Aerothermodynamics 2017-18

Q1. Was straightforward and well answered. (i) $A/A^*=2.64$, $p_0=341.9$ kN/m^2, $T_0=360$ K, $\rho_0=3.31$ kg/m^3 (ii) upper: $p=14.3$ kN/m^2 $M=2.72$; lower: $p=28.1$ kN/m^2, $M=2.27$ based on shock angle 27.5 deg. (iii) Upper 13.3 kN/m^2, lower 26.7 KN/m^2.(iv) Max angle 30 deg. For higher angles it was acceptable to show either a detached bow shock (corresponding to a thick plate) or a curved shock and expansion fan arrangement (corresponding to an infinitely thin plate); (v) transonic: supercritical/flat top to reduce shock strength and hence wave drag, supersonic: thin, uncambered to reduce wave drag. Simple theory gives a diamond shape as optimum.

Q2. (i) Proof should be complete and include each mathematically non-trivial step for full marks. (ii) $Cp_0=-2.48$. Many students lost marks because instead of including the derivation of the critical Mach number relation, they applied a memorised version of the equation, unfortunately often slightly incorrect or incomplete.

Q3. Lots of good answers, including correct numbers from the calculation. (i) this should include Riemann invariant definitions and the connection to points 4 and 7. (ii) $M=2.26$, $\theta=16.35$, $x=2.19$ and $y=0.72$ (intermediate results would be $\mu=26.3$ deg, $\alpha_{AP}=40.8$ deg and $\alpha_{BP}=-8.1$ deg). A common error was to get points A and B the wrong way round.

Q4 (i) mean $h=25.6$ W/(m^{2}K) giving width 26cm. Some students tried to compute mean h without integrating over the plate length, which – as the relation is nonlinear– leads to very incorrect results. (ii) as per lecture material.

Q5 (i) This was repeated from last year since only a few students attempted. It was good to see a large number of correct derivations. (ii) Error ~ h^2 and best estimate of correct $M=4.46$. It was a surprise to see how many calculation schemes students devised to still obtain the correct final result. However, the procedure is based on Taylor series and when the ansatz wasn't correctly laid out, marks were reduced accordingly.

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