ASE 167M Final "Quiz" Spring 1999

1. (18 pts.) An aircraft is flying straight and level at a constant true airspeed of 180 ft/sec and at a 7 degree angle of attack. The pilot then executes a 0.8 g coordinated turn while maintaining the initial airspeed and altitude for 20 seconds. After the turn the aircraft resumes straight and level flight at the initial airspeed and angle of attack.

- What are the flight path ($\gamma$) and sideslip angles ($\beta$) during the turn?
- During the turn, calculate the bank angle ($\mu$), turn rate ($\chi$), and turn radius ($r$). ($g = 32.2 \text{ft/sec}^2$)
- Give a sequence of Euler angle rotations ($\phi$, $\psi$, and $\theta$) (not necessarily in that order) that describes the vehicle attitude the moment after the aircraft exits the turn, relative to the vehicle attitude the moment before it enters the turn. Neglect the time it takes for the aircraft to transition into and out of the turn.

2. (12 pts.) Derive an expression for pressure as a function of altitude in a region of the atmosphere where the temperature varies linearly with altitude. You are given the temperature ($T_0$), pressure ($P_0$), and density ($\rho_0$) at the lowest level of this region ($h_0$) as well as the lapse rate ($\beta$) for the region. The equation of state for a perfect gas is $P = \rho RT$.

3. (20 pts.) Data from a climb performance flight test yields the following relationship between rate of climb and airspeed: (units in ft/sec)

$$\dot{h}(V) = 34 + .36V + 0.0046V^2$$  \hspace{1cm} (1)

- Calculate the velocity for max rate of climb, $V_{h_{\text{max}}}$
- Calculate the steepest flight path angle, $\gamma_{\text{max}}$

4. (20 pts.) An aircraft is flying at a constant velocity expressed in the local horizontal reference frame as (units in ft/sec):

$$\mathbf{V}^h = 185\dot{i}_h + 20\dot{j}_h + 25\dot{k}_h$$  \hspace{1cm} (2)

A mounted gyroscope indicates a pitch attitude of 15 degrees.
• Sketch a diagram of the flight path angle $\gamma$, angle of attack $\alpha$, and pitch angle $\theta$ of the aircraft including the body and local horizontal reference frames.

• Calculate the flight path angle $\gamma$ and the heading angle $\chi$.

• What is the velocity of the aircraft expressed in the wind axis system?

5. (20 pts.) Recall the development of the aircraft level flight envelope.

• What 5 limiting velocities were used to create the envelope?

• Discuss the physical reasoning that motivates the calculation of each of these limits.

6. (10 pts.) For the next five statements, answer either "True", "False", or "Uncertain". You need not justify your answer.

• The pitch attitude angle equals the sum of the angle of attack and flight path angle.

• Maximum range for gliding flight occurs when lift-to-drag ratio is maximum.

• Trailing edge stall occurs suddenly on one wing then the other.

• The instruments of an aircraft are not sensitive to changes in the atmosphere from meteorological events.

• Transformation matrices between two coordinate systems are independent of the order of rotation.

7. (Bonus 7 pts.) What modifications would you suggest to your supervisor if only the (3,3) element of your 3x3 sizing matrix returned an aircraft which meets your power and takeoff distance design constraints?