KS4 Maths Glider Racing Probability Challenge – Teacher Notes

Essential prior knowledge:

- Speed, distance, time calculations
- Conditional probability (and/or rules)
- Conversion between fractions, decimals and percentages
- Conversion of time between seconds, minutes and hours
- Knowledge of ratios
- Scaling ratios up and down
- Conversion between metres and kilometres

Introduction

Use the introduction to establish what a glider is and what it can do. Elicit experiences from the class. Has anyone been gliding? Seen a glider in the air? Are there any gliding sites local to the school?

The video shows how gliders are able to stay airborne despite not having an engine. By turning in circles in columns of rising air called 'thermals' or 'lift' the glider can gain height. We fly from thermal to thermal using the lift we find to increase our height. Sometimes there are only weak thermals or no lift at all and we run out of height. In these scenarios we must head back to the airfield or, if we're not in range, land in a farmer's field – learning to select a suitable field and land in it safely is part of every pilot's training. Then we have to wait for someone to come and get us with a trailer.

Importantly here we discuss glide ratios. Make sure students understand what this means. The higher the glide ratio the better as it means we can glide further.

Watch and listen as one of our pilots flies a competition cross country leg. Notice how she hunts for the best thermals, turns in circles in the lift and then flies fast between the thermals.

Student activity

Students will fly a 300km competition course and compete to finish in the best time. The video shows the competition course - 300km long (this is a typical race distance for a medium performance glider) from start to finish beneath 9 equally spaced clouds. Each cloud is a potential source of lift. The weather report says the chance of lift beneath each cloud is 20%.

INFORMATION

With around 80 sites throughout the UK stretching from the Highlands of Scotland to the south west tip of England, wherever you live you'll never be far from a gliding club. You can find your closest gliding club on the BGA website
AWESOME FACT:
After completing your training you can fly a glider solo at age 14!

As well as thermals gliders can also use the air forced up over hills and mountains to stay airborne; this is known as ridge lift.
There is also mountain wave lift caused by currents of air that rise to get over the top of hills or mountains and then flow and rebound. They create a wave-like motion that can continue for hundreds of miles.
Glide ratios vary between aircraft. A Boeing 747 has a glide ratio of 17:1.
The space shuttle is 4.5:1.
Visibility is poor in cloud, and so gliders typically climb to cloudbase and then glide to the next cloud.

There are a few competition rules that must be followed:

- You start at 2000m at cloudbase and mustn't fly above this height
- Your glider has a glide ratio of 50:1 (refer back to the video if students struggle with this concept)
- Your glider can fly at 100kph
- If you find yourself below 500m at any point you must immediately pick a suitable field below your position and land, ending your flight.

The student handout contains all the information on the course and the competition rules.

Students should complete the 'start thinking' questions before being given the second sheet.

Can you complete the course if there is no lift under any of the clouds? Explain your answer

You will be unable to complete the course without any lift. By scaling up the glide ratio of 50:1 we find that from 2000m the glider will be able to glide only 100km – and as we must stop gliding at 500m to select a field, in practice not that far.

Assuming lift production by each cloud is **independent,** what is the probability of there being no lift under any of the clouds?

The probability of lift = 0.2. P(no lift under any of the 9 clouds) = 0.2^9

Assumes independent events. In reality, clouds usually form rows of lift called 'streets' and so they are not usually isolated. Advanced discussion: Does this explain why the likelihood of this happening appears so small mathematically? Discussion of theoretical vs experimental probability?

If there are no thermals (i.e. none of the clouds has any lift under it) **how far** can your glider fly before you must land?

From Q1 we know we can glide 100km before we would reach the ground but we must land when we reach 500m. This means we only have 1500m of height to glide before finding our landing area. Since we would only be able to use 75% of the height available meaning it would have to land after 75km.

What is the probability of **at least one** of the first two clouds producing lift?

P(lift) = $\frac{1}{5}$ P(no lift) = $\frac{4}{5}$

= (Cloud 1 lift and Cloud 2 no lift) or (Cloud 1 no lift and Cloud 2 lift) or (Cloud 1 lift and Cloud 2 lift)

=($\frac{1}{5} \times \frac{4}{5}$) + ($\frac{4}{5} \times \frac{1}{5}$) + ($\frac{1}{5} \times \frac{1}{5}$) = $\frac{4}{25} + \frac{4}{25} + \frac{1}{25} = \frac{9}{25}$

How long (in minutes) would it take you to climb 300m in lift of $2m/s^{-1}$?

At a climb rate of 2 metres per second it will take us 150 seconds to climb 300m
In minutes, this is 2 minutes and 30 seconds so 2.5 minutes.

Why would a competition glider pilot choose not to stop and thermal at every cloud?

In practice it takes some time to find the centre of the thermal. You might not need to gain any more height. The lift at that cloud might be weak and take too long to gain sufficient height. The next cloud may be stronger. Pilots want to get to the finish as quick as possible and so will make calculated decisions as to whether or not to stop based on the predicted strength of the next thermal.

Time to fly!

Give students the 'breaking weather news' handout. They must now discuss and plan their competition route. There are many possibilities. Some will result in a finish, others will end in fields. Challenge students to complete the course in the best time possible.
They will need to calculate how far the glider can go before it will need to thermal to gain height and consider how high they will climb each time. Is it necessary to climb up to cloudbase every time you thermal? Could you thermal higher but do it fewer times? The possibilities are endless.

The total time will consist of a combination of time spent thermalling **and** time spent transitioning between clouds. Just don't forget you can't fly below 500m at any point on the course.

Student handout pages 1 and 2 are overleaf.

If you and your class enjoyed this, explore our other STEM activities!

Note: This experiment creates a launch machine which can be used for the Go Gliding Science unit on energy transfer - see separate teacher and student notes - if appropriate the two activities can be merged.

We hope you found this useful and a fun way to encourage young people into the world of STEM and aviation. Girls in particular are under-represented in these areas and we are working to change this. Inspire them with videos of our STEM role models along with other exciting gliding-based STEM resources covering various elements of the National Curriculum on gogliding.uk and at www.gliding.co.uk/STEM.

Students can find out all about gliding at the British Gliding Association website and the Junior Gliding and Women Gliding communities at the links below. There's information about flying with and without an engine and all types of aviation at https://stem.caa.co.uk/ & www.airleague.co.uk – aviation is not just about being a pilot! The CAA STEM site is particularly good, showcasing the breadth of aviation and associated careers.

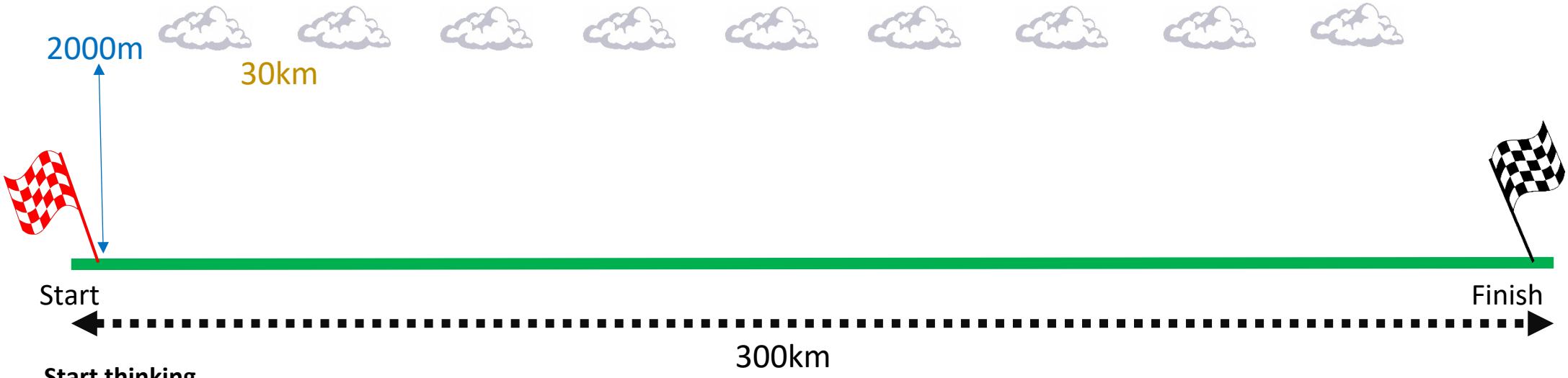
You can contact the Go Gliding team at gogliding@gliding.co.uk.

Glider Racing Probability Challenge

The challenge: Complete a 300km course from start to finish in the quickest time using the most efficient technique.

The course: 300km from start to finish beneath 9 equally spaced clouds (each of which may or may not be an indicator of the presence of a thermal). The Met Office weather report says that the probability of lift being present at any cloud is 20%.

The rules: Your timer starts at 2000m overhead the start flag. You must stay at or below cloudbase which is 2000m.. Your glider has a glide ratio of 50:1 and you will fly at 100kph between thermals. If your glider reaches 500m in height at any time you must land immediately in a field below you.



Start thinking…

- Can you complete the course if there is no lift under any of the clouds? Explain your answer.
- Assuming lift production by each cloud is **independent,** what is the probability of there being no lift under any of the clouds?
- If there are no thermals (i.e. none of the clouds has any lift under it) how far can your glider fly before you must land?
- What is the probability of **at least one** of the first two clouds producing lift?
- **How long** (in minutes) would it take you to climb 300m in lift of $2m/s^{-1}$?
- Why would a competition glider pilot choose not to stop and thermal at every cloud?

Breaking Weather News:

An area of high pressure has established itself over the UK bringing great thermal conditions.

You can expect to find lift at 3m/s^{-1} under all clouds on your route.

Time to fly!

Discuss and plan your route. How fast will you complete the course? Think about:

- How many times you will stop (if any)
- Where you will make those stops
- How high you will climb in the thermals. Are you climbing to cloudbase each time?
- Make sure you all understand the plan so you can feedback to the class.

Can you complete the course? Or are we coming to pick you up from a field with a trailer?

Good luck!!

Find out more about GLIDING at the links below, all types of AVIATION at airleague.co.uk & CAREERS at stem.caa.co.uk/careers-in-aviation-and-aerospace

Why not Go Gliding? Find your nearest gliding club at https://www.gliding.co.uk/club-finder/

We hope to see you on an airfield soon!

gliding.co.uk
members.gliding.co.uk/junior-gliding

gogliding.uk
womengliding.co.uk