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| UNIT OVERVIEW |
| **Course** Helicopter Crewmember, S-271 |
| **Unit** 5 – Helicopter Performance, Limitations, and Load Calculations |
| **Time** TBD |
| **Objectives**  1. Describe air density altitude and the effects on helicopter performance.  2. Define “in-ground-effect” and “out-of-ground-effect” as they relate to helicopter performance.  3. Discuss general aspects of helicopter design, flight controls, terminology, and principles of flight.  4. Describe the process for completing a load calculation form. |
| **Strategy**  This unit will help students to articulate the principles and general aspects of flight as they relate to helicopter performance. This will be accomplished through lecture, discussion, and hands-on exercises. |
| **Instructional Method(s)**   * Facilitation/informal lecture with PowerPoint * Group exercises |
| **Instructional Aids**   * Personal computer with LCD projector and presentation software * Fireline Handbook, PMS 410-1 * IRPG * IHOG |
| **Exercises**   * Load Calculation and Density Altitude * Daily Checks |
| **Evaluation Method**   * Review and discuss group exercises. |
| **Outline**  I. PRINCIPLES OF FLIGHT  A. Ground Effect  B. Autorotation  C. Height Velocity Diagram  D. Maximum Performance Takeoff  E. Density Altitude  F. Density Altitude Chart  II. HELICOPTER LOAD CALCULATIONS  A. Load Calculation Form  B. Reading the Form  III. HELICOPTER PERFORMANCE  A. Basic Helicopter Design  B. Helicopter Loading |
| **Aids and Cues Codes**  The codes in the Aids and Cues column are defined as follows:  IG – Instructor Guide IR – Instructor Reference  SW – Student Workbook SR – Student Reference  HO – Handout Slide – PowerPoint |

# UNIT PRESENTATION

COURSE: Helicopter Crewmember, S-271

UNIT: 5 – Helicopter Performance, Limitations, and Load Calculations

| OUTLINE | AIDS & CUES |
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| Unit Title Slide.  Present Unit Objectives.  Show Helicopter Capabilities And Limitations, NFES 2392  i. principles of flight  Certain terms are commonly used in reference to helicopter flight characteristics. Being familiar with these terms is important to persons involved with helicopter use.  A. Ground Effect  A condition of improved rotor system performance encountered when the helicopter is hovering near the ground. The apparent result is increased lift thus decreased power requirements. This provides for a greater allowable payload.  1. Hover-In-Ground-Effect (HIGE)  HIGE is achieved when the helicopter is hovering less than one-half the rotor diameter distance from the ground. In a hover, the rotor blades move large volumes of air from above the rotors down through the system.  The ground interrupts the airflow under the helicopter, this reduces downward velocity of the air and produces an outward airflow pattern.  Emphasize – diminishes when hovering over water or tall grass.  2. Hover-Out-Of-Ground-Effect (HOGE)  HOGE occurs when the helicopter exceeds about one-half the rotor diameter distance from the ground, and the cushion of air disintegrates.  To maintain a hover, the helicopter is now power dependent. This situation will occur when the terrain does not provide sufficient ground base, or when performing external load work. Maximum performance is required and payload may have to be reduced.  It is important to understand the capabilities and limitations presented by ground effect when choosing a landing site.  When planning a helicopter project, the safety and efficiency of the operation will be enhanced by selecting landing areas that allow the pilot to approach into the wind and HIGE. Normal take-off and landings are initiated by bringing the helicopter up to an in-ground-effect hover and translating the aircraft into forward flight.  Additional lift is gained as the helicopter moves from the turbulent air created from hovering, to undisturbed, “clean” air which moves through the rotor system as the helicopter increases airspeed.  3. Translational Lift  Translational lift occurs when the helicopter approaches 15 to 18 MPH indicated airspeed. Translational lift will also be produced when the helicopter is hovering with a 15 MPH steady headwind. Translational lift can be felt as an aircraft transitions from a hover to forward flight. A brief vibration can be felt as forward airspeed increases from a hover.  B. Autorotation  If available, show internet footage demonstrating safe autorotation.  Autorotation is a non-powered flight condition in which the rotor system maintains flight RPM by reversed airflow. It provides the pilot a means of safely landing the helicopter after an engine failure or other mechanical emergency.   * Helicopters have a freewheeling unit in the transmission which automatically disengages the engine from the rotor system in the event of failure. This allows the main rotor to rotate freely. * When the helicopter is powered by the engine, airflow is downward through the rotors. During an autorotation airflow is upward, “wind milling” the rotor blades as the helicopter descends.   The pilot maintains constant rotor RPM by changing the pitch to the blades as the aircraft continues descent. As the helicopter approaches a landing site, the pilot flares the aircraft by moving the cyclic back and gently lifting the nose. This slows the forward airspeed and rate of descent. Before touchdown, the helicopter is leveled and the pilot utilizes the stored-up blade inertia to cushion the helicopter to the ground. The autorotation is complete.  C. Height Velocity Diagram  In the flight manual for each helicopter type is a chart which provides necessary information to complete a safe autorotation. This is a height velocity curve, indicating the comparative combination of airspeed and altitude require accomplish a safe autorotation (for most light helicopter, 350 to 450 feet above ground level at zero airspeed). When flying low-level or performing extended hovers, we are dramatically reducing our safety margin and limiting the pilot’s options.  D. Maximum Performance Takeoff  On occasion, a maximum performance takeoff or landing must be accomplished. This occurs when the helicopter hovers- out-of-ground-effect before or after translational lift. In this situation, the helicopter is totally power dependent and the margin of safety is significantly reduced.  When possible, avoid confined areas, or large obstructions that require the pilot to use maximum power for extended periods.  E. Density Altitude  Density altitude refers to a theoretical air density which exists under standard conditions of a given altitude.  By definition, **density altitude is pressure altitude corrected for temperature and humidity.**  It can have a profound effect on aircraft performance. Air, like other gases and liquids, is fluid. It flows and changes shape under pressure. Air is said to be “thin” at higher elevations. There are more air molecules per cubic foot at sea level feet than at 8,500 feet. As density altitude increases, air thins out and aircraft performance decreases. At lower elevations, the rotor blade is cutting through more dense air, which provides additional lift and increased performance.  There are three factors that affect density altitude in varying degrees; **atmospheric pressure, temperature**, and to some degree, humidity.   * If we change the pressure .10 inches, from 29.92 to 30.02 inches Hg (inches of mercury), we will have a density altitude change of 100 feet. Or if the change was an inch in Hg (29.92 to 30.02) that would equal approximately 1,000 feet.   F. Density Altitude Chart  Handout Density Altitude Chart. Have students input the altitude and temperature on their chart.  Density altitude affects the performance. Locate the pressure altitude of 6000 feet at a temperature of 25 degrees C.  The helicopter under these conditions will perform as through it were at 8,400 feet.  Density Altitude Affects Performance  High elevation, high temperature, and high moisture content all contribute to high density altitude conditions and lessen performance.  Performance is reduced because the thinner air at high density altitudes reduces blade efficiency.  This in turn requires additional pitch to maintain the same lift capability. The greater pitch angle results in increased drag that requires additional power. Unsupercharged piston engines and turbines also operate less efficiently in this less dense air.  **Density altitude is the biggest factor when you are hot, high and heavy, be alert!**  ii. Helicopter Load Calculations  Refer to the IHOG – Chapter 7: Helicopter Load Calculations and Manifests and Appendix A.  A. Load Calculation Form  One of the most important documents you will need to become familiar with is the Load Calculation Form.  For a helicopter to fly safely it is critical that you obtain an allowable payload from the Load Calculation form.  The AMD-67 and FS-5700-17 load calculation is required for all helicopter flights conducted on interagency fires and project work.  In addition, some agencies utilize the “load calc” to predict performance on all flights associated with both fire and non-fire helicopter missions.  Many accidents have happened that involved aircraft that were operating in conditions that were too high or too hot for the weight of the aircraft.  Hand out and review completed Interagency Helicopter Load Calculation Form.  B. Reading the Form  1. Header Information   * Aircraft model   Make and model   * N Number   Actual aircraft tail number   * Mission   General mission description   * Date/Time   When will the mission take place?   * Departure   Departure location, altitude and temperature   * Destination   Destination location, altitude and temperature  2. Helicopter equipped weight  Found in the weight and balance data in the flight manual.  3. Operating weight  Add lines 3, 4, and 5 together to obtain the “operating weight” of the helicopter. Use 7 lbs per gallon for fuel weight.  4. Computed gross weight  The pilot must go to the performance charts to obtain the “computed gross weight.”  This reduces the maximum weight allowed, down to the weight that the aircraft can be at the altitude and temperature it is taking off or landing, or conducting high power demand operations, like sling work.  5. Weight reduction (download)  This set amount of weight is taken off the computed weight.  In this way, whenever performance capability has dropped below the limitations of the aircraft, an extra “margin of safety” will be provided.  The amount of reduction for each model of aircraft is found in the contract.  After the weight reduction is subtracted from the computed gross weight, the “adjusted weight” is recorded in line 9.  6. Gross weight limit  A limitation to the operation of that aircraft, found in the flight manual, and never to be exceeded.  Here is an example of a maximum weight limitation for a “non-jettisonable load” for an A-Star B3.  For this model of helicopter, the non-jettisonable gross weight limitation is a “structural” limitation, not a limitation to the performance capability of the engine.  The jettisonable load maximum weight limitation, however, is the maximum weight that the aircraft can sustain in the air, and is the limit of its performance capability.  These limitations are entered into line 10 of the form.  Line 9 is your adjusted weight, having been through the “computation” of the performance charts, and with the down load subtracted, if appropriate.  Line 10 is the gross (total) weight limitation of the helicopter for that situation (jettisonable or non-jettisonable).  You must choose whichever is less:  Line 9 (adjusted weight) or line 10 (the limitation).   * Allowable Payload – This is the weight of passengers and cargo that can be carried for any mission. The allowable payload is the computed gross weight minus the weight reduction minus the operating weight. * Hover-in-ground-effect. Used at in-ground effect helispots with internal cargo or passengers. * Hover-out-of-ground-effect. Used at out-of-ground effect helispots or external loads that are not jettisonable.   Hover-out-of-ground-effect jettisonable. For external jettisonable loads only.  7. Final Blocks of Load Calculation Form   * Passengers and cargo   Only applicable if load calculation specific to mission   * Actual payload   Total weight of passengers and cargo   * Pilot signature   Pilot must sign for load calculation to be valid.   * Manager signature   Manager must sign for load calculation to be valid.   * HazMat   Must be identified on the load calculation if on aircraft.  III. helicopter perfoRmance  The helicopter has proven its value and versatility throughout the world. Its abilities to operate from restricted area and to remain above a selected spot are perhaps the helicopter’s greatest attributes. Managed by trained personnel and treated with proper respect, it is as inherently safe as any equipment in use today.  To properly manage helicopters for safe and efficient use, we must know something of their basic capabilities and limitations.  A. Basic Helicopter Design  1. Rotor Systems   * Single-Rotor Helicopter - The most common design uses a single main rotor which imparts lift and thrust, and a smaller tail rotor, which compensates for torque induced by the powered turning of the main rotor. * Dual-Rotor Helicopter – Some helicopters have dual main rotors, mounted in tandem or side-by-side.   Torque compensation is achieved by turning the rotors in opposite directions.  2. Helicopter Controls  There are four controls that are used in conjunction with each other when flying a helicopter.  a. Collective Pitch Control  This changes the angle of the pitch (of angle of attack) of each main rotor blade simultaneously.  As the pitch of the blades is increased, lift is created causing the helicopter to rise from the ground, hover or climb, as long as sufficient power is available.  b. Throttle Control  As the pitch is increased, power must be added to maintain rotor RPM when the helicopter lifts off or climbs. On the turbine-powered helicopters, this power coordination is accomplished automatically through the fuel control and governor systems of the turbine engine. A manual throttle control may be located on the collective or on the control panel.  c. Anti-Torque Control  Two anti-torque pedals are provided to counteract the torque effect of the main rotor. This is done by increasing or decreasing the thrust of the tail rotor.  The anti-torque pedals accomplish this by changing the pitch (angle of attack) or the tail rotor blades.  Pedal action will provide heading and directional control in hover and at low airspeeds.  On dual rotor helicopters, the problem of torque control is solved through the counter-rotation of the main rotor system. Pedal movement induces pitch changes to the main rotor blades, thereby accomplishing heading and directional control in a hover.  As forward speed increases, the tail rotor becomes less necessary. The “slip-streaming” effect of the fuselage provides enough surface contact with the relative wind to counteract the torque of the main rotor.  d. Cyclic Control  The “cyclic” is controlled by the pilot’s right hand. The purpose of the cyclic pitch control is to vary the amount of lift in the portion of the rotor disk. The aircraft moves in the direction that pressure is applied to the cyclic.  If the pilot moves the cyclic forward, the lift in the rear half of the rotor disk is increased, and the aircraft moves forward.  3. Landing Gear   * Skids – Skids are the most common type of landing gear used in light and medium-class helicopters. * Wheels – Wheels are primarily used on medium and heavy helicopters. * Floats – Floats can be used on land as well as water. There are two types; fixed or inflated. “Pop Outs” are inflated only as needed.   B. Helicopter Loading  Talk about the importance of maintaining center of gravity for auto-rotations and slope landings.  1. Center-of-Gravity Effects   * Consideration of center-of –gravity (CG) limitations is important in the loading of all aircraft, but is particularly important and critical in helicopters.   In a helicopter, it is carried under a single point, like a pendulum; therefore, very little “out of CT” loading can greatly affect the controllability of the helicopter.   * The CG point of most helicopters is an imaginary line extending from the rotor hub through to the cargo hook and extended straight below if an external load is attached. * Always consult pilot about proper loading. Try to keep load centered.   It is also important to properly secure all materials loaded on or in a helicopter, as a shift in cargo could affect CG.  2. Floor Loading  Careful attention must be given to small, heavy parcels loaded into helicopters to determine that the maximum pounds-per-square-inch limitations are not exceeded. Small, object can punch holes in flooring or collapse decking and supporting stringer.  Review Unit Objectives.  Hand out unit quiz. Correct quiz as a class. | Slide 5-1  Slide 5-2  Slide 5-3  Video  Slide 5-4  Slide 5-5  Slide 5-6  Slide 5-7  Slide 5-8  Slide 5-9  Slide 5-10  Slide 5-11  Slide 5-12  Slide 5-13  Slide 5-14  Slide 5-15  Slide 5-16  Slide 5-17  Slide 5-18  Slide 5-19  Slide 5-20  Slide 5-21  HO-5-1  Slide 5-22  Slide 5-23  Slide 5-24  Slide 5-25  Slide 5-26  Slide 5-27  Slide 5-28  Slide 5-29  HO-5-2  Slide 5-30  Slide 5-31  Slide 5-32  Slide 5-33  Slide 5-34  Slide 5-35  Slide 5-36  Slide 5-37  Slide 5-38  Slide 5-39  Slide 5-40  Slide 5-41  Slide 5-42  Slide 5-43  Slide 5-44  Slide 5-45  Slide 5-46  Slide 5-47  Slide 5-48  Slide 5-49  Slide 5-50  HO-5-3 |