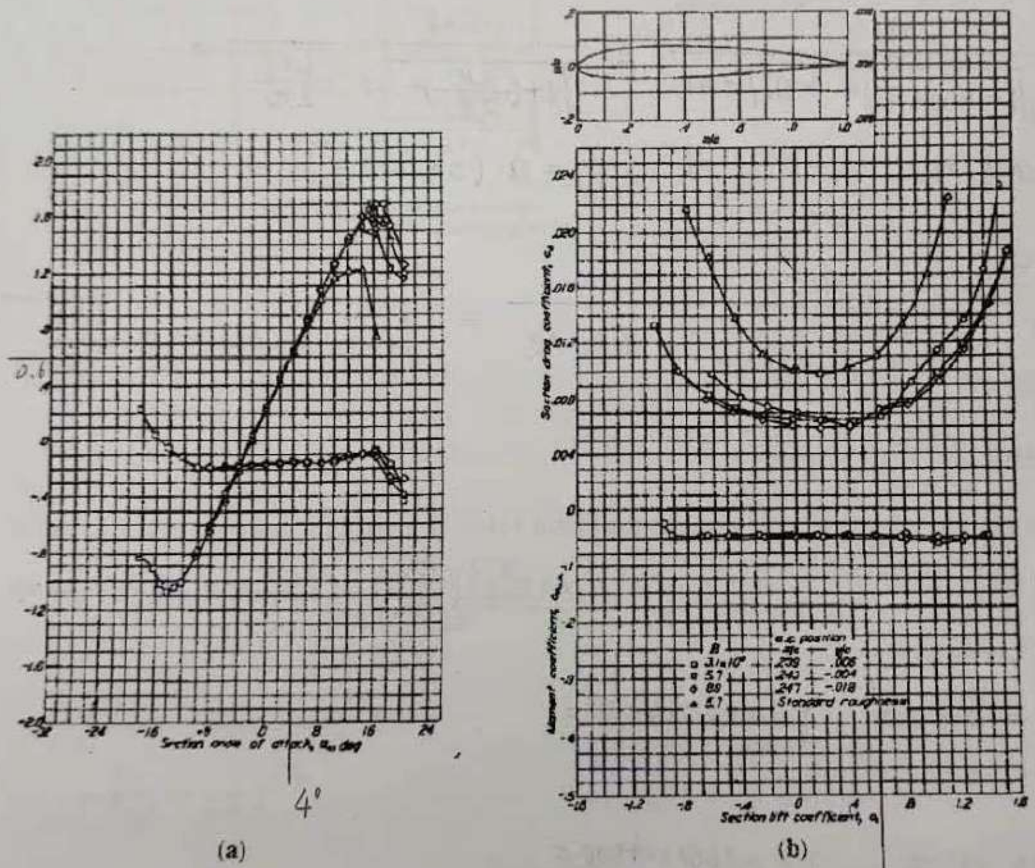
期中考试大题和此试卷类似，多了5个简答题，考察翼型命名、坐标系、SFC/TSFC等概念

MAE 312 Aircraft Flight Dynamics

Tutorial

Q1. Consider an NACA 2412 airfoil (data given in Figure below) with chord of 1.5 m at an angle of attack of 4°. For a free-stream velocity of 30 m/s at standard sea-level conditions, calculate the lift and drag per unit span. *Note*: The viscosity coefficient at standard sea-level conditions is 1.7894×10^{-5} $kg/(m\cdot s)$.



先确定 Re.

Figure 1: Data for the NACA 2412 airfoil. **(a)** Lift coefficient and moment coefficient about the quarter-chord versus angle of attack. **(b)** Drag coefficient and moment coefficient about the aerodynamic center as a function of the lift coefficient. (From Abbott and von Doenhoff, Ref. 19.)

解:

$C_l = \frac{L'}{q_\infty C}$, $L' = C_l \cdot q_\infty C$

$= C_l \cdot \frac{1}{2}\rho_\infty V_\infty^2 \cdot C$

$Cd = \frac{D'}{q_\infty C}$, $D' = Cd\, q_\infty \cdot C$

$= Cd \cdot \frac{1}{2}\rho_\infty V_\infty^2 \cdot C$

由图, at AoA = 4°

$C_l = 0.6$

由图, $Cd =$

$Re = \frac{\rho_\infty V_\infty C}{\mu_\infty} = \frac{\quad \times 30 \times 1.5}{1.7894\times10^{-5}} =$

$\therefore L' =$

$D' =$

Q2. Consider a finite wing of aspect ratio 2 with an NACA 2412 airfoil, the angle of attack is 5°. Calculate: (*a*) the lift coefficient at low speeds (incompressible flow) using the [Helmbold's equation] and (*b*) the lift coefficient for $M_0 = 0.7$.

~~a_0 A degree~~

解: $AR = 2 = \frac{b^2}{A}$ ~~$a_0 = 0.105/°$~~

a) $$a = \frac{a_0}{\sqrt{1+(a_0/\pi AR)^2} + a_0/\pi AR} = \frac{6.02}{\sqrt{1+(\frac{6.02}{2\pi})^2} + \frac{6.02}{2\pi}} =$$

Since NACA 2412, $a_0 = 6.02\ rad^{-1}$, $\alpha_{L=0} = -2.2°$, $C_L = a\cdot(5+2.2)\frac{\pi}{180} =$

b) subsonic

$$a_{comp} = \frac{a_0}{\sqrt{1-M_\infty^2+(a_0/\pi AR)^2} + a_0/\pi AR} = \frac{6.02}{\sqrt{1-0.7^2+(\frac{6.02}{2\pi})^2} + \frac{6.02}{2\pi}} =$$

$$C_L = a_{comp}\,(5+2.2)\frac{\pi}{180} =$$

Q3. The thrust of a turbofan engine decreases as the flight velocity increases. The maximum thrust of the Rolls-Royce RB21 l turbofan at zero velocity at sea level is 4500 *lb*. Calculate the thrust at an altitude of 6 km at Mach 0.6.

解: $\frac{T_{cruise}}{T_{V=0}} = 0.325$, $T_{cruise} = 0.325 \times 4500 =$

$\frac{T_{climb}}{T_{V=0}} = 0.35625$, $T_{climb} = 0.35625 \times 4500 =$

$M > 0.4$ $\frac{T}{T_{V=0}} = A\cdot M_\infty^{-n}$

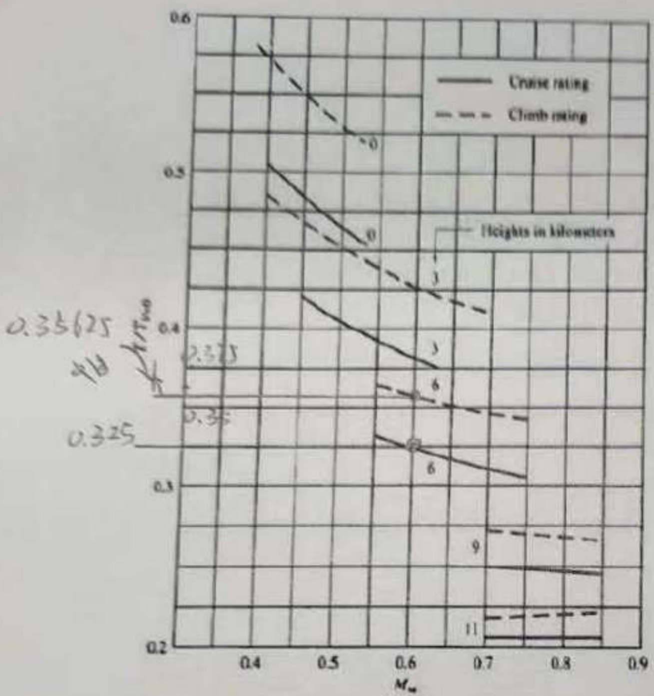


Figure 2: Variation of maximum thrust with Mach number and altitude for the Rolls-Royce RB211-535E4 turbofan. Note that $T_{V=0}$ is the thrust at zero velocity at sea level.

P175

$\frac{0.25}{4} = 0.06 = 0.0625$

$\frac{0.0625}{0.35}$ / 125

$0.35 + 0.00625$

$\frac{0.025}{4} = 0.00625$

$V=0$

Q4. The Allison T56 turboprop engine is rated at equivalent shaft horsepower at zero velocity at sea level. Consider an airplane with this engine at 600 *ft/s* at sea level. The jet thrust is 350 *lb* and the efficiency is 0.85. Calculate the equivalent shaft horsepower at this flight condition.

解： $\eta = 0.85$ $\quad \frac{ft \cdot lb}{s}$ $\quad P_{es} = P_{as} + \frac{T V_\infty}{\eta_{pr}}$

$$P = \frac{T V_\infty}{\eta_{pr}} = \frac{350 \times 600}{0.85} \left(\frac{ft \cdot lb}{s}\right) \quad ?$$

推导一下.

$P = (T_p + T_j) V_\infty$?

$$P_{es} = P_s + \frac{T_j V_\infty}{\eta_{pr}}$$

$$\begin{cases} P_A = T V_\infty \\ \frac{P_A}{P_{A,0}} = \left(\frac{\rho}{\rho_0}\right)^{0.7} \end{cases}$$

Q5. The specific fuel consumption (SFC) for the Teledyne Continental Voyager 200 liquid-cooled reciprocating engine is 0.375 *lb/(bhp·h)*. When installed in an airplane which is flying at 220 *mi/h* with a propeller efficiency of 0.8, calculate the thrust specific fuel consumption.

解： $SFC = 0.375$

$$TSFC = SFC \cdot \frac{V_\infty}{\eta_{pr}} = 0.375 \times \frac{220}{0.8} \left[\frac{lb \cdot mi}{bhp \cdot h^2}\right]$$

Q6. A turbofan engine on a test stand in the laboratory operates continuously at a thrust level of 50,000 lb with a thrust specific fuel consumption of 0.5/*h*. The fuel reservoir feeding the engine holds 1,000 gal of jet fuel. If the reservoir is full at the beginning of the test, how long can the engine run before the fuel reservoir is empty? *Note:* Density of the jet fuel is 6.7 *lb*/*gal*.

解：

$T = 50000\ lb$

$TSFC = 0.5\ /h$

$$TSFC = \frac{\dot{W}}{T}$$

$$\dot{W} = T \cdot TSFC$$
$$= 50000 \times 0.5 = 25000\ lb/h$$

$$t = \frac{W}{\dot{W}} = \frac{6.7 \times 1000}{25000} = \frac{6.7}{25}\ h$$