AERODYNAMICS

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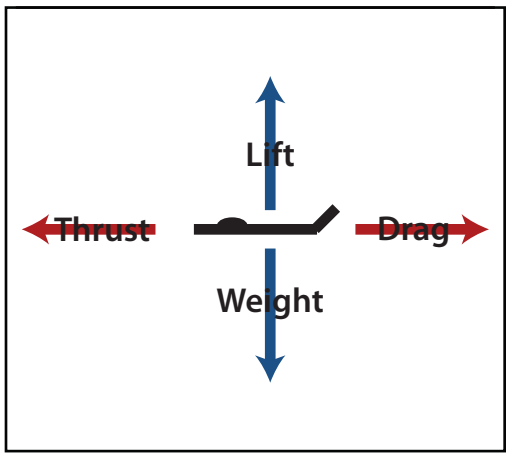
4 FORCES OF FLIGHT

Lift, Weight, Thrust & Drag

- LIFT: The upward force created by the effect of airflow as it passes over and under the wing
- WEIGHT: Opposes Lift and is caused by the downward pull of gravity
- THRUST: The forward force which propels the aircraft through the air
- DRAG: Opposes thrust and is the backward, or retarding, force which limits the speed of the aircraft

FORCES IN CLIMBS AND DESCENTS

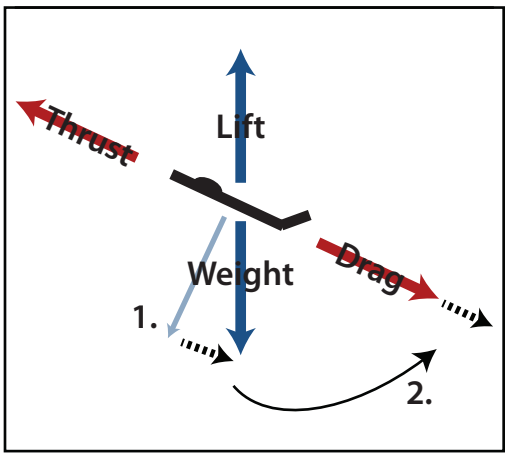
STRAIGHT AND LEVEL FLIGHT



In straight and level flight, lift is equal to weight and thrust is equal to drag. Airspeed and altitude do not change.

Note: Whether in straight and level flight, a climb, or a descent weight always points directly down (toward the center of the Earth), this is due to gravity.

CLIMBS



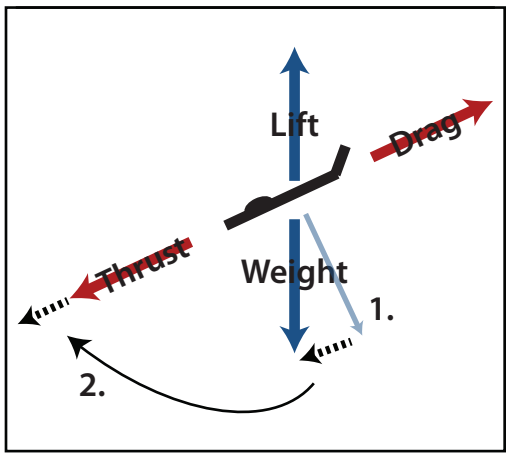
If a climb is entered with no change in the power setting, airspeed will diminish.

1. Notice the change in weight vectors between the Straight and level diagram (light blue line, perpendicular to the aircraft) and the climb diagram (dark blue line pointed straight down).

When inclined upward, a component of weight acts in the same direction as drag (dashed black line).

2. When inclined upward, the rearward movement of weight results in increased drag, therefore , in order to maintain airspeed in a climb thrust must be increased.

DESCENTS



If a descent is entered with no change in the power setting, airspeed will increase.

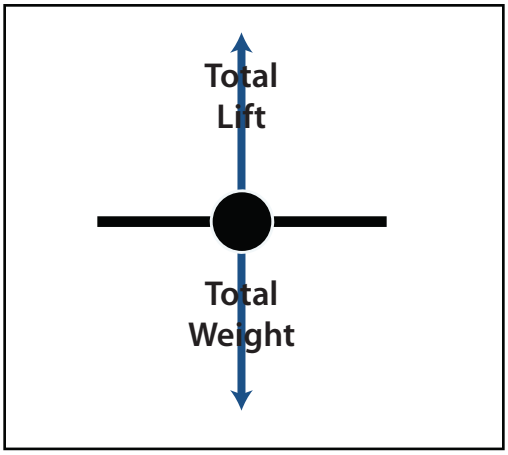
1. Notice the change in weight vectors between the Straight and level diagram (light blue line, perpendicular to the aircraft) and the climb diagram (dark blue line pointed straight down).

When pointed downward, a component of weight acts in the same direction as thrust (dashed black line).

2. When pointed downward, the forward movement of weight results in increased thrust, therefore increased drag or reduced thrust is needed to maintain a consistent airspeed during a descent.

THE AERODYNAMICS OF A TURN

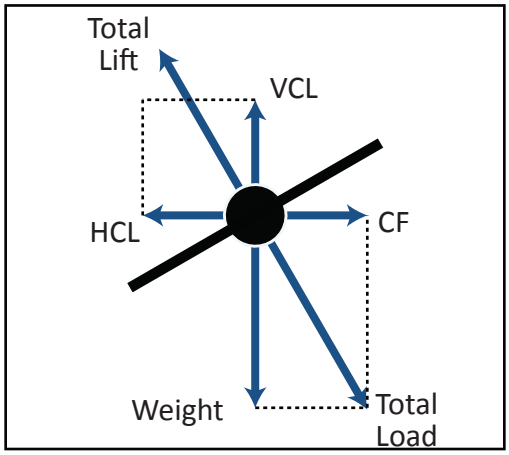
STRAIGHT AND LEVEL



As shown above, in straight and level flight, Lift is equal to Weight. When banked, total lift banks with an aircraft while Weight continues to point toward the center of the Earth (Center/Right Graphics).

As an aircraft banks, the total lift is divided into 2 components, a Vertical Component (VCL) of Lift as well as a Horizontal Component (HCL). The HCL is opposed by Centrifugal Force (CF).

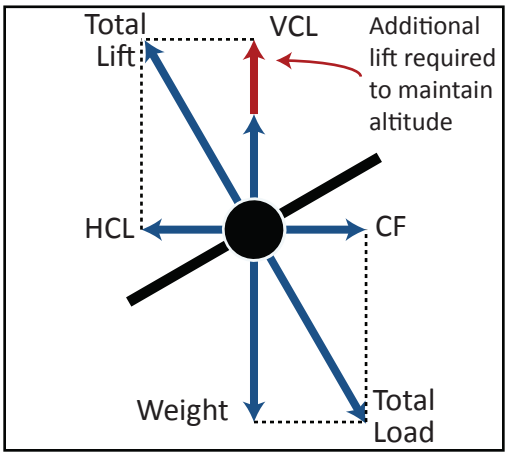
LEFT BANK, NO ADDITIONAL LIFT



Because weight is unchanged in a bank and vertical lift (VL) is decreased (since some VL becomes HL) the aircraft will lose altitude; weight now exceeds the VCL (Center Graphic).

In order to compensate for this, the VCL must be increased with the elevator. Altitude is maintained when the VCL becomes equal to weight (Right Graphic). Total Lift increases as well and becomes equal to Total Load

LEFT BANK WITH ADDITIONAL LIFT

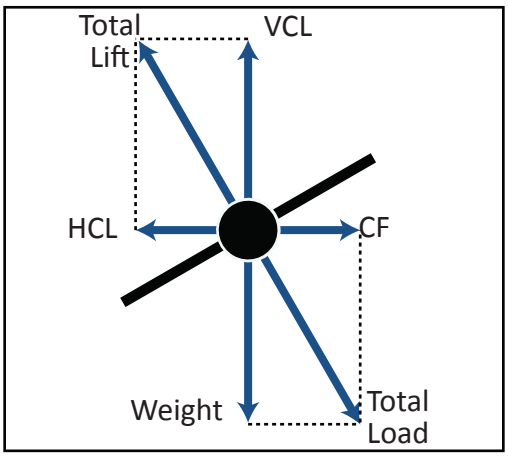


resulting in a level, coordinated turn.

In a level, coordinated turn:
VCL = Weight
- This maintains altitude
Horizontal Lift = Centrifugal Force
- This maintains coordination
Total Lift = Total Load
- When the previous two criteria are satisfied, total lift will equal total load and the turn is coordinated and level.

COORDINATED VS UNCOORDINATED TURNS

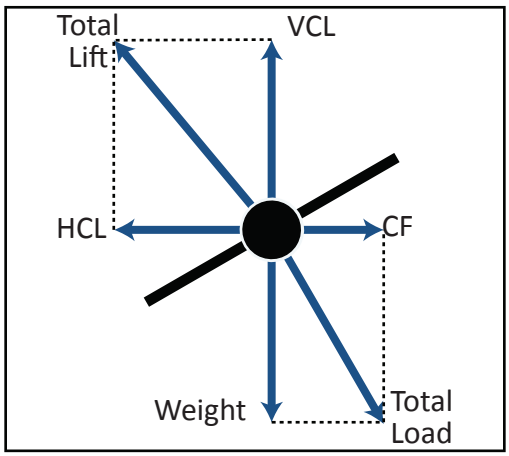
COORDINATED TURN



As mentioned above, in a turn some VL becomes HL. As you may remember, from Newtons 3rd Law, every force has an opposing force. The force opposite the HCL is called Centrifugal Force (CF).

As shown in the graphic above, a turn is coordinated when the HCL is equal in strength to the CF opposing it. If the HCL is not equal to the CF the turn will not be coordinated.

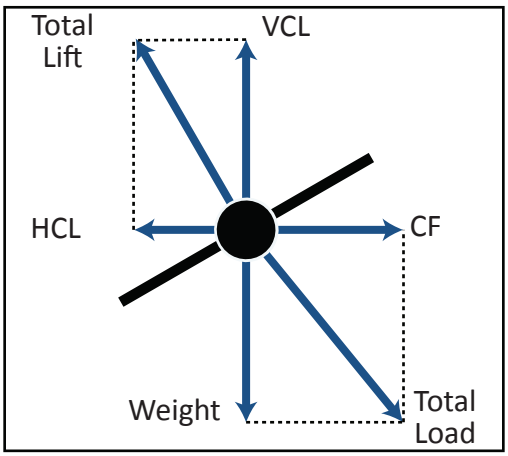
SLIPPING TURN



In a slipping turn, the HCL is greater than the CF. This is because the rate of turn is too slow for the angle of bank. The aircraft is yawed to the outside of the turning flight path in a slipping turn.

A slipping turn can be corrected by decreasing the angle of bank and/or increasing the rate of turn (increased rudder in the direction of the turn).

SKIDDING TURN



In a skidding turn, the CF is greater than the HCL. This is because the rate of turn is too great for the angle of bank. The aircraft is yawed to the inside of the turning flight path in a skidding turn.

A slipping turn can be corrected by reducing the rate of turn (decreased rudder in the direction of the turn) and/or increasing the rate of bank.