State Council for Science, Technology & Environment (SCSTE), H.P.
B-34, SDA Complex, Kasumpti, Shimla – 171009
Phone: 0177-2620998,2621992 Fax: 0177-2620998
Website: www.hpscste.gov.in & Email: stc-hp@nic.in

SCSTE/F(8)-1/2016-Vol.-I 5518 Dated:- 18-10-2016

SANCTION ORDER

Subject: **Financial Sanction of the research project titled "Biogas production for sustainable energy generation in rural H.P. using one-stage portable digester"-Reg.**

Principal Investigator (PI):

Dr. Sudhir Kumar
Associate Professor
Department of Bio-technology
& Bioinformatics, Jaypee University of Information & Technology,
Waknaghat, Solan-173234

Sanction of the **State Council for Science, Technology & Environment (SCSTE)** is hereby accorded to the above mentioned project at a total cost of **Rs.7,87,000/-** (Rupees seven lakh eighty seven thousand only) for a duration of **two** years from the date of sanction. The items of expenditure for which the total allocation of **Rs.7,87,000/-** has been approved for a period of **two** years, are given below:

S.No.	Head	Total (in Rs.)
1.	**Remuneration (Rs.)** **Project Associate – 1 No. @Rs.8000/- PM**	1,92,000/-
2.	**Consumables**	4,90,000/-
3.	**Travel**	55,000/-
4.	**Other Costs**	50,000/-
	Total Cost	**7,87,000/-**

NOTE:

(a) If the **Institute/ Organisation or/and Principal Investigator(PI)** agrees to execute the project as per the budget mentioned above and according to terms and conditions stated below, kindly send three (3) copies of the final project proposal duly filled up; signed & stamped and approved by the Head of the Institution/

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H.P. Council for Science, Technology & Environment (HIMCOSTE), Shimla
B-34, SDA Complex, Kasumpti, Shimla – 171009
Phone: 0177-2620998, 2621992 Fax: 0177-2620998
Website: www.hpscste.gov.in & Email: stc-hp@nic.in

SCSTE/F(8)-1/2016(Misc.)- Dated:

To

Dr. Sudhir Kumar (PI), Dr. Ashish Kumar (CO-PI)
Department of Bio-technology & Bioinformatics
Jaypee University of Information Technology
Waknaghat, Solan-173234

Subject: Release of 2nd Installment for HP Specific Research & Development Projects 2016-17

Sir,

This is in reference to mid-term evaluation held on 23rd January, 2018 in HIMCOSTE Shimla of the project proposal **"Biogas production for sustainable energy generation in rural H.P. using one-stage portable digester"** submitted by you during 2016-17.

The Project Approval & Evaluation Committee (PAEC) has made following observations for incorporation in your project:

1. Your progress during the first year of the project has been rated as very good by the committee.

2. Recommended to set up Four one-stage portable digesters (Matal Bakhog and Taali Bhujjal) at Rajgarh village under Vigyan Gram scheme in Sirmour District.

You are requested to take action on the recommendations of the committee during the execution of your project during the 2nd year.

Sanction of the HIMCOSTE is hereby accorded to your project at a total cost of **Rs. 3,65,293/-**(Rupees Three lakh sixty five thousand two hundred and ninety three only) as 2nd/final installment. The items of expenditure for which the total allocation of Rs **3,65,293/-** has been approved for a period of next one year, are given below:

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Sr. No.	Sanctioned Head	Sanctioned Budget	Expenditure	Balance	Revalidated Amount	Budget Sanctioned for 2nd Installment
1	Remuneration	96,000	91,355	4,645	4,645	91,355
2	Consumables	2,45,000	4,78,318	-2,33,318	-2,33,318	2,45,000
3	Travel	27,500	14,729	12,771	12,771	14,729
4	Others	25,000	14,209	10,791	10,791	14,209
	Total	**3,93,500**	**5,98,611**	**-2,05,111**	**-2,05,111**	**3,65,293**

You are requested to submit final utilization certificate, Statement of Expenditure and final progress report as per the terms and conditions of the sanction order of your project and intermediate communications from the HIMCOSTE.

All the terms and conditions mentioned in the original sanction letter No. SCSTE/F(8)-1/2016 Vol-I-5518 dated---1-8-16----would remain effective during the full tenure of the project.

Thanking you,

Yours sincerely,

Kunal Satyarthi, IFS
Member Secretary(EC)
HIMCOSTE,Shimla(H.P)

Endst No.- SCSTE/F(8)-1/2016(Misc.)- 6075 to 6076 (02) Dated:- 07-03-18

Copy for information and necessary action to:
The Vice Chancellor/Director, Jaypee University, Waknaghat, Solan-173234

(Kunal Satyarthi, IFS)
Member Secretary(EC)
HIMCOSTE,Shimla (H.P)

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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सत्यमेव जयते

File No: DDMA/Project Proposal/2020 - 22555

OFFICE OF THE DEPUTY COMMISSIONER-CUM-CHAIRMAN DISTRICT DISASTER MANAGEMENT AUTHORITY, SOLAN

Dated: 26-03-2021

To

The HOD, Civil Engineering, JUIT, Waknaghat, Distt. Solan

Sub: Release of funds against the project proposal "Geological Hazards mitigation using stone concrete block retaining walls"

Sir,

Your attention is drawn to the discussions held in the coordination meeting held under the Chairmanship of the undersigned, at D.C Office on 23.03.21, and the project proposal submitted by your office on 26/07/20.

In view of the same, this is to inform you that funds have been released from this office for implementation of the project **"Geological Hazards mitigation using stone concrete block retaining walls".** You are hereby requested to begin the implementation of the project at the earliest and apprise this office about the same.

Yours faithfully

(K. C. Chaman, I.A.S.)
Deputy Commissioner-cum-Chairman
DDMA, District Solan (H.P)
Email: - ddmasolan@gmail.com

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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Azadi Ka Amrit Mahotsav

File No: DDMA/MISC-2020-38473

OFFICE OF THE DEPUTY COMMISSIONER-CUM-CHAIRMAN, DISTRICT DISASTER MANAGEMENT AUTHORITY, SOLAN

Dated: 24/02/2022

To

The HOD, Civil Engineering, JUIT,
Waknaghat, Distt. Solan

Sub: **Request for declaration letter regarding the project "Geological hazards mitigation using stone concrete block retaining walls and helical soil nailing"**

Sir/Mam,

This in reference to your office letter no. JUIT/CED/2021-22/003/DC dated 10.02.2022, regarding the subject cited above. In view of the same, this is to certify that the mitigation project "Geological hazards mitigation using stone concrete block retaining walls and helical soil nailing" has been sanctioned by Distt. Disaster Management Authority, Solan, and is being implemented/monitored by the investigators, Dr. Tanmay Gupta(Prof. CED JUIT), Dr. Saurabh Rawat (Asst. Prof. CED JUIT) and Dr. Ashok Gupta(Prof. CED JUIT and Dean Academics, JUIT) since 26/03/2022, for a period of three years. An amount to the tune of Rs.25 Lakhs has been transferred to Dept. of Civil Engineering for implementation of the same.

Yours faithfully

(Zaffar Iqbal) IAS
Addl. Deputy Commissioner
-cum-Nodal Officer
DDMA, District Solan (H.P)

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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Directorate of Innovation, Research and Development

(JIIT Noida, JUIT Waknaghat, JUET Guna & Jaypee University, Anoopshahr)

DRID/Projects/2022 Dated : 05 April 2022

To,

Prof Ashok Kumar Gupta
(Dean A&R), JUIT

SUB : SANCTION LETTER

1. As already informed by email, Hon Chancellor has approved your project (w.e.f 1.4.2022) as per the following details.

(a)	Title	:	Intelligent Evaluation and Rehabilitation of Structures.
(b)	Deliverable for 1st year :		(i) Lab prototype of Early landslide detection system and lab - scale model development of stonecrete blocks and helical soil nailed slope. (ii). Development of android based GUI for real time information and warning on potential landslide threats. (iii) Lab testing of the developed early landslide detection system and landslide protection technique for all weathers.
(c)	Coordinators	:	Prof Ashok Kumar Gupta (Dean A&R), JUIT
(d)	Co-Coordinators	:	Prof Vivek Sehgal (HoD, CSE), JUIT
(e)	Approved budget	:	Rs 35 Lakh (Equipment) Rs 3.0 L (Manpower & Contingency)
(f)	Equipments	:	(i) Accelerometers, gyroscopes, dopple sensors, acoustic sensors, moisture sensors, saturation sensors, ultrasonic sensors, temperature-humidity sensors, programmable development boards, etc. (ii) Plaxis 3D, HeliCap, CSI Bundle, MIDAS software, and cloud storage for data synchronization (iv) Actuator, LVDTs, strain gauges, pressure cells, deflectometers, water jet etc. (v) Stonecrete blocks, prototype helical soil nails.

Contd. 2/-

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2. You are requested to immediately take actions towards initiating research activities so that all the deliverable are achieved in time. The actions towards the purchase of equipment must be immediately started and the purchase should be finalized in the first 2 months. All the projects will be reviewed regularly (on completion of each 3 month period).

3. Coordinator are requested to ensure that only the equipment which is not available in the institute may only be purchased.

4. Coordinator may ensure that equipments purchased with these funds are also available for use to other faculty members.

Prof BR Mehta
Director, DRID

Copy to :-

1. **Pro Chancellor**
2. **VC (JUIT)**
3. **CFO (JUIT)**

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Title	Centre of Excellence in **"INTELLIGENT EVALUATION AND REHABILITATION OF STRUCTURES"**
Core team members	1. Prof. Ashok Kumar Gupta (Dean A&R), JUIT 2. Prof. Vivek Sehgal, HoD CSE JUIT 3. Prof. Ashish Kumar, HoD CE JUIT 4. Dr. Saurabh Rawat, Assistant Professor CE, JUIT 5. Dr. Tanmay Gupta, Assistant Professor CE, JUIT 6. Mr. Chandra Pal Gautam, Assistant Professor CE, JUIT 7. Dr. Emjee Puthooran, Assistant Professor ECE, JUIT 8. Mr. Janardan Verma, Assistant Professor CSE, JIIT 9. Mr. SK Sharma, Project Director, NHAI Shimla 10. Dr. Yash Pal Vasistha, Executive Engineer, HPPWD Shimla
Coordinator	Prof. Ashok Kumar Gupta (Dean A&R), JUIT
Co-Coordinator	Prof. Vivek Sehgal (HoD, CSE), JUIT
Deliverables (Technology, product and application only)	
1 year	1. Lab prototype of Early landslide detection system. 2. Lab scale model development of stonecrete blocks and helical soil nailed slope. 3. Development of android based GUI for real time information and warning on potential landslide threats.
2 year	1. Lab testing of the developed early landslide detection system and landslide protection technique for all weathers. 2. Processing for National/ International Patent filing. 3. Trainings and capacity building of local workers to implement above mentioned technique in collaboration with HPDDMA.
3 year	1. Commercialization of developed solution and prototypes after testing with high reliability. 2. Field implementation of the early landslide detection system. 3. Application of developed mitigation technique on National

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	Highway 5 (Kalka –Shimla Highway) in collaboration with NHAI. 4. Formulation of hazard zone mapping of research area, emergency preparedness guidelines and recorded data set from various sensors.

Funding requirements (pl limit these to essentials only)

Year	Items	Budget
1 year	1. Accelerometers, gyroscopes, doppler sensors, acoustic sensors, moisture sensors, saturation sensors, ultrasonic sensors, temperature-humidity sensors, programmable development boards, etc. 2. High-performance computing systems, software, and cloud storage for data synchronization 3. Lab setup for AI based structural evaluation 4. Stonecrete blocks, prototype helical soil nails. 5. Research Associate - 03 6. Miscellaneous	20 lakhs + 15 lakhs + 5 lakhs + 10 lakhs + 9 lakhs + 1 lakhs = **60 lakhs**
2 year	1. Actuators, data acquisition systems, LVDTs, strain gauges, pressure cells, deflectometers, etc. 2. Unmanned aerial vehicles (UAVs) for advanced research in risk reduction. 3. Site identification and preliminary site testing. 4. Workshop/training	12 lakhs + 8 lakhs + 5 lakhs + 5 lakhs + 9 lakhs + 1 lakhs = **40 lakhs**

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	5. Research Associate - 03 6. Miscellaneous	
3 year	1. Field implementation (Construction equipments, manpower, inspection, and monitoring, etc.) 2. Research Associate - 03 3. Miscellaneous	40 lakhs + 9 lakhs + 1 lakhs = **50 lakhs**
	TOTAL	**150 lakhs**

Scope for commercialization of deliverables	1. Landslide detection and warning system. 2. Landslide mitigation technique (Coupled stonecrete and helical soil nailing method)
List of important stakeholders	1. NHAI 2. HPDDMA 3. HPPWD

30/3/22

Prof. Ashok Kumar Gupta
(Coordinator)

Vivek Sehgal 30/3/22

Prof. Vivek Sehgal
(Co - cordinator)

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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MEMORANDUM OF UNDERSTANDING

between

South Dakota School of Mines & Technology
Rapid City, South Dakota, USA

and

Jaypee University of Information Technology, Waknaghat,
Solan, Himachal Pradesh, India

Jaypee University of Information Technology University (hereafter referred to as "JUIT" and the South Dakota School of Mines & Technology of Rapid City, South Dakota, USA (hereafter referred to as "SDSMT"), believe the development of collaborative academic, educational, and scientific goals are of mutual value, which are set forth in this Memorandum of Understanding (MOU).

All collaborative efforts will be entered into with due diligence given to ethical and professional considerations and standards. Cooperative activities will be developed on the basis of equality and reciprocity, and promoting sustainable partnerships.

Within fields that are mutually acceptable, the following general forms of cooperation will be pursued:

- Staff exchange and collaboration
    - The two institutions agree in principle to the possibility of exchanges by general staff (administrative and technical) and faculty members. The details of such arrangements will be negotiated at the appropriate time and will be governed by the institutional staffing rules and relevant approval processes. The participating institutions shall not be responsible for any private arrangements made by participating staff members concerning exchange of accommodation, vehicles, etc.
- Joint research activities and publications
    - Cooperative research is to be encouraged as individual scholars establish contact and develop mutual interests.
- Each party will encourage continuing education and professional development for teachers, professors, and academic staff, which may include
    - Visits for studying teaching principles and methods
    - Exchange of academic materials and other information
    - Participation in seminars, congresses and meetings
- Student exchange
    - Each party will recommend potential students to participate in an exchange for the matriculation of the other university's appropriate academic programs on a reciprocal basis. The student's acceptance is subject to approval by the host university. The host institution will provide guidance and identify options for students in locating living accommodations and will place the students in appropriate academic programs. Unless otherwise specified in a supplemental written agreement, students will be responsible for meeting their own costs of living and pay tuition and fees to the host institution.

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"JUIT" and SDSMT agree to continue discussions on further cooperative activities as opportunities arise. Both institutions recognize that collaborative efforts will be of mutual benefit and will contribute to an enduring institutional linkage for cooperation in education and research.

Detailed descriptions of additional activities shall be defined in a separate addendum to the MOU. The addendum will include detailed information on the activity, including legal considerations for each university's home country and governing body.

Both universities agree that all additional activities are dependent on the availability of funds. Both universities agree to seek financial support for the activities stated in this MOU.

This Memorandum of Understanding becomes effective on the date of signature. It is valid for five years with the understanding that it can be terminated by either party with six months notice, unless an earlier termination is mutually agreed upon. Revisions or modifications may be proposed at any time, effective from the date of written agreement signed by both parties.

Signed on behalf of
Jaypee University of Information Technology
University
by

Prof. Vinod Kumar
Vice Chancellor

Date: June 13, 2018

Signed on behalf of
South Dakota School of Mines & Technology
by

Dr. James Rankin
President

Date: 08-22-18

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY * WAKNAGHAT * IQAC

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

Memorandum of Understanding

Between

University of Nebraska at Omaha, USA
and
Jaypee Education Systems (JES), India
(JUIT, JIIT and JUET)

Preamble

In 2007, Jaypee Education System (JES) and the College of Information Science & Technology (IS&T) at the University of Nebraska at Omaha (UNO) signed a MoU to explore partnership opportunities in research and education. This agreement was for five years and since then the partnership has matured and continues to grow. UNO students have visited JES for an immersion experience, a student exchange program has been established, a research partnership in Bioinformatics/Biotechnology is being formalized, a plus 2 program is being implemented in collaboration with JUIT, faculty/post-docs have visited both campuses, and customized education/training programs have been offered at multiple JES campus locations.

The goal of this agreement is to continue to build on these successes and renew the long-term commitment to enhance the partnership between the two institutions in all these areas and others that might develop.

Areas of Cooperation

The following have been identified as areas of the partnership that are expected to continue or further developed. These areas of cooperation may be adjusted by mutual consent.

i. Faculty exchange programs (shot-term): The partners will continue to expand the academic faculty/staff between the two institutions for faculty development, on-site teaching, distance learning/education, collaborative research and other areas as deemed of interest by both faculties.

ii. Cooperative research and development projects: The two partners will continue to explore and work on joint collaborative research projects between faculty and/or research groups. Collaborating faculty will approach various funding agencies in both the USA and India to submit joint project proposals.

iii. Customized educational/training programs: Both partners shall explore the possibility of providing customized educational/training and other summer programs for students and faculty that are mutually beneficial.

iv. Student Mobility: The partners will continue to strongly encourage, pursue and support student mobility in both directions. Tuition reciprocity and/or remission support will be worked out on an annual basis.

v. Plus 2 Program at UNO: JES will identify qualified students for the plus 2 track in the graduate programs at UNO's College of IS&T. Detailed requirements for the Plus 2 program will be made available by IS&T to JES.

For the University of Nebraska at Omaha

Hesham Ali, Dean
College of Information Science & Technology

Thomas E. Goutierre
Dean, International Studies and Programs

John Christensen, Chancellor

For Jaypee Education System

Yaj Medury, COO (Education)

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY * WAKNAGHAT * IQAC

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (MOU) is made and entered into as of 09 August, 2018 between Jaypee University of Information Technology, Waknaghat, Solan, Himachal Pradesh – 173234, India and G.K. Skryabin Institute of Biochemistry and Physiology of Microorganisms of Russian Academy of Sciences with an address: 5, Prospect Nauki, Pushchino, 142290 Russia ("Institute"), hereinafter referred to individually as a "Party" or collectively as "Parties".

Background

During their previous meetings and discussions, the University and the Institute have expressed interest to create a long-term institutional partnership in research and education.

This MOU sets forth the understanding of the Parties related to further advance scientific knowledge and discoveries. This partnership also aims at enhancing technological, social and cultural relations of both countries.

This document presents a general framework for such a partnership. It also includes some specifically identified areas of cooperation, which shall be updated from time to time. The terms of co-operation for each specific activity implemented under this MoU shall be mutually discussed and agreed upon in writing by both Parties prior to the initiation of that activity and will be the subject of separate agreements.

This MOU is at-will and may be modified by mutual consent of the authorized officials of the Parties. This MOU shall become effective upon signature by the authorized officials and will remain in effect until modified or terminated by any one of the Partners by mutual consent.

Areas of Collaboration

The following have been identified as possible starting points of the partnership. The areas of cooperation can he further increased by the mutual consent. In many cases specific programs will require other agreements to be separately detailed out and documented.

The Parties wishing to promote co-operation between the two institutions in education and in academic research, agree to explore:

a. Promotion of contact between the research staff, faculty staff, and Ph.D. students of the Parties,
b. Co-operation on academic programs; the development of joint research activities and implementation of joint research projects: Parties will approach funding agencies to submit joint project proposals. Focus will be given to industry-funded projects and those funded by international funding agencies.

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Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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c. Staff exchanges or mutual visits to both institutions; student exchange and/or visiting programs.
d. The exchange of information and data including the results of research collaboration; - e. Organization of joint seminars and conferences.
f. Any other activities viewed to be mutually beneficial.

Mutual Obligations

1. The two Parties hereto undertake to jointly solicit for funds including donor funds, research grants, contributions, subscriptions and such related funds for the purpose of realizing any or all the objectives of the collaboration.
2. The overall Memorandum does not entail any obligation for the two Parties to fund any travels for researchers from the other institution. Provided that funds are available from elsewhere (e.g. concrete collaborative projects), both Parties will facilitate practical arrangements related to study visits from the collaborating institution including office accommodation and necessary administrative functions (such as flight reconfirmation and hotel reservation) to enable them to carry out program objectives.
3. Both institutions shall seek waiver of duty and value added tax applicable on any equipment and materials for use by students and staff participating in this collaboration. As a general rule, the title and custody of any equipment acquired in the course of the collaboration shall remain with the host institution upon the expiry of that particular project as specified in individual "agreements of collaboration".
4. Both institutions shall abide by current international guidelines on good research practice and ethics available in relation to all research activities.
5. Both institutions further agree to bear the cost of administering the program on such terms as shall be mutually agreed upon from time to time.
6. Both Parties shall make rules governing the use of their respective facilities including laboratories, library and workshops where such facilities are used to conduct any of the functions of this collaboration as specified in 'agreements of collaboration' regarding each individual project.
7. Both Parties jointly and independently agree to make available suitable facilities and personnel as and when required and on such terms as to fees, remuneration, insurance, and any other incidents thereto as specified in 'agreements of collaboration' regarding each individual project.
8. The Parties shall share both in gains and losses of the collaboration including skills, inventions/patents, profits and liabilities whether pecuniary or otherwise provided always Intellectual Property rights shall be shared equally.
9. The Parties shall keep each other indemnified against all damages to or losses resulting from the fault of their respective agents and/or servants.

Intellectual Property

Each institution will adhere to the intellectual laws of their respective nations. Intellectual property developed during the visit of an exchange student will be governed by the rules of the host institute unless otherwise specified by an alternate

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Jaypee University of Information Technology
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agreement. The two institutions shall jointly own results of clearly defined collaborative projects. Whenever one institution receives any information from the partner under a clearly defined non-disclosure agreement, necessary steps will be taken to protect the intellectual property received.

Material Transfer Agreement

Any and all materials transferred between the parties shall be subject to an acceptable 'material transfer agreement' signed by the parities and appended to the agreement of collaboration regarding the individual projects.

Force Majeure

Either Party shall promptly notify the other party, in writing, of any situation or event arising from circumstances beyond their control, which they could not have reasonably foreseen, and which make the performance of all or part of the parties obligations under this contract impossible. Upon notification of the occurrence of such a situation or event, the performance of this contract shall be deemed to be postponed for a period of time equivalent to that caused by the Force Majeure and reasonable period not exceeding one (1) week thereafter shall be allowed for remobilization to continue the performance of the contract.

Review and Amendments

This MOU may be amended or revised if both Parties agree. Such amendments or revision shall be effective from the date of signature. Amendments may be decided at any time and shall be made in writing upon mutual consent of the parties.

Termination of Memorandum

This MOU may be terminated with immediate effect by mutual agreement between the parties or by either party giving the other not less than six (6) months notice in writing.

Validity

This agreement is valid for an initial period of five years and becomes effective from the date it is signed by the partners. The partnership period may be extended by mutual consent. In case one partner wishes to cancel the contract, intimation will have to be sent by June of that year. In that case the agreement will terminate at the end of year i.e. 31 December.

Coordination

In this Partnership, Alexey A. Leontievsky, Director of IBPM shall be the Coordinator from Russia and Vinod Kumar, Vice Chancellor of the University shall be the Coordinator from India.

In Witness Whereof, the Parties hereto have executed this Memorandum of Understanding

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY * WAKNAGHAT * IQAC

SIGNED for and on behalf of:
Jaypee University of Information Technology,

14. 9th Aug 2018

Vinod Kumar
Vice Chancellor

G.K. Skryabin Institute of Biochemistry and Physiology of Microorganisms of Russian Academy of Sciences

Alexey A. Leontievsky
Director

Date 12.09.2018

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

A
REPORT ON
INDUSTRIAL VISIT
TO
Minchy Food product ltd.
Sadhupul-Kandaghat

Minchy's
- The richness of fresh fruits in every bottle.

ON 19th AUGUST 2017
BY STUDENTS OF
BIOTECHNOLOGY

ORGANIZED BY
Department of Biotechnology
JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY-
WAKNAGHAT

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
juit
विद्या तत्व ज्योतिसम

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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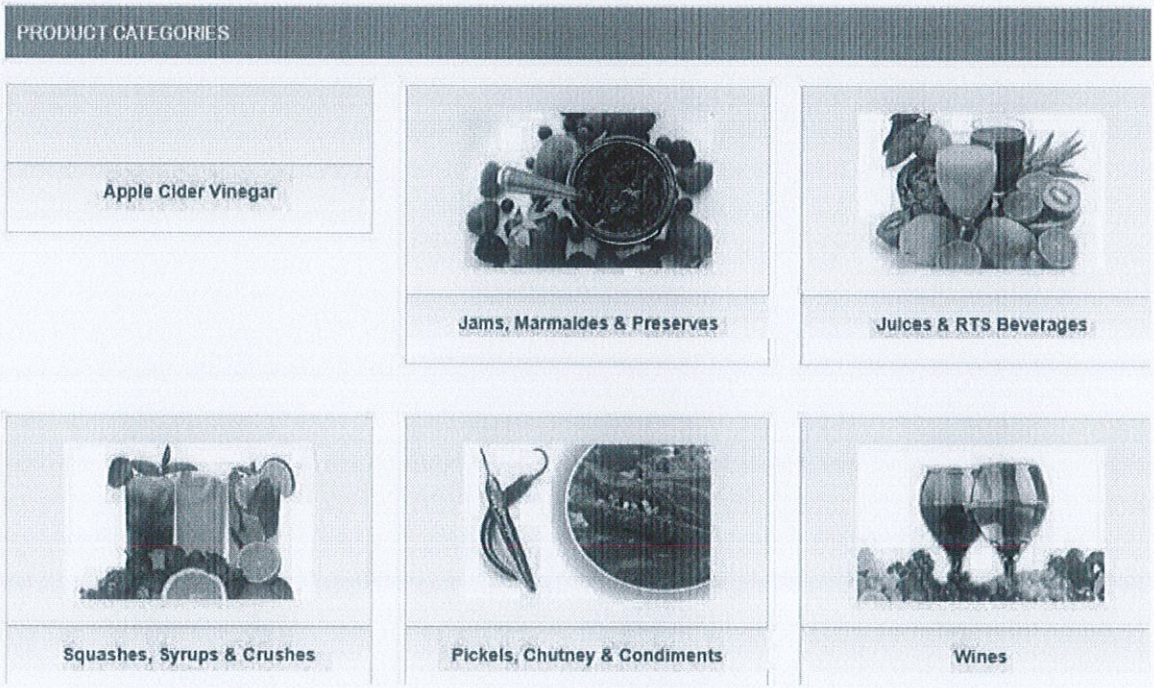
WAKNAGHAT

Industrial visit was carried out at Minchys food product ltd- sadhupul, kandaghat on 19th August, 2017 especially for semester one student. The main objective behind the visit was to make student aware about how various activities related to food product processing, packing marketing, are carried out in company and give them feel of biotechnology applications as soon as they start there course.

I along with 33 students and one faculty member (Dr. Poonam Sharma) left for visit at 10 a.m. and took about one hour to cover the distance. The company is located in Sadhupul, tehsil kandaghat, Distt. Solan- H.P.

As soon as we reached company we were guided by Mr sunil to the production house where a orientation of company was given by Mr. Varinder (GM-Production) about history and main products.



As a food product company, Minchys is active in Himachal Pradesh especially in Solan and Shimla district. Their greatest asset is their brand and its values. Their brand promises the richness of fresh fruit in every packing.

Assistant Registrar (Academics)
Jaypee University of Information Technology
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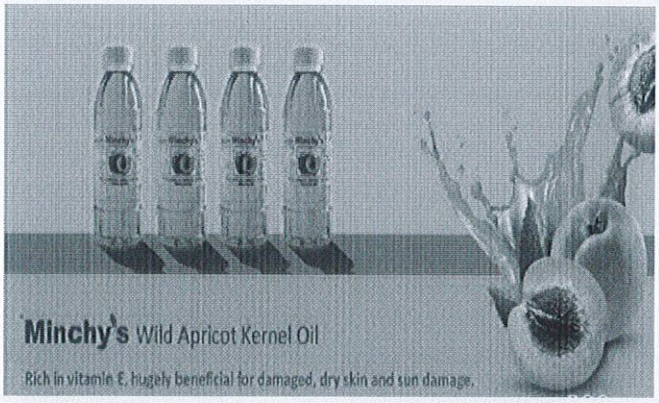
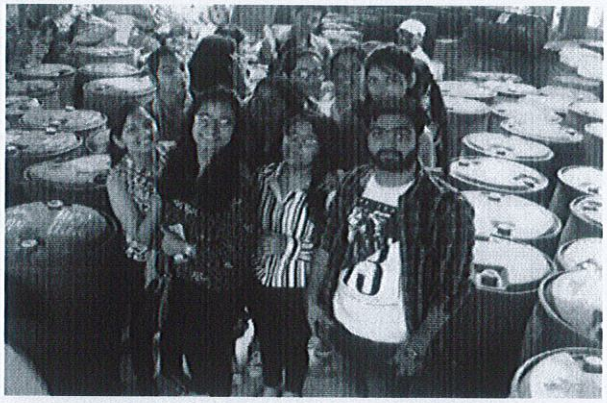
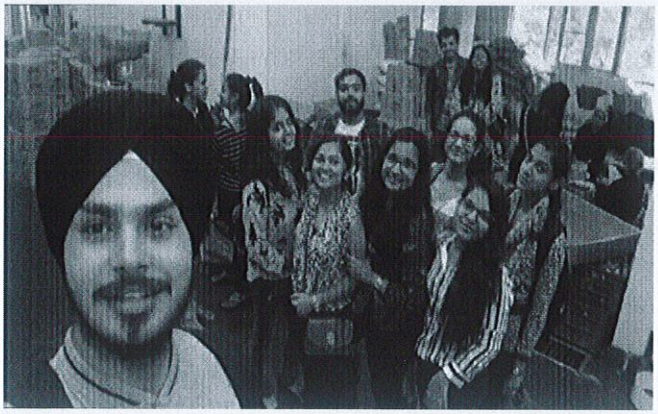
After introduction, all students were divided in two groups of 17 and 16 students and were headed by one staff member of company who helped them to understand how production is carried out in company and how company reach their customer.

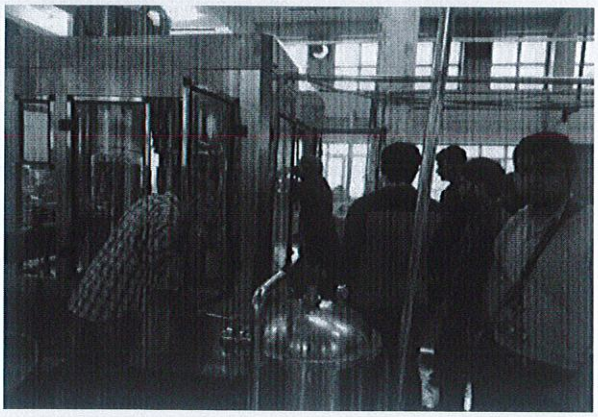
Maximum production in company is carried out by means of machinery subdivide in various activities like inception of raw material, mixing process, pasturization, covering the product and then converting it into finished products. Finally Finished products are packed and are sealed where production batch no is embossed for its future verification required.

We took almost two hour to see complete set of production which was followed by questions of students. I appreciate staff member who guided students with each and every question with detailed answers.









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It is rightly said that "See & know' is better than 'read & learn'. Students have got real feel of company's working after this visit. They got a chance to transfer their theoretical knowledge to practical implication. This will even help students to understand subject matter clearly in future also.

Me and Dr. Sharma along with student would like to extend our gratitude to company for permission and support they gave to make our visit a success with accomplishment of objective and our HOD Sir, Dr. Sudhir Kumar Syal, Director sir, Dr. Sameer Dev Gupta and V.C Sir, Dr. Vinod kumar for arranging this visit for our student.

Thanks

Dr. Abhishek

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MEMORANDUM OF UNDERSTANDING

Between

Magbro Healthcare Pvt. Ltd

and

Jaypee University of Information Technology - Solan Himachal Pradesh

JUIT Waknaghat offers a challenging academic environment to its students. It aims to instill the habit of life-long learning and therefore, provides a learner-centric rather than a teacher-centric educational process. The Department of Biotechnology and Bioinformatics Jaypee University of Information Technology Waknaghat imparts education to equip students with modern skills compatible to the needs of industry, academia, government and non-government organizations. The Department is actively involved in research by having the distinction of running externally funded R & D projects worth Rs. 25 crore* from various Govt. of India agencies such as the Department of Biotechnology, Department of Science & Technology, DRDO, Ministry of Environment and Forest, ICMR, and industries. Recently Department has been funded by DBT under Skill Vigyan Program in Biotechnology and aspiring similar type of funding in future as well. The major objective of this program is to provide skills to the young graduates to upgrade their existing skills, so that the students are able to setting up self-employment ventures and for salaried jobs in the relevant industries.

For the accomplishment of the mentioned objective, Jaypee University of Information Technology-Solan Himachal Pradesh offers and agrees to enter into mutual consent with the "**Magbro Healthcare Pvt Ltd**" in the form included in the tie-up document to provide a platform to the young talent in the form of skills development for sustainable livelihood. One of the identified areas is Health care industries.

It shall be pleasure for us to pay a token of honorarium and transportation expenses for your visit and kind participation in the mentioned activities as per your availability in this long term venture.

We would be very delight to have your positive response in this activity.

Prof. Vinod Kumar
Vice Chancellor
Jaypee University of Information Technology-
Solan, HP- 173234

27/05/2020

Prof. Sudhir Kumar
HOD- Department of Biotechnology & Bioinformatics
Jaypee University of Information Technology
Solan, HP - 173234

Mr. Sudhir Maingi
Managing Director
Magbro Healthcare Pvt Ltd
Nalagarh Solan
HP--174101

MAGBRO HEALTHCARE PVT. LTD. * NALAGARH *

DR. SUDHIR KUMAR
Professor & Head
Deptt. of Biotechnology & Bioinformatics
Jaypee University of Information Technology
Waknaghat, Solan-173234 (H.P.)

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

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A MEMORANDUM OF UNDERSTANDING FOR COLLABORATION FOR DOCTORAL PROGRAM LEADING TO DOCTOR OF PHILOSOPHY (PH D) DEGREE BETWEEN ICAR-NATIONAL BUREAU OF ANIMAL GENETIC RESOURCES, KARNAL AND JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN, HIMACHAL PRADESH

ICAR-NATIONAL BUREAU OF ANIMAL GENETIC RESOURCES, KARNAL and JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN, HIMACHAL PRADESH hereby sign the memorandum of understanding (MoU) for jointly undertaking the research program with the following terms and conditions and agree to carry out their respective responsibilities as detailed in the MoU.

Terms and conditions:

- Advisor/Supervisor/Guide: The criterion for allocation of major guide/advisor may be decided by mutual consent. Supervisor I will be from PhD degree awarding institution (JUIT) and Supervisor 2 will be from partnering institution (NBAGR). According to JUIT ordinance both supervisor/guide have equal share/weightage toward award of degree.
- The student shall be uniformly charged a fee of Rs. 30,000/- per semester at ICAR-NBAGR. The fee structure may be revised by ICAR-NBAGR. Student will be required to do lab work at ICAR-NBAGR for at least one year for PhD thesis.
- Fee of JUIT will be applicable as per fee structure including thesis submission/evaluation and miscellaneous fee as per JUIT guidelines.
- The students need to fulfill the criteria including:
    - Course work of one semester as per JUIT Ordinance for Ph.D Program.
    - The Scholar has to present his/her progress before the Doctoral Progress Monitoring Committee (DPMC) at the end of each semester. DPMC members include Advisory members from JUIT and both supervisors as per JUIT ordinance for Ph.D Program.
    - The Scholar submits at least four research paper in SCI/Scopus indexed journals for Ph.D thesis submission as per JUIT Ordinance for Ph.D Program.
- The norms of publications in peer-reviewed journals/conferences: Scholars as the first author followed by both the Supervisors. Authors sequence and Corresponding will be depending upon their scientific input. Additional authors can be included depending upon their contribution to the research work (from NBAGR), Karnal and can be decided after due approval of competent authorities.
- The ownership of any intellectual properties, generated by research performed by the Ph.D scholar will be shared between the ICAR-NBAGR, Karnal and the JUIT, Waknaghat depending upon the intellectual contributions in the Ph.D work. The IPR policy will be as per ICAR and JUIT Guidelines for Intellectual Property Management and Technology Transfer/ Commercialization as amended from time to time, with mutual consent.

Executed this 20 day of July, 2021 for the period of 05 years, and further extendable with the consent of both the parties.

The authorized representatives of both parties hereunto affixed their signature below:

Director, NBAGR, Karnal

Vice Chancellor, JUIT, Waknaghat

(Dr. Tirtha Raj Singh)

Prof. Sudhir Kumar
Head, BT & BI

Assistant Registrar (Academics)
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)

हिमाचल प्रदेश HIMACHAL PRADESH

396770

MEMORANDUM OF UNDERSTANDING (MoU)

The Jaypee University of Information Technology (JUIT), Waknaghat was set up by Act No. 14 of 2002 vide Extraordinary Gazette notification of Government of Himachal dated May 23, 2002 and approved by the University Grants Commission under section 2(f) of the UGC Act. The University commenced academic activities from July 2002.

Central Potato Research Institute (CPRI), Shimla-171001 HP a Constitutional Research Institute of Indian Council of Agriculture Research (ICAR), a society registered under the registration of societies Act (Act XX1 of 1860). The institute has scientific staff with specializations in Agronomy, Biotechnology, Biochemistry, Crop Improvement, Plant Protection, Plant Physiology and Post Harvest Technology, Seed Production, Social Sciences, Computer sciences, GIS & Remote sensing, etc. These scientists are well trained in their field in India and abroad. There are several prestigious international collaborative projects ongoing at the CPRI.

It is, therefore, proposed to extend collaborative efforts between the Jaypee University of Information Technology, Waknaghat henceforth being referred as JUIT, Waknaghat which is having adequate facilities in post graduate teaching and

CPRI

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Research with that of Central Potato Research Institute, Shimla henceforth referred as CPRI, Shimla, which has well-equipped laboratories having most modern scientific instruments/facilities and also excellent physical and technical facility for doing research on potato. This Memorandum of Understanding entered into on 20 th day of May, 2013 at Shimla between CPRI, Shimla and the JUIT, Waknaghat - a University offering educational courses such as B. Tech. in Bioinformatics, B. Tech. Biotechnology, M. Tech. Dual Degree Biotechnology, B.Pharm-M.Pharm Practice, Ph.D. Bioinformatics and Ph.D. Biotechnology.

Now this Memorandum of Understanding witnesses that:

The JUIT, Waknaghat shall offer Ph.D. degrees to JRFs/SRFs/RAs/ and other candidates working at the CPRI, Shimla and fulfilling the educational qualifications as per the following requirements of the JUIT, Waknaghat.

The minimum entry qualification for admission to the PhD programme shall be:

(a) A Master's degree in Engineering / Technology / Life Sciences / Humanities and Social Science in the relevant area or any other equivalent qualification recognized by the University.

(b) A Bachelor's degree in Engineering / Technology of the University or any equivalent qualification recognized by the University. Further in such cases, the student must also have an excellent academic record throughout besides having a minimum of two years work experience, in a company of repute in the relevant area.

(c) The minimum cumulative grade point average (CGPA) / percent marks; in each category shall be as follows: -

(i) Master's Degree: CGPA of 6.75 on scale of 10 or equivalent or 60% in aggregate, where marks are awarded

(d) The eligibility criteria may be revised while formulating the admission procedure for the year after being duly approved by the Research Board.

CPRI

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(e) A tuition fee of Rs. 10,000 (ten thousand only) will be charged from Ph.D. scholars at the time of registration in every semester. The tuition fees of the respective course may be fixed and revised as and when required.

(f) The Memorandum of Understanding also envisages that the Ph.D. scholars will be assigned Research Supervisor from the CPRI, Shimla and the Co-supervisor can be a University faculty from JUIT, Waknaghat.

(g) The JUIT, Waknaghat will provide laboratory bench space to the Ph.D. scholar for carrying out experimental work. The cost of research supplies to be incurred in the research work will be met by the Ph.D. scholar.

(h) The ownership of any intellectual properties, generated by research performed by the Ph.D. scholar will be shared between the CPRI, Shimla and the JUIT, Waknaghat depending upon the intellectual contributions in the Ph.D. work.

For and on behalf of CPRI, Shimla

निदेशक / Director
केन्द्रीय आलू अनुसंधान संस्थान
Central Potato Research Institute
शिमला / Shimla - 171001

For and on behalf of JUIT, Waknaghat

DIRECTOR
Jaypee University of Information Technology
Waknaghat, Distt. Solan (H.P.)-173234

Witness:

1 20/5/13

2

1.

2.

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Collaborative Research Acknowledgement

This is to inform that I, Prof. (Dr.) ***Pradeep Verma***, Professor at Department of Microbiology, Central University of Rajasthan, Ajmer, India, Distinguished ***Expert***, & working as collaborator with Dr. Jata Shankar, Genomic laboratory, Jaypee University of Information Technology, Solan HP. Our collaborative works on 'Insight into multicopper oxidase laccase from *Myrothecium verrucaria* ITCC-8447: a case study using in silico and experimental analysis' have been published in high impact journal JOURNAL OF ENVIRONMENTAL SCIENCE AND HEALTH, PART B. In another project, 'Multicopper oxidase (MCO) laccase from *Stropharia* sp. ITCC-8422: an apparent authentication using integrated experimental and in silico analysis' have been published in 3 Biotech, respectively. We are working on various research aspects with the aim to provide consolidated information to the students, academicians and researchers.

Best regards,

20/04/22

Dr. Pradeep Verma
Professor, Department of Microbiology
Central University of Rajasthan, Bandarsindri, Kishangarh
Ajmer-305801, Rajasthan, India
Phone: +91-1463-238734; Mobile: +91-9414071791
Email: pradeepverma@curaj.ac.in; vermaprad@yahoo.com
Website: www.vermapradeep-lab.com and www.curaj.ac.in

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AMITY UNIVERSITY
UTTAR PRADESH

AMITY INSTITUTE OF BIOTECHNOLOGY

Collaborative Research Acknowledgement

This is to inform that I, Prof. (Dr.) **Pooja Vijayaraghavan,** Amity Institute of Biotechnology (AIB), NOIDA, UP, India, Distinguished ***Expert* in Mycology, &** working as collaborator with Dr. Jata Shankar, Genomic laboratory, Jaypee University of Information technology, Solan HP. Our collaborative works on 'cis-9-hexadecenal, a natural compound targeting cell wall organization, critical growth factor, and virulence of Aspergillus fumigatus. *ACS omega*, *5*(17), 10077-10088.' have been published in high impact journal. In another project, SEM and qRT-PCR revealed quercetin inhibits morphogenesis of Aspergillus flavus conidia via modulating calcineurin-Crz1 signalling pathway, *Mycology*, *11*(2), pp.118-125 have been published. Other publication includes, Hoda, Shanu, Maansi Vermani, Rajesh K. Joshi, Jata Shankar, and Pooja Vijayaraghavan. "Anti-melanogenic activity of Myristica fragrans extract against Aspergillus fumigatus using phenotypic based screening." *BMC Complementary Medicine and Therapies* 20, no. 1 (2020): 1-13 and Molecular insights into development and virulence determinants of Aspergilli: A proteomic perspective." *Frontiers in Cellular and Infection Microbiology* 8 (2018): 180. We are working on various research aspects with the aim to provide consolidated information to the students, academicians and researchers.

Thanks & regards,

Prof. (Dr.) Pooja Vijayaraghavan
Head: Corporate Resource Center-AIB
Coordinator: Admissions-AIB
Jt. Co-ordinator: Webinar and Guest lecture-AIB
Lab-120, Anti-mycotic and Drug Susceptibility Lab
J-3 Block, First Floor
Amity Institute of Biotechnology (AIB)
Amity University Uttar Pradesh
Sector-125, Noida-201303
Email: vrpooja@amity.edu

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Fwd: Spoken Tutorial, IIT Bombay - Change in Training Policy
Punit Gupta
to:
sp.ghrera
06/25/2018 10:29 AM
Show Details

---------- Forwarded message ----------
From: <administrator@spoken-tutorial.org>
Date: Tue, Jun 19, 2018 at 4:01 PM
Subject: Spoken Tutorial, IIT Bombay - Change in Training Policy
To: punit.gupta@juit.ac.in

Dear Faculty Organiser,

We are truly happy to be associated with you as a Knowledge Partner for the past few years. We provided Spoken Tutorial Software/ IT Courses training in your college and have grown together. The team at IIT Bombay has continued to offer new and exotic courses of world class quality, so essential for our students to get an employability worthy Skill Set.

The new academic year will start soon - this is the right time to plan. You have already submitted planners & calendars in advance, covering the next 2 semesters. Be assured we will be with you all the way guiding, enabling & enhancing the quality of our delivery. In this connection, I wish to inform you of a policy change that has come to us from MHRD Govt. Of India. Effective July, 2018 we are expected to charge a nominal annual amount from the colleges we are working with. This decision has been driven by the fact that we are a mature and successful program, therefore from now on need to generate revenue and sustain our Project financially, on our own. The amount is ***Rs. 25,000 per year*** to be paid by colleges for an unlimited number of Training Workshops & Certification Tests taken by any number of their students & staff. There is no upper limit. Note also, we will not charge anything to colleges who have just come into the program and might train less than 100 students in a year.

We did extensive enquiries with our Engg., as well as Arts, Science, Commerce colleges and found out pleasantly that this amount was very manageable. In fact, considering a simple calculation for providing Basic Computer Skills - say getting our LibreOffice package training with Certificates of Word Processing, Spreadsheet & Slide presentation at Rs.200/ student - just for 125 students the amount works out to a total of Rs. 25000/year/college. Most of you will be training 100s of students as you move to additional courses and more departments. You will roll out our Drupal, OpenFOAM, Java, C/C++, PHP, Linux, GIT and many other lucrative courses. Certainly it is tremendous value for money. At the outset, this news could come as a surprise, as till now, the Spoken Tutorial training programs were free of cost. But it is my belief that this move will be accepted in a positive way.

The Information Module & Payment Link on our website will be live in July, and we will keep you informed. In the meanwhile -

1. Please discuss with your management Principal/ Director/ VC et al. about the policy change.
2. After approval/permission, please send us the name & contact details of the point person in your college who will access the payment link and take care of the financial transaction. This person will mostly be from the Accounts/Finance section of your college.

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Do drop a mail immediately to your respective state Training Coordinator, informing them of your college's decision, so we can proceed with the training. We guarantee our continued high quality services to all. If you have questions, don't hesitate to contact the Training Coordinator of your respective state.

Yours Sincerely,

Shyama Iyer
National Coordinator - Training
Spoken Tutorial, IIT Bombay
NMEICT, MHRD, Govt. Of India

--

Regards
Dr. Punit Gupta
MACM, MIEEE, MCSI
Assistant Professor (Sr. Grade)
Department of Computer Science & Engineering and InformationTechnology

1. Refer to change in policy for Spoken Tutorial. (A)
2. So far spoken tutorial programme was free of cost. Now MHRD has issued a policy whereby we have to pay Rs 25000/ per year (for any and all courses and student). This fee will be payable from July 2018.
3. In view of above it is proposed to sanction } A'
a sum of Rs 25000/- to be paid annually and
specifically to pay a sum of Rs 25000/- for
the year 2018.

20/6/2018

S P GHRERA

Dir & Academic Head

Appd 'A'

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Dr. Hemant

19/7/2018

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Faculty members of CSE & IT completed Professional Courses at Infosys Springboard

S.No.	First Name	Last Name	Course Completed
1	Ruchi	Verma	Computer Vision 101
2	Amol	Vasudeva	Computer Vision 101
3	P.K.	Gupta	Computer Vision 101
4	Ravindara	Bhatt	Computer Vision 101
5	Ruchi	Verma	Introduction to Artificial Intelligence
6	Amol	Vasudeva	Introduction to Artificial Intelligence
7	P.K.	Gupta	Introduction to Artificial Intelligence
8	Ravindara	Bhatt	Introduction to Artificial Intelligence
9	Ruchi	Verma	Introduction to Data Science
10	Amol	Vasudeva	Introduction to Data Science
11	P.K.	Gupta	Introduction to Data Science
12	Ravindara	Bhatt	Introduction to Data Science
13	Ruchi	Verma	Introduction to Deep Learning
14	Amol	Vasudeva	Introduction to Deep Learning
15	P.K.	Gupta	Introduction to Deep Learning
16	Ravindara	Bhatt	Introduction to Deep Learning
17	Ruchi	Verma	Introduction to Natural Language Processing
18	Amol	Vasudeva	Introduction to Natural Language Processing
19	P.K.	Gupta	Introduction to Natural Language Processing
20	Ravindara	Bhatt	Introduction to Natural Language Processing
21	Ruchi	Verma	Introduction to Python
22	Amol	Vasudeva	Introduction to Python
23	P.K.	Gupta	Introduction to Python
24	Ravindara	Bhatt	Introduction to Python
25	Ruchi	Verma	Introduction to Robotic Process Automation
26	Amol	Vasudeva	Introduction to Robotic Process Automation
27	P.K.	Gupta	Introduction to Robotic Process Automation
28	Ravindara	Bhatt	Introduction to Robotic Process Automation
29	Ruchi	Verma	Programming Fundamentals using Python - Part 1
30	Amol	Vasudeva	Programming Fundamentals using Python - Part 1
31	P.K.	Gupta	Programming Fundamentals using Python - Part 1
32	Ravindara	Bhatt	Programming Fundamentals using Python - Part 1
33	Ruchi	Verma	Programming Fundamentals using Python - Part 2
34	Amol	Vasudeva	Programming Fundamentals using Python - Part 2
35	P.K.	Gupta	Programming Fundamentals using Python - Part 2
36	Ravindara	Bhatt	Programming Fundamentals using Python - Part 2

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Student's completed Professional Certification courses at Infosys Springboard

S.No.	Roll No.	First Name	Last Name	Awarded Certification
1	191201	Aakash	Karad	Python Programmer Certification
2	191204	Deepanshu kumar	Kain	Python Programmer Certification
3	191205	Kunal S	Bhandari	Python Programmer Certification
4	191207	Nidhi	Rajput	Python Programmer Certification
5	191208	Aisha	Sajjad	Python Programmer Certification
6	191209	Shivansh	Saigal	Python Programmer Certification
7	191211	Anushka	Srivastava	Python Programmer Certification
8	191213	Ananya	Mishra	Python Programmer Certification
9	191215	Shivansh	Thakur	Python Programmer Certification
10	191216	Nikhil	Thakur	Python Programmer Certification
11	191217	Piyushika	Sachdeva	Python Programmer Certification
12	191218	Ananya	Joshi	Python Programmer Certification
13	191219	Himanshu	Sharma	Python Programmer Certification
14	191220	Saksham	Chaturvedi	Python Programmer Certification
15	191222	Reet	Sethi	Python Programmer Certification
16	191223	Prishita	Singh	Python Programmer Certification
17	191226	Vipasha	Rana	Python Programmer Certification
18	191227	Kunika	Sharma	Python Programmer Certification
19	191228	Aman	Gupta	Python Programmer Certification
20	191229	Piyush	Sharma	Python Programmer Certification
21	191230	Sahil	Thakur	Python Programmer Certification
22	191232	Ria	Singla	Python Programmer Certification
23	191233	Adhiraj	Gupta	Python Programmer Certification
24	191236	Ria	Mahajan	Python Programmer Certification
25	191237	Rishabh	Bharota	Python Programmer Certification
26	191239	Varun	Mishra	Python Programmer Certification
27	191241	Shivam	Sharma	Python Programmer Certification
28	191242	Simarjot	Singh	Python Programmer Certification
29	191245	Saksham	Thakur	Python Programmer Certification
30	191248	Devesh	Vyas	Python Programmer Certification
31	191249	Ayush	Pathania	Python Programmer Certification
32	191250	Shubham	Patial	Python Programmer Certification
33	191255	Kashik	Baglwan	Python Programmer Certification
34	191257	Prince	Nag	Python Programmer Certification
35	191258	Abhishek	Sharma	Python Programmer Certification
36	191259	Anirudh pal	Dev	Python Programmer Certification
37	191260	Shivam singh	Negi	Data Science Foundation Certification

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38	191260	Shivam singh	Negi	Python Programmer Certification
39	191262	Ayush	Dharmani	Python Programmer Certification
40	191263	Kuldeep	Mishra	Python Programmer Certification
41	191264	Harshit	Singh	Python Programmer Certification
42	191266	Vipul	Sharma	Python Programmer Certification
43	191267	Sushant	Rohan	Python Programmer Certification
44	191268	Priyansh	Khatri	Python Programmer Certification
45	191270	Divyansh	Mandhan	Python Programmer Certification
46	191272	Kunwar pratap	Singh	Python Programmer Certification
47	191273	Shivam	Dabral	Python Programmer Certification
48	191275	Ajay	katyal	Python Programmer Certification
49	191276	Piyush	Singh	Python Programmer Certification
50	191277	Archit	Dogra	Python Programmer Certification
51	191281	Parth	Purwar	Python Programmer Certification
52	191283	Sachin	Sharma	Python Programmer Certification
53	191284	Samanvaya	Tripathi	Python Programmer Certification
54	191285	Kritika	Pathak	Python Programmer Certification
55	191286	Vatsal	Singh	Python Programmer Certification
56	191287	Abhishek	Mishra	Python Programmer Certification
57	191288	Pragam	Kaistha	Python Programmer Certification
58	191289	Shaan	Srivastava	Python Programmer Certification
59	191290	Saransh	Saini	Python Programmer Certification
60	191291	Mangal chhotelal	Gupta	Python Programmer Certification
61	191292	Nitesh	Tyagi	Python Programmer Certification
62	191294	Aman	Tiwari	Python Programmer Certification
63	191297	Utkarsh	Bhatnagar	Python Programmer Certification
64	191304	Tarun	Soni	Python Programmer Certification
65	191305	Harshit	Sinha	Python Programmer Certification
66	191312	Hridyesh	Khandelwal	Python Programmer Certification
67	191313	Nikunj	Dubey	Python Programmer Certification
68	191320	Piyush	Kanungo	Python Programmer Certification
69	191322	Aryan	Srivastava	Python Programmer Certification
70	191324	Ritik		Python Programmer Certification
71	191325	Sumit	Kumar	Python Programmer Certification
72	191326	Ishita	goyal	Citizen Data Science using Python Certification
73	191326	Ishita	goyal	Python Programmer Certification
74	191327	Lalita	Gupta	Python Programmer Certification
75	191328	Yasharth	.	Python Programmer Certification
76	191329	Shreesh	Tripathi	Artificial Intelligence Primer Certification
77	191329	Shreesh	Tripathi	Python Programmer Certification
78	191330	Aryaman	Sinha	Artificial Intelligence Primer Certification

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79	191332	Sparsh	Aggarwal	Python Programmer Certification
80	191335	Abhishek	Thakur	Python Programmer Certification
81	191337	Narendra bahadur	Verma	Python Programmer Certification
82	191338	Shubham	Kumar	Artificial Intelligence Primer Certification
83	191338	Shubham	Kumar	Python Programmer Certification
84	191340	Shivam	Gour	Python Programmer Certification
85	191347	Aharnish	Dwivedi	Python Programmer Certification
86	191348	Harshit	Singh	Python Programmer Certification
87	191349	Siddhant	Tyagi	Python Programmer Certification
88	191350	Navya	Yadav	Python Programmer Certification
89	191351	Mohit	Mayank	Artificial Intelligence Primer Certification
90	191351	Mohit	Mayank	Python Programmer Certification
91	191352	Malay	Srivastava	Python Programmer Certification
92	191353	Divyansh	Joshi	Artificial Intelligence Primer Certification
93	191353	Divyansh	Joshi	Python Programmer Certification
94	191354	Gautmi	Singh	Python Programmer Certification
95	191358	Shubham	Kumar	Associate in IT Foundation Skills (Python)
96	191358	Shubham	Kumar	Python Programmer Certification
97	191359	Raghav	Verma	Python Programmer Certification
98	191360	Aditya	Singh	Python Programmer Certification
99	191361	Tarun	Bhardwaj	Python Programmer Certification
100	191362	Harshul	Choudhary	Python Programmer Certification
101	191363	Shreyansh	Puri	Python Programmer Certification
102	191365	Samarth	Sharma	Python Programmer Certification
103	191366	Ujjwal	Rajput	Python Programmer Certification
104	191367	Abhishek	Kumar	Artificial Intelligence Primer Certification
105	191367	Abhishek	Kumar	Python Programmer Certification
106	191368	Kush	Verma	Python Programmer Certification
107	191369	Harshit	Saxena	Artificial Intelligence Primer Certification
108	191370	Yashasvi singh	Rathore	Artificial Intelligence Primer Certification
109	191370	Yashasvi singh	Rathore	Python Programmer Certification
110	191372	Mukund	Soni	Python Programmer Certification
111	191373	Vaibhav	Jariyal	Python Programmer Certification
112	191375	Paritosh	Sengar	Python Programmer Certification
113	191376	Ashutosh	Kumar	Python Programmer Certification
114	191378	Kaushik	Deka	Python Programmer Certification
115	191380	Prazwal	Thakur	Python Programmer Certification
116	191381	Suveer	Sharma	Python Programmer Certification
117	191382	Divyansu	.	Python Programmer Certification
118	191385	Mohit	Gautam	Python Programmer Certification
119	191386	Manan	Mehta	Python Programmer Certification

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120	191387	Sarthak	Kumar	Python Programmer Certification
121	191389	Shreya	Srivastava	Associate in IT Foundation Skills (Python)
122	191389	Shreya	Srivastava	Python Programmer Certification
123	191390	Arj	Srivastava	Python Programmer Certification
124	191391	Achyut	Tiwari	Python Programmer Certification
125	191392	Akshat	Tripathi	Python Programmer Certification
126	191394	Shivam kumar	Mishra	Python Programmer Certification
127	191395	Ankit	Mishra	Python Programmer Certification
128	191396	Pushp	Jain	Python Programmer Certification
129	191397	Yash	Bhardwaj	Python Programmer Certification
130	191398	Abhinav	Jain	Python Programmer Certification
131	191400	Vasundhara	Pandey	Python Programmer Certification
132	191401	Aryan	Agnihotri	Python Programmer Certification
133	191402	Shubham	Singh	Python Programmer Certification
134	191403	Rohit	Sharma	Python Programmer Certification
135	191404	Adarsh	Kumar	Python Programmer Certification
136	191405	Shaswat	Sahu	Python Programmer Certification
137	191406	Mayank	Ekaghara	Python Programmer Certification
138	191407	Arjun	Seth	Python Programmer Certification
139	191408	Shubham	.	Python Programmer Certification
140	191409	Aryan	Chugh	Python Programmer Certification
141	191410	Akshat gopal	Sundriyal	Python Programmer Certification
142	191411	Anshul	Jaiswal	Python Programmer Certification
143	191413	Nandini	Singh	Python Programmer Certification
144	191414	Simran	Verma	Python Programmer Certification
145	191416	Tanmay	Agarwal	Python Programmer Certification
146	191417	Abhimanyu	Singh Anand	Python Programmer Certification
147	191418	Anushka	Gupta	Python Programmer Certification
148	191419	Aman	Kumar	Python Programmer Certification
149	191422	Ajay	Yadav	Python Programmer Certification
150	191423	Varsha	Singh	Associate in IT Foundation Skills (Python)
151	191423	Varsha	Singh	Python Programmer Certification
152	191424	Shivank	Prajapati	Python Programmer Certification
153	191426	Aditya	Srivastava	Python Programmer Certification
154	191427	Manya	Malhotra	Python Programmer Certification
155	191429	Raghav	Mangal	Python Programmer Certification
156	191432	Vishalika	Katiyar	Python Programmer Certification
157	191434	Aryan	Bathla	Python Programmer Certification
158	191435	Oshin	Dhawan	Python Programmer Certification
159	191436	Anshul	Thakur	Python Programmer Certification
160	191440	Abhishek	Thakur	Python Programmer Certification

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161	191442	Aishwary kumar	Tiwari	Python Programmer Certification
162	191445	Kunal	Garg	Python Programmer Certification
163	191447	Shivansh	Garg	Python Programmer Certification
164	191448	Dikshant	Gupta	Python Programmer Certification
165	191450	Aakash	Changra	Python Programmer Certification
166	191451	Prashant	Agarwal	Python Programmer Certification
167	191452	Ugyen	Dorji	Python Programmer Certification
168	191453	Tenzin	Gyaltshen	Python Programmer Certification
169	191454	Ashima	Pal	Python Programmer Certification
170	191504	Varun	Chodha	Python Programmer Certification
171	191505	Vaibhav	Mishra	Python Programmer Certification
172	191506	Pankaj	Kumar	Python Programmer Certification
173	191507	Ngawang	Choega	Python Programmer Certification
174	191508	Shubham	Rana	Python Programmer Certification
175	191509	Prakhar	Srivastava	Python Programmer Certification
176	191512	Nishant	Attri	Python Programmer Certification
177	191513	Arpit	Sood	Python Programmer Certification
178	191515	Ayush	Sharma	Python Programmer Certification
179	191517	Nitika	Sharma	Python Programmer Certification
180	191520	Dev vishal	Panwar	Python Programmer Certification
181	191523	Lalit	Yadav	Python Programmer Certification
182	191525	Ajay	Tyagi	Python Programmer Certification
183	191526	Yash	Kataria	Python Programmer Certification
184	191527	Ujjawal	Tomar	Python Programmer Certification
185	191528	Aayush	Kakkar	Python Programmer Certification
186	191529	Sulbha	Sharma	Python Programmer Certification
187	191531	Silky	Agarwal	Python Programmer Certification
188	191533	Himanshu	.	Python Programmer Certification
189	191534	Madhumesh	Shukla	Python Programmer Certification
190	191537	Kalpit	Bansal	Python Programmer Certification
191	191539	Anmol	Jain	Python Programmer Certification
192	191540	Devbrat	Srivastava	Python Programmer Certification
193	191541	Ansh	Jaiswal	Python Programmer Certification
194	191543	Bhavya	Gupta	Python Programmer Certification
195	191544	Arnav	Saraswat	Python Programmer Certification
196	191545	Vaibhav	Sharma	Python Programmer Certification
197	191546	Aditi	Tyagi	Python Programmer Certification
198	191547	Akanksha	Varshney	Python Programmer Certification
199	191549	Saran deep	Singh	Associate in IT Foundation Skills (Python)
200	191549	Saran deep	Singh	Python Programmer Certification
201	191550	Aanjaneya	Sharma	Python Programmer Certification

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202	191553	Manish	Gupta	Python Programmer Certification
203	191555	Rahul	Sharma	Data Science Foundation Certification
204	191555	Rahul	Sharma	Python Programmer Certification
205	191384	Kartik	Joshi	Python Programmer Certification
206	191398	Abhinav	Jain	Python Programmer Certification
207	191446	ABHIN	SHARMA	Python Programmer Certification
208	191393	Aishani	Pachauri	Python Programmer Certification
209	191419	Aman	Kumar	Python Programmer Certification
210	191317	Anshu	Sharma	Python Programmer Certification
211	191339	Arushi	191339	Python Programmer Certification
212	191330	Aryaman	Sinha	Python Programmer Certification
213	191203	Aryan	Koundal	Python Programmer Certification
214	191202	Ayush	Guleria	Python Programmer Certification
215	191415	Bharat	Bhatia	Python Programmer Certification
216	191397	Yash	Bhardwaj	Python Programmer Certification
217	191341	Gulshan	kumar	Python Programmer Certification
218	191371	Harshil	Chaudhary	Python Programmer Certification
219	191355	Chandan kumar	Yadav	Python Programmer Certification
220	191298	Raghav	Dalmia	Python Programmer Certification
221	191270	Divyansh	Mandhan	Python Programmer Certification
222	191447	Shivansh	Garg	Python Programmer Certification
223	191383	Gourav	.	Python Programmer Certification
224	191240	Prerna	Gupta	Python Programmer Certification
225	191369	Harshit	Saxena	Python Programmer Certification
226	191312	Hridyesh	Khandelwal	Python Programmer Certification
227	191384	Kartik	Joshi	Python Programmer Certification
228	191225	Abhiti	Labroo	Python Programmer Certification
229	191256	Paras	Sharma	Python Programmer Certification
230	191206	Parul	Sharma	Python Programmer Certification
231	191518	Pranav	Chauhan	Python Programmer Certification
232	191554	Pratyush	Bhangalia	Python Programmer Certification
233	191342	Priyanshi	Khippal	Python Programmer Certification
234	191396	Pushp	Jain	Python Programmer Certification
235	191316	Ridham	Godha	Python Programmer Certification
236	191336	Rijul	Sharma	Python Programmer Certification
237	191388	Shaurya	Awasthi	Python Programmer Certification
238	191402	Shubham	Singh	Python Programmer Certification
239	191428	Priya	Verma	Python Programmer Certification
240	191338	Shubham	Kumar	Python Programmer Certification
241	191551	Srishti	Budholia	Python Programmer Certification
242	191265	Ravi	Srivastava	Python Programmer Certification

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243	191344	Utkarsh	Kumar	Python Programmer Certification
244	191420	Vishal	Nadda	Python Programmer Certification
245	191455	Shivam	Verma	Python Programmer Certification

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Student's completed Professional Courses at Infosys Springboard

S.No.	Email	First Name	Last Name	Course Completed
1	201529	Aditi	Gupta	A Beginner's Guide to Web Development
2	191267	Sushant	Rohan	Angular
3	191275	Ajay	katyal	Angular
4	201101	Ananya	Dhangar	Angular
5	201103	Priyank	Gupta	Angular
6	201105	Saransh	Sharma	Angular
7	201108	Aditya partap	Singh	Angular
8	201109	Vansh	Gulati	Angular
9	201111	Surbhi	Sood	Angular
10	201113	Gurleen	Kaur	Angular
11	201114	Krishna	Modi	Angular
12	201116	Rohan	Rana	Angular
13	201117	Amisha	Chauhan	Angular
14	201119	Medhavi	Singh	Angular
15	201120	Bhavik	Chauhan	Angular
16	201122	Garvita	Sharma	Angular
17	201123	Abhishek	Anand	Angular
18	201127	Bhavy	Jindal	Angular
19	201128	Abhinav	Jain	Angular
20	201131	Saurabh	Singh	Angular
21	201132	Ishita	Gupta	Angular
22	201133	Paras	Sharma	Angular
23	201134	Arnav	Seth	Angular
24	201136	Sayam	Puri	Angular
25	201137	Ansh	Mahajan	Angular
26	201138	Yashaswi	Kohli	Angular
27	201139	Sanya	Mahajan	Angular
28	201141	Kartik	Dogra	Angular
29	201144	Siddharth	Kuthiala	Angular
30	201146	Anoushka	Sud	Angular
31	201148	Deepankar	Singla	Angular
32	201149	Kaushik	Sharma	Angular
33	201150	Nitika	Bhatt	Angular
34	201151	Vipul	Arora	Angular
35	201153	Aryan	Malhotra	Angular
36	201156	Vaidehi	Pandey	Angular

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37	201157	Jyotirmay	Verma	Angular
38	201159	Anshit	Goel	Angular
39	201160	Anant	Rao	Angular
40	201164	Tanvi	Thakur	Angular
41	201165	Aman	Jain	Angular
42	201167	Aryan kant	Singh	Angular
43	201168	Sai	Hritvik	Angular
44	201170	Satyam	.	Angular
45	201171	Soumya	Goyal	Angular
46	201172	Karna	Chaudhary	Angular
47	201173	Mohit	Verma	Angular
48	201174	Mitushi	Kohli	Angular
49	201175	Sheel bhadra	Joshi	Angular
50	201177	Kartik	Parihar	Angular
51	201178	Aahana	Dutta	Angular
52	201179	Siddharth	Misra	Angular
53	201180	Vansh	Jain	Angular
54	201183	Dhruv	Rastogi	Angular
55	201185	Karanveer	Singh	Angular
56	201187	Parth	Agarwal	Angular
57	201188	Kanishk	Gupta	Angular
58	201191	Anmol	Bhopal	Angular
59	201192	Aryan	Kalsi	Angular
60	201193	Khushboo	Gupta	Angular
61	201194	Prakhar	Singh	Angular
62	201195	Samridhi	Chauhan	Angular
63	201196	Praksh pranab	Rathour	Angular
64	201197	Ankit kumar	Singh	Angular
65	201198	Janhvi	Singh	Angular
66	201199	Anmol	Sharma	Angular
67	201200	Shashwat	Bhaik	Angular
68	201201	Aniket	.	Angular
69	201203	Shivanshu	Mehta	Angular
70	201205	Vishruti	Sharma	Angular
71	201206	Tanish	Mahajan	Angular
72	201207	Siddharth	Raj	Angular
73	201208	Mayank	Gupta	Angular
74	201209	Divyansh	Chauhan	Angular
75	201210	Geetali	Goel	Angular
76	201211	Hridhima	Sen	Angular
77	201212	Priyanjana	Srivastava	Angular

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78	201214	Sumeet Birendra	Singh	Angular
79	201215	Vibhav	Ahuja	Angular
80	201216	Aditya	.	Angular
81	201218	Jagrit	Kamra	Angular
82	201219	Ranvir	Sorrot	Angular
83	201221	Aarhan ali	Khan	Angular
84	201223	Shrutika	.	Angular
85	201224	Ishita	Sarin	Angular
86	201225	Abhishek	Rawat	Angular
87	201227	Aneesh	Azad	Angular
88	201228	Saransh	Mehta	Angular
89	201229	Yogeshwar	.Verma	Angular
90	201230	Aditya	Sharma	Angular
91	201231	Anubhav	Thakur	Angular
92	201232	Rohan	Sood	Angular
93	201233	Rushil	Wadhawan	Angular
94	201234	Harshit	.	Angular
95	201235	Parth	Kumar	Angular
96	201236	Amit	Sharma	Angular
97	201237	Raunak kumar	Thakur	Angular
98	201238	Khushi	.	Angular
99	201239	Satvik	Tripathi	Angular
100	201240	Abhinav	Nayak	Angular
101	201241	Anubhav	Gupta	Angular
102	201242	Devansh	Barki	Angular
103	201243	Shardul	Verma	Angular
104	201248	Saksham	Verma	Angular
105	201249	Arpan	Gupta	Angular
106	201250	Shivansh	Goyal	Angular
107	201251	Shyamansh	Sharma	Angular
108	201252	Harsh	Galgate	Angular
109	201253	Ayush	Vaish	Angular
110	201254	Amrit	Raj	Angular
111	201255	Prachi	Chauhan	Angular
112	201256	Sanskar	Rai	Angular
113	201257	Akshat	Kumar	Angular
114	201258	Pankaj	Sharma	Angular
115	201259	Vaibhav	Sharma	Angular
116	201260	Yashaswi	.	Angular
117	201261	Lakshika	Gupta	Angular
118	201262	Abhyuday	Banshtu	Angular

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119	201263	Ansh	Goyal	Angular
120	201265	Vijay deep	Jain	Angular
121	201266	Ayush	Gupta	Angular
122	201267	Chirag	Jain	Angular
123	201269	Khushi	Chhabra	Angular
124	201270	Aradhya	Taneja	Angular
125	201271	Anuj	Taneja	Angular
126	201273	Lakshay	Arora	Angular
127	201274	Anmol	Bansal	Angular
128	201275	Amritanshu	Suyal	Angular
129	201276	Radhika	Sharma	Angular
130	201277	Nikita	Sehgal	Angular
131	201278	Archie	Tomar	Angular
132	201279	Tanya	Gupta	Angular
133	201280	Shambhavi	Patial	Angular
134	201281	Pranav	Thakur	Angular
135	201282	Anshul	Bhardwaj	Angular
136	201283	Komal	Dhall	Angular
137	201285	Sonam	Chophel	Angular
138	201286	Meghna	Chaudhary	Angular
139	201287	Manan	Gupta	Angular
140	201288	Shivangi	Thakur	Angular
141	201291	Monisha	Surana	Angular
142	201292	Utsav	.	Angular
143	201293	Devanshi	Vashistha	Angular
144	201294	Shaily	Tiwari	Angular
145	201295	Sagnik	Ghosh	Angular
146	201296	Shubhang	Shukla	Angular
147	201297	Shivam	Karn	Angular
148	201298	Yash	Garg	Angular
149	201299	Rajat	Sagar	Angular
150	201300	Ansh	Agrawal	Angular
151	201301	Sivon	Tehraik	Angular
152	201302	Ansh	Choudhary	Angular
153	201303	Kushagra	Shukla	Angular
154	201304	Chirag	Walia	Angular
155	201306	Kshitiz	Bashyal	Angular
156	201308	Nitin	Saini	Angular
157	201310	Hari Priya Radhika	Sharma	Angular
158	201313	Danish	Sharma	Angular
159	201314	Satwik sidharth	Rana	Angular

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160	201315	Gunjan	Verma	Angular
161	201316	Shivangi	Paliwal	Angular
162	201317	Angel	Singh	Angular
163	201318	Naman	Puri	Angular
164	201319	Muskan	mittal	Angular
165	201321	Vishwadeep	Nigam	Angular
166	201322	Prakhar singh	Chauhan	Angular
167	201323	Shivanshu	Sharma	Angular
168	201324	Abhinay	Kumar	Angular
169	201325	Annu	Chauhan	Angular
170	201326	Moulik	Chaturvedi	Angular
171	201327	Suditi	Rathore	Angular
172	201329	Rohit	Rakesh	Angular
173	201330	Himanshu	Pant	Angular
174	201331	Ishika	Goswami	Angular
175	201332	Rudra partap	Singh	Angular
176	201334	Vaibhav	Sharma	Angular
177	201335	Aryan	Verma	Angular
178	201337	Isha	Rawat	Angular
179	201338	Md asif	Ahmed	Angular
180	201339	Karan	Hansraj	Angular
181	201341	Yashvardhan	Sharma	Angular
182	201342	Saloni	.	Angular
183	201343	Rashik	Walia	Angular
184	201344	Kriti	Vij	Angular
185	201345	Manoj	Mehta	Angular
186	201346	Dhruv	Srivastava	Angular
187	201348	Priyansh	Garg	Angular
188	201349	Animesh	Singh	Angular
189	201350	Aniket	Sharma	Angular
190	201351	Amritanshu	.	Angular
191	201352	Basu	Narayan	Angular
192	201353	Vriti	Sharma	Angular
193	201354	Abhinav	Thakur	Angular
194	201355	Daksh	Malik	Angular
195	201357	Ritick	.	Angular
196	201358	Kunal	Kaliramna	Angular
197	201359	Sohail	Khan	Angular
198	201360	Jigyasa	Sharma	Angular
199	201361	Kshitij	Vats	Angular
200	201362	Naman	Sharma	Angular

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201	201363	Sanidhya	Kapoor	Angular
202	201366	Abhishek	Anand	Angular
203	201367	Anurag	Kumar	Angular
204	201369	Akarsh	Walia	Angular
205	201370	Garv	Mehta	Angular
206	201390	Manav	Gupta	Angular
207	201395	Om hari	Shukla	Angular
208	201403	Swastik	Guleria	Angular
209	201404	Rithik	Mishra	Angular
210	201405	Akhil	Shahni	Angular
211	201406	Umang	Sharma	Angular
212	201407	Prakhar	Jain	Angular
213	201408	Nikhil	Sharma	Angular
214	201409	Anmol	Goyal	Angular
215	201412	Ayushi	Tripathi	Angular
216	201413	Amartya	Vibhu	Angular
217	201414	Dazzle	.	Angular
218	201416	Ridhi	Sood	Angular
219	201418	Arpit	Kaushal	Angular
220	201419	Varuni	Sood	Angular
221	201420	Arjit	Upadhyay	Angular
222	201421	Himanshu	Dutt	Angular
223	201422	Samagra	Dvivedi	Angular
224	201423	Yash	Srivastava	Angular
225	201424	Anshaj	Dharmani	Angular
226	201425	Akash	Rathore	Angular
227	201426	Sahil azad	Katiyar	Angular
228	201427	Kartikay	Narula	Angular
229	201428	Vansh	Bansal	Angular
230	201429	Archit	Kaushal	Angular
231	201430	Shiveen	Nadda	Angular
232	201432	Aastha	Verma	Angular
233	201433	Aditi	Saxena	Angular
234	201434	Bhanu pratap	Singh	Angular
235	201435	Vasu	Goel	Angular
236	201436	Harshit	Upadhyay	Angular
237	201439	Mridul	Singhal	Angular
238	201440	Ritik	Raushan	Angular
239	201441	Shikhar	Khandelwal	Angular
240	201442	Aditya	Sahni	Angular
241	201443	Sara	Walia	Angular

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242	201445	Chaitanya	Dua	Angular
243	201446	Anirudh	Farwaha	Angular
244	201447	Devansh	Batra	Angular
245	201448	Vipransh	Agarwal	Angular
246	201450	Divyav dev	Vashisht	Angular
247	201451	Rahul	.	Angular
248	201453	Ambikesh	Jha	Angular
249	201454	Aryaman singh	Kanwar	Angular
250	201455	Raadhika	Singh	Angular
251	201457	Yashvardhan	Singh	Angular
252	201458	Pratyush	Sharma	Angular
253	201460	Akash Kumar	Singh	Angular
254	201461	Devansh	Chaudhary	Angular
255	201462	Rakshita	Jain	Angular
256	201464	Vedanta	Koul	Angular
257	201465	Rohit	Mishra	Angular
258	201466	Sachin	Mishra	Angular
259	201467	Vidur	Sharma	Angular
260	201468	Thakur Uday	Singh	Angular
261	201469	Shivansh	Gupta	Angular
262	201472	Jai	Singh	Angular
263	201474	Arpit	Aggarwal	Angular
264	201476	Malay	Acharya	Angular
265	201478	Rohit	Sharma	Angular
266	201479	Aryan	Bhadwaj	Angular
267	201480	Priyansh	Agarwal	Angular
268	201486	Shubham	Sharma	Angular
269	201487	Supriti	Sharma	Angular
270	201488	Anushka	Pandey	Angular
271	201489	Rohit	Kumar	Angular
272	201501	Kushagra	Singhal	Angular
273	201504	Tejas	Anand	Angular
274	201505	Pratyush	Dengta	Angular
275	201507	Arpit	Agrawal	Angular
276	201508	Rahul	Sharma	Angular
277	201509	Samyak	Pahalwan	Angular
278	201510	Sujal	Upadhyay	Angular
279	201511	Nikhil	Jindal	Angular
280	201512	Harish	Thakur	Angular
281	201513	Kunal	Verma	Angular
282	201514	Vasu	Yadav	Angular

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283	201515	Sahaj	Katiyar	Angular
284	201516	Gavin	Chandel	Angular
285	201517	Parth kr	Khare	Angular
286	201520	Yuyutsu	Chinaria	Angular
287	201521	Surbhit	Sharma	Angular
288	201522	Aditya	Bhardwaj	Angular
289	201524	Kartik	Joshi	Angular
290	201525	Sahil	Thakur	Angular
291	201526	Shridhar	Singh	Angular
292	201527	Himanshu	Jindal	Angular
293	201528	Siddhanth	Verma	Angular
294	201529	Aditi	Gupta	Angular
295	201530	Advik kumar	Singh	Angular
296	201531	Rohit	Ranjan	Angular
297	201532	Rishabh	Kesarwani	Angular
298	201534	Harsh	Thakran	Angular
299	201536	Aatish	Sharma	Angular
300	201537	Abhinandan	Thakur	Angular
301	201538	Nitin	Sharma	Angular
302	201539	Rakshit	.	Angular
303	201541	Snehan	Tagnaat	Angular
304	201543	Rishik	.	Angular
305	201545	Adhyyan	Thakur	Angular
306	201546	Sanskar	Singhal	Angular
307	201547	Anmol	Sharma	Angular
308	201549	Parush kumar	Sinha	Angular
309	201551	Aditya	Sharma	Angular
310	201552	Suryansh	Garg	Angular
311	201554	Mohd awaan	Nisar	Angular
312	201556	Yash	Tyagi	Angular
313	201558	Sushant	Kumar	Angular
314	201559	Abhishek	.	Angular
315	201560	Geetanjali	Singh	Angular
316	201565	Adarsh	Pandey	Angular
317	201567	Animesh	.	Angular
318	201569	Akshit	Kumar	Angular
319	201570	Siddharth singh	Negi	Angular
320	201571	Mehak	Chauhan	Angular
321	191250	Shubham	Patial	Association Analysis using Python
322	191267	Sushant	Rohan	Association Analysis using Python
323	191276	Piyush	Singh	Association Analysis using Python

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324	191365	Samarth	Sharma	Association Analysis using Python
325	191403	Rohit	Sharma	Association Analysis using Python
326	191417	Abhimanyu	Singh Anand	Association Analysis using Python
327	191206	Parul	Sharma	Basics of Linear Algebra using Python
328	191226	Vipasha	Rana	Basics of Linear Algebra using Python
329	191245	Saksham	Thakur	Basics of Linear Algebra using Python
330	191346	Tripti	Gupta	Basics of Linear Algebra using Python
331	191379	Aditi	Garg	Basics of Linear Algebra using Python
332	191455	Shivam	Verma	Basics of Linear Algebra using Python
333	191529	Sulbha	Sharma	Basics of Linear Algebra using Python
334	191550	Aanjaneya	Sharma	Basics of Linear Algebra using Python
335	191249	Ayush	Pathania	Basics of Python
336	191345	Aashima	Juneja	Basics of Python
337	191346	Tripti	Gupta	Basics of Python
338	191393	Aishani	Pachauri	Basics of Python
339	191430	Jayant	Sharma	Basics of Python
340	191431	Aditya	Tomar	Basics of Python
341	191504	Varun	Chodha	Basics of Python
342	191527	Ujjawal	Tomar	Basics of Python
343	191605	Harish singh	Kanwar	Basics of Python
344	201418	Arpit	Kaushal	Basics of Python
345	191529	Sulbha	Sharma	Blockchain 101
346	191369	Harshit	Saxena	Cascading Style Sheets - CSS3
347	191439	Radhika	Gupta	Cascading Style Sheets - CSS3
348	191284	Samanvaya	Tripathi	Computer Vision 101
349	191329	Shreesh	Tripathi	Computer Vision 101
350	191330	Aryaman	Sinha	Computer Vision 101
351	191338	Shubham	Kumar	Computer Vision 101
352	191347	Aharnish	Dwivedi	Computer Vision 101
353	191351	Mohit	Mayank	Computer Vision 101
354	191352	Malay	Srivastava	Computer Vision 101
355	191353	Divyansh	Joshi	Computer Vision 101
356	191367	Abhishek	Kumar	Computer Vision 101
357	191369	Harshit	Saxena	Computer Vision 101
358	191370	Yashasvi singh	Rathore	Computer Vision 101
359	191400	Vasundhara	Pandey	Computer Vision 101
360	191427	Manya	Malhotra	Computer Vision 101
361	191435	Oshin	Dhawan	Computer Vision 101
362	191520	Dev vishal	Panwar	Computer Vision 101
363	191202	Ayush	Guleria	Creating Responsive Web Pages using Bootstrap 4
364	191208	Aisha	Sajjad	Creating Responsive Web Pages using Bootstrap 4

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365	191211	Anushka	Srivastava	Creating Responsive Web Pages using Bootstrap 4
366	191213	Ananya	Mishra	Creating Responsive Web Pages using Bootstrap 4
367	191214	Sanyam	Saxena	Creating Responsive Web Pages using Bootstrap 4
368	191218	Ananya	Joshi	Creating Responsive Web Pages using Bootstrap 4
369	191225	Abhiti	Labroo	Creating Responsive Web Pages using Bootstrap 4
370	191226	Vipasha	Rana	Creating Responsive Web Pages using Bootstrap 4
371	191238	Akshat	A	Creating Responsive Web Pages using Bootstrap 4
372	191260	Shivam singh	Negi	Creating Responsive Web Pages using Bootstrap 4
373	191264	Harshit	Singh	Creating Responsive Web Pages using Bootstrap 4
374	191268	Priyansh	Khatri	Creating Responsive Web Pages using Bootstrap 4
375	191277	Archit	Dogra	Creating Responsive Web Pages using Bootstrap 4
376	191289	Shaan	Srivastava	Creating Responsive Web Pages using Bootstrap 4
377	191318	Mudit	Mahajan	Creating Responsive Web Pages using Bootstrap 4
378	191321	Anubhav	Garg	Creating Responsive Web Pages using Bootstrap 4
379	191338	Shubham	Kumar	Creating Responsive Web Pages using Bootstrap 4
380	191342	Priyanshi	.	Creating Responsive Web Pages using Bootstrap 4
381	191348	Harshit	Singh	Creating Responsive Web Pages using Bootstrap 4
382	191352	Malay	Srivastava	Creating Responsive Web Pages using Bootstrap 4
383	191354	Gautmi	Singh	Creating Responsive Web Pages using Bootstrap 4
384	191379	Aditi	Garg	Creating Responsive Web Pages using Bootstrap 4
385	191389	Shreya	Srivastava	Creating Responsive Web Pages using Bootstrap 4
386	191390	Arj	Srivastava	Creating Responsive Web Pages using Bootstrap 4
387	191413	Nandini	Singh	Creating Responsive Web Pages using Bootstrap 4
388	191438	Mayank	Gupta	Creating Responsive Web Pages using Bootstrap 4
389	191504	Varun	Chodha	Creating Responsive Web Pages using Bootstrap 4
390	191507	Ngawang	Choega	Creating Responsive Web Pages using Bootstrap 4
391	191516	Khushi	Shah	Creating Responsive Web Pages using Bootstrap 4
392	191517	Nitika	Sharma	Creating Responsive Web Pages using Bootstrap 4
393	191520	Dev vishal	Panwar	Creating Responsive Web Pages using Bootstrap 4
394	191526	Yash	Kataria	Creating Responsive Web Pages using Bootstrap 4
395	191528	Aayush	Kakkar	Creating Responsive Web Pages using Bootstrap 4
396	191529	Sulbha	Sharma	Creating Responsive Web Pages using Bootstrap 4
397	191540	Devbrat	Srivastava	Creating Responsive Web Pages using Bootstrap 4
398	191550	Aanjaneya	Sharma	Creating Responsive Web Pages using Bootstrap 4
399	191555	Rahul	Sharma	Creating Responsive Web Pages using Bootstrap 4
400	201421	Himanshu	Dutt	CSS Bootcamp: Master CSS (Including CSS Grid/Flexbox)
401	191202	Ayush	Guleria	CSS3
402	191207	Nidhi	Rajput	CSS3
403	191208	Aisha	Sajjad	CSS3
404	191211	Anushka	Srivastava	CSS3
405	191218	Ananya	Joshi	CSS3

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406	191220	Saksham	Chaturvedi	CSS3
407	191221	Rishabh singh	Parmar	CSS3
408	191226	Vipasha	Rana	CSS3
409	191227	Kunika	Sharma	CSS3
410	191229	Piyush	Sharma	CSS3
411	191238	Akshat	A	CSS3
412	191260	Shivam singh	Negi	CSS3
413	191264	Harshit	Singh	CSS3
414	191268	Priyansh	Khatri	CSS3
415	191277	Archit	Dogra	CSS3
416	191289	Shaan	Srivastava	CSS3
417	191307	Mayank	Kumar	CSS3
418	191318	Mudit	Mahajan	CSS3
419	191321	Anubhav	Garg	CSS3
420	191338	Shubham	Kumar	CSS3
421	191342	Priyanshi	.	CSS3
422	191347	Aharnish	Dwivedi	CSS3
423	191348	Harshit	Singh	CSS3
424	191351	Mohit	Mayank	CSS3
425	191352	Malay	Srivastava	CSS3
426	191354	Gautmi	Singh	CSS3
427	191369	Harshit	Saxena	CSS3
428	191379	Aditi	Garg	CSS3
429	191389	Shreya	Srivastava	CSS3
430	191390	Arj	Srivastava	CSS3
431	191413	Nandini	Singh	CSS3
432	191423	Varsha	Singh	CSS3
433	191425	Riya	Gupta	CSS3
434	191438	Mayank	Gupta	CSS3
435	191504	Varun	Chodha	CSS3
436	191507	Ngawang	Choega	CSS3
437	191516	Khushi	Shah	CSS3
438	191517	Nitika	Sharma	CSS3
439	191520	Dev vishal	Panwar	CSS3
440	191526	Yash	Kataria	CSS3
441	191528	Aayush	Kakkar	CSS3
442	191529	Sulbha	Sharma	CSS3
443	191540	Devbrat	Srivastava	CSS3
444	191550	Aanjaneya	Sharma	CSS3
445	191555	Rahul	Sharma	CSS3
446	191211	Anushka	Srivastava	Data Structures and Algorithms using Python - Part 1

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447	191213	Ananya	Mishra	Data Structures and Algorithms using Python - Part 1
448	191230	Sahil	Thakur	Data Structures and Algorithms using Python - Part 1
449	191240	Prerna	Gupta	Data Structures and Algorithms using Python - Part 1
450	191305	Harshit	Sinha	Data Structures and Algorithms using Python - Part 1
451	191389	Shreya	Srivastava	Data Structures and Algorithms using Python - Part 1
452	191390	Arj	Srivastava	Data Structures and Algorithms using Python - Part 1
453	191423	Varsha	Singh	Data Structures and Algorithms using Python - Part 1
454	191438	Mayank	Gupta	Data Structures and Algorithms using Python - Part 1
455	191439	Radhika	Gupta	Data Structures and Algorithms using Python - Part 1
456	191549	Saran deep	Singh	Data Structures and Algorithms using Python - Part 1
457	191211	Anushka	Srivastava	Data Structures and Algorithms using Python - Part 2
458	191230	Sahil	Thakur	Data Structures and Algorithms using Python - Part 2
459	191240	Prerna	Gupta	Data Structures and Algorithms using Python - Part 2
460	191305	Harshit	Sinha	Data Structures and Algorithms using Python - Part 2
461	191389	Shreya	Srivastava	Data Structures and Algorithms using Python - Part 2
462	191390	Arj	Srivastava	Data Structures and Algorithms using Python - Part 2
463	191423	Varsha	Singh	Data Structures and Algorithms using Python - Part 2
464	191438	Mayank	Gupta	Data Structures and Algorithms using Python - Part 2
465	191439	Radhika	Gupta	Data Structures and Algorithms using Python - Part 2
466	191549	Saran deep	Singh	Data Structures and Algorithms using Python - Part 2
467	191250	Shubham	Patial	Data Visualisation using Python
468	191267	Sushant	Rohan	Data Visualisation using Python
469	191276	Piyush	Singh	Data Visualisation using Python
470	191281	Parth	Purwar	Data Visualisation using Python
471	191365	Samarth	Sharma	Data Visualisation using Python
472	191403	Rohit	Sharma	Data Visualisation using Python
473	191417	Abhimanyu	Singh Anand	Data Visualisation using Python
474	191230	Sahil	Thakur	Database Fundamentals: Database Concepts
475	191211	Anushka	Srivastava	Database Management System Part - 1
476	191230	Sahil	Thakur	Database Management System Part - 1
477	191240	Prerna	Gupta	Database Management System Part - 1
478	191305	Harshit	Sinha	Database Management System Part - 1
479	191389	Shreya	Srivastava	Database Management System Part - 1
480	191390	Arj	Srivastava	Database Management System Part - 1
481	191423	Varsha	Singh	Database Management System Part - 1
482	191438	Mayank	Gupta	Database Management System Part - 1
483	191439	Radhika	Gupta	Database Management System Part - 1
484	191549	Saran deep	Singh	Database Management System Part - 1
485	191211	Anushka	Srivastava	Database Management System Part - 2
486	191230	Sahil	Thakur	Database Management System Part - 2
487	191240	Prerna	Gupta	Database Management System Part - 2

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488	191305	Harshit	Sinha	Database Management System Part - 2
489	191389	Shreya	Srivastava	Database Management System Part - 2
490	191390	Arj	Srivastava	Database Management System Part - 2
491	191423	Varsha	Singh	Database Management System Part - 2
492	191438	Mayank	Gupta	Database Management System Part - 2
493	191439	Radhika	Gupta	Database Management System Part - 2
494	191549	Saran deep	Singh	Database Management System Part - 2
495	191250	Shubham	Patial	Exploratory Data Analysis
496	191267	Sushant	Rohan	Exploratory Data Analysis
497	191276	Piyush	Singh	Exploratory Data Analysis
498	191365	Samarth	Sharma	Exploratory Data Analysis
499	191403	Rohit	Sharma	Exploratory Data Analysis
500	191417	Abhimanyu	Singh Anand	Exploratory Data Analysis
501	191250	Shubham	Patial	Explore Machine Learning using Python
502	191267	Sushant	Rohan	Explore Machine Learning using Python
503	191276	Piyush	Singh	Explore Machine Learning using Python
504	191365	Samarth	Sharma	Explore Machine Learning using Python
505	191403	Rohit	Sharma	Explore Machine Learning using Python
506	191417	Abhimanyu	Singh Anand	Explore Machine Learning using Python
507	191214	Sanyam	Saxena	Fundamentals of Cryptography
508	191221	Rishabh singh	Parmar	Fundamentals of Cryptography
509	191307	Mayank	Kumar	Fundamentals of Cryptography
510	191311	Gautam	Gupta	Fundamentals of Cryptography
511	191318	Mudit	Mahajan	Fundamentals of Cryptography
512	191323	Sudeep	.	Fundamentals of Cryptography
513	191504	Varun	Chodha	Fundamentals of Cryptography
514	191514	Salil	Verma	Fundamentals of Cryptography
515	191516	Khushi	Shah	Fundamentals of Cryptography
516	191552	Kanishak	Vyas	Fundamentals of Cryptography
517	191214	Sanyam	Saxena	Fundamentals of Information Security
518	191221	Rishabh singh	Parmar	Fundamentals of Information Security
519	191307	Mayank	Kumar	Fundamentals of Information Security
520	191311	Gautam	Gupta	Fundamentals of Information Security
521	191311	Gautam	Gupta	Fundamentals of Information Security
522	191318	Mudit	Mahajan	Fundamentals of Information Security
523	191323	Sudeep	.	Fundamentals of Information Security
524	191504	Varun	Chodha	Fundamentals of Information Security
525	191514	Salil	Verma	Fundamentals of Information Security
526	191514	Salil	Verma	Fundamentals of Information Security
527	191516	Khushi	Shah	Fundamentals of Information Security

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528	191552	Kanishak	Vyas	Fundamentals of Information Security
529	191202	Ayush	Guleria	HTML5 - The Language
530	191208	Aisha	Sajjad	HTML5 - The Language
531	191211	Anushka	Srivastava	HTML5 - The Language
532	191213	Ananya	Mishra	HTML5 - The Language
533	191214	Sanyam	Saxena	HTML5 - The Language
534	191218	Ananya	Joshi	HTML5 - The Language
535	191225	Abhiti	Labroo	HTML5 - The Language
536	191226	Vipasha	Rana	HTML5 - The Language
537	191238	Akshat	A	HTML5 - The Language
538	191260	Shivam singh	Negi	HTML5 - The Language
539	191264	Harshit	Singh	HTML5 - The Language
540	191268	Priyansh	Khatri	HTML5 - The Language
541	191277	Archit	Dogra	HTML5 - The Language
542	191289	Shaan	Srivastava	HTML5 - The Language
543	191318	Mudit	Mahajan	HTML5 - The Language
544	191321	Anubhav	Garg	HTML5 - The Language
545	191338	Shubham	Kumar	HTML5 - The Language
546	191342	Priyanshi	.	HTML5 - The Language
547	191347	Aharnish	Dwivedi	HTML5 - The Language
548	191348	Harshit	Singh	HTML5 - The Language
549	191351	Mohit	Mayank	HTML5 - The Language
550	191352	Malay	Srivastava	HTML5 - The Language
551	191354	Gautmi	Singh	HTML5 - The Language
552	191369	Harshit	Saxena	HTML5 - The Language
553	191379	Aditi	Garg	HTML5 - The Language
554	191389	Shreya	Srivastava	HTML5 - The Language
555	191390	Arj	Srivastava	HTML5 - The Language
556	191413	Nandini	Singh	HTML5 - The Language
557	191423	Varsha	Singh	HTML5 - The Language
558	191438	Mayank	Gupta	HTML5 - The Language
559	191504	Varun	Chodha	HTML5 - The Language
560	191507	Ngawang	Choega	HTML5 - The Language
561	191516	Khushi	Shah	HTML5 - The Language
562	191517	Nitika	Sharma	HTML5 - The Language
563	191520	Dev vishal	Panwar	HTML5 - The Language
564	191526	Yash	Kataria	HTML5 - The Language
565	191528	Aayush	Kakkar	HTML5 - The Language
566	191529	Sulbha	Sharma	HTML5 - The Language
567	191540	Devbrat	Srivastava	HTML5 - The Language
568	191550	Aanjaneya	Sharma	HTML5 - The Language

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569	191555	Rahul	Sharma	HTML5 - The Language
570	191329	Shreesh	Tripathi	Introduction to Artificial Intelligence
571	191330	Aryaman	Sinha	Introduction to Artificial Intelligence
572	191338	Shubham	Kumar	Introduction to Artificial Intelligence
573	191347	Aharnish	Dwivedi	Introduction to Artificial Intelligence
574	191351	Mohit	Mayank	Introduction to Artificial Intelligence
575	191352	Malay	Srivastava	Introduction to Artificial Intelligence
576	191353	Divyansh	Joshi	Introduction to Artificial Intelligence
577	191367	Abhishek	Kumar	Introduction to Artificial Intelligence
578	191369	Harshit	Saxena	Introduction to Artificial Intelligence
579	191370	Yashasvi singh	Rathore	Introduction to Artificial Intelligence
580	191400	Vasundhara	Pandey	Introduction to Artificial Intelligence
581	191427	Manya	Malhotra	Introduction to Artificial Intelligence
582	191435	Oshin	Dhawan	Introduction to Artificial Intelligence
583	191520	Dev vishal	Panwar	Introduction to Artificial Intelligence
584	191214	Sanyam	Saxena	Introduction to Cyber Security
585	191221	Rishabh singh	Parmar	Introduction to Cyber Security
586	191307	Mayank	Kumar	Introduction to Cyber Security
587	191311	Gautam	Gupta	Introduction to Cyber Security
588	191318	Mudit	Mahajan	Introduction to Cyber Security
589	191323	Sudeep	.	Introduction to Cyber Security
590	191504	Varun	Chodha	Introduction to Cyber Security
591	191514	Salil	Verma	Introduction to Cyber Security
592	191516	Khushi	Shah	Introduction to Cyber Security
593	191552	Kanishak	Vyas	Introduction to Cyber Security
594	191202	Ayush	Guleria	Introduction to Data Science
595	191206	Parul	Sharma	Introduction to Data Science
596	191207	Nidhi	Rajput	Introduction to Data Science
597	191208	Aisha	Sajjad	Introduction to Data Science
598	191218	Ananya	Joshi	Introduction to Data Science
599	191222	Reet	Sethi	Introduction to Data Science
600	191226	Vipasha	Rana	Introduction to Data Science
601	191227	Kunika	Sharma	Introduction to Data Science
602	191229	Piyush	Sharma	Introduction to Data Science
603	191238	Akshat	A	Introduction to Data Science
604	191245	Saksham	Thakur	Introduction to Data Science
605	191248	Devesh	Vyas	Introduction to Data Science
606	191249	Ayush	Pathania	Introduction to Data Science
607	191264	Harshit	Singh	Introduction to Data Science
608	191266	Vipul	Sharma	Introduction to Data Science
609	191268	Priyansh	Khatri	Introduction to Data Science

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610	191270	Divyansh	Mandhan	Introduction to Data Science
611	191284	Samanvaya	Tripathi	Introduction to Data Science
612	191289	Shaan	Srivastava	Introduction to Data Science
613	191299	Mehul	Kansal	Introduction to Data Science
614	191320	Piyush	Kanungo	Introduction to Data Science
615	191321	Anubhav	Garg	Introduction to Data Science
616	191328	Yasharth	.	Introduction to Data Science
617	191329	Shreesh	Tripathi	Introduction to Data Science
618	191330	Aryaman	Sinha	Introduction to Data Science
619	191338	Shubham	Kumar	Introduction to Data Science
620	191342	Priyanshi	.	Introduction to Data Science
621	191345	Aashima	Juneja	Introduction to Data Science
622	191346	Tripti	Gupta	Introduction to Data Science
623	191347	Aharnish	Dwivedi	Introduction to Data Science
624	191350	Navya	Yadav	Introduction to Data Science
625	191351	Mohit	Mayank	Introduction to Data Science
626	191352	Malay	Srivastava	Introduction to Data Science
627	191353	Divyansh	Joshi	Introduction to Data Science
628	191354	Gautmi	Singh	Introduction to Data Science
629	191361	Tarun	Bhardwaj	Introduction to Data Science
630	191362	Harshul	Choudhary	Introduction to Data Science
631	191366	Ujjwal	Rajput	Introduction to Data Science
632	191367	Abhishek	Kumar	Introduction to Data Science
633	191369	Harshit	Saxena	Introduction to Data Science
634	191370	Yashasvi singh	Rathore	Introduction to Data Science
635	191372	Mukund	Soni	Introduction to Data Science
636	191373	Vaibhav	Jariyal	Introduction to Data Science
637	191379	Aditi	Garg	Introduction to Data Science
638	191396	Pushp	Jain	Introduction to Data Science
639	191400	Vasundhara	Pandey	Introduction to Data Science
640	191402	Shubham	Singh	Introduction to Data Science
641	191413	Nandini	Singh	Introduction to Data Science
642	191414	Simran	Verma	Introduction to Data Science
643	191427	Manya	Malhotra	Introduction to Data Science
644	191435	Oshin	Dhawan	Introduction to Data Science
645	191455	Shivam	Verma	Introduction to Data Science
646	191501	Ananya	Sood	Introduction to Data Science
647	191507	Ngawang	Choega	Introduction to Data Science
648	191511	Atishya	Jain	Introduction to Data Science
649	191517	Nitika	Sharma	Introduction to Data Science
650	191520	Dev vishal	Panwar	Introduction to Data Science

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651	191529	Sulbha	Sharma	Introduction to Data Science
652	191550	Aanjaneya	Sharma	Introduction to Data Science
653	191555	Rahul	Sharma	Introduction to Data Science
654	191329	Shreesh	Tripathi	Introduction to Deep Learning
655	191330	Aryaman	Sinha	Introduction to Deep Learning
656	191338	Shubham	Kumar	Introduction to Deep Learning
657	191347	Aharnish	Dwivedi	Introduction to Deep Learning
658	191351	Mohit	Mayank	Introduction to Deep Learning
659	191352	Malay	Srivastava	Introduction to Deep Learning
660	191353	Divyansh	Joshi	Introduction to Deep Learning
661	191367	Abhishek	Kumar	Introduction to Deep Learning
662	191369	Harshit	Saxena	Introduction to Deep Learning
663	191370	Yashasvi singh	Rathore	Introduction to Deep Learning
664	191400	Vasundhara	Pandey	Introduction to Deep Learning
665	191427	Manya	Malhotra	Introduction to Deep Learning
666	191435	Oshin	Dhawan	Introduction to Deep Learning
667	191520	Dev vishal	Panwar	Introduction to Deep Learning
668	191329	Shreesh	Tripathi	Introduction to Natural Language Processing
669	191330	Aryaman	Sinha	Introduction to Natural Language Processing
670	191338	Shubham	Kumar	Introduction to Natural Language Processing
671	191347	Aharnish	Dwivedi	Introduction to Natural Language Processing
672	191351	Mohit	Mayank	Introduction to Natural Language Processing
673	191352	Malay	Srivastava	Introduction to Natural Language Processing
674	191353	Divyansh	Joshi	Introduction to Natural Language Processing
675	191367	Abhishek	Kumar	Introduction to Natural Language Processing
676	191369	Harshit	Saxena	Introduction to Natural Language Processing
677	191370	Yashasvi singh	Rathore	Introduction to Natural Language Processing
678	191400	Vasundhara	Pandey	Introduction to Natural Language Processing
679	191427	Manya	Malhotra	Introduction to Natural Language Processing
680	191435	Oshin	Dhawan	Introduction to Natural Language Processing
681	191520	Dev vishal	Panwar	Introduction to Natural Language Processing
682	191211	Anushka	Srivastava	Introduction to NoSQL databases
683	191230	Sahil	Thakur	Introduction to NoSQL databases
684	191259	Anirudh pal	Dev	Introduction to NoSQL databases
685	191305	Harshit	Sinha	Introduction to NoSQL databases
686	191389	Shreya	Srivastava	Introduction to NoSQL databases
687	191390	Arj	Srivastava	Introduction to NoSQL databases
688	191423	Varsha	Singh	Introduction to NoSQL databases
689	191438	Mayank	Gupta	Introduction to NoSQL databases
690	191439	Radhika	Gupta	Introduction to NoSQL databases
691	191549	Saran deep	Singh	Introduction to NoSQL databases

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692	181491	Samvad	Sharma	Introduction to Python
693	191206	Parul	Sharma	Introduction to Python
694	191220	Saksham	Chaturvedi	Introduction to Python
695	191304	Tarun	Soni	Introduction to Python
696	191339	Arushi	Khokhar	Introduction to Python
697	191365	Samarth	Sharma	Introduction to Python
698	191389	Shreya	Srivastava	Introduction to Python
699	191403	Rohit	Sharma	Introduction to Python
700	191416	Tanmay	Agarwal	Introduction to Python
701	191448	Dikshant	Gupta	Introduction to Python
702	191501	Ananya	Sood	Introduction to Python
703	191534	Madhumesh	Shukla	Introduction to Python
704	191543	Bhavya	Gupta	Introduction to Python
705	191547	Akanksha	Varshney	Introduction to Python
706	191550	Aanjaneya	Sharma	Introduction to Python
707	191284	Samanvaya	Tripathi	Introduction to Robotic Process Automation
708	191329	Shreesh	Tripathi	Introduction to Robotic Process Automation
709	191330	Aryaman	Sinha	Introduction to Robotic Process Automation
710	191338	Shubham	Kumar	Introduction to Robotic Process Automation
711	191347	Aharnish	Dwivedi	Introduction to Robotic Process Automation
712	191351	Mohit	Mayank	Introduction to Robotic Process Automation
713	191352	Malay	Srivastava	Introduction to Robotic Process Automation
714	191353	Divyansh	Joshi	Introduction to Robotic Process Automation
715	191367	Abhishek	Kumar	Introduction to Robotic Process Automation
716	191369	Harshit	Saxena	Introduction to Robotic Process Automation
717	191370	Yashasvi singh	Rathore	Introduction to Robotic Process Automation
718	191400	Vasundhara	Pandey	Introduction to Robotic Process Automation
719	191427	Manya	Malhotra	Introduction to Robotic Process Automation
720	191435	Oshin	Dhawan	Introduction to Robotic Process Automation
721	191520	Dev vishal	Panwar	Introduction to Robotic Process Automation
722	191605	Harish singh	Kanwar	Java Programming Fundamentals
723	191236	Ria	Mahajan	Learning Neo4j Graphs and Cypher
724	191514	Salil	Verma	Network Fundamentals
725	191211	Anushka	Srivastava	Object Oriented Programming using Python
726	191213	Ananya	Mishra	Object Oriented Programming using Python
727	191230	Sahil	Thakur	Object Oriented Programming using Python
728	191240	Prerna	Gupta	Object Oriented Programming using Python
729	191305	Harshit	Sinha	Object Oriented Programming using Python
730	191389	Shreya	Srivastava	Object Oriented Programming using Python
731	191390	Arj	Srivastava	Object Oriented Programming using Python
732	191393	Aishani	Pachauri	Object Oriented Programming using Python

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733	191423	Varsha	Singh	Object Oriented Programming using Python
734	191438	Mayank	Gupta	Object Oriented Programming using Python
735	191439	Radhika	Gupta	Object Oriented Programming using Python
736	191549	Saran deep	Singh	Object Oriented Programming using Python
737	191202	Ayush	Guleria	Probability and Statistics using Python
738	191206	Parul	Sharma	Probability and Statistics using Python
739	191207	Nidhi	Rajput	Probability and Statistics using Python
740	191208	Aisha	Sajjad	Probability and Statistics using Python
741	191218	Ananya	Joshi	Probability and Statistics using Python
742	191226	Vipasha	Rana	Probability and Statistics using Python
743	191238	Akshat	A	Probability and Statistics using Python
744	191245	Saksham	Thakur	Probability and Statistics using Python
745	191264	Harshit	Singh	Probability and Statistics using Python
746	191268	Priyansh	Khatri	Probability and Statistics using Python
747	191270	Divyansh	Mandhan	Probability and Statistics using Python
748	191277	Archit	Dogra	Probability and Statistics using Python
749	191289	Shaan	Srivastava	Probability and Statistics using Python
750	191299	Mehul	Kansal	Probability and Statistics using Python
751	191320	Piyush	Kanungo	Probability and Statistics using Python
752	191321	Anubhav	Garg	Probability and Statistics using Python
753	191342	Priyanshi	.	Probability and Statistics using Python
754	191346	Tripti	Gupta	Probability and Statistics using Python
755	191354	Gautmi	Singh	Probability and Statistics using Python
756	191362	Harshul	Choudhary	Probability and Statistics using Python
757	191366	Ujjwal	Rajput	Probability and Statistics using Python
758	191379	Aditi	Garg	Probability and Statistics using Python
759	191455	Shivam	Verma	Probability and Statistics using Python
760	191507	Ngawang	Choega	Probability and Statistics using Python
761	191529	Sulbha	Sharma	Probability and Statistics using Python
762	191550	Aanjaneya	Sharma	Probability and Statistics using Python
763	191555	Rahul	Sharma	Probability and Statistics using Python
764	191211	Anushka	Srivastava	Programming Fundamentals using Python - Part 1
765	191213	Ananya	Mishra	Programming Fundamentals using Python - Part 1
766	191220	Saksham	Chaturvedi	Programming Fundamentals using Python - Part 1
767	191223	Prishita	Singh	Programming Fundamentals using Python - Part 1
768	191225	Abhiti	Labroo	Programming Fundamentals using Python - Part 1
769	191230	Sahil	Thakur	Programming Fundamentals using Python - Part 1
770	191240	Prerna	Gupta	Programming Fundamentals using Python - Part 1
771	191291	Mangal chhotelal	Gupta	Programming Fundamentals using Python - Part 1
772	191305	Harshit	Sinha	Programming Fundamentals using Python - Part 1
773	191389	Shreya	Srivastava	Programming Fundamentals using Python - Part 1

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774	191390	Arj	Srivastava	Programming Fundamentals using Python - Part 1
775	191391	Achyut	Tiwari	Programming Fundamentals using Python - Part 1
776	191393	Aishani	Pachauri	Programming Fundamentals using Python - Part 1
777	191423	Varsha	Singh	Programming Fundamentals using Python - Part 1
778	191438	Mayank	Gupta	Programming Fundamentals using Python - Part 1
779	191439	Radhika	Gupta	Programming Fundamentals using Python - Part 1
780	191539	Anmol	Jain	Programming Fundamentals using Python - Part 1
781	191549	Saran deep	Singh	Programming Fundamentals using Python - Part 1
782	191551	Srishti	Budholia	Programming Fundamentals using Python - Part 1
783	191211	Anushka	Srivastava	Programming Fundamentals using Python - Part 2
784	191213	Ananya	Mishra	Programming Fundamentals using Python - Part 2
785	191225	Abhiti	Labroo	Programming Fundamentals using Python - Part 2
786	191230	Sahil	Thakur	Programming Fundamentals using Python - Part 2
787	191240	Prerna	Gupta	Programming Fundamentals using Python - Part 2
788	191291	Mangal chhotelal	Gupta	Programming Fundamentals using Python - Part 2
789	191305	Harshit	Sinha	Programming Fundamentals using Python - Part 2
790	191389	Shreya	Srivastava	Programming Fundamentals using Python - Part 2
791	191390	Arj	Srivastava	Programming Fundamentals using Python - Part 2
792	191391	Achyut	Tiwari	Programming Fundamentals using Python - Part 2
793	191393	Aishani	Pachauri	Programming Fundamentals using Python - Part 2
794	191423	Varsha	Singh	Programming Fundamentals using Python - Part 2
795	191438	Mayank	Gupta	Programming Fundamentals using Python - Part 2
796	191439	Radhika	Gupta	Programming Fundamentals using Python - Part 2
797	191549	Saran deep	Singh	Programming Fundamentals using Python - Part 2
798	191249	Ayush	Pathania	Python for Beginners: Learn Python Programming (Python 3)
799	191206	Parul	Sharma	Python for Data Science
800	191226	Vipasha	Rana	Python for Data Science
801	191245	Saksham	Thakur	Python for Data Science
802	191346	Tripti	Gupta	Python for Data Science
803	191379	Aditi	Garg	Python for Data Science
804	191438	Mayank	Gupta	Python for Data Science
805	191439	Radhika	Gupta	Python for Data Science
806	191455	Shivam	Verma	Python for Data Science
807	191529	Sulbha	Sharma	Python for Data Science
808	191550	Aanjaneya	Sharma	Python for Data Science
809	191249	Ayush	Pathania	Python Programming
810	191202	Ayush	Guleria	React JS
811	191218	Ananya	Joshi	React JS
812	191226	Vipasha	Rana	React JS
813	191238	Akshat	A	React JS

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814	191260	Shivam singh	Negi	React JS
815	191264	Harshit	Singh	React JS
816	191268	Priyansh	Khatri	React JS
817	191277	Archit	Dogra	React JS
818	191289	Shaan	Srivastava	React JS
819	191321	Anubhav	Garg	React JS
820	191342	Priyanshi	.	React JS
821	191354	Gautmi	Singh	React JS
822	191379	Aditi	Garg	React JS
823	191413	Nandini	Singh	React JS
824	191504	Varun	Chodha	React JS
825	191507	Ngawang	Choega	React JS
826	191516	Khushi	Shah	React JS
827	191517	Nitika	Sharma	React JS
828	191529	Sulbha	Sharma	React JS
829	191550	Aanjaneya	Sharma	React JS
830	191555	Rahul	Sharma	React JS
831	191250	Shubham	Patial	Regression Analysis
832	191267	Sushant	Rohan	Regression Analysis
833	191276	Piyush	Singh	Regression Analysis
834	191365	Samarth	Sharma	Regression Analysis
835	191403	Rohit	Sharma	Regression Analysis
836	191417	Abhimanyu	Singh Anand	Regression Analysis
837	191211	Anushka	Srivastava	Software Engineering and Agile software development
838	191259	Anirudh pal	Dev	Software Engineering and Agile software development
839	191305	Harshit	Sinha	Software Engineering and Agile software development
840	191389	Shreya	Srivastava	Software Engineering and Agile software development
841	191390	Arj	Srivastava	Software Engineering and Agile software development
842	191423	Varsha	Singh	Software Engineering and Agile software development
843	191549	Saran deep	Singh	Software Engineering and Agile software development
844	191202	Ayush	Guleria	Statistical Inference using Python
845	191206	Parul	Sharma	Statistical Inference using Python
846	191208	Aisha	Sajjad	Statistical Inference using Python
847	191218	Ananya	Joshi	Statistical Inference using Python
848	191226	Vipasha	Rana	Statistical Inference using Python
849	191238	Akshat	A	Statistical Inference using Python
850	191245	Saksham	Thakur	Statistical Inference using Python
851	191264	Harshit	Singh	Statistical Inference using Python
852	191268	Priyansh	Khatri	Statistical Inference using Python
853	191270	Divyansh	Mandhan	Statistical Inference using Python
854	191277	Archit	Dogra	Statistical Inference using Python

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855	191289	Shaan	Srivastava	Statistical Inference using Python
856	191321	Anubhav	Garg	Statistical Inference using Python
857	191342	Priyanshi	.	Statistical Inference using Python
858	191354	Gautmi	Singh	Statistical Inference using Python
859	191362	Harshul	Choudhary	Statistical Inference using Python
860	191366	Ujjwal	Rajput	Statistical Inference using Python
861	191379	Aditi	Garg	Statistical Inference using Python
862	191455	Shivam	Verma	Statistical Inference using Python
863	191507	Ngawang	Choega	Statistical Inference using Python
864	191529	Sulbha	Sharma	Statistical Inference using Python
865	191550	Aanjaneya	Sharma	Statistical Inference using Python
866	191555	Rahul	Sharma	Statistical Inference using Python
867	191250	Shubham	Patial	Time Series Analysis using Python
868	191267	Sushant	Rohan	Time Series Analysis using Python
869	191276	Piyush	Singh	Time Series Analysis using Python
870	191365	Samarth	Sharma	Time Series Analysis using Python
871	191403	Rohit	Sharma	Time Series Analysis using Python
872	191417	Abhimanyu	Singh Anand	Time Series Analysis using Python
873	191423	Varsha	Singh	Twitter Bootstrap

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MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (the **"MOU"**) is entered into on 20th day of January 2022 (the **"Effective Date"**), by and between:

Sorting Hat Technologies Private Limited, a private company incorporated under the provisions of the Companies Act, 2013 bearing CIN U72200KA2015PTC082063 and having its registered office at Maruti Infotech Centre, 3rd Floor, A-Block, Domlur, Koramangala Inner Ring Road, Bangalore- 560 071, Karnataka, India (hereinafter referred to as **"CodeChef"**, which expression shall, unless repugnant to the meaning or context thereof, be deemed to include its legal representatives and permitted assigns) of the **FIRST PART;**

AND

Jaypee University of Information Technology, with its campus at Waknaghat, Solan, Himachal Pradesh 17323 , (hereinafter referred to as "**University**", which expression shall, unless repugnant to the meaning or context thereof, be deemed to include its legal representatives and permitted assigns) **of the SECOND PART;**

The CodeChef and the University shall thereafter, as the context may require, individually be referred to as a "**Party**" and collectively be referred to as the "**Parties**".

WHEREAS:

i. The University is engaged in education to students across various domains.
ii. The Parties wish to enter into a collaboration wherein CodeChef shall provide one-year free access to its platform, to the students and faculty of the University.
iii. The University has represented and warranted to CodeChef that it has relevant authority, permit and licenses to fulfill its obligations under this MoU and based on the said representation and warranties, CodeChef has agreed to enter into this MoU with the University on a non-exclusive basis and the Parties have agreed to fulfill their obligations under this MoU.

NOW THEREFORE, in consideration of the mutual promises and covenants contained herein, the Parties agree as follows

1. The University shall enroll approximately 1664 students with CodeChef.
    a. The University shall share the student details in a timely basis and in one-go by sending CodeChef a spreadsheet containing student's account creation details such as - Name, Roll number (optional), email id, University name (preferred way of referring the University), and preferred pattern for creating their usernames on CodeChef.
    b. For those students whose accounts are already on CodeChef, the University shall share their existing CodeChef usernames as well in the spreadsheet.

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c. By using the information in the spreadsheet, CodeChef shall create bulk accounts/profiles of students and share the same with the University.

2. CodeChef shall conduct an Orientation session for faculty and students of the University on a time mutually decided by both the parties.

3. The University shall review the program curriculum shared by CodeChef and map it to its existing semester/curriculum.

   a. The program curriculum is given as Annexure 2 to this MOU.

   b. In case of changes, CodeChef and University shall discuss and finalize the same before commencement of the program.

   c. CodeChef shall organize meeting(s) with the faculty of the University to understand the curriculum in depth, and select problems per topic.

4. Periodic practice sessions & Assessment-based tests (for grading) shall be created by CodeChef for the students and shared regularly with the University. The program structure is given as Annexure 1 to this MOU.

5. Monthly report shall be sent to the University about the students' overall performance on CodeChef.

6. CodeChef has no liability whatsoever other than that of providing access to the platform for one year and creating practice & assessment-based tests.

7. University and CodeChef agree that the information shared during the term of this MoU is confidential in nature and shall not disclose it with any third-party without prior written consent.

8. University hereby agrees to indemnify and save harmless CodeChef including, where applicable, its affiliates, directors, officers, employees and agents (each such party being an "Indemnified Party") harmless from and against and agree to be liable for any and all losses, claims, actions, suits, proceedings, damages, liabilities or expenses of whatever nature or kind, incurred by the Indemnified Party that arises out of:

   a) breach of any of its obligations, covenants or representations and warranties under this Agreement; or
   b) Violation of any applicable laws; or
   c) Infringement of any third-party intellectual property rights;

9. This MoU shall be valid for a period of one year from Effective Date.

10. This MoU may be terminated at any time by either Party upon fifteen (15) days written notice to the other party.

11. This MoU shall be governed by the laws of India. The courts of India shall have exclusive jurisdiction.

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12. In the event that the Parties desire to change, add, or otherwise modify any terms, they shall do so in writing to be signed by both parties.

The Parties agree to the terms and conditions set forth above as demonstrated by their signatures as follows:

Signature		Vivek Sehgal
Name	Tony Mathew	Prof. Vivek Kumar Sehgal
Title	Authorized Signatory	Prof and Head
	For, **CodeChef**	For, **University**

Annexure 1

Program Structure (mapped to the University semester)

Week Count	Tasks

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Week 0	Orientation
Week 1	Practice Link (6 hand-picked coding problems)
Week 2	Week 1 Assignment Link (3 hand-picked coding problems) Week 2 Practice Link (6 hand-picked coding problems) Live Doubt-Solving Session
Week 3	Week 2 Assignment Link (3 hand-picked coding problems) Week 3 Practice Link (6 hand-picked coding problems)
Week 4	Week 3 Assignment Link (3 hand-picked coding problems) Week 4 Practice Link (6 hand-picked coding problems) Live Doubt-Solving Session
Week 4	Rated Contest (global) participation Report
Week 5 - Week 7	Assignment Link of Previous Week (3 hand-picked coding problems) Practice Link for the current Week (6 hand-picked coding problems) Live Doubt-Solving Session (Week 6)
Week 7	Rated Contest (global) participation Report
Week 8 - Week 10	Assignment Link of Previous Week (3 hand-picked coding problems) Practice Link for the current Week (6 hand-picked coding problems) Live Doubt-Solving Session (Weeks 8 & 10)
Week 10	Rated Contest (global) participation Consolidated Report

Annexure 2

CodeChef Program - At A Glance

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Note:

- The topics per week can be rearranged based on the academic curriculum and semester plan.
- From 2nd year onwards, the program will always start with Beginner's Course, and once completed, will progress to Intermediate and then to Advanced levels (in strict order).

Year 1 (Semesters 1 and 2) - Foundation (Non-DSA) Program

- Problems which make the students use various constructs of the programming language (like loops, if-else, operators, variables, etc.) will be shared as part of the foundation syllabus.
- Students will be challenged to think of the ways in which each construct can be used differently for each problem, and by doing so, they develop an understanding for the power of each programming construct and become very comfortable with the basic tools that the language gives them.
- This fluency which comes with practicing writing code is critical for future semesters when the students learn about more advanced algorithms and data structures built on top of these constructs.

Year 2 and Year 3 - Indicative Beginners DSA-Focused Program

Week 1	Basics of Programming, Time Complexity
Week 2	Arrays and Strings I
Week 3	Arrays and Strings II
Week 4	Sorting I
Week 5	Sorting II
Week 6	Binary Search
Week 7	Stacks, Queues
Week 8	BSTs, STLs - I
Week 9	BSTs, STLs - II
Week 10	Greedy Algorithms

Year 3 Intermediate DSA-Focused-(for Universities with existing programming culture)

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Week 1	Basic Number Theory, Asymptotic Analysis
Week 2	Recursion and Dynamic Programming I
Week 3	Dynamic Programming II
Week 4	Dynamic Programming III
Week 5	Graphs I - Introduction to Trees, BFS, DFS
Week 6	Graphs II - LCA and more BFS, DFS
Week 7	Tree DP
Week 8	Graphs III - Shortest Paths
Week 9	Graphs IV - More Shortest Paths
Week 10	Graphs V - DSU, MSTs

Year 4 (Semesters 7 and 8) - Advanced DSA-Focused Program (for Universities with advanced programming culture)

Week 1	Advanced Graphs I - DAGs and SCCs
Week 2	Advanced Graphs II - Network Flows
Week 3	Advanced Graphs III - More Network Flows
Week 4	Square Root Decomposition
Week 5	Segment Trees I
Week 6	Segment Trees II
Week 7	Advanced Number Theory
Week 8	Advanced Dynamic Programming I
Week 9	Advanced Dynamic Programming II
Week 10	Advanced Dynamic Programming III

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Design of $\mathcal{T}$-*Direct* codes over $\mathtt{GF}(2^{\mathcal{N}})$ with increased users

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ABSTRACT

This paper presents design of $\mathcal{T}$-*Direct* codes over $\mathtt{GF}(2^{\mathcal{N}})$ with increased users. The class of $\mathcal{T}$-*Direct* codes are an extension to the class of *linear codes with complementary duals* (LCD codes) and can be effectively used over a multiple access channel environment. In this paper, a construction procedure that constructs an n^3-*Direct* code from an n-*Direct* code is described. An n^n-*Direct* codes are also constructed. Further, a recursive construction procedure is presented that constructs n^{3^m}-*Direct* codes for $m \geq 0$. Finally, $\mathcal{T}^{\mathcal{T}}$-*Direct* codes with constituent codes having variable code rates are obtained. The advantage of these constructions is that it increases the number of *constituent* codes (users) of an existing $\mathcal{T}$-*Direct* code, thereby supporting more users in a multi-user environment.

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1. Introduction

A $\mathcal{T}$-*Direct* code is the set of $\mathcal{T}\mathbb{F}$-ary linear codes $\Gamma_1, \Gamma_2, \ldots, \Gamma_\mathcal{T}$ such that $\Gamma_i \cap \Gamma_i^\perp = \{\mathbf{0}\}$, where $\Gamma_i^\perp = \Gamma_1 \oplus \Gamma_2 \oplus \cdots \oplus \Gamma_{i-1} \oplus \Gamma_{i+1} \oplus \cdots \oplus \Gamma_\mathcal{T}$ is the dual of Γ_i with respect to the direct sum $\Lambda = \Gamma_1 \oplus \Gamma_2 \oplus \cdots \oplus \Gamma_\mathcal{T} \subseteq \mathbb{F}^n$ for each $i = 1, 2, \ldots, \mathcal{T}$ and denoted by $(\Gamma_1, \Gamma_2, \ldots, \Gamma_\mathcal{T})$ [1]. The class of $\mathcal{T}$-*Direct* codes are in fact an extension to the class of LCD codes [2]. The LCD-notion of a linear code $\mathcal{C}$ together with its *dual* $\mathcal{C}^\perp$ having $\mathcal{C} \cap \mathcal{C}^\perp = \{\mathbf{0}\}$ was first introduced by J.L. Massey [2]. Since the inception of LCD codes many researchers have proposed new classes of LCD codes that can be evidenced in [3], [4], [5], [6], [7], [8] and [9] etc. Recently, LCD codes also found application in the study of side-channel attack [10]. Despite having a rich algebraic structure, coding applications of LCD codes to multiple-access channel are restricted only to 2-user case until 2001. In [1], the notion of *LCD* codes has been generalized to include $\mathcal{T} > 2$ *constituent* codes, termed as $\mathcal{T}$-*Direct* codes. These classes of multi-user algebraic codes can be used in a multiple access channel environment for encoding and decoding (or separating the user codewords). The inception of $\mathcal{T}$-*Direct* codes lead to the development of coding schemes for the $\mathcal{T}$-user $\mathbb{F}$-Adder Channel. A coding scheme for the $\mathcal{T}$-user $\mathtt{GF}(2^n)$-Adder Channel is studied in [1], [11], and [12], where a class of $\mathcal{T}$-*Direct* codes is constructed; the class of $\mathcal{T}$-*Direct* codes are shown to be effective in coding over both *noiseless* and *noisy* $\mathcal{T}$-user $\mathbb{F}$-Adder Channel, in that they uniquely determine the transmitted codewords from the received sequence. A construction method for the class of $\mathcal{T}$-*Direct* codes (defined over $\mathtt{GF}(2^n)$) that can increase the minimum distance of the *constituent* codes is proposed in [13] and [14], where it is shown that the proposed construction method also increases the number of *constituent* codes from n to $2n-1$ [13], and further to $\frac{n(n+1)}{2}$. The constructions given in [13], [14] are further generalized in [15] to construct n^2-*Direct* codes. The sum-rate $\mathcal{R}$ of a $\mathcal{T}$-user code $(\Gamma_1, \Gamma_2, \ldots, \Gamma_\mathcal{T})$ is defined as $\mathcal{R} = \mathcal{R}_1 + \mathcal{R}_2 + \cdots + \mathcal{R}_\mathcal{T}$, where $\mathcal{R}_i$ is the information rate of Γ_i [16].

This paper presents constructions of n^3-*Direct* codes, n^n-*Direct* codes, n^{3^m}-*Direct* codes, and $\mathcal{T}^\mathcal{T}$-*Direct* codes which support handling more number of users in a multi-user environment. In all the constructions, Kronecker product represented by the symbol $\otimes$ is used as a basic tool. These constructions require *constituent* codes of an existing $\mathcal{T}$-*Direct* code. The *constituent* codes considered are chosen from the class of rank distance codes introduced by Gabidulin in 1985 [17]. The rank distance codes have been well studied in terms of properties, bounds and decoding [18], [19], [20]. The remaining part of the paper is organized as follows. The section 2 present the basic definitions and notations. Section 3 constructs the class of n^3-*Direct* codes from the class of n-*Direct* codes. Section 4 generalizes the construction procedure outlined in section 3 and obtains n^n-*Direct* codes. A recursive construction of $n^{3^{m+1}}$-*Direct* codes from n^{3^m}-*Direct* codes for $m \geq 0$ is presented in section 5 along with an example which clearly illustrates the construction procedure. Finally, a construction procedure to construct $\mathcal{T}^\mathcal{T}$-*Direct* codes with flexible code-rates is explained in section 6. Section 7 draws the conclusion based on the results.

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2. Preliminary ideas

This section recalls certain fundamentals of rank distance codes introduced by Gabidulin in 1985 [17] and $\mathcal{T}$-*Direct* codes [1].

2.1. Rank distance codes

Most studies in the literature concerning the error-correcting codes are dealing with the Hamming metric introduced by Hamming [21]. However, in comparison to codes with Hamming metric, the rank metric introduced by E.M. Gabidulin [17] is found to be an ideal metric as it recognizes well the linear dependence among the code symbols of the alphabet, especially when the symbols are from higher dimensional Galois fields. The rank metric codes have been well studied in terms of properties, bounds and decoding [18], [19], [20].

Definition 2.1 *([17]).* The class of *rank distance* (RD) codes are defined as subsets of an n-dimensional space $\mathbb{F}_{q^N}^n$ of n-vectors over an extension field $\mathbb{F}_{q^N}$, where $n \leq N$.

Definition 2.2 *([17]).* The class of (n, k, d) RD codes which attains equality in the Singleton-like bound are called *maximum rank distance* (MRD) codes; i.e. codes for which $d = n - k + 1$.

Definition 2.3 *([17]).* A $k \times n$ generator matrix $\mathbf{G}$ defining an (n, k, d) MRD code is given by

$$\mathbf{G} = \begin{pmatrix} g_1 & g_2 & \cdots & g_n \\ g_1^q & g_2^q & \cdots & g_n^q \\ \vdots & \vdots & \ddots & \vdots \\ g_1^{q^{k-1}} & g_2^{q^{k-1}} & \cdots & g_n^{q^{k-1}} \end{pmatrix}$$

where $g_1, g_2, \ldots, g_n \in \mathtt{GF}(q^N)$ are linearly independent over $\mathtt{GF}(q)$. The paper considers the case when $n = N$.

Definition 2.4 *([22]).* An MRD code with parameters (n, k, d) generated by $\mathbf{G}$ with $\{g_1, g_2, \ldots, g_n\}$ is a *trace-orthogonal* basis in $\mathtt{GF}(q^n)$ is an LCD code.

2.2. $\mathcal{T}$-Direct codes

For an arbitrary finite field $\mathbb{F}$, the class of $\mathbb{F}$-ary $\mathcal{T}$-*Direct* codes is a natural extension to the class of *linear codes with complementary duals* (LCD). The following theorem gives the necessary and sufficient condition for a set of $\mathcal{T}$ $\mathbb{F}$-ary linear codes to constitute a $\mathcal{T}$-*Direct* code.

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Theorem 2.1 *([1]). Let Γ_i be an (n, k_i) $\mathbb{F}$-ary linear code with the generator matrix $\mathbf{G}_i$ such that $\mathbf{G}_i\mathbf{G}j^{\mathbf{T}} = (\mathbf{0})$ for each $i = 1, 2, \ldots, \mathcal{T}$ with $i \neq j$. Then $(\Gamma_1, \Gamma_2, \ldots, \Gamma_\mathcal{T})$ is a $\mathcal{T}$-*Direct *code if and only if the $k_i \times k_i$ matrix $\mathbf{G}_i\mathbf{G}_i^{\mathbf{T}}$ is non-singular for every i. Further, if $(\Gamma_1, \Gamma_2, \ldots, \Gamma_\mathcal{T})$ is a $\mathcal{T}$-*Direct *code, then $\Pi_{\Gamma_i} = \mathbf{G}_i^{\mathbf{T}}(\mathbf{G}_i\mathbf{G}_i^{\mathbf{T}})^{-1}\mathbf{G}_i$ is the orthogonal projector from $\Lambda = \Gamma_1 \oplus \Gamma_2 \oplus \cdots \oplus \Gamma_\mathcal{T}$ onto Γ_i for each i.*

2.3. Notations and abbreviations

We use the notation $(\{n_1, n_2, \ldots, n_\mathcal{T}\}, \{k_1, k_2, \ldots, k_\mathcal{T}\}, \{d_1, d_2, \ldots, d_\mathcal{T}\})$ to denote a *$\mathcal{T}$-Direct* code constituted by the *constituent* codes (n_1, k_1, d_1), (n_2, k_2, d_2), ..., $(n_\mathcal{T}, k_\mathcal{T}, d_\mathcal{T})$ and is abbreviated as $(\{n_i\}, \{k_i\}, \{d_i\})$. In particular, a *$\mathcal{T}$-Direct* code with $k_1 = k_2 = \cdots = k_\mathcal{T} = k$ (say) is denoted by $(\{n_i\}, \{k\}, \{d_i\})$ rather than $(\{n_i\}, k, \{d_i\})$ – to distinguish a *$\mathcal{T}$-Direct* code from a conventional single user code, namely (n, k, d). Let $[m] = 2^m$ for some positive integer m.

3. Construction of n^3-*Direct* codes

The number of users that can be assigned a *constituent* code (for each user) in case of a *$\mathcal{T}$-Direct* code, defined over $\mathtt{GF}(2^n)$, is at most n^2 [15]. This section attempts to extend an $(\{n^2\}, \{1\}, \{n^2\})$ *$\mathcal{T}$-Direct* code defined over $\mathtt{GF}(2^n)$ to include more *constituent* codes, thereby increasing the number of users that can be supported by a conventional *$\mathcal{T}$-Direct* code. In what follows, a coding procedure to construct a *$\mathcal{T}$-Direct* code which can assign *constituent* codes to more than n^2 users is presented.

Consider an $(\{n\}, \{1\}, \{n\})$ *n-Direct* code $(\Gamma_1, \Gamma_2, \ldots, \Gamma_n)$ with $n \geq 3$ along with the generator matrices of the *constituent* codes:

$$\mathbf{G}_1 = \begin{bmatrix} \alpha_1^{[1]} & \alpha_2^{[1]} & \cdots & \alpha_n^{[1]} \end{bmatrix}$$
$$\mathbf{G}_2 = \begin{bmatrix} \alpha_1^{[2]} & \alpha_2^{[2]} & \cdots & \alpha_n^{[2]} \end{bmatrix}$$
$$\vdots$$
$$\text{and } \mathbf{G}_n = \begin{bmatrix} \alpha_1^{[n]} & \alpha_2^{[n]} & \cdots & \alpha_n^{[n]} \end{bmatrix}$$

where $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$ is a *trace-orthogonal basis* in $\mathtt{GF}(2^n)$. For each $j, k = 1, 2, \ldots, n$ using $\mathbf{G}_j$ and $\mathbf{G}_k$, define the following generator matrices:

$$\mathcal{G}_{1jk} = \mathbf{G}_1 \otimes \mathbf{G}_j \otimes \mathbf{G}_k$$
$$\mathcal{G}_{2jk} = \mathbf{G}_2 \otimes \mathbf{G}_j \otimes \mathbf{G}_k$$
$$\vdots$$
$$\text{and } \mathcal{G}_{njk} = \mathbf{G}_n \otimes \mathbf{G}_j \otimes \mathbf{G}_k.$$

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For each $j = 1, 2, \ldots, n$ and each $k = 1, 2, \ldots, n$, let Γ_{ijk} denote the $\mathtt{GF}(2^n)$-ary code obtained by $\mathcal{G}_{ijk} = \mathbf{G}_i \otimes \mathbf{G}_j \otimes \mathbf{G}_k$ for $i = 1, 2, \ldots, n$. It is clear that the *constituent* codes Γ_{ijk} generated are in fact obtained from $\mathcal{G}_{ijk}$ which is the Kronecker product of distinct generator matrices: $\mathcal{G}_{ijk} = \mathbf{G}_i \otimes \mathbf{G}_j \otimes \mathbf{G}_k$. By this very nature of Kronecker product multiplication of generator matrices, the construction procedure generates distinct *constituent* codes. Also, note that the resultant codes Γ_{ijk} are not rank distance codes and consequently the minimum distance of these codes can be found as discussed below. Let $\eta \in \Gamma_{ijk}$ be a non-zero codeword for $i, j, k \in \{1, 2, \ldots, n\}$. By the very construction of Γ_{ijk}-code, an arbitrary codeword $c \in \Gamma_{ijk}$ can be written as the Kronecker product of $c_i \in \Gamma_i$, $c_j \in \Gamma_j$, and $c_k \in \Gamma_k$. Consequently, the weight $w(\eta)$ of a non-zero codeword $\eta \in \Gamma_{ijk}$ can be calculated as follows:

$$\begin{aligned} w(\eta) &= w\left((\alpha_1,\ \alpha_2, \ldots,\ \alpha_n) \otimes (\beta_1,\ \beta_2, \ldots,\ \beta_n) \otimes (\gamma_1,\ \gamma_2, \ldots,\ \gamma_n)\right) \\ &= w(\alpha_1,\ \alpha_2, \ldots,\ \alpha_n) w(\beta_1,\ \beta_2, \ldots,\ \beta_n) w(\gamma_1,\ \gamma_2, \ldots,\ \gamma_n) \\ &= w(\alpha) w(\beta) w(\gamma) \\ &\geq d_i d_j d_k \end{aligned}$$

for some non-zero codewords $\alpha \in \Gamma_i, \beta \in \Gamma_j, \gamma \in \Gamma_k$, where d_i, d_j, d_k are respectively the minimum distances of $\Gamma_i, \Gamma_j, \Gamma_k$. It follows that, the minimum distance of the $(i, j, k)^{th}$ *constituent* code Γ_{ijk} is $d_i d_j d_k$. Since each Γ_i is an $(n, 1, n)$ code, each Γ_{ijk} is an $(n^3, 1, n^3)$ code.

It remains now to verify that the newly obtained n^3 codes $(\Gamma_{ijk},\ i, j, k = 1, 2, \ldots, n)$ constitute an $(\{n^3\}, \{1\}, \{n^3\})$ n^3-*Direct* code. This is proved in the following theorem.

Theorem 3.1. *Set* $\{\Gamma_{ijk} \mid i, j, k = 1, 2, \ldots, n\}$ *constitutes an* n^3-Direct *code.*

Proof. For every $(i,\ j,\ k)$ and $(r,\ s,\ t)$:

$$\begin{aligned} \mathcal{G}_{ijk} \mathcal{G}_{rst}^{\mathbf{T}} &= (\mathbf{G}_i \otimes \mathbf{G}_j \otimes \mathbf{G}_k)(\mathbf{G}_r \otimes \mathbf{G}_s \otimes \mathbf{G}_t)^{\mathbf{T}} \\ &= (\mathbf{G}_i \otimes \mathbf{G}_j \otimes \mathbf{G}_k)(\mathbf{G}_r^{\mathbf{T}} \otimes \mathbf{G}_s^{\mathbf{T}} \otimes \mathbf{G}_t^{\mathbf{T}}) \\ &= (\mathbf{G}_i \mathbf{G}_r^{\mathbf{T}}) \otimes (\mathbf{G}_j \mathbf{G}_s^{\mathbf{T}}) \otimes (\mathbf{G}_k \mathbf{G}_t^{\mathbf{T}}) \\ &= \begin{cases} 1 & , \quad (i,\ j,\ k) = (r,\ s,\ t) \\ 0 & , \quad (i,\ j,\ k) \neq (r,\ s,\ t) \end{cases}. \end{aligned}$$

Thus, $\{\Gamma_{ijk} \mid i, j, k = 1, 2, \ldots, n\}$ forms an $(\{n^3\}, \{1\}, \{n^3\})$ n^3-*Direct* code. It is shown that, the n^3 codes thus obtained constitute an n^3-*Direct* code. This construction of n^3-*Direct* codes from n-*Direct* codes (over the same underlying field $\mathtt{GF}(2^n)$) allows more users to participate simultaneously in a multi-user environment. □

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4. Construction of n^n-*Direct* codes

Consider an $(\{n\},\{1\},\{n\})$ *n-Direct* code $(\Gamma_1,\Gamma_2,\ldots,\Gamma_n)$ along with the generator matrices of the *constituent* codes:

$$\mathbf{G}_1 = \begin{bmatrix} \alpha_1^{[1]} & \alpha_2^{[1]} & \cdots & \alpha_n^{[1]} \end{bmatrix}$$
$$\mathbf{G}_2 = \begin{bmatrix} \alpha_1^{[2]} & \alpha_2^{[2]} & \cdots & \alpha_n^{[2]} \end{bmatrix}$$
$$\vdots$$
$$\text{and } \mathbf{G}_n = \begin{bmatrix} \alpha_1^{[n]} & \alpha_2^{[n]} & \cdots & \alpha_n^{[n]} \end{bmatrix},$$

where $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$ is a *trace-orthogonal basis* in $\mathtt{GF}(2^n)$. For each $i_1, i_2, \ldots, i_n \in \{1,2,\ldots,n\}$ define the following generator matrices:

$$\mathcal{G}_{1i_2\ldots i_n} = \mathbf{G}_1 \otimes (\mathbf{G}_{i_2} \otimes \mathbf{G}_{i_3} \otimes \cdots \otimes \mathbf{G}_{i_n})$$
$$\mathcal{G}_{2i_2\ldots i_n} = \mathbf{G}_2 \otimes (\mathbf{G}_{i_2} \otimes \mathbf{G}_{i_3} \otimes \cdots \otimes \mathbf{G}_{i_n})$$
$$\vdots$$
$$\text{and } \mathcal{G}_{ni_2\ldots i_n} = \mathbf{G}_n \otimes (\mathbf{G}_{i_2} \otimes \mathbf{G}_{i_3} \otimes \cdots \otimes \mathbf{G}_{i_n}).$$

For each $i_1 = 1,2,\ldots,n$, let $\Gamma_{i_1 i_2\ldots i_n}$ denote the $(n^n, 1, n^n)$ $\mathtt{GF}(2^n)$-ary code obtained by $\mathcal{G}_{i_1 i_2\ldots i_n} = \mathbf{G}_{i_1} \otimes \mathbf{G}_{i_2} \otimes \cdots \otimes \mathbf{G}_{i_n}$ for $i_2, i_3, \ldots, i_n = 1,2,\ldots,n$. It remains now to verify that the newly obtained n^n codes $\Gamma_{i_1 i_2\ldots i_n}$, $1 \le i_1, i_2, \ldots, i_n \le n$ constitute an $(\{n^n\},\{1\},\{n^n\})$ n^n-*Direct* code. This is proved in the following theorem.

Theorem 4.1. $\{\Gamma_{i_1 i_2\ldots i_n} \mid 1 \le i_1, i_2, \ldots, i_n \le n\}$ *constitutes an* n^n-Direct *code.*

Proof. For every $(i_1, i_2, \ldots, i_n)$ and $(j_1, j_2, \ldots, j_n)$:

$$\begin{aligned}
\mathcal{G}_{i_1 i_2\ldots i_n}\mathcal{G}^{\mathbf{T}}_{j_1 j_2\ldots j_n} &= (\mathbf{G}_{i_1} \otimes \mathbf{G}_{i_2} \otimes \cdots \otimes \mathbf{G}_{i_n})(\mathbf{G}_{j_1} \otimes \mathbf{G}_{j_2} \otimes \cdots \otimes \mathbf{G}_{j_n})^{\mathbf{T}} \\
&= (\mathbf{G}_{i_1} \otimes \mathbf{G}_{i_2} \otimes \cdots \otimes \mathbf{G}_{i_n})(\mathbf{G}^{\mathbf{T}}_{j_1} \otimes \mathbf{G}^{\mathbf{T}}_{j_2} \otimes \cdots \otimes \mathbf{G}^{\mathbf{T}}_{j_n}) \\
&= (\mathbf{G}_{i_1}\mathbf{G}^{\mathbf{T}}_{j_1}) \otimes (\mathbf{G}_{i_2}\mathbf{G}^{\mathbf{T}}_{j_2}) \otimes \cdots \otimes (\mathbf{G}_{i_n}\mathbf{G}^{\mathbf{T}}_{j_n}) \\
&= \begin{cases} 1 & , \quad (i_1, i_2, \ldots, i_n) = (j_1, j_2, \ldots, j_n) \\ 0 & , \quad (i_1, i_2, \ldots, i_n) \neq (j_1, j_2, \ldots, j_n) \end{cases}.
\end{aligned}$$

Thus, $\{\Gamma_{i_1 i_2\ldots i_n} \mid 1 \le i_1, i_2, \ldots, i_n \le n\}$ forms an $(\{n^n\},\{1\},\{n^n\})$ n^n-*Direct* code. It is shown that, the n^n codes thus obtained constitute an n^n-*Direct* code. This generalized construction of n^n-*Direct* codes from *n-Direct* codes offers the benefit of more users to participate simultaneously in a multi-user environment. An example is given below to facilitate the construction procedure. It illustrates the construction procedure

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for a $(\{27\},\{1\},\{27\})$ 27-*Direct* code from a $(\{3\},\{1\},\{3\})$ 3-*Direct* code defined over $\mathtt{GF}(2^3)$. □

Example 4.1. Consider the $(\{3\},\{1\},\{3\})$ 3-*Direct* code $(\Gamma_1,\Gamma_2,\Gamma_3)$ along with the generator matrices of its *constituent* codes:

$$\mathbf{G}_1 = \begin{bmatrix} \alpha^3 & \alpha^6 & \alpha^5 \end{bmatrix}$$
$$\mathbf{G}_2 = \begin{bmatrix} \alpha^6 & \alpha^5 & \alpha^3 \end{bmatrix}$$
$$\text{and} \quad \mathbf{G}_3 = \begin{bmatrix} \alpha^5 & \alpha^3 & \alpha^6 \end{bmatrix},$$

where α is the root of the primitive polynomial x^3+x+1 in $\mathtt{GF}(2^3)$. Employing the construction procedure as mentioned below:

$$\mathcal{G}_{111} = \mathbf{G}_1 \otimes \mathbf{G}_1 \otimes \mathbf{G}_1$$
$$= \begin{bmatrix} \alpha^2 & \alpha^5 & \alpha^4 & \alpha^5 & \alpha & 1 & \alpha^4 & 1 & \alpha^6 & \alpha^5 & \alpha & 1 & \alpha & \alpha^4 \\ \alpha^3 & 1 & \alpha^3 & \alpha^2 & \alpha^4 & 1 & \alpha^6 & 1 & \alpha^3 & \alpha^2 & \alpha^6 & \alpha^2 & \alpha \end{bmatrix}$$
$$\mathcal{G}_{112} = \mathbf{G}_1 \otimes \mathbf{G}_1 \otimes \mathbf{G}_2$$
$$= \begin{bmatrix} \alpha^5 & \alpha^4 & \alpha^2 & \alpha & 1 & \alpha^5 & 1 & \alpha^6 & \alpha^4 & \alpha & 1 & \alpha^5 & \alpha^4 & \alpha^3 \\ \alpha & \alpha^3 & \alpha^2 & 1 & 1 & \alpha^6 & \alpha^4 & \alpha^3 & \alpha^2 & 1 & \alpha^2 & \alpha & \alpha^6 \end{bmatrix}$$
$$\mathcal{G}_{113} = \mathbf{G}_1 \otimes \mathbf{G}_1 \otimes \mathbf{G}_3$$
$$= \begin{bmatrix} \alpha^4 & \alpha^2 & \alpha^5 & 1 & \alpha^5 & \alpha & \alpha^6 & \alpha^4 & 1 & 1 & \alpha^5 & \alpha & \alpha^3 & \alpha \\ \alpha^4 & \alpha^2 & 1 & \alpha^3 & \alpha^6 & \alpha^4 & 1 & \alpha^2 & 1 & \alpha^3 & \alpha & \alpha^6 & \alpha^2 \end{bmatrix}$$
$$\mathcal{G}_{121} = \mathbf{G}_1 \otimes \mathbf{G}_2 \otimes \mathbf{G}_1$$
$$= \begin{bmatrix} \alpha^5 & \alpha & 1 & \alpha^4 & 1 & \alpha^6 & \alpha^2 & \alpha^5 & \alpha^4 & \alpha & \alpha^4 & \alpha^3 & 1 & \alpha^3 \\ \alpha^2 & \alpha^5 & \alpha & 1 & 1 & \alpha^3 & \alpha^2 & \alpha^6 & \alpha^2 & \alpha & \alpha^4 & 1 & \alpha^6 \end{bmatrix}$$
$$\mathcal{G}_{122} = \mathbf{G}_1 \otimes \mathbf{G}_2 \otimes \mathbf{G}_2$$
$$= \begin{bmatrix} \alpha & 1 & \alpha^5 & 1 & \alpha^6 & \alpha^4 & \alpha^5 & \alpha^4 & \alpha^2 & \alpha^4 & \alpha^3 & \alpha & \alpha^3 & \alpha^2 \\ 1 & \alpha & 1 & \alpha^5 & \alpha^3 & \alpha^2 & 1 & \alpha^2 & \alpha & \alpha^6 & 1 & \alpha^6 & \alpha^4 \end{bmatrix}$$
$$\mathcal{G}_{123} = \mathbf{G}_1 \otimes \mathbf{G}_2 \otimes \mathbf{G}_3$$
$$= \begin{bmatrix} 1 & \alpha^5 & \alpha & \alpha^6 & \alpha^4 & 1 & \alpha^4 & \alpha^2 & \alpha^5 & \alpha^3 & \alpha & \alpha^4 & \alpha^2 & 1 \\ \alpha^3 & 1 & \alpha^5 & \alpha & \alpha^2 & 1 & \alpha^3 & \alpha & \alpha^6 & \alpha^2 & \alpha^6 & \alpha^4 & 1 \end{bmatrix}$$
$$\mathcal{G}_{131} = \mathbf{G}_1 \otimes \mathbf{G}_3 \otimes \mathbf{G}_1$$

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$$= \Big[\alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^2 \quad \alpha^5 \quad \alpha^4 \quad \alpha^5 \quad \alpha \quad 1 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^5 \quad \alpha$$

$$1 \quad \alpha \quad \alpha^4 \quad \alpha^3 \quad \alpha^6 \quad \alpha^2 \quad \alpha \quad \alpha^4 \quad 1 \quad \alpha^6 \quad 1 \quad \alpha^3 \quad \alpha^2\Big]$$

$$\mathcal{G}_{132} = \mathbf{G}_1 \otimes \mathbf{G}_3 \otimes \mathbf{G}_2$$

$$= \Big[1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^5 \quad \alpha^4 \quad \alpha^2 \quad \alpha \quad 1 \quad \alpha^5 \quad \alpha^3 \quad \alpha^2 \quad 1 \quad \alpha \quad 1$$

$$\alpha^5 \quad \alpha^4 \quad \alpha^3 \quad \alpha \quad \alpha^2 \quad \alpha \quad \alpha^6 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^3 \quad \alpha^2 \quad 1\Big]$$

$$\mathcal{G}_{133} = \mathbf{G}_1 \otimes \mathbf{G}_3 \otimes \mathbf{G}_3$$

$$= \Big[\alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^4 \quad \alpha^2 \quad \alpha^5 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^2 \quad 1 \quad \alpha^3 \quad 1 \quad \alpha^5$$

$$\alpha \quad \alpha^3 \quad \alpha \quad \alpha^4 \quad \alpha \quad \alpha^6 \quad \alpha^2 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^2 \quad 1 \quad \alpha^3\Big]$$

$$\mathcal{G}_{211} = \mathbf{G}_2 \otimes \mathbf{G}_1 \otimes \mathbf{G}_1$$

$$= \Big[\alpha^5 \quad \alpha \quad 1 \quad \alpha \quad \alpha^4 \quad \alpha^3 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^4 \quad 1 \quad \alpha^6 \quad 1 \quad \alpha^3$$

$$\alpha^2 \quad \alpha^6 \quad \alpha^2 \quad \alpha \quad \alpha^2 \quad \alpha^5 \quad \alpha^4 \quad \alpha^5 \quad \alpha \quad 1 \quad \alpha^4 \quad 1 \quad \alpha^6\Big]$$

$$\mathcal{G}_{212} = \mathbf{G}_2 \otimes \mathbf{G}_1 \otimes \mathbf{G}_2$$

$$= \Big[\alpha \quad 1 \quad \alpha^5 \quad \alpha^4 \quad \alpha^3 \quad \alpha \quad \alpha^3 \quad \alpha^2 \quad 1 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^3 \quad \alpha^2$$

$$1 \quad \alpha^2 \quad \alpha \quad \alpha^6 \quad \alpha^5 \quad \alpha^4 \quad \alpha^2 \quad \alpha \quad 1 \quad \alpha^5 \quad 1 \quad \alpha^6 \quad \alpha^4\Big]$$

$$\mathcal{G}_{213} = \mathbf{G}_2 \otimes \mathbf{G}_1 \otimes \mathbf{G}_3$$

$$= \Big[1 \quad \alpha^5 \quad \alpha \quad \alpha^3 \quad \alpha \quad \alpha^4 \quad \alpha^2 \quad 1 \quad \alpha^3 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^2 \quad 1$$

$$\alpha^3 \quad \alpha \quad \alpha^6 \quad \alpha^2 \quad \alpha^4 \quad \alpha^2 \quad \alpha^5 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^6 \quad \alpha^4 \quad 1\Big]$$

$$\mathcal{G}_{221} = \mathbf{G}_2 \otimes \mathbf{G}_2 \otimes \mathbf{G}_1$$

$$= \Big[\alpha \quad \alpha^4 \quad \alpha^3 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^5 \quad \alpha \quad 1 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^6 \quad \alpha^2$$

$$\alpha \quad \alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^5 \quad \alpha \quad 1 \quad \alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^2 \quad \alpha^5 \quad \alpha^4\Big]$$

$$\mathcal{G}_{222} = \mathbf{G}_2 \otimes \mathbf{G}_2 \otimes \mathbf{G}_2$$

$$= \Big[\alpha^4 \quad \alpha^3 \quad \alpha \quad \alpha^3 \quad \alpha^1 \quad 1 \quad \alpha \quad 1 \quad \alpha^5 \quad \alpha^3 \quad \alpha^2 \quad 1 \quad \alpha^2 \quad \alpha$$

$$\alpha^6 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha \quad 1 \quad \alpha^5 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^5 \quad \alpha^4 \quad \alpha^2\Big]$$

$$\mathcal{G}_{223} = \mathbf{G}_2 \otimes \mathbf{G}_2 \otimes \mathbf{G}_3$$

$$= \Big[\alpha^3 \quad \alpha \quad \alpha^4 \quad \alpha^2 \quad 1 \quad \alpha^3 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^2 \quad 1 \quad \alpha^3 \quad \alpha \quad \alpha^6$$

$$\alpha^2 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^4 \quad \alpha^2 \quad \alpha^5\Big]$$

$$\mathcal{G}_{231} = \mathbf{G}_2 \otimes \mathbf{G}_3 \otimes \mathbf{G}_1$$

$$= \Big[1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^5 \quad \alpha \quad 1 \quad \alpha \quad \alpha^4 \quad \alpha^3 \quad \alpha^6 \quad \alpha^2 \quad \alpha \quad \alpha^4 \quad 1$$

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$$\alpha^6 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^2 \quad \alpha^5 \quad \alpha^4 \quad \alpha^5 \quad \alpha \quad 1\Big]$$

$$\mathcal{G}_{232} = \mathbf{G}_2 \otimes \mathbf{G}_3 \otimes \mathbf{G}_2$$

$$= \Big[\alpha^3 \quad \alpha^2 \quad 1 \quad \alpha \quad 1 \quad \alpha^5 \quad \alpha^4 \quad \alpha^3 \quad \alpha \quad \alpha^2 \quad \alpha \quad \alpha^6 \quad 1 \quad \alpha^6$$

$$\alpha^4 \quad \alpha^3 \quad \alpha^2 \quad 1 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^5 \quad \alpha^4 \quad \alpha^2 \quad \alpha \quad 1 \quad \alpha^5\Big]$$

$$\mathcal{G}_{233} = \mathbf{G}_2 \otimes \mathbf{G}_3 \otimes \mathbf{G}_3$$

$$= \Big[\alpha^2 \quad 1 \quad \alpha^3 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^3 \quad \alpha \quad \alpha^4 \quad \alpha \quad \alpha^6 \quad \alpha^2 \quad \alpha^6 \quad \alpha^4$$

$$1 \quad \alpha^2 \quad 1 \quad \alpha^3 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^4 \quad \alpha^2 \quad \alpha^5 \quad 1 \quad \alpha^5 \quad \alpha\Big]$$

$$\mathcal{G}_{311} = \mathbf{G}_3 \otimes \mathbf{G}_1 \otimes \mathbf{G}_1$$

$$= \Big[\alpha^4 \quad 1 \quad \alpha^6 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^6 \quad \alpha^2 \quad \alpha \quad \alpha^2 \quad \alpha^5 \quad \alpha^4 \quad \alpha^5 \quad \alpha$$

$$1 \quad \alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^5 \quad \alpha \quad 1 \quad \alpha \quad \alpha^4 \quad \alpha^3 \quad 1 \quad \alpha^3 \quad \alpha^2\Big]$$

$$\mathcal{G}_{312} = \mathbf{G}_3 \otimes \mathbf{G}_1 \otimes \mathbf{G}_2$$

$$= \Big[1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^3 \quad \alpha^2 \quad 1 \quad \alpha^2 \quad \alpha \quad \alpha^6 \quad \alpha^5 \quad \alpha^4 \quad \alpha^2 \quad \alpha \quad 1$$

$$\alpha^5 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha \quad 1 \quad \alpha^5 \quad \alpha^4 \quad \alpha^3 \quad \alpha \quad \alpha^3 \quad \alpha^2 \quad 1\Big]$$

$$\mathcal{G}_{313} = \mathbf{G}_3 \otimes \mathbf{G}_1 \otimes \mathbf{G}_3$$

$$= \Big[\alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^2 \quad 1 \quad \alpha^3 \quad \alpha \quad \alpha^6 \quad \alpha^2 \quad \alpha^4 \quad \alpha^2 \quad \alpha^5 \quad 1 \quad \alpha^5$$

$$\alpha \quad \alpha^6 \quad \alpha^4 \quad 1 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^3 \quad \alpha \quad \alpha^4 \quad \alpha^2 \quad 1 \quad \alpha^3\Big]$$

$$\mathcal{G}_{321} = \mathbf{G}_3 \otimes \mathbf{G}_2 \otimes \mathbf{G}_1$$

$$= \Big[1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^6 \quad \alpha^2 \quad \alpha \quad \alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^5 \quad \alpha \quad 1 \quad \alpha^4 \quad 1$$

$$\alpha^6 \quad \alpha^2 \quad \alpha^5 \quad \alpha^4 \quad \alpha \quad \alpha^4 \quad \alpha^3 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^5 \quad \alpha \quad 1\Big]$$

$$\mathcal{G}_{322} = \mathbf{G}_2 \otimes \mathbf{G}_2 \otimes \mathbf{G}_2$$

$$= \Big[\alpha^3 \quad \alpha^2 \quad 1 \quad \alpha^2 \quad \alpha \quad \alpha^6 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha \quad 1 \quad \alpha^5 \quad 1 \quad \alpha^6$$

$$\alpha^4 \quad \alpha^5 \quad \alpha^4 \quad \alpha^2 \quad \alpha^4 \quad \alpha^3 \quad \alpha \quad \alpha^3 \quad \alpha^2 \quad 1 \quad \alpha \quad 1 \quad \alpha^5\Big]$$

$$\mathcal{G}_{323} = \mathbf{G}_3 \otimes \mathbf{G}_2 \otimes \mathbf{G}_3$$

$$= \Big[\alpha^2 \quad 1 \quad \alpha^3 \quad \alpha \quad \alpha^6 \quad \alpha^2 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^6 \quad \alpha^4$$

$$1 \quad \alpha^4 \quad \alpha^2 \quad \alpha^5 \quad \alpha^3 \quad \alpha \quad \alpha^4 \quad \alpha^2 \quad 1 \quad \alpha^3 \quad 1 \quad \alpha^5 \quad \alpha\Big]$$

$$\mathcal{G}_{331} = \mathbf{G}_3 \otimes \mathbf{G}_3 \otimes \mathbf{G}_1$$

$$= \Big[\alpha^6 \quad \alpha^2 \quad \alpha \quad \alpha^4 \quad 1 \quad \alpha^6 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^4 \quad 1 \quad \alpha^6 \quad \alpha^2 \quad 1$$

$$\alpha^4 \quad \alpha^5 \quad \alpha \quad 1 \quad 1 \quad \alpha^3 \quad \alpha^2 \quad \alpha^5 \quad \alpha \quad 1 \quad \alpha \quad \alpha^4 \quad \alpha^3\Big]$$

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$$\mathcal{G}_{332} = \mathbf{G}_3 \otimes \mathbf{G}_3 \otimes \mathbf{G}_2$$
$$= \Big[\alpha^2 \quad \alpha \quad \alpha^6 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^3 \quad \alpha^2 \quad 1 \quad 1 \quad \alpha^6 \quad \alpha^4 \quad \alpha^5 \quad \alpha^4$$
$$\alpha^2 \quad \alpha \quad 1 \quad \alpha^5 \quad \alpha^3 \quad \alpha^2 \quad 1 \quad \alpha \quad 1 \quad \alpha^5 \quad \alpha^4 \quad \alpha^3 \quad \alpha \Big]$$

and $\mathcal{G}_{333} = \mathbf{G}_3 \otimes \mathbf{G}_3 \otimes \mathbf{G}_3$

$$= \Big[\alpha \quad \alpha^6 \quad \alpha^2 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^2 \quad 1 \quad \alpha^3 \quad \alpha^6 \quad \alpha^4 \quad 1 \quad \alpha^4 \quad \alpha^2$$
$$\alpha^5 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^2 \quad 1 \quad \alpha^3 \quad 1 \quad \alpha^5 \quad \alpha \quad \alpha^3 \quad \alpha \quad \alpha^4 \Big].$$

It is straightforward to verify that the codes $\Gamma_{111}, \Gamma_{112}, \ldots, \Gamma_{333}$ thus obtained indeed constitute a $(\{27\}, \{1\}, \{27\})$ 27-*Direct* code $(\Gamma_{111}, \Gamma_{112}, \ldots, \Gamma_{333})$. The example clearly shows that the number of users have been increased from 3 to 27.

5. Construction of n^{3^m}-*Direct* codes

For $m \geq 0$, a generalized construction of $(\{n^{3^{m+1}}\}, \{1\}, \{n^{3^{m+1}}\})$ $n^{3^{m+1}}$-*Direct* codes is described in this section. As the construction requires the use of tensors to represent the quantities such as *constituent* codes and generator matrices, we briefly outline the notion of tensors.

An $n^{\times\Delta}$-tensor (Δ-order tensor) is an $n^{\times\Delta}$-array $[a_{i_1 i_2 \ldots i_\Delta}]_{i_1,i_2,\ldots,i_\Delta=1}^{n}$, whose entries $a_{i_1 i_2 \ldots i_\Delta}$ are thought of as mathematical objects. A tensor is a natural generalization of a vector (first order tensor) and a matrix (second order tensor). A line in an $n^{\times\Delta}$-tensor Γ is a set of n entries in Γ which are indexed by Δ-tuples $(i_1, i_2, \ldots, i_\Delta)$, in which $\Delta - 1$ (arbitrary indices) out of Δ indices $i_1, i_2, \ldots, i_\Delta$ are fixed, whereas the Δ^{th} index (remaining index) ranges over the integers between 1 and n. In fact, lines in tensors are generalizations of rows and columns in matrices. In this paper, an $n^{\times\Delta}$-tensor $[a_{i_1 i_2 \ldots i_\Delta}]_{i_1,i_2,\ldots,i_\Delta=1}^{n}$ is sometimes conveniently represented as an n^{Δ}-tuple vector $(a_{i_1 i_2 \ldots i_\Delta})_{i_1,i_2,\ldots,i_\Delta=1}^{n}$.

Consider an $(\{n^{3^m}\}, \{1\}, \{n^{3^m}\})$ n^{3^m}-*Direct* code $\left(\Gamma^{(m)}_{i_1 i_2 \ldots i_{3^m}}\right)_{i_1 i_2 \ldots i_{3^m}=1}^{n}$ whose $(i_1, i_2, \ldots, i_{3^m})^{th}$ *constituent* code $\Gamma^{(m)}_{i_1 i_2 \ldots i_{3^m}}$ is defined by the $1 \times n^{3^m}$ generator matrix $\mathcal{G}^{(m)}_{i_1 i_2 \ldots i_{3^m}}$. These n^{3^m} generator matrices can be conveniently represented as an $n^{\times 3^m}$-array $\left[\mathcal{G}^{(m)}_{i_1 i_2 \ldots i_{3^m}}\right]_{i_1 i_2 \ldots i_{3^m}=1}^{n}$. In particular, for $m = 0$, the n^{3^m} generator matrices are precisely the initial generator matrices:

$$\mathcal{G}_1^{(0)} = \mathbf{G}_1 = \Big[\alpha_1^{[1]} \quad \alpha_2^{[1]} \quad \cdots \quad \alpha_n^{[1]} \Big]$$
$$\mathcal{G}_2^{(0)} = \mathbf{G}_2 = \Big[\alpha_1^{[2]} \quad \alpha_2^{[2]} \quad \cdots \quad \alpha_n^{[2]} \Big]$$
$$\vdots$$
$$\text{and} \quad \mathcal{G}_n^{(0)} = \mathbf{G}_n = \Big[\alpha_1^{[n]} \quad \alpha_2^{[n]} \quad \cdots \quad \alpha_n^{[n]} \Big].$$

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Define $\mathcal{G}^{(m+1)}_{i_1\dots i_{3^m} j_1\dots j_{3^m} k_1\dots k_{3^m}} = \mathcal{G}^{(m)}_{i_1\dots i_{3^m}} \otimes \mathcal{G}^{(m)}_{j_1\dots j_{3^m}} \otimes \mathcal{G}^{(m)}_{k_1\dots k_{3^m}}$ for $1 \leq i_1, \dots, i_{3^m}$, $j_1, \dots, j_{3^m}$, $k_1, \dots, k_{3^m} \leq n$. Let $\Gamma^{(m+1)}_{i_1\dots i_{3^m} j_1\dots j_{3^m} k_1\dots k_{3^m}}$ denote the resultant $(n^{3^{m+1}}, 1, n^{3^{m+1}})$ $\mathtt{GF}(2^n)$-ary code obtained from $\mathcal{G}^{(m+1)}_{i_1\dots i_{3^m} j_1\dots j_{3^m} k_1\dots k_{3^m}}$. The following theorem affirms the fact that the set of codes constructed indeed constitute an $n^{3^{m+1}}$-*Direct* code.

Theorem 5.1. *Set* $\left\{\Gamma^{(m+1)}_{i_1 i_2\dots i_{3^{m+1}}}\right\}^{n}_{i_1 i_2\dots i_{3^{m+1}}=1}$ *of* constituent *codes determines an* $(\{n^{3^{m+1}}\}, \{1\}, \{n^{3^{m+1}}\})$ $n^{3^{m+1}}$-Direct *code* $\left(\Gamma^{(m+1)}_{i_1 i_2\dots i_{3^{m+1}}}\right)^{n}_{i_1 i_2\dots i_{3^{m+1}}=1}$.

Proof. For $(i_1, \dots, i_{3^m}, j_1, \dots, j_{3^m}, k_1, \dots, k_{3^m})$ and $(r_1, \dots, r_{3^m}, s_1, \dots, s_{3^m}, t_1, \dots, t_{3^m})$:

$$
\begin{aligned}
&\mathcal{G}^{(m+1)}_{i_1\dots i_{3^m} j_1\dots j_{3^m} k_1\dots k_{3^m}} \mathcal{G}^{(m+1)\,\mathbf{T}}_{r_1\dots r_{3^m} s_1\dots s_{3^m} t_1\dots t_{3^m}} \\
&= (\mathcal{G}^{(m)}_{i_1\dots i_{3^m}} \otimes \mathcal{G}^{(m)}_{j_1\dots j_{3^m}} \otimes \mathcal{G}^{(m)}_{k_1\dots k_{3^m}})(\mathcal{G}^{(m)}_{r_1\dots r_{3^m}} \otimes \mathcal{G}^{(m)}_{s_1\dots s_{3^m}} \otimes \mathcal{G}^{(m)}_{t_1\dots t_{3^m}})^{\mathbf{T}} \\
&= (\mathcal{G}^{(m)}_{i_1\dots i_{3^m}} \otimes \mathcal{G}^{(m)}_{j_1\dots j_{3^m}} \otimes \mathcal{G}^{(m)}_{k_1\dots k_{3^m}})(\mathcal{G}^{(m)\,\mathbf{T}}_{r_1\dots r_{3^m}} \otimes \mathcal{G}^{(m)\,\mathbf{T}}_{s_1\dots s_{3^m}} \otimes \mathcal{G}^{(m)\,\mathbf{T}}_{t_1\dots t_{3^m}}) \\
&= (\mathcal{G}^{(m)}_{i_1\dots i_{3^m}} \mathcal{G}^{(m)\,\mathbf{T}}_{r_1\dots r_{3^m}}) \otimes (\mathcal{G}^{(m)}_{j_1\dots j_{3^m}} \mathcal{G}^{(m)\,\mathbf{T}}_{s_1\dots s_{3^m}}) \otimes (\mathcal{G}^{(m)}_{k_1\dots k_{3^m}} \mathcal{G}^{(m)\,\mathbf{T}}_{t_1\dots t_{3^m}}) \\
&= \begin{cases} 1 & , \quad (i_1, \dots i_{3^m}, j_1, \dots, j_{3^m}, k_1, \dots, k_{3^m}) = (r_1, \dots, r_{3^m}, s_1, \dots, s_{3^m}, t_1, \dots, t_{3^m}) \\ 0 & , \quad (i_1, \dots i_{3^m}, j_1, \dots, j_{3^m}, k_1, \dots, k_{3^m}) \neq (r_1, \dots, r_{3^m}, s_1, \dots, s_{3^m}, t_1, \dots, t_{3^m}) \end{cases}
\end{aligned}
$$

where we have used the fact that $(\{n^{3^m}\}, \{1\}, \{n^{3^m}\})$ is an n^{3^m}-*Direct* code:

$$
\mathcal{G}^{(m)}_{i_1\dots i_{3^m}} \mathcal{G}^{(m)\,\mathbf{T}}_{j_1\dots j_{3^m}} = \begin{cases} 1 & , \quad (i_1, \dots i_{3^m}) = (j_1, \dots, j_{3^m}) \\ 0 & , \quad (i_1, \dots i_{3^m}) \neq (j_1, \dots, j_{3^m}) \end{cases}.
$$

Thus, $\left\{\Gamma^{(m+1)}_{i_1 i_2\dots i_{3^{m+1}}} | 1 \leq i_1, i_2, \dots, i_{3^{m+1}} \leq n\right\}$ constitutes an $n^{3^{m+1}}$-*Direct* code. The procedure above allows the recursive construction of $(\{n^{3^m}\}, \{1\}, \{n^{3^m}\})$ n^{3^m}-*Direct* codes for the values of $m \geq 0$. In all the above mentioned constructions, dimensions of *constituent* codes were one only, allowing maximum possible error correcting capabilities of individual *constituent* codes. Due to this restriction on the dimension, the *constituent* codes were to support the same code rate. But, this is not the situation in practice; the real-time users require variable-rate (*constituent*) codes to be assigned. Keeping this in mind, in the next section, we constitute a $\mathcal{T}^{\mathcal{T}}$-*Direct* code from a $\mathcal{T}$-*Direct* code with variable rates for *constituent* codes. □

6. Construction of $\mathcal{T}^{\mathcal{T}}$-*Direct* codes

Let $\{\alpha_1, \alpha_2, \dots, \alpha_n\}$ be a *trace-orthogonal basis* in $\mathtt{GF}(2^n)$. Let $k_1, k_2, \dots, k_{\mathcal{T}} > 0$ be a set of positive integers such that $k_1 + k_2 + \cdots + k_{\mathcal{T}} \leq n$. Consider an $(\{n\}, \{k_i\}, \{d_i\})$ $\mathcal{T}$-*Direct* code $(\Gamma_1, \Gamma_2, \dots, \Gamma_{\mathcal{T}})$ such that the i^{th} *constituent* code Γ_i is an (n, k_i, d_i) $\mathtt{GF}(2^n)$-ary MRD code generated by the following $k_i \times n$ generator matrix:

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$$\mathbf{G}_i = \left[\alpha_s^{[k_o+k_1+\cdots+k_{i-1}+r]} \right]_{r,s=1}^{k_i,n} \quad (i = 1, 2, \ldots, \mathcal{T})$$

where $k_o = 0$ and it is so used to write the $k_i \times n$ matrix $\mathbf{G}_i$ in compact form. In order to construct $\mathcal{T}^{\mathcal{T}}$ constituent codes from the existing $\mathcal{T}$ constituent codes, consider Kronecker products among the generator matrices $\mathbf{G}_1, \mathbf{G}_2, \ldots, \mathbf{G}_{\mathcal{T}}$ $\mathcal{T}$ times as follows:

$$\begin{aligned}
\mathcal{G}_{1i_2\ldots i_{\mathcal{T}}} &= \mathbf{G}_1 \otimes (\mathbf{G}_{i_2} \otimes \mathbf{G}_{i_3} \otimes \cdots \otimes \mathbf{G}_{i_{\mathcal{T}}}) \\
\mathcal{G}_{2i_2\ldots i_{\mathcal{T}}} &= \mathbf{G}_2 \otimes (\mathbf{G}_{i_2} \otimes \mathbf{G}_{i_3} \otimes \cdots \otimes \mathbf{G}_{i_{\mathcal{T}}}) \\
&\vdots \\
\text{and} \quad \mathcal{G}_{\mathcal{T}i_2\ldots i_{\mathcal{T}}} &= \mathbf{G}_{\mathcal{T}} \otimes (\mathbf{G}_{i_2} \otimes \mathbf{G}_{i_3} \otimes \cdots \otimes \mathbf{G}_{i_{\mathcal{T}}}),
\end{aligned}$$

where $1 \leq i_1, i_2, \ldots, i_{\mathcal{T}} \leq \mathcal{T}$. Let $\Gamma_{i_1 i_2 \ldots i_{\mathcal{T}}}$ denote the $(n^{\mathcal{T}}, 1, n^{\mathcal{T}})$ $\mathtt{GF}(2^n)$-ary code obtained by $\mathcal{G}_{i_1 i_2 \ldots i_{\mathcal{T}}} = \mathbf{G}_{i_1} \otimes \mathbf{G}_{i_2} \otimes \cdots \otimes \mathbf{G}_{i_{\mathcal{T}}}$ for $i_1, i_2, \ldots, i_{\mathcal{T}} \in \{1, 2, \ldots, \mathcal{T}\}$. It remains now to verify that the newly obtained $\mathcal{T}^{\mathcal{T}}$ codes $\Gamma_{i_1 i_2 \ldots i_{\mathcal{T}}}$, $1 \leq i_1, i_2, \ldots, i_{\mathcal{T}} \leq \mathcal{T}$ constitute an $(\{n^{\mathcal{T}}\}, \{k_1, k_2, \ldots, k_{\mathcal{T}}\}, \{n^{\mathcal{T}}\})$ $\mathcal{T}^{\mathcal{T}}$-*Direct* code. This is proved in the following theorem.

Theorem 6.1. $\{\Gamma_{i_1 i_2 \ldots i_{\mathcal{T}}} \mid i_1, \ldots, i_{\mathcal{T}} = 1, 2, \ldots, \mathcal{T}\}$ *constitutes a* $\mathcal{T}^{\mathcal{T}}$-Direct *code.*

Proof. For every $(i_1, i_2, \ldots, i_{\mathcal{T}})$ and $(j_1, j_2, \ldots, j_{\mathcal{T}})$:

$$\begin{aligned}
\mathcal{G}_{i_1 i_2 \ldots i_{\mathcal{T}}} \mathcal{G}^{\mathbf{T}}_{j_1 j_2 \ldots j_{\mathcal{T}}} &= (\mathbf{G}_{i_1} \otimes \mathbf{G}_{i_2} \otimes \cdots \otimes \mathbf{G}_{i_{\mathcal{T}}})(\mathbf{G}_{j_1} \otimes \mathbf{G}_{j_2} \otimes \cdots \otimes \mathbf{G}_{j_{\mathcal{T}}})^{\mathbf{T}} \\
&= (\mathbf{G}_{i_1} \otimes \mathbf{G}_{i_2} \otimes \cdots \otimes \mathbf{G}_{i_{\mathcal{T}}})(\mathbf{G}^{\mathbf{T}}_{j_1} \otimes \mathbf{G}^{\mathbf{T}}_{j_2} \otimes \cdots \otimes \mathbf{G}^{\mathbf{T}}_{j_{\mathcal{T}}}) \\
&= (\mathbf{G}_{i_1} \mathbf{G}^{\mathbf{T}}_{j_1}) \otimes (\mathbf{G}_{i_2} \mathbf{G}^{\mathbf{T}}_{j_2}) \otimes \cdots \otimes (\mathbf{G}_{i_{\mathcal{T}}} \mathbf{G}^{\mathbf{T}}_{j_{\mathcal{T}}}) \\
&= \begin{cases} \mathbf{I} & , \quad (i_1, i_2, \ldots, i_{\mathcal{T}}) = (j_1, j_2, \ldots, j_{\mathcal{T}}) \\ (\mathbf{0}) & , \quad (i_1, i_2, \ldots, i_{\mathcal{T}}) \neq (j_1, j_2, \ldots, j_{\mathcal{T}}) \end{cases},
\end{aligned}$$

where $\mathbf{I}$ is the $k_{i_1} k_{i_2} \ldots k_{i_{\mathcal{T}}} \times k_{j_1} k_{j_2} \ldots k_{j_{\mathcal{T}}}$ identity matrix and $(\mathbf{0})$ is the $k_{i_1} k_{i_2} \ldots k_{i_{\mathcal{T}}} \times k_{j_1} k_{j_2} \ldots k_{j_{\mathcal{T}}}$ zero-matrix.

Thus, the resultant codes $\Gamma_{i_1 i_2 \ldots i_{\mathcal{T}}}$ $(1 \leq i_1, i_2, \ldots, i_{\mathcal{T}} \leq \mathcal{T})$ form an $(\{n^{\mathcal{T}}\}, \{k_1, k_2, \ldots, k_{\mathcal{T}}\}, \{n^{\mathcal{T}}\})$ $\mathcal{T}^{\mathcal{T}}$-*Direct* code. This construction of $\mathcal{T}^{\mathcal{T}}$-*Direct* codes from $\mathcal{T}$-*Direct* codes not only offers the benefit of more users to participate, but also supports variable code rates for users.

In all the $\mathcal{T}$-*Direct* code constructions, the overall sum-rate is maintained in addition to the increase in the user count. The *constituent* codes considered in the constructions are not necessarily rank distance codes – can be any *linear codes having complementary duals*. Rank distance codes are merely used in this paper to facilitate the presentation of the paper. □

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7. Conclusion

In this paper, several constructions of the class of $\mathcal{T}$-*Direct* codes have been presented. Firstly, a class of n^3-*Direct* codes is constructed from n-*Direct* codes. Then, a construction procedure to obtain a class of n^n-*Direct* codes is proposed. A generalized construction of $(\{n^{3^m}\}, \{1\}, \{n^{3^m}\})$ n^{3^m}-*Direct* codes for $m \geq 0$ is obtained. Finally, a construction of $\mathcal{T}^{\mathcal{T}}$-*Direct* codes is explained. The design of constructed class of codes is such that it support more numbers of users in a multi-user environment in comparison to the existing $\mathcal{T}$-*Direct* codes. The construction of $\mathcal{T}^{\mathcal{T}}$-*Direct* codes also supports flexible code rates for users.

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27 January 2022

TO WHOM IT MAY CONCERN

This is to certify that the project entitled "Construction of T-Direct Codes using an Almost Self-Dual Basis" has been successfully completed. The details of the project are as follows:

Principal Investigator: Dr. M. Devi

Co-investigator 1: Prof. R. S. Raja Durai

Co-investigator 2: Prof. Hongjun Xu

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Some important results on $\mathcal{T}$-Direct codes

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$\mathcal{T}$-Direct codes are an extension to the class of *linear codes having complementary duals* (LCD codes). Defined over a finite field $\mathbb{F}_q$, it is comprised of $\mathcal{T}$ linear codes $\mathcal{C}_i \subseteq \mathbb{F}_q^n$, $i = 1, 2, \ldots, \mathcal{T}$ with $\mathcal{C}_i \cap \mathcal{C}_i^{\perp} = \{\mathbf{0}\}$, where $\mathcal{C}_i^{\perp}$ is the dual with respect to $\Lambda = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_{\mathcal{T}} \subseteq \mathbb{F}_q^n$. A 2-Direct code $(\mathcal{C}_1, \mathcal{C}_2)$ with respect to $\mathbb{F}_q^n$ is comprised of only LCD codes: $\mathcal{C}_1 \cap \mathcal{C}_2 = \{\mathbf{0}\}$. On the contrary, two LCD codes do not set up a 2-Direct code in general. This paper presents some important and generalized results on $\mathcal{T}$-Direct codes, in that it attempts to construct $\mathcal{T}$-Direct codes from LCD codes. The class of q-cyclic *maximum rank distance* (MRD) codes as having *complementary duals* over $\mathbb{F}_q$ are generalized. Dual bases such as *self-dual basis* and *self-dual normal basis* play a crucial role in constructions. Further, construction implausibility of $\mathcal{T}$-Direct codes from *almost self-dual bases* is also dealt. Results obtained are demonstrated through examples.

Keywords: LCD codes; $\mathcal{T}$-Direct codes; almost self-dual basis; maximum rank distance codes.

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1. Introduction

Let $\mathbb{F}_q$ be a finite field with q elements, where q is a prime power. Consider the field extension $\mathbb{F}_{q^m}$ of degree m of $\mathbb{F}_q$. The concept of an $\mathbb{F}_{q^m}$-ary linear code $\mathcal{C}$ together with its *dual* $\mathcal{C}^\perp$ having $\mathcal{C} \cap \mathcal{C}^\perp = \{\mathbf{0}\}$ was first introduced by Massey in 1992 [22]. Certain class of codes are technically abbreviated as LCD (*linear code with a complementary dual*) codes. Prior to [22], constructions of LCD codes were known in the name of *reversible* codes [21]. By the very notion of LCD codes, $\mathbb{F}_{q^m}^n = \mathcal{C} \oplus \mathcal{C}^\perp$.

In 2002, an extension to the class of LCD codes, namely $\mathcal{T}$-Direct codes was proposed [29]. A $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ is defined to be a collection of $\mathcal{T}$ $\mathbb{F}_{q^m}$-ary linear (*constituent*) codes $\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T}$ satisfying $\mathcal{C}_i \cap \mathcal{C}_i^\perp = \{\mathbf{0}\}$, where $\mathcal{C}_i^\perp = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_{i-1} \oplus \mathcal{C}_{i+1} \oplus \cdots \oplus \mathcal{C}_\mathcal{T}$ is the dual of $\mathcal{C}_i$ with respect to the direct sum $\Lambda = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_\mathcal{T} \subseteq \mathbb{F}_{q^m}^n$ for each $i = 1, 2, \ldots, \mathcal{T}$. The inception of $\mathcal{T}$-Direct codes led to the development of coding schemes for the multi-user *adder channel*; they are shown to be effective in coding over both noiseless and noisy $\mathcal{T}$-user $\mathbb{F}_{q^m}$-*Adder Channel* (FAC), in that they uniquely determine the transmitted codewords from the received sequence [29].

The class of LCD codes is important from both its practical and theoretical points of view. An LCD code $\mathcal{C}$ together with its dual $\mathcal{C}^\perp$ when $\mathcal{C} \oplus \mathcal{C}^\perp = \mathbb{F}_{q^m}^n$ is termed as *linear complementary pair* (LCP) of codes [5]. Apart from their rich algebraic structures [31, 27, 2], LCD codes in the context of LCP codes have drawn the attention of researchers due to their cryptographic applications [3, 1, 4]; especially in the preventive implementations against *side-channel* and *fault injection attacks*. Some generalized LCD codes constructions have been discussed in [18, 28]. It is interesting to note that, under the setting of a $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ with $\mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_\mathcal{T} = \mathbb{F}_{q^m}^n$, $\mathcal{C}_i$ and $\mathcal{C}_i^\perp$ are in fact an LCP! For information on LCP codes and their applications, the reader is encouraged to refer [1]. As $\mathcal{T}$-Direct codes are a straightforward generalization of LCD codes, their study is imperative.

An LCD code $\mathcal{C}$ together with its dual $\mathcal{C}^\perp$ in fact constitutes a 2-Direct code $(\mathcal{C}, \mathcal{C}^\perp)$. Moreover, each *constituent* code of a $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ such that $\mathbb{F}_{q^m}^n = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_\mathcal{T}$ is an LCD code [24]; the converse is not true. Note that for an LCD code $\mathcal{C}$, in order to constitute a 2-Direct code along with its dual $\mathcal{C}^\perp$, it simply requires the non-singularity of $\mathbf{G}\mathbf{G}^\mathbf{T}$. Consequently, the requirements for a 2-Direct code are trivially satisfied for an LCD code pair $(\mathcal{C}, \mathcal{C}^\perp)$ as $\mathbf{G}\mathbf{H}^\mathbf{T} = (\mathbf{0})$. Clearly, an arbitrary collection of $\mathcal{T}$ LCD codes themselves does not constitute $\mathcal{T}$-Direct codes, except for the case $\mathcal{T} = 2$ where the constituent codes are dual to each other. It is now evident that for an arbitrary collection of $\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T}$ to form a $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$, in addition to the non-singularity requirement $|\mathbf{G}_i \mathbf{G}_i^\mathbf{T}| \neq 0$ among their generator matrices, the (generator matrices of) constituent codes are to satisfy $\mathbf{G}_i \mathbf{G}_j^\mathbf{T} = (\mathbf{0})$ for every $i \neq j$. This requirement for the converse part demands that the rows of $\mathbf{G}_i$ are to be orthogonal to the rows of $\mathbf{G}_j$ for $i \neq j$. This fact motivates us to use LCD MRD codes constructed systematically through

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self-dual bases, *self-dual normal bases* and *almost self-dual bases* as constituent codes for constructing $\mathcal{T}$-Direct codes.

The rest of this paper is organized as follows. Basic definitions and preliminary results needed are reviewed in the following section. LCD codes as constituent codes do not, in general, constitute $\mathcal{T}$-Direct codes; Sec. 3 attempts a positive answer to this. In that, it systematically define $\mathcal{T}$ MRD codes from q-power shifts of a *self-dual basis* and show that the resultant LCD codes constitute a $\mathcal{T}$-Direct code. Implausibility of $\mathcal{T}$-Direct codes from almost self-dual bases is discussed in Sec. 4. Section 5 proves that q-cyclic MRD codes constructed from *self-dual normal basis* are LCD codes and constructs $\mathcal{T}$-Direct q-cyclic MRD Codes. We conclude our results in Sec. 6.

2. Preliminaries

This section briefly summarizes some basic definitions, and fundamentals concerning the dual bases [17], rank distance codes [7] and $\mathcal{T}$-Direct codes [24].

2.1. *Dual bases*

Being a field extension, $\mathbb{F}_{q^m}$ is a vector space over the base field $\mathbb{F}_q$. Consider a basis $\boldsymbol{\alpha} = \{\alpha_1, \alpha_2, \ldots, \alpha_m\}$ of $\mathbb{F}_{q^m}$ over $\mathbb{F}_q$. A basis $\boldsymbol{\beta} = \{\beta_1, \beta_2, \ldots, \beta_m\}$ satisfying the trace-orthogonal relation $\mathbf{tr}(\alpha_i\beta_j) = \delta_{ij}$ is said to be dual to $\{\alpha_1, \alpha_2, \ldots, \alpha_m\}$, where the trace function $\mathbf{tr}$ is a linear map from $\mathbb{F}_{q^m}$ to $\mathbb{F}_q$ defined as $\mathbf{tr}(x) = x + x^q + \cdots + x^{q^{m-1}}$ for all elements $x \in \mathbb{F}_{q^m}$. Consider the following base-change matrix between the bases $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$:

$$\mathbf{M}_{\boldsymbol{\alpha},\boldsymbol{\beta}} = \begin{pmatrix} \mathbf{tr}(\alpha_1\beta_1) & \mathbf{tr}(\alpha_1\beta_2) & \cdots & \mathbf{tr}(\alpha_1\beta_m) \\ \mathbf{tr}(\alpha_2\beta_1) & \mathbf{tr}(\alpha_2\beta_2) & \cdots & \mathbf{tr}(\alpha_2\beta_m) \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{tr}(\alpha_m\beta_1) & \mathbf{tr}(\alpha_m\beta_2) & \cdots & \mathbf{tr}(\alpha_m\beta_m) \end{pmatrix},$$

where $\mathbf{M}_{\boldsymbol{\alpha},\boldsymbol{\beta}}$ is in fact the Gram matrix of the trace bilinear form. A particularly interesting class of dual bases considered in this paper are *self-dual bases*. If $\mathbf{tr}(\alpha_i\beta_j) = \delta_{ij}$, $\alpha_i = \beta_i$, then the basis is called *self-dual basis* (*trace-orthogonal basis* for $q = 2$) [11]. Let $\mathbf{M}_{\boldsymbol{\alpha}} := \mathbf{M}_{\boldsymbol{\alpha},\boldsymbol{\beta}}$ denote the Gram matrix of the trace bilinear form with respect to the basis $\boldsymbol{\alpha}$=$\boldsymbol{\beta}$. For a *self-dual basis* $\boldsymbol{\alpha}$=$\{\alpha_1, \alpha_2, \ldots, \alpha_m\}$, the matrix $\mathbf{M}_{\boldsymbol{\alpha}}$ is in fact an $m \times m$ identity matrix [12]. Every extension field $\mathbb{F}_{q^m}$ with either q is even or both q and m are odd has a *self-dual basis* over $\mathbb{F}_q$ [14]. The paper [15] provides some constructions of *self-dual basis* of $\mathbb{F}_{q^m}$ over $\mathbb{F}_q$ when m is a prime power.

2.2. *Rank distance codes*

In comparison to codes with Hamming metric [10], the rank metric introduced by Gabidulin [7] has received considerable attention as it recognizes well the linear

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dependence among the code symbols of the alphabet, especially when the symbols are from higher dimensional Galois field [26]. The class of *rank distance* (RD) codes is defined as subspaces of an n-dimensional space $\mathbb{F}_{q^m}^n$ of n-vectors over an extension field $\mathbb{F}_{q^m}$, where $n \leq m$ [7]. This paper considers the case when $n = m$. The properties, bounds and decoding of the rank distance codes have been studied in [8, 9, 20].

Definition 2.1. The class of (n, k, d) RD codes which attains equality in the Singleton-like bound is called *maximum rank distance* (MRD) codes; i.e., codes for which $d = n - k + 1$.

Definition 2.2. Let $\mathbf{g} = (g_1, g_2, \ldots, g_n) \in \mathbb{F}_{q^n}^n$ be linearly independent over $\mathbb{F}_q$. The MRD code (n, k, d) over $\mathbb{F}_{q^n}$ is the code generated by the matrix $\mathbf{G}$:

$$\mathbf{G} = \begin{pmatrix} g_1 & g_2 & \cdots & g_n \\ g_1^{[1]} & g_2^{[1]} & \cdots & g_n^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ g_1^{[k-1]} & g_2^{[k-1]} & \cdots & g_n^{[k-1]} \end{pmatrix},$$

where and hereafter we use the notation $[i]$ to represent the ith Frobenius power q^i, for some non-negative integer i. Call the vector $\mathbf{g}$ as the generator-vector of $\mathbf{G}$. In general, $\mathbf{g}$ is not unique. Consequently, given a basis $\mathbf{g}$, there exists at least one $\mathbf{H}$ with $\mathbf{G}\mathbf{H}^{\mathbf{T}} = (\mathbf{0})$.

2.3. *Codes with complementary duals*

A construction of LCD codes was known as reversible codes [21]. After a decade of its inception in 1992, apart from [22, 31], further constructions and studies on related properties of LCD codes began during 2004. The interesting point is that each constituent code of a $\mathcal{T}$-Direct code meets the complementary-duality property with the rest. The following theorems give a complete characterization to the class of $\mathcal{T}$-Direct codes.

Theorem 2.3 ([24]). *Let $\mathcal{C}_i$ be an (n, k_i) $\mathbb{F}_{q^n}$-ary linear code with the generator matrix $\mathbf{G}_i$ such that $\mathbf{G}_i\mathbf{G}_j^{\mathbf{T}} = (\mathbf{0})$ for each $i = 1, 2, \ldots, \mathcal{T}$ with $i \neq j$. Then $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ is a $\mathcal{T}$-Direct code if and only if the $k_i \times k_i$ matrix $\mathbf{G}_i\mathbf{G}_i^{\mathbf{T}}$ is non-singular for each $i = 1, 2, \ldots, \mathcal{T}$.*

Theorem 2.4 ([24]). *Let $\mathcal{C}_i$ be an (n, k_i) $\mathbb{F}_{q^n}$-ary linear code with generator matrix $\mathbf{G}_i$ for each $i = 1, 2, \ldots, \mathcal{T}$ and $\Lambda = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_\mathcal{T}$. Then $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ is a $\mathcal{T}$-Direct code if the $k_1 + k_2 + \cdots + k_\mathcal{T}$ row vectors of $\mathbf{G}_1$, $\mathbf{G}_2$, ..., $\mathbf{G}_\mathcal{T}$ are orthonormal vectors in $\mathbb{F}_{q^n}^n$.*

Notations and abbreviations:

- Let $\mathbf{I}_{r\times r}$ (or $\mathbf{I}_r$) denote the identity matrix of order $r \times r$ and $\mathbf{O}_{r\times t}$ denote the all-zero matrix of order $r \times t$. For $\mathbf{x} = (x_1, x_2, \ldots, x_n) \in \mathbb{F}_{q^n}^n$, $(x_n^{[s]}, x_1^{[s]}, x_2^{[s]}, \ldots, x_{n-1}^{[s]})$

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is termed as the $[s]$-cyclic shift of $\mathbf{x}$, and the $[s]$-power shift of $\mathbf{x}$ as the vector $(x_1^{[s]}, x_2^{[s]}, \ldots, x_n^{[s]})$.

- For $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n \in \mathbb{F}_{q^n}^n$, let $\langle \mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n \rangle_{\mathbb{F}_{q^n}}$ denote the subspace spanned by $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n$ over $\mathbb{F}_{q^n}$.
- Observe that the rows of the generator matrix $\mathbf{G}$ are nothing but the consecutive q-powers of $\mathbf{g}$. By abuse of notation, let the generator matrix $\mathbf{G}$ of an MRD code with the k q-power shifts of $\mathbf{g} = (\alpha_1, \alpha_2, \ldots, \alpha_n)$ be conveniently abbreviated as $\mathbf{G}_k = \langle \alpha_1, \alpha_2, \ldots, \alpha_n \rangle$.

3. Construction of $\mathcal{T}$-Direct Codes Over $\mathbb{F}_{q^n}$ Using Self-Dual Basis

A linear code $\mathcal{C}$ qualifies to be an LCD code simply when $\mathcal{C} \cap \mathcal{C}^\perp = \{\mathbf{0}\}$, where the dual code $\mathcal{C}^\perp$ of $\mathcal{C}$ (with respect to $\mathbb{F}_{q^n}^n$) is such that $\mathbb{F}_{q^n}^n = \mathcal{C} \oplus \mathcal{C}^\perp$. We simply modify this definition in what follows to leverage the notion of LCD codes.

Definition 3.1. An $\mathbb{F}_{q^n}$-ary linear code $\mathcal{C}$ is called a *generalized* LCD code if $\mathcal{C} \cap \mathcal{C}^\perp = \{\mathbf{0}\}$, where $\mathcal{C}^\perp$ is the dual of $\mathcal{C}$ with respect to $\Lambda = \mathcal{C} \oplus \mathcal{C}^\perp \subseteq \mathbb{F}_{q^n}^n$.

Under this definition, the constituent codes of a $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ are all *generalized* LCD codes with respect to $\Lambda = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_\mathcal{T} \subseteq \mathbb{F}_{q^n}^n$.

In 2004 [24], it was discovered that certain class of MRD codes defined by *trace-orthogonal basis* in $\mathbb{F}_{2^n}$ are LCD codes [30]. Later it was also shown that not all MRD codes are LCD codes [6]. More recently, the result is proved for the case of MRD codes over $\mathbb{F}_{q^n}$ [19]; that is, it is proved that MRD codes constructed by using *self-dual bases* over $\mathbb{F}_q$ are LCD codes. Prior to [19], in order to construct $\mathcal{T}$-Direct codes, MRD codes obtained by *trace-orthogonal bases* over $\mathbb{F}_2$ were considered as constituent codes. These recent results give direction to generalize previous results on $\mathcal{T}$-Direct codes and motivate to construct $\mathcal{T}$-Direct codes over $\mathbb{F}_{q^n}$ using *self-dual basis.*

As noted earlier, an interesting relationship of the constituent codes of a $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ is that they are LCD codes [24]. The converse is not true in general; that is, an arbitrary collection of $\mathcal{T}$ LCD codes does not constitute a $\mathcal{T}$-Direct code. However, the converse part can be justified if the generator matrices of the $\mathcal{T}$ LCD codes are formed out of q-power shifts of a *self-dual basis* as rows. The construction is given in the following theorem.

Theorem 3.2. *Let $\mathcal{C}_i(n, k_i)$ be an MRD code with generator matrix $\mathbf{G}_i$ for each $i = 1, 2, \ldots, \mathcal{T}$. Suppose that $\alpha_1, \alpha_2, \ldots, \alpha_n$ is a self-dual basis in $\mathbb{F}_{q^n}$. Then $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ is a $\mathcal{T}$-Direct code if $\mathcal{C}_i$ is an LCD code with $\mathbf{G}_i := \mathbf{G}_{k_i} = \langle \alpha_1^{[\sum_{r=0}^{i-1} k_r]}, \alpha_2^{[\sum_{r=0}^{i-1} k_r]}, \ldots, \alpha_n^{[\sum_{r=0}^{i-1} k_r]} \rangle$ for $i = 1, 2, \ldots, \mathcal{T}$ and $k_0 = 0$.*

Proof. Let $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$ be a *self-dual* basis of $\mathbb{F}_{q^n}$ over $\mathbb{F}_q$. Let $k_1, k_2, \ldots, k_\mathcal{T} \geq 0$ be such that $1 \leq k_1 + k_2 + \cdots + k_\mathcal{T} \leq n$. Choose the codes $\mathcal{C}_1(n, k_1, d_1)$, $\mathcal{C}_2(n, k_2, d_2), \ldots, \mathcal{C}_\mathcal{T}(n, k_\mathcal{T}, d_\mathcal{T})$, respectively, defined by the generator matrices

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$\mathbf{G}_1, \mathbf{G}_2, \ldots, \mathbf{G}_{\mathcal{T}}$:

$$\mathbf{G}_i = \begin{pmatrix} \alpha_1^{[\sum_{r=0}^{i-1} k_r]} & \alpha_2^{[\sum_{r=0}^{i-1} k_r]} & \cdots & \alpha_n^{[\sum_{r=0}^{i-1} k_r]} \\ \alpha_1^{[\sum_{r=0}^{i-1} k_r+1]} & \alpha_2^{[\sum_{r=0}^{i-1} k_r+1]} & \cdots & \alpha_n^{[\sum_{r=0}^{i-1} k_r+1]} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_1^{[\sum_{r=0}^{i-1} k_r+(k_i-1)]} & \alpha_2^{[\sum_{r=0}^{i-1} k_r+(k_i-1)]} & \cdots & \alpha_n^{[\sum_{r=0}^{i-1} k_r+(k_i-1)]} \end{pmatrix}$$

for $i = 1, 2, \ldots, \mathcal{T}$ and $k_0 = 0$. Clearly, $\mathbf{G}_i$ defines an MRD code $\mathcal{C}_i(n, k_i, d_i)$ for each $i = 1, 2, \ldots, \mathcal{T}$. Set $\Lambda = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \cdots \oplus \mathcal{C}_{\mathcal{T}}$. Clearly, $\Lambda \subseteq \mathbb{F}_{q^n}^n$. Let

$$\mathbf{A} = \begin{pmatrix} \alpha_1 & \alpha_2 & \cdots & \alpha_n \\ \alpha_1^{[1]} & \alpha_2^{[1]} & \cdots & \alpha_n^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_1^{[n-1]} & \alpha_2^{[n-1]} & \cdots & \alpha_n^{[n-1]} \end{pmatrix} \quad \text{and}$$

$$\mathbf{B} = \begin{pmatrix} \alpha_1 & \alpha_2 & \cdots & \alpha_n \\ \alpha_1^{[1]} & \alpha_2^{[1]} & \cdots & \alpha_n^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_1^{[\kappa-1]} & \alpha_2^{[\kappa-1]} & \cdots & \alpha_n^{[\kappa-1]} \end{pmatrix},$$

where and hereafter $\kappa = k_1 + k_2 + \cdots + k_{\mathcal{T}}$. Observe that, for $i, j = 1, 2, \ldots, n$, the ith and jth column vectors of $\mathbf{A}$ are orthonormal to each other: $\sum_{r=0}^{n-1} \alpha_i^{[r]} \alpha_j^{[r]} = \mathtt{tr}(\alpha_i^{[r]} \alpha_j^{[r]}) = \delta_{ij}$ as $\{\alpha_1, \alpha_2, \ldots, \alpha_n\}$ being a *self-dual basis*. So, $\mathbf{A}^{\mathbf{T}}\mathbf{A} = \mathbf{I}_n$. Then, it is immediate that $\mathbf{A}\mathbf{A}^{\mathbf{T}} = \mathbf{M}_{\boldsymbol{\alpha}}\mathbf{M}_{\boldsymbol{\alpha}}^{\mathbf{T}} = \mathbf{I}_n$. It follows that $\mathbf{B}\mathbf{B}^{\mathbf{T}} = \mathbf{I}_\kappa$. That is,

$$\begin{pmatrix} \sum_{i=1}^n \alpha_i^2 & \sum_{i=1}^n \alpha_i \alpha_i^{[1]} & \cdots & \sum_{i=1}^n \alpha_i \alpha_i^{[\kappa-1]} \\ \sum_{i=1}^n \alpha_i^{[1]} \alpha_i & \sum_{i=1}^n \alpha_i^{[1]} \alpha_i^{[1]} & \cdots & \sum_{i=1}^n \alpha_i^{[1]} \alpha_i^{[\kappa-1]} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_{i=1}^n \alpha_i^{[\kappa-1]} \alpha_i & \sum_{i=1}^n \alpha_i^{[\kappa-1]} \alpha_i^{[1]} & \cdots & \sum_{i=1}^n \alpha_i^{[\kappa-1]} \alpha_i^{[\kappa-1]} \end{pmatrix} = \mathbf{I}_\kappa.$$

Observe that

$$\mathbf{B} = \begin{pmatrix} \mathbf{G}_1 \\ \mathbf{G}_2 \\ \vdots \\ \mathbf{G}_{\mathcal{T}} \end{pmatrix} \quad \text{and} \quad \mathbf{B}\mathbf{B}^{\mathbf{T}} = \begin{pmatrix} \mathbf{G}_1\mathbf{G}_1^{\mathbf{T}} & \mathbf{G}_1\mathbf{G}_2^{\mathbf{T}} & \cdots & \mathbf{G}_1\mathbf{G}_{\mathcal{T}}^{\mathbf{T}} \\ \mathbf{G}_2\mathbf{G}_1^{\mathbf{T}} & \mathbf{G}_2\mathbf{G}_2^{\mathbf{T}} & \cdots & \mathbf{G}_2\mathbf{G}_{\mathcal{T}}^{\mathbf{T}} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{G}_{\mathcal{T}}\mathbf{G}_1^{\mathbf{T}} & \mathbf{G}_{\mathcal{T}}\mathbf{G}_2^{\mathbf{T}} & \cdots & \mathbf{G}_{\mathcal{T}}\mathbf{G}_{\mathcal{T}}^{\mathbf{T}} \end{pmatrix}.$$

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Clearly, $\mathbf{G}_i\mathbf{G}_j^{\mathbf{T}} = \begin{cases}\mathbf{I}_{k_i\times k_j}, & i=j\\ \mathbf{0}_{k_i\times k_j}, & i\neq j\end{cases}$. Consequently, the $\mathcal{T}$ MRD codes generated by the generator matrices $\mathbf{G}_1, \mathbf{G}_2, \ldots, \mathbf{G}_{\mathcal{T}}$ defined via the q-cyclic shifts of *self-dual basis* as above are (*generalized*) LCD codes (with respect to $\Lambda \subseteq \mathbb{F}_{q^n}^n$) for $\Lambda = \mathbb{F}_{q^n}^n$, and constitute a $\mathcal{T}$-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_{\mathcal{T}})$. □

Example 3.3. Let $\mathbb{F}_{3^5}$ be constructed using the primitive polynomial x^5+2x^4+1. Take $k_1 = 2, k_2 = 1, k_3 = 2$; consider $\mathbf{g} = \{\alpha^6, \alpha^{13}, \alpha^{81}, \alpha^{90}, \alpha^{97}\}$, a *self-dual basis* over $\mathbb{F}_3$. For the MRD codes $\mathcal{C}_1(5,2,4)$, $\mathcal{C}_2(5,1,5)$ and $\mathcal{C}_3(5,2,4)$, the corresponding generator and parity check matrices are given by

$$\mathbf{G}_1 = \begin{pmatrix}\alpha^6 & \alpha^{13} & \alpha^{81} & \alpha^{90} & \alpha^{97}\\ \alpha^{18} & \alpha^{39} & \alpha & \alpha^{28} & \alpha^{49}\end{pmatrix}; \quad \mathbf{H}_1 = \begin{pmatrix}\alpha^{27} & \alpha^{90} & \alpha^{218} & \alpha^{57} & \alpha^{120}\\ \alpha^{81} & \alpha^{28} & \alpha^{170} & \alpha^{171} & \alpha^{118}\\ \alpha & \alpha^{84} & \alpha^{26} & \alpha^{29} & \alpha^{112}\end{pmatrix}$$

$$\mathbf{G}_2 = \begin{pmatrix}\alpha^{54} & \alpha^{117} & \alpha^3 & \alpha^{84} & \alpha^{147}\end{pmatrix}; \quad \mathbf{H}_2 = \begin{pmatrix}\alpha^9 & \alpha^{198} & \alpha^{98} & \alpha^{99} & \alpha^{46}\\ \alpha^{27} & \alpha^{110} & \alpha^{52} & \alpha^{55} & \alpha^{138}\\ \alpha^{81} & \alpha^{88} & \alpha^{156} & \alpha^{165} & \alpha^{172}\\ \alpha & \alpha^{22} & \alpha^{226} & \alpha^{11} & \alpha^{32}\end{pmatrix}$$

and

$$\mathbf{G}_3 = \begin{pmatrix}\alpha^{162} & \alpha^{109} & \alpha^9 & \alpha^{10} & \alpha^{199}\\ \alpha^2 & \alpha^{85} & \alpha^{27} & \alpha^{30} & \alpha^{113}\end{pmatrix}; \quad \mathbf{H}_3 = \begin{pmatrix}\alpha^{27} & \alpha^{34} & \alpha^{102} & \alpha^{111} & \alpha^{118}\\ \alpha^{81} & \alpha^{102} & \alpha^{64} & \alpha^{91} & \alpha^{112}\\ \alpha & \alpha^{64} & \alpha^{192} & \alpha^{31} & \alpha^{94}\end{pmatrix}.$$

Here, $\mathbb{F}_{3^5}^5 = \Lambda = \langle \mathbf{g}^{[0]}, \mathbf{g}^{[1]}, \mathbf{g}^{[2]}, \mathbf{g}^{[3]}, \mathbf{g}^{[4]}\rangle_{\mathbb{F}_{3^5}}$. It is easy to verify that $\mathbf{G}_1\mathbf{G}_1^{\mathbf{T}} = \mathbf{I}_{2\times 2}$, $\mathbf{G}_2\mathbf{G}_2^{\mathbf{T}} = \mathbf{I}_{1\times 1}$ and $\mathbf{G}_3\mathbf{G}_3^{\mathbf{T}} = \mathbf{I}_{2\times 2}$. Further, $\mathbf{G}_i\mathbf{G}_j^{\mathbf{T}} = \mathbf{0}_{k_i\times k_j}$ for $i \neq j$. Thus, the LCD codes $\mathcal{C}_1$, $\mathcal{C}_2$ and $\mathcal{C}_3$ constitute a 3-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \mathcal{C}_3)$ with respect to $\mathbb{F}_{3^5}^5$.

4. Non-Existence of $\mathcal{T}$-Direct Codes via *Almost Self-Dual Basis*

Unlike *normal* bases — which exist in every finite extension [23] — *self-dual* bases do not always exist. *Self-dual* bases exist only for finite fields $\mathtt{GF}(q^n)$ for which either q is even or q and n are both odd. In such cases, another type of *trace-orthogonal* basis which is slightly different from *self-dual* bases known as *almost self-dual* basis is considered for defining LCD codes [19]. An *almost self-dual* basis satisfies the conditions of *self-dual basis* with an exception as in the following definition.

Definition 4.1 ([12]). The elements $g_1, g_2, \ldots, g_n \in \mathbb{F}_{q^n}$ form an *almost self-dual basis* of $\mathbb{F}_{q^n}$ over $\mathbb{F}_q$ if and only if (for $a \neq 1$)

$$\mathbf{tr}(g_ig_j) = 0 \quad \text{for } i \neq j$$

$$\text{and} \quad \mathbf{tr}(g_1g_1) = \mathbf{tr}(g_2g_2) = \cdots = \mathbf{tr}(g_{n-1}g_{n-1}) = 1, \mathbf{tr}(g_ng_n) = a \neq 0.$$

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For q odd, $\mathbb{F}_{q^n}$ has an *almost self-dual basis* over $\mathbb{F}_q$ [12]. It has been proved recently [19] that LCD MRD codes can be constructed by using *almost self-dual basis* of $\mathbb{F}_{q^n}$. However, as pointed out earlier, construction of $\mathcal{T}$-Direct codes $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ demands that the rows of $\mathbf{G}_i$ are to be orthogonal to the rows of $\mathbf{G}_j$ for $i \neq j$.

Let $\boldsymbol{\beta} = \{\beta_1, \beta_2, \ldots, \beta_n\}$ be an *almost self-dual basis* of $\mathbb{F}_{q^n}$ over $\mathbb{F}_q$. Consider the distinct q-power shifts of $\boldsymbol{\beta}$ and list them as in the following matrix:

$$\mathbf{A} = \begin{pmatrix} \beta_1 & \beta_2 & \cdots & \beta_n \\ \beta_1^{[1]} & \beta_2^{[1]} & \cdots & \beta_n^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_1^{[n-1]} & \beta_2^{[n-1]} & \cdots & \beta_n^{[n-1]} \end{pmatrix}.$$

Unlike $\mathbf{M}_{\boldsymbol{\alpha}} = \mathbf{I}_n$ for a *self-dual basis* $\boldsymbol{\alpha}$, for an *almost self-dual basis* we have

$$\mathbf{M}_{\boldsymbol{\beta}} = \begin{pmatrix} \mathbf{tr}(\beta_1\beta_1) & \mathbf{tr}(\beta_1\beta_2) & \cdots & \mathbf{tr}(\beta_1\beta_n) \\ \mathbf{tr}(\beta_2\beta_1) & \mathbf{tr}(\beta_2\beta_2) & \cdots & \mathbf{tr}(\beta_2\beta_n) \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{tr}(\beta_n\beta_1) & \mathbf{tr}(\beta_n\beta_2) & \cdots & \mathbf{tr}(\beta_n\beta_n) \end{pmatrix} = \mathtt{diag}(1, 1, \ldots, 1, \mathtt{a}).$$

Consequently, $\mathbf{A}^\mathbf{T}\mathbf{A} = \mathtt{diag}(1, 1, \ldots, 1, \mathtt{a})$; but, $\mathbf{A}\mathbf{A}^\mathbf{T} \neq \mathtt{diag}(1, 1, \ldots, 1, \mathtt{a})$. Moreover, $\mathbf{A}\mathbf{A}^\mathbf{T} = \mathbf{M}_{\boldsymbol{\beta}}\mathbf{M}_{\boldsymbol{\beta}}^\mathbf{T}$ is not even a diagonal matrix. It follows that the n q-power shifts of an *almost self-dual basis* (as row-vectors) are not mutually orthogonal, consequently do not help in the construction of $\mathcal{T}$-Direct codes as the following example demonstrates.

Example 4.2. Consider the basis $\mathbf{g} = (\beta^{12}, \beta^{41}, \beta^{165}, \beta^{1352}, \beta^{452})$ which is an *almost self-dual basis* of $\mathbb{F}_{5^5}$, where β is the root of the primitive polynomial $x^5 + 4x^4 + 3x^3 + x^2 + 2x + 3$ over $\mathbb{F}_5$. Consider the 5-cyclic shifts of the *almost self-dual basis* and list them as in the following matrix:

$$\mathbf{G} = \begin{pmatrix} \mathbf{g}^{[0]} \\ \mathbf{g}^{[1]} \\ \mathbf{g}^{[2]} \\ \mathbf{g}^{[3]} \\ \mathbf{g}^{[4]} \end{pmatrix} = \begin{pmatrix} \beta^{12} & \beta^{41} & \beta^{165} & \beta^{1352} & \beta^{452} \\ \beta^{60} & \beta^{205} & \beta^{825} & \beta^{512} & \beta^{2260} \\ \beta^{300} & \beta^{1025} & \beta^{1001} & \beta^{2560} & \beta^{1928} \\ \beta^{1500} & \beta^{2001} & \beta^{1881} & \beta^{304} & \beta^{268} \\ \beta^{1252} & \beta^{633} & \beta^{33} & \beta^{1520} & \beta^{1340} \end{pmatrix}.$$

Clearly,

$$\mathbf{G}\mathbf{G}^\mathbf{T} = \begin{pmatrix} \beta^{1162} & \beta^{369} & \beta^{37} & \beta^{1501} & \beta^{2573} \\ \beta^{369} & \beta^{2686} & \beta^{1845} & \beta^{185} & \beta^{1257} \\ \beta^{37} & \beta^{1845} & \beta^{934} & \beta^{2977} & \beta^{925} \\ \beta^{1501} & \beta^{185} & \beta^{2977} & \beta^{1546} & \beta^{2389} \\ \beta^{2573} & \beta^{1257} & \beta^{925} & \beta^{2389} & \beta^{1482} \end{pmatrix}.$$

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Also, $\mathbf{G^T G} = \mathtt{diag}(1, 1, 1, 4)$. Although $\mathbf{GG^T}$ is non-singular: $|\mathbf{GG^T}| = 4 \neq 0$ (a requirement for an LCD), the rows of $\mathbf{G}$ are not orthogonal. That is, $\mathbf{GG^T}$ is not a diagonal matrix (as shown above). Consequently, the 5-cyclic shifts of the basis cannot be used (as row vectors) in generator matrices of constituent codes for a $\mathcal{T}$-Direct code.

5. q-Cyclic MRD Codes as Complementary Duals

It has also been proved in [25] that the class of (n, k, d) 2-cyclic MRD codes defined by the generator matrices with a *trace-orthogonal* basis being the first row are LCD codes, along with a construction to $\mathcal{T}$-Direct 2-cyclic MRD codes, is given. In that construction, 2-cyclic MRD codes obtained from *trace-orthogonal basis* over $\mathbb{F}_2$ were used as constituent codes. In both the above constructions of 2-cyclic MRD codes and $\mathcal{T}$-Direct 2-cyclic MRD codes, generator matrices are defined by using first row as *trace-orthogonal normal basis* [13]. However, a *self-dual normal basis* exists in $\mathbb{F}_{q^n}$ if and only if either n is odd, or q is even and $n \not\equiv 0 \pmod 4$ [16] which gives us a motivation to generalize the previous results for $q \neq 2$.

Theorem 5.1. *For a self-dual normal basis $\{\gamma^{[0]}, \gamma^{[1]}, \ldots, \gamma^{[n-1]}\}$ of $\mathbb{F}_{q^n}$ over $\mathbb{F}_q$, the (n, k, d) q-cyclic MRD code defined by the following generator matrix*

$$\mathbf{G} = \begin{pmatrix} \gamma^{[0]} & \gamma^{[1]} & \ldots & \gamma^{[n-1]} \\ \gamma^{[1]} & \gamma^{[2]} & \ldots & \gamma^{[n]} \\ \vdots & \vdots & \ddots & \vdots \\ \gamma^{[k-1]} & \gamma^{[k]} & \ldots & \gamma^{[k+n-2]} \end{pmatrix}$$

is an LCD code.

Proof. In order to prove that the code, say $\mathcal{C}$, generated by $\mathbf{G}$ is an LCD code, it is enough to show that the $k \times k$ matrix $\mathbf{GG^T}$ is non-singular [22]. Since $\{\gamma^{[0]}, \gamma^{[1]}, \ldots, \gamma^{[n-1]}\}$ being a *self-dual normal basis* in $\mathbb{F}_{q^n}$ over $\mathbb{F}_q$. It immediately follows that $\mathbf{GG^T} = \mathbf{I}_k$. Consequently, the class of (n, k, d) q-cyclic MRD codes defined by the generator matrices with a *self-dual normal basis* being the first row are LCD codes.

It is clear that for an generator matrix $\mathbf{G}$ defined through *self-dual normal basis*, $\mathbf{GG^T} = \mathbf{I}_k$. Further, a *self-dual normal basis* is also a *self-dual basis*, they can also be used to define the constituent codes for $\mathcal{T}$-Direct q-cyclic MRD codes. As the construction is similar to the case of *self-dual basis*, in the following, the statement is made without proof. □

Theorem 5.2. *Let $\gamma_1, \gamma_2, \ldots, \gamma_n$ be a self-dual normal basis in $\mathbb{F}_{q^n}$. Let $\mathcal{C}_i$ be an (n, k_i) MRD code with $\mathbf{G}_i := \mathbf{G}_{k_i} = \langle \gamma_1^{[\sum_{r=0}^{i-1} k_r]}, \gamma_2^{[\sum_{r=0}^{i-1} k_r]}, \ldots, \gamma_n^{[\sum_{r=0}^{i-1} k_r]} \rangle$ for $i = 1, 2, \ldots, \mathcal{T}$ and $k_0 = 0$. Then $(\mathcal{C}_1, \mathcal{C}_2, \ldots, \mathcal{C}_\mathcal{T})$ is a $\mathcal{T}$-Direct q-cyclic MRD code, where $\gamma_i = \gamma^{q^{i-1}}$ $(1 \leq i \leq n)$ for a normal element γ.*

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The following example illustrates the construction of $\mathcal{T}$-Direct ($q = 3$)-cyclic MRD codes (with respect to a subspace Λ of $\mathbb{F}_{3^7}^7$) from the generator matrices having 3-cyclic shifts of an *self-dual normal basis* as rows.

Example 5.3. Consider the primitive polynomial $\mathrm{p}(x) = x^7 + 2x^6 + x^5 + 1$ over $\mathbb{F}_3$. Let $\alpha \in \mathbb{F}_{3^7}$ be a root of $\mathrm{p}(x)$ satisfying $\alpha^7 + 2\alpha^6 + \alpha^5 + 1 = 0$. Consider the *self-dual normal basis* $\mathbf{g} = (\alpha^{31}, \alpha^{93}, \alpha^{279}, \alpha^{837}, \alpha^{325}, \alpha^{975}, \alpha^{739})$. Take $\Lambda = \langle \mathbf{g}^{[0]}, \mathbf{g}^{[1]}, \mathbf{g}^{[2]}, \mathbf{g}^{[3]}, \mathbf{g}^{[4]}, \mathbf{g}^{[5]} \rangle_{\mathbb{F}_{3^7}}$. Let $\mathcal{C}_1$, $\mathcal{C}_2$ and $\mathcal{C}_3$, respectively, denote $[7, 2, 6]_{3^7}$, $[7, 1, 7]_{3^7}$ and $[7, 3, 5]_{3^7}$ 3-cyclic MRD codes with the generator matrices $\mathbf{G}_1$, $\mathbf{G}_2$ and $\mathbf{G}_3$ are defined by the 3-cyclic shifts of the *self-dual normal basis* $\mathbf{g} = (\alpha^{31}, \alpha^{93}, \alpha^{279}, \alpha^{837}, \alpha^{325}, \alpha^{975}, \alpha^{739})$ as follows:

$$\mathbf{G}_1 = \begin{pmatrix} \mathbf{g}^{[0]} \\ \mathbf{g}^{[1]} \end{pmatrix} = \begin{pmatrix} \alpha^{31} & \alpha^{93} & \alpha^{279} & \alpha^{837} & \alpha^{325} & \alpha^{975} & \alpha^{739} \\ \alpha^{93} & \alpha^{279} & \alpha^{837} & \alpha^{325} & \alpha^{975} & \alpha^{739} & \alpha^{31} \end{pmatrix}$$

$$\mathbf{G}_2 = (\mathbf{g}^{[2]}) = (\alpha^{279} \quad \alpha^{837} \quad \alpha^{325} \quad \alpha^{975} \quad \alpha^{739} \quad \alpha^{31} \quad \alpha^{93})$$

$$\text{and } \mathbf{G}_3 = \begin{pmatrix} \mathbf{g}^{[3]} \\ \mathbf{g}^{[4]} \\ \mathbf{g}^{[5]} \end{pmatrix} = \begin{pmatrix} \alpha^{837} & \alpha^{325} & \alpha^{975} & \alpha^{739} & \alpha^{31} & \alpha^{93} & \alpha^{279} \\ \alpha^{325} & \alpha^{975} & \alpha^{739} & \alpha^{31} & \alpha^{93} & \alpha^{279} & \alpha^{837} \\ \alpha^{975} & \alpha^{739} & \alpha^{31} & \alpha^{93} & \alpha^{279} & \alpha^{837} & \alpha^{325} \end{pmatrix}$$

with the corresponding parity-check matrices

$$\mathbf{H}_1 = \begin{pmatrix} \alpha^{27} & \alpha^{585} & \alpha^{73} & \alpha^{723} & \alpha^{487} & \alpha^{1965} & \alpha^{2027} \\ \alpha^{81} & \alpha^{1755} & \alpha^{219} & \alpha^{2169} & \alpha^{1461} & \alpha^{1523} & \alpha^{1709} \\ \alpha^{243} & \alpha^{893} & \alpha^{657} & \alpha^{2135} & \alpha^{11} & \alpha^{197} & \alpha^{755} \\ \alpha^{729} & \alpha^{493} & \alpha^{1971} & \alpha^{2033} & \alpha^{33} & \alpha^{591} & \alpha^{79} \end{pmatrix}$$

$$\mathbf{H}_2 = \begin{pmatrix} \alpha^{9} & \alpha^{1683} & \alpha^{147} & \alpha^{2097} & \alpha^{1389} & \alpha^{1451} & \alpha^{1637} \\ \alpha^{27} & \alpha^{677} & \alpha^{441} & \alpha^{1919} & \alpha^{1981} & \alpha^{2167} & \alpha^{539} \\ \alpha^{81} & \alpha^{2031} & \alpha^{1323} & \alpha^{1385} & \alpha^{1571} & \alpha^{2129} & \alpha^{1617} \\ \alpha^{729} & \alpha^{791} & \alpha^{977} & \alpha^{1535} & \alpha^{1023} & \alpha^{1673} & \alpha^{1437} \\ \alpha & \alpha^{187} & \alpha^{745} & \alpha^{233} & \alpha^{883} & \alpha^{647} & \alpha^{2125} \end{pmatrix}$$

$$\text{and } \mathbf{H}_3 = \begin{pmatrix} \alpha^{243} & \alpha^{305} & \alpha^{491} & \alpha^{1049} & \alpha^{537} & \alpha^{1187} & \alpha^{951} \\ \alpha^{729} & \alpha^{915} & \alpha^{1473} & \alpha^{961} & \alpha^{1611} & \alpha^{1375} & \alpha^{667} \\ \alpha & \alpha^{559} & \alpha^{47} & \alpha^{697} & \alpha^{461} & \alpha^{1939} & \alpha^{2001} \end{pmatrix},$$

where $\mathbf{g}^{[6]} = (\alpha^{739}, \alpha^{31}, \alpha^{93}, \alpha^{279}, \alpha^{837}, \alpha^{325}, \alpha^{975})$ with $\Lambda^{\perp} = \langle \mathbf{g}^{[6]} \rangle_{\mathbb{F}_{3^7}}$; $\Lambda \oplus \Lambda^{\perp} = \mathbb{F}_{3^7}^7$. Here, $\mathcal{C}_1^{\perp} = \mathcal{C}_2 \oplus \mathcal{C}_3$, $\mathcal{C}_2^{\perp} = \mathcal{C}_1 \oplus \mathcal{C}_3$, $\mathcal{C}_3^{\perp} = \mathcal{C}_1 \oplus \mathcal{C}_2$ are dual with respect to $\Lambda \subseteq \mathbb{F}_{3^7}^7$. It is easy to verify that $\mathbf{G}_i \mathbf{G}_i^{\mathbf{T}}$ is an identity matrix for each $i = 1, 2, 3$. Note that $\mathbf{G}_i \mathbf{G}_j^{\mathbf{T}} = (\mathbf{0})$ for each $i \neq j$. Thus, the MRD codes $\mathcal{C}_1$, $\mathcal{C}_2$ and $\mathcal{C}_3$ which

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are (*generalized*) LCD codes with respect to $\Lambda = \mathcal{C}_1 \oplus \mathcal{C}_2 \oplus \mathcal{C}_3 \subset \mathbb{F}_{3^7}^7$ constitute a 3-Direct code $(\mathcal{C}_1, \mathcal{C}_2, \mathcal{C}_3)$.

6. Conclusion

Similar to LCD codes, the constituent codes of $\mathcal{T}$-Direct codes enjoy having complementary-duality with each other. Some important and generalized results on $\mathcal{T}$-Direct codes are given — constructing $\mathcal{T}$-Direct codes from $\mathcal{T}$ LCD codes are considered in this paper. The results obtained show that a fixed set of LCD codes can also be used to define $\mathcal{T}$-Direct codes, in that *self-dual bases* and *self-dual normal bases* play an integral part. A class of q-cyclic MRD codes having complementary duals over $\mathbb{F}_{q^n}$ is presented. It is further shown that generator matrices from *almost self-dual bases* do not construct $\mathcal{T}$-Direct codes.

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Acknowledgments

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27 January 2022

TO WHOM IT MAY CONCERN

This is to certify that the project entitled "Construction of T-Direct Codes using an Almost Self-Dual Basis" has been successfully completed. The details of the project are as follows:

Principal Investigator: Dr. M. Devi

Co-investigator 1: Prof. R. S. Raja Durai

Co-investigator 2: Prof. Hongjun Xu

Funding Amount: ZAR 50000

Funding Agency: ABSA

Duration: January 2020 – December 2020

The anticipated outputs mentioned in the project have been achieved. The details are as follows:

Journal Publication:

1. **Devi, Meenakshi,** Raja Durai, R. S., Kumar, Ashwini, Xu, Hongjun, "Some Important Results on T-Direct Codes", *Discrete Mathematics, Algorithms and Applications,* (***World Scientific***), Vol. 13, pp. 1-12, 2021. **(ESCI and Scopus Indexed)** https://doi.org/10.1142/S1793830921500671

Conference Presentation:

2. **Devi, Meenakshi,** Raja Durai, R. S., Kumar, Ashwini, Xu, Hongjun, "Generalized Results on T-Direct Codes", International Conference on Frontiers in Industrial and Applied Mathematics, Jamshedpur, India, December 2020. (Oral presentation).

Prof AC Gelebe

HoS: School of Natural and Applied Sciences

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Date: 4th March, 2017

Dr Adrien Savoyant,
Department of Physics
IM2NP, CNRS UMR 6242,FST
Aix Marseille University,
F-13397 Marseille Cedex 20, France

Subject: Research collaboration on "Transition metal doped ZnO nanostructures for spintronic devices"

Dear Dr. Adrien Savoyant,

Based on our previous discussion on Electron Spin Resonance study of Co doped ZnO nanoparticles, this letter is to confirm my interest in collaborating on the research under the title " Transition metal doped ZnO nanostructures for spintronic devices". I have keen interest in understanding the origin of ferromagnetism in ZnO based semiconductors and I appreciate your valuable contribution on above said topic in several reputed journals. I also appreciate you, and your colleagues for raising some important, complex issue on the same.

I am sure that the research proposed under this effort would help us in better understanding of magnetic properties of oxide nanoparticles, strongly correlated electronic systems and possible design of spintronic devices. Thus, I would be glad to synthesize, model, and provide all support you needed. I am very hopeful that in future I would be able to write joint international project with you either under "Department of Science and Technology (DST, India) or IAR programme of your university.

I look forward to this collaboration with your group.

Thanks and regards

Dr. Sanjiv Kumar Tiwari
Department of Physics and Materials Science,
Jaypee University of Information Technology
Waknaghat, Solan -173234 H.P, India

Dr Adrien Savoyant,
Department of Physics
IM2NP, CNRS UMR 6242,FST
Aix Marseille University
F-13397 Marseille Cedex 20, France

Head of the department and signing authority

Prof. Dr. P.B Barman
Head of the Department of Physics and Materials Science
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No. INT/FRG/DAAD/P-24/2017
Government of India
Ministry of Science and Technology
Department of Science & Technology
(International Bilateral Cooperation Division)

Technology Bhavan, New Mehraulli Road
New Delhi-110016
Date: 31/07/2017

ORDER

Subject: Implementation of Indo-Germany Joint project entitled: "Formation of Room Temperature Ferrite Thin Films for the Applications of Spintronic Devices" coordinated by Rajeesh Kumar, with the Germany partner Joachim Wollschlager, - regarding.

Sanction of the President is hereby accorded for incurring an expenditure not exceeding Rs. 11,72,000/- (Rupees Eleven Lac Seventy Two Thousand Only) for implementation of the Indo-Germany joint project entitled **"Formation of Room Temperature Ferrite Thin Films for the Applications of Spintronic Devices"** coordinated by Rajeesh Kumar, Assistant Professor, Department of Physics and Materials Science, Jaypee University of Information Technology Solan(H.P) India in collaboration with Joachim Wollschlager, Professor, Department of Physics, University of Osnanrück, Germany for a total duration of 2 years from the date of issue of the sanction order. The detailed breakup of the grant for General as well as Capital Components are given below:-

General Component	:	Rs. **11,72,000/-**
Capital Component	:	Rs. NIL.

2. As per the terms and conditions, agreed by both side, under the project the sending side will bear the cost related to the International air travel, medical insurance and visa charges whereas the receiving side shall bear the cost of accommodation, hospitality and local travels of the visiting scientist. The break-up of approved expenditure is as indicated below :

Headings	Estimated expenditure(s)		
	1st year	2nd year	Total
1. Expenses for Indian scientists to visit Germany under the project	(2 visits)	(2 visits)	4 visits
International air-fare (by IATA excursion/ economy class by shortest route) including surface travel from place of work in India to place of work in Germany & back; Visa charges,	15 &25 days 3,06,000/-	15 &25 days 3,06,000/-	80 days 6,12,000/-
Medical Insurance etc	10,000/-	10,000/-	20,000/-
2.Expenses for German scientists to visit India under the project	(2 visits) (22 day each)	(2 visits) (22 day each)	4 visits 88 days
(i)Accommodation charges	1,60,000/-	1,60,000/-	3,20,000/-
(ii) Per-diem charges @ Rs. 2500/- per day	1,10,000/-	1,10,000/-	2,20,000/-
3. Total	**5,86,000/-**	**5,86,000/-**	**11,72,000/-**

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3. Sanction of the President is hereby accorded for release of 1st instalment amounting of **Rs. 5,86,000/- (Rupees Five Lac Eighty Six Thousand Only)** to the grantee Institute. The amount of grant will drawn by the Drawing and Disbursing Officer, DST and will be disbursed to Department of Physics and Materials Science, Jaypee University of Information Technology Solan(H.P) India. The bank details for electronic transfer of funds through RTGS are given below:-

Account Holders name/ designation	Jaypee University of Information Technology
Name of Bank	Punjab National Bank, Waknaghat, Distt. Solan (H. P.)
Bank Account Number	**0427032100000010**
IFSC Code	PUNB0637100
E-Mail	rajesh.kumar@juit.ac.in
Darpan Protal Unique ID	**HP/2016/0106622**

Condition for placing of grant amount :

4. The institute will maintain separate audited account for the project and the amount of grant will be kept in a bank account earning interest. The interest earned should be reported to DST while submitting the (financial year wise) Statement of Expenditure/Utilization Certificate. The interest thus earned will be treated as a credit to the institute to be adjusted towards further instalment of the grant.

Conditions for submission of SE/UC and Progress report.

5. This sanction is subject to the condition that :

(a) the grantee organisation will furnish to the Department of Science & Technology, financial year wise Utilization Certificate (UC) in the proforma prescribed as per GFR 2017 and audited statement of expenditure (SE) along with up to date progress report at the end of each financial year duly reflecting the interest earned / accrued on the grants received under the project. This is also subject to the condition of submission of the final statement of expenditure, utilization certificate and project completion report within one year from the scheduled date of completion of the project.

(b) While submitting Utilisation Certificate/Statement of Expenditure, the organisation has to ensure submission of supporting documentary evidences with regard to purchase of equipment/capital assets as per the provisions of GFR 2017. Subsequent release of grants under the project shall be considered only on receipt of the said documents.

(c) a transparent procurement procedure in line with the Provisions of General Financial Rules 2017 will be followed by the Institute/Organisation under the appropriate rules of the grantee organisation while procuring capital assets sanctioned for the above mentioned project and a certificate to this effect will be submitted by the Grantee organisation immediately on receipt of the grant;

6. The grantee organisation will have to enter & upload the Utilization Certificate in the PFMS portal besides sending it in physical form to this Division. The subsequent/final instalment will be released only after confirmation of the acceptance of the UC by the Division and entry of previous Utilization Certificate in the PFMS.

7. In the event grant has been released under capital head through separate sanction order under the same project for purchase of equipment(s), separate SE/UC has to be furnished for the released Capital head grant.

Conditions of Assets (If any) :

8. DST reserves sole rights on the assets created out of grants. Assets acquired wholly or substantially out of government grants (except those declared as obsolete and unserviceable or condemned in accordance with the procedure laid down in GFR 2017), shall not be disposed of without obtaining the prior approval of DST.

Conditions for International Visits :

9. All project related visits to be undertaken by the Scientists from either side in connection with the implementation of the project shall require prior approval from this Department separately on a case to case basis before any expenditure is incurred in this regard.

10. As per MoF instructions, it has been decided that in all cases of air travel, both domestic and international, where the Government of India bears the cost of air passage, the officials concerned

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may travel only by Air India. For travel to stations not connected by Air India, the officials may travel by Air India to the hub/point closest to their eventual destination, beyond which they may utilize the services of another airline which should also preferable be an alliance partner of Air India.

Other Conditions:

11. The account of the grantee organisation shall be open to inspection by the sanctioning authority and audit (both by C&AG of India and Internal Audit by the Principal Accounts Office of the DST), whenever the organisation is called upon to do so, as laid down under Rule 236(1) of General Financial Rules 2017.

12. Due acknowledgement of technical support / financial assistance resulting from this project grant should mandatorily be highlighted by the grantee organisation in bold letters in all publications / media releases as well as in the opening paragraphs of their Annual Reports during and after the completion of the project.

13. In case the scheme provides for payment of honorarium / remuneration / fellowship / scholarship to the PI,a para may suitably be incorporated in the DSO to the effect that "PI is not drawing any emoluments/ salary/fellowship from any other project either supported by DST or by any other funding agency.

14. **Failure to comply with the terms and conditions of the Bond will entail full refund with interest in terms of Rule 231 (2) of GFR 2017.**

15. The expenditure involved is debitable to Demand No 84, Department of Science & Technology for the year 2017-18:

3425	:	Other Scientific Research (Major Head)
60	:	Others
60 798	:	International Cooperation (Minor Head)
14	:	S & T Cooperation with Other countries
14.00.31	:	Grants-in-aid General for the year 2017-18 (Plan)
		(Previous : ICD-3425.60.798.14.00.31)

16. This sanction order being 1st instalment for implementation of this project, no SE/UC is due from the grantee institution against this project.

17. This issues with the concurrence of IFD vide their concurrence Dy. No. **C/1735/IFD 2017-18 dated 24.07.2017.**

18. As per Rule 234 of GFR 2017, this sanction has been entered at S. No. .....in the register of grants maintained in the Division for the scheme (Name of the Scheme).

(Dr. Chadaram Sivaji)
Scientist-F / IBCD

To,

The Pay & Accounts Officer,
Department of Science & Technology,
New Delhi-110016

Copy to:

1. Office of the Principal Director of Audit, AGCR Bldg., IP Estate, New Delhi-110002
2. Cash Section (3 copies), DST
3. I.F. Division/Accounts Section, DST
4. Sanction Folder
5. Project File.
6. Rajeesh Kumar, Assistant Professor, Department of Physics and Materials Science, Jaypee University of Information Technology Solan(H.P) India
7. Jaypee University of Information Technology

(Dr. Chadaram Sivaji)
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