**Aviation merit badge requirements**

1. Do the following:
   1. Define 'aircraft'. Describe some kinds and uses of aircraft today. Explain the operation of piston, turboprop, and jet engines.
   2. Point out on a model airplane the forces that act on an airplane in flight.
   3. Explain how an airfoil generates lift, how the primary control surfaces (ailerons, elevators, and rudder) affect the airplane's attitude, and how a propeller produces thrust.
   4. Demonstrate how the control surfaces of an airplane are used for takeoff, straight climb, level turn, climbing turn, descending turn, straight descent, and landing.
   5. Explain the following: the sport pilot, the recreational pilot and the private pilot certificates; the instrument rating.
2. Do TWO of the following:
   1. Take a flight in an aircraft, with your parent's permission. Record the date, place, type of aircraft, and duration of flight, and report on your impressions of the flight.
   2. Under supervision, perform a preflight inspection of a light aircraft.
   3. Obtain and learn how to read an aeronautical chart. Measure a true course on the chart. Correct for magnetic variation, compass deviation, and wind drift to determine a compass heading.
   4. Using one of many flight simulator software packages available for computers, 'fly' the course and heading you established in requirement 2c or another course you have plotted.
   5. Explain the purposes and functions of the various instruments found in a typical single-engine aircraft: attitude indicator, heading indicator, altimeter, airspeed indicator, turn and bank indicator, vertical speed indicator, compass, navigation (GPS and VOR) and communication radios, tachometer, oil pressure gauge, and oil temperature gauge.
   6. Create an original poster of an aircraft instrument panel. Include and identify the instruments and radios discussed in requirement 2e.
3. Do ONE of the following:
   1. Build and fly a fuel-driven or battery-powered electric model airplane. Describe safety rules for building and flying model airplanes. Tell safety rules for use of glue, paint, dope, plastics, fuel, and battery packs.
   2. Build a model FPG-9 (Foam Plate Glider). Get others in your troop or patrol to make their own model, then organize a competition to test the precision of flight and landing of the models.
4. Do ONE of the following:
   1. Visit an airport. After the visit, report on how the facilities are used, how runways are numbered, and how runways are determined to be 'active.'
   2. Visit a Federal Aviation Administration facility - a control tower, terminal radar control facility, air route traffic control center, or Flight Standards District Office. (Phone directory listings are under U.S. Government Offices, Transportation Department, Federal Aviation Administration. Call in advance.) Report on the operation and your impressions of the facility.
   3. Visit an aviation museum or attend an air show. Report on your impressions of the museum or show.
5. Find out about three career opportunities in aviation. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

1. Do the following:

* 1. Define 'aircraft'. Describe some kinds and uses of aircraft today. Explain the operation of piston, turboprop, and jet engines.

M 9-10

Aircraft: an aircraft is a vehicle that is able to fly by gaining support from the air.

Examples: Commercial and cargo airliners; military tankers, transport, fighter, bomber, and surveillance aircraft; helicopters; general aviation; corporate; balloons; sailplanes; acrobatic; crop sprayers.

M 28-31

Piston: also referred to as a reciprocating internal combustion engine, it compresses a mixture of gasoline and air. A spark ignites the compressed mixture causing the gases to expand rapidly and forcing the piston to move away from the cylinder that houses it. The motion is transferred to a connecting rod, then to a crankshaft which turns the propeller and forces the piston back to the top of the cylinder. An exhaust valve at the top of the cylinder opens to release the burned mixture. The exhaust valve then closes, and the intake valve opens to let in a new mixture of gas and air.

Turboprop: a turboprop engine is a turbine engine that drives the propeller. It consists of an intake, compressor, combustor, turbine, and a propelling nozzle. Air is drawn into the intake and then compressed. Fuel is then added to the air in the combustor. The combustion gases expand through the turbine. This power is transmitted through reduction gearing to the propeller.

Jet: a jet uses a turbine engine like a turboprop. However, instead of using the energy to drive a propeller, a jet takes the energy of the hot, high pressure air and converts it to kinetic energy by passing it through a narrower nozzle.

* 1. Point out on a model airplane the forces that act on an airplane in flight.

M 15

Gravity and drag are the natural forces that affect an aircraft. To offset these, an aircraft must produce thrust and lift. [NASA](https://www.grc.nasa.gov/WWW/K-12/airplane/forces.html) has a good website to explain this.

* 1. Explain how an airfoil generates lift, how the primary control surfaces (ailerons, elevators, and rudder) affect the airplane's attitude, and how a propeller produces thrust.

M 15–17

The bottom surface of an aircraft wing tends to be flat, while the upper surface curves upward. The wing is also attached at a slight angle (angle of incidence) instead of being level with the ground. Both of these aspects help to produce lift. Air travels faster over the top of the wing creating an area of lower relative pressure. Since the wing is attached higher in the front than the back, as air hits it, the wing is pushed upward.

M 21-23

Ailerons are located in the wing. As the pilot turns the control wheel left or right, the ailerons move up or down on opposite wings causing the aircraft to rotate on its longitudinal axis. This causes an airplane to turn.

Elevators are located in tail in line with the wings. Moving the control wheel up and down causes the elevator to move up or down, and the aircraft moves on its lateral axis. This causes an airplane to climb or descend.

The rudder is located in the horizontal portion of the tail. Moving the rudder pedals left or right causes the aircraft to pivot on the vertical axis. This helps an airplane to maintain a coordinated turn.

M 16

Propeller blades work by creating greater air pressure on one side of their surfaces than on the other. As the blades cut through the air, they pull or push the plane along because the pressure behind them is greater than the pressure in front.

* 1. Demonstrate how the control surfaces of an airplane are used for takeoff, straight climb, level turn, climbing turn, descending turn, straight descent, and landing.

M 24-26

It may be easier to understand if I try to provide examples of how the flight controls are moved from inside the cockpit. All of the flight controls are actuated inside the cockpit from the control wheel (or stick) and rudder pedals with the exception of the flaps. The flaps are controlled by a switch or handle.

Moving the control wheel left moves the left aileron up and the right aileron down, causing the airplane to turn left. Using left rudder at the same time allows the turn to be coordinated. That means the nose moves in the direction of the turn without yawing to the right. Pushing down on the rudder pedal deflects the rudder in the same direction. To perform a right turn, the control wheel is turned right, and the right rudder pedal is pushed down. In order to maintain a constant speed, power may need to be added.

Moving the control wheel aft moves the elevator upward. This causes the nose to move up and the aircraft climbs. Pushing the control wheel forward moves the elevator downward, and the aircraft descends. In order to maintain constant speed, power needs to be added to climb or pulled back to descend.

Flaps are extended to create more lift and allow the aircraft to takeoff and land at lower speeds. Moving the flap handle or switch down causes the flaps to lower from the wing, essentially making the wing bigger and more curved. Moving the flap handle or switch up causes the flaps to retract. The reason flaps are not left down all the time is because it also creates more drag. More power needs to be added to fly the same speed than with a clean wing (flaps up). If you fly too fast with the flaps down, you may overspeed them and cause damage.

This [video](https://www.youtube.com/watch?v=WhQ8Ai4fa_Q) from Embry Riddle University does a good job of demonstrating this.

Takeoff: elevator neutral, aileron level or into the wind, rudder centered or offset to compensate for aileron; once rotation speed is reached, the elevator is moved to lift the nose off the runway; flaps are used to minimize takeoff roll, they are retracted after takeoff.

Straight climb: elevator is moved to increase pitch attitude.

Level turn: aileron and rudder work together for a coordinated turn. Elevator is moved slightly to maintain altitude.

Climbing turn: same as level turn but control wheel is moved aft to use more elevator

Descending turn: control wheel is moved forward

Straight descent: elevator is moved to decrease pitch attitude

Landing: as the plane nears the ground, power is reduced and the control wheel is moved aft to flare the aircraft; flaps are used to increase lift, allow slower approach speeds, and minimize landing rollout.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Maneuver | Ailerons | Elevators | Rudder | Flaps |
| Takeoff | Level or into the wind | Neutral until rotation speed is reached, then moved to lift the nose off the runway | Centered or offset to compensate for aileron use into the wind | Used to increase lift and minimize takeoff roll |
| Straight Climb | Neutral | Moved to increase pitch | Centered | Not used |
| Level Turn | Used to turn | Moved slightly to compensate for loss of lift | Used with aileron for a coordinated turn | Not used |
| Climbing Turn | Used to turn | Moved to increase pitch | Used with aileron for a coordinated turn | Not used |
| Descending Turn | Used to turn | Moved to decrease pitch | Used with aileron for a coordinated turn | Not used |
| Straight Descent | Neutral | Moved to decrease pitch | Centered | Not used |
| Landing | Level or into the wind | Neutral until the flare, then moved to increase pitch | Centered or offset to compensate for aileron use into the wind | Used to increase lift and minimize landing roll |

* 1. Explain the following: the sport pilot, the recreational pilot and the private pilot certificates; the instrument rating.

M 58-59

Sport Pilot: created by the FAA in 2004 to lower the barriers to entry level aviation, it pertains only to light sport aircraft. You must be 17, have a driver’s license or an FAA medical certificate. You need a student pilot certificate. You may only carry one passenger up to 10,000’ and may only operate in daytime VFR.

Recreational Pilot: requires 30 hours of flight instruction, including three hours solo. The pilot may carry one passenger in a single engine with up to four seats and 180 hp. The pilot my fly up to 10,000’ in VFR up to 50 NM from the home airport.

Private Pilot: requires 40 hours of flight instruction, including ten hours solo. The pilot can carry more than one passenger, fly higher than 10,000’, go farther than 50 NM from the home airport, fly at night and into controlled airspace.

Instrument Rating: requires 50 hours pilot in command cross country, 40 hours of simulated or actual instrument time, and 15 hours of flight instruction toward an instrument rating. It allows a pilot to fly in IFR conditions.

1. Do TWO of the following:
   1. Take a flight in an aircraft, with your parent's permission. Record the date, place, type of aircraft, and duration of flight, and report on your impressions of the flight.
   2. Under supervision, perform a preflight inspection of a light aircraft.
   3. Obtain and learn how to read an aeronautical chart. Measure a true course on the chart. Correct for magnetic variation, compass deviation, and wind drift to determine a compass heading.

[How to Read a VFR Sectional Chart Video](https://www.youtube.com/watch?v=6ITjUfl80bs) – 11:37 may be too intensive, but a good start.

[Plotting a Course](https://www.youtube.com/watch?v=pRJaU0y5RHY) – First 2:00 explain measuring a true course and correcting for magnetic variation.

Compass deviation is specific to each aircraft. Airplanes are surrounded by metal and electrical parts which can deflect the compass from its normal reading. When the planes are certified, the compass reading is checked for variation, and the results are posted on a compass card.

Wind drift is accounted for by calculating the magnitude of force the wind will push you off course and correcting for it. This can be done with a plotter or flight computer (whiz wheel or E6B).

* 1. Using one of many flight simulator software packages available for computers, 'fly' the course and heading you established in requirement 2c or another course you have plotted.
  2. Explain the purposes and functions of the various instruments found in a typical single-engine aircraft: attitude indicator, heading indicator, altimeter, airspeed indicator, turn and bank indicator, vertical speed indicator, compass, navigation (GPS and VOR) and communication radios, tachometer, oil pressure gauge, and oil temperature gauge.

M 34-39, 54-55

Attitude Indicator: represents the plane’s position with respect to the real horizon. It is attached to a gyroscope and is the pilot’s primary reference during instrument flight.

Heading Indicator: a gyroscope that shows the plane’s magnetic compass heading

Altimeter: a barometer that measures air pressure and converts it into an altitude. In the US, below 18,000’, it is set to a local pressure setting. Above 18,000’, it is set to 29.92 in mg.

Airspeed Indicator: shows how fast the plane is moving. It measures the plane’s impact on the air by registering the velocity of air molecules striking the sensor. This is translated into nautical miles per hour, or knots.

Turn and Bank Indicator: shows when the plane is turning and whether or not the turn is coordinated. It also will indicate whether the aircraft is properly trimmed to fly in straight and level flight.

Vertical Speed Indicator: shows how fast the plane is climbing or descending in hundreds of feet per minute.

Compass: used as a backup or reference to the heading indicator. The compass must be corrected for magnetic variation, metal and electrical equipment on the plane, and wind drift.

Navigation: ground based stations a pilot may use to navigate include VHF Omni Range (VOR), Non Directional Beacon (NDB), and Instrument Landing System (ILS). Space based navigation uses the global positioning system (GPS), a series a geostationary satellites orbiting around 11,000 miles to indicate latitude and longitude.

Radios: pilots use VHF, UHF, and HF radios to communicate with ATC and each other. In order to enter certain controlled airspace, a pilot is required to have an operating radio.

Tachometer: in a piston engine, it will show whether or not the propeller is turning at the recommended speed for a particular maneuver and whether the engine is operating normally.

Oil Pressure Gauge: shows the pressure of the oil in the engine which is a good indicator of the health of the engine.

Oil Temperature Gauge: measures the temperature of the oil and cylinder heads and indicates whether the engine is running well, too hot or too cold.

* 1. Create an original poster of an aircraft instrument panel. Include and identify the instruments and radios discussed in requirement 2e.

Examples of cockpits with the above instruments:

[Flight Instruments](https://en.wikipedia.org/wiki/Flight_instruments)

[Cessna 172 Instrument Panel Diagram & Equipment List](https://www.hodgeflightservices.com/wp-content/uploads/2017/09/N9520D-Instrument-Panel-Diagram_Equip-List.pdf)

[Learning About Aircraft Instruments](https://www.wikihow.com/Fly-a-Cessna)

1. Do ONE of the following:
   1. Build and fly a fuel-driven or battery-powered electric model airplane. Describe safety rules for building and flying model airplanes. Tell safety rules for use of glue, paint, dope, plastics, fuel, and battery packs.
   2. Build a model FPG-9 (Foam Plate Glider). Get others in your troop or patrol to make their own model, then organize a competition to test the precision of flight and landing of the models.

M 83-89

1. Do ONE of the following:
   1. Visit an airport. After the visit, report on how the facilities are used, how runways are numbered, and how runways are determined to be 'active.'

M 71-73

Airport runways are designed when possible to allow takeoffs and landings into the prevailing wind. Runways are numbered according to the compass heading indicated when lined up with the centerline of the runway, from 1 to 36. A runway with a heading of 051, as at Anderson Regional, would be indicated as Runway 5. The opposite direction, 180 degrees out, would be Runway 23. At large airports with multiple runways, as in Atlanta, the runways may include a left, right, or center indication, such as 8L, 8R, and 8C.

If there is an operating control tower, they will determine which runway is “active” based on winds and weather. Headwinds are preferred for takeoff and landing because they reduce the amount of runway that needs to be used. Crosswinds also are preferred to be minimized if there are intersecting runways. Some aircraft have limits on how much crosswind or tailwind they can accept. For example, the B-757 can take off with up to 15 knots of tailwind and 30 knots of crosswind, but it is preferable to have a headwind and less crosswind.

Some airports, like Aspen, can only land and takeoff in one direction because of terrain.

Larger airports have control towers. These facilities provide local weather, flight clearances, ground control, and air traffic control in the vicinity of the airport. At some airports, like Greenville, the tower has limited hours and closes at night.

At larger commercial airports, each airline may have its own terminal and hangar space, along with fuel trucks and ground service crews. If the airport is serviced by an airline, there will be firefighting and rescue equipment.

* 1. Visit a Federal Aviation Administration facility - a control tower, terminal radar control facility, air route traffic control center, or Flight Standards District Office. (Phone directory listings are under U.S. Government Offices, Transportation Department, Federal Aviation Administration. Call in advance.) Report on the operation and your impressions of the facility.
  2. Visit an aviation museum or attend an air show. Report on your impressions of the museum or show.

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M 91-93

Commercial, corporate, and military pilots and flight engineers

Flight attendants

Aircraft maintenance

Aircraft manufacturing

Aeronautical engineering

Airline dispatcher

Air traffic controller

Corporate aviation

Fixed base operator

Air Force Pilot: must earn a bachelor’s degree, be 18-34 years old, become an officer by graduating from a service academy, participating in AFROTC, or attending Officer Training School, pass the flight physical, pass the air force physical fitness test, pass Initial Flight Training (IFT), and complete Undergraduate Pilot Training (UPT). No prior experience is required, but having prior flying experience is very helpful.

Commercial Pilot: some commercial airlines require a bachelor’s or associate’s degree, must be at least 23 and have logged at least 1,500 hours, and must earn an Airline Transport Pilot (ATP) rating.

FedEx: ATP, first class medical certificate, bachelor’s degree

Airline Transport Pilot (ATP) Rating: requires 1500 hours, 500 hours cross country, 100 hours night, 75 hours instrument, 250 hours pilot in command, 50 hours multiengine.

**Notes**:

M – Aviation Merit Badge pamphlet 2017 printing

GSP ATC

* Tower 864-879-2156
* Tracon 864-879-2155