FATAL TRAPS
for Helicopter Pilots

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Basic flight principles

Some books refer to 'helicopter behavior' rather than 'flight principles' and perhaps they are nearer the mark. Some helicopter maneuvers certainly seem to defy scientific explanation.

A good working knowledge of the principles of flight is required when operating helicopters, but the best weapons in your armory are preparation and judgment – a quaint old-fashioned word.

This chapter could have included a mountain of advanced calculus to truly reflect the principles of helicopter flight, but knowing how to differentiate some mind-boggling aerodynamic formulae is of little help when you are trying to resolve a critical situation. So I will keep it simple. However, make no mistake. Unless you study and understand the simple principles of flight, you are poorly armed to embark on safe helicopter flying either for recreation or as a career. Knowledge of the subject is imperative to the well-being of yourself and those who fly with you. Think of this knowledge as a form of health insurance (without the exorbitant premiums) and read on.

For readers who are non-fliers, this rudimentary understanding of the principles of helicopter flight will reveal the secrets of a number of the hazards explained in the remaining chapters of the book.

Terminology

Symmetrical and unsymmetrical airfoils

Fig 1.1 FEDERAL ADVISORY CIRCULAR 61-13B

Chord line

An imaginary line that connects the leading edge of an airfoil to the trailing edge.

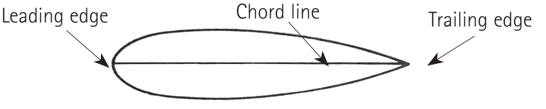


Fig 1.2 FEDERAL ADVISORY CIRCULAR 61-13B

Relative wind/airflow (RAF)

The direction of the airflow with respect to an airfoil.

Pitch angle

The acute angle between the blade chord line and a reference plane determined by the main rotor hub.

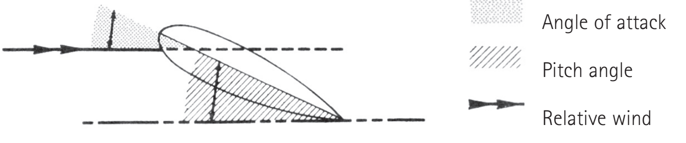


Fig 1.3 FEDERAL ADVISORY CIRCULAR 61-13B

Angle of attack

The angle between the chord line of the airfoil and the direction of RAF.

Lift

Lift is a force created by the pressure differential generated by the relative movement of an airfoil through the air.

$$\text{Lift} = C_L \tfrac{1}{2}\rho V^2 S$$

C_L is the co-efficient of lift and relates to the design shape of the wing, for example:

Fig 1.4

➢ High speed, as on a jet fighter .

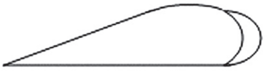


Fig 1.5

➢ High lift, as on an agricultural fixed wing .

½ is a mathematical constant

ρ is a Greek symbol that represents air density

V^2 is velocity (speed and direction); the squared function signifies that it is a primary factor

S is the surface area of the airfoil

Drag

Drag is the force that resists the movement of the airfoil through the air. Drag is produced any time there is movement of a body, be it an airfoil or fuselage.

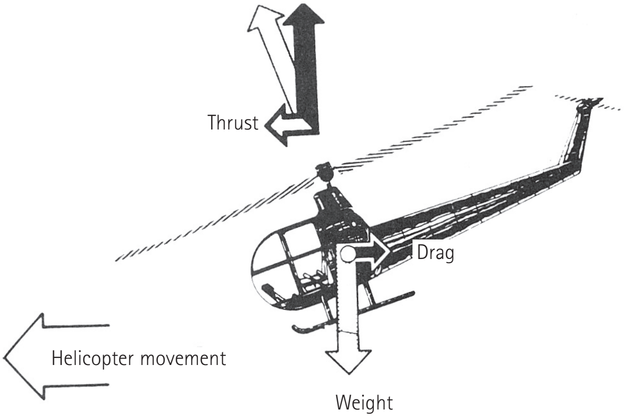


Fig 1.6 FEDERAL ADVISORY CIRCULAR 61–13B

Weight

The total weight of a helicopter is the first force that must be overcome before flight is possible. Lift, obtained from the rotation of the main rotor blades, overcomes or balances the force of weight.

Thrust

Thrust is the force that overcomes drag and moves the helicopter in the desired direction.

Rotor thrust

The same basic laws of physics govern the flight of both fixed-wing aircraft and helicopters. Both must produce an aerodynamic lifting force to overcome the weight of the aircraft. In both that lifting force is obtained from the aerodynamic reaction resulting from a flow of air over an airfoil section. On a fixed-wing aircraft, the airfoil is fixed to the fuselage as a wing, whereas the helicopter has engine-driven rotating wings. The rotor provides both lift and horizontal thrust.

While the rotor is simply an attachment that produces a lifting force, we need to consider two distinct aspects:

1. The rotor, with its behavior and characteristics, as a producer of lifting force.
2. The helicopter as a whole, with its behavior and characteristics determined largely by the rotor.

Helicopter rotors form a disc to produce rotor thrust. To understand the characteristics and control of this disc, we need to study how each rotor blade moves, and how it reacts to different control movements and airflows. This allows us to understand what happens to the helicopter when the disc performs in a manner that the laws of physics and aircraft manufacturers deem inappropriate.

Rotor blades are attached by a rotor head to a mast, which extends almost vertically from the fuselage (see Fig 1.7). Rotation of the mast allows the rotor blades to rotate. The axis of rotation is the axis through the main rotor mast. The plane of rotation is at right angles to the axis of rotation at the head of the main rotor mast. The rotor blades are connected to the rotor head at an angle to the plane of rotation called the pitch angle.

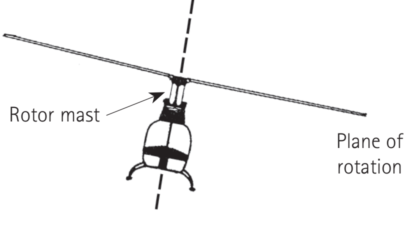


Fig 1.7

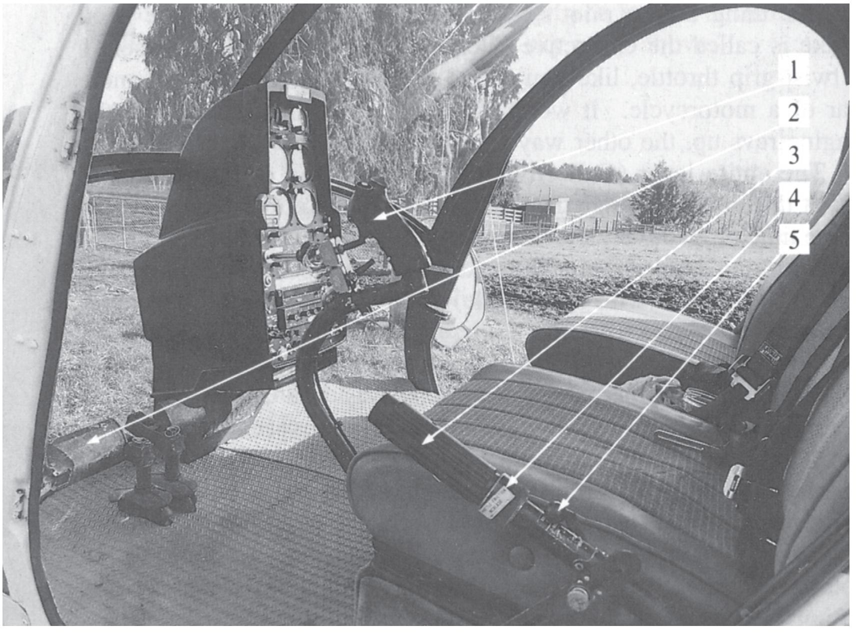
Effects of controls

The pitch angle is of primary importance. To a point, the greater the pitch angle, the greater the lift generated. If the blade is overpitched, sections of it will stall, much like the wing of an airplane will stall.

One of the main controls the pilot uses is the collective pitch lever. This increases or decreases the pitch angle of all the blades at the same time. This control, which resembles the parking brake in a car, is on the pilot's left (see Fig 1.8).

The stick in a helicopter is called a cyclic control. This also changes the pitch of the blades, but one blade at a time as it passes a certain position. If the pilot moves the cyclic control forward, the front of the disc drops and the rear rises. The helicopter then moves forward. Move the cyclic control backward and the opposite happens. Move it left to go left and right to go right.

A tail rotor is a very necessary part of the running gear for most helicopters. When the engine supplies power to the main rotors through the transmission, it applies a force. Newton tells us that for every action there is an equal and opposite



1 Cyclic control
2 Anti-torque pedal

Collective pitch lever
3 Throttle
4 Throttle friction
5 Collective friction

Fig 1.8 Controls LOGAN SHARPLIN

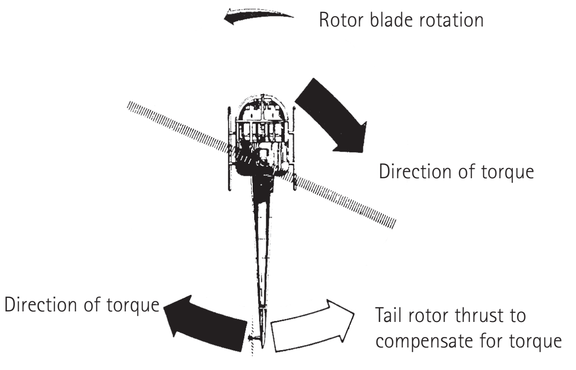


Fig 1.9 Purpose of tail rotor FEDERAL ADVISORY CIRCULAR 61–13B

reaction. That reaction in our case is called torque. The tail rotor's purpose is to counteract torque. Fig 1.9 shows how this works for a helicopter that has its main rotors turning anticlockwise.

For the most part, the amount of thrust required from the tail rotor depends on how much torque has to be overcome. This varies with the amount of power being used. It is also affected by the helicopter's airspeed. To turn a hovering helicopter, the pilot over- or under-compensates for the torque. A helicopter with its main rotors turning anticlockwise needs less tail rotor thrust to turn to the right. The opposite applies for a turn to the left (see Fig 1.10). For a right turn, relax the pressure on the left pedal and the torque will initiate a turn to the right.

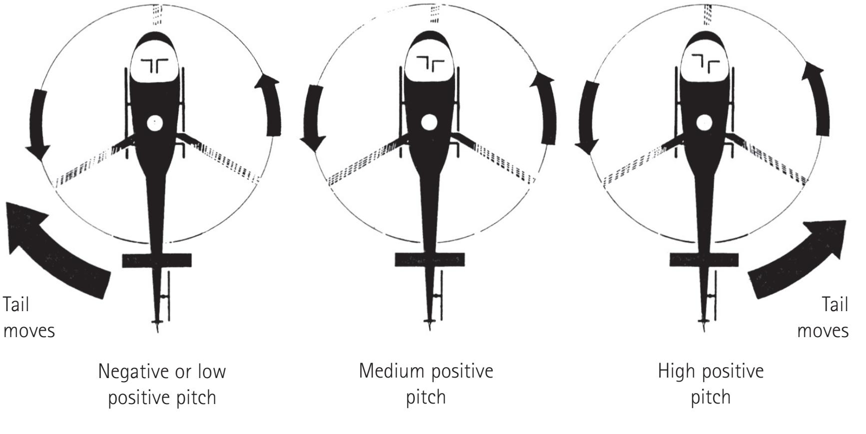


Fig 1.10 Yawing turns through tail rotor pitch variations. Note the pedal positions
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