Exam Date & Time: 26-Nov-2022 (02:00 PM - 05:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

MANIPAL NSTITUTE OF TECHNOLOGY
V SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV 2022

GAS DYNAMICS [AAE 3158]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) For a stagnation temperature of 400 K, derive the expression for maximum value of flow velocity achieved and find the value. (2)

A)

B) With a neat sketch, explain the heat addition process in a constant area duct for subsonic and supersonic flows. (3)

C) Derive the Area - Mach number relation for a supersonic flow in a C-D nozzle. (5)

2) Consider a Mach 3.5 flow over a compression corner with a deflection angle of 15^o. If the flow deflection angle is doubled to 30^o, what is the increase in shock strength? Is it also doubled? (2)

A)

B) Describe with reasons:

a. The variation of shock angle (β) when the wedge angle is changed from a lower to a higher value for a constant flow Mach number, M. Also give the limiting condition for the Mach number.

b. The variation of shock angle (β) when the flow Mach number is varied from lower to higher value for a wedge of constant angle, θ. Also give the limiting condition for the wedge angle. (4)

C) Write a brief note on:

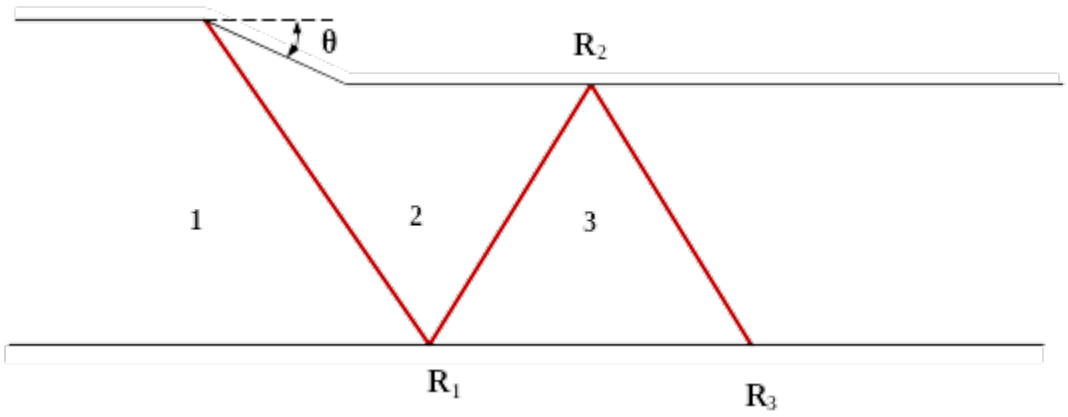
a. 3-D relieving effect

b. Fanno flow (4)

3) A supersonic flow with Mach number 2 enters a duct, as shown in figure. The free stream static properties are 1 bar and 300 K. The wedge angle is θ = 8^o. Determine how (5)

many regular reflections are possible for the shock wave in the duct.

A)



B) What is the significance of stagnation pressure in a flow? Prove that across a shock wave stagnation pressure is lost. (3)

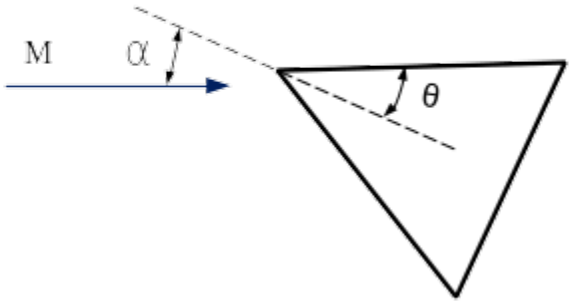
C) Write a brief note on Prandtl-Glauert Compressibility Correction. (2)

4) For a sonic free stream flow, what is the maximum expansion possible for a Prandtl-Meyer centered expansion fan. (2)

A)

B) With neat sketches, describe some possible forms of shockwaves found in nature. (3)

C) A symmetrical half-diamond airfoil ($\theta=24^o$) is placed in a supersonic flow of Mach 3 at an angle of attack 6^o. The free stream pressure and temperature are 1 bar and 300 K. Calculate the flow Mach number, static and stagnation temperatures and pressures at the upper and lower surface of the wedge. (Take $\gamma=1.4$)



(5)

5) Prove that the tangential component of flow velocity is invariant across an oblique shock wave. (2)

A)

B) Explain Crocco's theorem with an example for its consequence in a real flow. (3)

C) A uniform supersonic stream with Mach number 2.5, static pressure and temperature 1800 kPa and 450 K, respectively, encounters an expansion corner which deflects the stream by an angle, $\theta = 23^{o}$. Calculate the flow Mach number, static pressure and temperature, stagnation pressure and temperature behind the expansion fan and the angles the forward and rearward Mach lines make with respect to the upstream and downstream flow directions. (5)

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