Private Pilot Ground School

Winter 23/24 – Week 2

HOSSFLIGHT

1

Aircraft Components Review

Main Structural Sections

- Wings
- Fuselage
- Empennage
  - Horizontal Stabilizer
  - Vertical Stabilizer
- Powerplant(s)

Control Surfaces

- Primary
  - Ailerons
  - Rudder
  - Elevator or Stabilator
- Secondary
  - Flaps
  - Trim Tab

Other Components

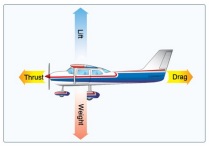
- Landing Gear
- Wheel Strut
- Sump Drain
- Pitot Tube
- Static Port
- Stall Warning Device
  - Suction & Electric
- Fuel Tank Vent
- Anticollision and Position Lights
- Cowling

2

Aerodynamics Review

Four Forces

- **Lift** – Always perpendicular to wing
- **Weight** – Always pulling towards the center of the planet
- **Thrust** – always pulls from the hub of the propeller in the direction the propeller is pointed
- **Drag** – Always pulls with the relative wind on the airframe

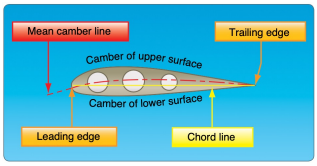


How does affect weight's relationship to the other forces?

3

Wing Shape

- Leading Edge
- Trailing Edge
- Upper Cambered Surface
- Lower Cambered Surface
- Camber Line
- Chord Line



- Angle of Attack vs Angle of Incidence

4

Producing Lift

- Newton
  - Impact Lift
  - Equal and opposite
- Bernoulli
  - Venturi Effect
  - Faster air has a lower pressure
- Lift production increases with Angle of Attack

5

The Lift Equation

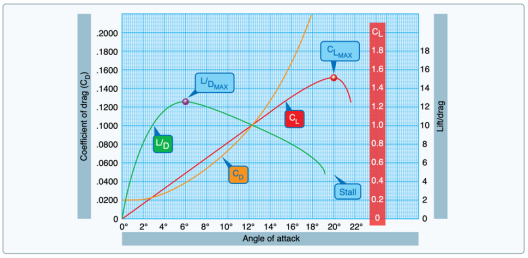
$$L = \frac{C_L \cdot \rho \cdot V^2 \cdot S}{2}$$

- A way of understanding the relationship lift-producing factors
- L – Lift
- C_L – Coefficient of Lift
- ρ – Air Density
- V – Airspeed
- S – Airfoil Surface Area

6

Lift Chart

A way of visualizing the lift equation for a particular airfoil



We'll revisit this chart later…

7

Continuing on with aerodynamics…

8

Stalls

- What is a stall?
- Critical AoA – relative wind does not care which way is up
- Airflow detachment
- Does weight affect stall AoA?
- Does weight affect stall airspeed?

9

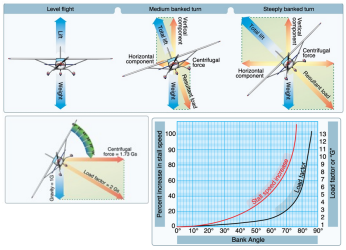
Load Factor

- Why does weight affect stall speed?
- The four forces in the lateral/vertical plane
  - Lift
  - Weight
  - ?
  - ?

10

Load Factor in a Bank

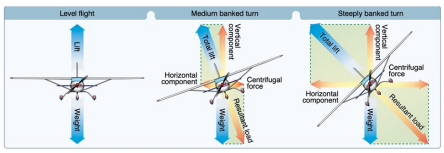
- The Four Forces in the vertical/lateral plane
  - Vertical Component of Lift
  - Weight
  - Horizontal Component of Lift
  - Centrifugal Force
- Additional lift is required to maintain altitude
- Load factor is felt as Gs and represents the increase
- Increased AoA at same airspeed



11

How an Airplane Turns

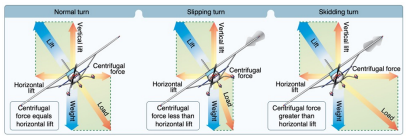
- Need a force that pulls in the direction we want to turn
- Control surfaces create or change forces on the airframe in different locations
  - Elevator
  - Ailerons
  - Rudder
- Turning requires a balance of all three
  - Ailerons to bank
  - Rudder to align the nose to the relative wind
  - Elevator to increase the AoA
  - Control inputs affect each other



12

Coordinated Flight

- When the nose is pointed into the relative wind, the relative wind flows equally across both wings and straight across the vertical stab
- Less drag – more efficient
- Spin avoidance at high AoA



13

Uncoordinated Flight

- Slipping and Skidding
- Increased drag from wind hitting the side of the fuselage and vertical stab
- Causes unequal lift on wings, which is a necessary condition for spins
- Not always bad, even when landing—when used appropriately

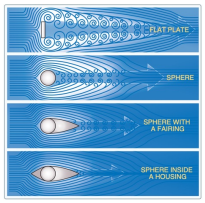
14

So… what makes an airplane turn?

15

Drag

- Resistance to the airplane moving through air
- Drag is a side effect of generating lift – lift cannot be generated without drag!
- The same mechanics that generate lift generate drag
  - Impact (Newton)
  - Pressure (Bernoulli)



16

Types of Drag

- Parasitic
  - Resistance to moving through air due to the shape of the airframe
  - Increases exponentially with speed
- Induced
  - Resistance to moving through air due to generating lift
  - Caused by shifting of lift vector rearward, so higher AoA = more induced drag
  - Decreases exponentially with speed

17

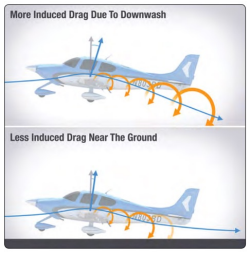
Vortices

- Two types of vortices talked about frequently with airplanes, totally different phenomena
- Wing surfaces vortices
  - Improve attachment of high velocity flow to upper surface of wings
  - Some aircraft have these installed to introduce these vortices to improve stall characteristics
- Wingtip vortices
  - Caused by lift generation – more lift, stronger vortices
  - What situations would have the objectively strongest vortices?
  - Wake turbulence

18

Ground Effect

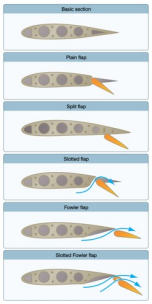
- The air column under the wing is less compressible close to the ground
- Air flowing under the wing cannot deflect downward as easily
- Approximately a wingspan height above terrain
- Can be dangerous or useful



19

Flaps

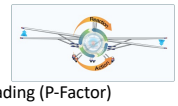
- Change the chord line of the wing
- Thus, change the AoA
- But also the Angle of Incidence
- Better visibility
- Also increase drag
- Various designs

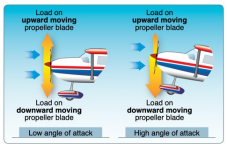


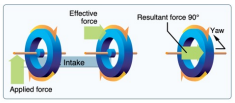
20

The Four Left Turning Tendencies

- Torque
- Slipstream Effect
- Asymmetric disc loading (P-Factor)
- Gyroscopic Precession







21

Structural Limits

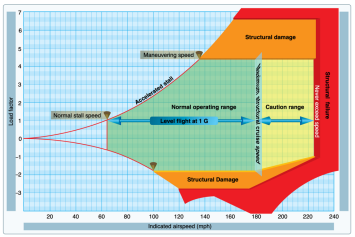
- Load Factor – an expression of the increased lift requirements for the aircraft attitude
- Maneuvering Speed – Va
  - Airspeed at which the plane would stall before exceeding its design limit load factor due to turbulence or control deflection
  - POH-specified value is at gross weight
  - For a 2% reduction in weight, reduce Va by 1%

22

The Stress Envelope – V-g Diagram

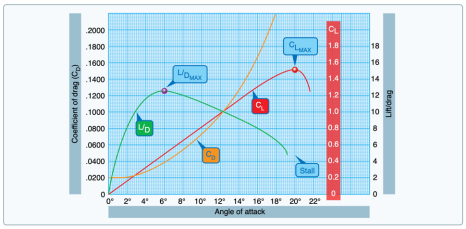
- Load Factor vs Airspeed
- Positive/Negative Load Factor Max
- Vd – Test-pilot-discovered flutter speed
- Vne – 90% of Vd, red line at top of yellow arc
- Vs1 – stall speed in clean configuration
- Positive/Negative Load Factor Stall Lines
- Vc/Vno – Caution Line, top of green arc
- Gust Lines – 25 fps = 15 kt

Consider gusts in various scenarios
Takeoff, Landing, Cruise, Steep Turns



23

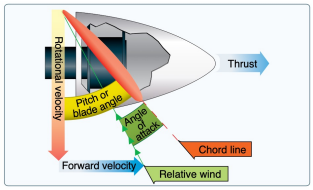
Lift Chart Revisited



24

Propeller Power

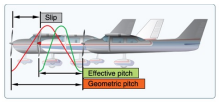
- An airfoil that rotates
- Lift for the prop is thrust for the airplane
- Fixed and variable pitch props

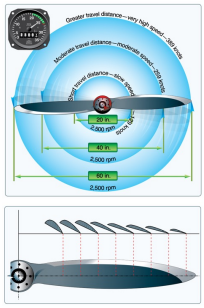


25

Propeller Power

- Relative wind speed is dependent on distance from the center of rotation
- Props have a twist to balance the AoA from root to tip
- Moves through the air like a screw, but air is compressible





26

Break before we start on Engines!

27

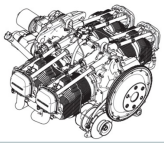
Powerplants

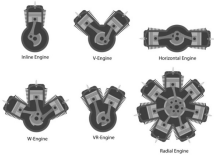
- Turbine Engines
  - Use highly compressed air to release an enormous amount of energy from fuel in a combustion chamber
  - Due to complexity of operation, requires a rating for each specific type of aircraft with a turbine engine
  - Kinds
    - Turbo Prop (Airline Prop Planes)
    - Turbo Fan (Airline Jets)
    - Turbo Jet (Military)
    - Turbo Shaft (Helicopters, APUs)
- Piston/Reciprocating Engines

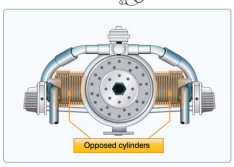
28

Piston Engines

- Kinds
  - Radial
  - Inline
  - Opposed
  - Vee



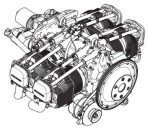


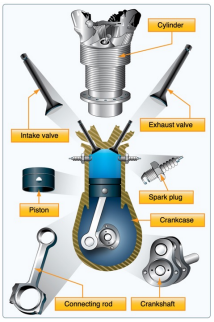


29

Piston Engine Components

- Crankshaft
- Connecting Rod
- Piston
- Cylinder
- Crank Case
- Cylinder Head
- Spark Plugs
- Magneto
- Valves
- Camshaft
- Carburetor or Fuel Injection System

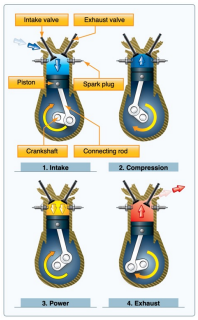




30

The Four Stroke Engine

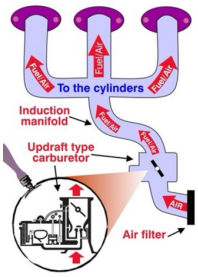
- Each movement of the piston up or down is called a stroke
- Two strokes occur for each complete turn of the crankshaft
- Strokes
  - Intake (Down)
  - Compression (Up)
  - Power (Down)
  - Exhaust (Up)
- Power stroke is timed so that at least one cylinder will fire on any stroke (with at least 4 cylinders)



31

Induction System

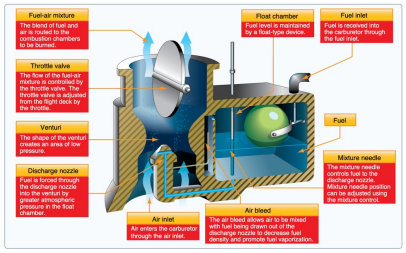
- Fancy word for intake
- Components
  - Air Filter
  - Intake Manifold
  - Carburetor/Fuel Injection System



32

Carburetor

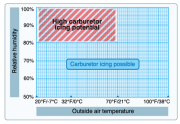
- Supplies a fuel/air mixture to cylinders
- Intake stroke draws air through the induction system
- Venturi effect causes fuel to be pulled into the air
- Throttle valve limits the flow to control engine power

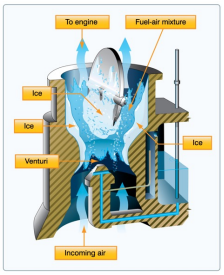


33

Carb Ice

- Carburetor evaporates fuel into air
- Evaporation absorbs energy from surrounding environment
- Air contains water vapor, which can deposit as frost on carb surfaces





34

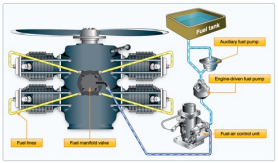
Fuel/Air Mixture

- The amount of energy that can be extracted from burning fuel depends on a balance of the ratio of air and fuel
- The amount of fuel mixed into air can be controlled in the cockpit using the red knob, called the Mixture Control
- Full Lean to Full Rich
- Lean the mixture ← → Enrich the mixture
- Reasons to adjust mixture
  - Maximize power – "Lean the mixture" for altitude
  - Cool the engine

35

Fuel Injection

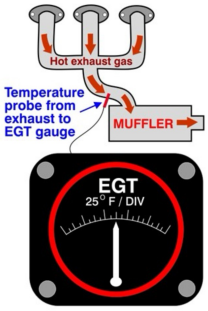
- Some aircraft have fuel injection systems instead of carbs
- Air quantity is measured as it moves through the induction system
- A metered amount of fuel is dispensed directly into each cylinder on the intake stroke
- Improved reliability at the expense of complexity



36

Exhaust System

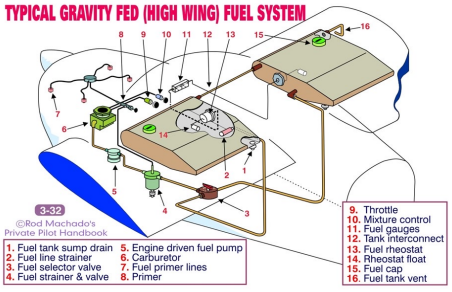
- Exhaust Manifold
- Muffler



37

Fuel System

- High wing planes use gravity feed and sometimes have a boost pump
- Low wing planes use an engine driven pump and an electric backup pump



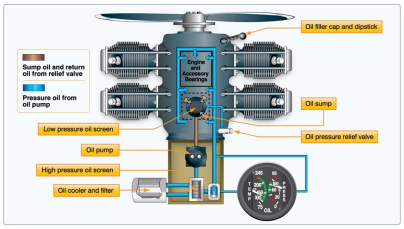
38

Oil System

- The engine requires lubrication where moving or turning surfaces contact
- Without lubrication, the contact would generate destructive amounts of heat due to friction
- A thin layer of motor oil rides in between these surfaces to prevent contact while they move
- Oil pools in the oil pan and is splashed inside the crankcase to lubricate the parts that move inside it
- Oil is pumped into other parts of the engine and through a filter to remove debris

39

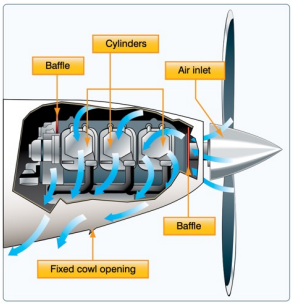
Oil System



40

Engine Cooling

- Air Cooling
- Water Cooling
- Cowl Flaps



41

Transmitting Power - Propellers

- Propellers are usually connected directly to the crankshaft
- Some experimental aircraft have a reduction drive
- With fixed pitch propellers, power output is correlated with how fast it is turning, so power is measured in RPM
- With constant speed propellers, power output is correlated with how much air the engine is drawing in, so it is measured with manifold pressure – the intake manifold

42

Constant Speed Props

- Use a governor system to change the angle of the propeller blades to maintain a constant RPM
- RPM is selected using the blue knob “Prop Control”
- Pushing the lever forward increases RPM
- Full Coarse ← → Full Fine
- Fine: takes a smaller bite of air, Coarse: bigger bite of air
- Allows the aircraft to be configured for best performance at varying altitudes
- The governor system uses high pressure engine oil pumped through the engine crankshaft into the propeller hub to control the propeller position.
- An instructor endorsement is required to operate an aircraft with a constant speed prop.

43