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University Examinations 2013/2014

FIRST YEAR, FIRST TRIMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN APPLIED MATHEMATICS

SMA 3134: FLUID MECHANICS I

DATE: DECEMBER 2013 **TIME: 3 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*

- **The variables used have their own usual meaning**

QUESTION ONE – (30 MARKS)

a) Distinguish between the following terms as used in thermodynamics.
   i. Path function and point function (2 Marks)
   ii. Reversible process and irreversible process. (2 Marks)
   iii. Heat engine and heat pump (2 Marks)

b) Define a function of state hence show that the quantity of heat Q is not a function of state. (5 Marks)

c) Give the ranges of the mach number for subsonic, transonic, supersonic and hypersonic flows. (2 Marks)

d) A projectile travelling at a speed of M=3 passes 250m above an observer. (take γ =1.4, R=287J/(kg.K)
   i. Find its velocity. (2 Marks)
   ii. How far beyond the observer will the projectile be first heard? (3 Marks)

e) i) Define a cycle as used in relation to heat engines. (2 Marks)
   ii) Draw an indicator diagram for the following cycle. A perfect gas is initially at a state A at pressure P_1 and temperature T_1. It is then cooled at constant pressure to a state B. The gas is expanded adiabatically to a state C at a pressure P_2 and volume V_2. It is then heated at constant volume to a state D before being finally compressed adiabatically back to state A. (2 Marks)

f) state the second law of thermodynamics hence or otherwise show that the energy equation for the dimensional compressible fluid flows

$\frac{\gamma}{\gamma-1}\ \frac{p}{\rho}+\frac{1}{2}u^2 = constant$ (8 Marks)

QUESTION TWO (20 MARKS)

a) prove that the prandtl meyer function is given by

$v(M) = \sqrt{\frac{\gamma+1}{\gamma-1}}arc\ \tan\sqrt{\frac{\gamma+1}{\gamma-1}(M^2-1)} - arc\tan\sqrt{M^2-1}$ (9 Marks)

b) State and prove the Carnot's theorem. (11 Marks)

QUESTION THREE (20 MARKS)

a) Differentiate between compressible and incompressible fluid flows. (2 Marks)

b) Given that $\emptyset, \vec{q}$ and a are scalar function, fluid velocity and speed of sound respectively. show that the mass conservation equation of a two dimensional irrotational fluid flow of a compressible fluid can be written as

$\frac{\partial^2\emptyset}{\partial t^2} + \vec{q}.\frac{\overrightarrow{\partial q}}{\partial t} + \frac{a^2}{\rho}\frac{\partial\rho}{\partial t} = 0$ (8 Marks)

c) Discuss the flow of a compressible fluid through a converging – diverging nozzle. (10 Marks)

QUESTION FOUR (20 MARKS)

a) Show that the enthalpy H is a function of state. (4 Marks)

b) Find the heat per unit mass absorbed from the hot source along CD in the cycle described in Question one (e). (9 Marks)

c) Discuss the fluid flow past a circular cylinder with circulation. (7 Marks)