PRIVATE PILOT
I. AREA OF OPERATION: PREFLIGHT PREPARATION
F. TASK: PERFORMANCE AND LIMITATIONS

OBJECTIVE
To determine that the applicant:
1. Exhibits knowledge of the elements related to performance and limitations by explaining the use of charts, tables, and data to determine performance and the adverse effects of exceeding limitations.
2. Computes weight and balance. Determines if the computed weight and center of gravity are within the airplane's operating envelope and if the weight and center of gravity will remain within the operating envelope during all phases of flight.
3. Demonstrates use of appropriate performance charts, tables and data.
4. Describes the effects of atmospheric conditions on the airplane's performance.

ELEMENTS
1. The Performance section of the POH / AFM contains operational data pertaining to takeoff, climb, range, endurance, descent and landing performance for a range of conditions.
2. Some manufactures use data tables, others use graphical data.
3. At sea level, the average pressure exerted by the atmosphere is approximately 14.7 PSI (pounds per square inch).
4. International Standard Atmosphere (ISA):
    a. Sea level temperature = 15°C (59°F) with a 2°C (3.5°C) per 1000' standard lapse rate.
    b. Sea level pressure = 29.92" Hg (1013.2 millibars) with a 1" Hg (33.9 millibars) per 1000' standard lapse rate.
5. Adjustments for non-standard conditions are found in the POH / AFM data.
6. Pressure altitude (PA) is determined by:
    a. Setting the altimeter to 29.92" Hg., or
    b. Applying the lapse rate to the reported altimeter setting.
7. Water vapor is lighter than air, so moist air is lighter, and density ↓, DA ↑, performance ↓.
8. Density altitude (DA) = PA corrected for non-standard temperature (use flight computer).
    a. Temp ↑, density ↓, DA ↑, performance ↓.
    b. Temp ↓, density ↑, DA ↓, performance ↑.
9. At lower pressure (higher DA), the air becomes less dense (use POH / AFM data):
    a. Power is reduced because the engine takes in less air to mix with the fuel.
    b. Thrust is reduced because the propeller is less efficient in thin air.
    c. Lift is reduced because the thin air exerts less force on the airfoils.
10. In straight-and-level unaccelerated flight, lift equals weight (L=W) and thrust equals drag (T=D).
11. Total drag = induced drag (from wing lift) and parasite drag (everything but wings).
    a. High speed results in mostly parasite drag, low speed results in mostly induced drag.
    b. Minimum total drag results when induced drag and parasite drag are equal.
12. V_X (max angle of climb) is also the speed that maximizes excess thrust available.
13. V_Y (max rate of climb) is also the speed that maximizes excess power available.
14. At the absolute ceiling, $V_X = V_Y$ and produces zero feet per minute rate-of-climb.
15. Weight ↑, required lift ↑, required angle of attack ↑, drag ↑, required power ↑.
16. Power loading = total weight / total horsepower. Affects takeoff and climb capabilities.
17. Wing loading = total weight / wing area. Affects landing speed.
18. Ground effect is due to the interference of the surface with the flow pattern around the airplane.
    a. Reduces the amount of induced drag by reducing wingtip vortices.
    b. Affects flight within approximately one wing span of the surface (flare and touchdown).
19. Maximum range (distance) results from maximizing speed per fuel flow rate (also L/D max).
20. Maximum endurance (time) results from minimizing fuel flow rate.
21. Region of reverse command ("behind the power curve"):
    a. Airspeed below the best endurance airspeed.
    b. Higher airspeed requires less power and lower airspeed requires more power.
22. Runway surface and gradient (consult AF/D and POH / AFM for specifics):
    a. Runway gradient ↑: Retarding force ↑, time to accelerate to V_R ↑, takeoff distance ↑.
    b. Runway roughness ↑: Retarding force ↑, time to accelerate to V_R ↑, takeoff distance ↑.

23. Water reduces runway friction and produces hydroplaning dangers.
    a. Minimum initial dynamic hydroplaning speed = 9 x square root of tire pressure (in PSI).
    b. Once begun, dynamic hydroplaning can continue below the minimum initial dynamic hydroplaning speed.
24. Takeoff performance (consult AF/D and POH / AFM for specifics):
    a. Gross weight ↑: Mass to accelerate ↑, retarding force (friction) ↑, lift-off speed ↑.
    b. Headwind ↑: Groundspeed required ↓. Tailwind ↑: Groundspeed required ↑.
    c. Density altitude ↑: Engine power ↓, propeller efficiency ↓, takeoff speed required ↑.
25. Landing performance (consult AF/D and POH / AFM for specifics):
    a. Gross weight ↑: Landing speed ↑, mass to decelerate ↑, retarding force (inertia) ↑.
    b. Headwind ↑: Groundspeed required ↓. Tailwind ↑: Groundspeed required ↑.
    c. Density altitude ↑: Landing true airspeed required ↑ (indicated airspeed stays the same).
26. Performance speeds (consult POH / AFM for specifics):
    a. Indicated airspeed (IAS): Uncorrected speed observed on the airspeed indicator.
    b. Calibrated airspeed (CAS): IAS corrected for static port position and installation errors.
    c. Equivalent airspeed (EAS): CAS corrected for adiabatic compressible flow at altitude.
    d. True airspeed (TAS): Airspeed relative to undisturbed air, TAS = EAS($\rho_o/\rho)^{1/2}$.
    e. Groundspeed (GS): Airspeed relative to the surface of the earth.
    f. V_{SO}: Power-off stalling speed in the landing configuration.
    g. V_{S1}: Power-off stalling speed in a specified configuration (usually cruise).
    h. V_Y: Best rate-of-climb speed (unit of altitude per unit time).
    i. V_X: Best angle-of-climb speed (unit of altitude per unit of horizontal distance).
    j. V_{LE}: Maximum speed with landing gear extended.
    k. V_{LO}: Maximum speed for extending or retracting (operating) the landing gear.
    l. V_{FE}: Maximum speed with flaps extended.
    m. V_A: Design maneuvering speed. Maximum load limit can be imposed without damage.
    n. V_{NO}: Maximum structural cruising speed. Exceed only in smooth air.
    o. V_{NE}: Never exceed speed. Structural damage can occur even in smooth air.
27. Performance charts and tables (consult POH / AFM for specifics):
    a. Developed during flight tests with new airplanes.
    b. Requires interpolation for specific flight conditions.
    c. Density altitude charts: Find density altitude from airport elevation, outside air temperature (OAT) and altimeter setting (inches Hg).
    d. Takeoff distance charts: Find takeoff roll and distance over a 50' obstacle from pressure altitude, OAT, takeoff weight and headwind.
    e. Climb and cruise charts: Find climb and cruise performance from pressure altitude, OAT, cruise altitude, cruise OAT and power settings.
    f. Crosswind and headwind component chart: Find crosswind and headwind components from wind speed and direction.
    g. Landing distance charts: Find landing roll and distance over a 50' obstacle from pressure altitude, OAT, landing weight and headwind.
    h. Stall speed performance charts: Find adjusted stall speeds from power setting, flap setting, landing gear setting and angle of bank.

REFERENCES

1. AC 61-84, Role of Preflight Preparation.
2. FAA-H-8083-1, Aircraft Weight and Balance Handbook.
3. AC 61-23 / FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge, Chapter 9.
4. POH / AFM, Pilot Operating Handbook / FAA-Approved Airplane Flight Manual.