APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Scheme for Valuation/Answer Key

Scheme of evaluation (marks in brackets) and answers of problems/key

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: ME409

Course Name: COMPRESSIBLE FLUID FLOW

Max. Marks: 100 Duration: 3 Hours

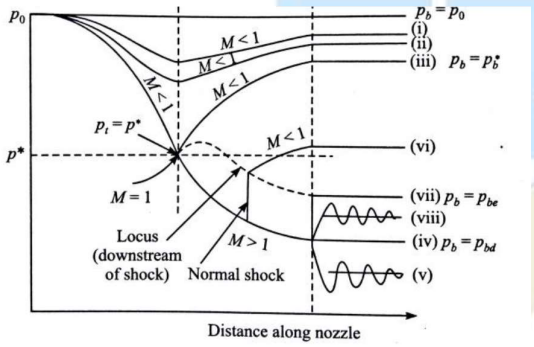
PART A

1 a) Newton's second law statement **2 marks**, figure **2 marks**, derivation intermediate steps **5 marks** and final expression **1 mark** (10)

2 a) Derivation **2 marks**, Four flow regimes on the ellipse – **2 marks** (4)

b) i. Velocity of sound at 400 K = 400.9 m/s (1mark) (6)
ii. Velocity of sound at stagnation condition = 438.98 m/s ~ 439 m/s (2marks)
iii. Reference Mach number = 1 (1mark)
iv. Maximum velocity of jet = 981.6 m/s (1mark)
v. Stagnation enthalpy ~ 482000 J/kg (1mark)

3 a) Behaviour at design pressure ratio **2 marks** and at lower value **2 marks**. (4)



b) Mach number at second section = 0.595 (2 marks) (6)

Area at the section where M is 1 = 251.57 x 10-6 m^2 (4 marks)

4 a) Explanation **4 marks**. (4)

b) Mass flow rate **2 marks**, area **1 mark**, pressure **1 mark**, temperature **1 mark** and velocity **1 mark.** (6)

PART B

Answer any three full questions, each carries 10 marks.

5 a) 2 parts – 2 marks each (4)

b) Assumptions **1 mark**, Governing equations – **2 marks**, Steps – **2 marks**, Final expression ($V_1V_2 = a^{*2}$)– **1 mark** (6)

6 a) Nozzle operates in design condition (10)
Mach number = 2.64 (2 Marks)
Velocity = 836.5 m/s (2 Marks)

Pressure= 4.74 x 10^4N/m^2 (1 Mark)
Condition of air in the duct if a normal shock occurs
Mach number = 0.325 (2 Marks)
Velocity = 157.8 m/s (2 Marks)
Pressure= 5.84 x 10^5 N/m^2 (1 Mark)

7 a) Figure - 2 Marks, Explanation -2 Marks (4)

b) Diameter of the duct = 22.66 cm (1 Mark) (6)

Length of duct = 309 m (1 Mark)

Pressure = 1.008 bar (1 Mark)

Temperature = 297.59 K (1 Mark)

Stagnation pressure loss = 2.31 bar (2 Marks)

8 a) Proof – 3 marks (3)

b) Maximum length of the duct = 38.48 cm (3 Marks) (7)

Condition of air at the exit

Pressure = 0.99 bar (2 Marks)

Temperature = 250 K (2 Marks)

PART C

Answer any four full questions, each carries 10 marks.

9 a) i) M_1= 0.25 , P_1= 4.9 bar , T_1= 378 K (2+2+2 = 6 marks) (10)

ii) Q = 1301.7 kJ/kg (4 marks)

iii) Q_{max} = 1315.82 kJ/kg (4 marks)

10 a) i) M_2 = 0.63 (3 marks) (10)

ii) P_2 = 0.397 MPa (2 marks)

iii) $P_{01} – P_{02}$ = 0.0427 MPa (2 marks)

iv) $s_2 – s_1$ = 0.4662 kJ/kg K (3 marks)

11 a) Correct derivation – (4 marks) (4)

b) (i) P_2 = 519.03 kPa (2 marks) (6)

(ii) T_2= 382.47 K (2 marks)

(iii) Q = 42.05 kJ/kg (2 marks)

12 a) Variation of density(interferometer)/density gradient(Schlieren)/change in density gradient(shadowgraph) may be given marks (4)
Figure and explanation (2+2 = 4 marks)

b) Adiabatic recovery factor (R) and correction factor (K) correct explanation (6)

(3+3 = 6marks)

Explanation:

The variation due to the transport phenomena in BL can be accommodated by defining, *adiabatic recovery factor*, R_f

$$R_f = \frac{T_{aw} - T}{T_o - T} = \frac{T\left(\frac{T_{aw}}{T} - 1\right)}{T\left(\frac{T_o}{T} - 1\right)}$$

$$\frac{T_{aw}}{T} = 1 + R_f\left(\frac{T_o}{T} - 1\right) = 1 + R_f\left(1 + \frac{\gamma - 1}{2}M^2 - 1\right) = 1 + R_f\frac{\gamma - 1}{2}M^2$$

The deviation of the actually measured T_o from the theoretical T_o can be represented by another **correction factor** , K

$K = \frac{T_p - T}{T_o - T}$ where Tp is the temperature measured by the probe

13 a) Interferometer figure and explaination (2+2 = 4marks) (4)

b) Can be used as constant temperature and constant current anemometer, simple explanation (4 marks) (6)

Constant temperature anemometer is used in turbulent flow field (2 marks)

14 a) Sketch and working (2+2 =4 marks) (4)

b) Any 2 advantages – 3 marks (6)

Any 2 disadvantages – 3 marks

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