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Free convection flow about a cone under mixed thermal boundary conditions and a magnetic field

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Abstract

A similarity analysis was performed to investigate the laminar free-convection boundary-layer flow in the presence of a transverse magnetic field over a vertical down-pointing cone with mixed thermal boundary conditions. Boundary layer velocity and temperature profiles were determined numerically for various values of the magnetic parameter and the Prandtl number. The results show that the magnetic field suppresses the velocity profiles and increases the skin friction. The temperature profiles were expanded with increasing values of the magnetic parameter resulting in higher surface temperatures. A transformation relating the similarity solutions of the boundary-layer velocity and temperature profiles associated with different values of the mixed thermal boundary condition parameter was obtained.

Keywords: Free convection; Magnetic field; Mixed thermal boundary conditions; Cone

1. Introduction

Laminar free-convection boundary-layer flow over a heated vertical surface is encountered in variety of engineering applications including thermal insulation, cooling of metallic surfaces in a bath and heat dissipation from electronic components and a large number of investigations have

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Nomenclature

B	magnetic field strength
F	boundary layer stream function
G	boundary layer temperature
g	gravitational acceleration
Gr	Grashof number
L	characteristic length
M	magnetic parameter
m	transformation scale for magnetic field
Pr	Prandtl number
r	local radius of the cone
T	temperature
U	reference velocity
u	velocity component in the x-direction
v	velocity component in the y-direction
x	coordinate measured along the surface
y	coordinate normal to the surface

Greek symbols

α	thermal diffusivity of the fluid
β	coefficient of thermal expansion of the fluid
χ	similarity exponent in the stream function
Δ	transformation scale for the stream function
δ	transformation scale for the normal coordinate
ε	mixed thermal boundary condition parameter
ϕ	vertex half angle
Γ	transformation scale for the temperature
γ	similarity exponent in the boundary layer normal variable
η	boundary layer normal variable
κ	similarity exponent in the temperature
Λ	magnetic field function
λ	similarity exponent in the magnetic field parameter
ν	kinematic viscosity of the fluid
θ	dimensionless temperature ratio
ρ	density of the fluid
σ	electrical conductivity of the fluid
ψ	dimensionless stream function

Superscript

$*$	dimensional variable