workfromanywhere

Become a Professional Drone Pilot

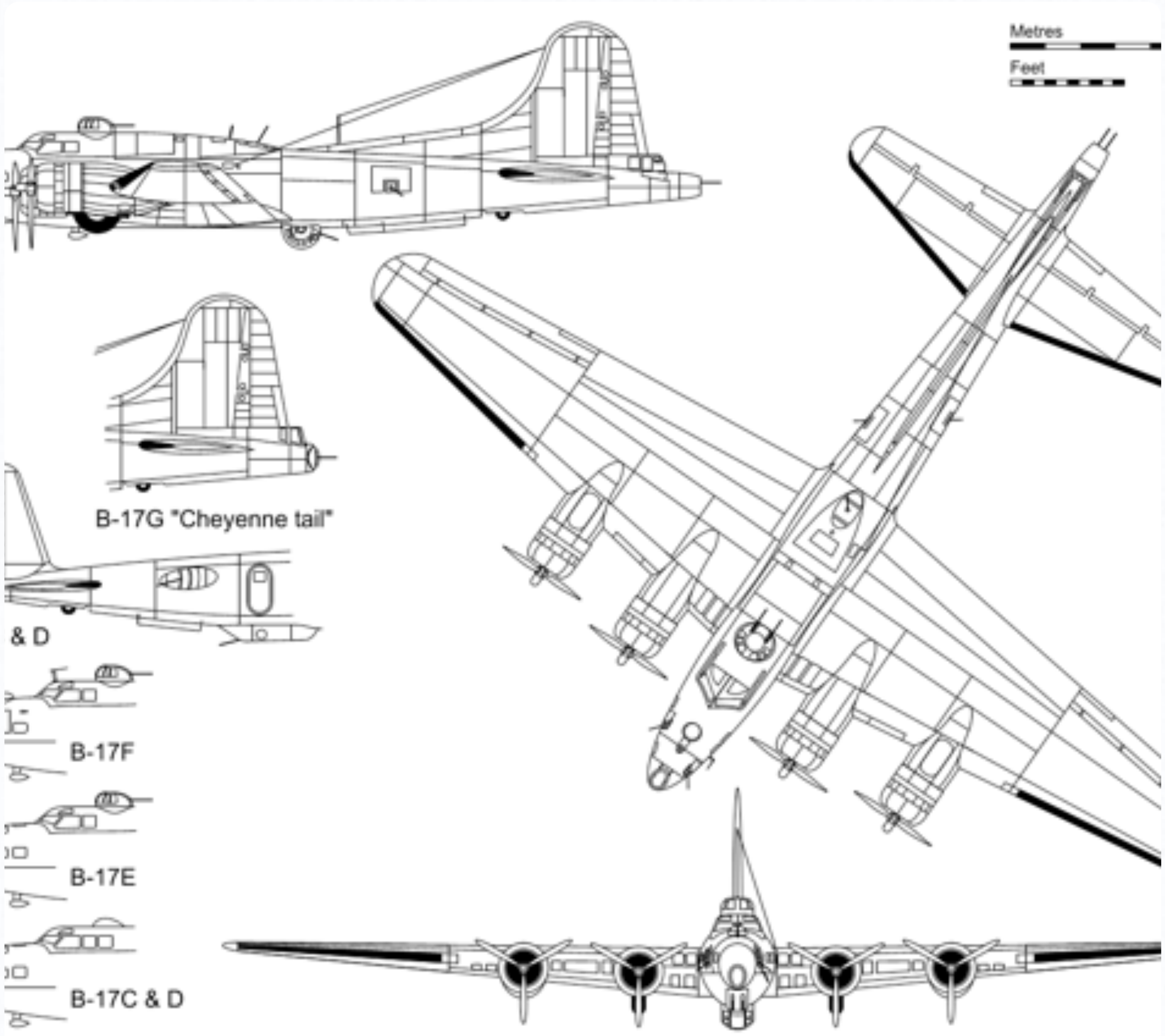
Loading & Performance

Let’s get physical.

As a remote pilot, the FAA expects you to understand the invisible forces that act on your aircraft, as well as the atmospheric conditions that can affect maneuverability, speed, or other performance factors.

Aerodynamics is an immense topic, so we’ll avoid the intricacies of lift, drag, thrust, and weight and focus on what the FAA wants you to know. But, as always, we’ll aim for understanding over memorization.

II



Aircraft Performance & Design Characteristics

Today's aircraft are designed with the primary goal of improving a few key performance characteristics:

Stability

An aircraft's ability to correct for conditions that disrupt its original flight path.

A stable aircraft won't be buffeted around as easily, which makes it easier to control.

Maneuverability

An aircraft's ability to withstand the stresses imposed by maneuvers.

An aircraft endures a lot of force during flight, especially when maneuvering. A maneuverable aircraft can take the added stress that comes from turns and climbs.

Controllability

An aircraft's ability to respond to pilot control.

A well-designed aircraft will respond to its pilot, even under additional stress.

Balance

When upward force (lift) and downward force (gravity) are centered in the same place.

An aircraft's center of gravity (central point of downward force) must be aligned with its center of pressure (central point of upward force). If these points are misaligned, the aircraft will pitch or roll.

Angle of Attack

The angle at which an aircraft's wings meet the oncoming air.

An aircraft's wings or rotors don't cut through the air like a knife, they are angled slightly upwards. This way, the wind hits the bottom of the wing and pushes the aircraft from below. It also creates lift from above (check out Bernoulli's principle here if you're interested in the physics).

This upward angle is called the angle of attack (AOA). You should know that as the AOA increases, the amount of lift the wing generates increases as well, but only up to a certain point. If the AOA is too large, airflow will be interrupted, lift will plummet, and the aircraft will stall.

Weight & Angle of Attack

If weight is added to an aircraft, it will require more lift by means of a greater AOA. But the maximum AOA stays the same no matter what, so by adding weight to an aircraft and increasing the minimum AOA, the chances of stalling go up.

Load Factors

A load factor is the amount of stress acting upon an aircraft as it alters its course from a straight line, as it does while banking for a turn.

Load factors are expressed in Gs, and each G equals the weight of the aircraft itself. So a load factor of 4 Gs means the force acting on the aircraft is 4 times its weight. For a 20lb aircraft, 4Gs would be 80lbs of force.

The FAA wants you to know that:

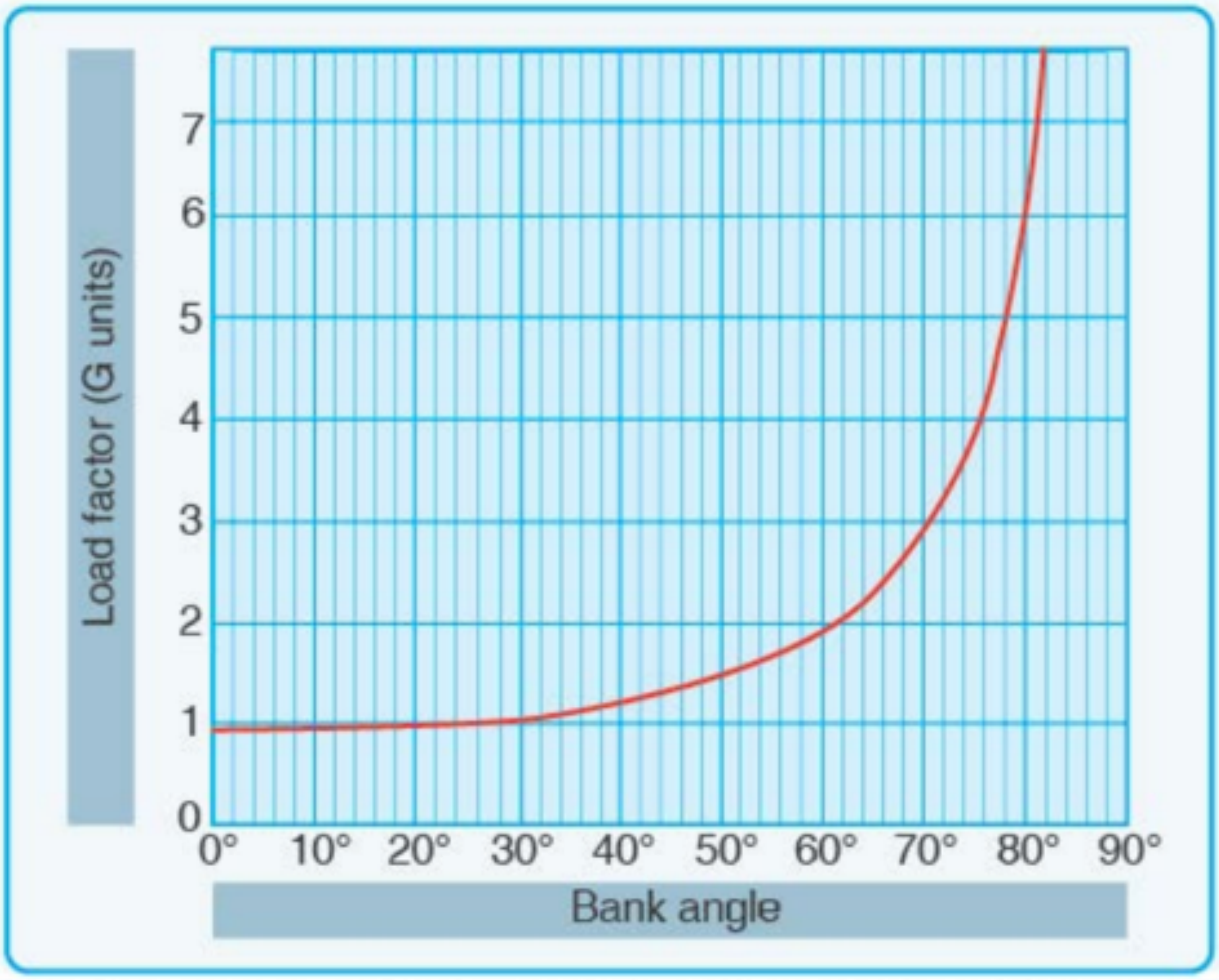
- Too much force can overload an aircraft's structure.

- Increasing the load factor decreases performance and can lead to stalls at seemingly safe speeds.

Turning

As an aircraft banks for a turn, it sustains a certain load factor according to the steepness of the bank. That load factor depends on the aircraft's design and is defined in a graph that the manufacturer provides.

On your test, you'll have one of these graphs, and you'll be asked to name the load factor or amount of force acting upon an aircraft based on its bank angle.



This task is pretty simple. Just find the bank angle on one axis, trace it to the line, and find the load factor on the other axis.

In the example above, a 60º bank angle would generate a load factor of 2 Gs on the aircraft. A question may provide the weight of the aircraft and ask you to convert the load factor from Gs to pounds. So if the aircraft weighs 20lbs, a 60º bank angle would generate 40lbs of force on the aircraft’s structure.

Pilot's Operating Handbook / UAS Flight Manual

Most aircraft have a handbook that provides crucial information about performance, including the exact center of gravity and load factor graph. I've never seen one for a drone.

If you see a question on your test asking about loading instructions or maintenance schedule, remember that you're supposed to check the handbook.

III

Atmospheric Conditions & Aircraft Performance

While the design of an aircraft largely determines its flight characteristics, external conditions can undermine even the best design and negatively impact performance.

Density Altitude

Aviators around the world have agreed on an exact set of standard atmospheric conditions to be used as reference points.

One measurement based on these standards is Density Altitude.

Density altitude is a reference to air density at a particular altitude in perfectly standard conditions, where the temperature is exactly 59º F and atmospheric pressure is an unwavering 29.92Hg. In these standard conditions, air is dense at low altitudes and thin at high altitudes.

So when we refer to a "high density altitude," we're basically saying the air is thin. And if we say density altitude is low, it means the air is dense.

If the air is too thin (high density altitude), an aircraft's wings won’t produce enough force and performance will decrease. Using a measurement like density altitude makes it easier for manufacturers to define an aircraft’s minimum air density and easier for pilots to make sure the air is dense enough to fly.

For your test, you'll need to know how different conditions affect density altitude, which you can figure out by learning which conditions make the air more thin and which make it more dense.

Elevation

As elevation rises, air density falls and density altitude rises.

Since elevation is synonymous with altitude, it's easy to infer that air density decreases with higher elevation.

Temperature

As temperature rises, air density falls and density altitude rises.

As a substance heats up, its molecules move quicker and begin to spread apart, like water becoming steam. In other words, density decreases with heat.

Humidity

As humidity rises air density falls and density altitude rises.

Water vapor is less dense than air, so as the air becomes more saturated with water, density decreases.

Atmospheric Pressure

As pressure rises, air density increases and density altitude falls.

As atmospheric pressure increases, air is compressed, which increases density.

Summary of Density Altitude

High Density Altitude (Low Air Density)

- High Elevations
- High temperature
- High humidity

- Low atmospheric pressure

Low Density Altitude (High Air Density)

- Low elevations
- Low temperature
- Low humidity
- High atmospheric pressure

The hazards of wind.

Turbulence from Obstructions

Buildings, mountains, and other large obstructions can create turbulence when the wind passes from one side to the other. The most dangerous turbulence occurs in mountainous areas where wind passes smoothly up one side of a mountain before crossing the peak and swirling around in downward circles that can push aircraft down towards the mountain itself.

Low-Level Wind Shear

Wind shear is a sudden, drastic change in wind speed or direction in a small area. Low-level wind shear occurs at a low altitude and is particularly dangerous as a result. For example, if the wind shifts from a headwind to a tailwind, an aircraft can lose a substantial amount of speed relative to the wind, which can result in a drop in altitude.

Atmospheric Stability

A stable atmosphere is one that resists vertical motion and is generally the result of cool, dry air. An unstable atmosphere is the result of warm, wet air and is prone to turbulence, updrafts, and thunderstorms.

The FAA produced a chart with four characteristics of stable air and unstable air that will likely show up on the test.

Unstable Air	Stable Air
Cumuliform clouds	Stratiform clouds and fog
Showery precipitation	Continuous precipitation
Rough air (turbulence)	Smooth air
Good visibility (except in blowing obstructions)	Fair to poor visibility in haze and smoke

If it helps you internalize these, here is a quick explanation for each.

Stable Air

Stratiform Clouds and Fog

Stratiform clouds (the wispy and flat ones) and fog both require stable air.

Continuous Precipitation

In stable air, rain is slow, steady, and continuous.

Smooth Air

Stable air has little turbulence and disruption.

Fair to Poor Visibility

In stable air, haze takes longer to dissipate, which can lead to reduced visibility.

Unstable Air

Cumuliform Clouds

Unstable air allows for updrafts, which lead to tall, puffy cumuliform clouds.

Showery Precipitation

Unstable air leads to tall rain clouds, and tall rain clouds release rain in showery bursts.

Rough Air

Unstable air is turbulent and unpredictable.

Good Visibility

In unstable air, haze dissipates quickly, which can improve visibility.

Inversion

Normally, air is cooler at higher altitudes. But sometimes, a layer of warm air can trap a layer of cool air beneath it. This is inversion, and commonly takes the form of fog or haze.

Temperature, Dew Point, & Frost

The warmer the air, the more moisture it can hold. Remember from our section on weather that the dew point is the temperature at which the air can no longer hold onto its moisture content, so it releases it.

When cold air and warm air mix, or when warm air passes over a cool surface, its temperature can drop below the dew point and produce clouds or rain.

On cool nights, the ground temperature can drop below the dew point and collect moisture as dew or frost.

Structural Icing

Structural icing is simply the formation of ice on an aircraft. The FAA wants you to know that it dangerously reduces performance.

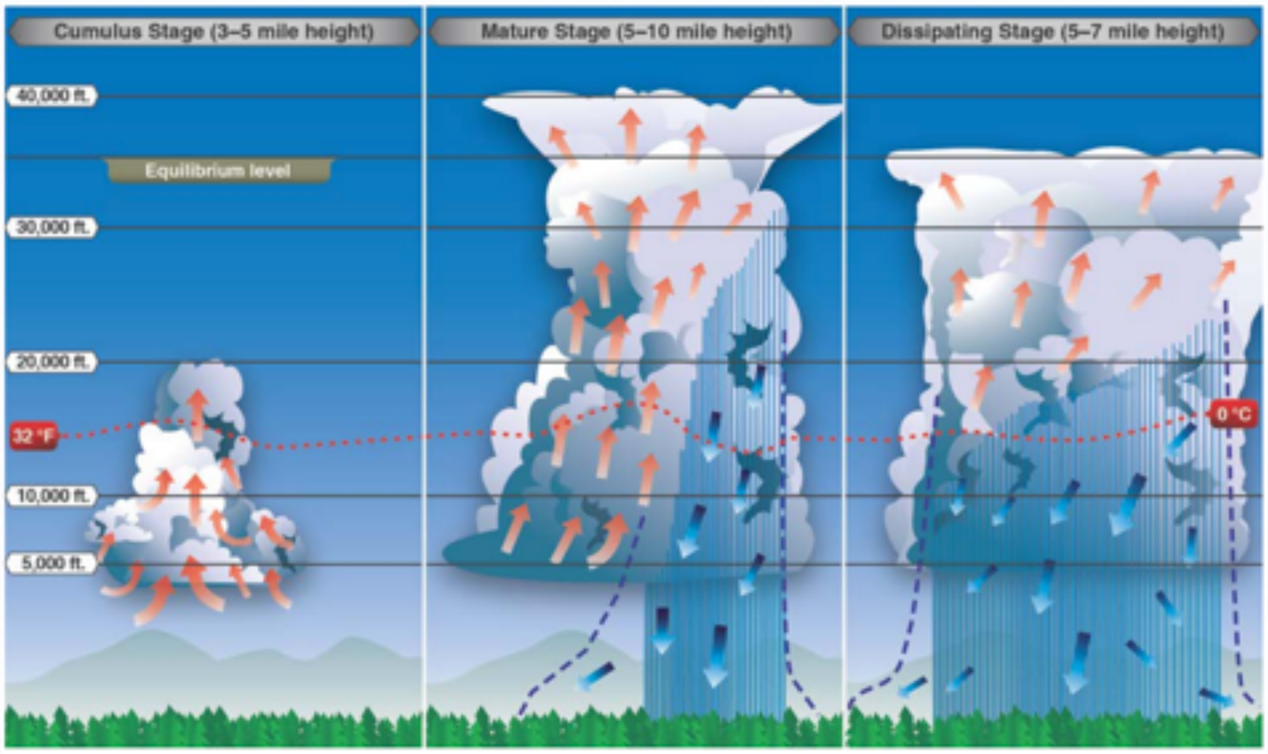
Structural icing occurs when:

1. An aircraft flies through visible water such as rain or cloud droplets and
2. The air at the surface of the aircraft is 0° C or colder.

Fronts

Fronts are the zones between different masses of air with different properties. Remember that temperature, humidity and wind often change rapidly over short distances in these areas.

Thunderstorm Lifecycle



A thunderstorm comes and goes in three main stages.

1. Cumulus Stage

It all begins with warm air rising upwards due to mountains or weather fronts. The warm air creates a tall cumulus cloud as it carries moisture into the colder air at higher altitudes. The air drops below the dew point and water begins to fall, creating a downdraft of cold air.

Tall cumulonimbus cloud should be recognized as the most dangerous to aircraft, as they are formed by air in vertical motion.

2. Mature Stage

This downdraft becomes a full-on highway for cold air rocketing towards the ground, creating gusts, temperature drops, and high pressure. Right next to it, warm air is flying upwards, which creates dangerous wind shear and turbulence.

3. Dissipating Stage

The downdraft of cold air takes over, and the turbulence subsides. All that's left is for the rain to clear. On your test, you may see this stage described as "characterized by downdrafts."