

# Measuring Wind Power

## Maths Activity

A joint Genesis and Emirates Team New Zealand education resource.

Genesis and Emirates Team New Zealand are working together to provide STEM resources for schools in the lead up to the defence of the 36th America's Cup. Both organisations are known for their creative innovation and design solutions. This activity is an extension of the 'Harnessing the power of the wind' [activity](#) for levels 3-4.

TĀTAITANGA analysis is a large part of America's Cup racing!

### Overview

Investigate how the energy of wind can drive the America's Cup boats and affect their speed.  
Measure the distances involved in the America's Cup course.

**Curriculum links:** NZ Curriculum

LEARNING AREAS	ACHIEVEMENT OBJECTIVES	LEVELS	YEARS
Mathematics	<p><b>Number and Algebra</b> Use a range of additive and simple multiplicative strategies with whole numbers, fractions, decimals, and percentages.</p> <p><b>Measurement</b> Use appropriate scales, devices, and metric units for length, area, volume and capacity, weight (mass), temperature, angle, and time. Convert between metric units, using whole numbers and commonly used decimals. Use side or edge lengths to find the perimeters and areas of rectangles, parallelograms, and triangles and the volumes of cuboids. Interpret and use scales, timetables and charts.</p>	3-4	5-8



# Background information

*Wind energy can be harnessed by sails to enable a yacht to go faster. Wind energy can also be transformed into electricity for us using wind turbines. Wind speed can affect how efficiently both sailboats and wind turbines work.*

## Harnessing the wind for the America's Cup

Wind can be highly variable. Wind speed contributes to how fast the Emirates Team New Zealand boat goes. Sailboats or yachts must change direction and sail position in order to maximise their use of the wind energy available.

## What is a nautical mile (NM)?

A nautical mile is a measurement of distance at sea, based on the circumference of the Earth. One nautical mile is equal to the 'distance travelled in one minute of latitude'. A nautical mile (NM) can be defined as 1852 metres.

## What is a knot?

A knot is a measurement of speed that is equal to one nautical mile per hour (1 knot = 1.85 km per hour). 10 knots = 18.5 km/hr.

## Perimeter

A perimeter is the length of the closed outside line that is the boundary of a two-dimensional shape or object. To work out the perimeter of a shape with straight edges, add the lengths of the sides together.

View the wind energy slideshow to revise learning about potential energy, kinetic energy and harnessing the wind using sails and turbines, see: <http://bit.ly/2VhtL4W>



## Did you know?

Both wind turbines and sails adjust their angle and direction to capture the wind as it moves and changes.

The sails on an America's Cup boat catch the wind just like KAPOHAU wind turbines do.

# Student activity sheet 1:

## Wind speed and Emirates Team New Zealand (ETNZ)

AHUHAU windward is the high side of the boat facing towards the wind. TAUAHUHAU leeward is the low side of the boat facing away from the wind.

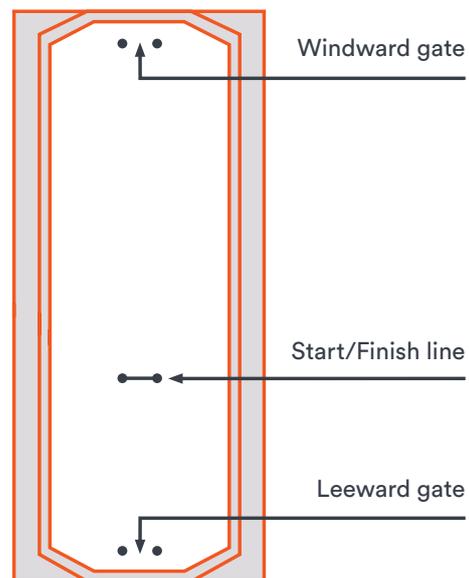
Note: For easier calculation, use the maximum potential boat speeds in the table as a constant speed of the boat during the course. In reality the boat will not be able to sail into the wind and go at maximum speed for the whole course and will vary in speed with changes in direction and wind.

The America's Cup will be held in Auckland in March, 2021. The table below (left) shows examples of how wind speed can affect boat speed. The diagram: Generic course (below right) shows an example of what a race course could look like.

Wind speed and maximum potential boat speeds	
Wind speed (knots)	Maximum potential boat speed (knots) of ETNZ
8	29
12	37
16	43
20	44

### Generic Course

2.2 nm windward leeward, suitable in 20 knots



### Handy hints:

1 knot = 1.85 km/hr

A boat travelling at 1 knot travels 1,852 metres (or 1.8 km) per hour

37 knots =  $37 \times 1.85 = 68.45$  km/hr

### Questions

1. If the wind speed is 12 knots, what is the maximum potential boat speed of Emirates Team New Zealand (ETNZ)?
2. If the wind speed is 16 knots, how fast could ETNZ possibly go in kilometres per hour?
3. How far does a boat travelling at 1 knot travel in one minute?
4. If the course is 10 nautical miles (NM), what is the fastest time that the ETNZ boat potentially could take to complete it, if the wind speed is 8 knots?

# Student activity sheet 2:

## Course perimeter length for the America's Cup

How many MÄERO MOANA nautical miles would ETNZ sail over the whole America's Cup?

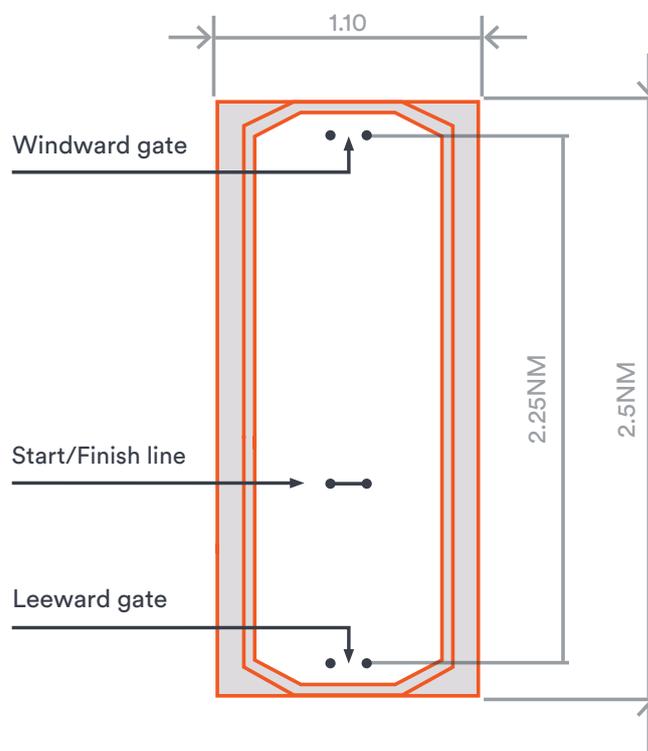
The America's Cup will be held in Auckland in March, 2021.

The course pictured below is similar to what the course might look like during the America's Cup event.

Answer the questions below to see if you can find the approximate distances involved in the race. Distances are given in nautical miles (NM).

### Generic Course

2.2 nm windward leeward, suitable in 20 knots



### Questions

1. What is the distance from the leeward gate to the windward gate?
2. Find the approximate perimeter of the course.
3. What area (in square nautical miles) does the course cover?

### Perimeter

A perimeter is the length of the closed outside line that is the boundary of a two-dimensional shape or object. To work out the perimeter of a shape with straight edges, add the length of all of the sides together.

Note: The course diagram above has been simplified for ease of calculation.

Boats do not go around the perimeter in the race, but will sail a course within the perimeter. Exact dimensions of the real course vary according to the location and the weather conditions. A nautical mile (NM) can be defined as 1852 metres.

# Answers to student activity sheets

PĀNGARAU mathematics includes the many numerical relationships America's Cup teams work on every day.

## Student activity sheet 1: Wind speed and Emirates Team New Zealand (ETNZ)

### Answers

1. 37 knots
2. 43 knots, which is equal to  $43 \times 1.85 = 79.55$  km/hr
3. 1852m divided by 60 (minutes) = 30.86 metres.
4. The course length is 10NM which is equal to 18.5 kilometres. The boat maximum speed is 29 knots or 53.7 kilometres per hour. The boat could therefore travel a maximum of 0.895 kilometres per minute ( $53.7/60$ ). So the fastest time is 18.5 divided by 0.895 = 20.67 minutes.

(Note : times this fast are not possible due to variabilities of wind angles and other factors. These have been left out for ease of calculation).

## Student activity sheet 2: Course perimeter length for the America's Cup

### Answers

1. Approximately 2.25NM (nautical miles).
2. Approximate perimeter of the course =  $1.1\text{NM} + 2.5\text{NM} + 1.1 + 2.5\text{NM} = 7.2\text{NM}$  (nautical miles). This is equal to 13,334 metres or 13.3 kilometres.
3. Area of the course:  $1.1\text{NM} \times 2.5\text{NM} = 2.75\text{NM}^2$