Click to verify

May 16, 2025 Severe Weather This picture shows an example of a high and low pressure system. At the surface, in the Northern Hemisphere, winds flow counterclockwise (cyclonically) around low pressure, and clockwise (anticyclonically) around high pressure. (Highs and lows spin the other way in the Southern Hemisphere.) The actual pressure of these systems can be measured in either inches of mercury (e.g., 30.10) or millibars (e.g., 1004 mb). Lines of equal pressure between highs and lows are called "isobars". Surface winds generally flow at an angle to the isobars from high to low pressure. Here, a typical surface weather map shows winds rotating counterclockwise around a low pressure system. Each reporting station's observation gives wind direction and speed, temperature, dewpoint, and pressure at that station. Surface low pressure systems usually have fronts associated with them. A front represents a boundary between two air masses that contain different temperature, wind, and moisture properties. Here, a cold front is shown which can be present any time of the year, but is most pronounced and noticeable during the winter. Air normally is warmer ahead of a cold front and colder behind it. With a cold front, cold air advances and displaces the warm air since cold air is more dense (heavier) than warm air. This vertical cross-section of a cold front shows cold air behind the cold front (dark blue lines) advancing into warmer air ahead of the front. Where the two air masses meet, convergence often occurs which can result in upward motion of air parcels. If the air contains enough moisture, rain can occur. If the air also is unstable, thunderstorms can develop as well. This is a simplified view of a cold front. Sometimes, fronts aloft (above the surface) can result in precipitation ahead of cold fronts. Warm fronts also are common, especially from Fall through Spring when larger temperature differences exist across the United States. Relatively cool or cold air is present ahead of a warm front with warmer air behind the front, i.e., the opposite from that of cold fronts. However, while cool air at the surface exists ahead of a warm front, relatively warmer air often is located above it as the warmer surface air behind the front rises up and over the cool air below. If enough moisture is present, this can result in precipitation along and ahead of the front. With a warm front, the cool air ahead of it must retreat before the warm air behind it can advance. A vertical cross-section of a warm front (dark red lines) shows how surface warm air behind the warm front flows upward in a slantwise manner over top low-level cool or cold air ahead of the position of the surface warm front. This causes clouds and precipitation ahead of the surface warm front, assuming enough upward motion of air parcels and available moisture. A stationary front is similar to a warm front, i.e., warm air is present behind it (to its south) with cool air ahead of it (to its north). However, while a warm front shows movement, a stationary front shows little or no movement as the cooler, more dense air remains in tact and does not retreat. Notice the winds from the northeast in the picture on the right above. Since these winds are blowing toward the front somewhat, this cooler air is not retreating, so the warmer air to the south of the front cannot lift northward. With a stationary front, a balance usually exists between the warmer and colder air masses on both sides of the front, so that neither air mass can advance on the other one. Thus, the front remains nearly stationary. Here, we see what a typical low pressure system might look like on a surface weather map. A cold front extends to the south of the low pressure center, with a warm front to the east. Warm air is located ahead of the cold front and behind the warm front (the so-called "warm sector"), while cool air exists ahead of the warm front and cold air is present behind the cold front. Not all weather systems, however, are as simple as this model. This graphic shows how temperature "advection" occurs. To "advect" means to move from one place to another via the wind. At far left, warm air is being advected to the north, i.e., from bottom (warmer) to top (cooler) by a south wind. This is called "warm air advection" and occurs, for example, with warm fronts. Warm air advection can occur at the surface or aloft, and given enough lift and moisture, will result in precipitation. At near left is the opposite. The wind is blowing from north to south moving cooler air toward the warmer air. This is called "cold air advection", and is what usually occurs behind cold fronts. The weather on the surface of the earth is controlled significantly by what occurs in the atmosphere above. Therefore, meteorologists always analyze "upper air charts" for weather disturbances, moisture, temperatures, etc. and their expected changes to determine what weather likely will occur at the surface. The pictures above show what a very basic upper air weather map might look like (in this example, at 500 mb or about 18,000 feet). At left, we see a "trough" of low pressure, which may be associated with a low pressure system (red "L"), fronts, and precipitation at the surface ahead of the upper trough location. At right, we see a "ridge" of high pressure aloft. A surface high pressure system and often fair weather typically are located ahead (east) of an upper ridge axis with lower surface pressure behind (west of) the ridge. Troughs and ridges can be weak or quite strong. In looking at upper air data, we also closely examine the "jet stream" which is a relatively high speed ribbon of air between 25,000 and 40,000 feet above the ground. The jet stream is strongest in the winter when the greatest temperature differences exist across the Northern Hemisphere. In a general sense, warmest air masses are located south of the jet with cold air to its north (left picture). Changes in the jet stream pattern and different wind speeds within the jet play a major role in surface temperature and precipitation patterns. At right is a typical upper air chart (300 or 200 mb, i.e., about 30,000 or 40,000 feet) showing height (white) lines revealing troughs across southern California/Baja of Mexico and the eastern United States, with a ridge across much of the Rocky Mountains. In addition, wind vectors and colored isotachs (lines of equal wind speed) show the location of the jet stream (green colors). Yellow, red, and pink colored isotachs represent a ribbon of higher speed winds within the jet. Notice that within the jet stream, wind speeds usually differ. It is these differences in wind speeds within the jet stream that can cause significant weather. In this example, the highest winds are located along the East Coast. This is called a "jet streak" within the overall jet stream. This picture is a satellite image showing clouds associated with a major low pressure system. Satellite pictures are taken by weather satellites located about 22,000 miles above the earth. The surface low center in this case likely would be located in western Iowa with a cold front extending south through Missouri into eastern Texas along the cloud band. Rain showers may be occurring within this band. Meanwhile, across Nebraska, South Dakata, Minnesota, and northern Wisconsin, steadier rain or snow may be occurring to the north and west of the surface low and warm front (which probably extends northeast from the low across central Wisconsin). Now we will look at different precipitation types. The red line above represents a vertical profile of temperature in the atmosphere. Notice that temperatures (the red line) remain colder than 0 deg C (32 deg F) throughout the atmosphere. Thus, snow will form aloft and remain as snow as it falls to the ground. Now we see a different temperature profile. The air is colder than 0 deg C aloft where snow forms, but then warms to just above freezing in a small layer. In this layer, the falling snow partially melts so that the precipitation is now partly snow and partly water. As it continues to fall toward the surface where cold air again exists (temperature below freezing), the precipitation refreezes to form sleet or ice pellets. This temperature profile is fairly similar to that for sleet, although a warmer and deeper warm layer exists with a shallower cold layer near the surface. Therefore, snow falls from above where the temperature is cold enough, then it completely melts to rain within the warm layer. As the rain then falls into the shallow cold layer at the surface, it does not have time to refreeze until it hits the surface. Upon doing so, the "supercooled" raindrops freeze on exposed surfaces. This can be a very dangerous situation as ice is more difficult to walk and drive on than snow or sleet. Back to Training Documents Weather Story Weather Map Local Radar Share copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. A Front is a boundary or transition zone between two air masses of different densities (think oil and vinegar). Air masses of different densities dont mix well, thus the layer in between them is the FRONT. There are a few different types of fronts, along with some special things you should know that apply to all fronts.Remember:There is always a change in wind when flying across a front.An easy way to know you are crossing a front is a change in temperature or a change in wind.Cold fronts have those blue pointy icicles, warm fronts are depicted with beads of sweat.We have a couple of different types of fronts we commonly encounter while flying:Warm FrontsCold FrontsOccluded FrontsStationary FrontsLets break it down by each type:Cold FrontsCold fronts come in two flavors, fast and slow. Fast moving cold fronts have been known to race across the continent at up to 60mph (this is what we mean when we say the weather is changing fast)!A cold front is basically a wave of cold air generally plunging down from the polar region above the United States. These cold fronts carry cold dense (high pressure) air with them. You will almost always notice an area of high pressure right behind a cold front. The frontal line itself will generally be located along a trough or an area where the pressure drops between two air masses. This is because as the cold front moves along, the colder air forces the warmer (and moist) air it is meeting upward. As the warm air moves upward, the moisture in it begins to condense, releasing more heat energy and further lowering the pressure of the air on the boundary of the front. We can generally expect an increase in atmospheric pressure after a cold front moves in and a HIGH moves into the area. This high-pressure mass will generally bring cooler temperatures, clear skies, and of course, bumps and turbulence as the ground heats and the warm air at the ground rises into the cool air aloft.The faster the cold front moves, the more rapidly the weather will change, plus, as a general rule, the more intense the weather will be along the frontal line (taller thunderstorms and stronger winds).Warm FrontsInstead of cold air plunging down from the Arctic to form cold fronts, this is a case where the polar air retreats pulling in warmer (and moister) air from the south in its place. Since cold dense air is often reluctant to give way to the warmer lighter air, warm fronts typically only move at around 15mph and have much shallower slopes of around 1/100 (the warm front is only 1 mile tall 100 miles from where it starts). This shallow slope means that weather associated with a warm front is generally distributed along a larger area and is probably less intense than that associated with a cold front.One major hazard associated with warm fronts is the possibility of rain to fall from above in the warm front down into the colder air it is overtaking. If the colder air is really cold, this could be a great recipe for freezing rain and fast accumulation of clear ice on your airframe. ICE+AIRPLANE=BAD DAYStationary FrontsSometimes air masses exert similar strength forces on each other and no one wins. When one air mass is no stronger than the other, no movement occurs and you get a stationary front. Although the forces of nature are rarely in perfect equilibrium, these fronts remain mostly stationary (movement of less than 5 knots ~5mph). When you encounter a stationary front, there are a few things you should know about it:wind on either side of the boundary blows parallel to the frontal line, not across itweather associated with a stationary front is similar to that of a warm front (but even less intense drizzly precipitation due to the lack of lifting forces available)weather patterns typically persist for several days Occluded FrontsOccluded fronts also come in two different flavors, warm occlusions, and cold occlusions. First, what is an Occluded Front you might ask? Well, it is simply a front that is overtaking another front because the slower front is driving in the left lane and wont get out of its way. Actually, check out this diagram below to see what it looks like. It literally is just one front that is overtaking another front. What are the differences between the two types? Well in a Cold Occlusion, a faster moving cold front catches up and overtakes a slower moving warm front. In a Warm Occlusion, a cold air mass overtakes a retreating colder air mass (and behind the retreating colder air mass there is usually some warm air being drawn up from the south) and catches warm air in between it and the colder air mass it was overtaking. This may be difficult to wrap your mind around the fronts wrapping themselves around each other. Take a few minutes to study the diagrams below to get a clearer picture of what is going on when this is happening. System RotationOne important thing to note is the direction in which high and low-pressure systems rotate. In the Northern hemisphere, High-pressure systems always rotate clockwise, while Low-pressure systems always rotate counter-clockwise (remember that the Atlantic Ocean is very heavy and high pressure and it always rotates clockwise as well). With this important bit of information, let me propose this fact to you:When flying along at altitude, if you have a crosswind from the left, you are flying towards an area of Low Pressure and probably bad weather. If you have a crosswind from the right, you are flying towards an area of High Pressure and probably good weather.These systems rotate this way because of Coriolis Effect (the rotation on the Earth). We know that the winds aloft always flow parallel to the isobars due to this Coriolis Effect, but very close to the ground due to the surface friction from the Earth, the wind direction changes to flow directly from high pressure to low pressure.Remember:Up high, wind flows parallel to isobars from Coriolis EffectDown low, the friction of the earths surface slows down that movement and wind flows simply from high pressure to low pressure as youd expect it to. Aviation Weather Handbook, Front Symbology Aviation Weather Handbook, Cold Front Cold Front Passage Aviation Weather Handbook, Warm Front Warm Front Passage The severity of the clouds and precipitation occurring along a front are dependent on: The amount of moisture available (shown by the dew point) The degree of stability of the lifted air The slope of the front The speed of the frontal movement The contrast in the amounts of temperature and moisture between the two air masses There are four types of fronts: [Figure 1] Cold fronts, depicted in blue with triangles protruding in the direction of movement Warm fronts, depicted in red with half circles protruding in the direction of movement Stationary fronts, depicted in blue and red with opposing red half circles and blue triangles Occluded fronts, depicted in pink with half circles and blue triangles protruding in the direction of movement Aviation Weather Handbook, Front Symbology A cold front is a body of cold, dense, and stable air overtaking and replacing warmer air It is so dense, it stays close to the ground and acts like a snowplow, sliding under the warmer air and forcing the less dense air aloft [Figure 2] Cold fronts have a steep slope, and the warm air is forced upward abruptly This often leads to a narrow band of showers and thunderstorms along, or just ahead of, the front if the warm rising air is unstable The rapidly ascending air causes the temperature to decrease suddenly, forcing the creation of clouds The type of clouds that form depends on the stability of the warmer air mass A cold front in the Northern Hemisphere is normally oriented in a northeast to southwest manner and can be several hundred miles long, encompassing a large area of land Cold fronts typically move at a faster rate than warm fronts (~25-30 mph) Extreme cold fronts have been recorded moving at speeds of up to 60 mph Cold fronts tend to move faster in the summer than in winter Movement is usually eastern while the front is usually a NE-SW line Precipitation always falls in front of a cold front Fast Moving Cold Fronts: Fast-moving cold fronts are pushed by intense pressure systems far behind the actual front As surface friction slows a front, the leading edge tends to bulge out and steepen the front's slope This results in a very narrow band of weather, concentrated along the leading edge of the front If the warm air being overtaken by the cold front is relatively stable, overcast skies and rain may occur for some distance behind the front If the warm air is unstable, scattered thunderstorms and rain showers may form. A continuous line of thunderstorms, or squall line, may form along or ahead of the front Squall lines present a serious hazard to pilots as squall-type thunderstorms are intense and move quickly Behind a fast-moving cold front, the skies usually clear rapidly, and the front leaves behind gusty, turbulent winds and colder temperatures Squal Lines: Squal lines are the result of two airmasses colliding Intensity is relative to the speed and difference between the airmasses, with highly diverse airmasses potentially colliding at ~50 knot speeds Weather products that mention potential for squall lines include: Convective outlooks and mesoscale products from the Storm Prediction Center website (spc.noaa.gov) will certainly mention their probability, as will convective sigmets on the Aviation Weather Center website (aviationweather.gov) Weather imagary/radar displays squall lines as thin red or magenta lines Slow Moving Cold Fronts: Less than 15 knots More like a warm front in properties and weather Aviation Weather Handbook, Cold Front Cold Front Passage A warm front is a body of warm air overtaking and replacing cooler air Warm fronts typically move at a slower rate than cold fronts (~10-25 mph) The slope of the advancing front slides over the top of the cooler air and gradually pushes it out of the area Warm fronts typically have a gentle slope, so the warm air rising along the frontal surface is gradual [Figure 4] This favors the development of widespread layered or stratiform cloudiness and precipitation along, and ahead of, the front if the warm rising air is stable In the summer months, cumulonimbus clouds (thunderstorms) are likely to develop Aviation Weather Handbook, Warm Front Warm Front Passage When the forces of two air masses are relatively equal, the boundary or front that separates them remains stationary and influences the local weather for days Less than 5 knots of movement Winds blow 180 off from one another on each side Weather in a stationary front is a mix of cold and warm front characteristics Stationary frontal slope can vary, but clouds and precipitation would still form in the warm rising air along the front Wind blows parallel to fronts, but opposite directions to one another Occurs when a fast-moving cold front catches up to a slow-moving warm front The temperature within each front is the primary determinant as to the type of front/weather to be expected Cause persistent weather lasting over 24 hours Classified cold or warm based on what is in contact with the ground A cold occlusion results when the coldest air is behind the cold front The cold air replaces the cooler air at the surface and forces the warm air aloft High potential for serious weather Warm occlusion results when the coldest air is ahead of the warm front The cold air forces the cooler air of the advancing front aloft Storm front over Lake Superior, US.EPAWhen a front passes over an area, it means a change in the weather. Many fronts cause weather events such as rain, thunderstorms, gusty winds, and tornadoes. At a cold front, there may be dramatic thunderstorms. At a warm front, there may be low stratus clouds. Usually, the skies clear once the front has passed.A weather front is a transition zone between two different air masses at the Earth's surface. Each air mass has unique temperature and humidity characteristics. Often there is turbulence at a front, which is the borderline where two different air masses come together. The turbulence can cause clouds and storms.Instead of causing clouds and storms, some fronts just cause a change in temperature. However, some storm fronts start Earth's largest storms. Tropical waves are fronts that develop in the tropical Atlantic Ocean off the coast of Africa. These fronts can develop into tropical storms or hurricanes if conditions allow.Fronts move across the Earth's surface over multiple days. The direction of movement is often guided by high winds, such as Jet Streams. Landforms like mountains can also change the path of a front.There are four different types of weather fronts: cold fronts, warm fronts, stationary fronts, and occluded fronts.Cold FrontWeather map showing a cold front. Air temperatures ahead of the front are warmer than temperatures in the cold air mass behind the front.L.S. Gardiner/UCARA cold front forms when a cold air mass pushes into a warmer air mass. Cold fronts can produce dramatic changes in the weather. They move fast, up to twice as fast as a warm front. As a cold front moves into an area, the heavier (more dense) cool air pushes under the lighter (less dense) warm air, causing it to rise up into the troposphere. Lifted warm air ahead of the front produces cumulus or cumulonimbus clouds and thunderstorms.As the cold front passes, winds become gusty. There is a sudden drop in temperature, and also heavy rain, sometimes with hail, thunder, and lightning. Atmospheric pressure changes from falling to rising at the front. After a cold front moves through your area, you may notice that the temperature is cooler, the rain has stopped, and the cumulus clouds are replaced by stratus and stratocumulus clouds or clear skies.On weather maps, a cold front is represented by a solid blue line with filled-in triangles along it, like in the map. The triangles are like arrowheads pointing in the direction that the front is moving. Notice on the map that temperatures at the ground level change from warm to cold as you cross the front line.Warm FrontWeather map showing a warm front. Air temperatures ahead of the front are cooler than temperatures in the warm air mass behind the front.L.S.Gardiner/UCARA warm front forms when a warm air mass pushes into a cooler air mass, shown in the image to the right (A). Warm fronts often bring stormy weather as the warm air mass at the surface rises above the cool air mass, making clouds and storms. Warm fronts move more slowly than cold fronts because it is more difficult for the warm air to push the cold, dense air across the Earth's surface. Warm fronts often form on the east side of low-pressure systems where warmer air from the south is pushed north.You will often see high clouds like cirrus, cirrostratus, and middle clouds like altostratus ahead of a warm front. These clouds form in the warm air that is high above the cool air. As the front passes over an area, the clouds become lower, and rain is likely. There can be thunderstorms around the warm front if the air is unstable.On weather maps, the surface location of a warm front is represented by a solid red line with red, filled-in semicircles along it, like in the map on the right (B). The semicircles indicate the direction that the front is moving. They are on the side of the line where the front is moving. Notice on the map that temperatures at ground level are cooler in front of the front than behind it.Stationary FrontA stationary front is represented on a map by triangles pointing in one direction and semicircles pointed in the other direction.L.S.Gardiner/UCARA stationary front forms when a cold front or warm front stops moving. This happens when two masses of air are pushing against each other, but neither is powerful enough to move the other. Winds blowing parallel to the front instead of perpendicular can help it stay in place.A stationary front may stay put for days. If the wind direction changes, the front will start moving again, becoming either a cold or warm front. Or the front may break apart.Because a stationary front marks the boundary between two air masses, there are often differences in air temperature and wind on opposite sides of it. The weather is often cloudy along a stationary front, and rain or snow often falls, especially if the front is in an area of low atmospheric pressure.On a weather map, a stationary front is shown as alternating red semicircles and blue triangles. Notice how the blue triangles point in one direction, and the red semicircles point in the opposite direction.Occluded FrontAn occluded front may share the characteristics of both warm and cold fronts. Occluded fronts are denoted by a line with both semicircles and triangles and are often colored purple on a weather map.UCAR Center for Science EducationSometimes a cold front follows right behind a warm front. A warm air mass pushes into a colder air mass (the warm front), and then another cold air mass pushes into the warm air mass (the cold front). Because cold fronts move faster, the cold front is likely to overtake the warm front. This is known as an occluded front.At an occluded front, the cold air mass from the cold front meets the cool air that was ahead of the warm front. The warm air rises as these air masses come together. Occluded fronts usually form around areas of low atmospheric pressure.There is often precipitation along an occluded front from cumulonimbus or nimbostratus clouds. Wind changes direction as the front passes and the temperature either warms or cools. After the front passes, the sky is usually clearer, and the air is drier.On a weather map, shown to the right, an occluded front looks like a purple line with alternating triangles and semicircles pointing in the direction that the front is moving. It ends at a low pressure area shown with a large L on the map, begins at the other end when cold and warm fronts connect. A lot of folks seem confused by when the last day of summer really happens. The calendar tells us one thing, but astronomy tells us something else. See how meteorologists officially determine the beginning and end of summer. Do you pay attention to the hurricane forecast each year? There are 5 important new storm forecast changes for hurricane season. See what the changes are, why they were made, and how they affect you. Our Tailwheel Pilot Training Course is designed to get you ready for your tailwheel endorsement in any conventional gear airplane. Get prepared with this course!Learn More The IFR Written Prep takes 10-15 hours to study the 850+ FAA test questions, watch all video courses, and understand the material.It has everything you need to ACE your FAA Written Exam.Learn More This BootCamp will prepare you to PASS your Commercial Pilot Checkride. The course contains four full-length FAA Oral Exams and all Flight Maneuvers explained in detail with graphics and animations.Learn More Whether you are getting ready for your BFR or IPC or haven't flown in 20 years, this course will save you money and help you get currentfast! Learn More There are three parts to the CFI Ground School Course:The CFI PTS Explained in Detail, FOI - Fundamentals of Instruction, and the CFI Full-Length Oral Exam.Learn More Everything you need to know about flying floatplanes! Glassy Water, Rough Water, Beaching, Docking, Floatplanes and Flying boats.Learn More Review what went wrong on a routine flight in Texas. Listen to the ATC audio tapes and see the radar data to better understand how this aircraft accident developed and how we can avoid similar situations like this as pilots in the future.Learn More Follow along with 11 real-world scenario based lessons to better understand aviation weather theory and aviation weather products. These videos explain in detail the topics of AC 06B and AC 00-45H.Learn More Take the FREE Spin Awareness course here!Learn what you need to know prior to your spin training with your CFI!Learn MoreOur online flight training courses are different than others. Let us prove it to you!The reality is no one is going to get through flight training on their own. You need a solid foundation and support system to get you the knowledge you need when you need it, and to help keep you on track.The better your knowledge foundation and the better your support system, the faster you will get through flight training the more money you will save.We have a simple two-step system for you.Step 1:To Save Money on your Flight Training: Use the best tools available to gain the knowledge you need to become a safe and skilled pilot.Step 2:Find the support system you need to be successful. Ask who is going to be there to answer your questions right away? Ask who is going to tell you and warn you about what to watch out for so you are not overcharged in flight training? Ask who will give you guidance so you can learn to fly and complete your ratings as quickly and cheaply as possible?FLY8MA is built specifically to be the best online flight training provider available in the United States to meet those two key needs.Why do more than 10,000 pilots use FLY8MA to pass their written exams and checkrides each year?Because FLY8MA is different. Here is how. Our students save on average 20% on their flight training costs 99% student satisfaction rating 100% Student Pass Rate! 1,000+ HD videos on our website Videos updated throughout the year Latest FAA test standards updated 12 times a year in our courses FAA test questions are updated 6 times a year The most modern filming and teaching methods Nationwide network of Flight Instructors Live support 7 days a week Screenshot any content in our courses and email it to us for a detailed explanation from our CFIs We explain any topics you have questions regarding in your local area Live office hours with Jon and our other CFIs Schedule a one-on-one time with a CFI or just Call or Email anytime 7 days/week Phone | Text | Email SupportOur goal here at FLY8MA is not to sell courses, get more likes, or get more subscribers.Our goal here is to make you a pilot. A pilot that is safe, competent, and confident.We are here to help you through the process of becoming a pilot and being successful in aviation from start to finish.NO ONE beats our customer service! Guaranteed!Do not hesitate to reach out to us via phone, text, or email with any aviation-related questions.-Fly Safe, Jon Kotwicki FLY8MA Founder and Chief CFI A cold front occurs at the leading edge of a cold air mass that is moving to replace a warmer air mass.Diagram showing a cold air front. The cold air mass is moving to replace the warmer air mass and at the boundary a cold front forms. These different air masses do not mix because they have different temperatures and densities. As the cold front develops the warm air ahead of the front is pushed up over the top of the cold air. This happens because the warm air is lighter (less dense) than the cold air. You often see clouds forming at a cold front. This is because as the warm air rises, it cools and moisture in the air condenses. Clouds are masses of cool, condensed air. Fronts can be several hundred kilometres in width.The air behind a cold front is cooler than the air in front of it. If a cold front passed overhead when you were standing outside, then you would feel the air cooling down.The air would also be dryer than before. Theweather maps below will help you understand how to recognise a cold front. The chart below shows a cold front over the UK. The front is the blue line with the triangles on it. It travels in the direction of the wind, in this case west to east. You can see that the weather conditions ahead of and behind the front are different. We said before that the air temperatures ahead of the cold front are usually warmer than the temperature behind the cold front. We can see the difference on this map. Weather forecast for 12pm Symbols on the map Thin grey-blue lines:These are isobars. They link areas with equal air pressure. the values marked on the lines, e.g. "1016"are air pressures in millibars Numbers in blue arrowed circles:These show the wind speed (in miles per hour) and wind direction Numbers in black circles:These are air temperature in degrees Celsius Icons:These symbols show the main weather features such as light cloud, rain or sunshine Thick blue and orange lines:These show weather fronts, i.e. where differing air masses meet Questions What is the change in air temperature ahead of and behind the cold front? What other weather conditions change ahead of and behind the front? Write down the main differences between a warm and a cold weather front. May 16, 2025 Severe Weather This picture shows an example of a high and low pressure system. At the surface, in the Northern Hemisphere, winds flow counterclockwise (cyclonically) around low pressure, and clockwise (anticyclonically) around high pressure. (Highs and lows spin the other way in the Southern Hemisphere.) The actual pressure of these systems can be measured in either inches of mercury (e.g., 30.10) or millibars (e.g., 1004 mb). Lines of equal pressure between highs and lows are called "isobars". Surface winds generally flow at an angle to the isobars from high to low pressure. Here, a typical surface weather map shows winds rotating counterclockwise around a low pressure system. Each reporting station's observation gives wind direction and speed, temperature, dewpoint, and pressure at that station. Surface low pressure systems usually have fronts associated with them. A front represents a boundary between two air masses that contain different temperature, wind, and moisture properties. Here, a cold front is shown which can be present any time of the year, but is most pronounced and noticeable during the winter. Air normally is warmer ahead of a cold front and colder behind it. With a cold front, cold air advances and displaces the warm air since cold air is more dense (heavier) than warm air. This vertical cross-section of a cold front shows cold air behind the cold front (dark blue lines) advancing into warmer air ahead of the front. Where the two air masses meet, convergence often occurs which can result in upward motion of air parcels. If the air contains enough moisture, rain can occur. If the air also is unstable, thunderstorms can develop as well. This is a simplified view of a cold front. Sometimes, fronts aloft (above the surface) can result in precipitation ahead of cold fronts. Warm fronts also are common, especially from Fall through Spring when larger temperature differences exist across the United States. Relatively cool or cold air is present ahead of a warm front with warmer air behind the front, i.e., the opposite from that of cold fronts. However, while cool air at the surface exists ahead of a warm front, relatively warmer air often is located above it as the warmer surface air behind the front rises up and over the cool air below. If enough moisture is present, this can result in precipitation along and ahead of the front. With a warm front, the cool air ahead of it must retreat before the warm air behind it can advance. A vertical cross-section of a warm front (dark red lines) shows how surface warm air behind the warm front flows upward in a slantwise manner over top low-level cool or cold air ahead of the position of the surface warm front. This causes clouds and precipitation ahead of the surface warm front, assuming enough upward motion of air parcels and available moisture. A stationary front is similar to a warm front, i.e., warm air is present behind it (to its south) with cool air ahead of it (to its north). However, while a warm front shows movement, a stationary front shows little or no movement as the cooler, more dense air remains in tact and does not retreat. Notice the winds from the northeast in the picture on the right above. Since these winds are blowing toward the front somewhat, this cooler air is not retreating, so the warmer air to the south of the front cannot lift northward. With a stationary front, a balance usually exists between the warmer and colder air masses on both sides of the front, so that neither air mass can advance on the other one. Thus, the front remains nearly stationary. Here, we see what a typical low pressure system might look like on a surface weather map. A cold front extends to the south of the low pressure center, with a warm front to the east. Warm air is located ahead of the cold front and behind the warm front (the so-called "warm sector"), while cool air exists ahead of the warm front and cold air is present behind the cold front. Not all weather systems, however, are as simple as this model. This graphic shows how temperature "advection" occurs. To "advect" means to move from one place to another via the wind. At far left, warm air is being advected to the north, i.e., from bottom (warmer) to top (cooler) by a south wind. This is called "warm air advection" and occurs, for example, with warm fronts. Warm air advection can occur at the surface or aloft, and given enough lift and moisture, will result in precipitation. At near left is the opposite. The wind is blowing from north to south moving cooler air toward the warmer air. This is called "cold air advection", and is what usually occurs behind cold fronts. The weather on the surface of the earth is controlled significantly by what occurs in the atmosphere above. Therefore, meteorologists always analyze "upper air charts" for weather disturbances, moisture, temperatures, etc. and their expected changes to determine what weather likely will occur at the surface. The pictures above show what a very basic upper air weather map might look like (in this example, at 500 mb or about 18,000 feet). At left, we see a "trough" of low pressure, which may be associated with a low pressure system (red "L"), fronts, and precipitation at the surface ahead of the upper trough location. At right, we see a "ridge" of high pressure aloft. A surface high pressure system and often fair weather typically are located ahead (east) of an upper ridge axis with lower surface pressure behind (west of) the ridge. Troughs and ridges can be weak or quite strong. In looking at upper air data, we also closely examine the "jet stream" which is a relatively high speed ribbon of air between 25,000 and 40,000 feet above the ground. The jet stream is strongest in the winter when the greatest temperature differences exist across the Northern Hemisphere. In a general sense, warmest air masses are located south of the jet with cold air to its north (left picture). Changes in the jet stream pattern and different wind speeds within the jet play a major role in surface temperature and precipitation patterns. At right is a typical upper air chart (300 or 200 mb, i.e., about 30,000 or 40,000 feet) showing height (white) lines revealing troughs across southern California/Baja of Mexico and the eastern United States, with a ridge across much of the Rocky Mountains. In addition, wind vectors and colored isotachs (lines of equal wind speed) show the location of the jet stream (green colors). Yellow, red, and pink colored isotachs represent a ribbon of higher speed winds within the jet. Notice that within the jet stream, wind speeds usually differ. It is these differences in wind speeds within the jet stream that can cause significant weather. In this example, the highest winds are located along the East Coast. This is called a "jet streak" within the overall jet stream. This picture is a satellite image showing clouds associated with a major low pressure system. Satellite pictures are taken by weather satellites located about 22,000 miles above the earth. The surface low center in this case likely would be located in western Iowa with a cold front extending south through Missouri into eastern Texas along the cloud band. Rain showers may be occurring within this band. Meanwhile, across Nebraska, South Dakata, Minnesota, and northern Wisconsin, steadier rain or snow may be occurring to the north and west of the surface low and warm front (which probably extends northeast from the low across central Wisconsin). Now we will look at different precipitation types. The red line above represents a vertical profile of temperature in the atmosphere. Notice that temperatures (the red line) remain colder than 0 deg C (32 deg F) throughout the atmosphere. Thus, snow will form aloft and remain as snow as it falls to the ground. Now we see a different temperature profile. The air is colder than 0 deg C aloft where snow forms, but then warms to just above freezing in a small layer. In this layer, the falling snow partially melts so that the precipitation is now partly snow and partly water. As it continues to fall toward the surface where cold air again exists (temperature below freezing), the precipitation refreezes to form sleet or ice pellets. This temperature profile is fairly similar to that for sleet, although a warmer and deeper warm layer exists with a shallower cold layer near the surface. Therefore, snow falls from above where the temperature is cold enough, then it completely melts to rain within the warm layer. As the rain then falls into the shallow cold layer at the surface, it does not have time to refreeze until it hits the surface. Upon doing so, the "supercooled" raindrops freeze on exposed surfaces. This can be a very dangerous situation as ice is more difficult to walk and drive on than snow or sleet. Back to Training Documents Weather Story Weather Map Local Radar Share copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. A Front is a boundary or transition zone between two air masses of different densities (think oil and vinegar). Air masses of different densities dont mix well, thus the layer in between them is the FRONT. There are a few different types of fronts, along with some special things you should know that apply to all fronts.Remember:There is always a change in wind when flying across a front.An easy way to know you are crossing a front is a change in temperature or a change in wind.Cold fronts have those blue pointy icicles, warm fronts are depicted with beads of sweat.We have a couple of different types of fronts we commonly encounter while flying:Warm FrontsCold FrontsOccluded FrontsStationary FrontsLets break it down by each type:Cold FrontsCold fronts come in two flavors, fast and slow. Fast moving cold fronts have been known to race across the continent at up to 60mph (this is what we mean when we say the weather is changing fast)!A cold front is basically a wave of cold air generally plunging down from the polar region above the United States. These cold fronts carry cold dense (high pressure) air with them. You will almost always notice an area of high pressure right behind a cold front. The frontal line itself will generally be located along a trough or an area where the pressure drops between two air masses. This is because as the cold front moves along, the colder air forces the warmer (and moist) air it is meeting upward. As the warm air moves upward, the moisture in it begins to condense, releasing more heat energy and further lowering the pressure of the air on the boundary of the front. We can generally expect an increase in atmospheric pressure after a cold front moves in and a HIGH moves into the area. This high-pressure mass will generally bring cooler temperatures, clear skies, and of course, bumps and turbulence as the ground heats and the warm air at the ground rises into the cool air aloft.The faster the cold front moves, the more rapidly the weather will change, plus, as a general rule, the more intense the weather will be along the frontal line (taller thunderstorms and stronger winds).Warm FrontsInstead of cold air plunging down from the Arctic to form cold fronts, this is a case where the polar air retreats pulling in warmer (and moister) air from the south in its place. Since cold dense air is often reluctant to give way to the warmer lighter air, warm fronts typically only move at around 15mph and have much shallower slopes of around 1/100 (the warm front is only 1 mile tall 100 miles from where it starts). This shallow slope means that weather associated with a warm front is generally distributed along a larger area and is probably less intense than that associated with a cold front.One major hazard associated with warm fronts is the possibility of rain to fall from above in the warm front down into the colder air it is overtaking. If the colder air is really cold, this could be a great recipe for freezing rain and fast accumulation of clear ice on your airframe. ICE+AIRPLANE=BAD DAYStationary FrontsSometimes air masses exert similar strength forces on each other and no one wins. When one air mass is no stronger than the other, no movement occurs and you get a stationary front. Although the forces of nature are rarely in perfect equilibrium, these fronts remain mostly stationary (movement of less than 5 knots ~5mph). When you encounter a stationary front, there are a few things you should know about it:wind on either side of the boundary blows parallel to the frontal line, not across itweather associated with a stationary front is similar to that of a warm front (but even less intense drizzly precipitation due to the lack of lifting forces available)weather patterns typically persist for several days Occluded FrontsOccluded fronts also come in two different flavors, warm occlusions, and cold occlusions. First, what is an Occluded Front you might ask? Well, it is simply a front that is overtaking another front because the slower front is driving in the left lane and wont get out of its way. Actually, check out this diagram below to see what it looks like. It literally is just one front that is overtaking another front. What are the differences between the two types? Well in a Cold Occlusion, a faster moving cold front catches up and overtakes a slower moving warm front. In a Warm Occlusion, a cold air mass overtakes a retreating colder air mass (and behind the retreating colder air mass there is usually some warm air being drawn up from the south) and catches warm air in between it and the colder air mass it was overtaking. This may be difficult to wrap your mind around the fronts wrapping themselves around each other. Take a few minutes to study the diagrams below to get a clearer picture of what is going on when this is happening. System RotationOne important thing to note is the direction in which high and low-pressure systems rotate. In the Northern hemisphere, High-pressure systems always rotate clockwise, while Low-pressure systems always rotate counter-clockwise (remember that the Atlantic Ocean is very heavy and high pressure and it always rotates clockwise as well). With this important bit of information, let me propose this fact to you:When flying along at altitude, if you have a crosswind from the left, you are flying towards an area of Low Pressure and probably bad weather. If you have a crosswind from the right, you are flying towards an area of High Pressure and probably good weather.These systems rotate this way because of Coriolis Effect (the rotation on the Earth). We know that the winds aloft always flow parallel to the isobars due to this Coriolis Effect, but very close to the ground due to the surface friction from the Earth, the wind direction changes to flow directly from high pressure to low pressure.Remember:Up high, wind flows parallel to isobars from Coriolis EffectDown low, the friction of the earths surface slows down that movement and wind flows simply from high pressure to low pressure as youd expect it to.