



# INEOS 1:59 CHALLENGE: PACEMAKER



INEOS | STEM **CREW**

**WHAT DOES IT TAKE  
TO RUN A MARATHON IN  
UNDER 2 HOURS?**

# JOIN THE TEAM!

Imagine you work for INEOS 1:59.

Your task is to repeat a sub- 2 hour marathon with your team.

You will need to carry out a series of experimental **investigations** in order to meet this challenge.

There are 3 areas to consider:

Pacemakers

Nutrition

Course Selection

# LEARNING OBJECTIVES

## Forces

- ❖ To understand air resistance is a force which slows things down
- ❖ To investigate how air resistance can be minimised

## Working scientifically

- ❖ How can I investigate the best way of minimising air resistance for a runner?
- ❖ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- ❖ Make predictions using scientific knowledge and understanding
- ❖ Use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
- ❖ Present observations and data using appropriate methods, including tables and graphs

**What force slows things down and how can we minimise it?**

# KEYWORDS



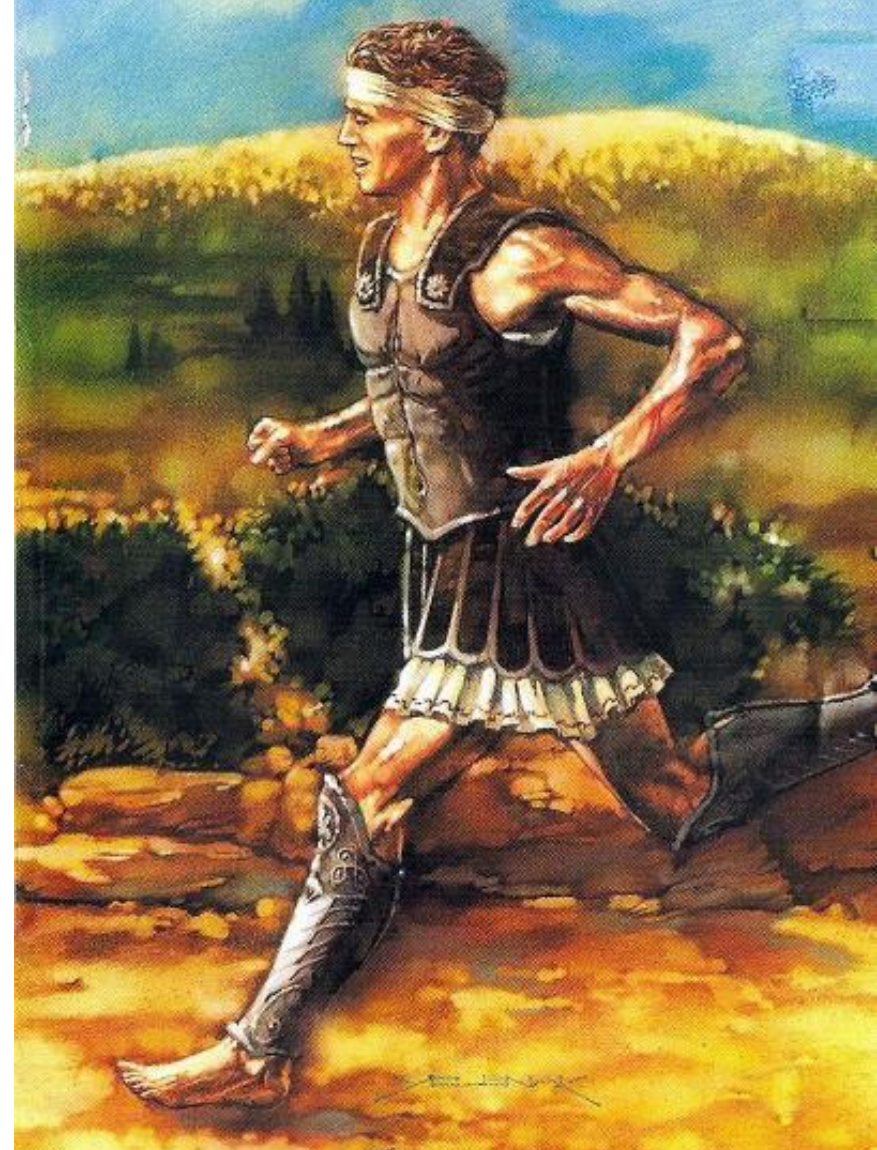
Air resistance  
Upthrust  
Gravity  
Friction  
Forward thrust  
Method  
Conclusion  
Investigation

# WHAT IS A MARATHON?

## The Legend of Pheidippides

The origin of the marathon begins around 490BC at the time when the Persians were invading Greece. The most popular legend tells of a Greek messenger: Pheidippides who was tasked with the mission of informing the peoples of Athens that the Greeks have defeated the Persians at the Battle of Marathon. The distance of this epic run was 25 miles and according to legend as soon as he had delivered the message Pheidippides died of exhaustion. The original footrace was called a marathon in honour of the legend and as a result it also covered 25 miles. The marathon ran from the original site in Marathon to the Olympic Stadium in the city of Athens.

And this was also the route used during the first Olympic Games back in 1896. Ever since, the marathon has been part of the Olympics and it is also an endurance event to end the games. The standard distance for a marathon is now 42.195km or 26.2 miles.





# HOW HARD IS IT TO RUN A MARATHON IN UNDER 2 HOURS?

Eliud Kipchoge ran the 26.2 miles of the marathon 1:59:40 that's the same as running at 21.1km per hour or running 100m in 17.1 seconds and then repeating it 422 times!



## THE RACE TO 1:59

THE PROGRESSION OF THE OFFICIAL MARATHON WORLD RECORD



# TRY IT YOURSELF

Can you run at the pace of a sub- 2 hour marathon?

Run the length of a:

- ❖ Badminton court in 2.3 seconds
- ❖ Tennis court in 4.1 seconds
- ❖ Netball court in 5.2 seconds
- ❖ Football pitch in less than 16 seconds

or

Measure your own distance calculate the time you would have to cover the distance by running at **5.86 m/sec**





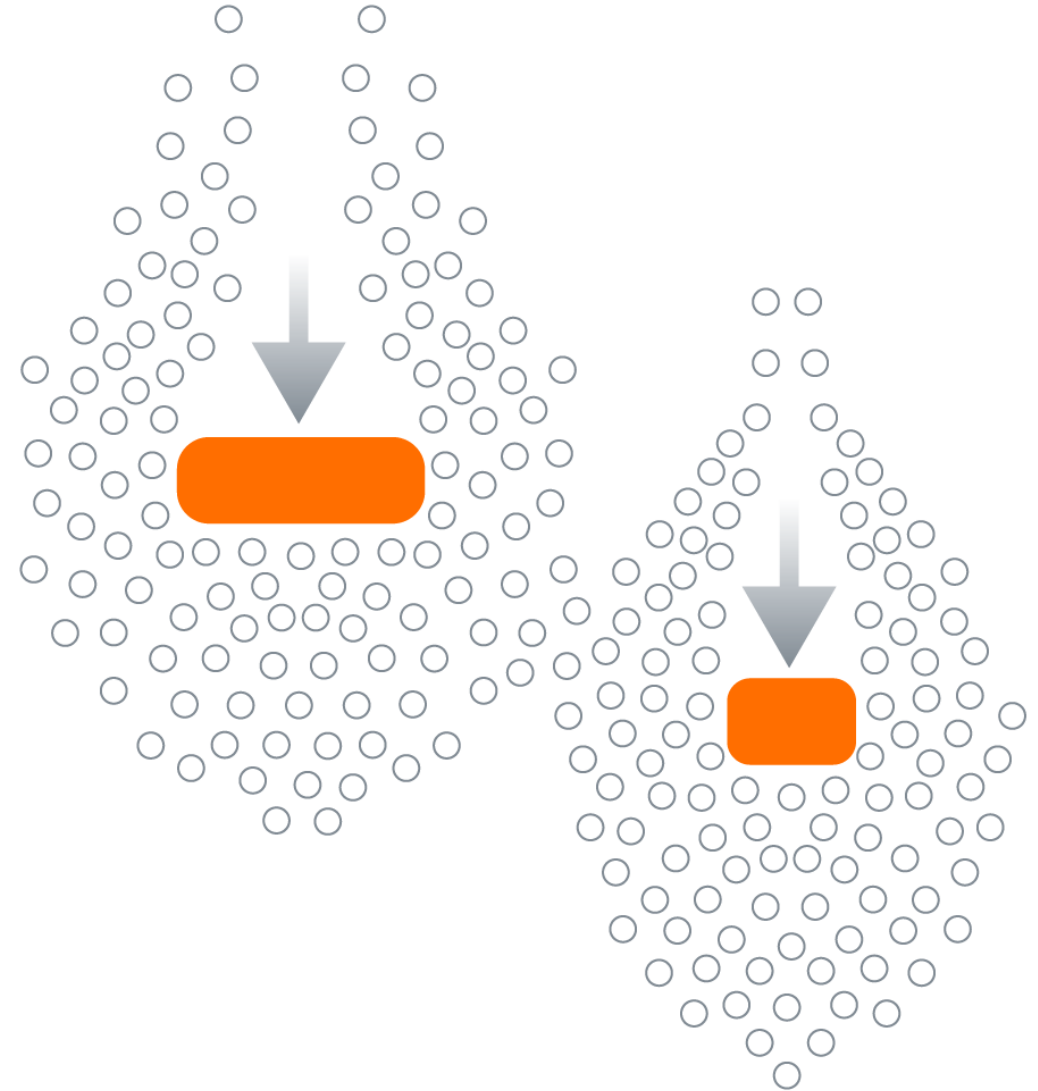
# AIR RESISTANCE

Wind, temperature, and altitude all have a common link, they all affect the air resistance acting on the runner.

## WHAT IS AIR RESISTANCE?

Whenever an object moves through air it hits air particles. The larger the object the more particles hit the object.

**But what effect do these particles have on the speed of a moving object?**



# QUICK FORCES ACTIVITY

1. Use the paper cone template to carefully cut out the disk and make one radius cut along the dotted line as indicated.
2. Make the paper disk into a cone shape by overlapping the radius cut up to line 1.
3. Tape in place using masking tape.
4. Drop the cone point down from a known height and accurately record the time taken to drop.
5. Repeat twice more for each cone size.
6. USING THE SAME PIECE OF PAPER, adjust the size of cone and repeat steps 1 to 5.



# RESISTIVE FORCES

## What is air resistance?

Some objects are streamlined so they can travel more smoothly through the air.

Less air resistance means objects are able to travel faster.



## Talking partners

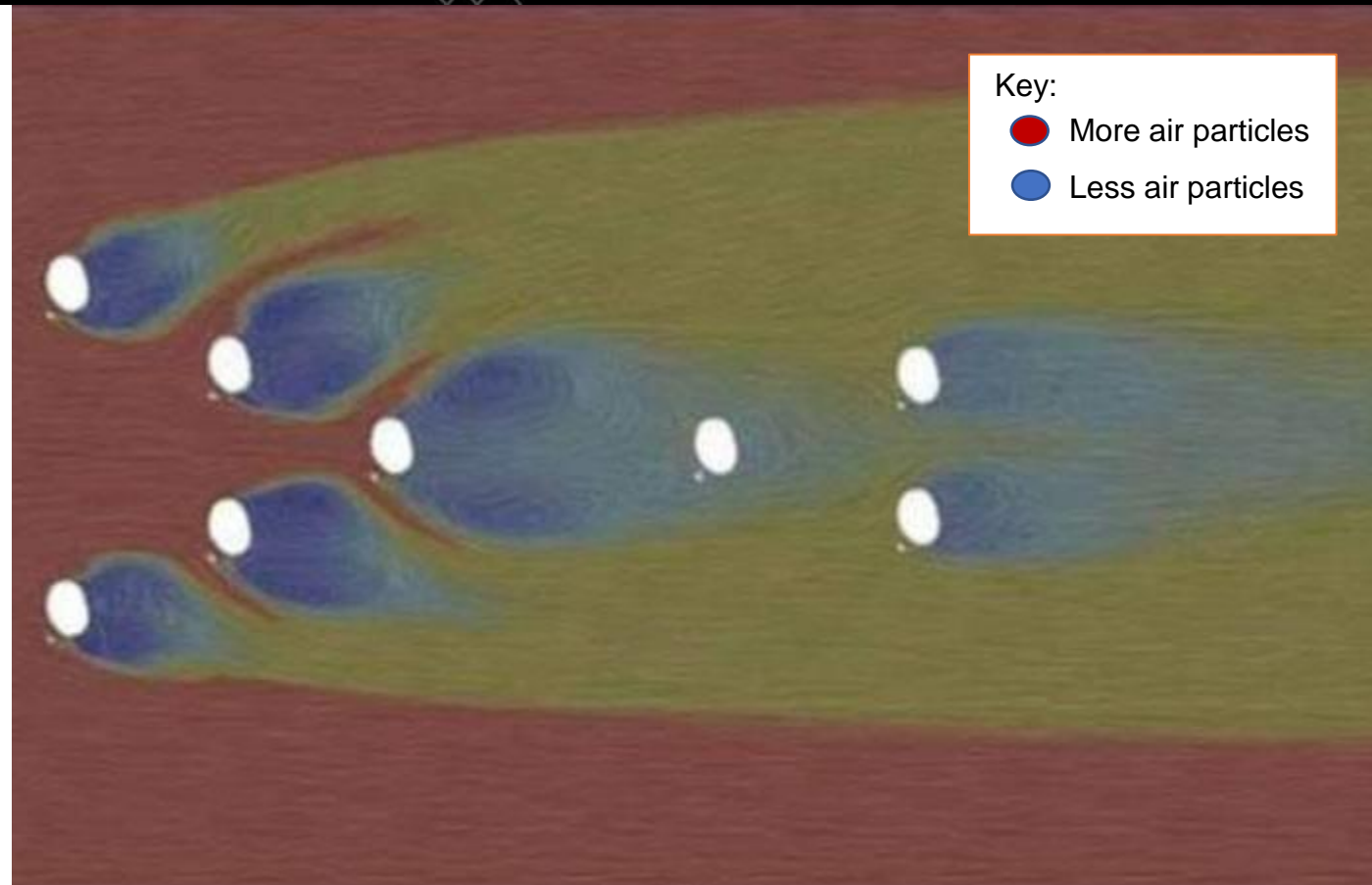
So what is air resistance?  
Discuss with a partner

# WHAT IS AIR RESISTANCE?

Air resistance is particles of air hitting the surface of an object (push force)

As an object goes faster it will hit more air particles every second, so more push forces on it means more air resistance.

By creating a human 'barrier' between air particles and Eliud means less air resistance at the same speed.



Graphic shows the airflow on each member of the 1:59 formation.

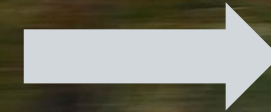
Which 'dot' represents Eliud and why?

# WHAT FORCES ARE ACTING ON THE RUNNERS?

Upthrust



Air resistance



Friction

Forward thrust



Gravity



# WHAT IS A PACEMAKER?

A pacemaker runs at a pre-determined speed in a race, typically a long-distance event. Other runners follow or stay with the pacer, to ensure that they're running at their desired speed. A good pacemaker must be a steady, consistent runner who is focused on maintaining his speed and helping other runners realise their goals.

## HOW DOES A PACEMAKER HELP A RUNNER GO FASTER?

The pacemaker encounters the air resistance first, pushing the air out of the way as they move through it, allowing other runners to tuck in behind them and gain the benefit of what's called drafting. Drafting behind other competitors or pacemakers has helped set many records over the years, including Roger Bannister's original four-minute mile.



# WHAT FACTORS AFFECT HOW FAST YOU RUN?

Other than fitness, how many other things can you think of that might affect how fast you are able to run a marathon?



## 2:50 minute challenge

You have got the time it takes Eliud to run 1 km, to work with your talking partner to think of as many factors that affect running speed as possible.

Tip: think scientifically and use the images to help you.



# WHAT FACTORS AFFECT HOW FAST YOU RUN?

Think about the following areas;

- ❖ Individual
- ❖ Equipment
- ❖ Environment
- ❖ Psychological



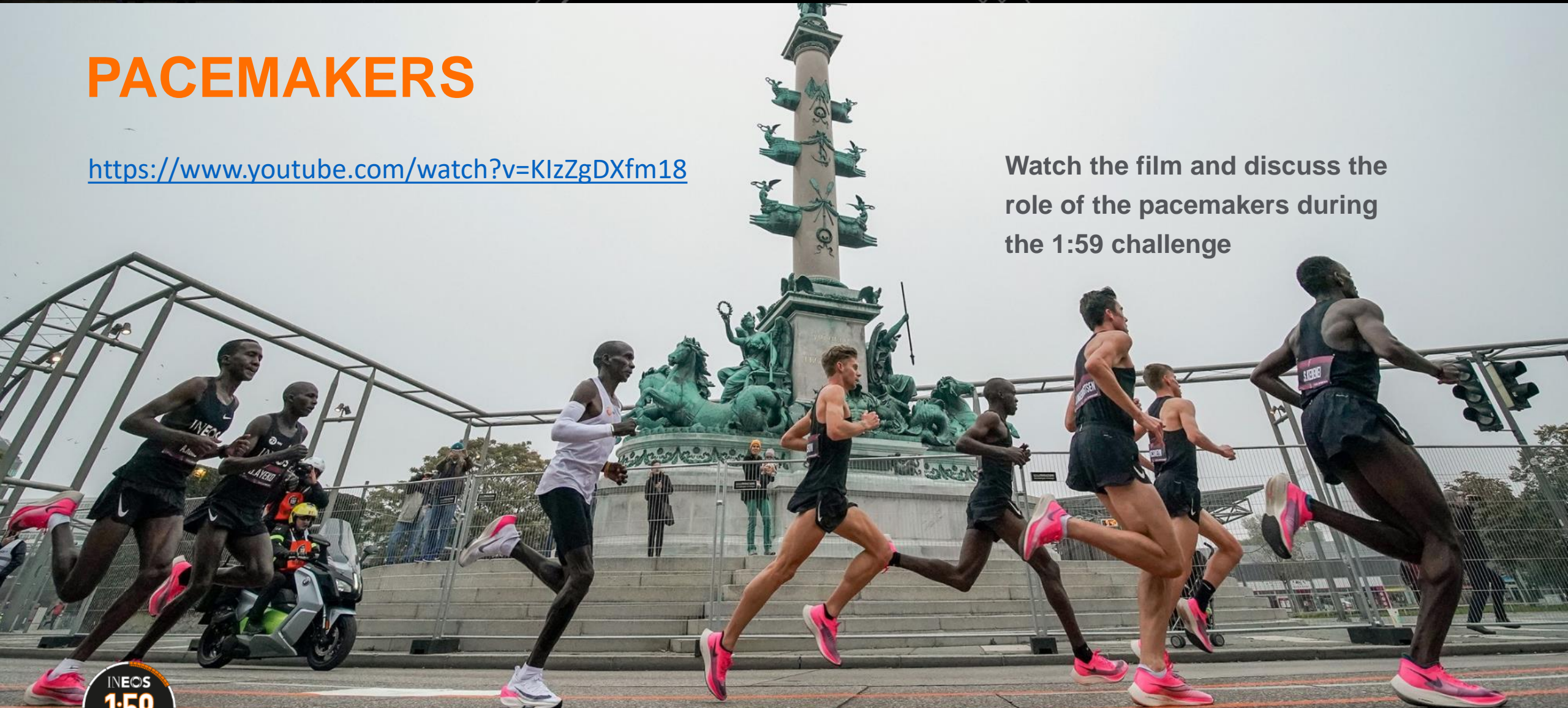
## How many did you get?



# PACEMAKERS

<https://www.youtube.com/watch?v=KlzZgDXfm18>

Watch the film and discuss the role of the pacemakers during the 1:59 challenge



# AIR RESISTANCE INVESTIGATION

You cannot make your runner smaller to reduce the amount of air resistance acting against them, but you can use the pacemakers to try and reduce the air particles hitting your runner and therefore reduce the air resistance.

**You have up to six pacemakers that you can use.**



Field testing the 'v' formation

	A	B	C	D	E	F	G	H
1				Runner				
2				Runner				
3				Runner				
4		Runner		Runner	Runner			
5								
6				Runner				
7								
8								



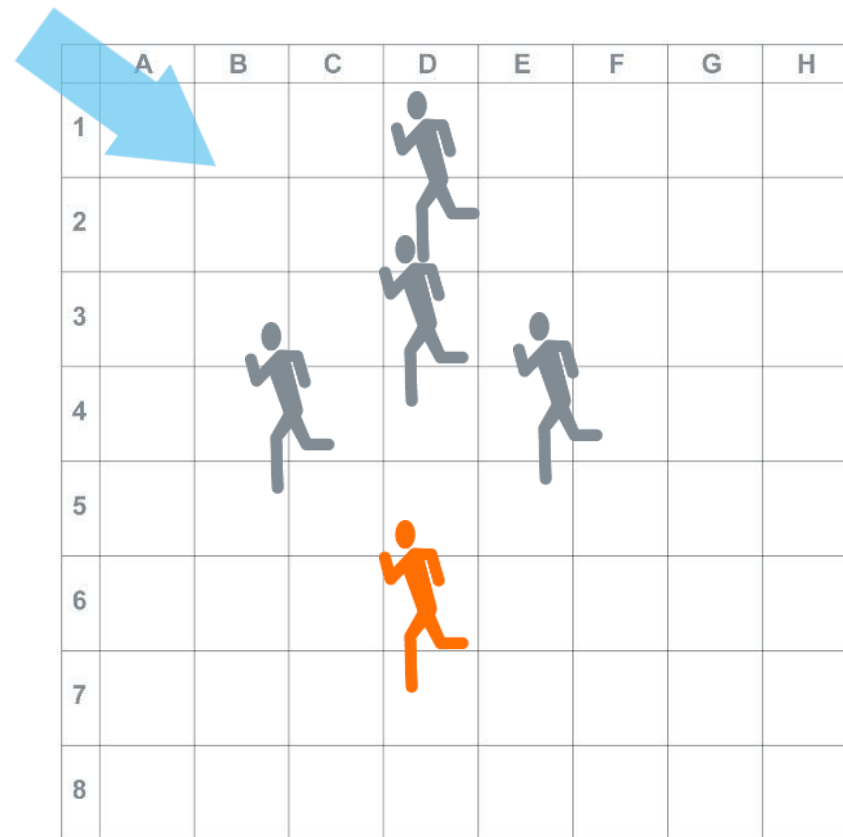
# INVESTIGATE

## How can we reduce the forces acting on the runners?

Your task is to investigate how to minimise the air resistance operating on your marathon runner.

You will be provided with the following equipment;

- ❖ A grid
- ❖ Runner templates



# PREDICT

A prediction is a guess at what may happen based on an observation. Predictions are important because they provide a reference point for the scientist. If the prediction is proved or disproved, then the scientist has increased their knowledge of the process.

## Task:



Task: with your partner/ team write a prediction about your pacemaker formation e.g. I predict an 'inverted v' will minimise air resistance the most.

Remember- your prediction may be proved or disproved in your investigation.

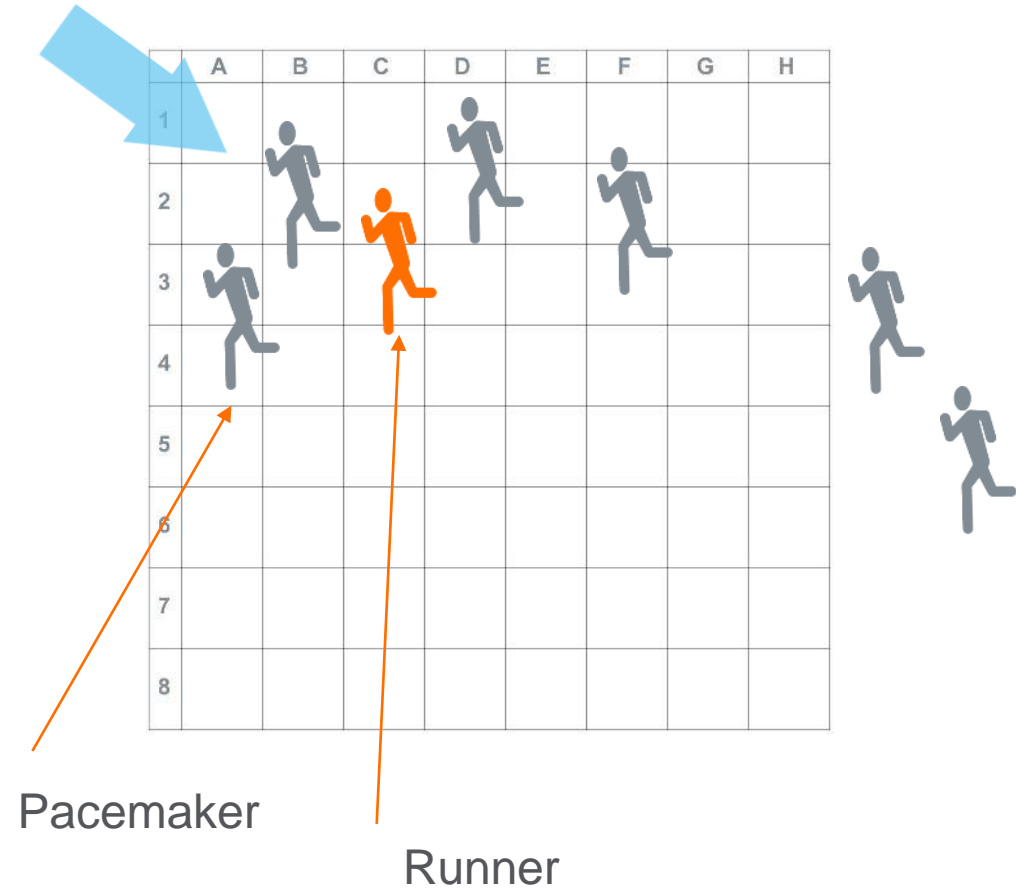
# WHAT PREDICTIONS DID THE 1:59 TEAM MAKE ABOUT PACEMAKERS?

- ✓ Pacemakers will ensure Eliud runs at the correct speed
- ✓ Pacemakers will ensure Eliud doesn't waste any energy
- ✓ Pacemakers will decrease the air resistance acting on Eliud
- ✓ An inverse 'V' formation will decrease air resistance acting on Eliud the most



# HOW TO USE THE GRID AND CONES

1. Use your paper runners to represent your pacemakers, you have up to six that you can use.
2. Choose where you are going to place them holding them in place with bluetack and note their position by recording the coordinates.
3. Place your runner on the grid but do not stick down and again note their position by recording the coordinates.
4. Place the desk fan 30cm from the front runner and turn it on at the lowest setting. Does your runner get blown over or out of position?
5. Repeat steps 1 to 4 choosing a new placement until you have found the best placement of your pacemakers to reduce the air resistance acting on your runner.



# WRITING A METHOD

The method should explain exactly what you are going to do in detail.

Scientific experiments should be repeatable so that anyone could pick up your work and repeat it to check their results against yours. The more results we have the more accurate the conclusions.

How do we go about writing a method?



# MODEL METHOD

- ✓ Sentences should be concise and to the point
- ✓ Include all the detail needed
- ✓ Chronological order
- ✓ Repeatable

## Model method

- ❖ *Choose 4 formations for your cones on the grid.*
- ❖ *Set up your first formation.*
- ❖ *Stick your pacemakers down with blutack.*
- ❖ *Make sure your 'runner' is free to move.*
- ❖ *Set up your fan 30cm from the start of the grid.*
- ❖ *Turn the fan on and measure how far the red cone travels.*
- ❖ *Make a note of its new position.*
- ❖ *Repeat 3 times for accuracy.*



# RESULTS

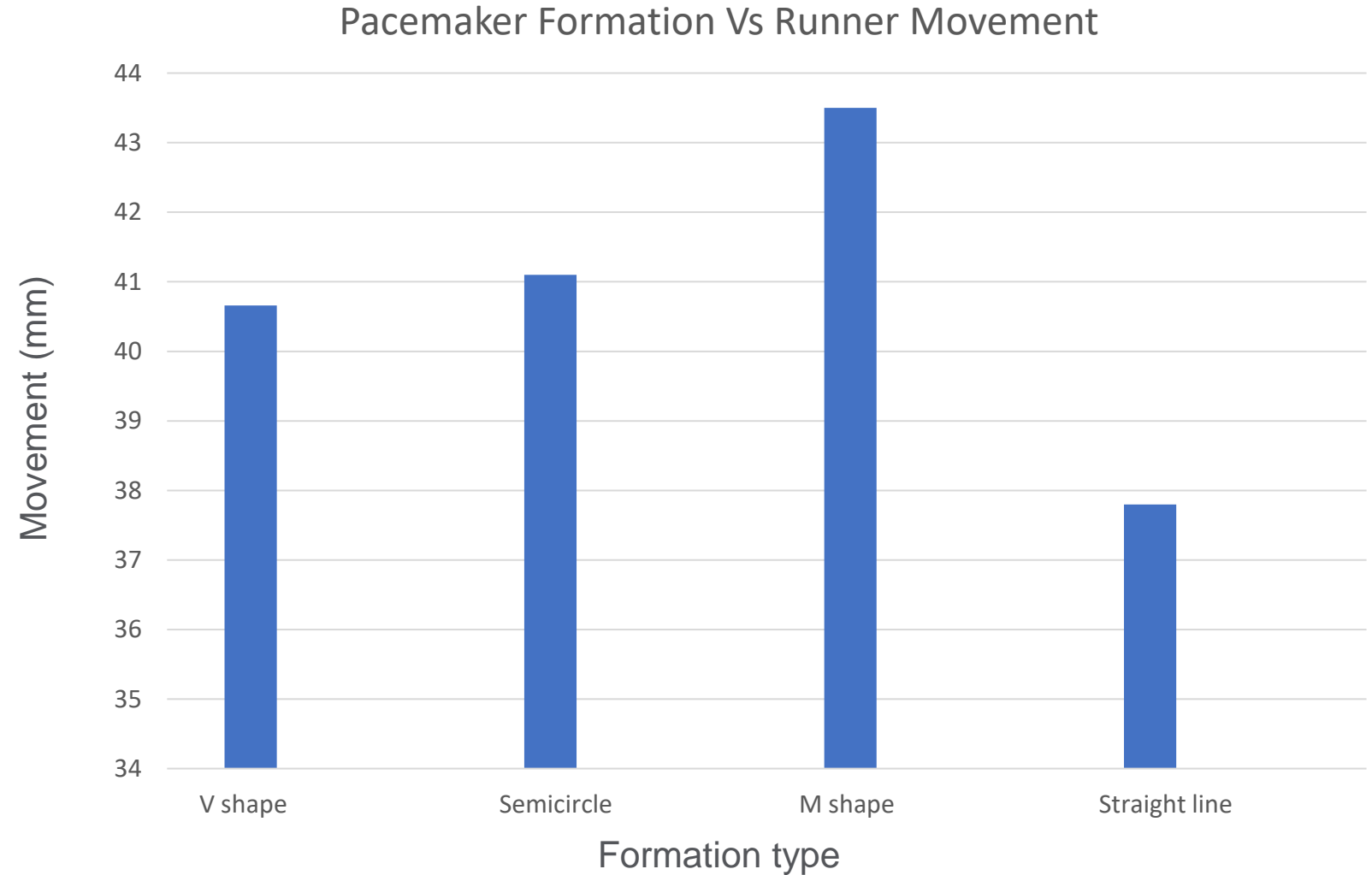
You will need to draw a table to record your results in. For example;

Formation	Location of runner at start	Location of runner trial 1	No. of mm	Location of runner trial 2	No. of mm	Location of runner trial 3	No. of mm	Average of 3 trials (mm)
V shape	F 10	E5	46	F4	35	E6	41	40.66
Semicircle								
M shape								
Straight line								

## RESULTS 2

In order to analyse your results you will need to draw a graph to show movement of your runner against formation type.

**How do you know which formation was the most effective at minimising air resistance?**



# DRAWING CONCLUSIONS



Writing a conclusion should have 2 parts and should answer your original question.

Which pacemaker formation is most effective at minimising air resistance?

*The 'x' formation was the most effective. This is because, from my results....*

*The 'y' formation is the least effective. I know this because...*

# BREAKING 2 VS INEOS 1:59

INEOS 1:59 was not the first time Eliud Kipchoge had attempted to run a marathon in under 2 hours. His first attempt was in 2017 with Nike. Watch the documentary Breaking 2.



## Research Task:

Compare Breaking2 with INEOS 1:59. What changes did the scientists make in order to ensure success in 2019?



# HOW SUCCESSFUL WERE YOU?

How well do you understand the following;

## Forces

- ❖ To understand air resistance is a force which slows things down
- ❖ To investigate how air resistance can be minimised

## Working scientifically

- ❖ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- ❖ Make predictions using scientific knowledge and understanding
- ❖ Present observations and data using appropriate methods, including tables and graphs

