Faculty Information

Dr. G.Sudhakar Rao
M.Sc., M.Phil., Ph.D.,
Assistant Professor(c)
Department of Mathematics.

Dr .G.Sudhakar Rao from Bhadradri Kothagudem district Telangana State, completed Master's degree in Mathematics from Kakatiya university in 2002. M.Phil from Osmania university awarded 2006. My M.Phil topic is Flow of a powerlaw fluid in a channel when the walls are provided with non erodible porous lining. Awarded doctorate in 2012 from Osmania university. My research area is Peristaltics Transportation of Non Newtonian fluids. One paper published International journal. Two papers presented in International conference and two papers presented in National confarences and attended work shop.

Faculty Information

Detailed CV

1. Personal Details

Name of the faculty	Dr.G.SUDHAKAR RAO
Gender	MALE
Department	MATHEMATICS
PAN	
Designation	ASSISTANT PROFESSOR(C)
Qualification	M.SC.,M.Phil.,Ph.D
Date of Joining (Submit Appointment Letter)	June 2006
Date of Birth	8-4-1976
Category	SC
Mobile Number	9959640334
E-Mail Id	Sudhaker.ouc@gmail.com
Address	Flat No 312A, Third block, Janapriya Heavens, Lalapet, Secunderabad.

2. Academic details:

Degree	Qualification	Month and Year of Passing	Division	% of Marks	Univ/Board/ Institution with State
PG (M.A./M.Com/ M.Sc/M.Tech/ MBA/ MCA/Any other)	M.Sc	JULY 2002	II	57	KAKATIYA UNI.
CSIR/UGC-NET /SELT/Any other					
Any other					
Research details	**Title of Thesis**			**Month and Year of award**	**Univ/Board/ Institution with State**
M.Phil	Flow of a powerlaw fluid in a channel when the walls are provided with non erodible porous lining.			April 2006	OSMANIA UNI.
Ph.D	Peristaltic transport of non-Newtonian fluids in tubes and channels with permeable walls			December 2012	OSMANIA UNI
Post Doctorial/ D.Sc./D.Litt.					
Any other					
*Please provide the scanned copies of certificates					

3. **Teaching Experience: Total: ___13 yrs UG: 13 yrs PG: ___yrs**

4. **Academic Promotions:**

Designation	**Month and Year of Promotion**
Associate Professor	
Professor	
* Please provide order copies	

5. **Resource persons:**

Guest Lectures/ Extension Lectures	**No. of Lectures**	**Name of Program**	**Organization / Institution**	**Date and Year**
* Please provide the certificates or letter of invitation				

6. **Carrier Development Programs: Orientation Course/ Refresher courses/Short Term Course/Faculty Development Programme**

Course attended	**Institution /University**	**Title of the Professional Development Programme**	**Duration**	
			From	**To**
* Please provide the certificates				

7. **Research Details:**

Research Experience (No. of years):			
Area of research :			
Supervisor for M.Phil/Ph.D (Guideship Letter)			
No of students working/Registered	**Ph.D:** **F:** **M:**		
No. of students with fellowship (JRF)	**M:** **F:** **Total:**		
No. of students with fellowship (SRF)	**M:** **F:** **Total:**		
No. of students with fellowship (Project fellow)	**M:** **F:** **Total:**		
No. of students with any other fellowship	**M:** **F:** **Total:**		
No of students working for M.Phil.	**M:** **F:** **Total:**		
No of students working as Post.docs.	**M:** **F:** **Total:**		
No of students working as RA	**M:** **F:** **Total:**		
No. of M.Phil/Ph.D. Produced	**Ph.D:** **M:** **F:** **Total:**	**M.Phil:** **M:** **F:** **Total:**	
Name of Students **awarded. M.Phil/Ph.D**	**Title of Thesis**	**Month and Year of Registration**	**Month and Year of Award**

1.			
2.			
* Please provide the list of students registered, along with their category and fellowship details			

8. Total No. of Research Publications: International: National:

8.1 List of publications(## If possible use MS-Excel file which is attached as separate file)

SNo	Title of Paper	Name of the Authors	Name of the Journal	Volume and Page No	Month and Year of Publication	Peer reviewed/ Non Peer reviewed	Impact factor	National/ International	ISSN No.	UGC Journal No	Citation index (SCI.,/SCOPUS /Web of Science/ ICI	No. of citation excluding self citation	h-index	Institutional affiliation as mentioned in publication
1														
2														
* please provide the PDF or scanned copy of the articles along with ISSN no. and DOI														

9. List of Publication in Conference proceedings:

SNo	Title of Paper	Name of Conference	Name of the Publisher	Month and Year of Publication	ISBN No.	State/National /International	Affiliated institute at the time of publication
1							
2							
* please provide the PDF or scanned copy of the articles along with ISBN no. and DOI							

10. List of Books Published:

S.No	Title of Book/Chapter	Edited/ Authored	Name of the Publisher	Month and Year of Publication	ISBN No.	State/National /International	Affiliated institute at the time of publication
1							
2							
* please provide the PDF or scanned copy of the first page along with ISBN no.							

11. Member on editorial board or referee for national/international

S.No.	Name of the Journal	Status on the editorial Board	ISSN Number	Periodicity of Publication	Month and Year of Inception of Journal	Impact factor
* Please provide the certificates or e-Copy of letter from editor or editorial board						

12. No. of Papers Presented in Conference/workshop/seminars: (Oral/Poster)

SNo	Title of the paper	Name of Conference/ workshop/ Seminars	Oral/Poster	Organized by	Date and year	State/National /International	Oral/ Poster
1	Peristaltic transport of a Jeffery through an annulus with permeable walls.	Innovations in commerce and science	oral	Nizam coll.	29 nov 2017	International	Oral
2	Effect of thickness of the porous material on the peristaltic transport of a Jeffrey fluid when the tube wall is provided with non-erodible porous.	Nano, bio & material science	oral	Nizam coll	8jan 2014	international	oral
3.	Peristaltic transport of a conducting	Contemporary approaches in science computing	oral	Dept. of Mathematics. Osmania	29,aug 2017	state	oral

	Bingham fluid in an inclined channel with permeable walls.			university.			
4.	Peristaltic transport of a Jeffery fluid in an inclined flexble channel lined with porous material.	Recent trends in applications of mathematics	oral	Dept. of Mathematics. Anurag group of institutions	13 dec2013	state	oral
	* Please provide the certificates						

13. Conferences/ workshop/ seminars/Training Program etc organized.

SNo	Name of the Seminar	International/ National/State/University/College level	Date	No. of papers presented	No. of Participants		Source of funding/ Sponsoring Agency
					Nizam College	Other Institutions	
1	**Mathematical modeling in engineering**	**state**	**2dec,2013**			**NIT Warangal**	**TEQIP-II**
* Please provide the proof of organization and sanction letter for funding							

14. Conferences/ workshop/ seminars/Training Program etc attended/participated.

S.No	Name of the Seminar attended	National/ International	Duration		Organized by	Funded/Not Funded	Funding agency	Amount
			From	To				
1								
2								
3								
* Please provide the certificates and sanction letter for funding								

15. Patents:

Total No. of Patents: _____ No. of Patents applied:_____ No. of Patents approved: _____

S.No	Month and Year	National/ International/ Commercialized	Country	Patent Information	Patent Filed/ Published /Granted	Patent Applicaton no./Grant No.
1						
2.						
* Please provide the copy of patent publication and Patent grant orders						

16. Research Projects:

Total No. Projects: Major: - Minor:

Title/Name of	Major	Funding	Amount	Amount	Duration	Date	Status –

Project	/Minor	Agency	Granted (in Rs. Lakhs)	Received (in Rs. Lakhs)		and Year	Completed /Ongoing/ Sanctioned/ Submitted
* Please provide the scanned copy of sanction letter/ grant received orders/project closure orders							

17. Consultancy Projects:

Name of the Consultant	Name of the Consultancy Project	Consulting/Sponsoring Agency with Contact Details	Month and Year	Funds earned/ Revenue generated during last five years (in Rs.)*
* Audited statement of accounts indicating the revenue generated through consultancy				

18. Collaboration activities for research:

Title of the collaborative activity	Name of the Collaborating agency with contact details	Source of financial support	Month and Year of collaboration	Duration	Nature of activity
* Audited statement of accounts indicating the revenue generated through consultancy					

19. Students Projects:

Total No.of Student Projects Guided:

S.No	Name of the student	Course	Title of the Project	Duration of the Project	Month & Year of the Award
* please provide copy of certificate page or certificate from Head/Principal					

20. Faculty visit abroad on academic purpose:

Institution Visited & Period of Visit	Country	Sponsoring of agency	Activity undertaken	Month and Year of Visit
* please provide invitations/sanction letters/grant received letter				

21. Awards / distinction received if any

Name of the award Received	International/ National/ State/University/District/College	Nature of Award	Month & Year of the Award

	level		
* please provide copy of certificate			

22. International fellowship for advanced studies/research received if any

Name of the award	Month and Year of Award	Awarding agency
* please provide copy of certificate		

23. Faculty Distinction/Nominations to University/State/National/International bodies.

Membership / Distinction earned	Organization	University/State/ National/International Level	Month and Year
*please provide copy of offer letters/appointment orders			

24. Collaborative programs if any other University / Organization/ Industries

Name of Program	Nature of Collaboration	Collaborating organization and Country	Objectives of MOU	Month and Year
* please provide copy of MoU letter				

25. Innovation adopted in Teaching (If any, provide details.):

26. Participation in Curriculum design/BOS etc. (copy of minutes of meeting)

27. List of ICT modules prepared (Please provide soft copies of modules, url link/videos):

28. Social outreach programs conducted (If any, proof as photographs, videos, certificate of appreciation, etc):

29. Life Members of any bodies (provide membership details):

30. Extension activities and institutional social responsibility (If any, provide proof)

31. Contribution to environmental awareness and protection (If any, provide proof)

32. Please provide the details if any MoUs/Linkages (If any, provide MoU letter):

33. Any another relevant information:

SIGNATURE

OU 374504

Osmania University

Faculty of *Science*

This is to certify that *Gunteti Sudhakar Rao*
son / daughter of *Nagaiah*
having pursued a course of study prescribed by this University and having passed the requirements by Examination and by thesis has been admitted to the Degree of

Doctor Of Philosophy

in the Subject of *Mathematics*

The title of the Thesis is :

Peristaltic Transport of Non-Newtonian Fluids in Tubes and Channels with Permeable Walls.

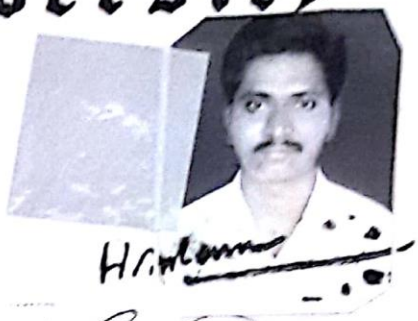
The candidate has been declared qualified for the award of the Degree of Ph.D. on *01 Dec 2012*

Given under the seal of the University

Hyderabad
Dated 07 FEB 2013

Vice-Chancellor

Osmania University



Faculty of Science

This is to certify that Gunteti Sudhakara Rao

son/daughter of Nagaraju having pursued a course of study prescribed by this University and having fulfilled the requirements by Examination and by dissertation, has been admitted to the Degree of

Master of Philosophy

(M. Phil)

in the Subject of Mathematics

"The title of the dissertation is Flow of Power Law Fluid in a Channel when the walls are provided with non erodable ; Porous Lining."

The candidate has been declared qualified for the award of the Degree of M. Phil. on 20th April 2006.

Given under the seal of the University

Hyderabad

Date MAGHA 14, 1928
FEBRUARY 01, 2007

Vice-Chancellor

Kakatiya University

Faculty of Science

Roll No. 00099-8039

This is to certify that Gunteti Sudhakar Rao

Son / ~~Daughter~~ of Nagaiah

has been admitted to the Degree of

Master of Science

of this University, he/~~she~~ having passed the qualifying Examination in July 2002, in Mathematics, in Pass Division / ~~Division with Distinction~~ with specialization in Discrete Mathematics

Given under the seal of the University

Warangal

Dated Phalguna 16, 1927
March 07, 2005

Vice-Chancellor

Date: 8.12 2006

To
The Head
Department of Maths.
Nizam College.

Sub: Allotment of work-load to the Academic Consultant –Regarding.

***

Sir/Madam,

You are requested to allot the excess work-load in your Department to the following persons for the period from UPTO to 31.03.2007.

Name	Work-load		Total
	Theory	Practical	
1. Ayesha Siddiqui (Court)	16 PPW		
2. G. Sudhakar Rao	16 PPW		
3. Seema Afroz	16 PPW		
4. Jeelani Begum Ashfiza	16 PPW		
5. Sushma Kasturi	16 PPW		

The Academic Consultant is eligible for remuneration @ Rs.9000/- per month. His/Her claim may be sent to the Principal's Office for making payment.

PRINCIPAL
Principal
Nizam College, Hyd-1

(1) I qv

NIZAM COLLEGE

(AUTONOMOUS)
A Constituent College of Osmania University
With NAAC – A Grade & CPE Status

OSMANIA UNIVERSITY 100 YEARS Centenary Celebrations 1917-2017

Two Day International Conference on

"INNOVATIONS IN COMMERCE AND SCIENCE"

(ICICS-2017)

29th & 30th November, 2017

Certificate

This is to certify that Prof/Dr/Mr/Ms. G. Sudhakar Rao, Assistant Professor *from* Nizam *College/University,* _____ *has participated in the International Conference on "INNOVATIONS IN COMMERCE AND SCIENCE", organized by, Nizam College, Hyderabad on 29th & 30th November,2017. He / She has presented an oral/poster presentation on the topic* Peristaltic Transport of a Jeffrey Fluid Through An Annulus With Permeable Walls.

Dr. P. Hima Bindu
Convener

Dr. C.V. Ranjani
Secretary

Prof. Syed Rahman
Principal, Nizam College

Certificate

International Conference on

"NANO, BIO & MATERIAL SCIENCES (ICONBMS-2014)"

DEPARTMENT OF PHYSICS, NIZAM COLLEGE (AUTONOMOUS)

Osmania University, Hyderabad-500001. A.P., India.

8 - 10 January, 2014

This is to certify that Dr./Mr/Ms. G. Sudhakar Rao

has participated / presented (oral / poster) in the International Conference on "Nano, Bio & Material Sciences" organized by the Department of Physics, Nizam College, Basheerbagh, Osmania University, Hyderabad from 8-10 January, 2014.

Prof. D. Ravinder
Convener

Prof. G. Veerabhadram
Vice - principal

Prof. T.L.N. Swamy
Principal

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Engineering Engineers

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(Regd.Off: Dept. of Mathematics, Osmania University, Hyderabad)

XXII Congress and National Conference on Recent Trends in Applications of Mathematics

(Sponsored by CSIR, Govt. India & APCOST, Govt. A.P)

13th to 15th December, 2013

Organized by

DEPARTMENT OF HUMANITIES & SCIENCES

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Venkatapur (V), Ghatkesar (M), Ranga Reddy(Dist) – 500 088.

CERTIFICATE

This is to certify that Dr./Mr./Mrs./Ms. G. SUDHAKAR RAO, NIZAM COLLEGE, O.U, HYD *has participated / presented a paper in the National Conference on Recent Trends in Applications of Mathematics and XXII Congress of APSMS – 2013 held at Anurag Group of Institutions, Hyderabad.*

Title of the paper presented: "Peristatic Transport of a Jeffery fluid in an Inclined Flexible Channel Lined with Porous material."

Dr. V.Srinivasa Rao
Organizing Secretary

Dr. S.Sivaiah
General Secretary, APSMS

Prof. G.Sarojamma
President, APSMS

TWO DAYS CONFERENCE ON CONTEMPORARY APPROACHES IN SCIENTIFIC COMPUTING

Department of Mathematics

Osmania University, Hyderabad, Telanagana State

100 Years Centenary Celebrations 1917-2017

CERTIFICATE

This is to certify that Dr./Mr./Ms. G. Sudhakar Rao, Nizam college, OU of _____ has participated/ delivered an invited talk / chaired a session /presented a paper entitled Peristaltic Transport of a conducting Bingham fluid in an inclined channel with permeable walls. at "Two Days Conference on Contemporary Approaches in Scientific Computing" organized by the Department of Mathematics, Osmania University, Hyderabad during August 29-30, 2017.

Organizing Secretary, Department of Mathematics | Chairman of BOS, Department of Mathematics | Head, Department of Mathematics | Dean, Faculty of Science

DEPARTMENT OF MATHEMATICS
NATIONAL INSTITUTE OF TECHNOLOGY, WARANGAL

Certificate

This is to certify that

Dr. G. Sudhakar Rao

from

Nizam College, Hyderabad.

has participated in a One Week Workshop on

Mathematical Modeling in Engineering (MME - 2013)

Organized by the Department of Mathematics, Sponsored by TEQIP Phase-II

during 2nd - 6th December, 2013

Dr. A. Benerji Babu, Coordinator | Prof. K.N.S. Kasi Viswanadham, HOD, Maths | Prof. T. Srinivasa Rao, Director

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Contents

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INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY AND CREATIVE ENGINEERING (ISSN:2045-8711)
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PERISTALTIC TRANSPORT OF A MICROPOLAR FLUID IN AN INCLINED CHANNEL WITH PERMEABLE WALLS

G. Sudhakar Rao[1] B.Shankar[1] SVHN Krishna Kumari.P[2]
[1]Department of Mathematics, Osmania University, Hyderabad, India
[2] Department of Mathematics, Aurora Scientific Technological & Research Academy, Bandlaguda, Hyderabad, INDIA
krishnagannamaraju@gmail.com, (Corresponding author)

Abstract - The peristaltic transport of a micro polar fluid in an inclined channel of half width 'a' with permeable walls is discussed . The effect of various parameters on the pumping characteristics is discussed through graphs
Keywords: Peristalsis, Micropolar Fluid , Permeable Walls

I. INTRODUCTION

Many researchers studied the peristaltic transport of fluids by considering Newtonian and non-Newtonian models. Classical continuum theory cannot explain the mechanical behavior of rheologically complex fluids, such as liquid crystals, colloidal fluids and blood. Due to this fact a new approach was necessitated. There are several approaches to the formulation of micro continuum theories of fluids such as simple deformable directed fluids, dipolar fluids, polar fluids, simple micro-fluids, micropolar fluids etc. All these consider the existence of couple stress and body couples.

Eringen [1,2] reported the theory of micropolar fluids in which the fluid micro elements undergo rotations without stretching. Micropolar fluids are superior to the Navier-stokes fluids and they can sustain stresses and body couples. Here the micro particles in the volume rotate with an angular velocity about the centre of gravity of the volume in an average sense and are described by the micro rotation vector $\overline{\Omega}$.The micropolar fluids can support stress and body couples and find their applications in a special case of fluid in which micro rotational motions are important. Arimon and Cakmak [3] discussed three basic viscous flows of micropolar fluids. They are couette and poiseuille flows between two parallel plates and the problem of a rotating fluid with a free surface. Srinivasacharya et al. [4] made a study on the peristaltic pumping of a micropolar fluid in a tube. In this paper, we considered the peristaltic transport of a micropolar fluid in an inclined channel with permeable walls. The effect of various parameter on the pumping characteristics is discussed through graphs. Kh. S. Mekheimer [5] discussed the micropolar fluid model for blood flow through a tapered artery with a stenosis. Anuar Ishak at al [6] studied on MHD boundary-layer flow of a micropolar fluid past a wedge with constant wall heat flux. Krishna Kumari et al. [7] worked on Peristaltic Pumping of a Jeffrey Fluid under the Effect of Magnetic Field in an Inclined Channel. Y.V.K.Ravi Kumar et al [8] made a study on Peristaltic transport of a power-law fluid in an asymmetric channel bounded by permeable walls. P. Muthu [9] discussed on the influence of wall properties in the peristaltic motion of micropolar fluid

II. MATHEMATICAL FORMULATION

Consider the peristaltic pumping of a micropolar fluid in an inclined channel of half-width 'a'. A longitudinal train of progressive sinusoidal waves takes place on the upper and lower walls of the channel. For simplicity we restrict our discussion to the half-width of the channel as shown in figure (1).

The wall deformation is given by

$$H(X,t)=a+b\sin\frac{2\pi}{\lambda}(X-ct) \qquad (1)$$

where b is the amplitude, λ is the wavelength and c is the wave speed.

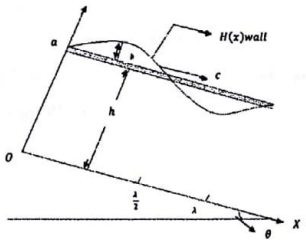


Figure. 1 Physical Model

III. EQUATIONS OF MOTION

Under the assumption that the channel length is an integral multiple of the wavelength λ and the pressure difference across the ends of the channel is a constant, the flow becomes steady in the wave frame (x, y) moving with velocity c away from the fixed (laboratory) frame (X, Y). The transformation between these two frames is given by

$$x = X - ct : y = Y : u(x,y) = U(X - ct, Y) - c : v(x,y) = V(X - ct, Y) \quad (2)$$

where U and V are velocity components in the laboratory frame and u, v are velocity components in the wave frame. In many physiological situations it is proved experimentally that the Reynolds number of the flow is very small. So, we assume that the flow is inertia-free. Further, we assume that the wavelength is infinite.
Using the non-dimensional quantities.

$$\bar{u} = \frac{u}{c}; \bar{x} = \frac{x}{\lambda}; \bar{y} = \frac{y}{a}; \bar{p} = \frac{p a^2}{\lambda c \mu}; \bar{\Omega} = \frac{\Omega a}{c}; h = \frac{H}{a}$$

The non-dimensional form of equations governing the motion (dropping the bars) is

$$\frac{\partial^2 u}{\partial y^2} + N\frac{\partial \Omega}{\partial y} - (1-N)\frac{\partial p}{\partial x} + \eta \sin\theta = 0 \quad (3)$$

$$\frac{2-N}{m^2}\frac{\partial^2 \Omega}{\partial y^2} - \frac{\partial u}{\partial y} - 2\Omega = 0 \quad (4)$$

where $N = \frac{k}{\mu + k}$ coupling number, Ω is the micro rotation velocity, u is the velocity, μ is the viscosity of the fluid, k is the micropolar viscosity
m is the micropolar parameter, p is the fluid pressure.
θ is the inclination angle to the horizontal.
α is dimensionless Beavers - Joseph constant which depends on the nature of the porous medium but not the fluid viscosity.
where 'Da' is the Darcy number given by
Da = $\frac{k}{a^2}$

The corresponding non-dimensional boundary conditions are

$$\frac{\partial u}{\partial y} = 0 \quad \text{at} \quad y = 0 \quad (5)$$

$$\frac{\partial \Omega}{\partial y} = 0 \quad \text{at} \quad y = 0 \quad (6)$$

$$u = -\frac{\sqrt{Da}}{\alpha}\frac{\partial u}{\partial y} \quad \text{at} \quad y = h(x) \quad (7)$$

$$\Omega = -1 - \frac{\sqrt{Da}}{\alpha}\frac{\partial \Omega}{\partial y} \quad \text{at} \quad y = h(x) \quad (8)$$

IV. SOLUTION OF THE PROBLEM

The general solution of (3) and (4) is given by

$$u = L_8\left(y + h - L_4 - \frac{\sin L_3 y}{L_3}\right) + \frac{L_5}{L_3}\left(\frac{L_6 \cos L_3 h}{L_3} - L_4 \sin L_3 h - \frac{\cos L_3 h}{L_3}\right) \quad (9)$$

$$-1 + L_5 L_7 L_8 + 2h L_4 L_5$$

$$\Omega = -\frac{L_5}{L_3}\cos(L_3 h)\sin(L_3 h) + L_5 h \cos(L_3 h) + \frac{L_5 L_6}{2L_3} - \frac{L_5 L_6 h}{2} \quad (10)$$

Where $L_1 = (1-N)\frac{\partial p}{\partial x} - \eta \sin\theta$,

$$L_2 = \frac{2-N}{m^2}, L_3 = \frac{N-2}{L_2} = -m^3,$$

$$L_4 = -\frac{\sqrt{Da}}{\alpha}$$

$$L_5 = 2 + L_2 L_3^2, L_6 = L_3 L_4 \, Sin\, L_3 h - Cos L_3 h$$

$$L_7 = \frac{L_5}{L_3}(-hL_3 - L_4 L_3 + L_3 L_4 Cos\, L_3 h + Sin L_3 h)$$

$$L_8 = 1 - \frac{L_1 L_5 L_6}{L_3^4} + \frac{L_1}{L_3^2}(2hL_4 - h^2)$$

The volume flux q through each cross section in the wave frame is given by

$$q = \int_0^h u dy \tag{11}$$

The pressure gradient is obtained from equation (11)

$$\frac{\partial p}{\partial x} = \frac{1}{1-N}\left\{\frac{S_1}{S_2(S_3 - S_4)} + \eta \sin\theta\right\} - S_5(S_6 - S_7) + \frac{h^3 m^3}{3} \tag{12}$$

where

$$S_1 = (q+h)m^5\left\{1 - \frac{1}{N}[2\cosh(mh) - 2mL_4\sinh(mh)]\right\}$$
$$S_2 = (-sinhmh + mL_4 coshmh - mL_4 + mh)$$
$$S_3 = 2coshmh - m^2h^2 - 2hmsinhmh + \frac{2hmL_2L_4}{N}coshmh$$
$$S_4 = \frac{4hm^2L_4 coshmh}{N} - 2h^2m^2 - 2L_4hm^2 - 2$$
$$S_5 = 1 - \frac{1}{N}(2coshmh - 2mL_4 sinhmh)$$
$$S_6 = Nsinhmh + m^4L_2L_4 sinhmh - 2L_4m^2 sinhmh$$
$$S_7 = Nmcoshmh + 2m^5h^2 + 4m^5hL_4$$

The time averaged flow rate is

$$\overline{Q} = q + 1 \tag{13}$$

V.PUMPING CHARACTERISTICS

Integrating the equation (12) with respect to over one wave length, we get the pressure rise (drop) over one cycle of the wave as

$$\Delta p = \int_0^1 \frac{\partial p}{\partial x} dx \tag{14}$$

The dimensionless frictional force F at the wall across one wavelength in the inclined channel is given by

$$F = \int_0^1 h\left(-\frac{\partial p}{\partial x}\right)dx \tag{15}$$

VI. RESULTS AND DISCUSSIONS

The variation of pressure rise Δp with time averaged flow rate for different values of α is shown in figure (2). It is observed that for a given $\overline{Q}$, Δp increases as the slip parameter α increases in the pumping and free pumping regions. The opposite behavior is observed in co-pumping region. And also for a given Δp the flux $\overline{Q}$, increases with increasing α.

The effect of the inclination angle θ on pumping characteristics is shown in figure (3). It is observed that for a given $\overline{Q}$, Δp increases as the angle of inclination θ increases.

The variation of pressure rise with time averaged flow rate for different values of micropolar parameter m is shown in figure (4). It is observed that for a given $\overline{Q}$, Δp decreases for a decreasing m in pumping and free pumping regions. For a given Δp the flux $\overline{Q}$, depends on m and it increases with increasing$m$.The effect of coupling parameter N on the pumping characteristics is shown in figure (5).We observed that the large the coupling number N the pressure rise against which the pumping works. For a given $\overline{Q}$, the pressure difference increases with increases N.The effect of amplitude ratio on pumping characteristics is shown in figure (6).

It is observed that the large the amplitude ratio, the greater the pressure rise against which the pump works. For a given Δp, the flux $\overline{Q}$, depends o n ϕ and it increases with increasing ϕ.

Figures (7) to (11) are drawn to study the effect of various parameters on the microrotation velocity. From figure (7) it is observed that an increase in the angle of inclination decreases the microrotation velocity. From figure (8) it is noticed that decrease in the darcy number decreases the microrotation velocity. It is also observed that the velocity profiles are parabolic and the velocity attains the maximum at the central line of the channel. From figure (9) it is observed that decrease in M decreases the microrotation velocity. The effect of micropolar parameter on the microrotation velocity is shown in figure (10). It can be seen that the decrease in m decreases the microrotation velocity.

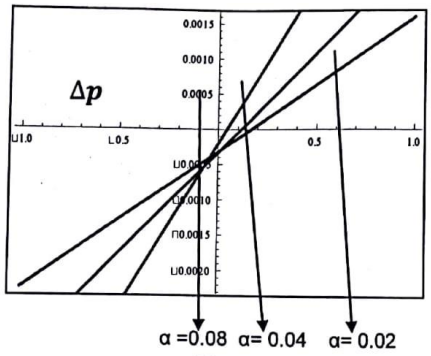


Fig.2. Variation of with $\overline{Q}$ for different values of slip parameter α ϕ.

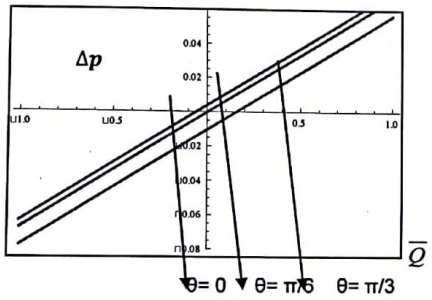
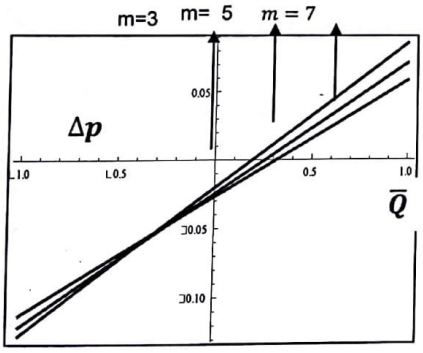


Fig 3. Variation of Δp with $\overline{Q}$ for different values of θ



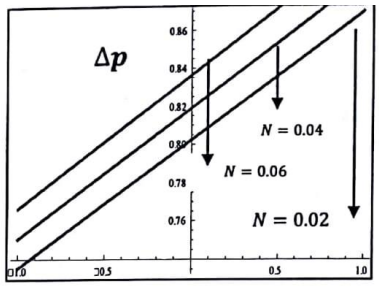


Fig. 5 Variation of Δp with $\overline{Q}$ for different values of N.

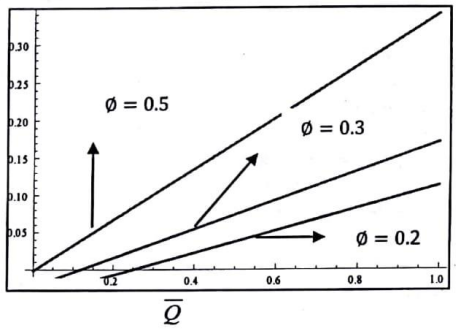


Fig. 6 Variation of Δp with $\overline{Q}$ for different values of ϕ.

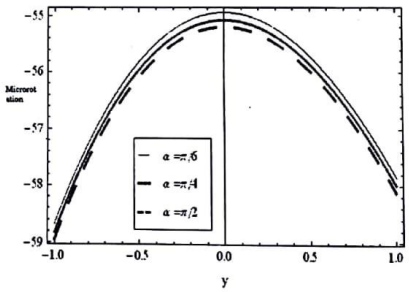


Fig.7 Variation of micro rotation velocity with y for different values of α

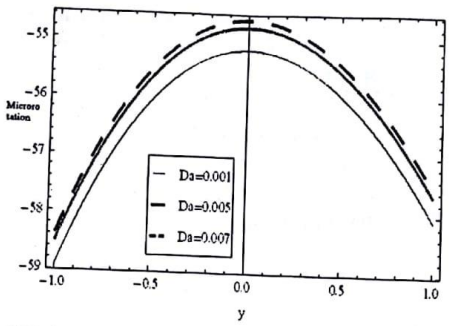


Fig. 8 Variation of microrotation velocity with y for different values of Da.

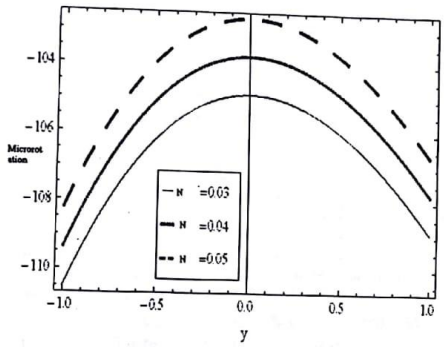


Fig.9 Variation of microrotation velocity with y for different values of N

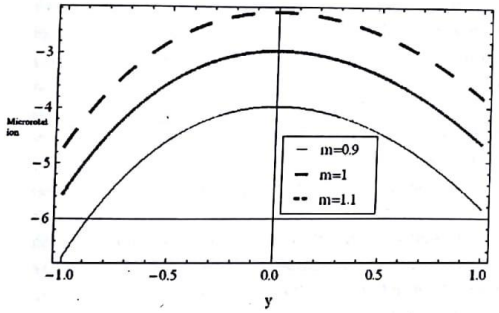


Fig.10 Variation of microrotation velocity with y for different values of m .

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