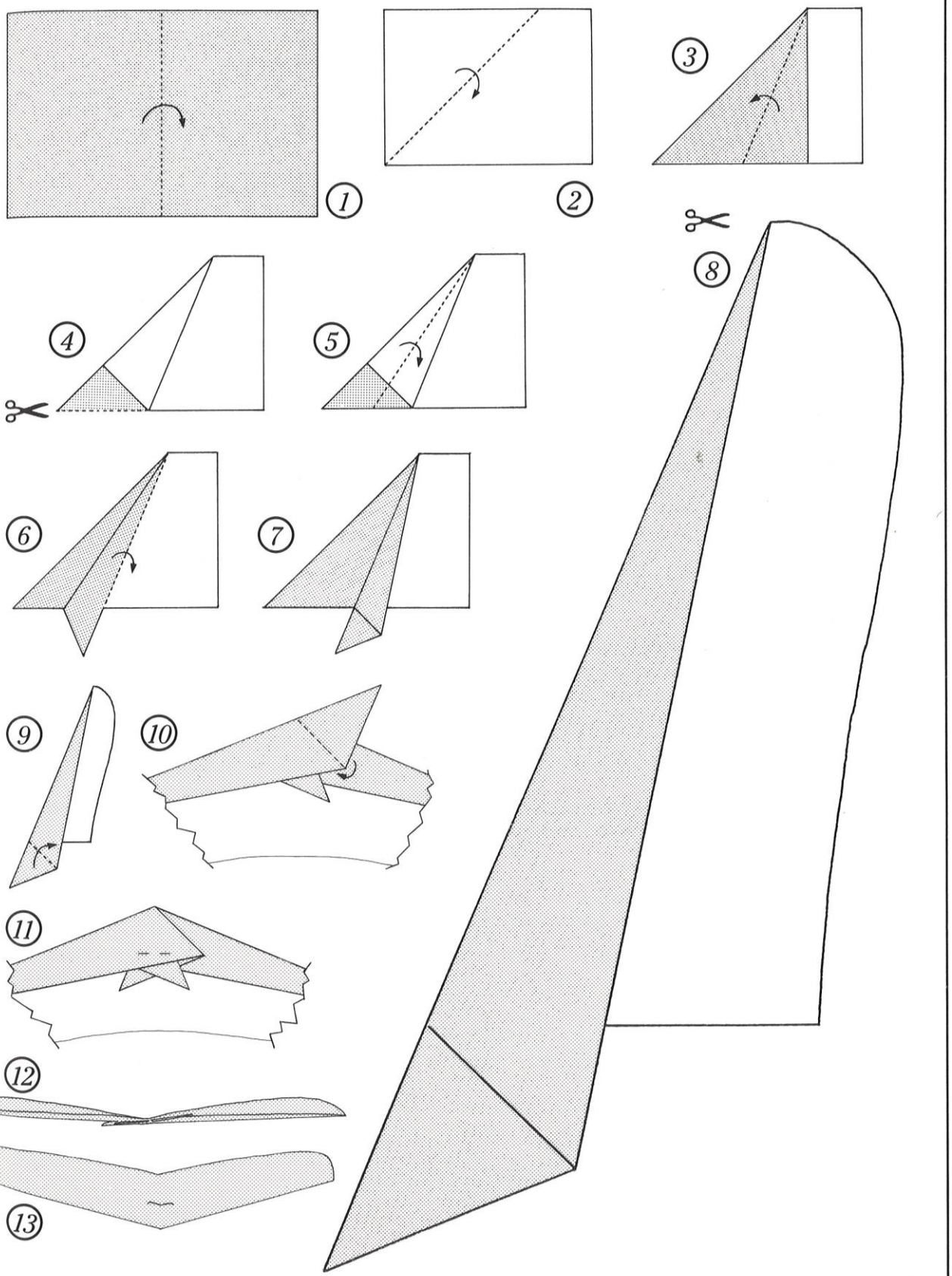
1
2
3
4
5
6
7
8
9
10
11
12
13

Approximate viscosities of a variety of fluids

Fluid	Viscosity / Pa s
Helium (2K)	0
Air (20°C)	0.0000183
Water (20°C)	0.001
Olive oil (20°C)	0.084
Shampoo (20°C)	100
Honey (20°C)	1000
Glass (540°C)	10^{12}

Effect of Reynold's number on the airflow around a ball or other object

Reynold's number	Boundary layer	Type of wake	Main drag force
<2000	Laminar	Small laminar	Viscous
2000 – 100 000	Laminar	Large turbulent	Pressure
>100 000	Turbulent	Small turbulent	Pressure

Important laws and equations

Poiseulle's Law

$$\frac{volume}{time} = \frac{\pi \Delta p D^4}{128 l \eta}$$

Where Δp = pressure difference, D = pipe diameter, l = pipe length and η = fluid viscosity.

Reynold's number

$$\text{Reynold's number} = \frac{\text{Density x obstacle length x flow speed}}{\text{viscosity}}$$

Problems

1 About how fast can a small fish swim before experiencing turbulent flow around its body?

2 How much higher must your blood pressure get to compensate for a 5% narrowing of your blood vessels? (The pressure difference across your blood vessels is essentially equal to your blood pressure)

3 If someone replaced the water in your home plumbing with olive oil, how much longer would it take you to fill a bath tub?

4 You are trying to paddle a canoe silently across a still lake and know that turbulence makes noise. How quickly can the canoe and paddle travel through the water without causing turbulence?

5 If the plumbing in your home carried honey instead of water, filling a cup to brush your teeth could take a while. If the cup takes 5s to fill with water, how long would it take to fill with honey, assuming all the pressures remain unchanged?

6 How quickly would you have to move a 1cm diameter stick through olive oil to reach a Reynold's number of 2000, when you would begin to see turbulence around the stick? (Olive oil has a density of 918kg m^{-3})

7 The effective obstacle length of a blimp is its width, that is the distance to which the air is separated as it flows around the blimp. How slowly would a 15m wide blimp have to fly in order to keep the air flow around it laminar? (Air has a density of 1.25kg m^{-3})

Data and problems from "How things work, the physics of everyday life" 3rd ed" by Louis Bloomfield, Wiley, 2006
How do wings work? Prof Holger Babinsky 2003 www.iop.org/journals/physed