SESA3029 2022/23 Exam Feedback

The exam contained five questions, question 1 being weighted the highest (36 marks out of 100). The overall module average was 58%. Around 30% of students had marks of 70 or above (10% were above 80). 96% of students achieved the MEng module qualifying mark (25%).

Q1 (i) one mark each for shock and expansion waves, including at the trailing edge.

(ii) Oblique shock angle is 47 deg giving M2L=1.36 and p2L=33.0 kPa on lower surface. Upper surface front half is at freestream conditions, rear half follows and expansion with angle 20 deg, giving M2U=2.44 and P2U=6.4 kPa

(iii) Moment calculation caused quite a few problems $-[(33-20)*c^2/8+(33-6.4)*3c^2/8]$ is one way of doing it, giving -0.26kN

(iv) Ackeret gives p2L=30.3kPa and p2U=-0.55kPa. Comment was required on the negative pressure that illustrated the limitations of the linear theory, even though the moment of -0.29 KN was close to the exact (shock-expansion) solution.

(v) Not many students suggested repeating the process for another angle of attack and working out the change in CM divided by the change in CL, with the aerodynamic centre expected at the half chord under supersonic conditions.

Q2 (i) Standard proof. (ii) A better estimate would be 0.337 by linearly interpolating between 0.3 and 0.4 (you could follow the lecture method and compute the LHS and RHS values of the Cp equation). The actual solution is 0.328.

Q3 (i) Standard definitions and short proof using expansion fan and invariant properties. (ii) M=1.7 using nearest values in IFT. Flow angle is 5.9 deg, nu=17.7 deg. (iii) The Mach angles are 36 and 32 degrees, but what we want here are the characteristic line angles, so 41.9 deg (2-4) and 32 deg (3-5)

Q4 (i) The 20 cm x 20 cm block cross-section is discretized with a 5 x 5 finite difference grid. Boundary points have constant temperatures 300 K or 500 K. The 4 corner points are not necessary. Two symmetry axes lie in the centre and of the 4 unknown values, 1 lies in the centre of each quadrant (standard interior point), 3 on the symmetry axes. One can construct adiabatic boundary conditions for these 3 points or simply use the standard interior stencil extending into the other quadrants. Identifying identical values from symmetries will lead to the same algebraic relations.

(ii) Multiplying the stencil equations with $\Delta x^2=\Delta y^2$ leads to the simple linear system

$$\begin{pmatrix} -4 & 1 & 1 & 0 \\ 2 & -4 & 0 & 1 \\ 2 & 0 & -4 & 1 \\ 0 & 1 & 1 & -2 \end{pmatrix} \begin{pmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \end{pmatrix} = \begin{pmatrix} -800 \\ -500 \\ -300 \\ 0 \end{pmatrix}$$

With solutions $T_1=T_4=400$ K, $T_2=425$ K, $T_3=375$ K.

Q5 (i) Using standard heat exchanger equations gives a massflow rate on the hot side of 5.1818 ks/s engine oil.

(ii) Considering the available information and that it is 10 tubes, the Reynolds number in each tube is found to be 23243. Many students did not divide the oil mass flow by 10 and thereby arrived at a

10x larger Reynolds number. Using the Nusselt number for a turbulent pipe flow under heating yields h'=353.73 W/(m^2K).

(iii) From a log-mean averaged temperature of 79.896 K, one arrives at an individual tube area of 2.589 m^2, a tube length of 32.964m and a pass length 4.12m.