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# RESULT ON RADIATION EFFECTS ON A UNSTEADY MHD FLOW

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***ABSTRACT***

*In the present paper study of result on radiation effects on unsteady flow. The differential equations governing the problems are solved exactly. The effects of radiation and suction parameters on the temperature and velocity field are given. the present analysis deal with the magneto hydrodynamic unsteady free convection flow over an infinite vertical plate in the presence of radiation. The fluid is considered to be a gray, absorbing –emitting radiating but non-scattering medium.*

***Key words**: buoyancy effects, Radiative heat flux, MHD.*

## 1. INTRODUCTION

**A** free convection flow past difference types of bodies is studied because of its wide application in geophysical and cosmic sciences., industrial areas and aerodynamics. A free convection flow past a vertical plate at normal temperature has been studied extensively under different physical conditions by many authors and many of these have been referred to in Gebhart et al.(1988). In the case of high temperatures, radiation effects are quite significant, studies of the interaction of thermal radiation and free convection were made by Alietal (1984), Hossain *et al.* (1998) Hossain *et al* (1999) and Ghaly (2002) in the case of steady flow.

## 2. MATHEMATICAL ANALYSIS

Consider the unsteady two-dimensional free convection flow of an electrically conducting, viscousand incompressible fluid bounded by an infinite vertical porous plate. A magnetic field of constant density is applied perpendicular to the plate. The fluid is a gray, emitting and absorbing radiating, but non-scattering medium, and the Rosseland approximation is used to describe the radiative heat flux in the energy equation. All the fluid properties are assumed constant except that the influence of the density variation with temperature is considered only in the body force term. The *x*-axis is taken along the plate in the upward direction and the *y*-axis normal to the plate. The radiative heat flux in the *x*-direction is assumed negligible in comparison with that in the *y*-direction. The governing equations for the two-dimensional MHD unsteady free convection flow for an incompressible fluid, in the presence of radiation, are written within the boundary layer as follows:

**Continuity equation:**

$$\frac{\partial v}{\partial y} = 0 \tag{1}$$

**Momentum equation:**

$$\frac{\partial u}{\partial t} + v\frac{\partial u}{\partial y} = v\frac{\partial^2 u}{\partial^2 y} + g_o\,\beta(T - T_\infty) - \frac{\sigma B_o^2}{\rho}\,u - \frac{u}{k}u - \frac{b}{k}u^2 \tag{2}$$

**Energy equation:**

$$\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 u}{\partial y^2} + \frac{v}{c_p}\left(\frac{\partial u}{\partial y}\right)^2 - \frac{1}{\rho c_p}\frac{\partial q_r}{\partial y} \tag{3}$$

where u and v are the components of the velocity parallel and pendicular to the plate respectively, t is the time $\rho$ is the density of the fluid. $v$ is kinematic viscosity, p is the pressure, g is the acceleration due to gravity, $\sigma$ is the electrical conductivity, $B_o$ is the magnetic induction. T is the temperature, $c_p$ is the specific heat at constant pressure, k is the thermal conductivity and $q_r$ is the radiative heat flux. The radiative heat flux term, by using the Rosseland approximation, is given by

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$$q_r = \frac{-4\sigma_1}{3k_1}\frac{\partial T^4}{\partial y} \tag{4}$$

where $\sigma_1$ is the Stefan –Boltzmann constant and $k_1$ is the mean absorption coefficient .When the temperature of the fluid and the temperature away fro,m the plate have a difference which is proportional to $T^4$ the boundary conditions are

u =U(t), v=$v_0$(t) , T= T(t) at y=0

u =0 T=$T_\infty$as y→ ∞ for t> 0 (5)

It is assumed that the temperature difference within the flow are sufficiently small such that $T^4$ may be expressed as a linear function of temperature, this is accomplished by expanding $T^4$ in a Taylor serios $T_\infty$ and neglecting higher –order terms, thus

$$T^4 \approx 4T_\infty^3 T - 3T_\infty^4 \tag{6}$$

Using (5) and (6) in equation (3) we have

$$\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 u}{\partial y^2} + \frac{v}{c_p}\left(-\frac{\partial u}{\partial y}\right)^2 + \frac{4\sigma_1 T_\infty^3}{\rho c_p k_1}\frac{\partial^2 T}{\partial y^2} \tag{7}$$

We introduce a similarity parameter$\delta = \delta(t)$, (8)

With this similarity parameter, a similarity variable is then introduced $as\ \eta = \frac{y}{\delta}$ (9)

In terms of this length scale, a convenient solution of the equation (1) can be taken as $v = v(t) = -\frac{v}{\delta}v_0$

Where $v_0$ is the mass transfer Hoaaain (1992) U(t) and T(t) are now consider to have the following from

U(t)=$U_0\delta_0^{2n+2}$

T(t)= $T_\infty + (T_0 - T_\infty)\,\delta_0^{2n}$ (10)

where n is a non- negative integer and $U_0$and $T_o$ are respectively the free stream velocity and mean temperature here $\delta_0 = \frac{\delta}{\delta_0}$ where $\delta_0$is the value of $\delta$ is the value of $\delta$ at t=$t_0$

Now to make the equation (2) and (7) dimensional, we introduce the following transformations:

u=U(t)f(t) =$U_0\delta_0^{2n+2}$f($\eta$)

T=$T_\infty$+( $T_0 - T_\infty$) $\delta_0^{2n}\Theta(\eta)$ (11)

Using equation (8) (9) and (11) the equation (2) and (7) (are become

$$f'' + (2\eta + v_0)\,f' - \left(4n+4+M+\frac{1}{Da}\right)f + Gr\theta - \frac{Fs_1}{Da}f^2 = 0 \tag{12}$$

$$\theta'' + (2\eta + v_0)\left(\frac{3NPr}{3N+4}\right)\theta' - \left(\frac{12nNPr}{3N+4}\right)\theta + \left(\frac{3NPr}{3N+4}\right)Ecf'^2 = 0 \tag{13}$$

where Gr =$\frac{\beta(T_0 - T_\infty)\delta_0^2 g_0}{vU_0}$ is the local Grashof number,

M= $\frac{\sigma B_0^2\delta^2}{\rho v}$ is local magnetic papameter. Pr=$\frac{v}{\alpha}$ is the pradtl number, Da=$\frac{k}{\delta^2}$ is the local darcy number, Re=$\frac{v_o\delta}{v}$ is the local Reynolds number $F_s = \frac{b}{\delta}$ is the forchhemier number and $F_{s_1} = \frac{b}{\delta}\left(\frac{\delta}{\delta_0}\right)^{2n+2}$ Re is the modified forchhemier number. N=$\frac{kk_1}{4\sigma_1 T_\infty^3}$ is the radiation number condition t>0 are given by

f=1, $\theta = 1, \eta = o$

f=1, $\theta = 1, as\ \eta \to \infty$ (14)

 

## 4. RESULTS AND DISCUSSION

1. The numerical calculations are presented in the form of none-dimensional velocity and temperatature profiles.
2. grashof number are taken to be large from the physical points of view .
3. We found that the velocity decreases with the increase of suction for cooling of the plate and increases for the heating of the plate.
4. It is also clear that suction stabilizes the boundary layer growth reveals that temperature decreases with the increase of the suction parameter.
5. The effect of non-negative integer n on the velocity and temperature profiles, from we see that velocity profiles decreases the velocity for the cooling plate while it increases with increase for the heating plate With the increase of n. the non zero value of n represents the case of time dependent velocity and temperature.

**Table- 1:** coefficient and rate of heat value transfer for different values of Ec=.2.N=.5, FS1 =1.0, n=1.0 and Da=0.25.

| $v_0$ | $Gr$ | Pr | $c_f$ | $N_u$ |
|---|---|---|---|---|
| 0.0 | 10 | 0.71 | -2.0239 | 0.96755 |
| 0.5 | 10 | 0.71 | -2.20139 | 1.01875 |
| 1.0 | 10 | 0.71 | -2.39638 | 1.07183 |
| 2.0 | 10 | 0.71 | -2.84188 | 1.18337 |
| 0.0 | -10 | 0.71 | -6.16298 | 0.84126 |
| 0.5 | -10 | 0.71 | -6.51201 | 0.88650 |
| 1.0 | -10 | 0.71 | -6.87269 | 0.93390 |
| 2.0 | -10 | 0.71 | -7.62243 | 1.03513 |
| 0.5 | 10 | 0.1 | -1.84548 | 0.37878 |
| 0.5 | 10 | 0.71 | -2.20139 | 1.01875 |
| 0.5 | 10 | 1.0 | -2.29305 | 1.21177 |
| 0.5 | 10 | 7.0 | -2.94205 | 3.25812 |
| 0.5 | 10 | 10.0 | -3.06843 | 3.91936 |
| 0.5 | -10 | 0.1 | -7.04351 | 0.35009 |
| 0.5 | -10 | 0.71 | -6.51201 | 0.88650 |
| 0.5 | -10 | 1.0 | -6.39626 | 1.04436 |
| 0.5 | -10 | 7.0 | -5.66090 | 2.75038 |
| 0.5 | -10 | 10.0 | -5.52584 | 3.32275 |

**Table-2:** coefficient and rate of heat value transfer for different values of$\upsilon_0$ =0.5.Gr=10, Pr=0.71. Ec=0.2, Fs1 =1.0

| $M$ | $N$ | $n$ | $Da$ | $c_f$ | $N_u$ |
|---|---|---|---|---|---|
| 0.0 | 0.5 | 1 | 0.25 | -2.11351 | 1.01995 |
| 1.5 | 0.5 | 1 | 0.25 | -2.37175 | 1.01636 |
| 3.0 | 0.5 | 1 | 0.25 | -2.61501 | 1.01279 |
| 5.0 | 0.5 | 1 | 0.25 | -2.91936 | 1.011811 |
| 0.5 | 0.01 | 1 | 0.25 | -1.71445 | 0.17387 |
| 0.5 | 0.10 | 1 | 0.25 | -1.92589 | 0.51118 |
| 0.5 | 0.50 | 1 | 0.25 | -2.20139 | 1.01875 |
| 0.5 | 1.0 | 1 | 0.25 | -2.32422 | 1.28088 |
| 0.5 | 5.0 | 1 | 0.25 | -2.51338 | 1.74547 |
| 0.5 | 0.5 | 0.0 | 0.25 | -1.16364 | 0.54941 |
| 0.5 | 0.5 | 0.5 | 0.25 | -1.73516 | 0.81536 |
| 0.5 | 0.5 | 1.0 | 0.25 | -2.20139 | 1.01875 |
| 0.5 | 0.5 | 2.0 | 0.25 | -2.95768 | 1.33587 |
| 0.5 | 0.5 | 1 | 0.1 | -3.68945 | 0.99792 |
| 0.5 | 0.5 | 1 | 0.25 | -2.20139 | 1.01875 |
| 0.5 | 0.5 | 1 | 0.5 | -1.53694 | 1.02612 |
| 0.5 | 0.5 | 1 | 1.0 | -1.14466 | 1.02969 |

 

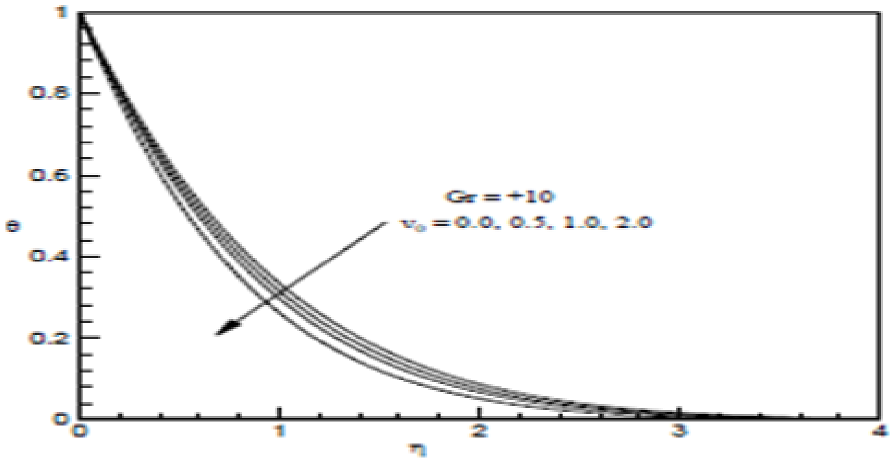


**Fig. 1:** Temperature profiles for different values of suction parameter ($\upsilon_0$)

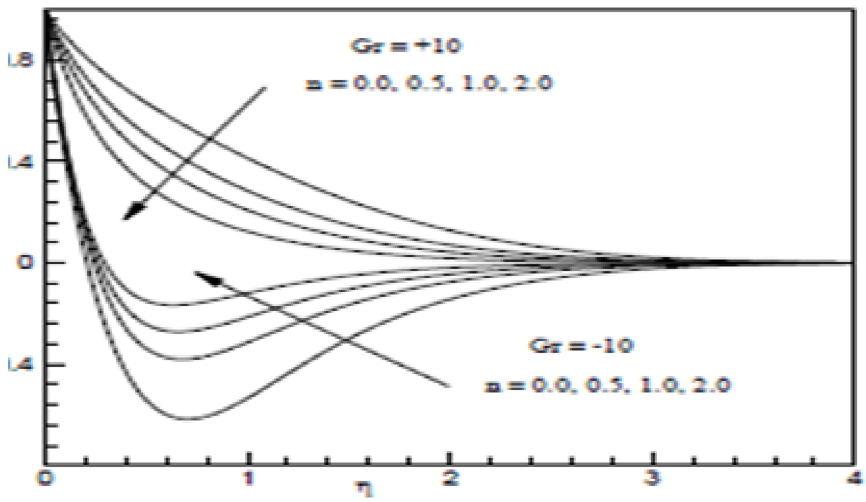


**Fig. 2:** velocity profiles for different values of prandtl number (Pr)

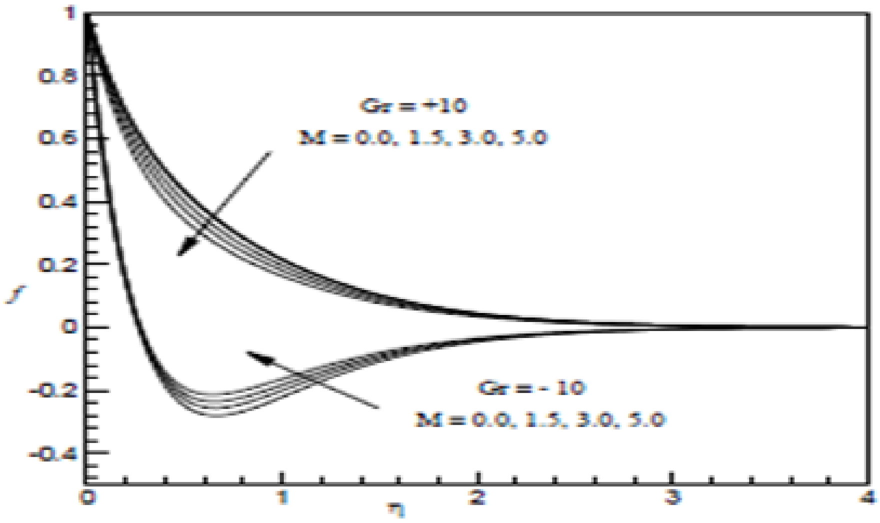


**Fig. 3:** velocity profiles for values of magnetic paramer (M)

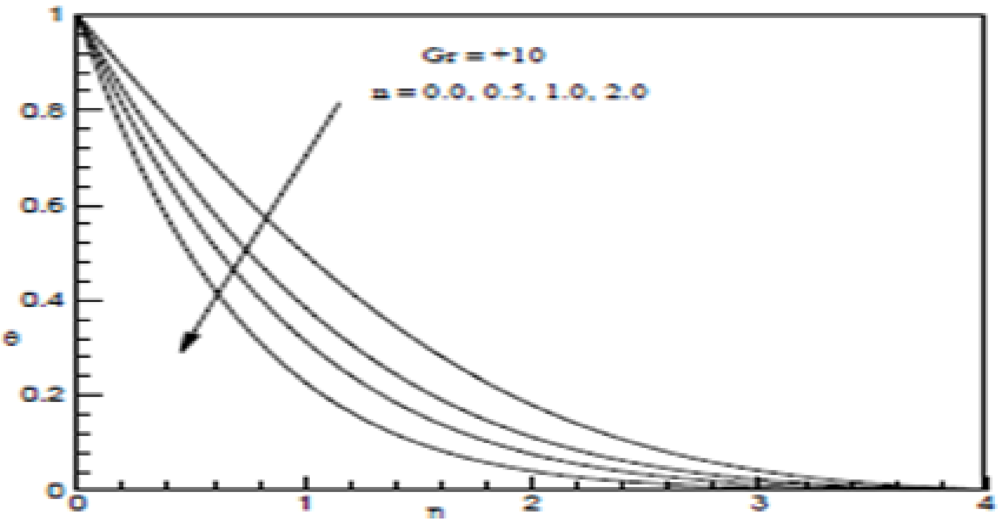


**Fig. 4:** Temperature profiles for different values of non-negative (n)

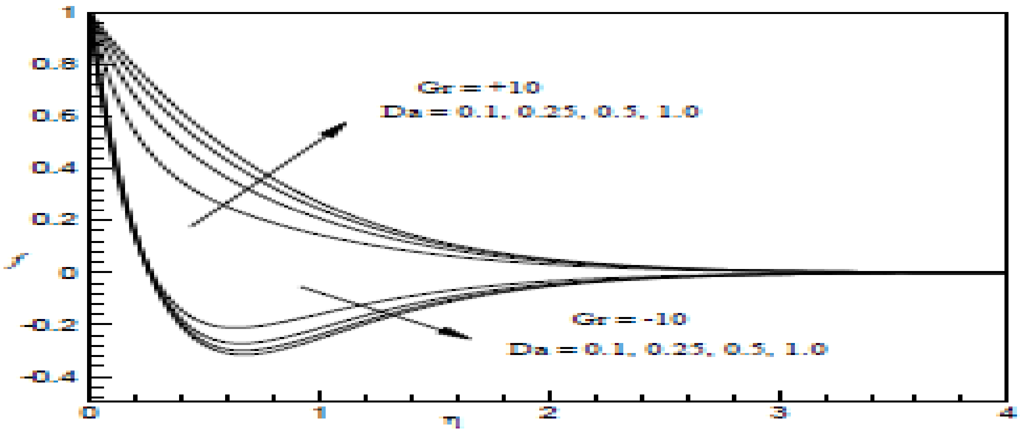


**Fig. 5:** Velocity profiles for different values of Darcy number (Da)S

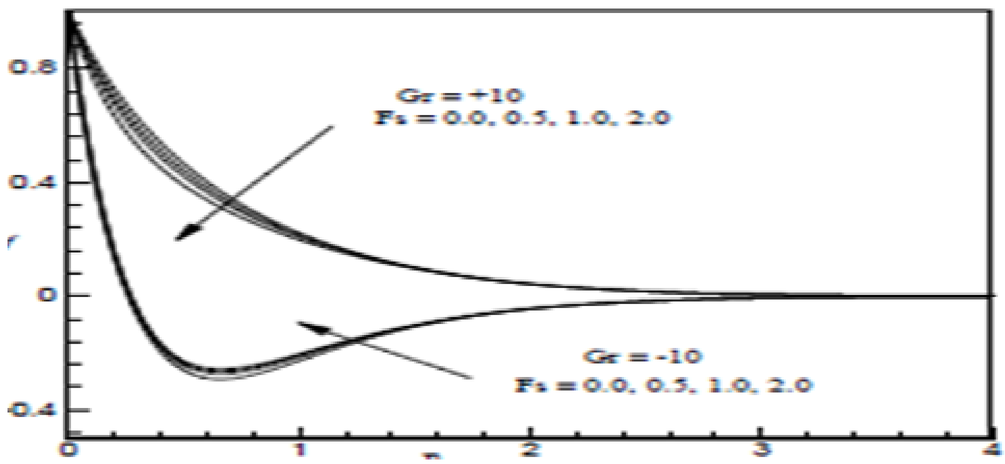


**Fig. 6:** Velocity profiles for different values of forchhemier number ($Fs_1$)

In order to investigate the effects of various parameters on the problems numerical calculations are carried out for temperature and velocity fields when M=0.2

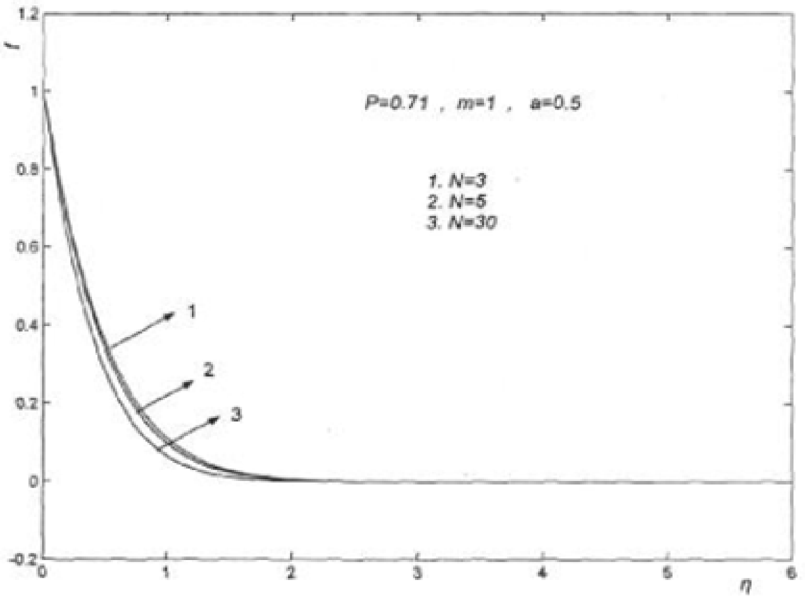


**Fig. 7:** temperature profiles for various values of the radiation parameter N

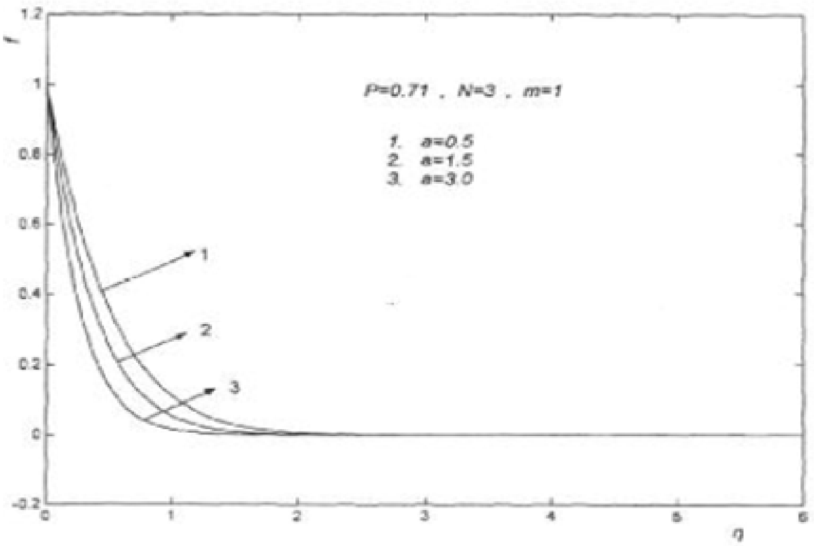


**Fig. 8:** temperature profil;es for various values of the suction parameter a temperature profil;es for various values of the suction parameter a

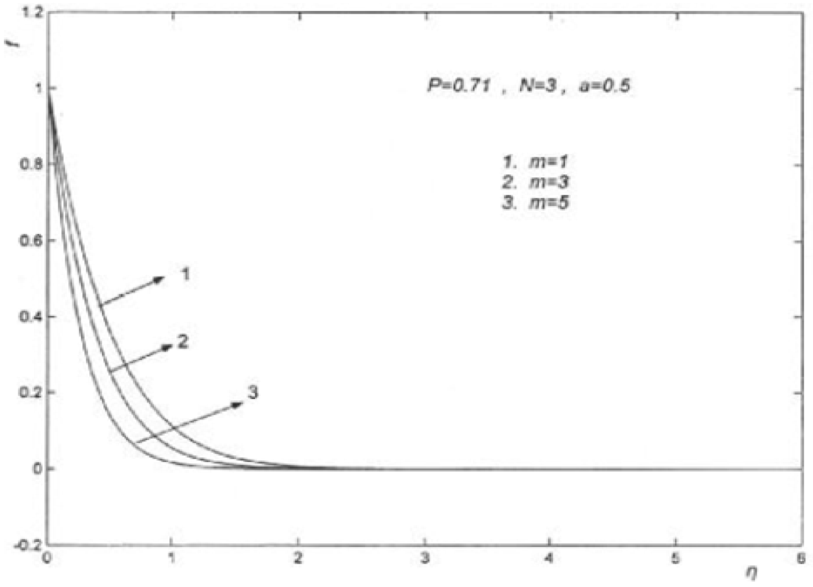


**Fig.9:** temperature profiles for various values of a parameter

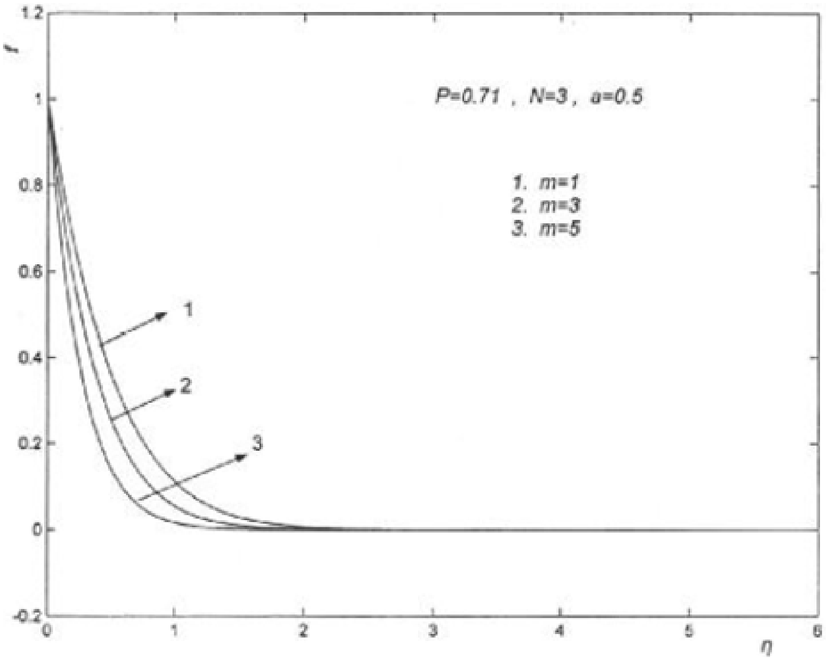


**Fig. 10:** Temperature profiles for various values of the suction a.

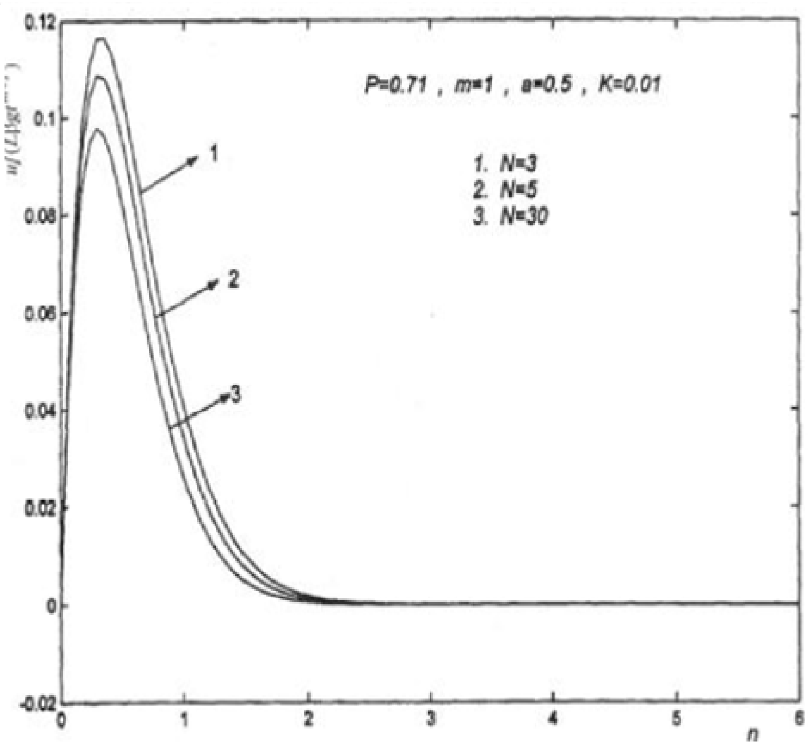


**Fig. 11:** Velocity profiles for mvarious values of the radiation parameter N

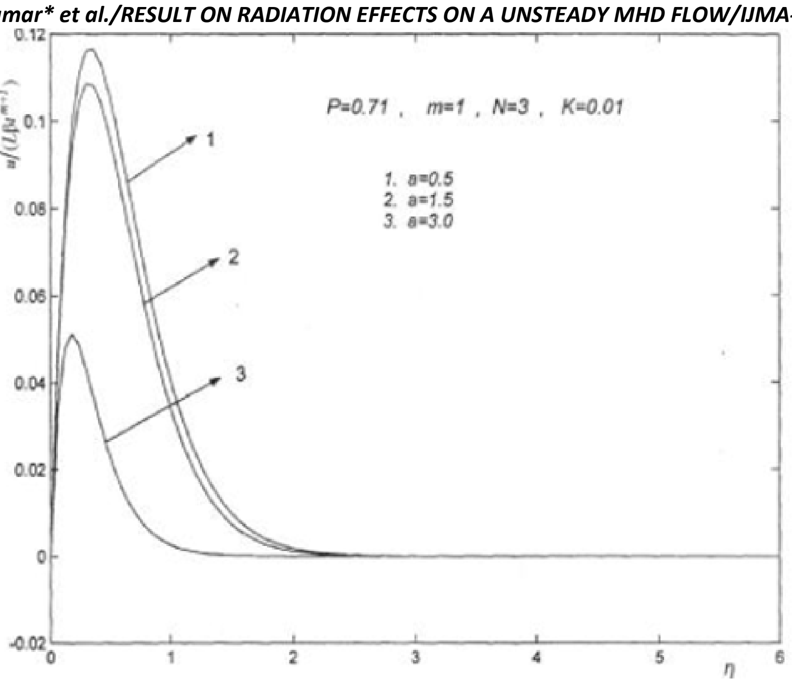


**Fig. 12:** Velocity profiles for mvarious values of the radiation parameter a

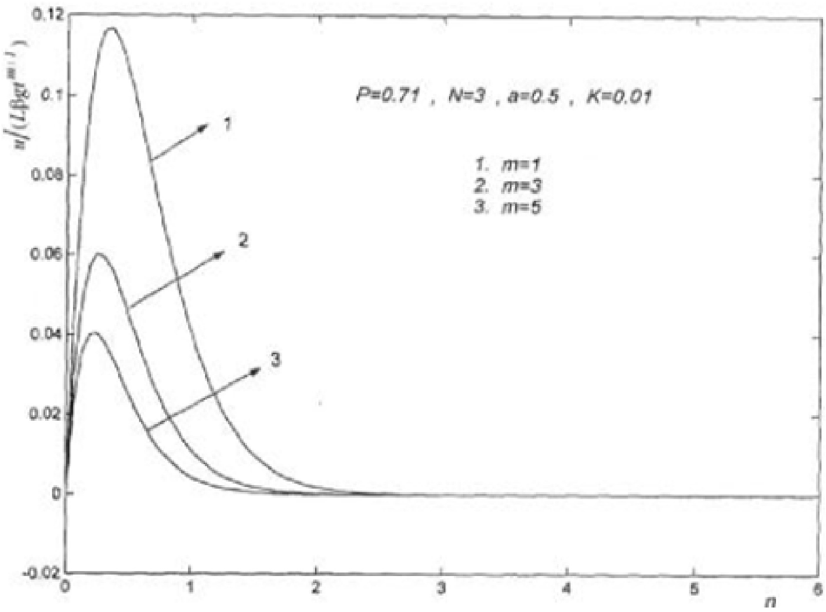


**Fig. 13:** velocity profiles for various values of the parameter m.


**REFERENCES**

1. Ali M.M., Chen T.S. and Armaly B.F. (1984): *Natural convection-radiation interaction in boundary-layer flow overhonzontal surfaces*. – AIAA Journal, vol.22, pp.1797-1803.
2. Ghaly A.Y. (2002): *Radiation effects on a certain MHD free-convection flow*. – Chaos, Solitons and Fractals, vol.13,
3. Hossain M.A., Alim M.A. and Rees D.A.S. (1999): *The effect of radiation on free convection from a porous vertical.*
4. Hossain M A., Rees D.A.S. and Pop I. (1998): *Free convection-radiation interaction from an isothermal plate inclined.*
5. Gebhart B., Jaluria Y. Mahajan R.L. and Sammakia B. (1988): *Buoyancy-induced flows and transport*. – HemispherePublishing Corporation, New York.
6. Jeffreys H. and Jeffreys B.S. (1972): *Method of Mathematical Physics*. – Cambridge: University Press.pp.1843-1850.*plate*. – Int. J. Heat Mass Transfer, vol.42, pp.181-191.*at a small angle to the horizontal*. – Acta Mechanica, vol.127, pp.63-73.


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