GATE Aerospace Engineering
Aerodynamics-Assignment -2
Incompressible flows- Airfoils

1. A thin aerofoil has a camber line defined by the relation $y_c = k c\, \xi\, (\xi - 1)(\xi - 2)$. Show that if the maximum camber is 2% of chord then k = 0.052. Determine the coefficients of lift and pitching moment, i.e. C_L and $C_{M1/4}$, at 3^o incidence.
2. Use thin- aerofoil theory to estimate the coefficient of lift at zero incidence and the pitching-moment coefficient $C_{M1/4}$ for a NACA 8210 wing section.
3. A thin aerofoil has a circular-arc camber line with a maximum camber of 0.025 chord. Determine the theoretical pitching-moment Coefficient $C_{M1/4}$ and indicate methods by which this could be reduced without changing maximum camber. The camber line may be approximated by the expression. $y_c = k_c[\frac{1}{4} - \left(\frac{x'}{c}\right)^2]$ where $x' = x - 0.5c$.
4. Find the a) coefficient of pressure at the mid-chord of the bi-convex aerofoil at zero incidence.
   b) coefficient of pressure at the trailing edge
$$\frac{y_t}{c} = \frac{t}{2c}[1 - \left(\frac{2x}{c}\right)^2]$$
5. The mean camber line of a thin airfoil is given by $z = \frac{0.21x^2(x-c)}{c^3}$ where c is the chord. Calculate the angle of zero lift when the airfoil is at small angle of attack.
6. An undersea vessel has hull diameter of 12 meters. Wings extending 12 meters from the hull on each side have a chord of 8 meters. What is the aspect ratio of the resulting wing?
7. The NACA 23012 airfoil has a theoretical lift co efficient of 0.3, has a maximum camber at 15 % of chord, and has a maximum thickness of 0.12c, where c is chord. The equation for the mean camber line is:
$$\frac{z}{c} = 2.6291[\left(\frac{x}{c}\right)^3 - 0.6075\left(\frac{x}{c}\right)^2 + 0.1147\left(\frac{x}{c}\right)]$$
For the region $0.0c \le x \le 0.2025c$ and
$$\frac{z}{c} = 0.022083[1 - \left(\frac{x}{c}\right)]$$
For the region $0.2025c \le x \le 1.0000c$ and
For this airfoil calculate the following
a. C_l b. α_0
8. Consider an airplane that weighs 14,700N and cruise in level flight at 300km/hr at an altitude of 3km. the wing has a surface area of 17m^2 and the AR=6.2. Assume that lift coefficient is linear function of angle of attack and that $\alpha_{0 = -1.2\text{ deg}}$, if load distribution is elliptic calculate value of circulation and induced drag coefficient.
9. A Cessna 172 is cruising at 1000ft on a standard day (ρ = 0.001756slugs/ft^3) at 130 mi/hr. if the airplane weighs 2300lb, what C_L is required to maintain level fligh? A Cessna 172 has a wing span of 36ft and an aspect ratio of 7.3.
10. The mean camber line of thin airfoil is given by
$$\frac{y}{c} = -k\,\{a + b\left(\frac{x}{c}\right) + d\left(\frac{x}{c}\right)^2$$
Where c=chord and k,a,b and d are assumed known real constants. Find the C_L value

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