AEE 427: Aircraft Performance and Dynamics
Fall 2015 Learning Objectives

General

1. Be able to work with both metric and English units systems, and to switch between the two.
2. Use Matlab to solve single-equation problems or numerical integration problems.

Flight simulator lab

3. Name the six main cockpit instruments.
4. Be able to name at least three items from the pilot takeoff checklist.
5. Name the legs of the standard flight pattern.
6. Effectively use data output from the flight simulator to confirm theoretical values/curves (including but not limited to: thrust required; maximum velocity; service ceiling; V-n diagrams; stick-fixed neutral point).

Standard Atmosphere

7. Use Standard Atmosphere tables to find pressure, density, temperature at given altitude *on a standard day.*
8. Determine pressure, density, and temperature on a non-standard day given sufficient information.
9. Use Matlab to create a plot of the temperature, pressure, or density standard atmosphere using only the information of altitudes of the different atmospheric levels and relevant temperature lapse rates, and thermodynamic relations.
10. Calculate static pressure, total pressure, or dynamic pressure from sufficient given information.

Airspeeds

11. Describe in your own words the difference between true airspeed, equivalent airspeed, calibrated airspeed, indicated airspeed, and ground speed.
12. Given the form of the basic equation, be able to make the appropriate changes for true, equivalent, and calibrated airspeeds.
13. Have a feeling for relative magnitudes among true airspeed, equivalent airspeed, calibrated airspeed (ICE-T).
14. Given sufficient information, calculate the indicated airspeed from the true airspeed.
15. Given sufficient information, calculate the true airspeed from the airspeed indicated in the cockpit.

16. Know the definitions of pressure altitude, density altitude and temperature altitude, and be able to interpret given data in those formats for solving problems.

Aerodynamics review

17. Calculate Mach number from relevant information, and know to not use equations that require an incompressible assumption if not appropriate.
18. Calculate the lift curve slope of a realistic wing from the 2D NACA airfoil data.
19. Sketch how a lift curve will change for varying AR.
20. Calculate how L/D will change for varying aspect ratio.
21. List the different kinds of drag experienced by an aircraft and use them in the equations properly.
22. Calculate stall velocity.
23. Explain in your own words what the stall velocity is.
24. Describe what wingtip vortices are, how they form, and the effect they have on aircraft lift and drag.
25. Formulate and use the drag polar for given aircraft information.

Aircraft performance: thrust & power

26. Derive the equations for SLUF (know the assumptions and how they affect the unsimplified equations).
27. Recall and apply the SLUF assumptions in appropriate situations.
28. Calculate the thrust required to maintain SLUF at given airspeed and altitude.
29. Explain in words what happens as the far left ("back end") and far right of the thrust or power curves.
30. Describe in words what quantity determines rate of climb.
31. Calculate rate of climb from sufficient information.
32. Describe in words what the service ceiling and the absolute ceiling are (making sure you're careful about units...).
33. Calculate service ceiling and absolute ceiling from either given information, or from a set of power required/power available curves at different altitudes.
34. Describe in words and algebraic relations how thrust available and power available change with altitude.
35. Be able to sketch thrust and power curves (both required and available) for both propeller-driven and jet aircraft for different conditions (changes in altitude, absolute ceiling).
36. Use Matlab to calculate and plot thrust required/available and power required/available as a function of velocity.

Aircraft performance: range & endurance

37. Describe in words how to calculate range and endurance (*not* using approximate equations).
38. Describe in words how ground effect affects takeoff and landing distances.
39. Approximate takeoff and landing distances given the relevant equations.
40. Describe in words how to calculate range and endurance (*not* using approximate equations).
41. Approximate range and endurance for either propeller-driven or jet aircraft given the relevant equations.
42. Be able to estimate how much fuel (in mass) is needed to travel a certain distance in SLUF.
43. Utilize the concept that $(C_L/C_D)^n$ for n=1, 1/2, or 3/2 correspond to maxima (or minima) for T_R, P_R, endurance, and range, and also relate to expressions between $C_{D,0}$ and $C_{D,i}$.
44. Calculate maximum glide distance.

Aircraft performance: Maneuver performance

45. Calculate load factor, turning rate, and turn radius.
46. Describe in words how turning rate and radius are maximized or minimized in terms of load factor and C_L.
47. Use Matlab to numerically integrate quantities along an aircraft's travel. Estimate quantities such as endurance, range, takeoff distance, and landing distance.

Aircraft dynamics: the basics

48. Draw the aircraft body coordinate system correctly.
49. Name and describe the three aircraft forces and three aircraft moments.
50. Given the name (or description), write down the symbol for a given force or moment coefficient. Given the force or moment coefficient symbol, describe in words what the force or moment is.
51. Recall and explain in words the letters and symbols for forces, moments, velocities, angular velocities, and Euler angles.

Aircraft dynamics: longitudinal static stability

52. Draw a C_m vs. α curve that is representatitive of a statically stable and properly trimmed aircraft.
53. Identify the two restrictions on a curve of C_m vs. α for statically stable, properly trimmed aircraft.

54. Explain in words why the slope of the C_m vs. α curve should be (positive or negative) for static stability.
55. Explain in words why C_{m_0} should be (positive or negative).
56. Describe whether the wing has a stabilizing or destabilizing effect on aircraft pitch stability, depending on the location of the aerodynamic center relative to the aircraft center of gravity.
57. Properly non-dimensionalize the moment contributions from each aircraft component.
58. Name the three aircraft control surfaces, and be able to describe in words the direction of deflection that will create positive moments.
59. Explain in words what happens when the center of gravity is too far forward or too far back.
60. Define the stick-fixed neutral point in words.
61. Given sufficient information, calculate the stick-fixed neutral point.

Aircraft dynamics: effect of control surfaces

62. Given sufficient information, calculate elevator effectiveness.
63. Use the flap effectiveness parameter figure (Nelson 2.21) correctly.
64. Properly size an elevator to create sufficient pitch moment for a given scenario.
65. Calculate the sufficient elevator deflection to create sufficient pitch moment for a given scenario (such as trim).
66. Given one C_m vs. α curve, properly sketch the related curves for a positive and negative elevator deflection.
67. Name the three aircraft control surfaces.
68. Name the motion that each control surface controls.
69. Write down the symbol for each control surface deflection.
70. Be able to describe how each control surface deflects for a positive angle of deflection, and the effect that deflection has on aircraft motion.
71. Describe in words how you, as a pilot in the cockpit, create positive deflections of each of the control surfaces.

Aircraft dynamics: lateral static stability

72. Draw representative curves of C_n and C_l for a statically stable aircraft about all three axes.
73. Describe in words why the slopes of C_n vs. β and C_l vs. β should be either positive or negative for static stability.
74. Describe in words the sideslip angle β and be able to implement it correctly (for example: in what direction does the aircraft turn for a positive sideslip angle?)

75. Correctly non-dimensionalize the yawing and rolling moments to obtain C_n and C_l.

76. Given sufficient information, calculate the contribution of the vertical tail to directional stability.

77. Given sufficient information, calculate the rudder control power.

78. Describe in words the effect of dihedral and high vs. low wings on roll stability.

79. Given sufficient information, calculate the aileron control power.

Aircraft dynamics: general static stability

80. Given sufficient information, design a control surface sufficient to create enough moment for a given scenario.

81. Given which factors contribute to a moment or force coefficient, write down general expression for that moment coefficient. (For example, given that side force depends on sideslip angle, aileron deflection, and rudder deflection, write down $C_y = C_{y_0} + C_{y_\beta}\beta + C_{y_{\delta_a}}\delta_a + C_{y_{\delta_r}}\delta_r$.)

82. Use the tables in Chapter 3 and given aircraft data to estimate stability derivatives.

83. Use the tables in Chapter 3 and given aircraft data to estimate stability coefficients.

84. For the stability derivatives discussed in Chapter 3, explain in words how they are estimated.

Aircraft dynamics: deriving the equations of motion

85. Use the tables and equations in Chapter 3 to write Newton's 2nd law for an aircraft.

86. Be able to describe in words what information is contained in the magnitude (and sign) of a (general) stability derivative.

87. For a given stability derivative or stability coefficient, explain in words what it represents.

88. For a given description, write the appropriate stability derivative or stability coefficient.

89. Given the equations of motion:

    (a) Be able to briefly describe the steps that were taken to derive it.

    (b) Be able to explain what each moment/force is affected by in terms of state variables or control inputs.

    (c) Be able to identify which terms are stability derivatives, the states (or dynamic variables), and the control inputs.

Aircraft dynamics: aircraft dynamic response

90. Given a set of matrix eigenvalues, be able to comment on whether the dynamic response of the system is stable or unstable, oscillating or non-oscillating.
91. For a given set of differential equations, write down the state-space representation.
92. For a given system, calculate the characteristics of the dynamic response (e.g. motion period, time to half-amplitude, damping ratio, etc.)
93. Given a list of all the stability derivatives of an aircraft, use MATLAB to simulate the aircraft dynamic response to a step input of elevator angle.
94. Given the full lateral equations of motion, be able to put them into state space form.
95. Given a list of all the stability derivatives of an aircraft, use MATLAB to simulate the aircraft dynamic response to a step input of aileron or rudder angle.
96. Given a list of all the stability derivatives of an aircraft, use MATLAB to simulate the aircraft dynamic response to a non-zero initial condition.

Aircraft dynamics: longitudinal & lateral approximations

97. Name and physically describe the two approximations of longitudinal motion.
98. Name and physically describe the three approximations of lateral motion.
99. Given the relevant assumptions and moment dependencies, be able to derive the equation of motions for pure pitching, yawing, and rolling motion.