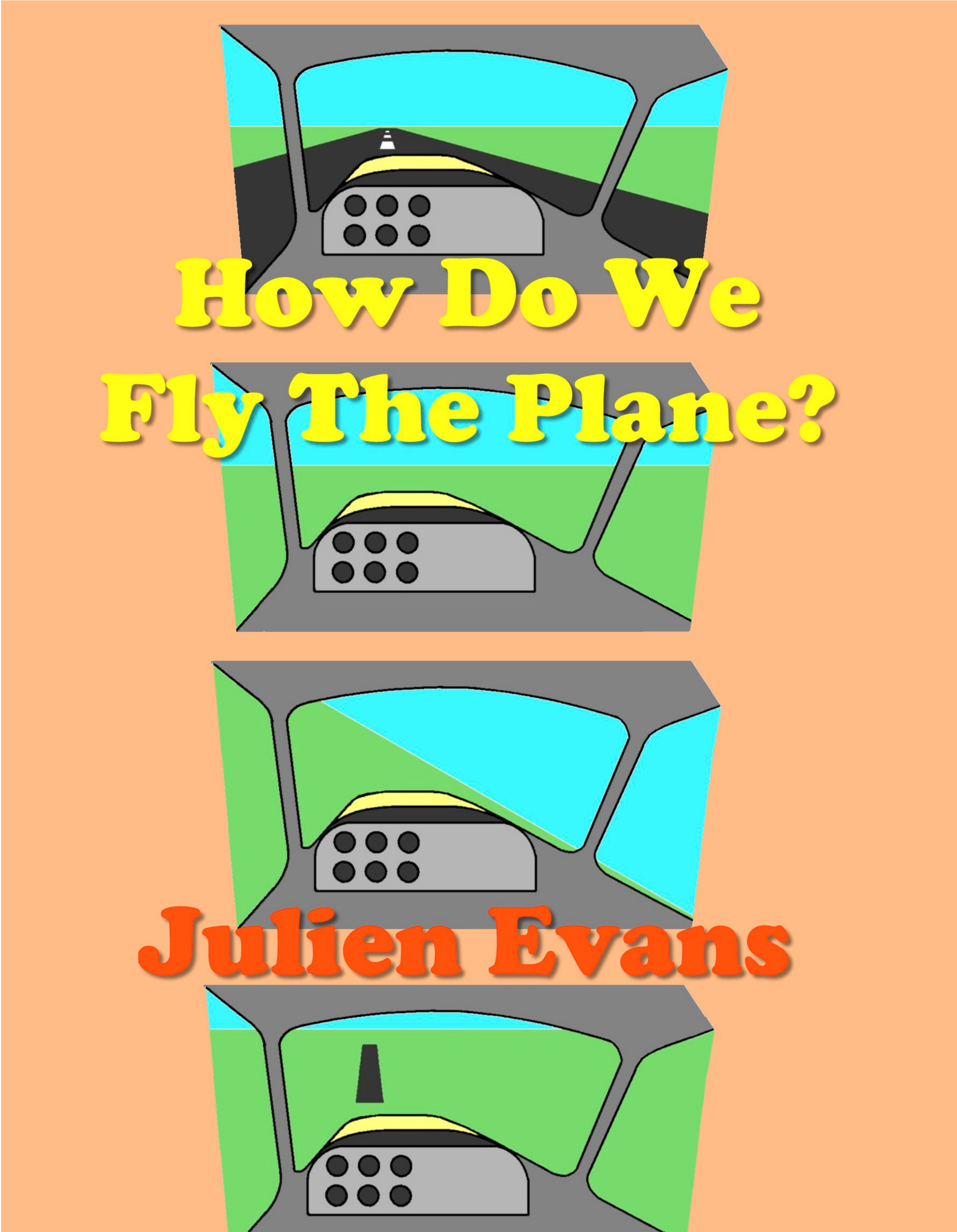
How Do We Fly The Plane?

Julien Evans



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Introduction

For readers with little or no knowledge of the subject, the purpose of this booklet is to describe basic operation of light aircraft. The contents are based on excerpts from the book 'Handling Light Aircraft' by Julien Evans.

Note that this booklet is not intended to teach aircraft handling or piloting procedures, which are the domain of professional instructors.

But if the reader is perhaps thinking about taking a trial lesson or might find himself or herself a passenger in a light aircraft whose pilot intends to offer them a chance to take the controls, these notes may be helpful.

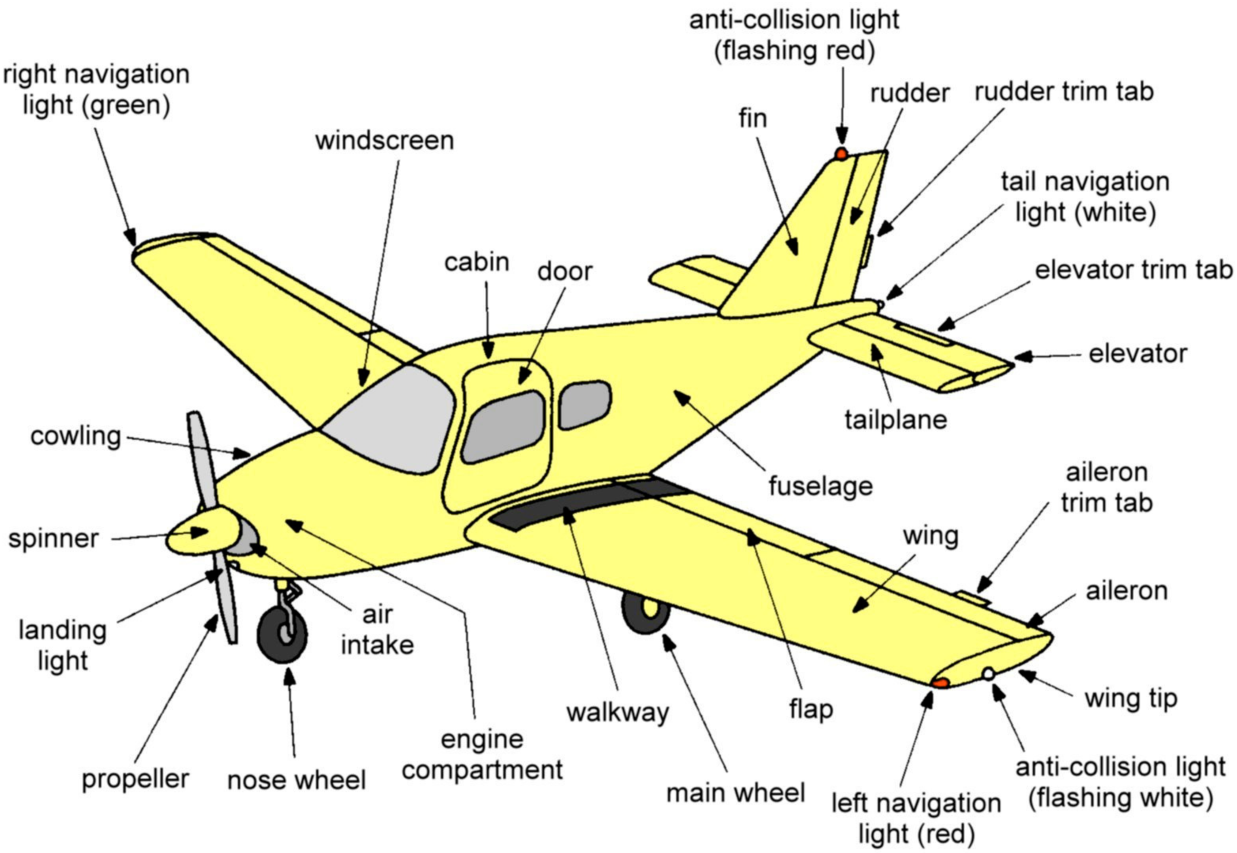
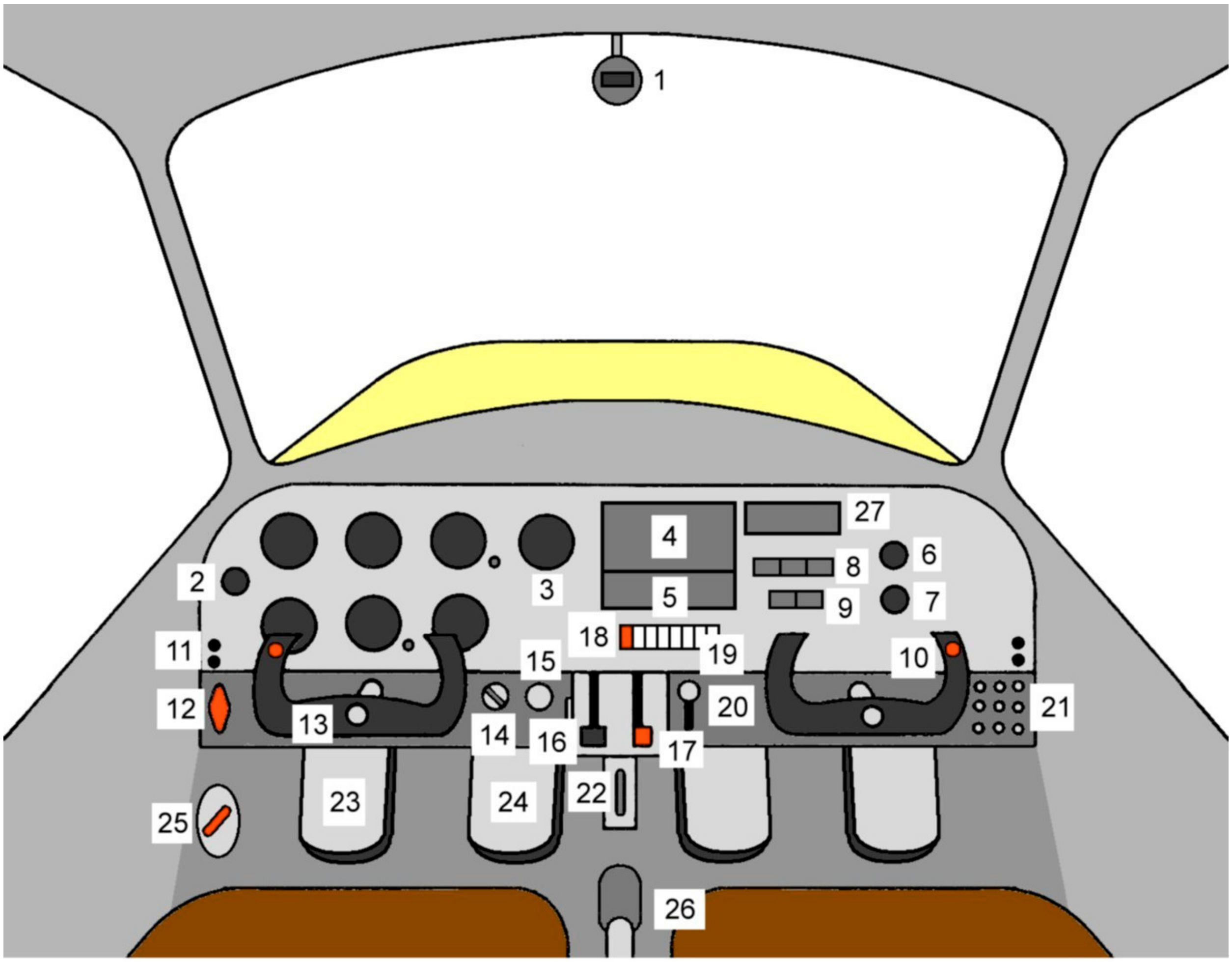


FIG 1. The aircraft

The main features of the typical modern light aircraft are shown in **Figure 1**.



1 Magnetic compass
2 Clock
3 Tachometer
4 GPS map display
5 COM transceiver
6 Ammeter
7 Suction gauge
8 Engine gauges
9 Fuel quantity
10 Transmit buttons
11 Headset jack points
12 Park brake control
13 Control wheel
14 Magneto switch control
15 Fuel primer
16 Throttle (friction control to left)
17 Mixture control (red capped)
18 Master switch
19 Electrical services
20 Carburettor heat control
21 Circuit breakers
22 Elevator trim wheel
23 Left rudder pedal
24 Right rudder pedal
25 Fuel cock
26 Flap lever
27 Transponder

FIG 2. Cabin layout

Figure 2 shows the layout of controls and instruments in the cabin. Although dual controls are standard on most aircraft, the pilot usually occupies the left hand seat, which is why the flight instruments are installed on the left side of the panel. The items that concern us are the **control wheel (13),** the **rudder pedals (23 and 24)**, the **throttle (16)**, the **flap lever (26)** and the **tachometer (3)**, which shows the power output from the engine.

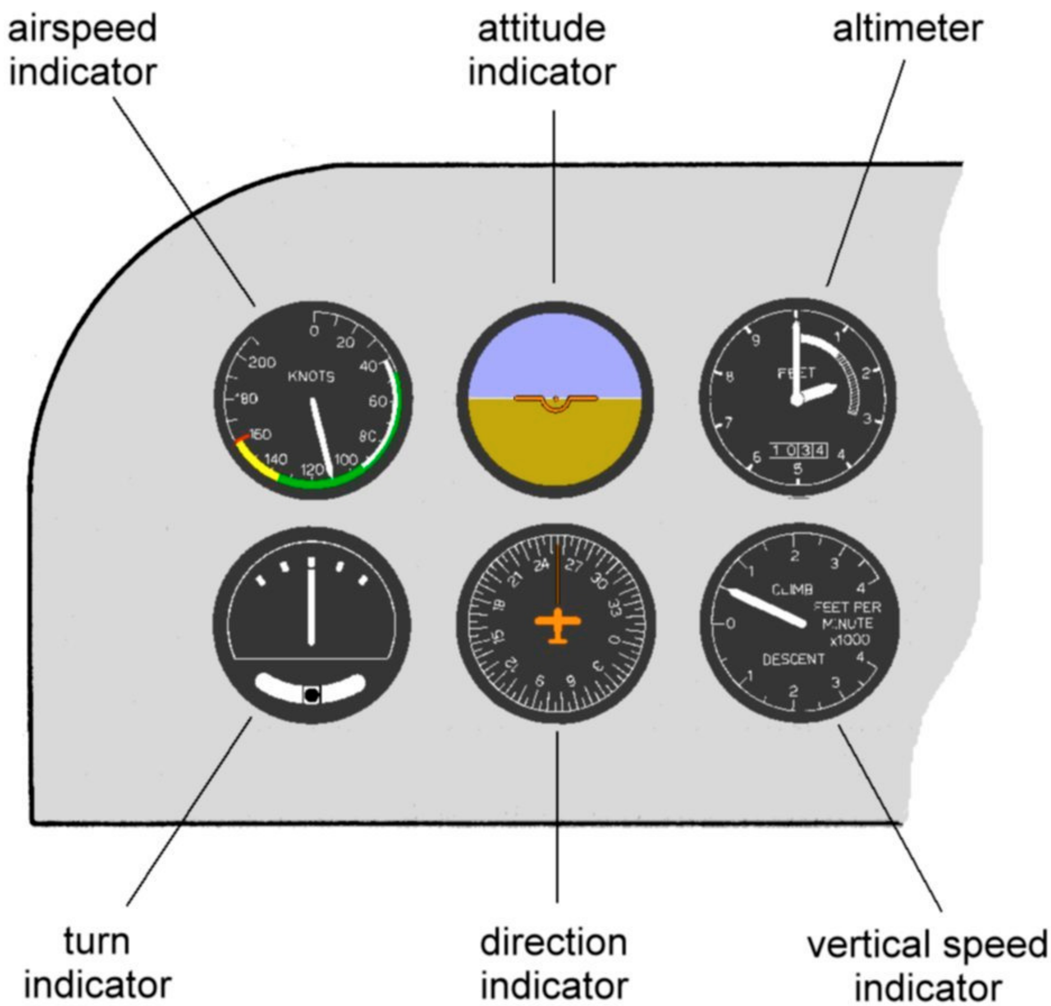


FIG 3. Flight instruments

Figure 3 shows the layout of the flight instruments. The ones that concern us are the **airspeed indicator**, the **altimeter** and the **direction indicator**.

The most obvious difference between aircraft and ground based vehicles is the freedom of aircraft to move in the third dimension. The pilot is able to control the vertical (up-and-down) flight path of the aircraft as well as its horizontal (left-and-right) flight path and the speed at which it is flying. **The flight path is controlled by inputs from the control wheel. Speed is controlled by either control wheel inputs or engine power setting.**

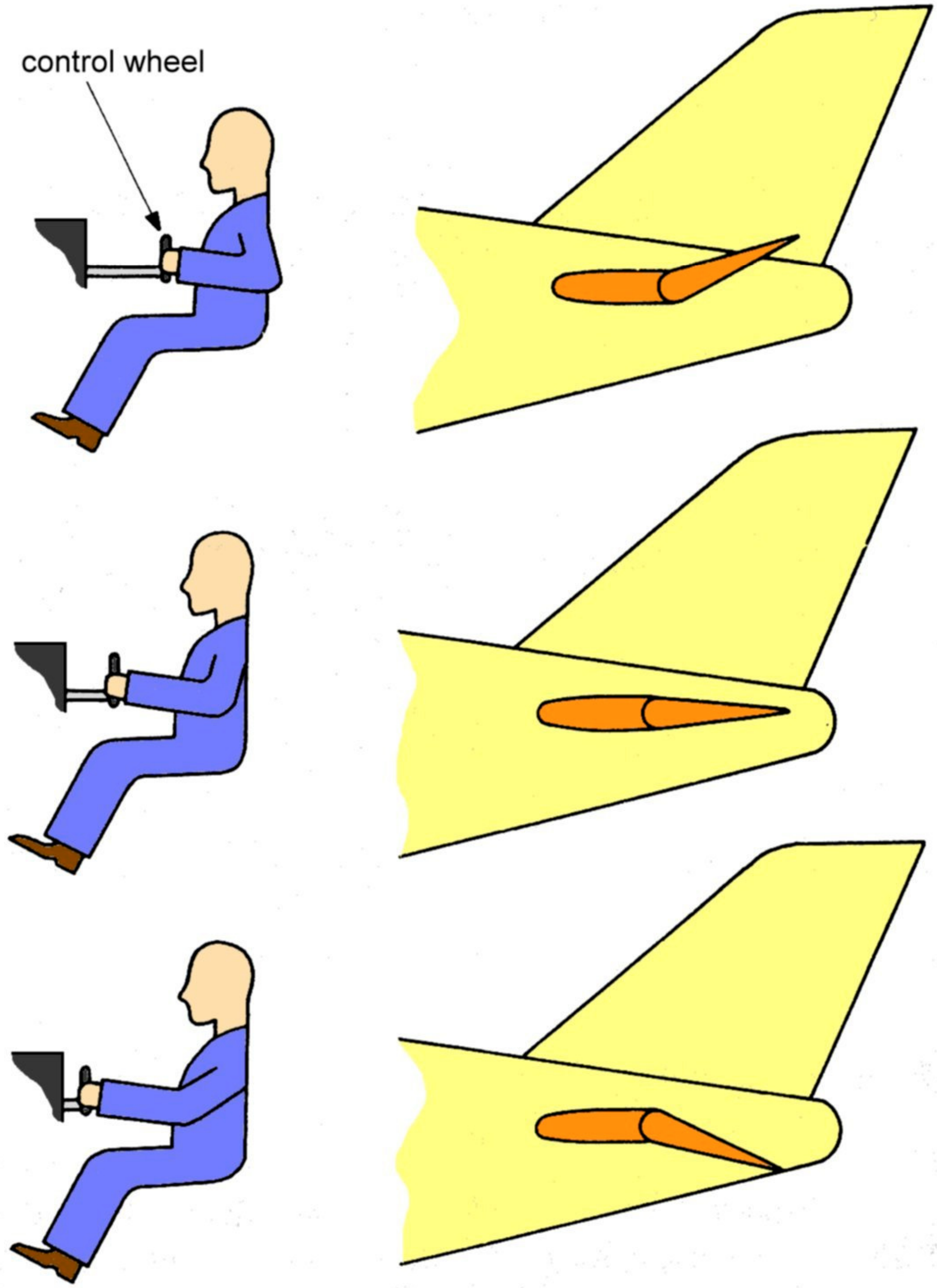


FIG 4. Elevator control

The Primary Flight Controls

The primary flight controls are the **ailerons**, **elevators** and **rudder**. The ailerons and elevators are connected to the **control wheel** and the rudder to the **rudder pedals**. The control wheel can be turned from side to side (like a car's steering wheel). Additionally it can be pulled towards the pilot or pushed away from him or her. When the control wheel is pulled back, the elevators move upwards, and vice versa (**Figure 4**).

In flight, the elevator position determines the airflow pattern past the tailplane. If the pilot pulls the wheel back the aircraft will raise its nose and its speed will decrease. If he or she pushes it forwards the aircraft's nose will drop and its speed will increase. **Figure 5** shows the pilot's view.

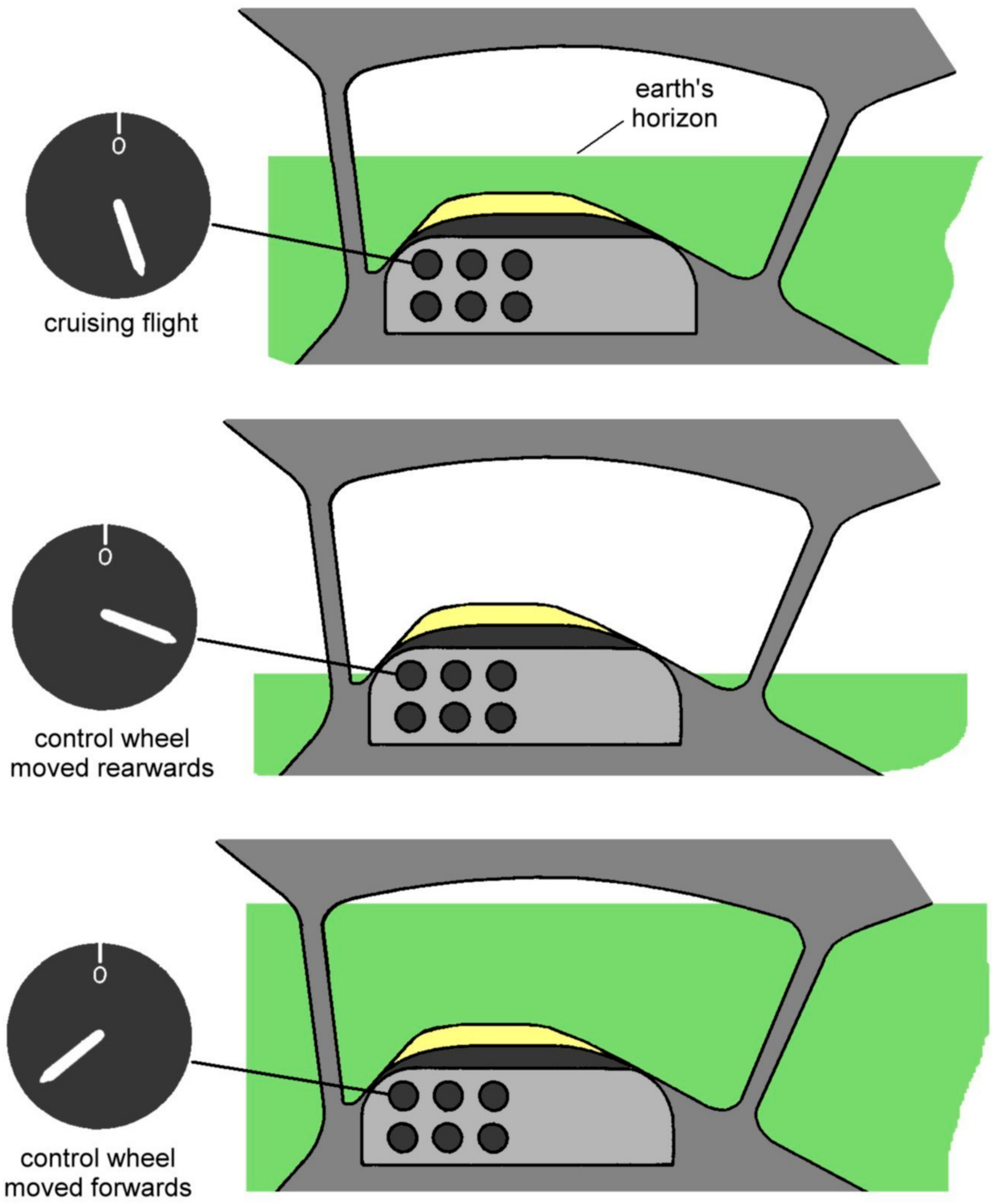


FIG 5. Effect of elevators

When the control wheel is turned to the left, the aileron on the left wing moves up and that on the right wing moves down. If the wheel is moved to the right the ailerons move in the opposite sense (**Figure 6**).

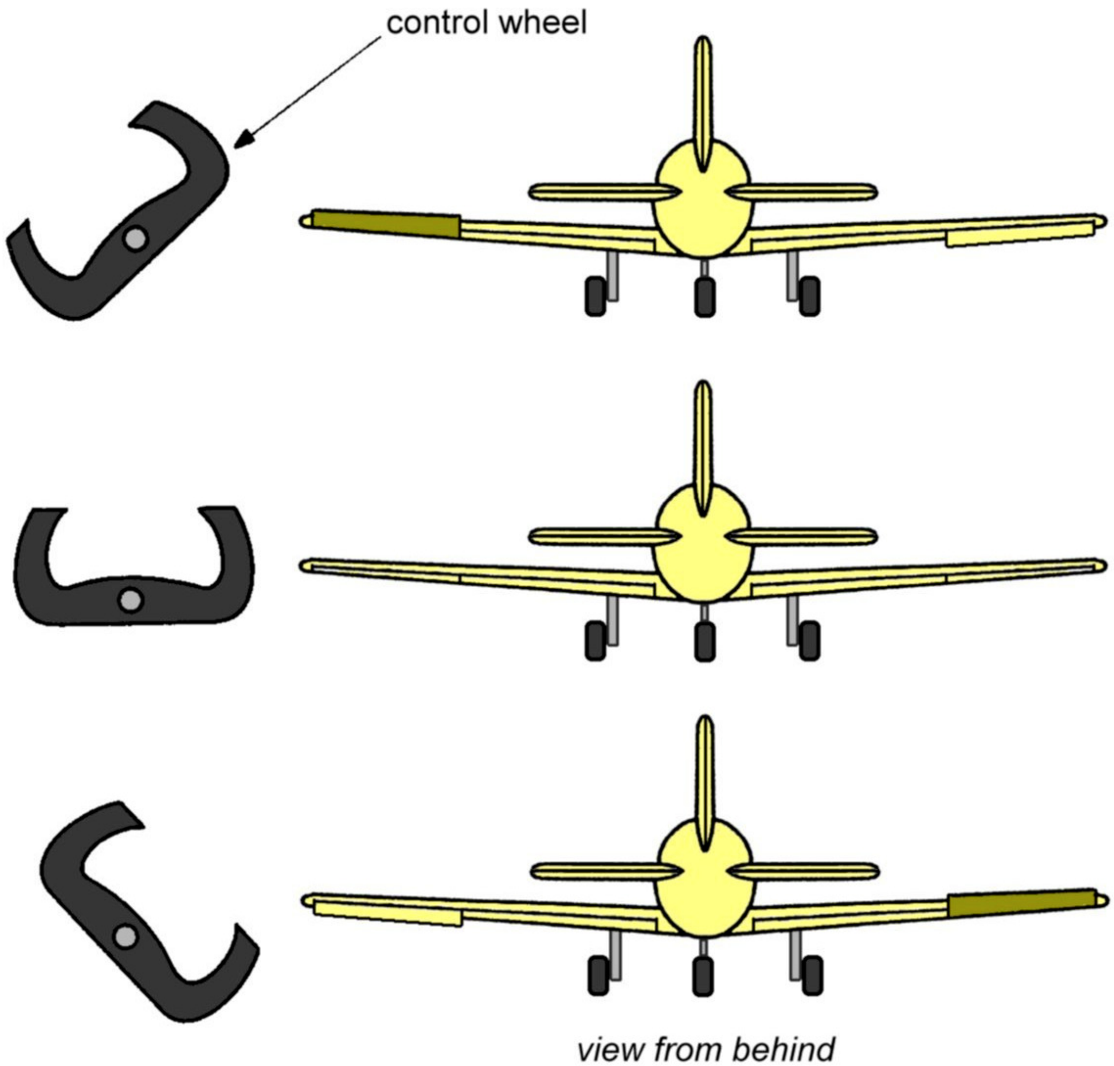


FIG 6. Aileron control

In flight, the effect of the aileron movement is to change the airflow patterns over the wings. If the pilot moves the wheel to the left the left wing will go down and the right wing up. This motion is called **rolling to the left**. Moving the wheel to the right makes the aircraft roll to the right. When the control wheel is centred the aircraft will maintain the angle of bank it has attained (**Figure 7**).

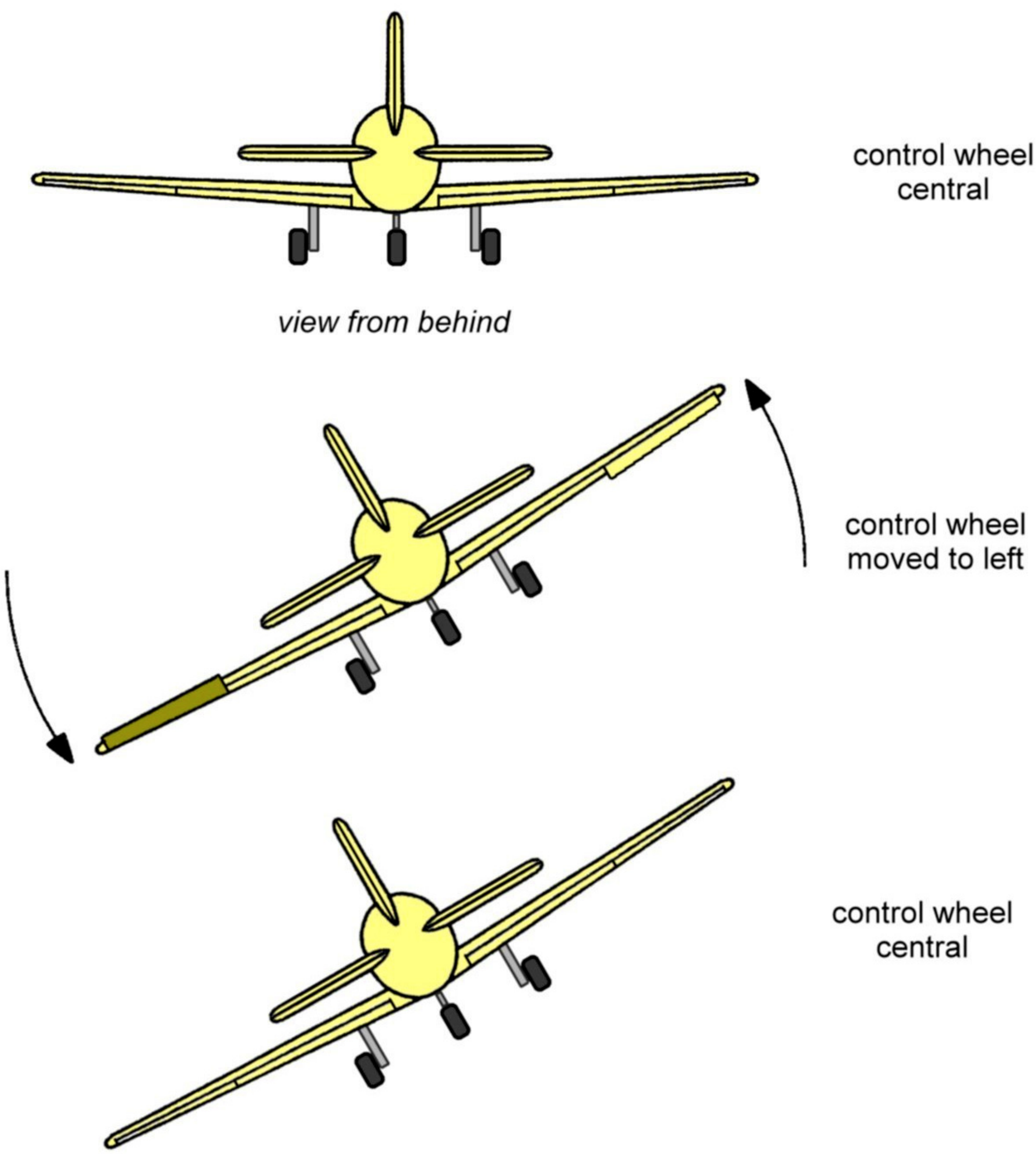


FIG 7. Effect of ailerons

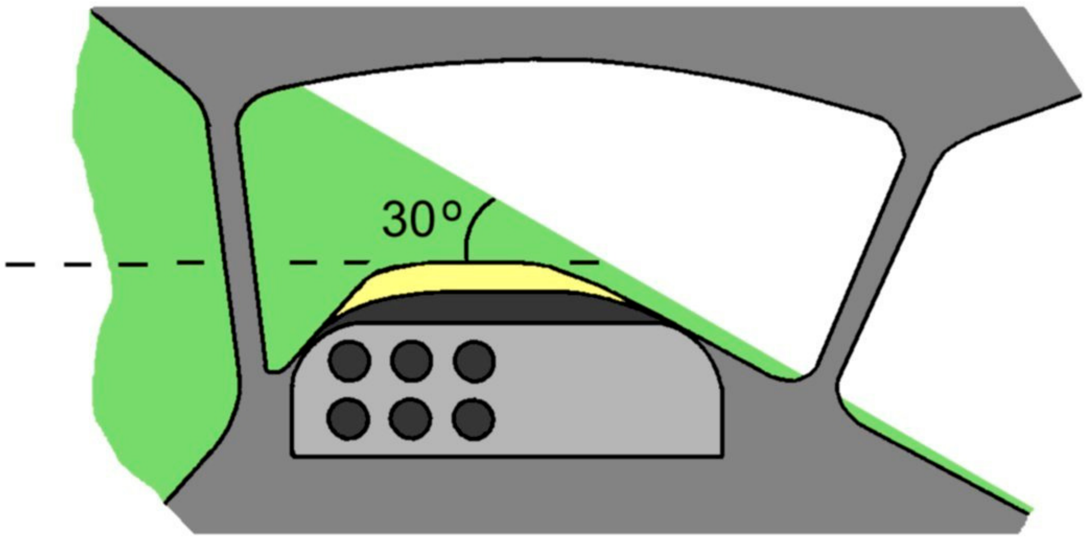


FIG 8. Pilot's view of 30° angle of bank to left

Figure 8 shows an angle of bank of 30° from the pilot's view.

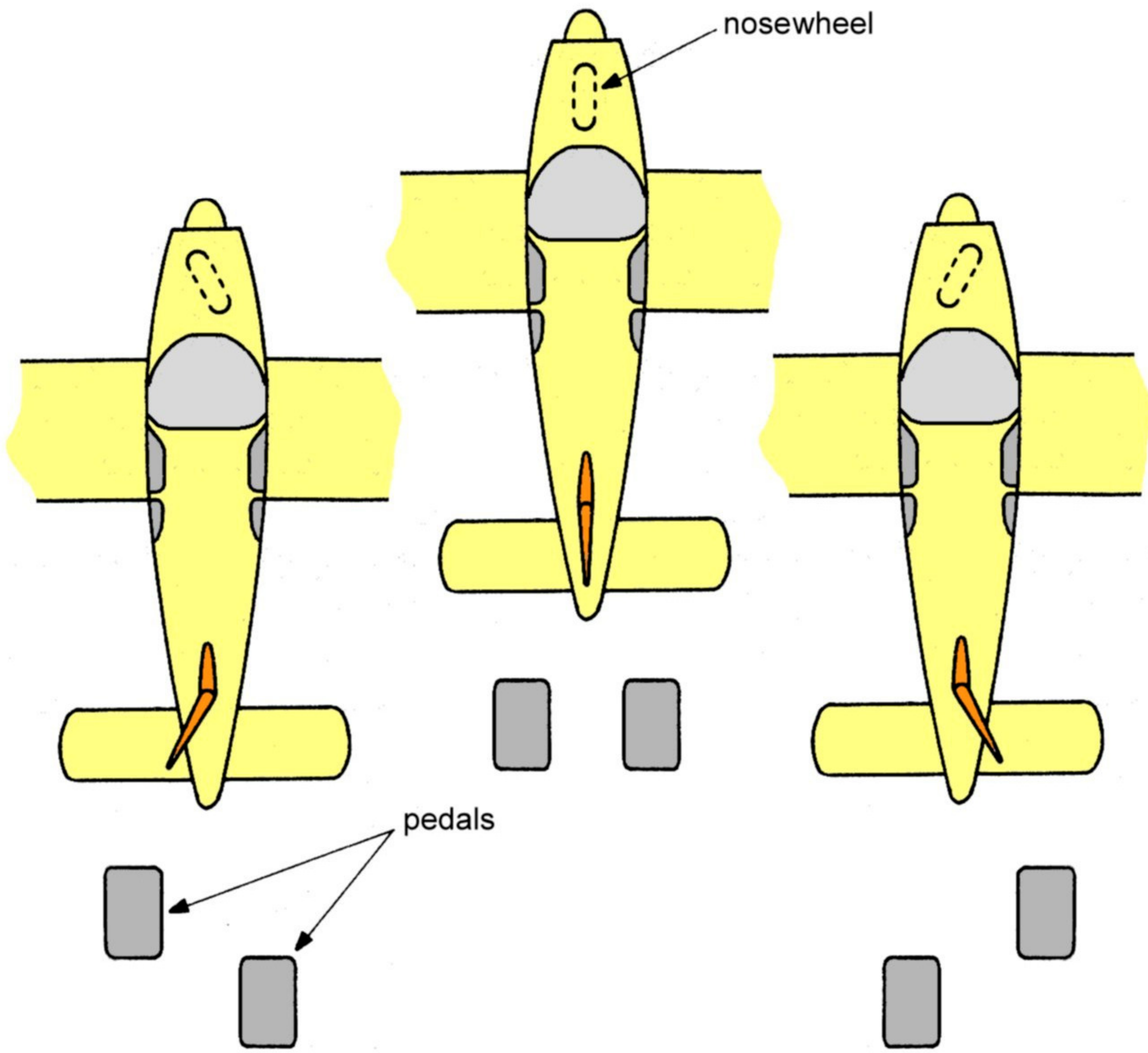


FIG 9. Rudder control and nosewheel steering (view from above)

When the left rudder pedal is pushed forward the rudder moves to the left, and vice versa. For manoeuvring on the ground the rudder pedals also activate the **nosewheel steering** (**Figure 9**). The top part of each pedal activates the brake on the appropriate mainwheel.

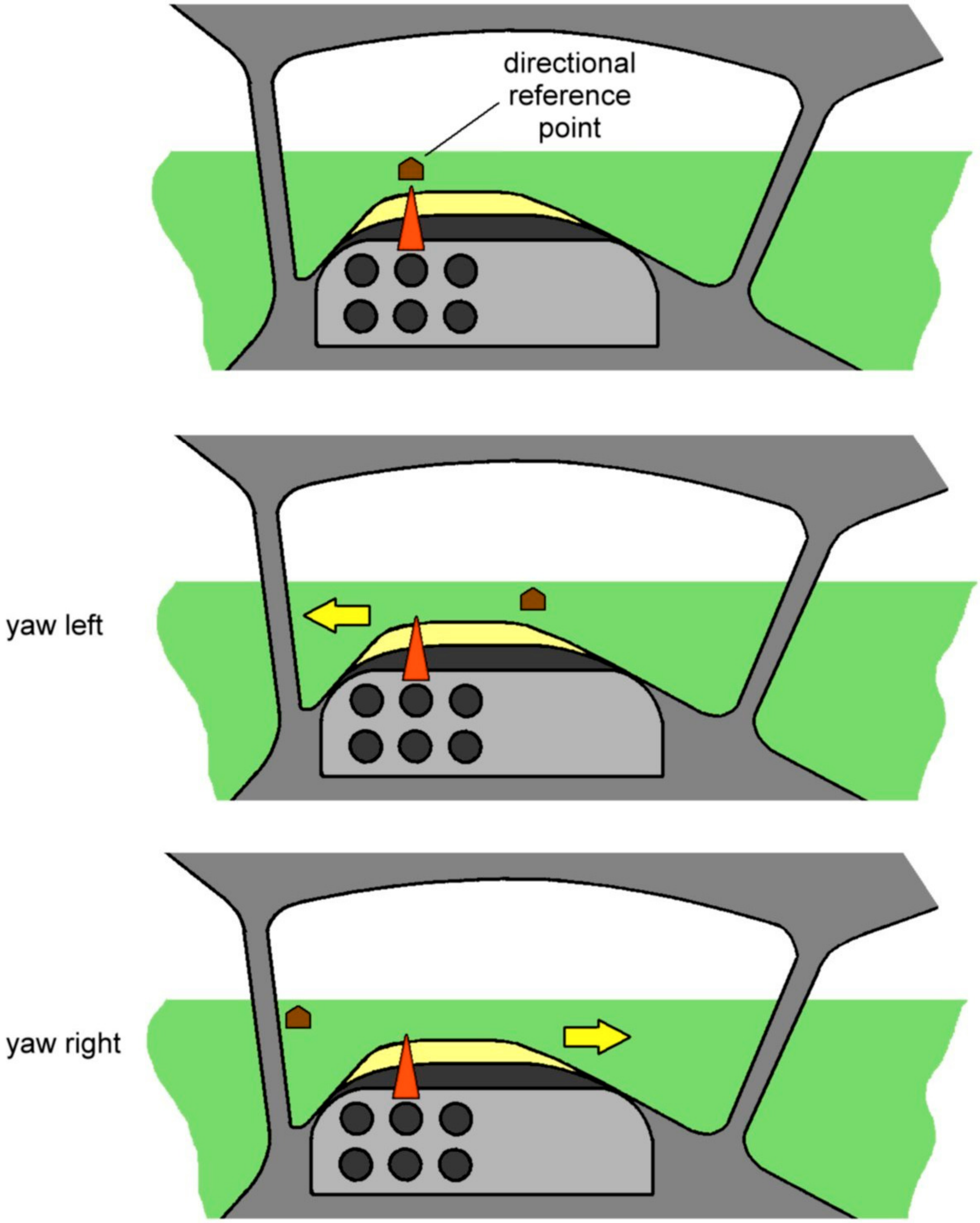


FIG 10. Effect of rudder

In flight, the rudder position determines the airflow pattern past the fin, which consequently affects the force experienced by the fin. For example, if the pilot pushes the left pedal forward, the nose of the aircraft moves to the left (because the tail moves to the right). If he or she pushes the right pedal forward then the nose movement will be to the right. This motion is called **yawing** (**Figure 10**). Note that **we don't turn the aircraft using the rudder pedals**. We'll see why later .

Power Control

If the pilot pushes the throttle forward, the fuel flow to the engine is increased and it develops greater power, which means that the propeller delivers greater thrust. Retarding the throttle reduces propeller thrust.

Pitch Attitude and Pitch Control

The pitch attitude relates to the aircraft's nose position in the vertical sense. The pilot assesses the aircraft's pitch attitude by reference to the earth's horizon, as was shown in **Figure 5**.

Of course, these pitching motions change the angle of attack of the wings and therefore affect the wing lift, which in turn affects the aircraft's flight path and speed, as we have already noted.

Bank Attitude and Roll Control

The bank attitude relates to the lateral position of the wings. As we have seen, if the wings are not level, they are said to be in a banked attitude, which again the pilot assesses by reference to the earth's horizon.

Speed Control

The second factor affecting the aircraft's flight path is its airspeed. The pilot can control speed by two methods. One is to change the power setting of the engine. For example, increasing the engine power in level flight (not climbing or descending) makes the aircraft accelerate, and vice versa. The second method of controlling speed is by change of pitch attitude, as we noted above. The method chosen depends on the phase of flight.

Vertical Flight Path and Speed

The combination of pitch attitude setting and power setting will determine whether the aircraft flies level or climbs or descends, and also the speed at which it flies. To make the aircraft achieve a desired vertical flight path and speed the pilot must select the appropriate pitch attitude and power setting. Only one combination will give the correct result. Expanding what was said above about phases of flight, the pitch attitude chosen by the pilot is sometimes used to control the vertical flight path of the aircraft and sometimes to control its speed.

Level Flight

In level flight the aircraft neither gains nor loses altitude. In other words the indication on the altimeter remains constant. **In level flight the vertical flight path is controlled by pitch attitude and the speed is controlled by power setting**. If an undesired increase in altitude is observed, the pilot will move the control wheel slightly forward to set a lower pitch attitude and thus correct the error. If the speed is too high, the pilot will retard the throttle slightly. An increase of power will be necessary if the speed is too low. **Figure 11** shows a typical cruise attitude.

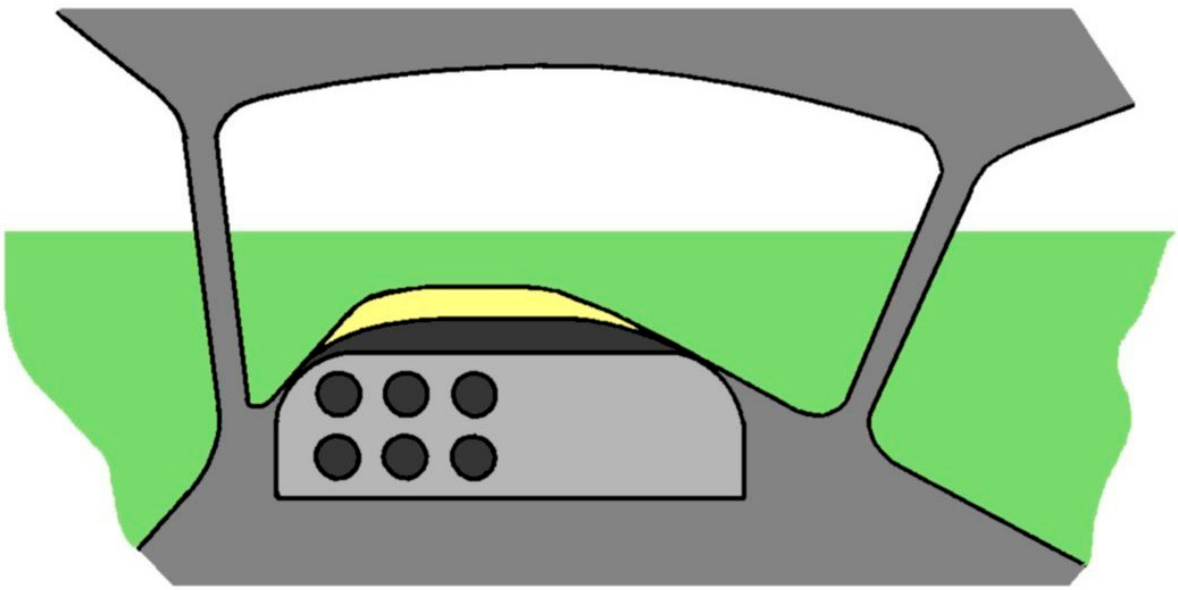


FIG 11. Aircraft in cruising flight

Climbing Flight

In climbing flight **the engine is set to climb power**. **The aircraft's speed is therefore controlled by pitch attitude**. If the indicated speed is too low, the pilot will move the control wheel forward to set a lower pitch attitude. If the speed is too high, a higher attitude will be needed. **Figure 12** shows a typical climb attitude.

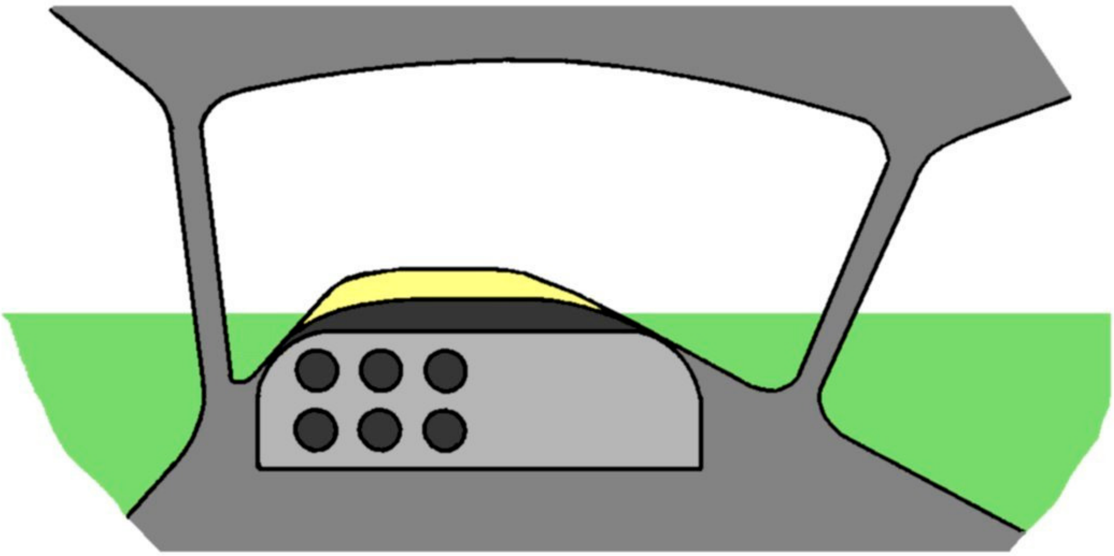


FIG 12. Typical climbing attitude

Descending Flight

The controls are used as for the climb. In other words **the speed is controlled by pitch attitude and the rate of descent is controlled by power**. **Figure 13** shows a descent at cruising speed with the engine at idle power.

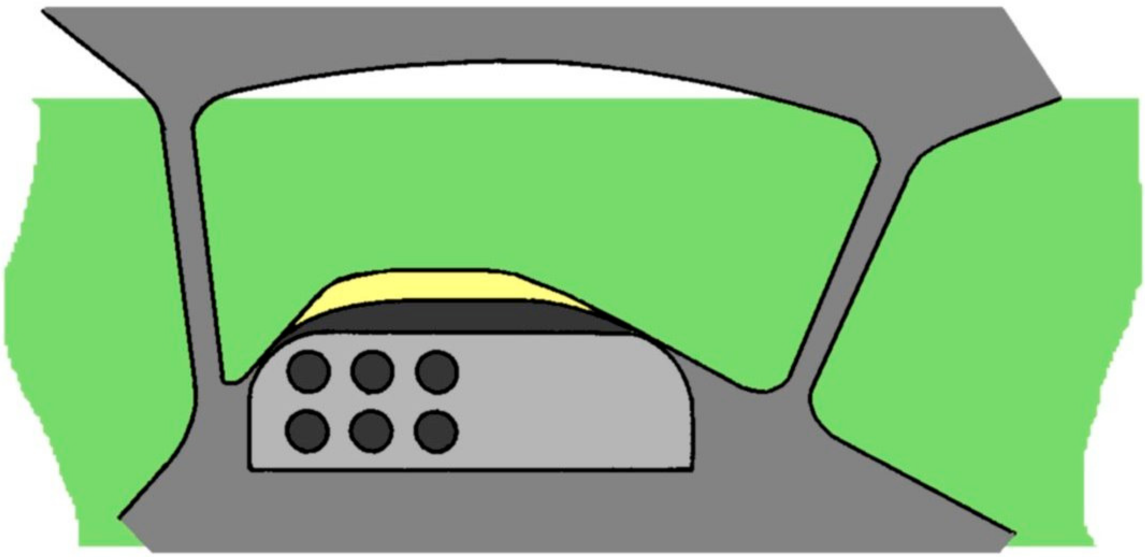


FIG 13. Descending at cruising speed with the engine at idle power

If engine power is increased the aircraft will begin to accelerate and so to maintain this speed a higher nose attitude will be needed. This new combination of pitch attitude and power setting will result in a reduced rate of descent and hence a shallower descent gradient. **When approaching to land, however, the controls are used differently. Now the pitch attitude is adjusted as necessary to control the vertical flight path, in this case to achieve the correct approach angle, while power is set as necessary to control speed**.

Turning

When the wings are level the aircraft will fly straight and the direction indicator will show a constant heading. The direction indicator is referenced to magnetic north, which is the datum for navigation. To start a turn, the control wheel is turned in the desired direction until the desired bank attitude is attained. Then the wheel is centred again. The bank will remain at the attained attitude and **the tilted lift force will make the aircraft turn**, with the direction indicator showing a changing heading.

Note the difference between turning a car and turning an aircraft. In a car the steering wheel must be held in its displaced position to maintain the turn, whereas the aircraft will turn whenever the wings are banked, even though the control wheel is centred. Therefore to stop the turn the control wheel must be turned away from the lower wing to level the wings again. **If the wings are level the aircraft will fly straight. If they are not, the aircraft will turn towards the lower wing**. The greater the angle of bank, the more quickly the aircraft will turn. Of course, this is true regardless of whether it is climbing, descending or flying level.

What Is The Rudder For?

Why do we bank the wings to turn the aircraft? Why don't we use the rudder? The answer is that the turn has to be **balanced**. If we used the rudder to turn, the aircraft would skid, flying sideways through the air, with its occupants feeling a sideways force. If however we bank the wings to turn, the outward force is balanced by the tilted attitude and so the occupants of the aircraft feel no sideways force one way or the other. Aerodynamically, this technique is the best to follow because the airflow past the aircraft is symmetrical and therefore no extra drag is incurred.

Why do we need a rudder at all, then? Well, there are times when we can't control heading with wing bank, for example during take-off and landing. Keeping straight on the runway will require inputs from the rudder.

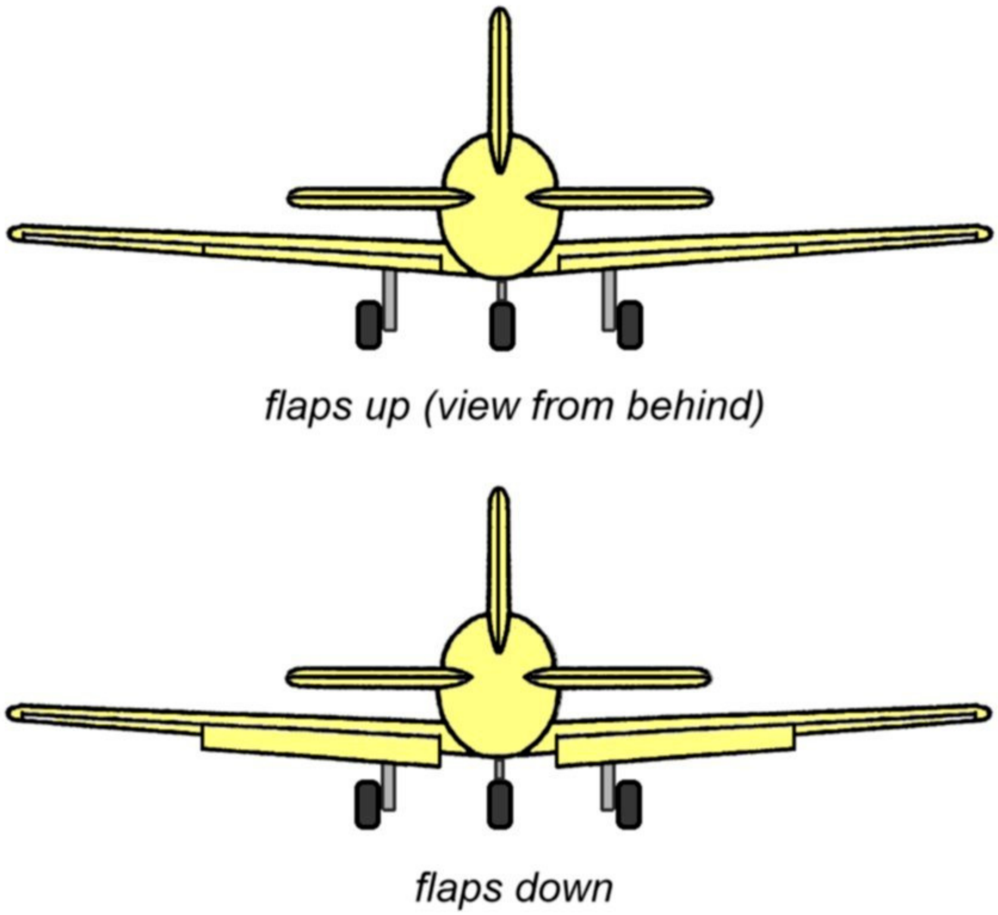


FIG 14. Flap control

Flaps

The lowering and raising of the flaps is controlled by the flap lever (**Figure 14**).

To fly safely at low speeds the flaps are lowered to increase the wing curvature and so generate more lift. On grass runways take-off is often made with flaps partially lowered to reduce length of ground run required. For the landing they are selected fully down.

The Take-off

The pilot opens the throttle fully and concentrates on keeping the aircraft running straight along the centreline, using the **rudder pedals** (but not the brakes at the tops of the pedals). Initially the steering is through the nosewheel steering mechanism but as airspeed builds up the rudder itself becomes effective. **Figure 15** shows the view ahead at the start of the take-off run.

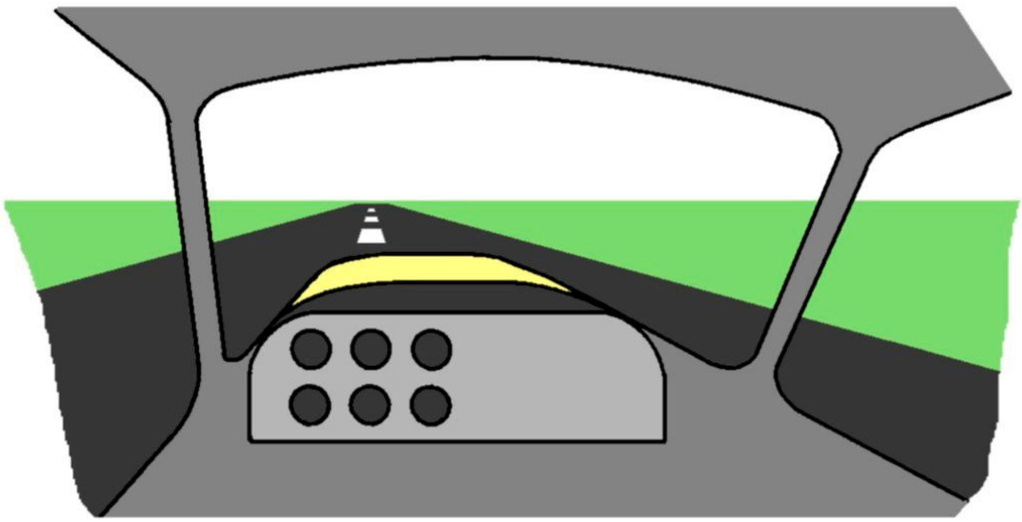


FIG 15. Positioned for take-off

At **rotation speed** the pilot pulls the control wheel back to lift, or rotate, the nose to the **take-off attitude**. During rotation, the angle of attack of the wings increases and so the lift they generate also increases. Eventually the lift force will exceed the aircraft's weight and the wheels will leave the ground. We're flying!

Now the pilot concentrates on adjusting pitch attitude to maintain the correct climb speed. **Any turning required will be done by bank inputs from the control wheel (not the rudder!)**.

The Landing

With **control wheel inputs** the pilot must maintain the **correct vertical flight path to the runway threshold**, simultaneously adjusting **engine power** as necessary to hold the **correct final approach speed**. The pilot must also keep the aircraft **lined up with the runway centreline**, using **bank inputs** to control heading (**Figure 16**).

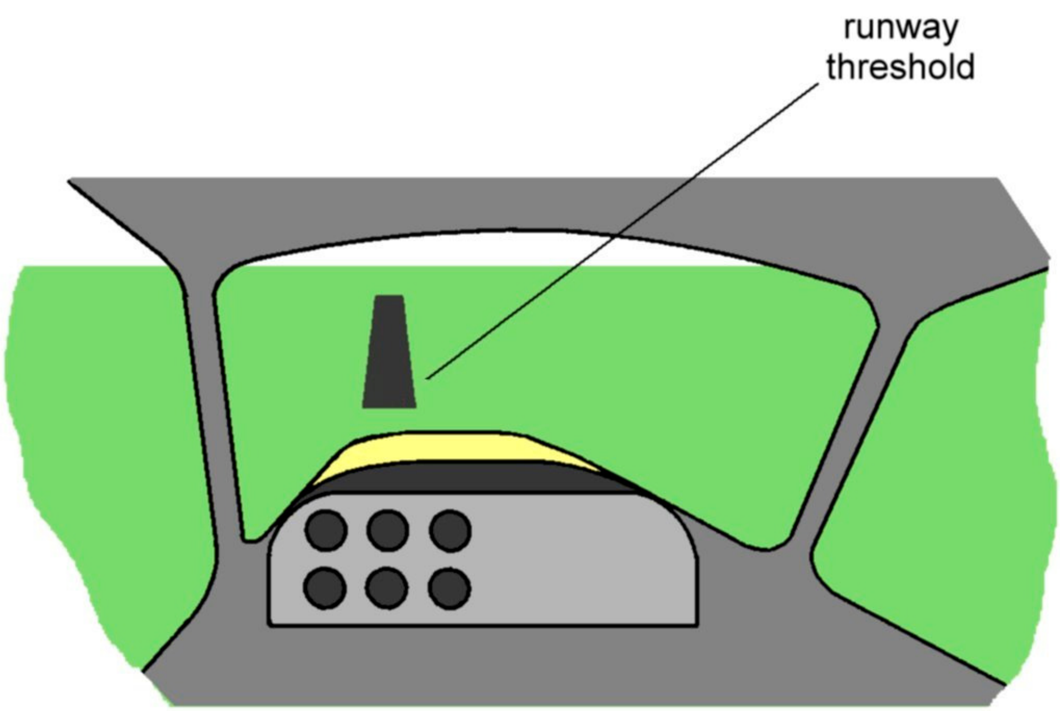


FIG 16. Final approach

As the aircraft nears the runway the pilot must raise the nose, or **flare**, to arrest the descent rate, simultaneously **retarding the throttle to idle**. This manoeuvre is judged visually, rather than by reference to the instruments. The aircraft will attain a **level flight path just above the runway**. As it loses speed it will start to sink, which is prevented by **raising the nose progressively (the hold off)** until the **landing attitude** has been achieved (**Figure 17**).

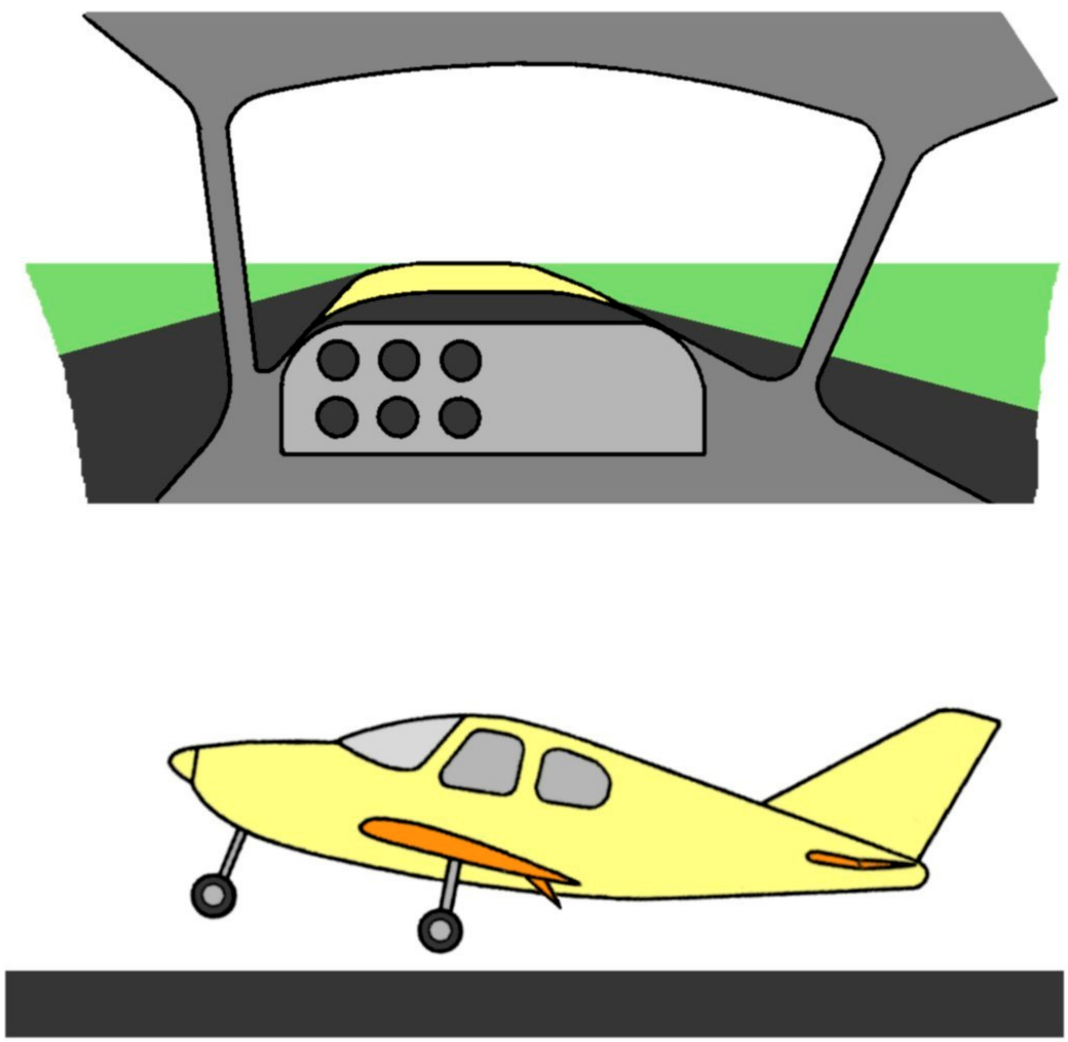


FIG 17.   Landing attitude

At this point it is allowed to touch down on its mainwheels, followed by the nosewheel. To **keep straight during the landing roll** requires **rudder inputs** (the control wheel will no longer be of any use). The brakes are applied as necessary to slow to taxying speed.