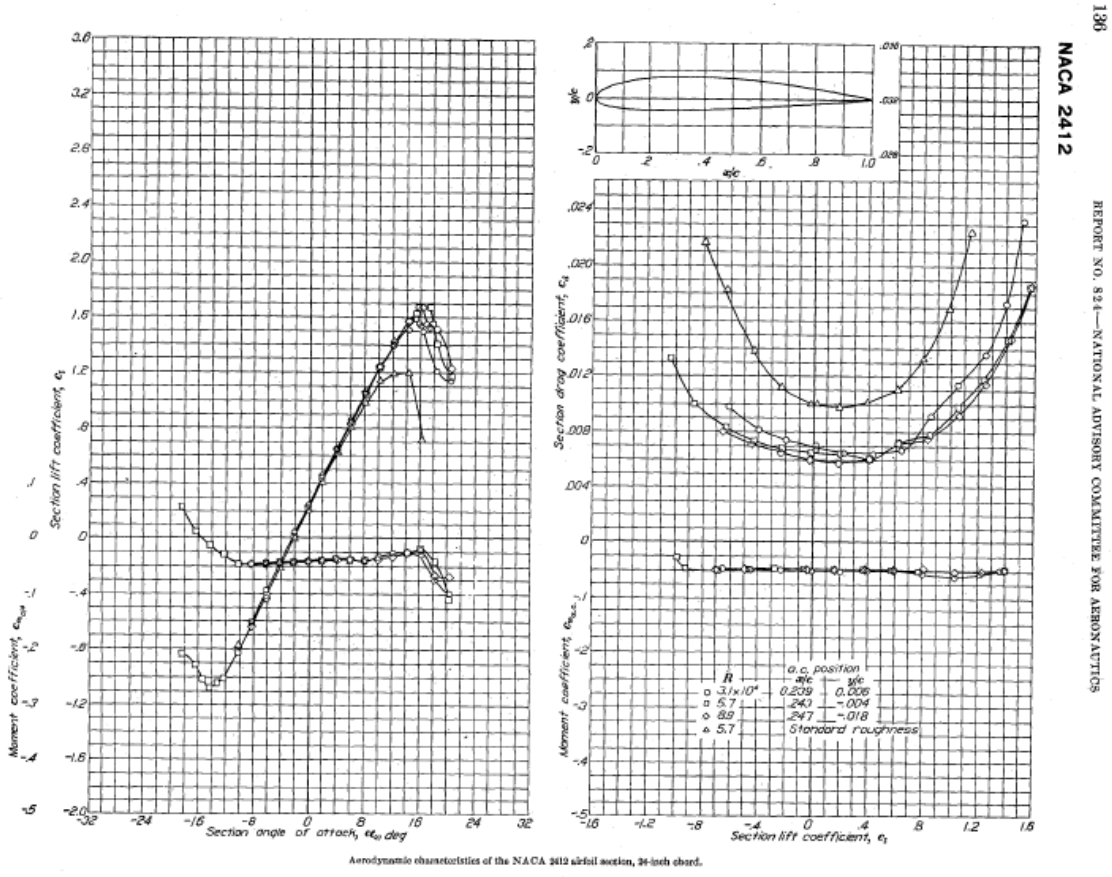
Homework #2

Due: Friday 01/30/2015
(4 problems worth 20 points)

1. [5 points] Anderson, Problem 1.4

2. [5 points] Consider an NACA 2412 airfoil. The numbering system for NACA airfoils as explained in Anderson, Ch. 4 or on page 4 of Abbott and Von Doenhoff, "Summary of Airfoil Data", NACA Report 824
http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19930090976_1993090976.pdf
a) Describe the airfoil geometry, e.g. the maximum camber and its location and the airfoil thickness.
b) The following graphs from Abbott & Von Doenhoff (page 136) present the lift, drag and the moment coefficient about the quarter chord for this airfoil, as a function of angle of attack. Calculate and plot the variation of x_{cp}/c as a function of angle of attack.



Aerodynamic characteristics of the NACA 2412 airfoil section, 24-inch chord.

3. [5 points] Consider two solid spheres that are dropped in air at standard atmospheric conditions at sea level. The first sphere is 2.00 mm in diameter and is made of a material with density ρ_1 = 9 g/cm^3. The second sphere is 3.00 mm in diameter and is made of a lighter material, such that its mass is the same as the first sphere. Find the terminal velocity for each sphere by balancing the gravitational force and the drag force. For

gravity assume g = 9.81 m/s^2. To compute the drag use the graph on page 11 in Reference Figures, Tables and Equations (333_tables.pdf) on piazza/Resources/Lecture Notes, which gives the drag coefficient as a function of the Reynolds number. Discuss your results.

4. [5 points] The Orion Multi-Purpose Crew Vehicle (MPCV) will replace the Space Shuttle as America's manned spacecraft. Orion MPCV is being designed to make water landings in case of inflight aborts. The Orion crew module (CM), therefore, needs to be able to survive the impact with the ocean. The upward force F on the CM upon water impact can be represented as a function of water entry velocity V, the CM nose diameter D, water density ρ, viscosity μ and acceleration of gravity g:

$$F = f(V, D, \rho, \mu, g)$$

a) Use the Buckingham Pi theorem to show that the force coefficient of water impact,

$$C_F = \frac{F}{\rho V^2 D^2}$$

depends on two non-dimensional parameters: the Froude number,

$$Fr = \frac{V}{\sqrt{Dg}}$$

and the Reynolds number,

$$\mathrm{Re} = \frac{\rho D V}{\mu}$$

b) A ¼ scale model of the Orion CM is being tested at a water impact testing facility. It has been found that the force coefficient is mainly determined by the Froude number and has little sensitivity to the Reynolds number. If the maximum design velocity of CM water landing is 30 ft/s what should be the maximum velocity at which the ¼ scale model is tested?

A model of Apollo Command Module being tested at the Langley Impacting Structures Facility. Source: NASA, http://www.youtube.com/watch?v=oUR8o6xehm8

Read about NASA's progress on Orion MPCV development at http://www.nasa.gov/exploration/systems/mpcv/index.html

Quote of the week:

"We must use time wisely and forever realize that the time is always ripe to do right."
Nelson Mendela, 1918 – 2013