Ain Shams University
Faculty of Engineering
Department of Engineering Physics and Mathematics

HEAT AND MASS TRANSFER OVER STRETCHING SURFACES

A Thesis Submitted
For The Degree of Masters of Science in Engineering Mathematics

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ABSTRACT

Some problems of Newtonian and non-Newtonian fluid flow with heat transfer over stretching surfaces are solved numerically. These problems were solved using the fourth/fifth Runge-Kutta method in combination with shooting method. A mathematical model is presented for analyzing the non-Newtonian (Maxwell) fluid over some stretching surfaces in the presence of some effects. Discussing of existence of some external influences and parameters such as thermal radiation, heat generation, slip effect, magnetic field, and porous media are considered and presented. The results presenting the influences of various dimensionless parameters on velocity, temperature, concentration, and microrotation profiles are discussed analytically and graphically.

Keywords: Maxwell Fluid, Stretching Surfaces, Porous Medium, Slip effect, and Thermal Radiation.

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LIST OF SYMBOLS

A	constant
a	acceleration
B_0	uniform magnetic field
b	stretching rate in the steady case
C	concentration of the fluid in the boundary layer
C_0	reference concentration
C_f	local skin-friction coefficient
C_w	concentration near the surface
C_∞	concentration far away from the surface
c_p	specific heat due to constant pressure
c	stretching rate in the unsteady case
D_B	mass diffusivity
De	Deborah number
F	force
f, g	dimensionless functions
f'	dimensionless velocity of the fluid
h	convective mass transfer film coefficient
j	The micro-inertia per unit mass
K	permeability parameter
K_l	the dimensionless chemical reaction parameter
k^*	mean absorption coefficient
k_p	permeability of the porous medium
L	length

ℓ	characteristic length
l	distance
M	the magnetic field parameter
m	mass
N	the micro-rotation of the fluid
Nu_x	local Nusselt number
n	surface temperature exponent
P	any property of the fluid like density, pressure, or velocity.
Pr	Prandtl number
q	heat passing through a surface
q_m	surface mass flux
q_r	radiation heat flux
q_w	surface heat flux
R	thermal radiation parameter
R_0	cylinder radius
Re_x	Reynolds number
r	radial coordinate perpendicular to the cylinder axis
S	surface area
S_c	Schmidt number
Sh_x	local Sherwood number
S_l	velocity slipping parameter
s	the vortex viscosity
T	temperature of the fluid in the boundary layer
T_0	reference temperature of fluid
T_w	temperature of fluid near the surface

T_∞	ambient temperature of fluid
∇T	temperature difference
t	time
u, v	velocity components along x, y −directions respectively
U_w	stretching surface velocity
U_0	reference velocity
V	system volume
V_0	fluid flow velocity field
x, y	cartesian coordinates along the surface and normal to it, respectively (in case of linear stretching surface)
x	axial coordinate of the cylinder

Greek letters:

α^*	mean absorption coefficient
α	the thermal diffusivity
β	modified Deborah number
γ	curvature parameter
γ_0	the spin-gradient viscosity
ζ	unsteadiness parameter
η	similarity variable
θ	similarity temperature function
κ	thermal conductivity of the fluid
λ_1	relaxation time of the period
μ	dynamic viscosity of the fluid
ν	kinematic viscosity
ρ	density of fluid