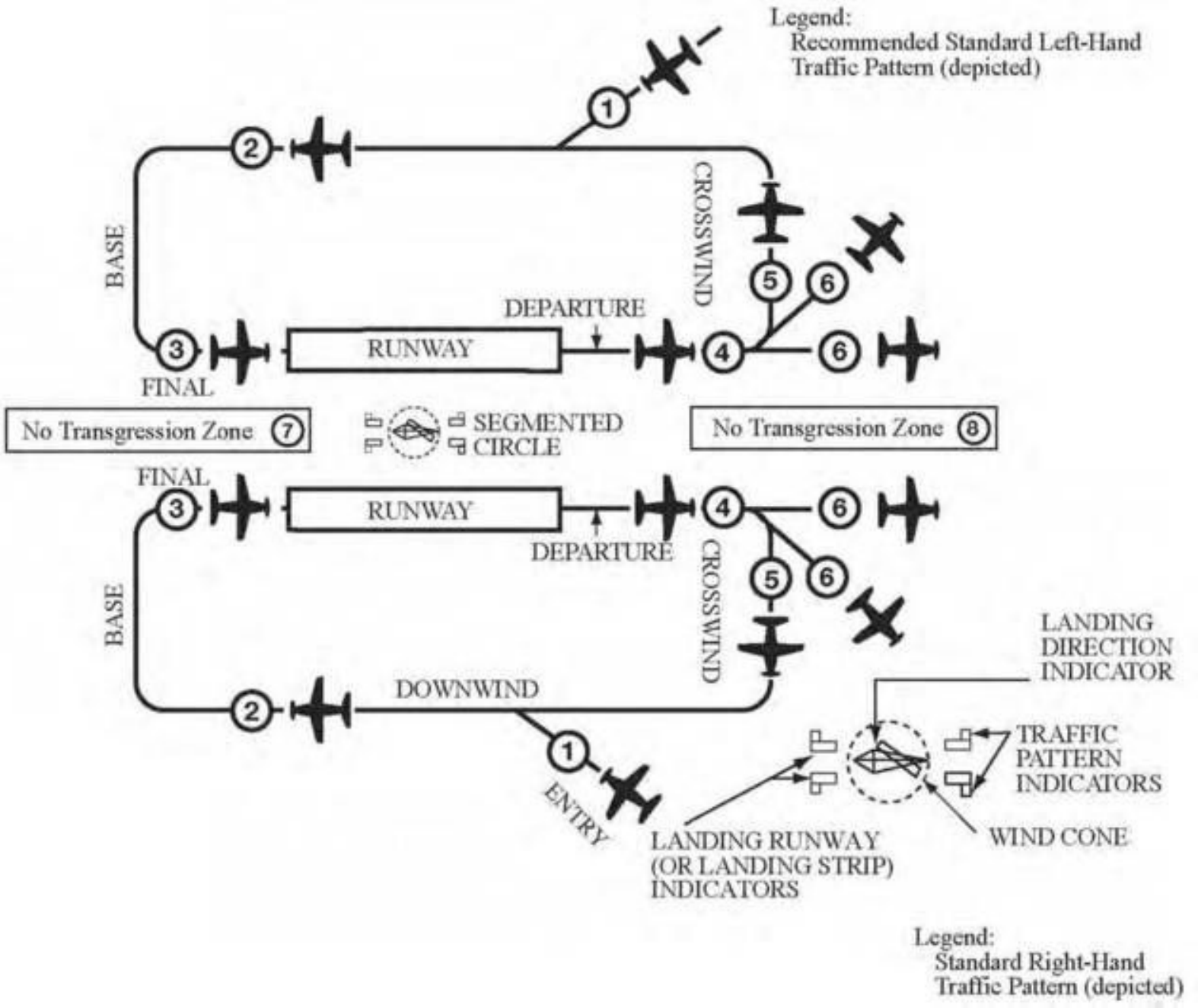
FAA Part 107 UAS Remote Pilot Prep- Part 2

Airport Operations, Weather, Physics

Part 4 Airport Operations

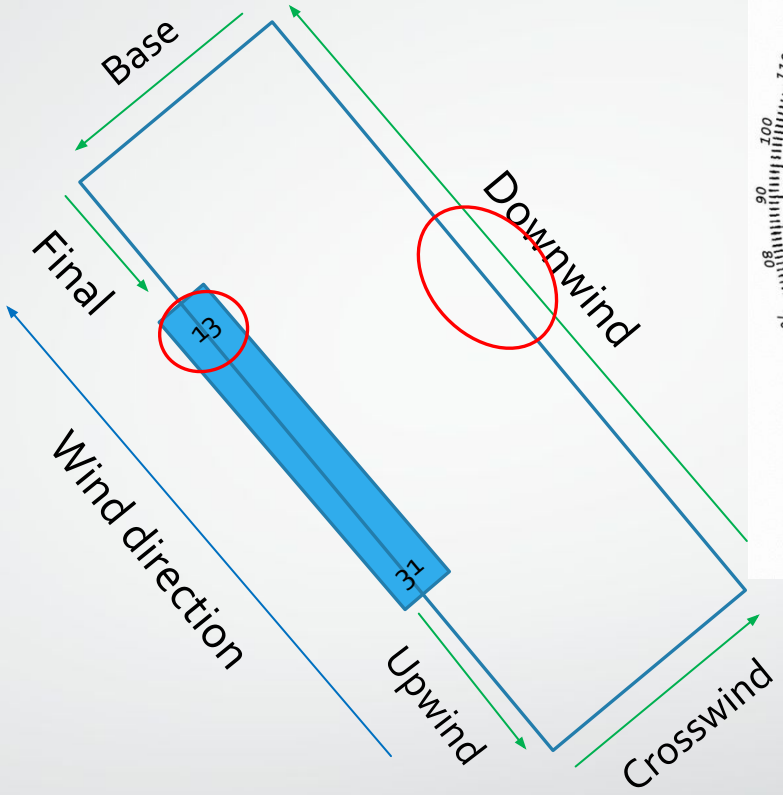
Traffic Patterns

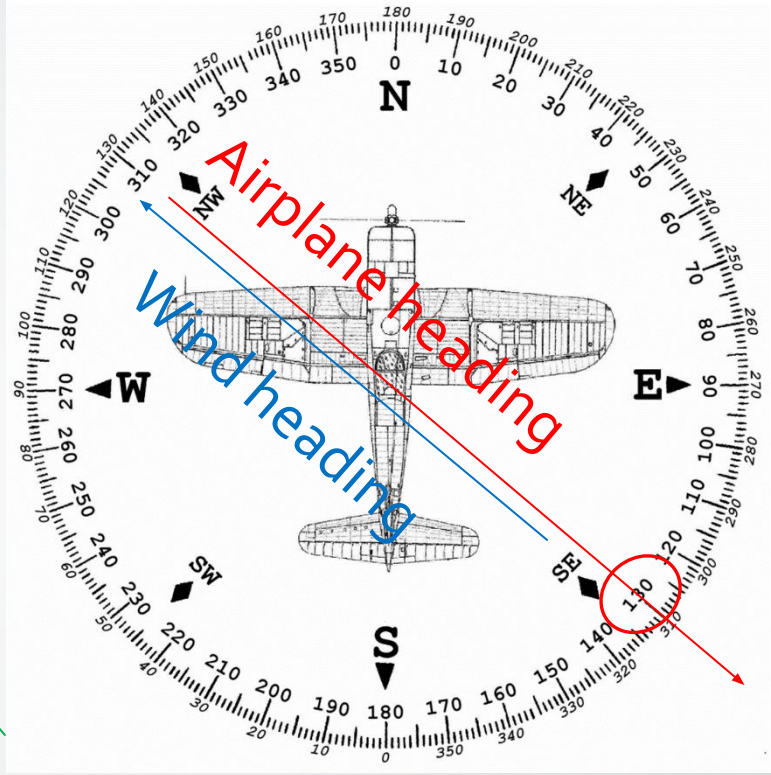


- Landing pattern typically 1000 AGL, but check CS
- Enter 45 deg at the midpoint of the downwind left at traffic pattern altitude
- Typical pattern is left handed
- Entries in to traffic patterns by UAS while descending create collision hazards and should be avoided

Airplane examples left hand traffic

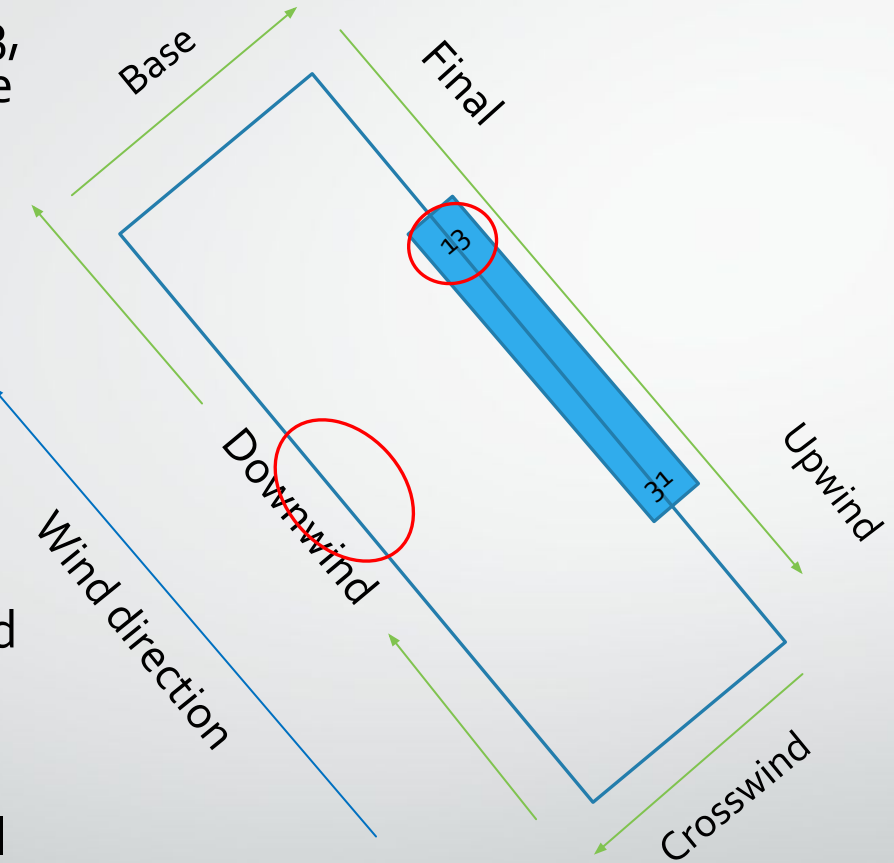
- Airplane is left downwind heading for runway 13, where is it relative to the runway?
- A) The aircraft is East.
  B) The aircraft is South.
  C) The aircraft is West.
- They didn't tell us it was right hand traffic so we can assume left
- For runway 13 (130 deg) the cockpit compass will read 130 on take off and landing

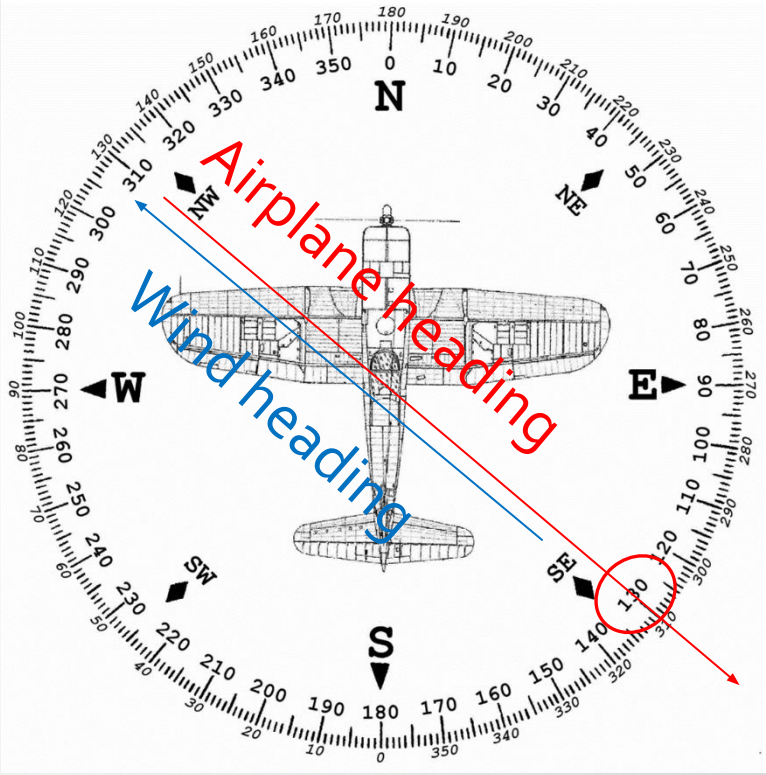




Airplane examples right hand traffic

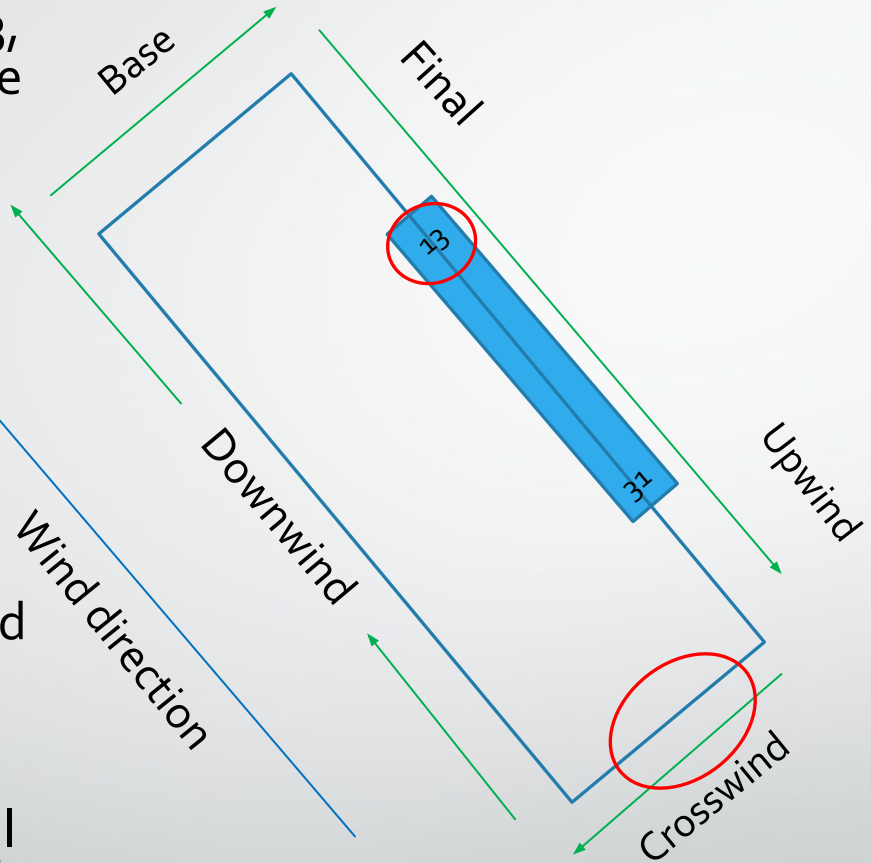
- Airplane is right mid field downwind for runway 13, where is it relative to the runway?
- A) The aircraft is East.
  B) The aircraft is North.
  C) The aircraft is West.
- They did tell us it was right hand traffic, so have to take a right hand turn to land
- For runway 13 (130 deg) the cockpit compass will read 130 on take off and landing

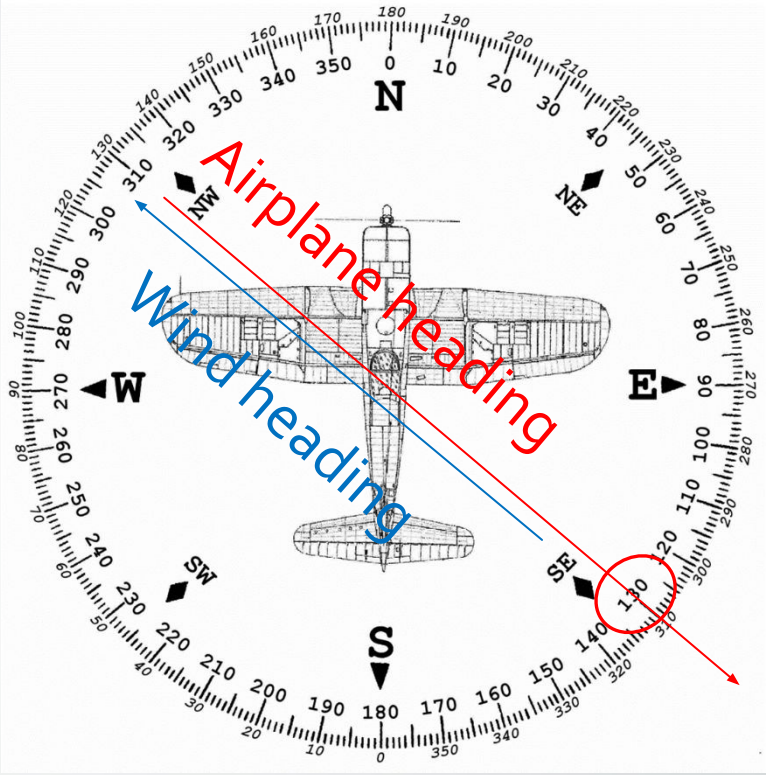




Airplane examples right hand examples

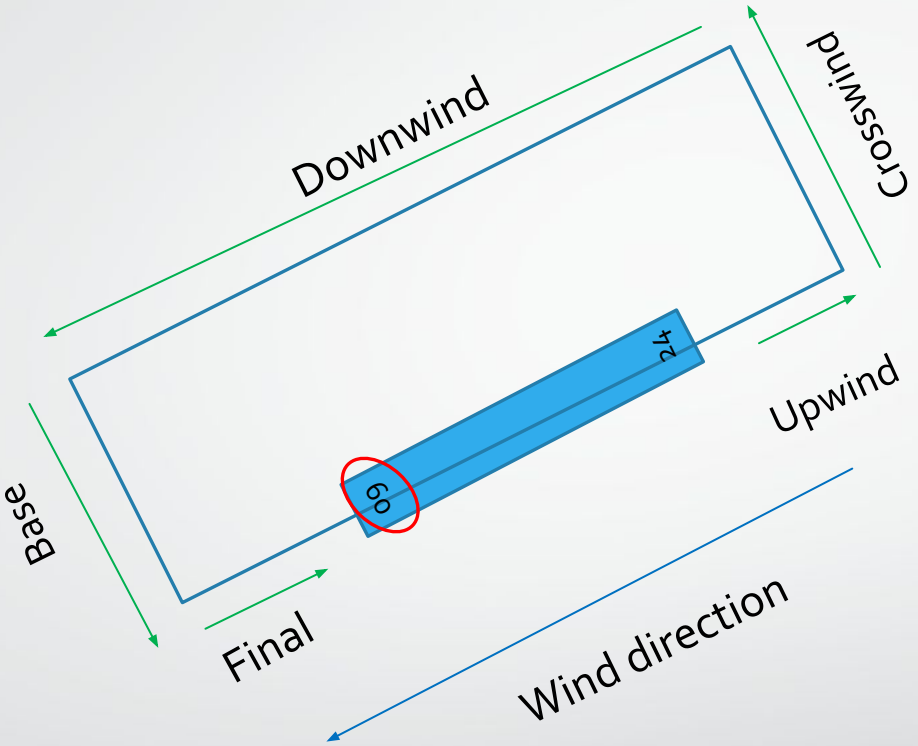
- Airplane is right crosswind for runway 13, where is it relative to the runway?
- A) The aircraft is East.
  B) The aircraft is South.
  C) The aircraft is West.
- They did tell us it was right hand traffic, so have to take a right hand turn to land
- For runway 13 (130 deg) the cockpit compass will read 130 on take off and landing

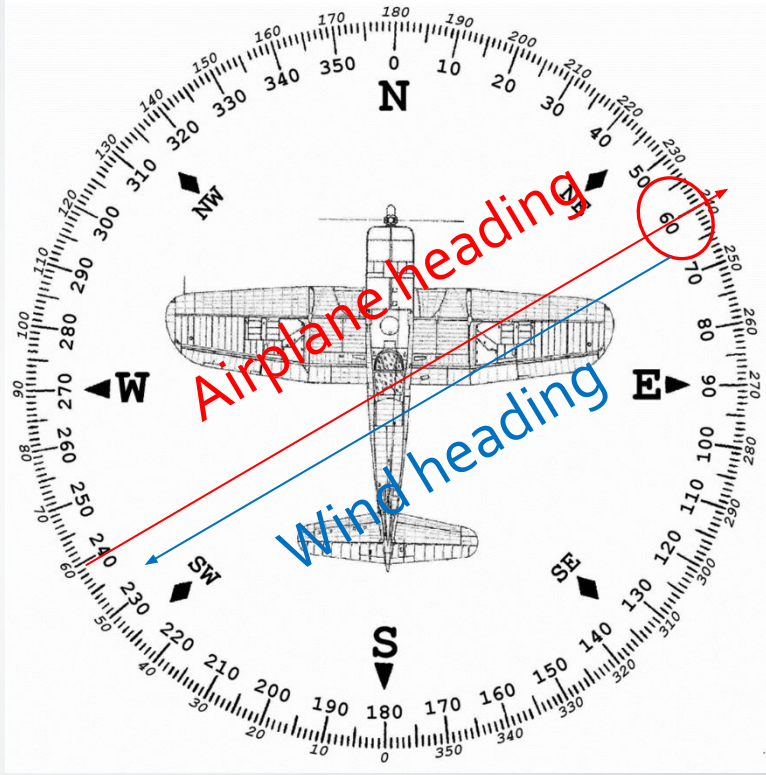




Airplane examples drone

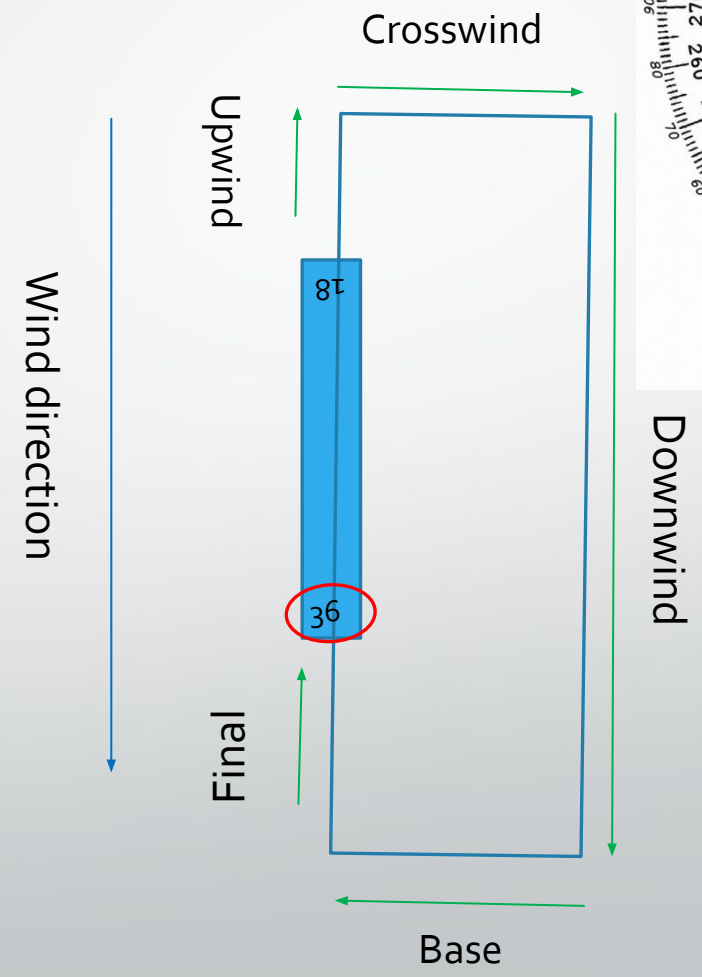
- You have ATC clearance to fly UAS south of an airport, ATC notifies you to stay clear of runway 6 final approach, what areas should you avoid?
- A) East.
  B) North.
  C) South.
- They did not tell us it was right hand traffic, so have to take a left hand turn to land
- For runway 6 (6o deg) the cockpit compass will read 6o on take off and landing

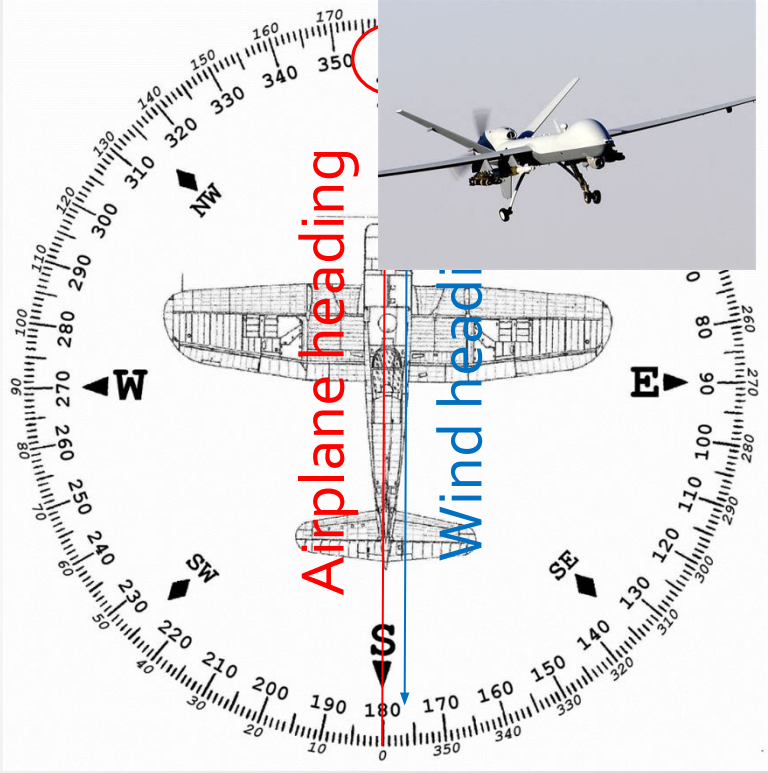




Airplane examples drone

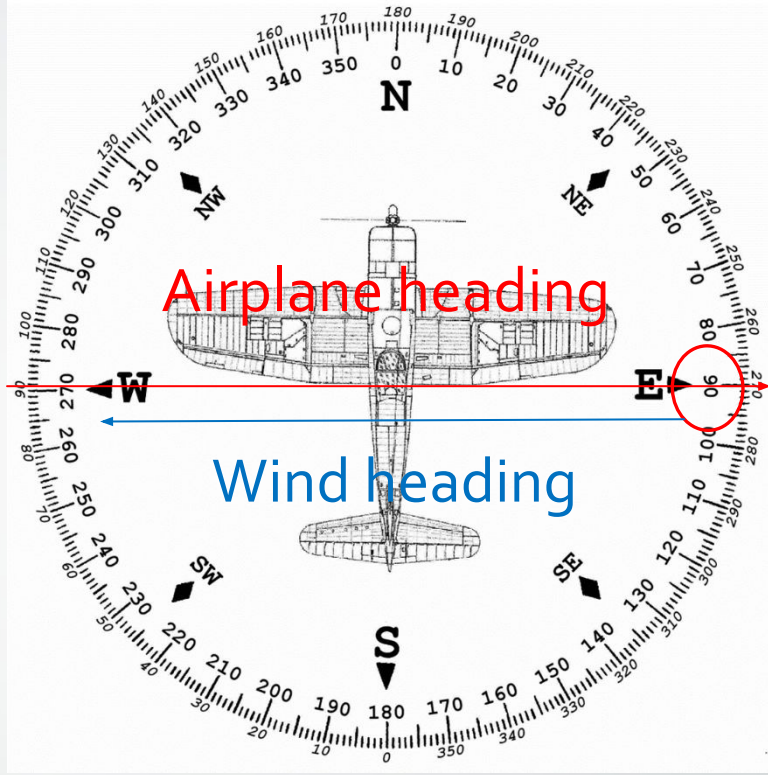
- You are flying under ATC clearance NE of an airport, ATC says an airplane is departing runway 36 using right hand traffic. Should you be worried?
- A) Yes.
  B) No.
- They did tell us it was right hand traffic, so have to take right hand turn after take off
- For runway 36 (360 deg) the cockpit compass will read 360 on take off and landing





Airplane examples drone

- ATC radios an airplane flying on a heading of 090 "Unmanned aircraft operations, 3' o'clock, 2 miles", you are flying that drone, where should you look for the airplane?

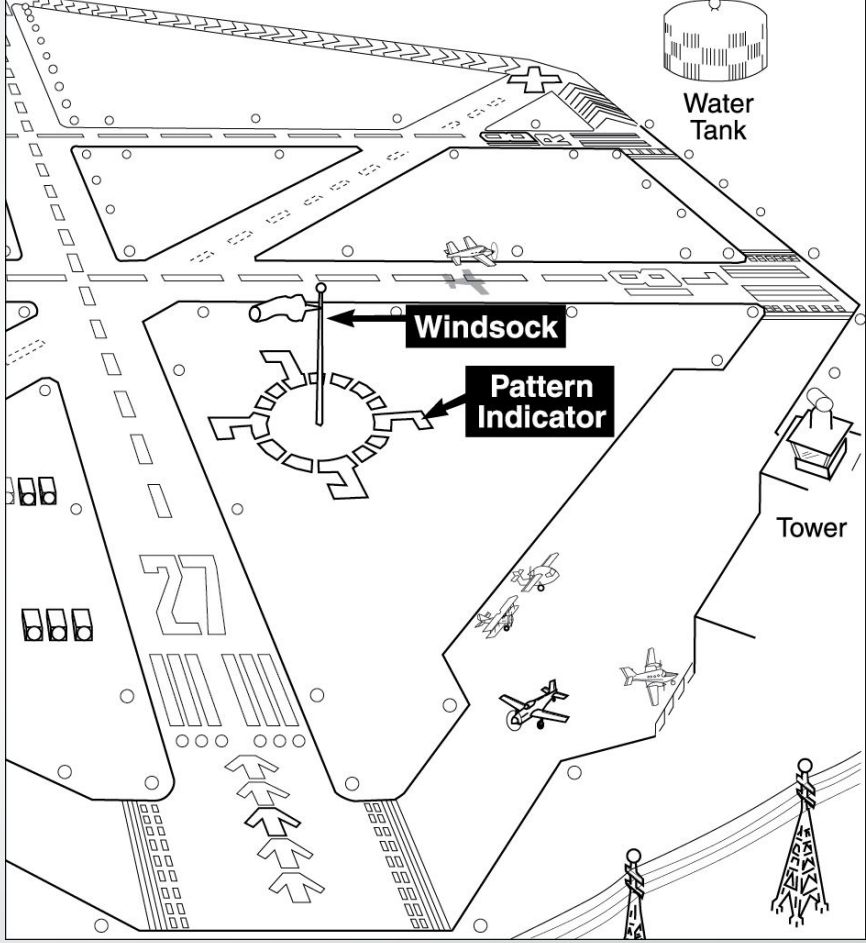


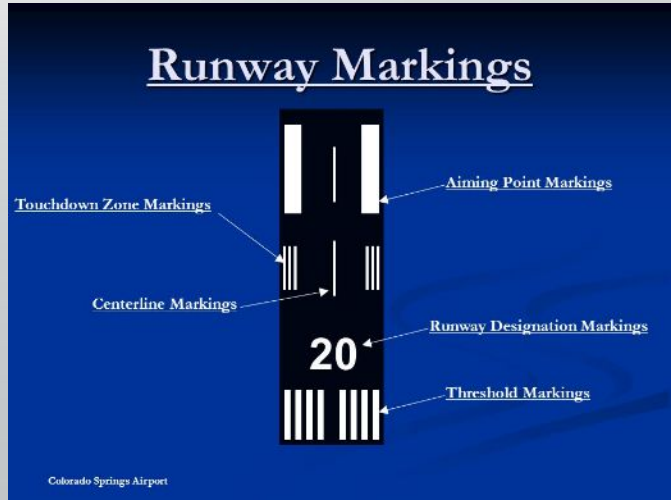
- A) East.
  B) North.
  C) South.

- 3 o'clock is 90 degrees to the right from the perspective of the pilot

Airport operations

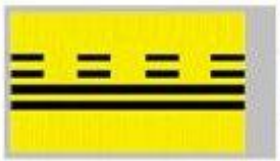
- UAS must remain clear of all manned aircraft patterns and operations.
- Air Traffic Control clearance provides authorization to proceed under specified traffic conditions in controlled airspace
- Runways numbered by direction 0-360 magnetic, rounded to nearest 10 deg with the last zero dropped, so 078° = 080°= runway 8, and the opposite end of the runway is 26 (the opposite end of the compass ± 180), if parallel runways are used it would be 26L and 26R
- Airplanes normally take off AND land INTO the wind
- Standard traffic is left handed, all turns are to the left, but there may be right handed patterns. On sectional chart it may say "RP 11 16", which means at RWYs 11 and 16 it is right handed traffic, if it says *RP, right hand pattern is only during certain hours.
- A runway is closed when a yellow X is placed at the center. If multiple runways, a runway is closed with an X at each end. If an airport complex has an X at the center, the whole airport is closed.





Airport signs

ILS critical area holding position sign
When the ILS is in use ATC may hold you short of this sign so your aircraft does not interfere with the ILS signal.



Runway boundary sign
This sign faces the runway and is visible to pilots exiting the runway. Taxi past this sign to be sure you are clear of the runway.

Runway approach area holding position sign
You must hold at this sign until cleared to cross the runway, to avoid interference with runway operations.

Taxiway ending marker
This sign indicates the termination of the taxiway. It is located at the far end of the intersection.

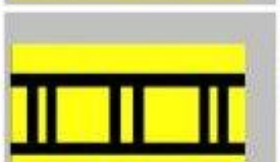
Taxiway location sign
This sign indicates which taxiway you're on. It may be posted next to direction or holding position signs.

Closed runway and taxiway marking
Located at both ends of permanently closed runways and at 1,000-foot intervals. It is also placed at taxiway entrances if they are permanently closed.

Runway holding position sign
Until cleared onto the runway you must hold at this sign. In this example, the runway 15 threshold is to the left and the runway 33 threshold is to the right.

Direction sign for runway exit
This sign will indicate the approaching taxiway while on the runway. In this example, taxiway Bravo is approaching to the left.

Destination signs and location sign
This sign indicates current position and direction to other taxiways. In this example, you are on taxiway Alpha. Taxiway Charlie passes from right to left and Alpha continues ahead to the right.



ILS critical area boundary sign
Indicates when you are safely clear of the ILS critical area. It is located directly beside the ILS holding position markings. While ILS approaches are in use, taxi past the sign before stopping on the taxiway.

Outbound destination sign
This sign indicates directions to common taxi routes. In this example, runway 27 and 33 are to the right. The dot in the middle separates destinations identified on the sign.

Holding position and location signs
In this example you are on taxiway Alpha; runway 5-23 passes perpendicular to your position. Runway 9-27 passes at an angle starting ahead and left of your position to behind and right of your position.

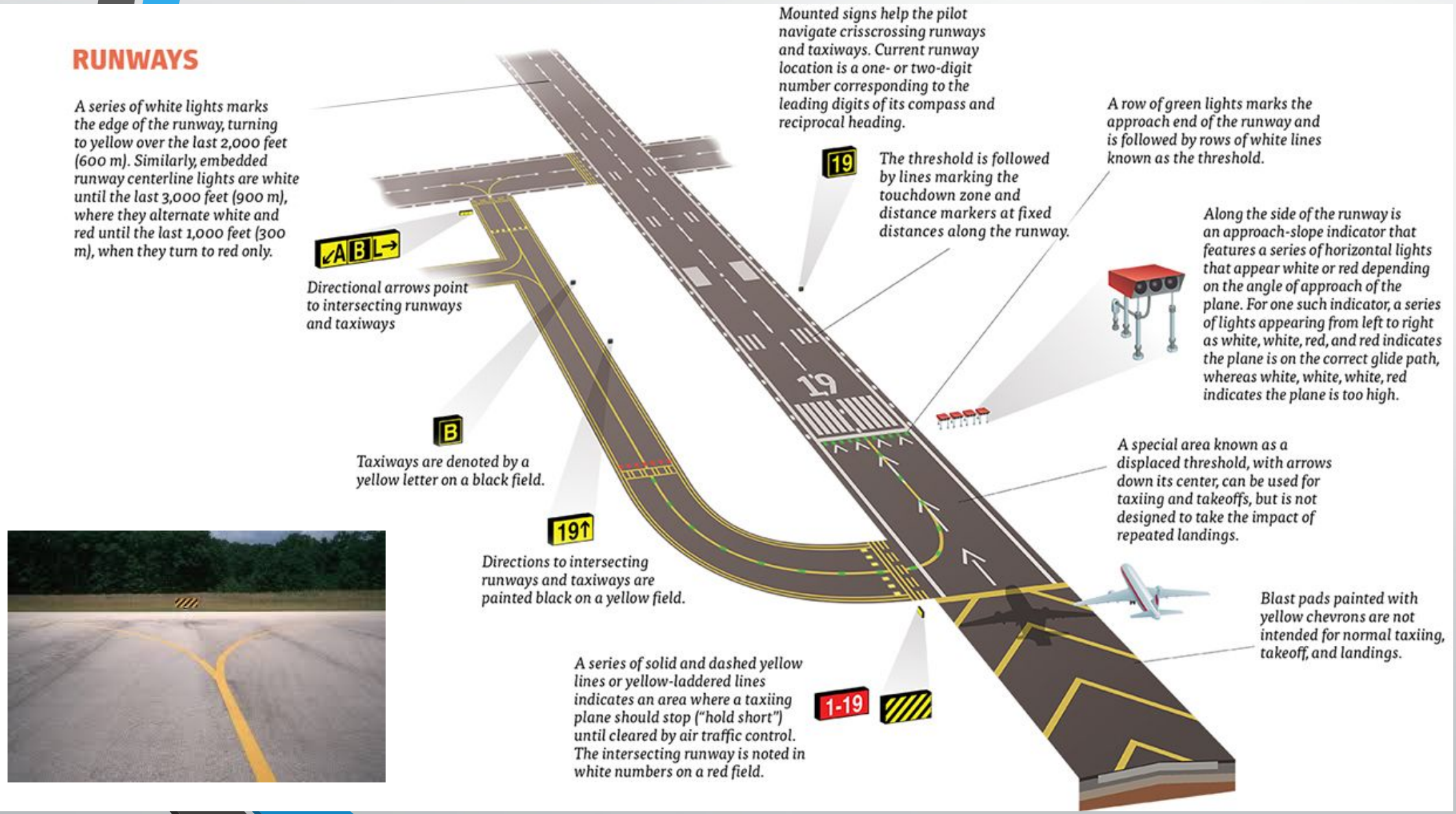
Inbound destination sign
This sign directs pilots to destinations on the airport. This example indicates that the military installation is to the right.

Runway location sign
This sign identifies the runway on which your aircraft is located.

No entry

- Mandatory instruction signs, red back white letters
- Instrument landing system ILS- radio beams to assist in guidance
- APCH- Approach, Low flying aircraft!
- Location signs black back, yellow letters, yellow border
- Direction signs yellow back black writing
- Holding position signs- red back, white numbers
- No entry- paved area,

Runway and taxiway markings



- Taxiway- Yellow
- Runway- White
- Taxi to runway- solid double yellow lines, with dashed yellow lines beyond
- Taxiway directional signs- indicate designation and direction of taxiway leading out of an intersection
- You are clear of the runway when all parts of the aircraft have crossed the hold line

Airport ops at control tower airports

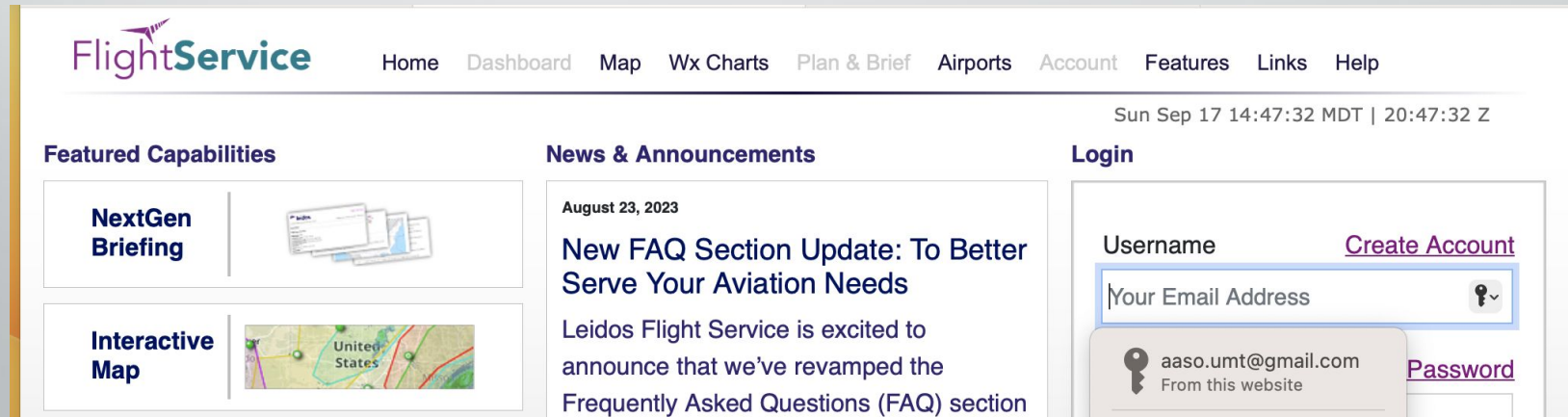
- Most airports with towers have Automatic Terminal Information Service (ATIS), broadcasts weather, runways in use and NOTAMs
- If ground control instructs to taxi to runway 6, you can proceed by taxiways and across runways to but not onto runway 6
- Pilots should state their position on the airport, when calling the tower for takeoff from a runway intersection
- When tower closes airport becomes Class E or G airspace. Check CS and NOTAMS.
- Listen to air traffic control on web- www.liveatc.net

Airport ops at non-control tower airports

- Manned aircraft must comply with any FAA traffic pattern established for the airport
- Most non-towered airports exist in Class G airspace, Monitor UNICOM or CTAF
- Not all aircraft will have radio or ADS-B
- Websites to track aircraft in area: www.flightradar24.com

Flight Service Stations (FSS)

- Air traffic facilities that provide: pilot briefings, enroute communications, VFR search and rescue services, assist lost aircraft and aircraft in emergency situations, relay ATC clearances, originate NOTAMs, broadcast aviation weather, receive and process IFR flight plans, and monitor NAVAIDS
- Can call by radio or phone
- https://www.1800wxbrief.com/Website/#!/



Airport Operations Test Questions

- There are runway hold positions markings on taxiways. What is the need for the markings?
  - A) Holds aircraft short of runway
  - B) Distinguish areas where aircraft are allowed and not allowed
  - C) Give aircraft approvals onto the runway
- UAS entering an airport traffic pattern are advised to enter in one of these positions
  - A) 45 degrees to the base leg just beneath the traffic pattern altitude
  - B) Direct crossing over the airport at traffic pattern altitude
  - C) 45 degrees entering at midpoint of the downwind left at traffic pattern altitude
- Numbers 9 and 27 present on a runway implies that the runway is oriented nearly
  - A) 090 degrees and 270 degrees magnetic
  - B) 090 degrees and 270 degrees true

Part 5 Radio Operation

Radio Frequencies

- You need a Federal Communications Commission license to transmit.
  - https://www.fcc.gov/wireless/support/universal-licensing-system-uls-resources/applying-new-license-universal-licensing
- Aviation band radio- very high frequency (VHF) 108-137 MHz. VHF is limited to line of sight
- Pilots should monitor **121.50** MHz at all times if possible. Aircraft emergency frequency (or GUARD or International Air Distress- IAD)
- Common traffic advisory frequency (CTAF)- manned aircraft announce position, intentions, and operations. Pilot to pilot communications
- MULTICOM- (**122.9** or **122.95** MHz) what you use if there is no CTAF. Usually very small airports.
- If an airport does not have a tower, FSS, or UNICOM, broadcast intentions in the blind on the CTAF **122.9**.
- Standard ops all inbound and local traffic approaching an airport without a tower from a distance of **10 miles**.

Automatic Terminal Information Service (**ATIS**) broadcasts **non-control information** in selected high-activity terminal areas.

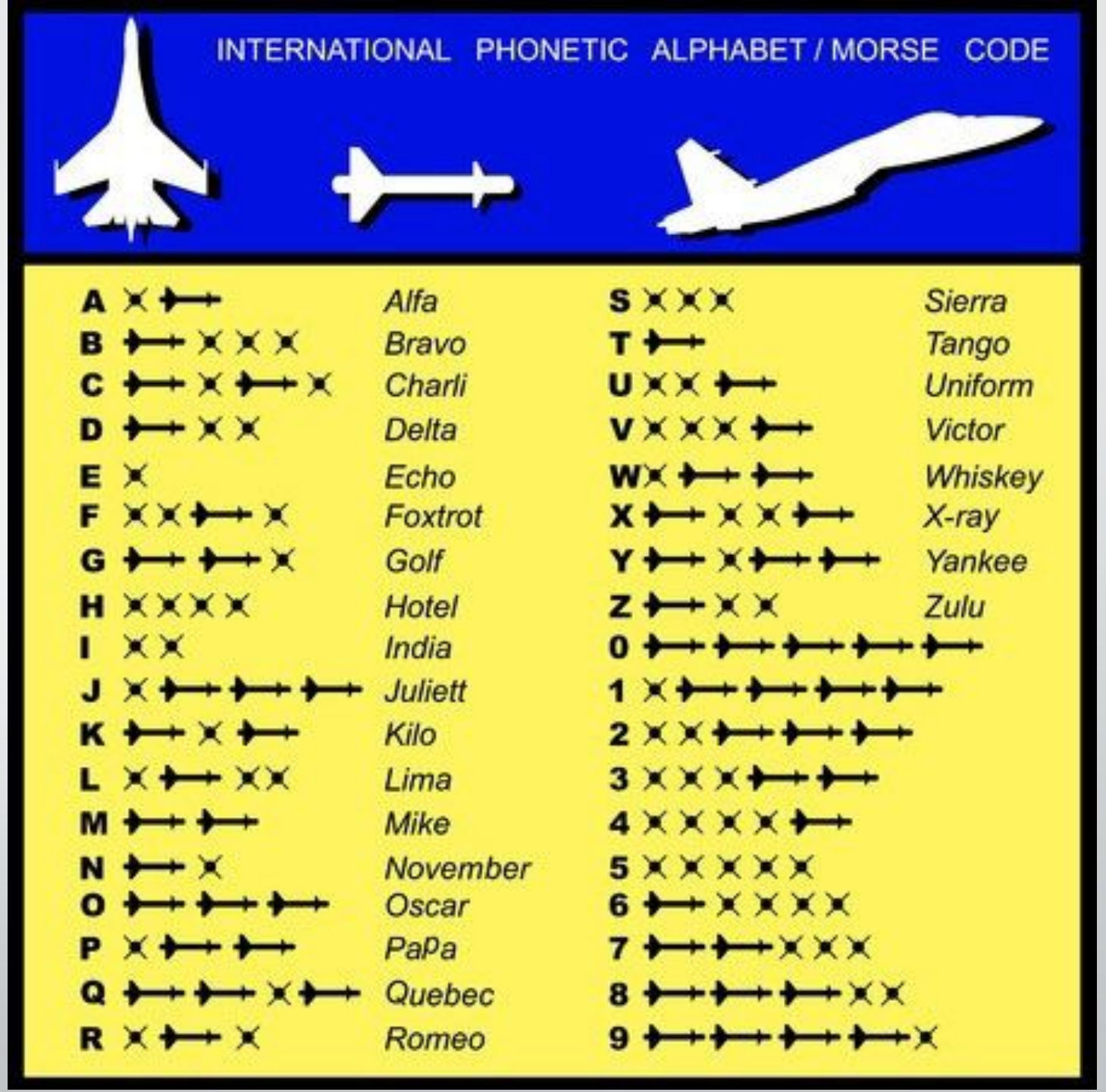
Radio Alphabet

International- multiple languages

The number three (3) is pronounced “**tree**.”

The number five (5) is pronounced “**fife**.”

The number nine (9) is pronounced “**niner**.”



Radio Etiquette

- Resource for phraseology airmen's information manual AIM
- 3,500= say "Tree thousand, Fife Hundred"
- 349°= say "Tree, Four, Niner"
- You want to contact the Whitted ATC tower, and your drone is HAWK N666CB. This would be the proper way to contact them:

"Whitted Tower, HAWK SIX SIX SIX CHARLIE BRAVO five NM west of the airport, request permission to enter Class D airspace for unmanned aircraft operations below four hundred AGL, three NM west of the airport"

- When entering controlled airspace broadcast intentions and monitor transmissions on the CTAF or MULTICOM frequencies. Give position reports in the traffic pattern.
- Minimize risk of radio frequency interference during UAS ops by monitoring frequency use with a spectral analyzer (aviation band scan function)

Radio Test Questions

- What is the definition of the CTAF?
  - A) The standard frequency that the majority of the towered airports use in the US
  - B) The air-to-air communication system for pilots to communicate with one another
  - C) The frequency you tune into to get info from the aeronautical advisory station (UNICOM)
- Inbound flight into an airport without tower, UNICOM, or FSS in operation. What MULTICOM frequency should the pilot use to self announce?
  - A) 122.7
  - B) 122.8
  - C) 122.9
- All inbound and local traffic moving close to an airport with no control tower should continue to monitor the appropriate facility from which distance?
- A) 28 miles
- B) 30 miles

Part 6 Weather

Weather

- Hot air = less dense= low pressure areas
- When hot air cools it descends and creates high pressure
- Every physical process of weather is a result of unequal heating of the earth (heat exchange)
- As a volume of air is heated, amount of moisture it can hold increases, ie for a 20°F increase in temp = 2x increase in air capacity to hold moisture.
- Dew point is the temp when air becomes saturated and cannot hold more moisture, if air temp is 65° and DT is 48° and then the temp cools (17°) suddenly it will create rain or fog
- If Temp and DT are within 5°F, there is a good chance for rain.
- When moist air moves over colder ground or water it creates fog, common in coastal areas.
- https://www.aviationweather.gov/

Airport Weather

- Automated terminal information system (ATIS)- requires a human to monitor, mostly larger airports, most airports broadcast at 55 mins past hr
- Automated surface observing system (ASOS)- run by NWS, DOD, and FAA. ASOS broadcasts minute-by-minute observations and is used to generate the METAR and other aviation weather information
- Automated weather observing system (AWOS)- mostly run by FAA, report weather every minute
- Barometric pressure, wind speed and direction, visibility, sky condition, ceiling height, and precipitation
- Before a planned flight, a PIC should obtain a **standard** weather briefing
- If there is no mention of sky condition an visibility, you can assume the ceiling is at least 5000' and the visibility is at least 5 miles.

https://www.faa.gov/air_traffic/weather/asos/?state=MT

Weather Questions

- All weather is a result of
  - High pressure and low-pressure fronts
  - Unequal heating of the earth
  - The Coriolis effect
- Before a planned UAS flight a PIC should obtain
  - Pilot flight briefing
  - Standard weather briefing
  - METAR briefing
- As an air mass is heated
  - Its ability to hold moisture is decreased
  - It becomes less dense and can hold more moisture
  - It descends

METAR weather

- KBTM 271953Z AUTO 33003KT 7SM -RA BKN021 BKN028 OVC032 11/06 A2994 RMK AO2 RAB1855 SLP116 P0001 T01110056
- KBTM- Bert Mooney
- 271953Z- 27th day, (month assumed), 1953Z time= 7:53p UTC = 1:53p local
- 33003KT- wind, 1st 3 =direction (mag) 330 deg= NNW, winds reported in direction they are coming FROM, 2nd 2= speed 3 knots
  - VRB= variable, G= gusts
- 7SM= visibility, if it was M7SM= minus than 7 statute miles
- -RA- Rain, BR- Mist (from French Brume), FG- fog, SN- snow, VC= vicinity, so VCTS= thunderstorms in vicinity, - means light, + means heavy
- BKN021 BKN028 OVC032 - cloud coverage in hundreds altitude, so broken clouds 2100 to 2800 ft and overcast at 3200 ft, VV= vertical visibility, SKC and CLR= clear, FEW= few, SCT= scattered, OVC= overcast
- 11/06- temperature and dewpoint in Celsius, 11 deg C, and 6 deg C dewpoint temperature, M11/M06 would be minus 11 and 6
- A2994- A= altimeter, pressure of the air measured in inches of mercury, 29.94. Allows altimeter to measure correct height off ground
- RMK AO2 RAB1855 SLP116 P0001 T01110056- RMK= remarks, AO2= code to say METAR automated and can tell difference between rain and snow, AO1 means it can not tell difference between rain and snow, RAB= rain began at 1855Z, SLP 116= sea level pressure in millibar, need to add at 10 before the first number and decimal before last so 1011.6
- P0001 T01110056- P= hourly precipitation in 100th of an inch, so 1/100th of an inch fell in the last hour, T01110056- hourly temp and dewpoint to the nearest 1/10th of a deg C this is the actual temp/dewpoint at the hour 2000Z, the zero after the T means it is higher than 0 deg C (a 1 would mean it is less than 0 deg C), so it was 11.1 C and DP 5.6C at 2pm local

METAR Abbreviations

Qualifier		Weather Phenomena		
Intensity or Proximity 1	Descriptor 2	Precipitation 3	Obscuration 4	Other 5
- Light	**MI** Shallow	**DZ** Drizzle	**BR** Mist	**PO** Dust/sand whirls
Moderate (no qualifier)	**BC** Patches	**RA** Rain	**FG** Fog	**SQ** Squalls
+ Heavy	**DR** Low Drifting	**SN** Snow	**FU** Smoke	**FC** Funnel cloud
VC in the vicinity	**BL** Blowing	**SG** Snow grains	**DU** Dust	**+FC** Tornado or Waterspout
	SH Showers	**IC** Ice Crystals (diamond dust)	**SA** Sand	**SS** Sandstorm
	TS Thunderstorms	**PL** Ice Pellets	**HZ** Haze	**DS** Dust storm
	FZ Freezing	**GR** Hail	**PY** Spray	
	PR Partial	**GS** Small hail or snow pellets	**VA** Volcanic ash	
		UP *Unknown Precipitation		

The weather groups are constructed by considering columns 1-5 in this table, in sequence; i.e., intensity, followed by descriptor, followed by weather phenomena; i.e., heavy rain showers(s) is coded as +SHRA.

* Automated stations only

Terminal Aerodrome Forecast (TAF)

- 5 m radius around airport
- P6SM= plus, greater than

TAF

KBWI 111505Z 1115/1218 27005KT P6SM SCT150
FM120000 VRB03KT P6SM FEW200
FM120500 28006KT P6SM SCT250
FM120900 31010KT P6SM SCT200

- Time information
  - FM → Read as "from"
  - 12 → Day of month
  - 0000 → Time of the forecasted conditions

Significant Meteorology- SIGMET

- Notification of any weather that can be potentially hazardous to all aircraft
  - Severe icing, turbulence, dust or sand storms, volcanic ash
- Convective SIGMET
  - Line of thunderstorms, area of thunderstorms, embedded or severe thunderstorms, tornados, hail >= ¾ " diameter, wind gusts >= 50 kts
- Center Weather Areas (CWA)
  - Same as above but just below severe criteria
- Air Meteorology (AIRMET)
  - Weather potentially hazardous to all aircraft but not meeting SIGMET criteria
  - Ceilings less than 1000', visibility less than 3 miles, moderate turbulence, wind >= 30 knots at surface, moderate icing

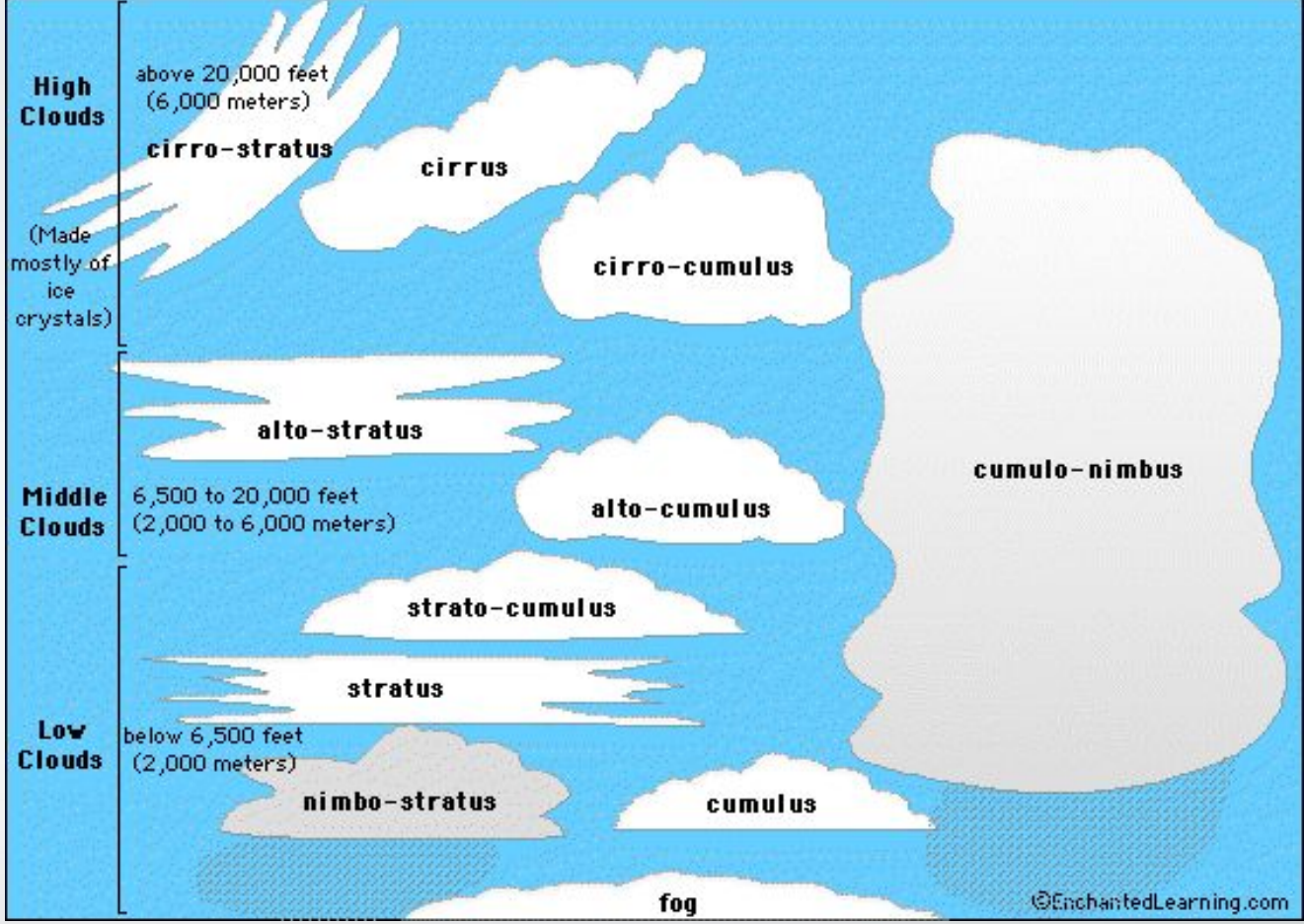
https://www.aviationweather.gov/sigmet

METAR Questions

- What are the current conditions at Chicago Midway Airport (KMDW)?
  - METAR KLAX 121852Z 25004KT 6SM BR SCT007 SCT250 16/15 A2991
  - SPECI KMDW 121856Z 32005KT 1 1/2SM RA OVC007 17/16 A2980 RMK RAB35]
    - Sky 700 ft overcast, visibility 1-1/2 SM, rain
    - Sky 7000’ overcast, 1-1/2 SM, heavy rain
    - Sky 700’ overcast, visibility 11, occasionally 2SM, rain
- The wind direction and velocity at KJFK is from
  - KJFK 121853Z 18004KT 1/2SM FG R04/2200 OVC005 20/18 A3006
    - 180 deg true at 4 knots
    - 180 deg magnetic at 4 knots
    - 040 deg true at 18 knots
- Terminal Aerodrome Forecasts (TAF) cover a radius of
    - 25 miles
    - 10 miles

Cloud Types

- Nimbus- big heavy clouds, grayish/black color, possible thunderstorms
- Stratus- wispy layer-like, fog when at ground, stable
- Cumulus- puffy cloud can become cumulo-nimbus, sign of instability
- Cirrus- thin, fibrous



Nimbus

Stratus

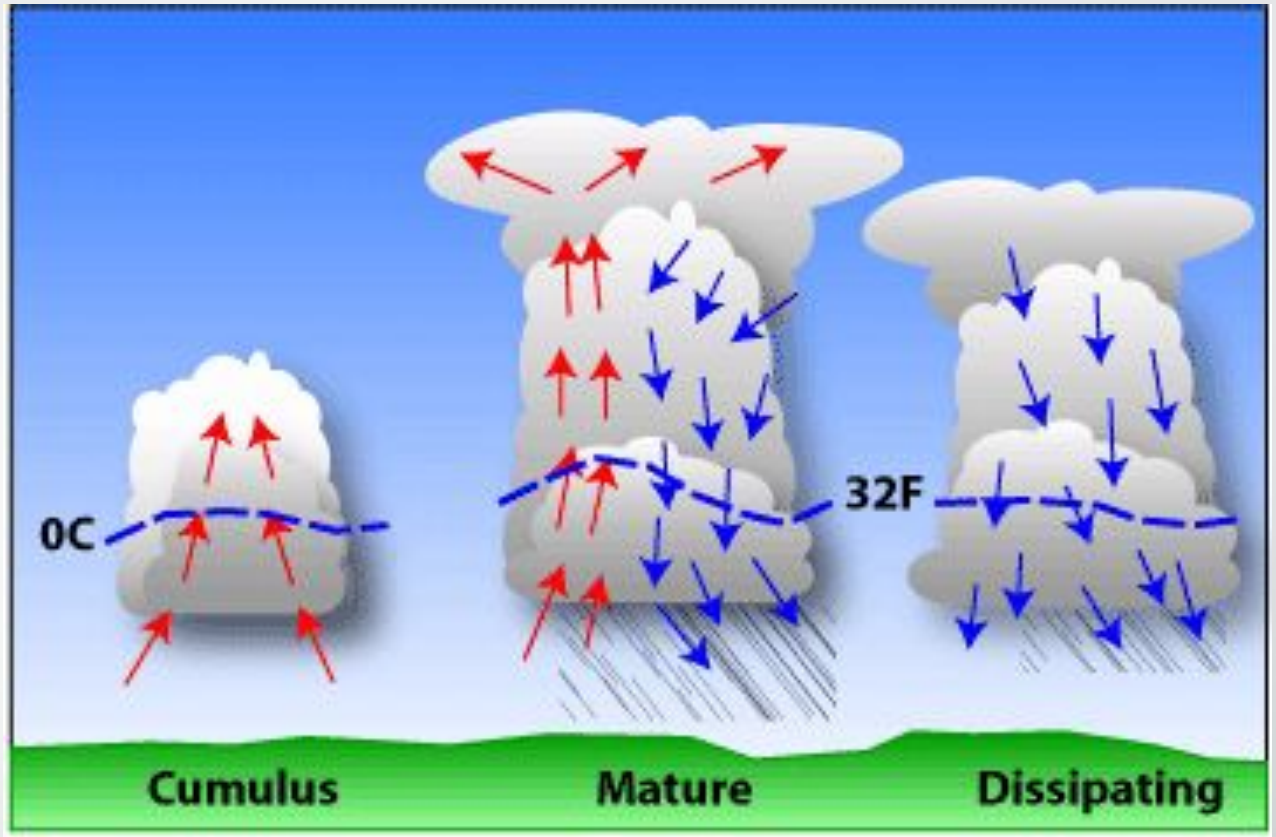
Cumulus

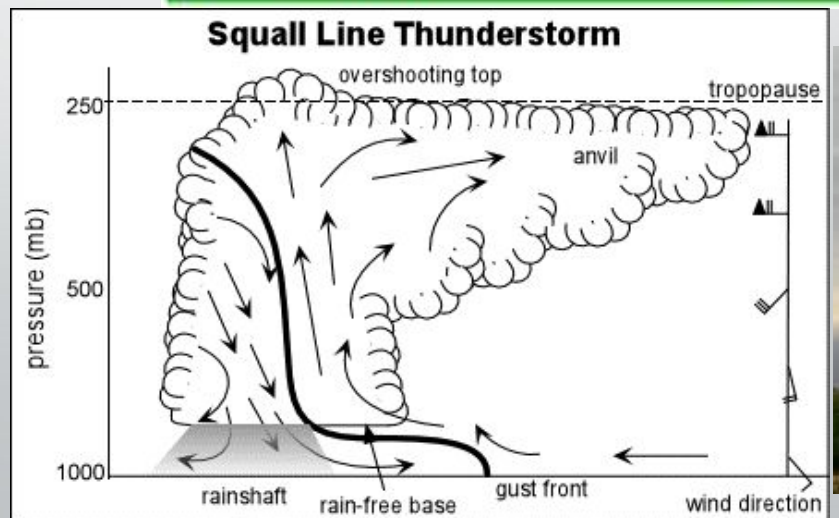
Cirrus

Thunderstorm life cycle

- Thunderstorms need high humidity, lifting force, and unstable conditions
- Cumulus- **updrafts**
- Mature- **updrafts and downdrafts,** greatest intensity, rain begins to fall
- Dissipating- **downdrafts**
- Squall lines are non-frontal, narrow band of active thunderstorms, often forming ahead of a cold front.
- Most dangerous thunderstorms to aircraft are squall line thunderstorms. Squalls can form at any altitude.
- Thunderstorms always associated with thunder and lightning

Thunderstorms are associated with wind-shear turbulence



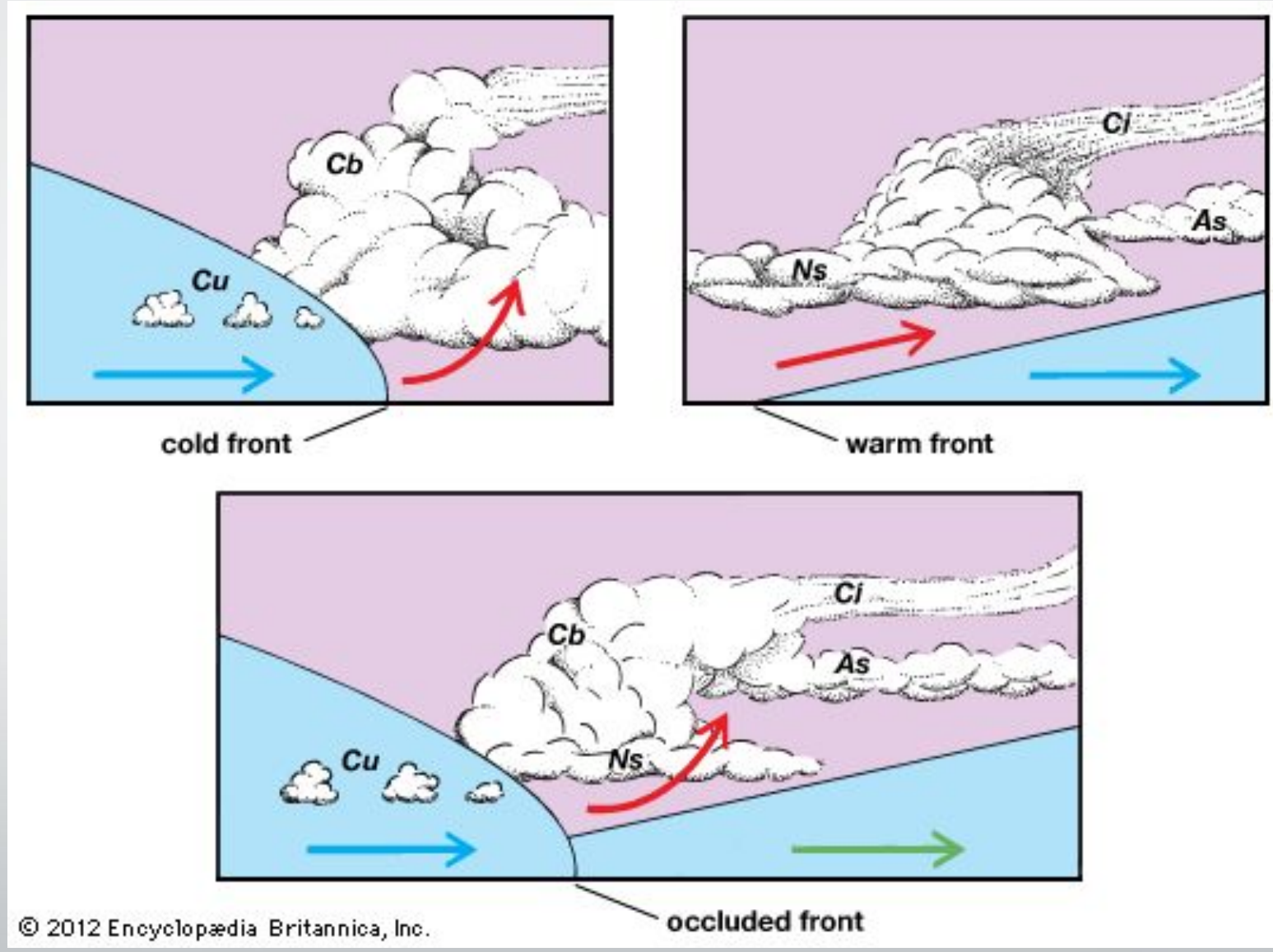


Thunderstorm Questions

- One of the weather phenomena is usually linked with a thunderstorm
  - Heavy rain
  - Hail
  - Lightning
- In general, one of the following types of thunderstorms create the greatest danger to aircraft
  - Supercell thunderstorm
  - Steady-state thunderstorm
  - Squall-line thunderstorm
- Which of these conditions is critical for a thunderstorm to form
  - Unstable conditions, lifting force, and high humidity
  - High temp, lifting force, and unstable conditions

Weather fronts

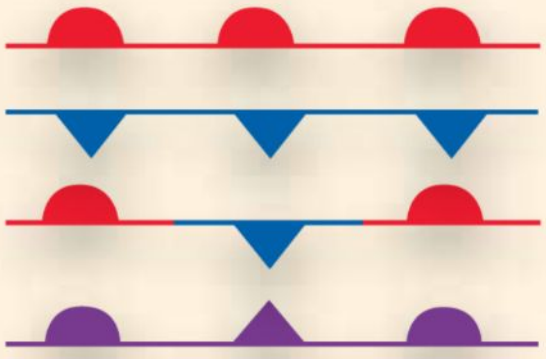
- Cold front- steep rounded face, cumulus and cumulonimbus, typical thunderstorms and heavy rain
- Warm front straighter slope high cirrus clouds and lower altostratus and nimbostratus
- Occluded front has cold air and cooler air (green), many cloud types, cold front overtaking a warm front
- A change in temperature is an easily recognized discontinuity along a front



Weather Fronts Symbols

Good introduction: http://www.nwclimate.org/guides/weather-charts-tutorial/

Symbols for surface fronts and other significant lines shown on the surface analysis chart



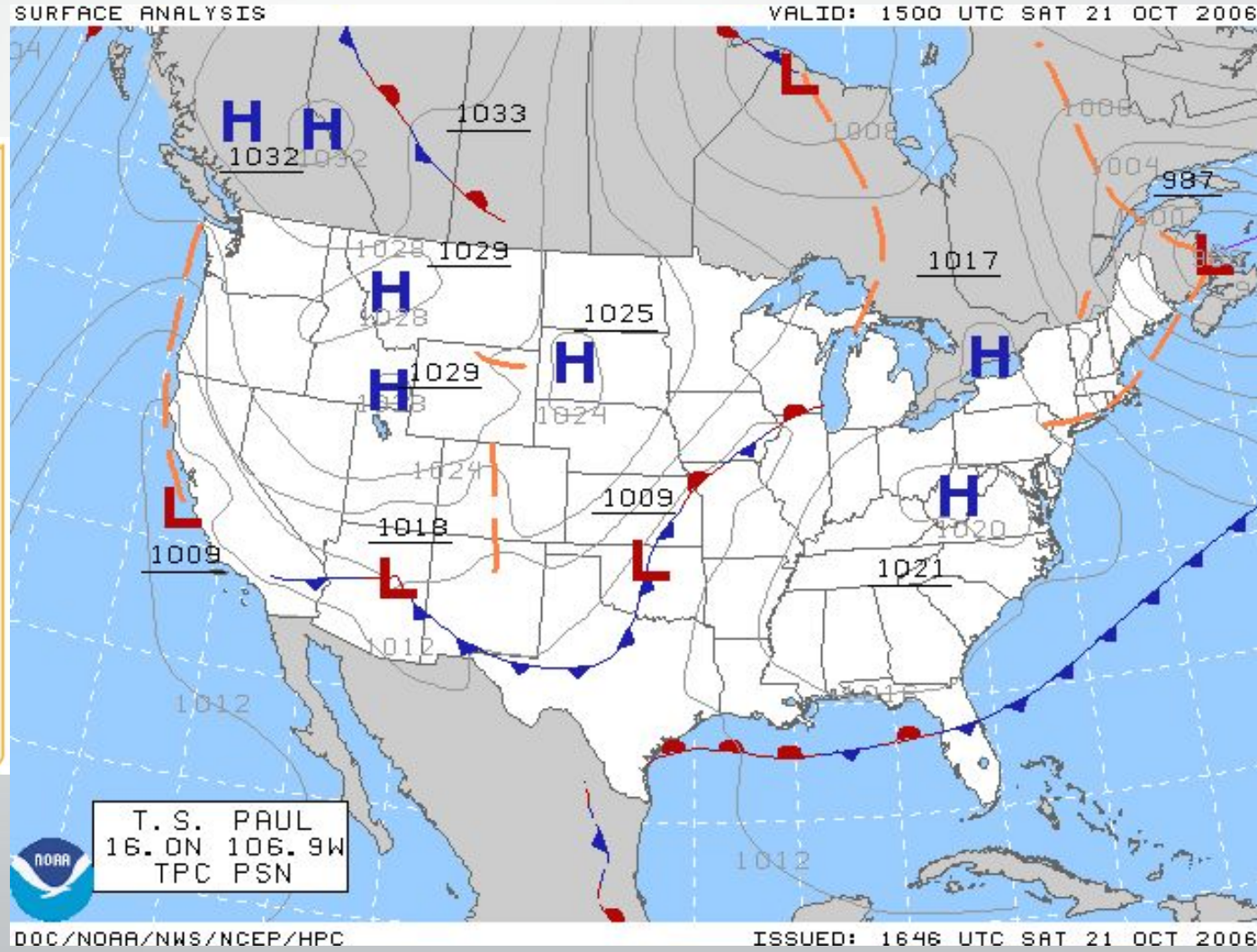
Warm front (red)*

Cold front (blue)*

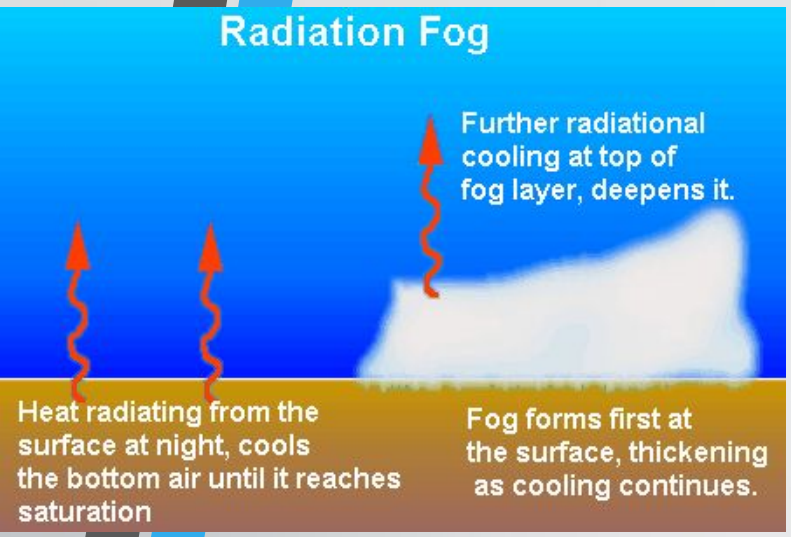
Stationary front (red/blue)*

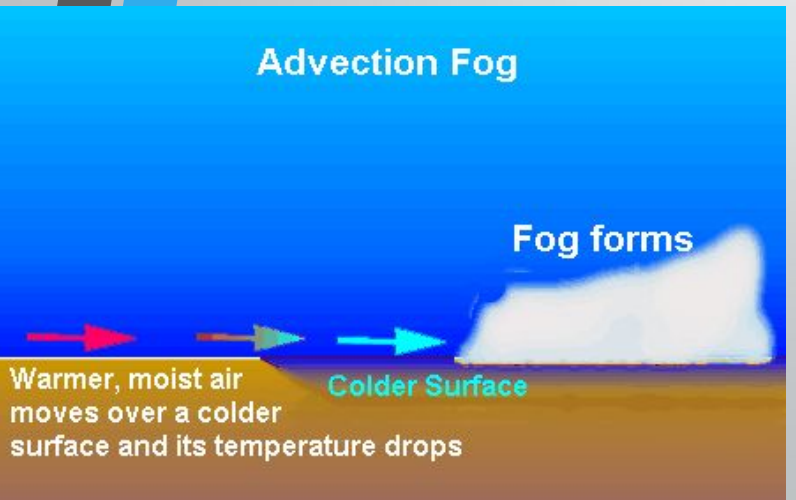
Occluded front (purple)*

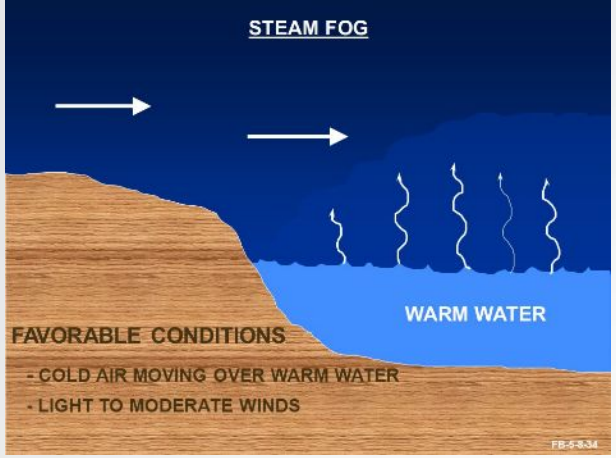
* Note: Fronts may be black and white or color, depending on their source. Also, fronts shown in color code will not necessarily show frontal symbols.

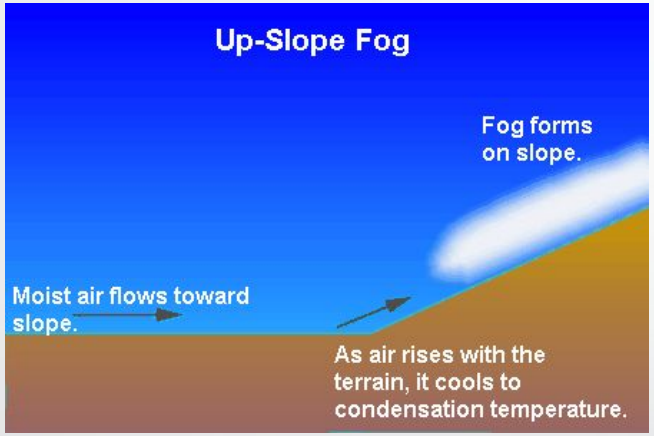


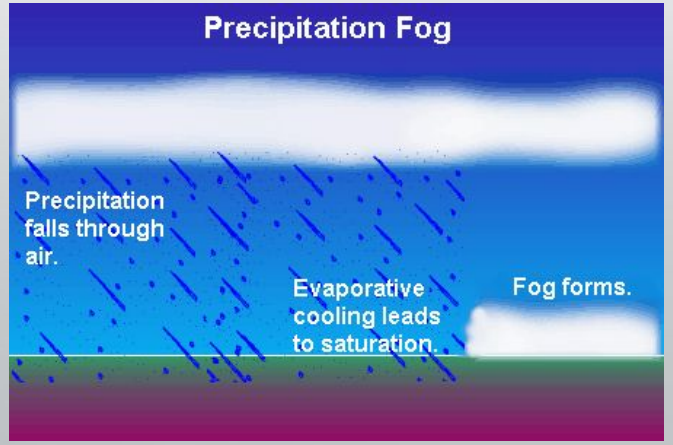
Fog Types





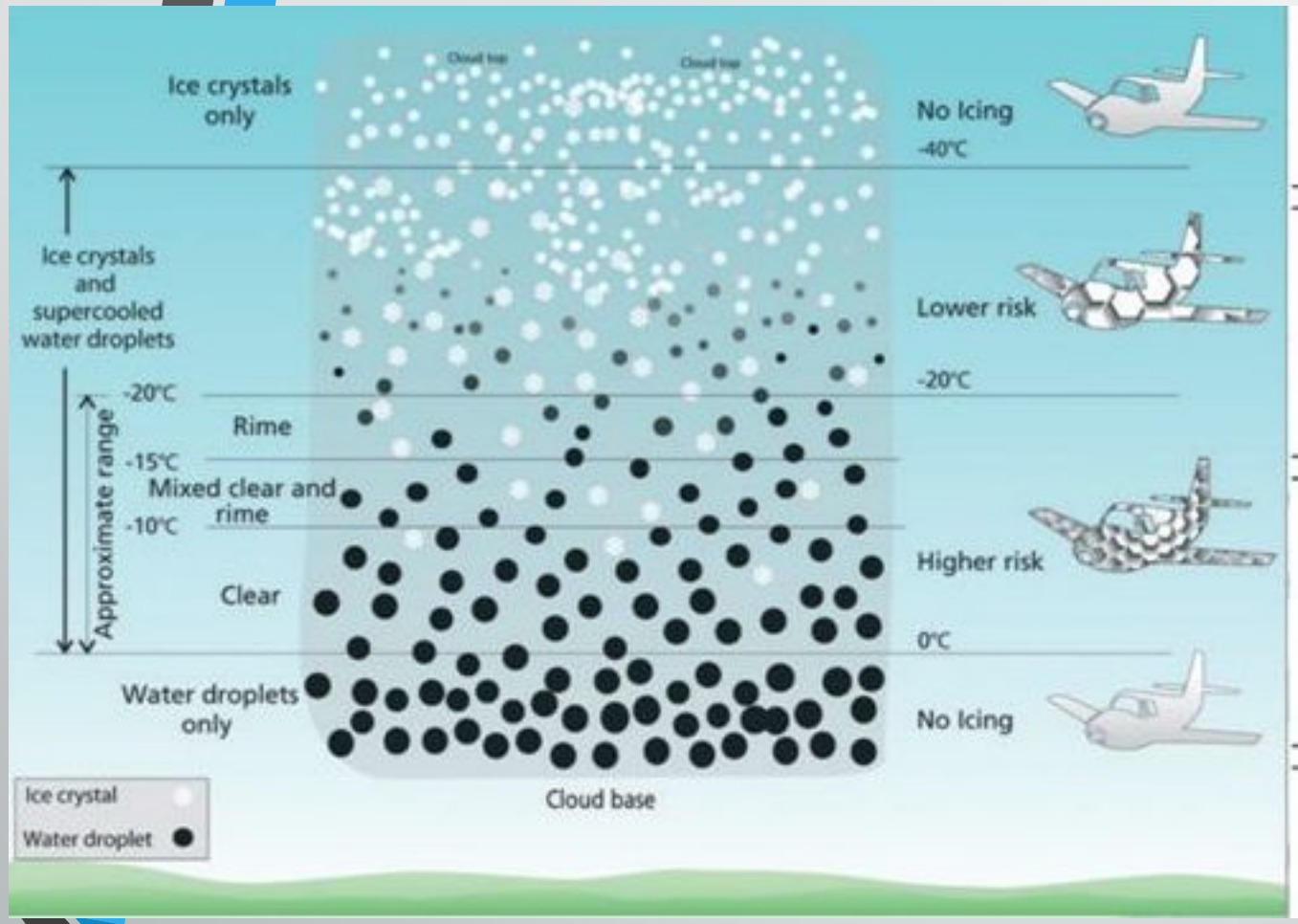


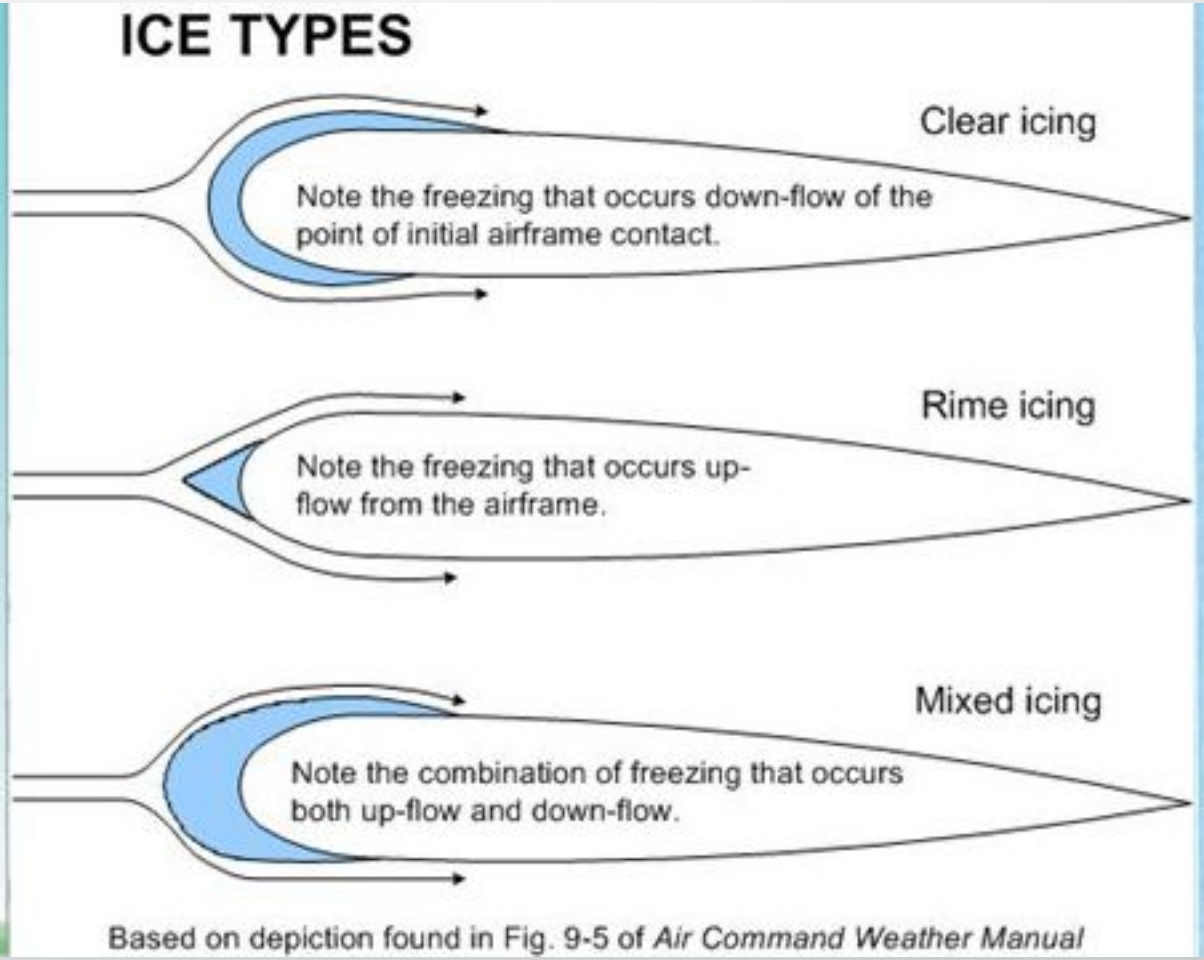




- Radiation- heat radiating from surface at night. Commonly warm moist air moving over flatland on clear, calm nights
- Advection- warm moist air moves over a colder surface. Typically an air mass moving inland from the coast in winter
- Up-slope- moist air moves toward slope and cools
- Precipitation- evaporative cooling leads to fog
- Steam- winter, dry cold air passes from land to ocean, turbulence, icing
- Advection and upslope fog need wind to exist

Structural icing





- Structural icing needs visible water (rain or cloud droplets) and temperature of o°C or colder

Weather indicators

- Ice pellets at surface= inversion with freezing rain at altitude
- Fog likely when temperature and dew point are **within 5°F**
- When flying across a weather front, there is always a change in wind direction
- Stable air mass= stratiform clouds, poor surface visibility, fog, continuous precipitation, haze
- Unstable air= cumulus clouds, turbulence, showery precipitation, good visibility
- A microburst typically lasts less than **15 minutes**
- Atmospheric pressure can be used to determine stability of the atmosphere
- Strong winds= high battery consumption and might make it impossible to overcome
- Generally thermals occur over dry areas more than moist areas. Thermals are updrafts in convective currents dependent on solar heating
- Around buildings, wind gusts can change rapidly in direction and speed causing turbulence
- **Standard** temperature and pressure values at sea level are **15°C and 29.92 Hg** (inches of mercury)
- An air mass would have decreased stability if it is warming from below

Clouds, fog, or dew will always form when water vapor condenses

Weather Indicator Questions

- What does the presence of ice pellets at the surface indicate?
  - That there are thunderstorms in the vicinity
  - That there is a temperature inversion with freezing rain at higher altitudes
  - It indicates there is turbulence
- How best can a PIC determine the possibility of local fog formation?
  - By monitoring the wind conditions to be sure there's no increase in speed
  - By monitoring the barometric pressure to be sure it isn't decreasing
  - By monitoring the temperature and dew point spread
- A crucial in-flight condition for structural icing formation is
  - Stratiform clouds
  - Visible moisture

Wake turbulence

- Can reach 1000 feet behind a large heavy plane
- Helicopters create turbulence during and after passing
- Even airflow from engines on runway can create turbulence

Turbulence

Turbulent skies

Air turbulence normally cannot be seen and often occurs unexpectedly. It is caused by different factors, including atmospheric pressure, jet streams, air around mountains, cold or warm weather fronts and thunderstorms. Turbulence can occur even when the sky is clear.

CLEAR AIR TURBULENCE (CAT)

CAT, also known as air pockets, is the erratic movement of air masses in the absence of any visible cues, such as clouds. It is caused when hot and cold air mix, or when wind currents travelling in different directions at very high speeds collide. This can happen around jet streams or near mountains.

Characteristics

- Little or no warning.
- Occurs when there are no clouds.
- Common at high altitudes.

WHAT CAUSES IT

Jet streams
Fast, high-altitude air currents shift, disturbing the surrounding air.

Mountains
Air that passes over mountains (obstacles) and causes turbulence.

Thermals
Heat from the sun makes warm air masses rise and cold ones sink.

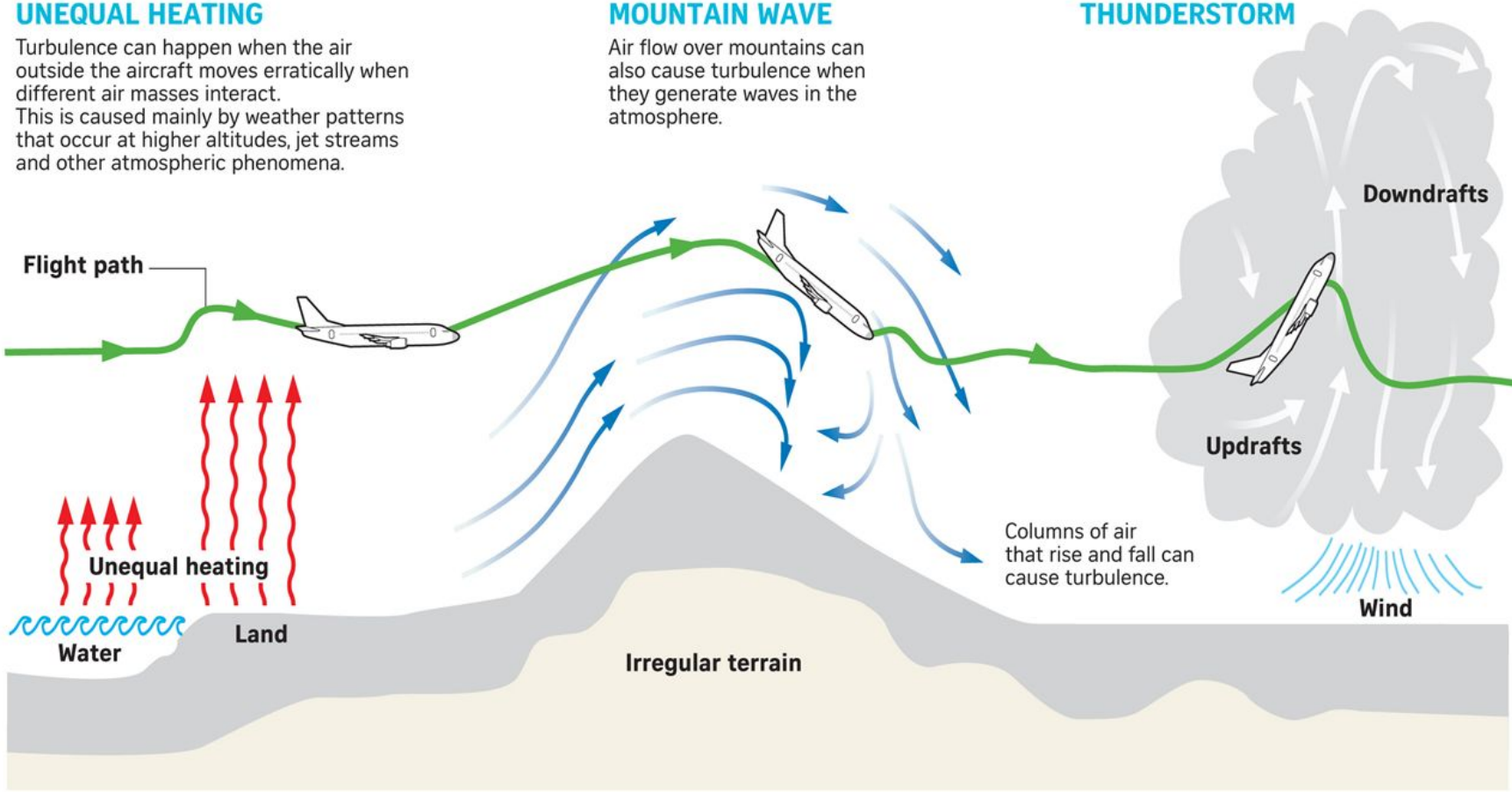
UNEQUAL HEATING

Turbulence can happen when the air outside the aircraft moves erratically when different air masses interact.
This is caused mainly by weather patterns that occur at higher altitudes, jet streams and other atmospheric phenomena.

MOUNTAIN WAVE

Air flow over mountains can also cause turbulence when they generate waves in the atmosphere.

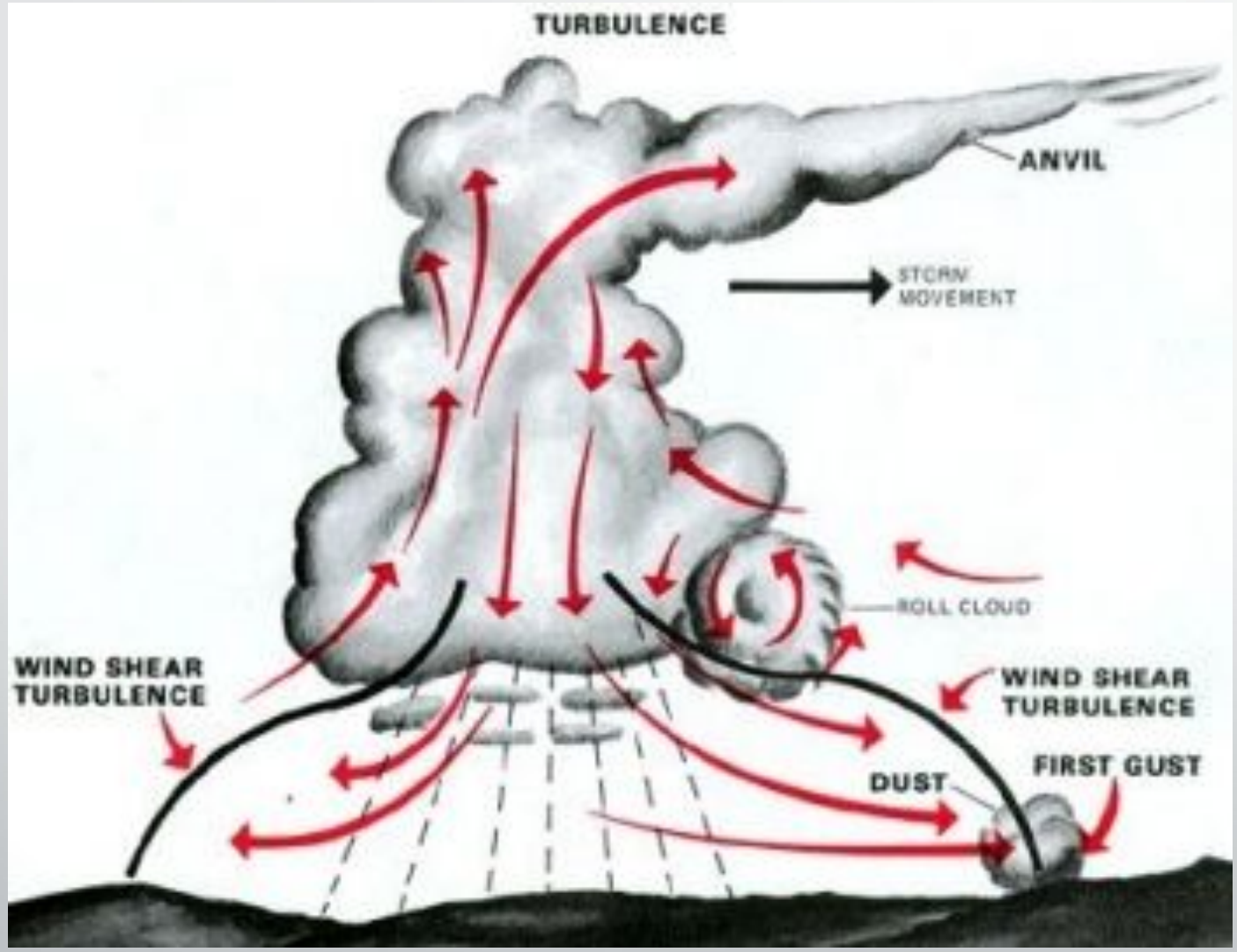
THUNDERSTORM



STRAITS TIMES GRAPHICS

- Unstable, Showery

Wind Shear



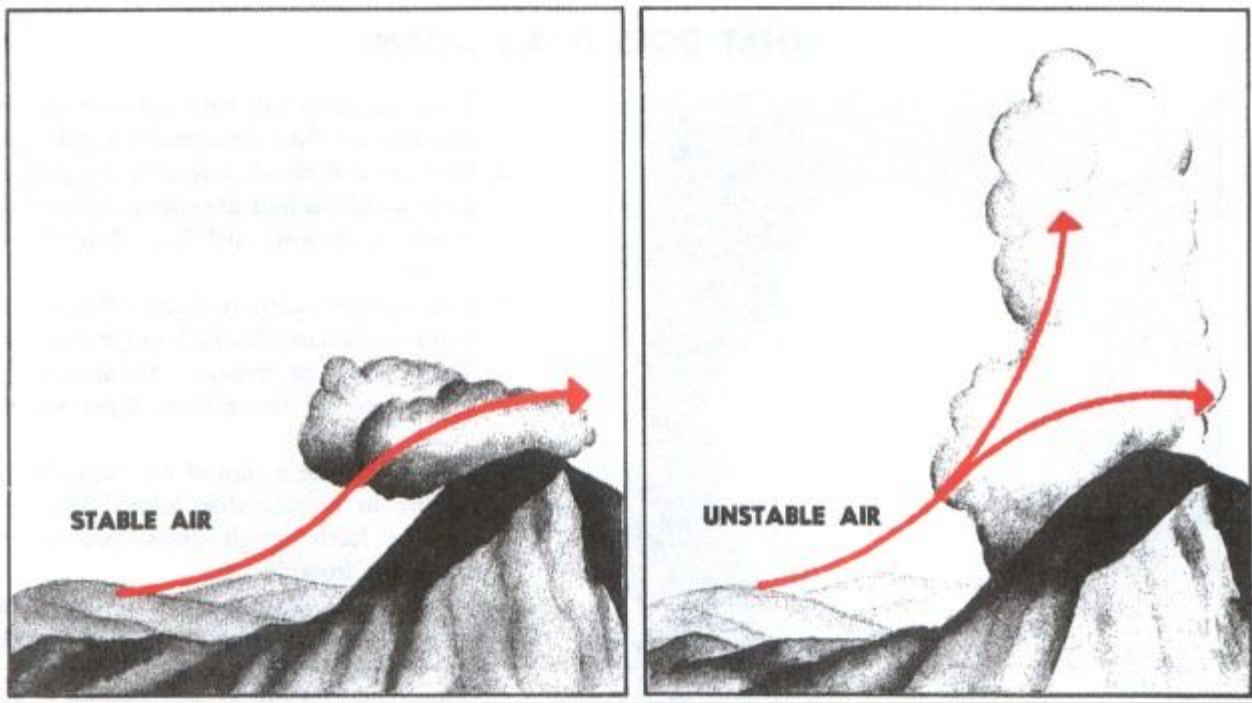
- Can happen at any altitude

Humidity

- Less visibility, hazy
- As humidity goes up, air pressure goes down
- Wings have fewer molecules to react with= less lift

Unstable vs stable air

- Unstable- hot and humid
  - Air mass with cold air overlying warm air. Warm air wants to rise to become thunderstorm
  - Showery precipitation
  - Rough air- turbulence
  - Good visibility except in blowing obstructions
- Stable- poor visibility, steady rain, drizzle
  - Air mass with warm air overlying cold air, cold air cannot rise to displace warm air.
  - Fog
  - Smooth air
  - Fair to poor visibility, haze

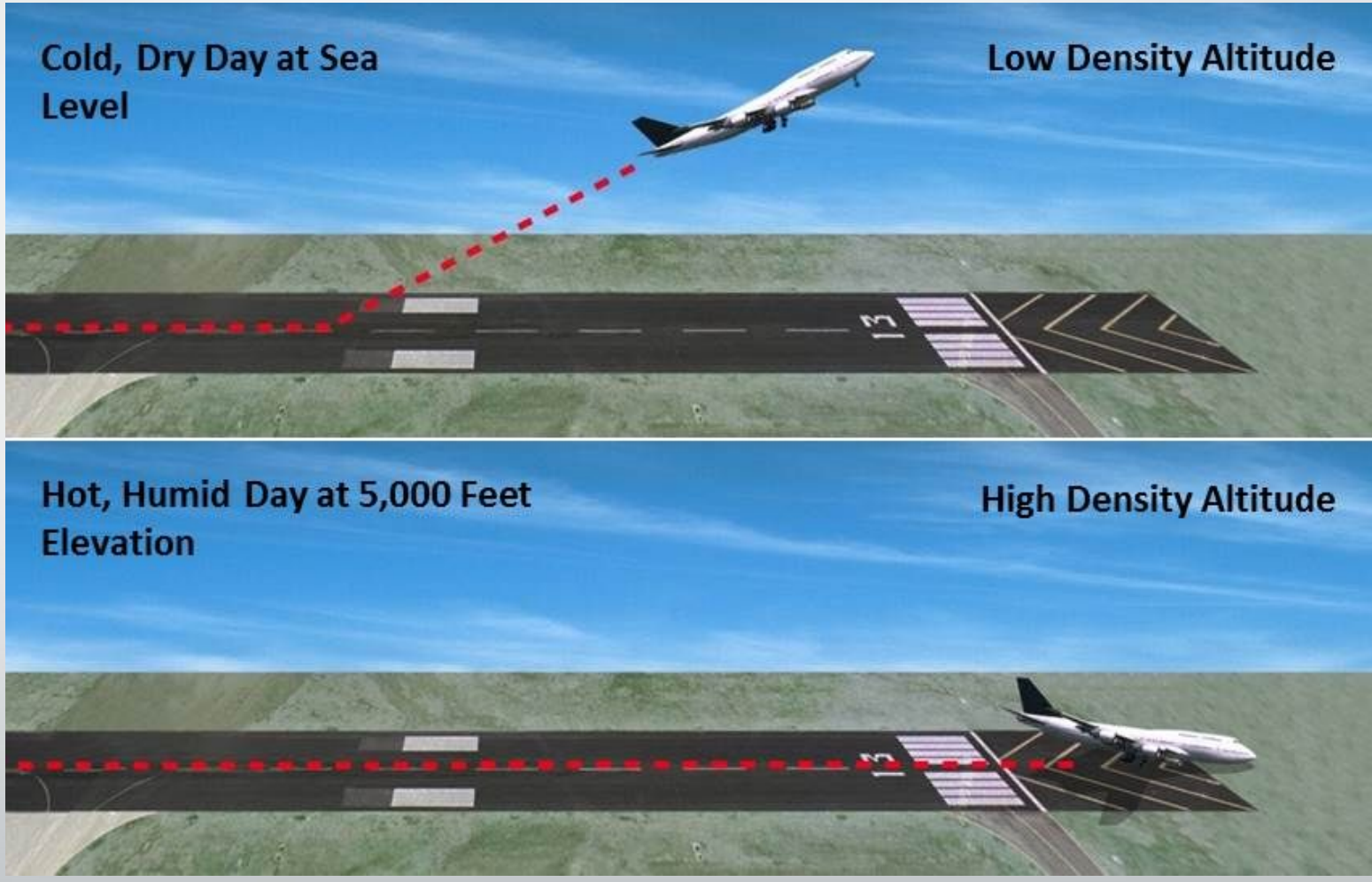


Air Stability Questions

- It is almost certain a stable air mass will have one of the following characteristics
  - Rough air
  - Poor visibility
  - Cumuliform clouds
- Atmospheric stability can be determined with which measurement
  - Actual lapse rate
  - The lifted index
  - Surface temperature
- Which weather conditions should be expected beneath a low-level temperature inversion layer when the relative humidity is high?
  - Smooth air, poor visibility, fog, haze, or low clouds
  - Turbulent air, poor visibility, fog, low stratus clouds, showery precipitation

Density altitude

- Air density given as a height above sea level. Increasing temperature and humidity and decreasing pressure will cause an increase in the density altitude.
- Reducing air density= reduction in prop/wing efficiency
- Hot and high airports- Mexico City= slow acceleration, slower climbing, reduced lift
- If outside air temperature at a given altitude is warmer than standard, the density altitude will be higher than the pressure altitude



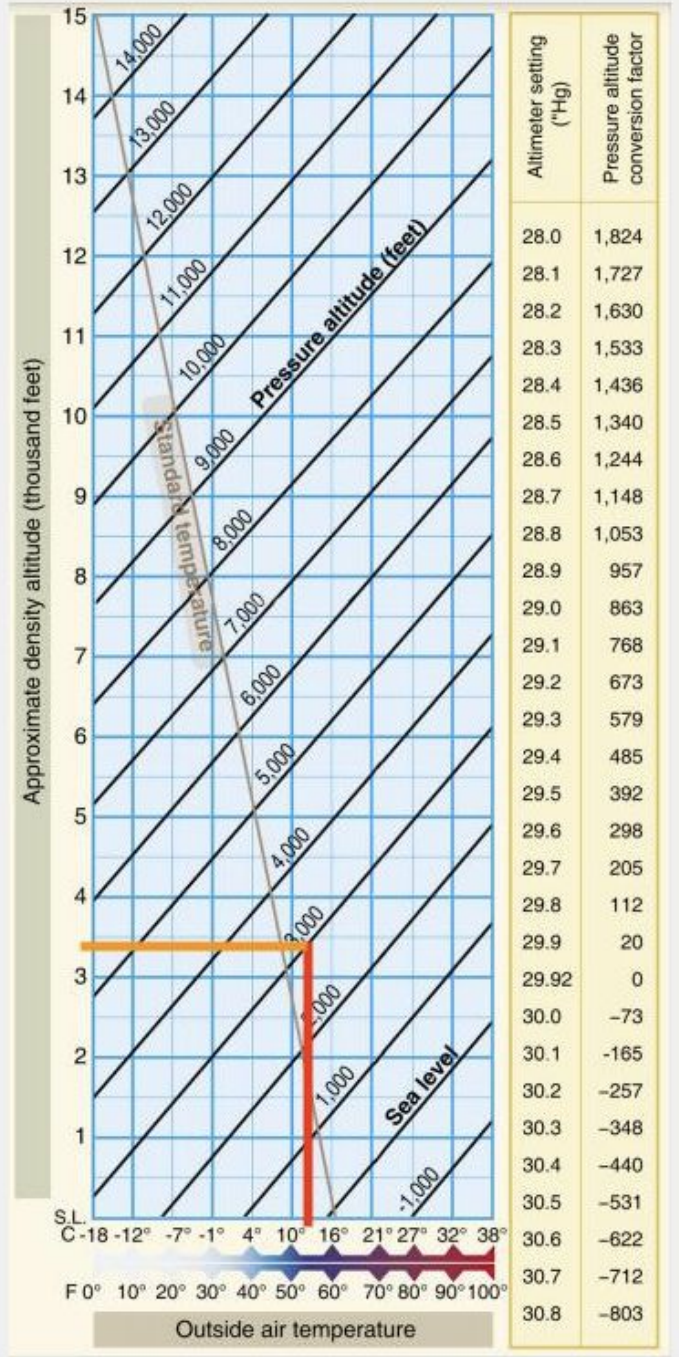
Atmosphere Lapse Rate

- As you increase in altitude, you decrease in pressure and temperature
- Pressure decreases because weight of air above you is reduced, and air density is reduced

Standard Atmosphere			
Altitude (ft)	Pressure (Hg)	Temperature	
		(°C)	(°F)
0	29.92	15.0	59.0
1,000	28.86	13.0	55.4
2,000	27.82	11.0	51.9
3,000	26.82	9.1	48.3
4,000	25.84	7.1	44.7
5,000	24.89	5.1	41.2
6,000	23.98	3.1	37.6
7,000	23.09	1.1	34.0
8,000	22.22	-0.9	30.5
9,000	21.38	-2.8	26.9
10,000	20.57	-4.8	23.3
11,000	19.79	-6.8	19.8
12,000	19.02	-8.8	16.2
13,000	18.29	-10.8	12.6
14,000	17.57	-12.7	9.1
15,000	16.88	-14.7	5.5
16,000	16.21	-16.7	1.9
17,000	15.56	-18.7	-1.6
18,000	14.94	-20.7	-5.2
19,000	14.33	-22.6	-8.8
20,000	13.74	-24.6	-12.3

More on Density Altitude

- Calculator: https://wahiduddin.net/calc/calc_da.htm
- Pressure altitude is 3000 ft (reading on altimeter)
- Outside air temperature is 12 deg C
- What is the density altitude ?
- Is it a high or low density altitude?
- Will your plane perform better or worse?



Density Altitude Chart

Density Altitude Questions

- At a given altitude where the outside air temperature is warmer than standard, then the density altitude is
  - Higher than the pressure altitude
  - Lower than the pressure altitude
  - Equal to the pressure altitude
- Which of the factors will probably increase the density altitude at a certain airport
  - A decrease in the relative humidity
  - An increase in the ambient temperature
  - An increase in the relative humidity
- How will high density altitude affect the efficiency of unmanned aircraft propellers?
  - Propellers are always efficient so there's no effect
  - Propellers become more efficient

Updrafts and Downdrafts

- Updrafts- gravel pits, plowed or barren land, give off heat and create updrafts
- Downdrafts- water, trees, and vegetation absorb heat and can cause downdrafts

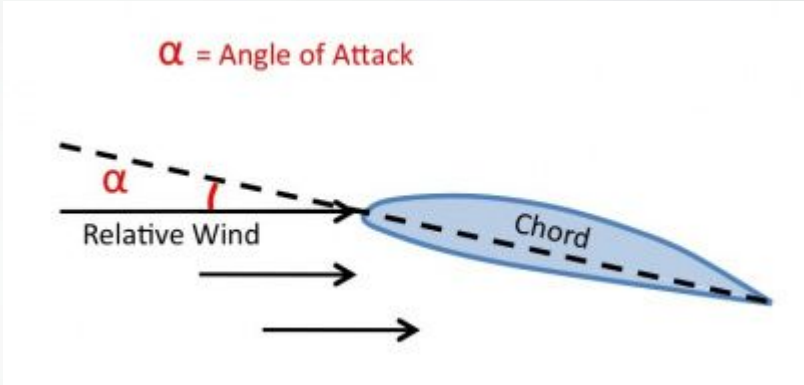
Weather Test Questions

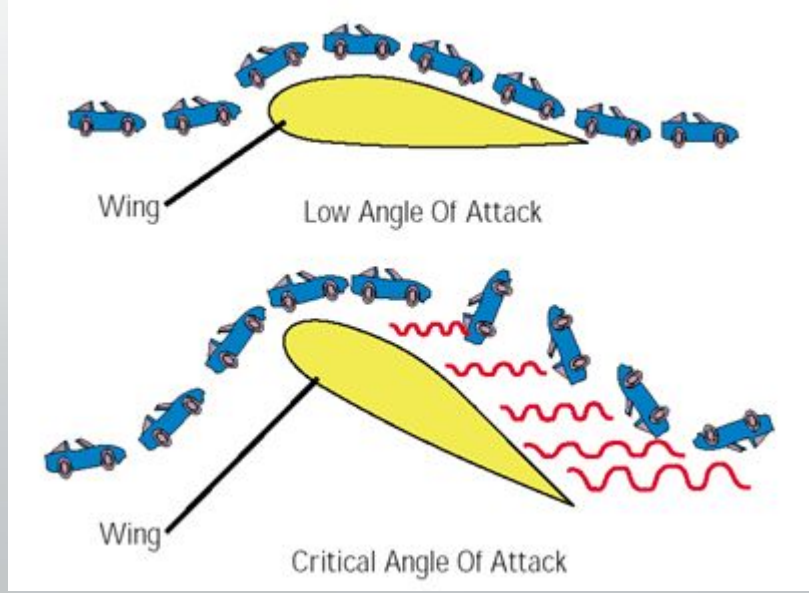
- What would make the stability of an air mass decrease?
  - A) Warming from below
  - B) Increase in water vapor
  - C) Impossible for air mass stability to decrease
- A moist, unstable air mass is characterized by
  - A) Good visibility and turbulence
  - B) Smooth air
  - C) Smoke and haze
- Which of the following statements is correct?
  - A) Wind shear can exist at all altitudes
  - B) Wind shear can only exist at moderately high altitudes

Part 7 Physics

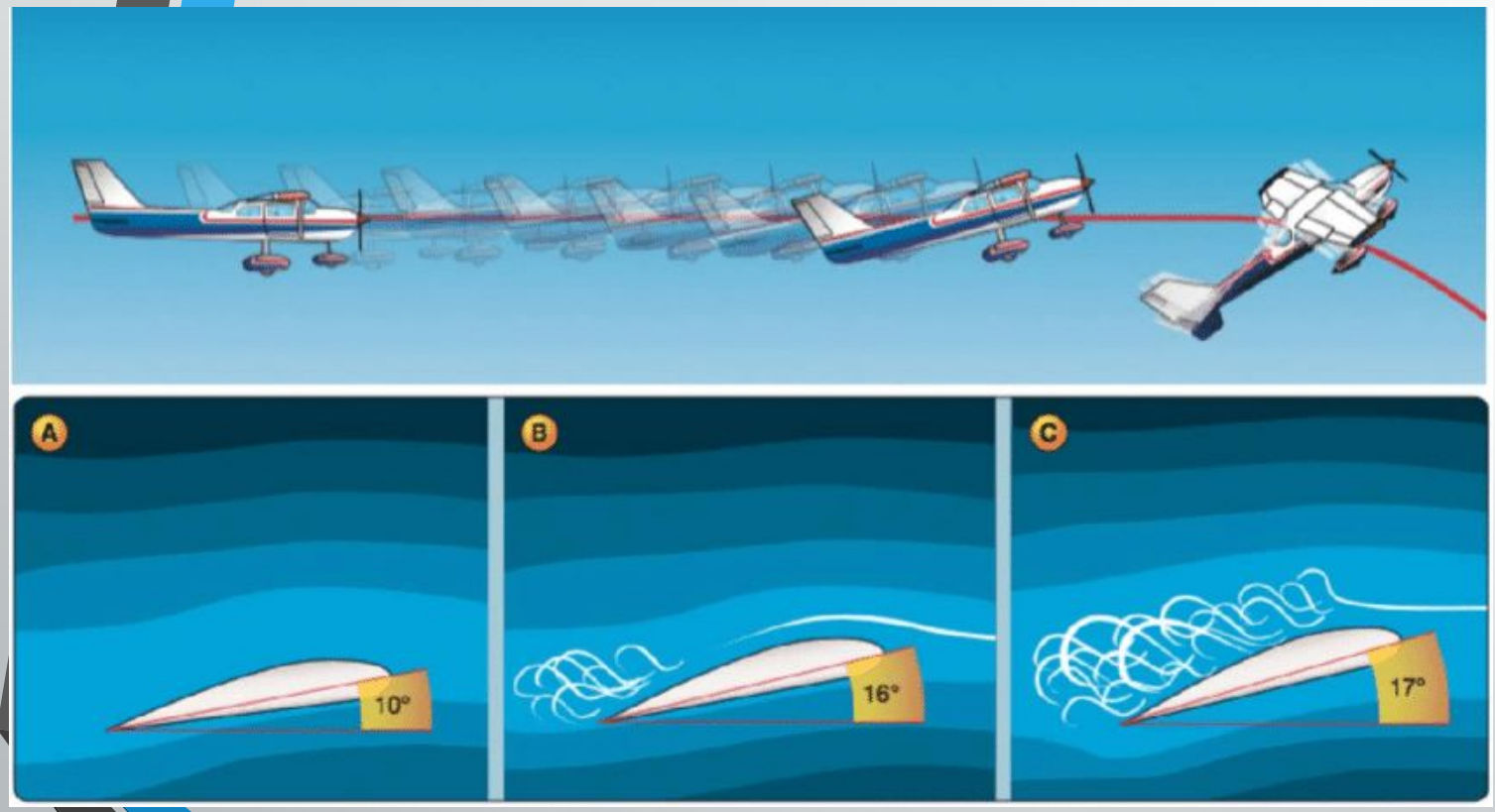
Stalling and Angle of Attack

- The angle of attack is the angle between the relative wind and the chord line of the wing
- When critical angle of attack (usually 16-20°, depends on airplane) is exceeded the aircraft stalls.
- Increasing stall speed is bad. Meaning you would stall at a faster speed.





Angle of Attack and Stalling



- Stalling can occur at any altitude or airspeed.
- **When critical angle of attack is exceeded, an airplane will stall regardless of airspeed, weight, load factor, bank angle, temperature, density altitude, or center of gravity.**
- Exceeding critical angle of attack is most common at low speeds, high speeds, and in turns

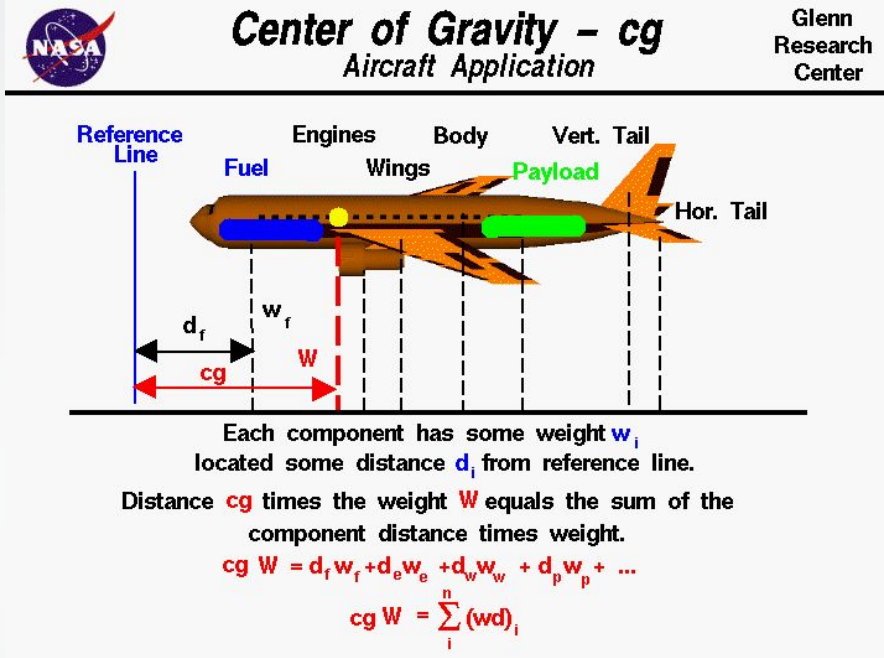
Angle of Attack Questions

- What is the definition of the term "angle of attack"?
  - An angle between the wing line of chord and the relative wind
  - An angle between the line of chord and the longitudinal axis of the airplane
  - The angle between the horizon and climb angle of the airplane
- A stall occurs when the smooth airflow over the unmanned aircraft's wing and/or propellers are disrupted, and the lift reduces rapidly. This is caused when the wing/propellers
  - Exceed the maximum allowable operating weight
  - Exceed the critical angle of attack
  - Exceed the maximum speed
- The critical angle of attack
  - Is always 10-20 degrees
  - Is constant for a specific airplane, always between 16-20 degrees

Center of Gravity

- Center of gravity- CG, changing CG beyond limits of design will impact handling and maneuverability. FAA thinks CG is listed in the **Pilot' Operating Handbook or UAS Flight Manual**.
- When loading UAS with cameras/sensors, mount them so they do not adversely affect the center of gravity
- Overloading can cause loss of control or performance anomalies
- In a 45 degree banking turn, UAV will stall at a higher speed

  If CG is outside approved limits UAS will be less stable at all speeds



Loading and Launching Questions

- To ensure the UAS center of gravity (CG) limits are not exceeded, follow the aircraft loading instructions in the
  - Pilot's operating handbook or UAS flight manual
  - Aeronautical Information Manual (AIM)
  - Aircraft weight and balance handbook
- When operating an unmanned airplane, the remote pilot should consider the load factor on the wings may be increased any time
  - The gross weight is decreased
  - The CG is shifted rearward to the aft CG limit
  - The airplane is subjected to maneuvers other than straight and level flight
- The most significant conditions affecting launch conditions are some combination of altitude, high gross weight, temperature, and
  - Power plant system
  - Obstacles around the launch area
  - Unfavorable wind

Load Factor

- Load factor- increases during turns, so maneuvers other than straight can cause erratic behavior. Increasing load factor will cause stalling at higher airspeeds.
- Stall speed increases in proportion to the square root of the load factor, so with a load factor of 4, the aircraft will stall at a speed double the normal stall speed.
- At slow speeds the lifting force of the wing is only slightly greater than the amount to support the weight of the UAS. But at high speeds a strong gust may increase load factor beyond safe limits.
- Load factor increases when maneuvers other than straight, level flight

Angle of bank Φ	Load factor n
0°	1.0
10°	1.015
30°	1.154
45°	1.414
60°	2.000
70°	2.923
80°	5.747
85°	11.473
90°	∞

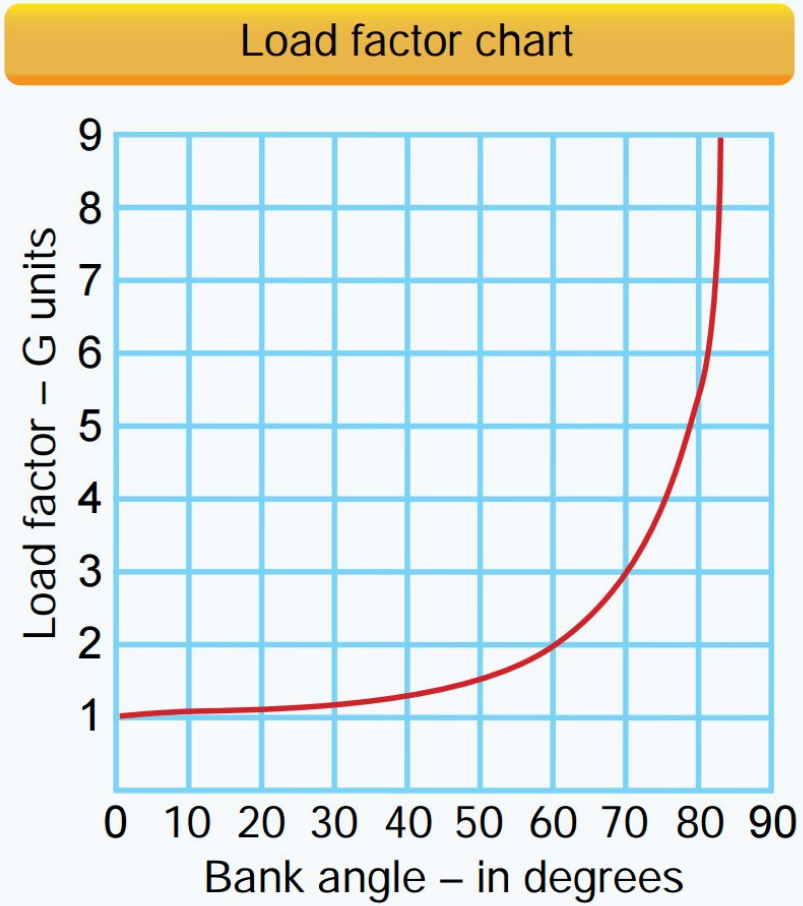


FIGURE 2.—Load Factor Chart.

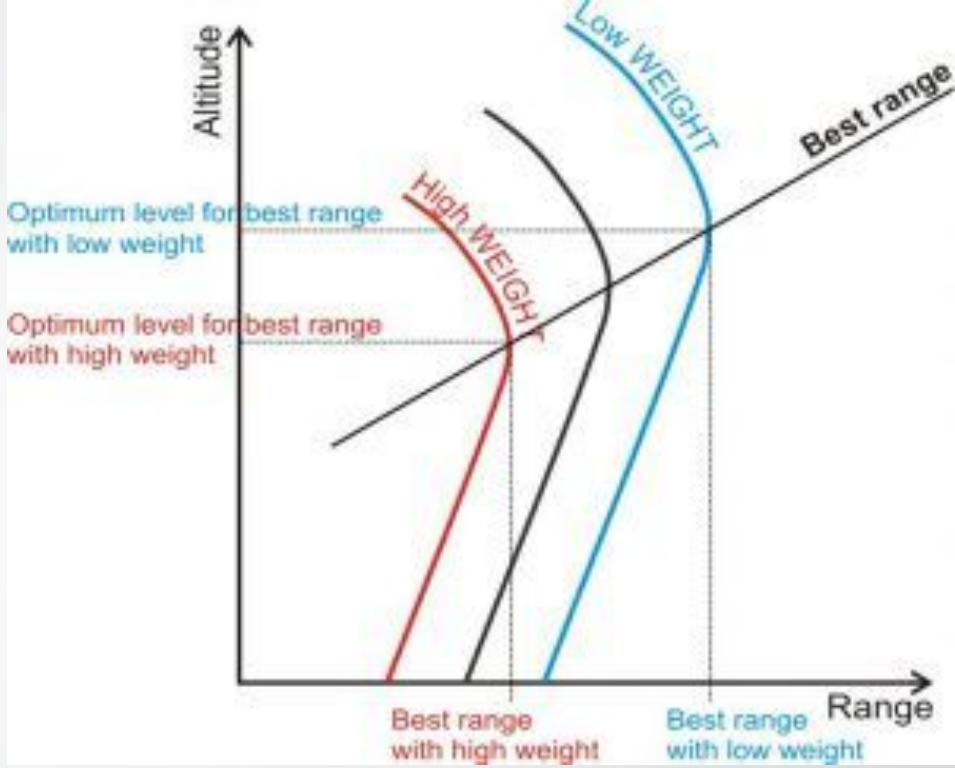
If your drone is 10lbs and it is taking a 60° turn, what is the weight the structure has to support?

Launching

- Uphill terrain slope= increased launch distance due to added drag and rolling fracture which reduces the accelerating force
- Critical launch performance conditions: high gross weight, altitude, temperature, unfavorable wind
- Overloading will cause shorter endurance

Range and Endurance

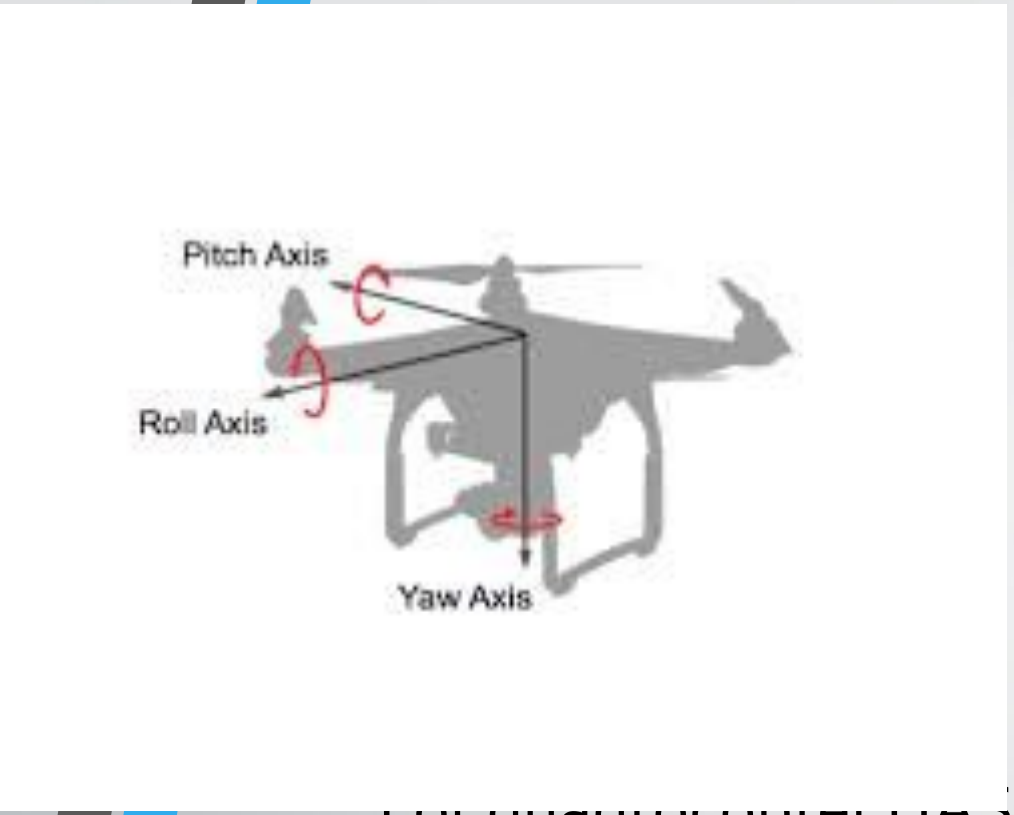
- When range (distance or total coverage) and economy of operation (fuel or batteries) are principal goals:
  - Pilot must operate at recommended long range cruise condition
  - Allows lesser flight distance with maximum fuel reserve at destination
- Maximum endurance = minimum power to maintain steady, level flight
- Loading a UAS above max weight = shorter endurance
- The best source for UAS performance data is the manufacturer publications

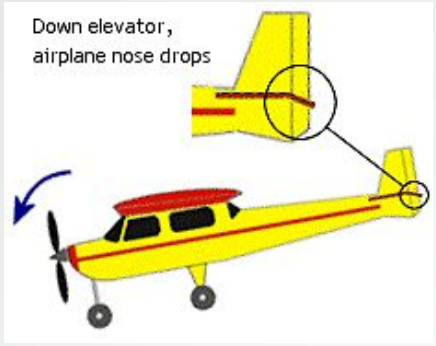


Performance Questions

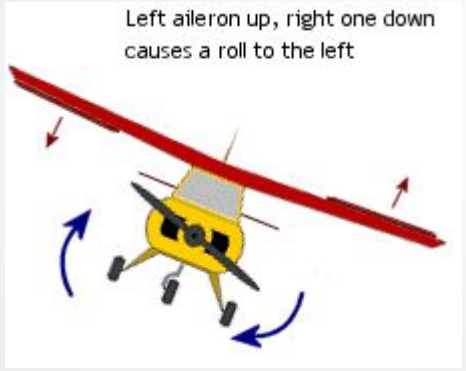
- When flying an aircraft, the maximum endurance is achieved when using its minimum power to help maintain the aircraft
  - In a long-range descent
  - In steady and level flight
  - At its maximum possible speed
- To get valuable information and data for the performance of a UAS, the best source is
  - Estimation from a similar system
  - Pilot report
  - Manufacture’s publications
- How does an uphill terrain slope affect launch performance?
  - Increases launch distances
  - Decreases launch distances
  - Increases launch speed

Pitch Roll Yaw

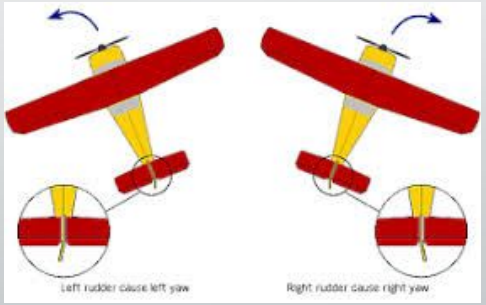




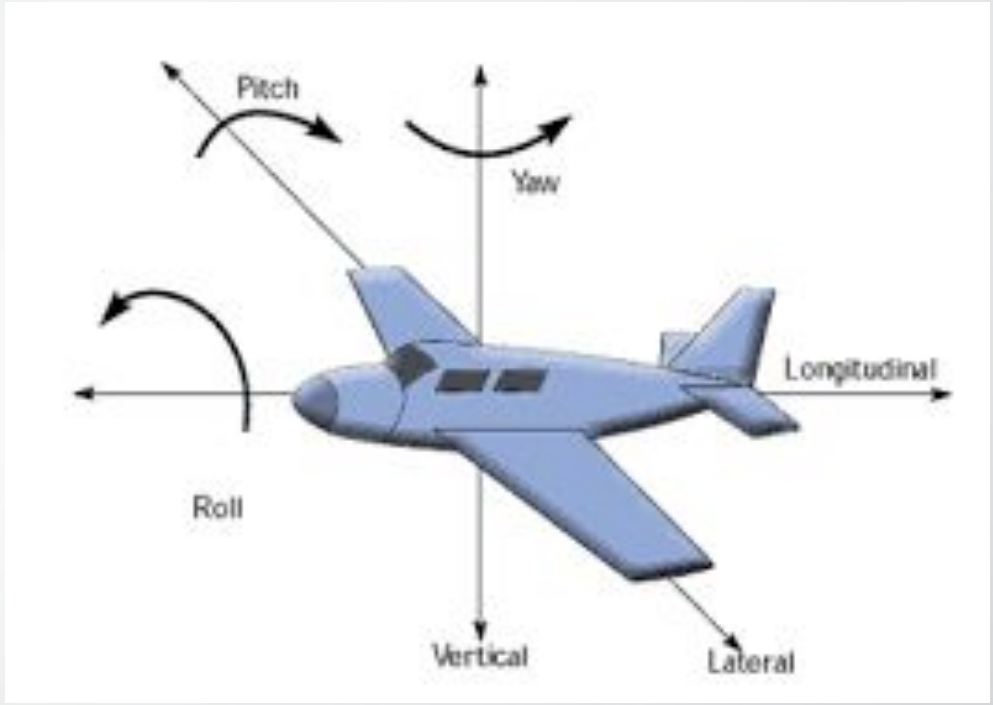
Elevator= Pitch



Aileron= Roll



Rudder= Yaw



For quadrocopter UAS:

- Pitch= forward or backward movement
- Roll= left or right movement
- Yaw= spinning left or right

- For an airplane
  - Pitch= nose up or down, controlled by elevator
  - Roll/bank= wings down or up, controlled by ailerons
  - Yaw= spin horizontally, controlled by rudders

GPS/Altimeter/Speed

- If your UAS does not have an altimeter or GPS to determine the operating altitude
  - Gain a visual perspective of what 400 ft looks like on the ground before the flight
- If GPS signal is lost, operate UAS normally, and keep track of any mode or control changes. Most UAS are designed to fly in the event of GPS loss.
- Altimeter settings are corrected to sea level, unequal heating of the earth causes pressure differences, so altimeter may need calibration based on location
- If you don't have a readout of speed, use dead reckoning. Fly between 2 fixed points, and estimate distance per time.
- If you have a lost link (between controller and UAS), notify all crew and ATC (if applicable) while executing the briefed

Physics Test Questions

- If the critical angle of attack is exceeded, then the airfoil will stall. This stall angle of attack will
  - A) Decrease when gross weight increases
  - B) Remain the same irrespective of gross weight
  - C) Slightly increase with a decrease in gross weight
- What is the function of the rudder on a UAS?
  - A) It controls the yaw
  - B) It controls the pitch
  - C) It controls the bank
- When the primary goals are range and economy of operation, the PIC must make sure the UAS will be operated at the recommended
  - A) Long range cruise performance
  - B) Airspeed

Organizations

- Academy of Model Aeronautics (AMA)
  - Membership $75/yr
  - Insurance coverage: $2.5M personal liability, $25k Medical Coverage
  - $1k Fire, theft, vandalism coverage
  - Magazine
  - Ability to fly at charter clubs
  - https://www.modelaircraft.org/membership/enroll
- Aircraft Owners and Pilots Association (AOPA)
  - Membership $59-$158/yr
  - Aviation training and safety resources
  - https://www.aopa.org/membership-vhsptob
- Association of Uncrewed Vehicle Systems International (AUVSI)
  - Membership $150/yr
  - Conference XPONENTIAL
  - Webinars

Links to More Information

- Study Material to take test on your own $175:
  - https://www.youtube.com/watch?v=6_ucCKFJUCU
  - https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/remote_pilot_study_guide.pdf
  - https://3dr.com/faa/drone-practice-tests/
  - http://www.treetop.academy/Sample_Test/Introduction_to_Sample_Exam.html
- Online link to FAA aeronautical sectional charts: https://skyvector.com/
- Phone/Tablet Apps for automated flight with drones
  - https://www.pix4d.com/product/pix4dcapture
  - https://www.dji.com/ground-station-pro
  - https://flylitchi.com/
- App to get near-instant FAA permission to fly: aloft air control
- Contacts for Drone Equipment/Support:
  - Andrew Coleman, UAV Sales and Project Consultant, Selby's, Billings, acoleman@selbys.com, 406-698-3229
  - Mike Digrandi, UAV Sales, Quadrocopter, Columbia Falls, mike@quadrocopter.com, 406-897-1027
  - Collin Kemmesat, UAS Technical Sales, Frontier Precision, Collin@frontierprecision.com, 701-222-2031

Study Guide and Practice Tests

- https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/remote_pilot_study_guide.pdf
- https://free-faa-exam.kingschools.com/drone-pilot
- https://www.faa.gov/sites/faa.gov/files/training_testing/testing/test_questions/uag_questions.pdf
- https://jrupprechtlaw.com/part-107-knowledge-test/
- https://pilotinstitute.com/part-107-practice-test/
- https://www.dronegenuity.com/faa-part-107-test-practice-questions/
- https://asa2fly.com/content/updates/TP-UAS-21_Update.pdf
- https://www.thedroneu.com/blog/faa-part-107-practice-test/
- https://dronelaunchacademy.com/part-107-test-21-practice-questions/
- https://catsr.vse.gmu.edu/SYST460/HW_WeatherQuiz_Solutions.pdf

Butte Drone Training Area

- Area: 470 acres
- Ownership: MTech, Butte Silver Bow, World Mining Museum

- Research-
  - Light Ranging and Detection (Lidar)- Real-time Mapping and Obstacle Avoidance
  - Magnetometer and Electromagnetic Sensor Development
  - Thermal and Multispectral Imaging Applications
  - Beyond Line of Sight, Flight Over People, Nighttime Flight

Getting your license

- Navigating the Process to Become a Drone Pilot:
- Step 1: Obtain an FAA Tracking Number (FTN) by creating an Integrated Airman Certification and Rating Application (IACRA) profile prior to registering for a knowledge test. Sign up as an applicant here: https://iacra.faa.gov/IACRA/Default.aspx
- Step 2: Sign up for a PSI account:https://candidate.psiexams.com/
- Step 3: On the PSI site you can choose the testing center date and time of test. Pay $175 on the site
- Step 4: Show up on the date/time at the test center for the test. Pass the initial aeronautical knowledge test.
- Step 5: Complete FAA Form 8710-13 for a remote pilot certificate using the IACRA
- Step 6: A confirmation email will be sent after the completion of TSA background check. It will have instructions to print a temporary remote pilot certificate.
- Step 7: A permanent remote pilot certificate will be mailed