KS3/4 DESIGN AND TECHNOLOGY
Zero Emissions Glider Launch Machine – Teachers' Notes

This unit builds students' ability to work scientifically, addressing the Design and Technology syllabus by designing & building a simple launch machine to launch a glider, investigating the impact of various design elements and identifying possible improvements. There is an extension task focussed on minimising launch machine emissions.

Note: there is a follow-on Science unit using the launch machine to examine energy transfers and construct an energy transfer diagram for the flight.

Equipment needed

For the launch machine:

- Something to make a launch ramp e.g. a breadboard or desktop
- Something to adjust the angle of the launch ramp eg blocks or books
- Elastic bands, drawing pins, string
- Tape measure and metre rule

For the glider:

- A piece of A4 card to make a glider to one of two possible simple designs – see overleaf for designs
- Paperclips to ballast the nose of the glider in flight

Introduction

Meet a gliding role model in our introductory video and use the introduction to establish what a glider is and what it can do. Pause the video before the Launch methods section. Elicit experiences from the class. Has anyone been gliding? Seen a glider in the air? Are there any gliding sites local to the school?

Glider launch methods

Gliders fly entirely on solar and wind energy once they are in the air, but need help launching first. The video shows the three common ways of launching a glider.

LAUNCH INFORMATION

Gliders fly entirely on solar and wind energy once they are in the air, but usually need a hand launching. Some gliders are able to 'self-launch' – with a small engine just powerful enough to get the glider airborne concealed within the fuselage behind the pilot. This is erected on a gas-strut for take-off. Gliders are very efficient flying machines and so this engine doesn't have to be very powerful. There are also 'self-sustainers' or 'turbos' – with even smaller engines, often electric, not capable of launching but with enough power to keep the glider in the air once flying. This reduces the chance of having to land in a field when weather conditions change and there is no lift to climb in.

GO GLIDING:
With over 80 sites throughout the UK you'll never be far from a gliding club.
AWESOME FACT: after completing your training you can fly a glider solo at age 14!

CAREERS INFORMATION:
Students can learn more about the breadth of aviation and careers in aviation and aerospace at **stem.caa.co.uk/careers-in-aviation-and-aerospace**

Gliding STEM Resources

Most glider launches are by **winch** which is fast, relatively cheap and with low emissions – many winches are powered by LPG and there are also electric winches. Winch launch height depends on the length of the runway and also the wind strength – stronger headwinds mean higher launches. An **aerotow** behind a powered aircraft can launch the glider to a specific height and position, this is another common launch method and is used to launch gliders in competitions. Most tow planes - also known as 'tugs' - are petrol powered but early tests on electric aircraft may result in emissions-free aerotowing in the next few years. **Bungee** launching by stretching a thick rubber rope is fun and has zero emissions but can only take place in the correct wind conditions at hill-top sites when the pilot can be sure of remaining airborne in the air rising over the hill.

Once a glider is launched, it can fly hundreds of kilometres at Formula 1 car racing speeds BUT, unlike the F1 car … with zero emissions!

Pause the video after the bungee launch for the design and build phase.

Designing the launch machine

The students' challenge is to build a launch machine to launch a standard design of glider into repeatable, stable flight, to a height of at least 30cm and flying a distance of at least 4m. **The glider must fly smoothly, not pitch up and stall.** Most students will design an angled launch ramp using board and blocks and construct a bungee from the elastic bands, but other designs that achieve the brief are acceptable!

Elicit class ideas as to the key features of a launch machine. Then students should embark on the activity, either solo or in groups – ideally make sure that each glider design is tested for a performance comparison. From their initial design, students should adjust the glider and launch machine to achieve stable flight. Student will investigate the impact of adjusting:

- the angle of the launch ramp
    - Typically students will angle this too steeply. Stable flight is easier to achieve with lower ramp angles – although this will shorten the flight length & peak height achieved. A good design would be easily adjustable.
- the amount of energy transferred to the glider for the launch ie how much they stretch the elastic band
    - more energy creates more speed and so more lift on the wing of the glider and increases its chance of pitching up and stalling which may mean more nose ballast is needed
    - students should identify that they can give the glider more energy either by stretching the bungee further or by creating a stronger bungee by adding more bands in parallel
    - repeatability requires a design feature such as fixed bungee ends and distance/tension marks on the board to ensure same energy each launch
- the ballast on the nose of the glider by adding or removing paperclips
    - typically an unballasted glider will not fly stably – it will pitch up and stall, at which point it may pitch back down and regain stable flight although not necessarily in the right direction! Several paperclips may be required to achieve stable flight.
    - Teachers' notes on pitch (ie fore and aft) stability: all aircraft must have their CofG within certain limits to fly safely. The CofG must be forward of the wings' centre of lift to create a stable situation and hence pilots always do a weight and balance calculation before each take-off. Almost all paper-dart designs are to heavy at the rear to fly in a stable manner, hence need paperclips at the nose to move the CofG forward.
- the angle of the glider wings to the fuselage

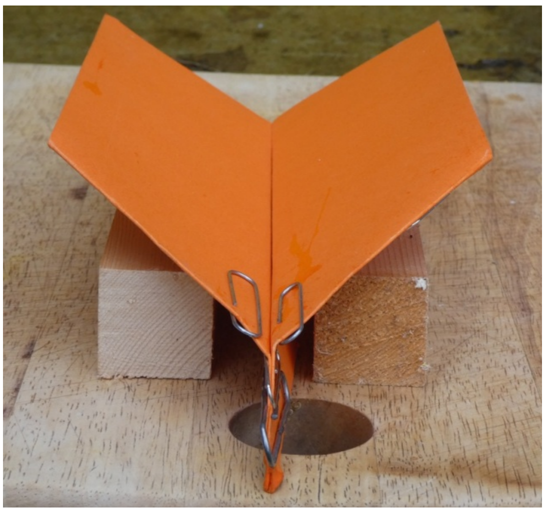
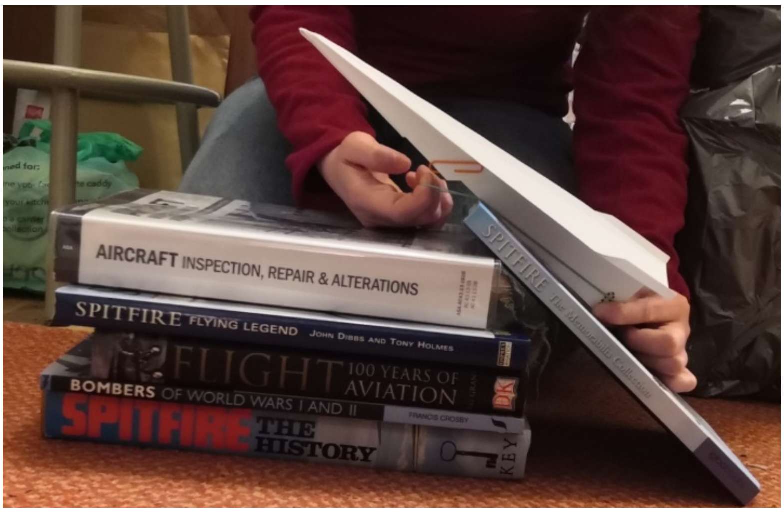
- students will generally start with the wings at right angles to the fuselage. To increase chances of flying in a straight line, angle the wings up slightly.
- Teachers' notes on roll stability (ie about the axis of the fuselage):
  - Wings that angle down are unstable – this makes the plane harder to fly but also more manoeuvrable, remind the students of the design of jet fighters which have down-swept wings for agility in combat. Wings that angle up from the fuselage are inherently stable* and most aircraft are designed this way to make them easier to fly. (* if horizontal flight is disturbed, the wing that tips down slightly gains a longer horizontal component and so generates more lift – whereas the upgoing wing has a shorter horizontal component and so generates less lift – hence the aircraft tends to right itself back to horizontal flight) Almost all gliders and commercial jets have mid-level wings which are angled up towards the tips.
  - Wings mounted at the top of the fuselage, as in the two designs here, are more stable than mid-level wings as the fuselage weight creates a 'pendulum' effect swinging back down if tilted.
  - The tilted-up wingtips now seen on most commercial aircraft were developed on gliders and reduce drag at the wingtip, improving performance and handling.

Repeatable stable flight is most easily achieved with the minimum ramp angle and bungee energy to achieve the height and distance required.

How have students demonstrated that the glider exceeds the 30cm height gain requirement? This could be done visually or with a bar using perhaps the string or metre rule set at the appropriate height approx 2m from the launch ramp.

The pictures below show some of the designs we made when developing this unit during COVID lockdown; optional video 'Launch Demo Ramp and Flight' shows how we did it!



Once the students have completed the challenge questions, lead a discussion on the ideal materials to make the launch machine.

Extension tasks (not listed on student worksheet)**:**

Discuss emissions in the various launch types:

- Winches are generally powered by petrol, diesel or LPG engines, but there are also electric winches. Discussion - would an electric winch have zero emissions? Answer: it would be largely emission-free at point of use but generating the electricity may have produced emissions; winch cable gradually wears but is generally steel and produces no problematic waste. It is interesting to compare this to electric cars - as well as any electricity emissions, a significant part of a car's emissions come from tyre wear, so a green-electricity-powered aircraft is potentially lower emission than a car!
- Electric aircraft are being developed – ask the students to research some examples of electric aircraft development. Might any be suitable as glider towplanes? They would need to be able to fly at speeds between 90 and 180kph with a load capacity of 250 - 850kg in addition to the towplane pilot & fuel load.

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.

KS3/4 DESIGN AND TECHNOLOGY

Zero Emissions Glider Launch Machine – Student Notes

Do you know about gliding?

Do you know what a glider can do? It's an awesome way to fly, and glider pilots fly hundreds of kilometres at speeds of over 100kph, just using renewable energy from the sun and the wind. To get into the air, they have to be launched using a winch, a bungee or be towed by a light aircraft.

Your challenge: Build a launch machine to launch a standard* design of glider into stable flight, to a peak height of at least 30cm and flying a distance of at least 4m

Materials available:

- A4 card; Elastic bands; Paperclips; Board at least 40cm length; String; Blocks
- Tape measure and metre rule

The Challenge:

1. Make your glider out of card to one of the two designs overleaf. If time permits, make both and see which performs better, or compare performance with a group using the other design.
2. Design and construct your launch machine.
3. Launch a glider from the ramp at ground level into stable flight to a height of at least 30cm and flying a distance of at least 4m.
4. **The glider must fly smoothly, not pitch up and stall.** Adjust the glider and launch machine until you achieve repeatable, stable flight. You might need to adjust:
    - the elevation angle of the launch ramp
    - the amount of energy transferred to the glider during the launch
    - the ballast on the nose of the glider
    - the angle of the glider wings
5. Carefully observe the effect that these adjustments have on how the glider flies.
6. Answer the challenge questions.

Challenge Questions

1. How far did your glider fly?

   ……

2. How did you measure to ensure it exceeded 30cm above launch level at the peak of its flight?

   ……

3. What gives the glider energy to start its flight?

   ……

4. What was the effect of adjusting the amount of energy in launching the glider?

   ……

   ……

5. What was the effect of adjusting the angle of the launch ramp?

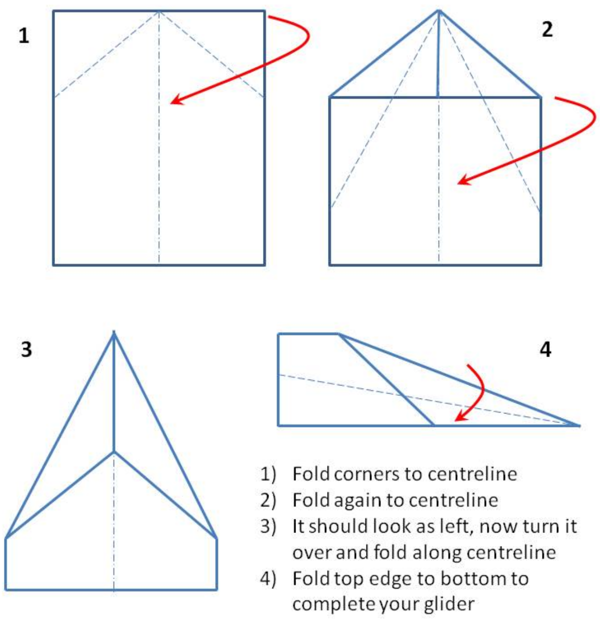
6. What was the effect of altering the ballast on the nose of the glider?

7. What was the effect of adjusting the angle of the wings? Was it easier to achieve stable flight with the wings at right angles to the fuselage, angled down or angled up?

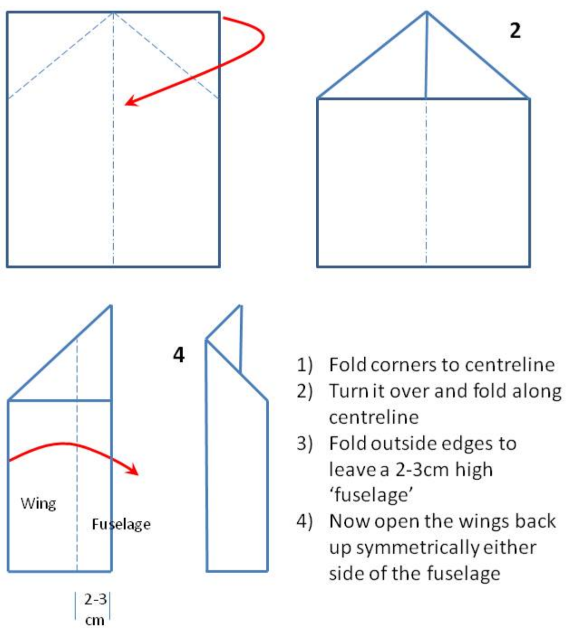
8. How would you improve your design if other materials were available?

**** Use one of these glider designs:***

Glider Design 1



Glider Design 2



We hope you had fun designing your Launch machine!

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