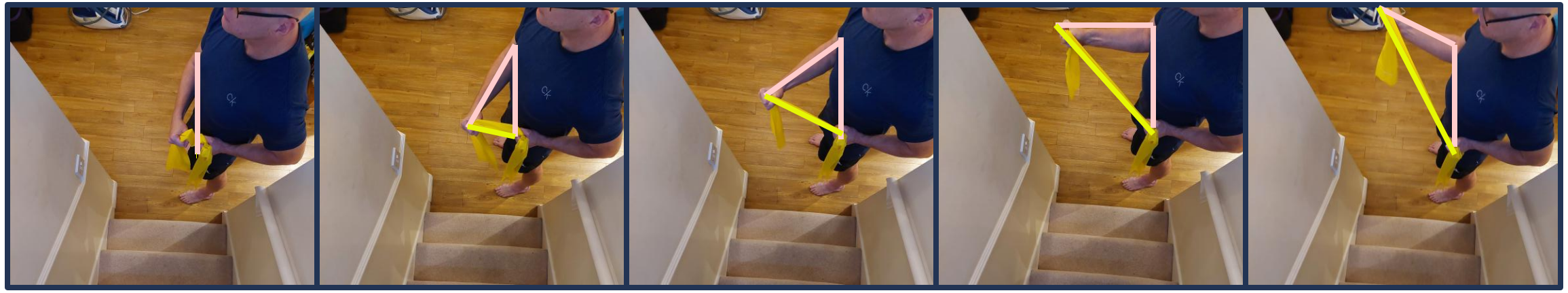
Optimal range in Pilates



What questions could we ask?

The Pilates instructor advises that “you won’t get additional benefit going beyond here”

Optimal range in Pilates



The Pilates instructor advises that “you won’t get additional benefit going beyond here”

Optimal range in Pilates

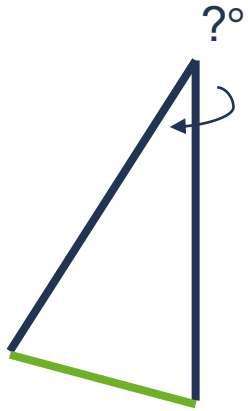
Optimal range in Pilates

Some modelling assumptions:

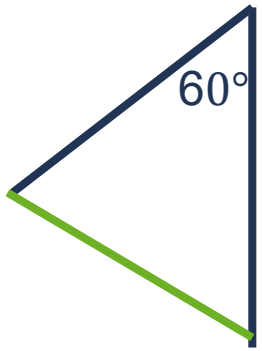
- Width across body = initial arm position = arm length
- $2 \times$ unstretched length of band = arm length
- Tension is directly proportional to extension

Optimal range in Pilates

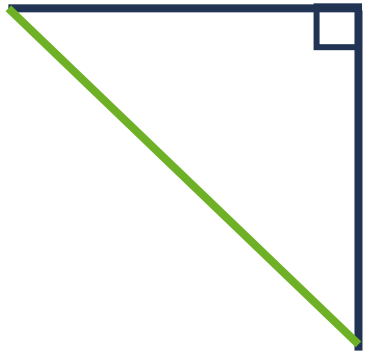
Closed position



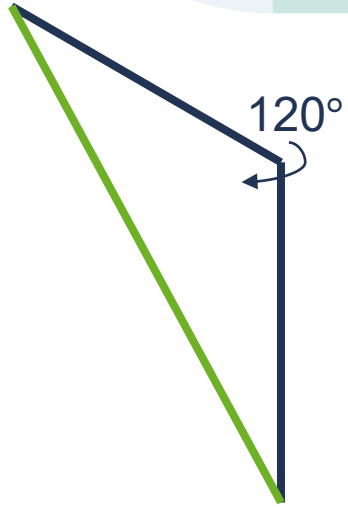
Band just taut



Band = arm length



Elbow at 90°



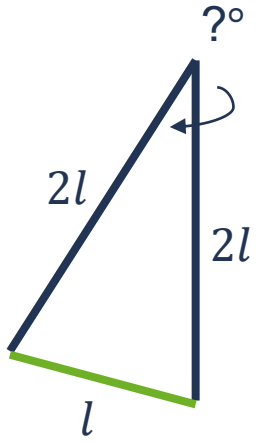
Elbow at 120°

What calculations could we do?

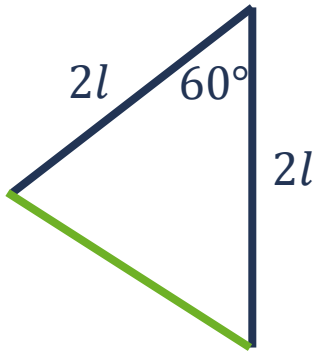
What geometry could we use?

Optimal range in Pilates

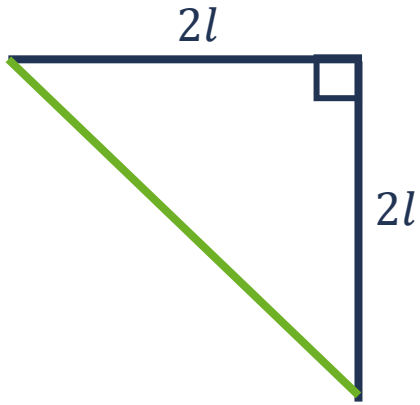
Closed position



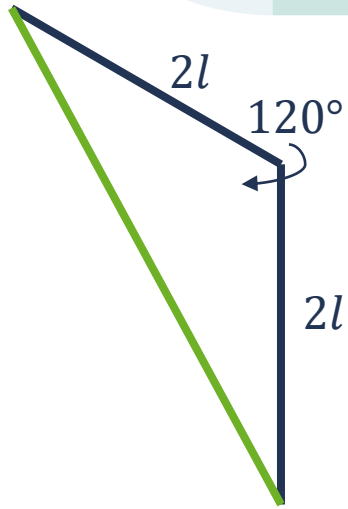
Band just taut



Band = arm length



Elbow at 90°

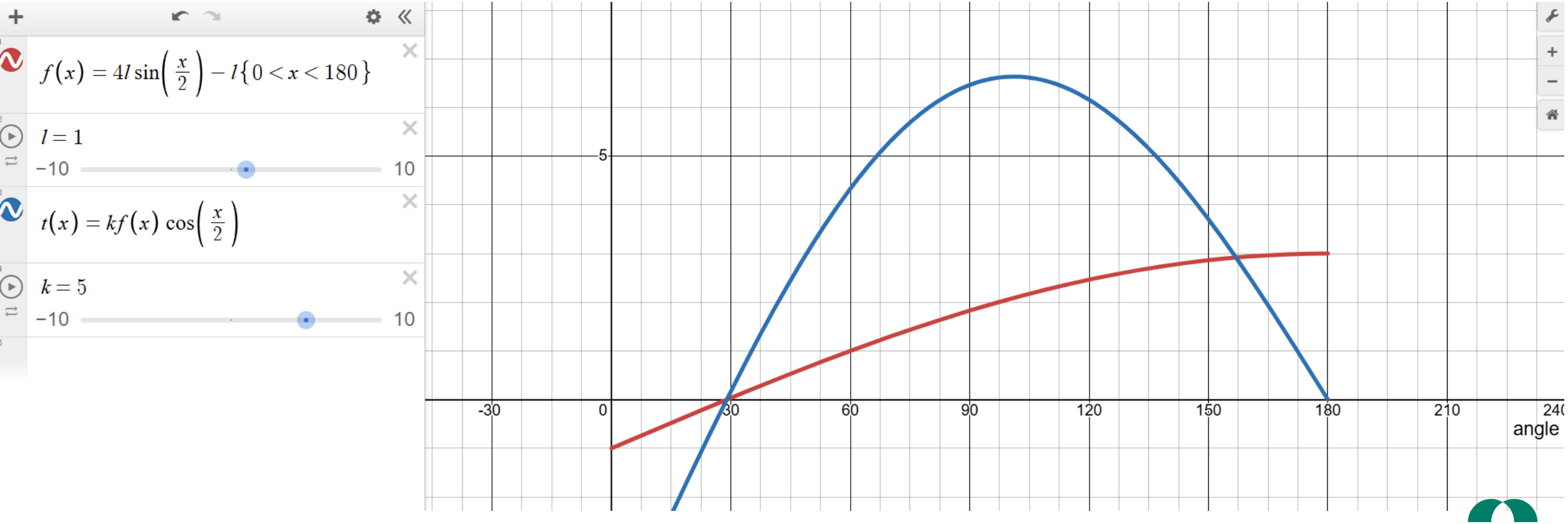


Elbow at 120°

Optimal range in Pilates

If you want to go there…

- x is the angle between the arm and its starting position
- $f(x)$ is the extension in the band
- $t(x)$ is the component of tension perpendicular to the arm



Martial Arts:

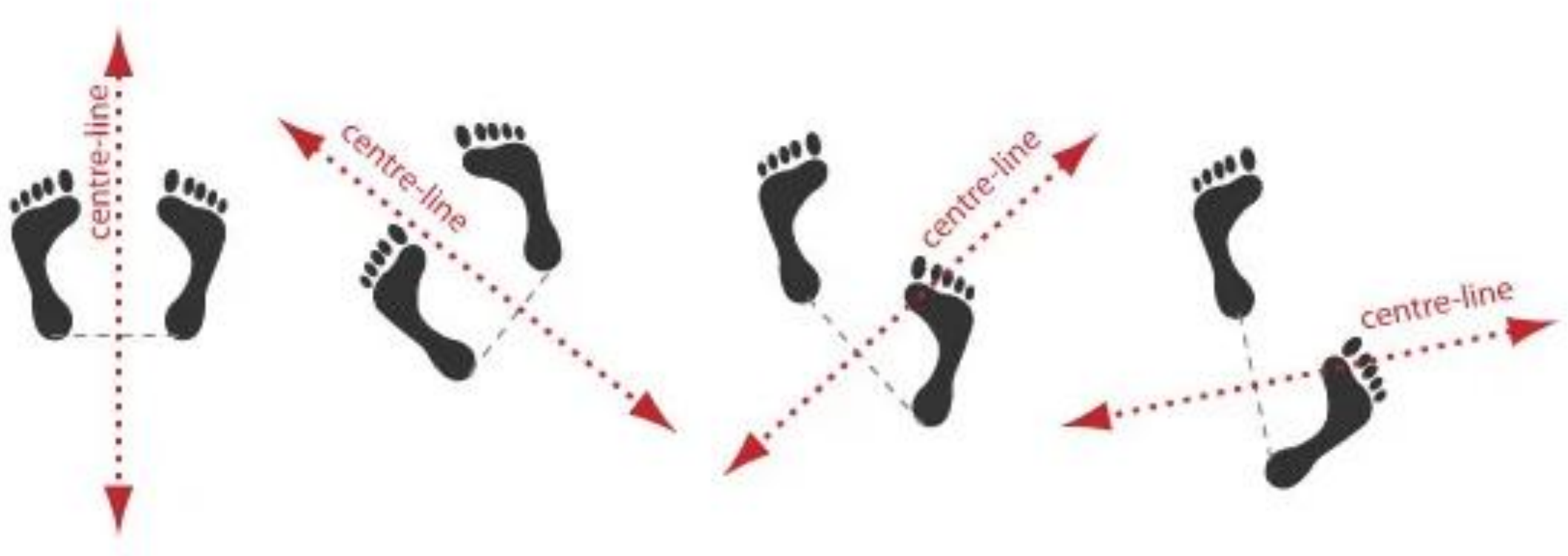
Investigate the line to unbalance your opponent

Centreline Theory

The centre-line is an imaginary line that guides a jujitsoka to affect the optimum angle and direction for unbalancing their opponent. This can then be used as a core principle for attack/counter-attack (using your opponent's centreline) and defence (protecting your own centreline).

The concept of centreline is a core principle for JuJitsu, and should form the core of any student's training. Moreover, its importance cannot be stressed enough, as not only can it be used for executing throws and takedowns, but also for delivering more effective strikes, locks, chokes and holds as well.

How to find the Centreline



Canoeing geometry

Ferry Gliding in a kayak

Ferry gliding in your kayak is a really useful skill to use on a flowing river.

It's a great way to control your kayak to give yourself time to plan your route, or to move across the river.

It works by facing your kayak upstream and paddling against the current to stop any downstream motion of the kayak.


x

Calculating the Ferry Angle

A Kayaking site uses the following calculations:

Calculating the Ferry Angle

Once you know the current speed, you can estimate your ferry angle using the following formula:

$$\text{Ferry angle} = \frac{\text{current speed}}{\text{paddling speed}} \times 60$$

Examples Using a paddling speed of 3 knots:

Current speed 1 knot: $1 \div 3 \times 60 = \mathbf{20}°$

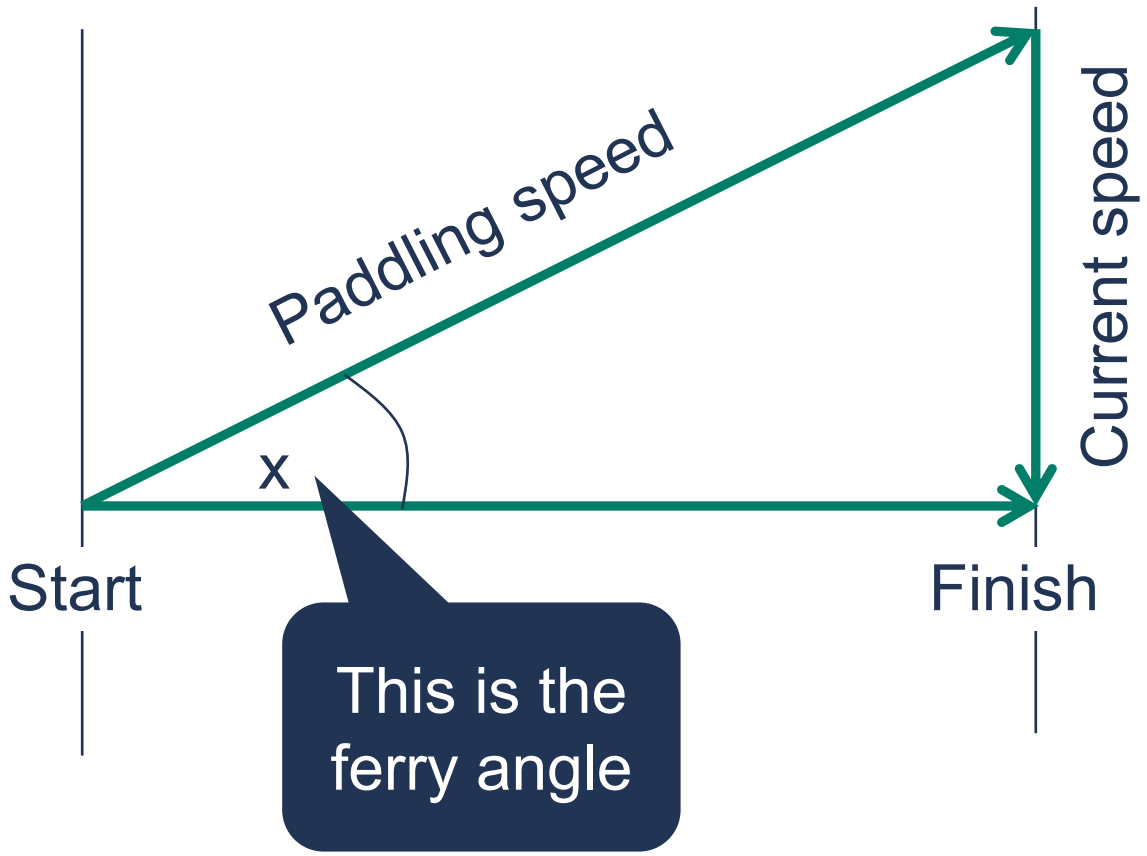
Current speed 2 knots: $2 \div 3 \times 60 = \mathbf{40}°$

Do these numbers match with your calculations?

Important Note

When the current speed is close to the paddling speed, the formula is no longer accurate.

What is the maths involved?



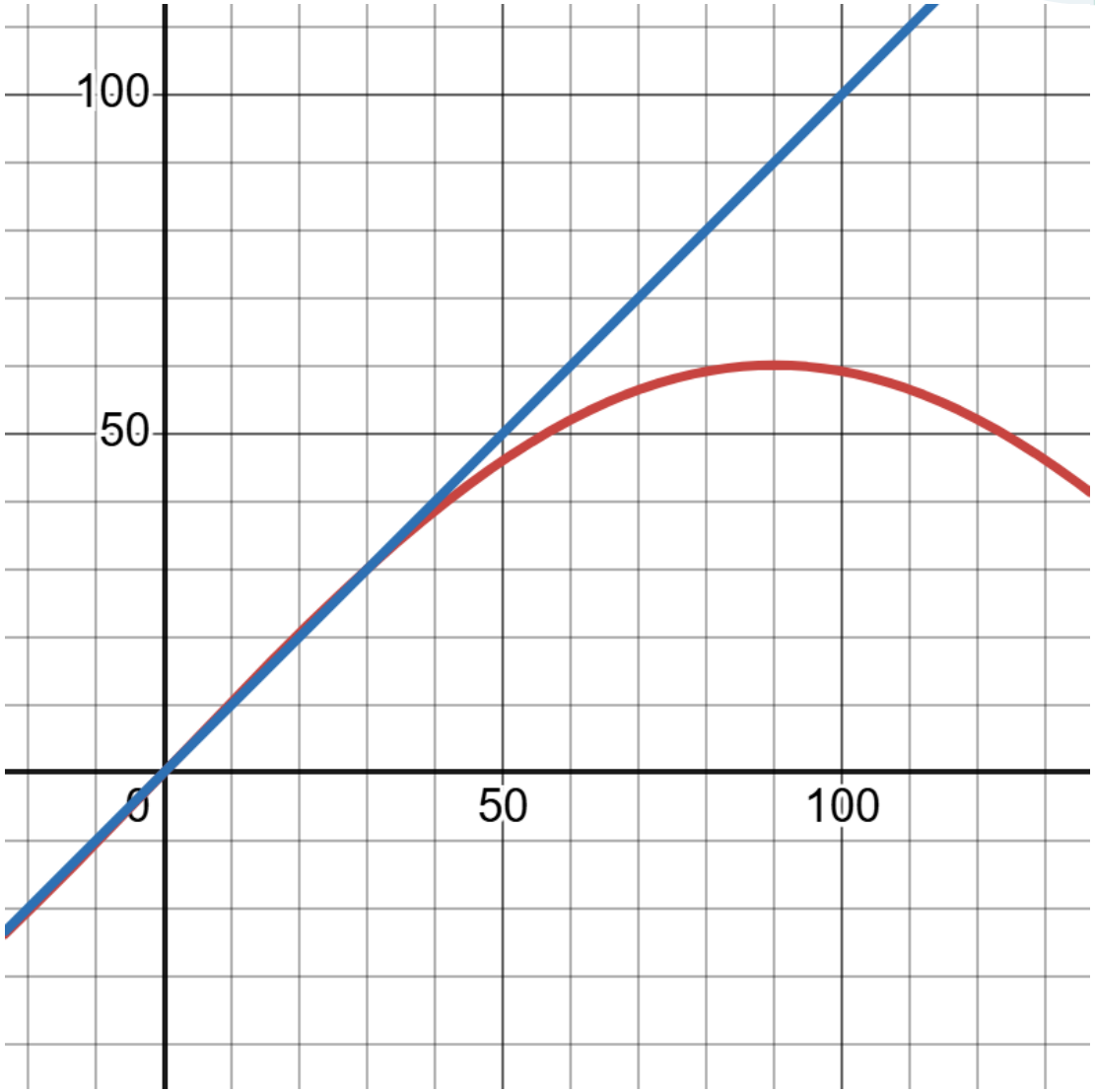
$$\sin x = \frac{\text{current speed}}{\text{paddling speed}}$$

Using desmos investigate if this is equivalent to:

$$\text{Ferry angle} = \frac{\text{current speed}}{\text{paddling speed}} \times 60$$

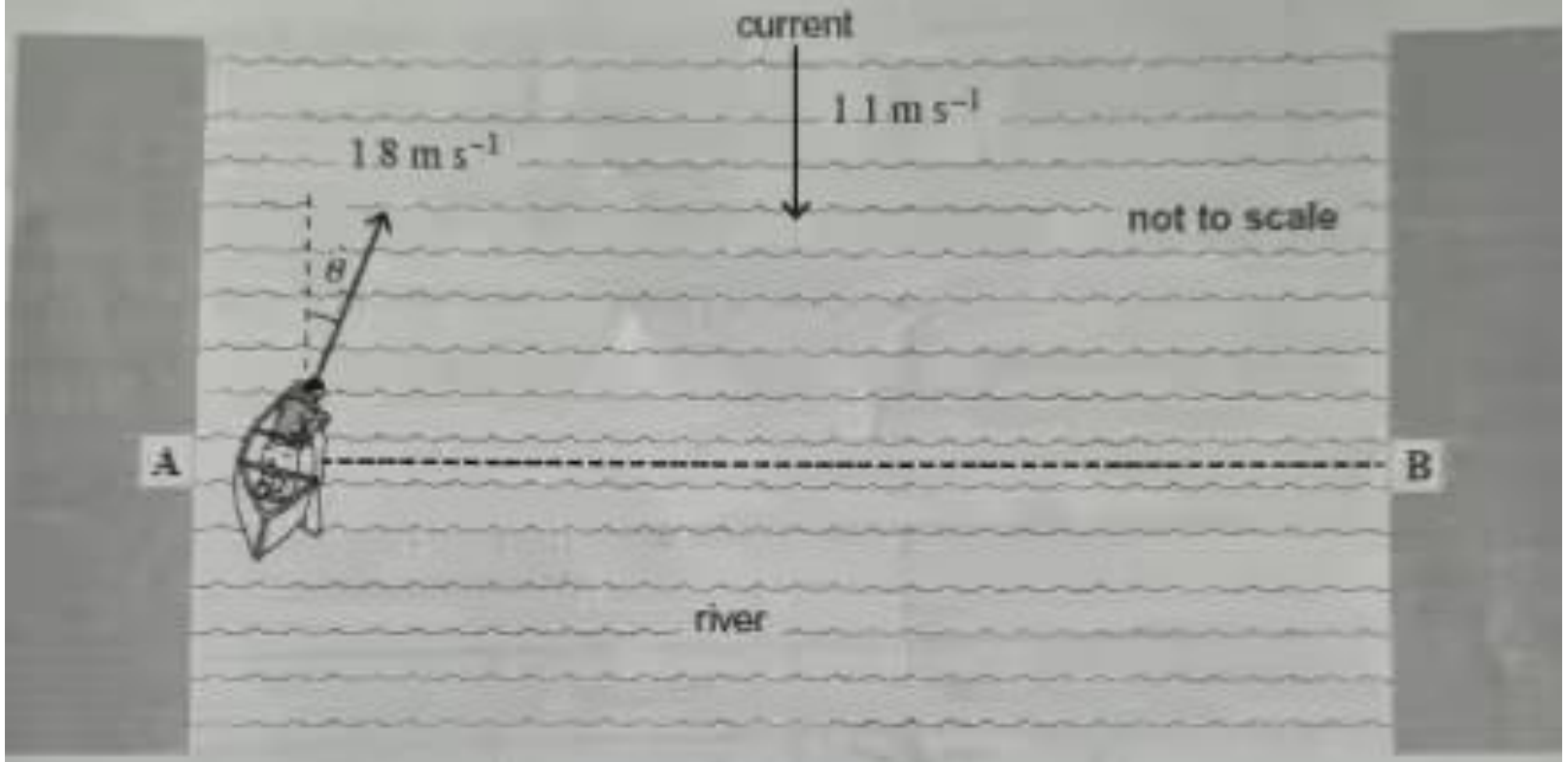
1 $y = 60 \sin x$

2 $y = x$



Q5.

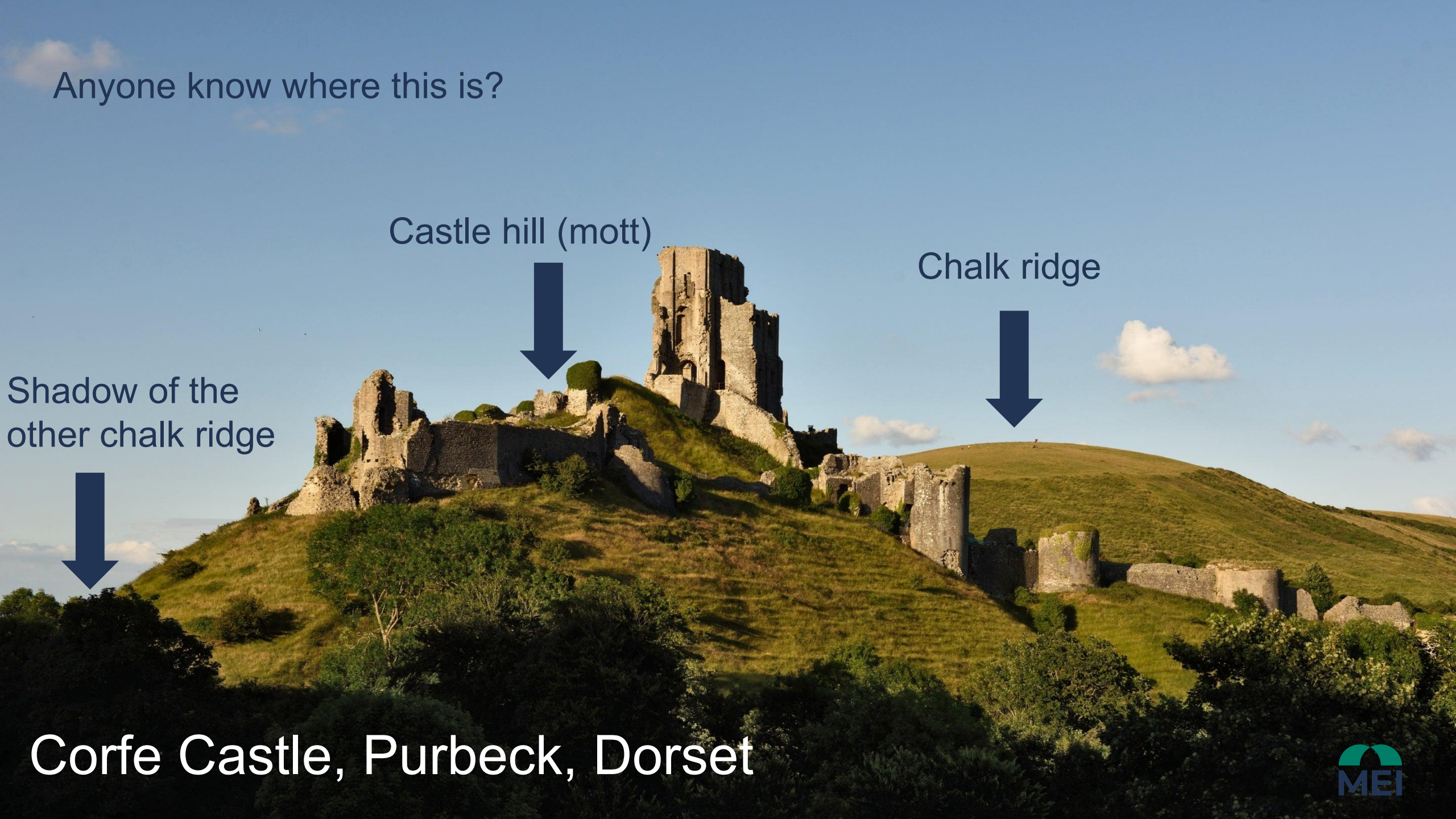
A canoeist wishes to cross a river in a straight line between two points labelled **A** and **B** as shown in the diagram below.
The canoeist can paddle the canoe at a speed of 1.8 m s^{-1} in still water.
The current in the river has a speed of 1.1 m s^{-1}.



To cross from **A** to **B** the canoeist has to paddle at an angle θ to the direction of the current, as shown above.

Determine θ using a scale drawing.

For the map nerds:


Anyone know where this is?
Castle hill (mott)
Chalk ridge
Shadow of the other chalk ridge
Corfe Castle, Purbeck, Dorset

How many tonnes of rock are there in the mott?

- How could we make a good estimate?
- What information would we need?

Suggested:

1. An estimate of the base area of the hill
2. An estimate of the height of the hill,
3. A way to calculate an estimate of its volume from those values
4. A density for the hill

Google Earth - woowwwwwww

…and the FitBit fans

Who walked the furthest?

Choose two areas your students might be aware of, ideally either local to them or in some way familiar. Choose one area that's fairly flat terrain and one that's more hilly.

The set up: Hannah and Sakera each walk a 5 km route. Hannah walks in [Flat area] and Sakera in [Hilly area]. Hannah complains that after her walk her step counter shows a lower total than Sakera's, even though they have the same pace length and walked the same distance.

Can you use Google Earth to explain why that might occur?

Discuss and reflect

Suggestions for discussion

- Do you have out-of-school pastimes which might yield some interesting geometry?
- What geometry can we ‘see’ under a real life system?
- Looking for triangles
- Simple model $\rightarrow$ More refined model $\rightarrow$ More challenging maths

Thank you

Abi Bown and Jo Sibley