The Forces of Flight Calculations

The questions below have been kindly set by Geoff Coxon from The SkyLab.

There are two tasks in this challenge which combine mathematics and science. In the first task you must work out the area of the wings of a Spitfire and a Typhoon. In the second task you will use calculations to compare the performance between the two aircraft. You will be amazed at the difference!

**Task 1**
In the pictures below you will see the Spitfire and Typhoon wings have been simplified into triangular shapes which will help with your calculations to establish the total wing area of each aircraft.
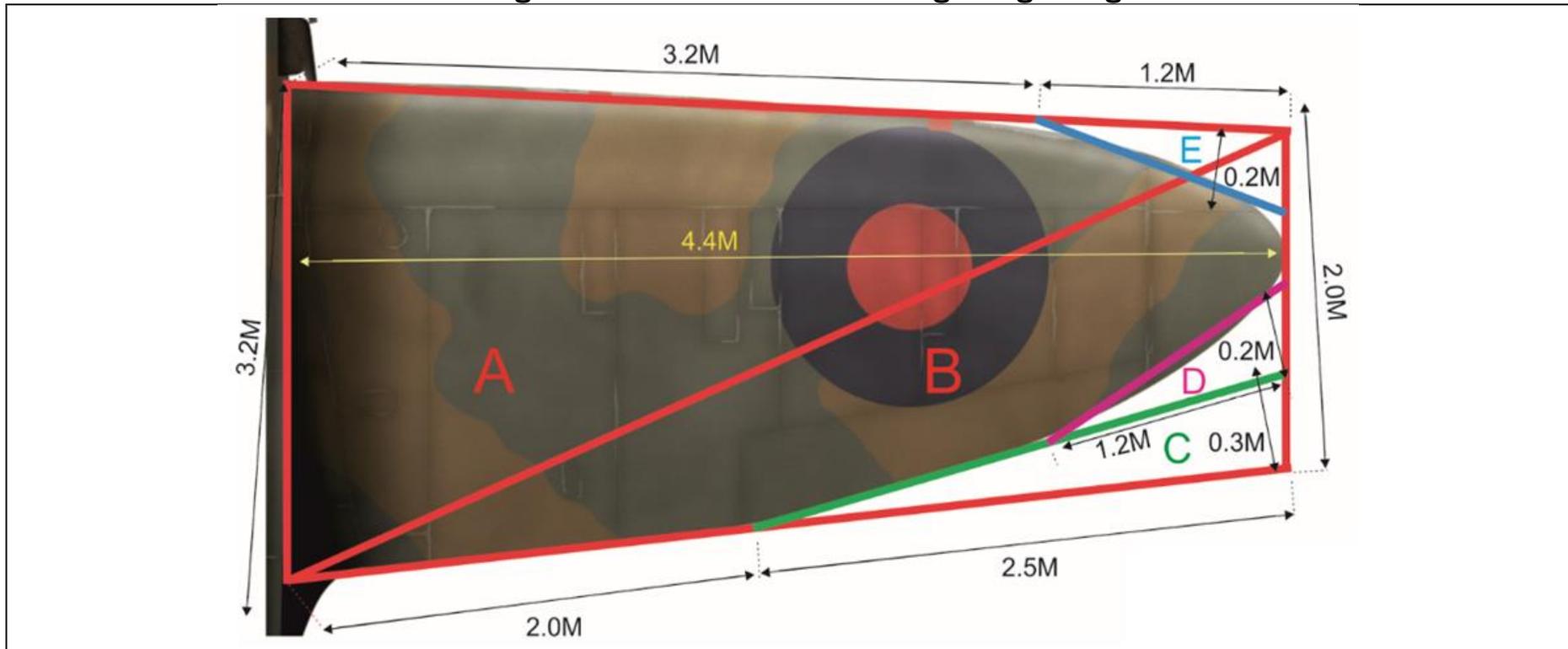
**The Spitfire**
Look at the picture of the Spitfire's starboard wing below. You will see that it is made up of triangles and by working out the area of these triangles you can work out the area of the wing.

To make this easier, the areas we need to work out have been given a letter. The total area of one wing will be the areas of triangles A + B − (C + D +E).

*Tip. To make it easier if your answers are close to a round number you can round them up and down. So, for instance if you have a figure of 4.9, you can round it up to 5.*

To help you, we have worked out the area of triangle A. Use this to help guide you to work out the area of the other triangles.

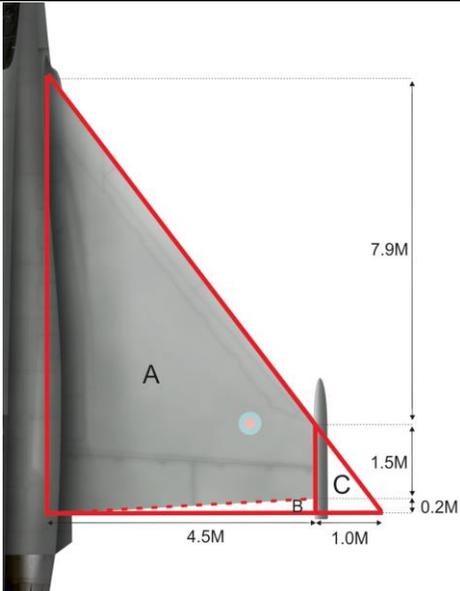# Calculating the area of the starboard wing using triangles



| Triangle A | Triangle B | Triangle C | Triangle D | Triangle E |
|---|---|---|---|---|
| **Area = ½ x base x height** | Area = ½ x base x height | Area = ½ x base x height | Area = ½ x base x height | Area = ½ x base x height |
| Area = ½ x (3.2 + 1.2) x 3.2 | Area = ½ x (2.0 + 2.5) x 2.0 | Area = ½ x 2.5 x 0.3 | Area = ½ x 1.2 x 0.2 | Area = ½ x 1.2 x 0.2 |
| Area = ½ x 4.4 x 3.2 | Area = ½ x 4.5 x 2.0 | Area = 1.25 x 0.3 | Area = 0.6 x 0.2 | Area = 0.6 x 0.2 |
| Area = 2.2 x 3.2 | Area = 2.25 x 2.0 | **Area = 0.38 M²** | **Area = 0.12 M²** | **Area = 0.12 M²** |
| **Area = 7 M²** | **Area = 4.5 M²** | | | |

Total wing area = A + B − (C + D + E)
Total wing area = 7 + 4.5 − (0.38 + 0.12 + 0.12)
Total wing area = 11.5 − 0.6
Total wing area = 10.9 M²
Total wing area = 11 M² (after rounding up to 11)
For both the starboard and the port wings = 2 x 11 = **22 M²**

## The Typhoon

We now want you to do exactly the same with the Typhoon. This time we need only work out the area of the large triangles A and then subtract the areas of B and C.

### Area of the starboard wing of Typhoon



| Triangle A | Triangle B | Triangle C |
|---|---|---|
| Area = ½ x base x height<br>Area = ½ x (4.5 + 1.0) x (0.2+1.5+7.9)<br>Area = ½ x 5.5 x 9.6<br>**Area = 26.4 M²** | Area = ½ x base x height<br>Area = ½ x 4.5 x 0.2<br>**Area = 0.45 M²** | Area = ½ x base x height<br>Area = ½ x 1.0 x (1.5+0.2)<br>Area = ½ x 1.0 x 1.7<br>**Area = 0.85 M²** |
| Total wing area = A – (B +C)<br>Total wing area = 26.4 – (0.45 + 0.85)<br>Total wing area = 26.4 – 1.3<br>Total wing area = 25.1 M²<br>Total wing area = 25 M² (after rounding down to 25)<br>For both the starboard and the port wings = 2 x 11 = **50 M²** | | |

**Task 2.**

Using the areas of the wings and the data in the aircraft comparison table below, answer the following questions.

*Tip: round your answers up or down to the nearest whole number*

| Parameter | Spitfire Mk2A | Typhoon FGR4 |
|---|---|---|
| Maximum speed (mph) | 354 | 1320 |
| Maximum rate of climb (m/s) | 15 | 318 |
| Maximum range (miles) | 430 | 1800 |
| Service ceiling (metres) | 10500 | 19800 |
| Maximum take-off mass (kg) | 2800 | 23500 |
| Fuel capacity (kg) | 800 | 5000 |
| Maximum thrust (kN) | 6.5 | 180 |

**Q1. Which aircraft should be the most manoeuvrable?** Remember, the higher the wing loading the more lift the wing creates and the better the manoeuvrability.

You can work out the wing loading by dividing the take-off mass of the aircraft by the area of the wings you calculated in task 1. In aviation wing load is measured in Kilogram per square metre (Kg/M$^2$).

1st calculate the wing loadings

The wing load of the Spitfire = 2800/22
                            = 127 kg/m$^2$


The wing load of a Typhoon = 23500/50
                            = 470 kg/m$^2$



How many times larger is the wing load of the Typhoon compared to the Spitfire?
470/127 = 3.7

The Typhoon wing load is __4__ times more than the Spitfire, so the more manoeuvrable

aircraft is ___Typhoon_____

**Q2. At maximum speed, how many times more powerful is the Typhoon compared to the Spitfire?**
*Tip: power = thrust*

180/6.5 = 27.7 so 28 times more powerful

**Q3. How many times faster is the Typhoon compared to the Spitfire?**

1320/354 = 3.7 so 4 times faster

**Q4. How many times quicker can the Typhoon climb than the Spitfire?**

318/15 = 21.2 so 21 times quicker

**Q5. How many times more fuel can the Typhoon carry compared to the Spitfire and why do you think it needs so much more?**

5000/800 = 6.25 so 6 times more fuel

It has two powerful jet engines that need more fuel to give the huge difference in power.

**Q5. What subjects at school do you think you would need to use if you wanted to work in aviation technology?**

Maths, science, design & technology, IT, Code