SESA3029 Aerothermodynamics

2018-19 Examination Feedback

Q1. (i) Throat 317 kPa, 1000K, exit 41 kPa, 558K. (ii) This is a straightforward oblique shock problem, just posed in a different order. From the P_{atm}/P_{exit} (i.e. the pressure jump across the shock) you can find the normal Mach number. Hence $\beta=\sin^{-1}(Mn1/M1)=38.7$ deg and then the change in flow direction from OSC is 15.5 deg. (iii) Over-expanded is shown. The two variants would be a regular crossing of the shock or a Mach reflection at the centreline, followed by expansion fans reflecting from the jet edges.(iv) P_{1U}=70 kPa, P_{2U}=38.7 kPa, P_{1L}=118 kPa, P_{2L}=70.7 kPa, F_x=3.4 kN/m, F_y=40.0 kN/m (v) we expect the actual lift to be close to the P-G and Ackeret results for M<<1 and M>>1 respectively, but remain finite in between (whereas the theories blow up at M=1).

Q2. (i) Standard proof. Some students proved (unnecessarily) the eigenvalues of the wave equation; some students proved the Prandtl-Glauert formula instead of Ackeret, including the corresponding potential equation, which had to score 0 marks. (ii) P_{1U}=70.0 kPa, P_{2U}=31.8 kPa, P_{1L}=108.0 kPa, P_{2L}=70.0 kPa. A frequent mistake was neglecting the angle of attack of the flow alpha. Many students did not evaluate the angle for P_{2L} correctly as 0.

Q3 (i) Standard proof. (ii) Many students included a lot of unnecessary calculations here. You only need to calculate θ_{max}=10.36 and the values of 2 Riemann invariants (constant along the line 0-1-2-4 equal to 10.36 deg and along 0-2-3-5 equal to 20.72 deg). Then you can fill in the table directly, with only two visits to IFT needed to find all the remaining Mach numbers (you should get M_1=1.44, $M_2=M_4$=1.62, $M_3=M_5$=1.8. (iii) Standard geometry calculations x_1=0.98 (based on α_{01}=-45.7 deg) x_2= 1.20, y_2=0.21 (based on α_{AP}=43.64, α_{BP}=-33.28.

Q4. (i) Reynolds analogy gives Nu as a function of Re and Pr. (ii) h=-271.4 W/(m^2K) from the data given and then qdot=122 kW/m^2 for the changed temperature. (iii) Re and Pr are constant so from (i) Nu must be the same. The reference length doubles, so h and qdot are halved giving qdot=47,500 W/m^2. Many students scored very well on (i) and (ii), but then lost time trying to solve (iii) by integrating a specific Nu-relation (typically laminar flat plate boundary layer at uniform wall temperature) elaborately over one or both of the given lengths.

Q5. (i) The two short derivations were completed by most students, however with significant variation in the number of steps. Using isentropic relations here is not permitted (shock!). (ii) Looks more complicated than it is. This only requires you to find the area ratio (either from the second column of the output A=2.28 or from line 33 of the code). Then (a) $0<p_b/p_0<0.4664$, (b) $0.9524<p_b/p_0<1$, (c) $0.4664<p_b/p_0<0.9524$ are simple calculations of p_{b3}, p_{b5} and p_{b6} following the example in lecture 2.7. (iii) The program is showing the design condition M_{exit}=2.34 with p_b/p_0=0.07479, which were the first values to obtain for (a) (see the last line of the output). A quick discussion about the importance of prescribing the pressure to simulate other cases than the design condition following arguments from lecture 6.3 was expected. Note that in the 1D case, there are only three waves.

NDS/RD

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