

PAPER • OPEN ACCESS

Preface

To cite this article: 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 011001

View the [article online](#) for updates and enhancements.

You may also like

- [Preface](#)
- [1st Paris Van Java International Seminar on Computer, Science, Engineering and Technology \(PVJ ISComSET\) 2020](#)
- [Learning Materials Based On Digital Art Student Creativity in Universitas Muhammadiyah Tapanuli Selatan](#)
Rizky Ariaji, Ahmad Husein Nasution, Andes Fuady Dharma Harahap et al.



The Electrochemical Society
Advancing solid state & electrochemical science & technology

241st ECS Meeting

Vancouver, BC, Canada. May 29 – June 2, 2022



ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University



Register now!



Preface

The International Conference on Engineering and Applied Technology (ICEAT) was first launched in 2017 at Mataram hosted by Universitas Muhammdiyah Mataram. The second conference was in 2018 at Banda Aceh hosted by Universitas Muhammdiyah Aceh. The third ICEAT present is hosted by Faculty of Industrial Technology, Universitas Muhammadiyah Sorong, West Papua, Indonesia. The 3rd ICEAT is organized by Science and Technology Association of Muhammadiyah Higher Education (AST-PTM) as well as jointly with Universitas Ahmad Dahlan, Universitas Muhammadiyah Magelang, Universitas Muhammadiyah Malang, Universitas Muhammadiyah Surakarta, Universitas Muhammadiyah Purwokerto, Universitas Muhammadiyah Makassar, Universitas Muhammadiyah Gresik, Universitas Muhammadiyah Jakarta, Universitas Muhammadiyah Yogyakarta, Universitas Muhammadiyah Jember, Universitas Muhammadiyah Surabaya, Universitas Muhammadiyah Sidoarjo, Universitas Muhammadiyah Banjarmasin, and Universitas Muhammadiyah Prof Dr Hamka (UHAMKA). On behalf of the organizing committee, I cordially welcome to all the delegates of the 3rd ICEAT 2019.

Being in the third event, the 3rd ICEAT 2019 is aimed at keeping abreast of the current development and innovation in the advanced of research area on Engineering and Applied Technology as well as providing an engage forum for participants to share knowledge and expertise in related issues. In this conference, submitted papers were limited in five conference tracks. The committee member blindly reviewed as well as provided the technical comments to all the submitted paper before ensuring that submitted paper is qualified. Finally we are accepting 52 papers to be presented in the conference. The accepting papers are covering the scope include: Electronics Engineering, Electrical Engineering, Informatics Engineering, Computer Engineering, Industrial Engineering, Mechanical Engineering, Civil Engineering, Architecture, Chemical Engineering, Applied Science, and Agrotechnology as well.

Last but not least, I do hope through this conference will convey a good opportunity for sharing at the forefront of the field and an informal exchange of ideas, knowledge and friendship in a relaxing environment. Then, our academic and social atmosphere will become more active year to year.

Warm Regards,

General Chair

Aster Rahayu, S.Si., M.Si., Ph.D



PAPER • OPEN ACCESS

Lists of committees

To cite this article: 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 011002

View the [article online](#) for updates and enhancements.

You may also like

- [National Conference on Theory of Magnetism](#)
- [Committees](#)
- [Using Self-Organizing Map \(SOM\) for Clustering and Visualization of New Students based on Grades](#)
I Y Purbasari, E Y Puspaningrum and A B S Putra

**The Electrochemical Society**
Advancing solid state & electrochemical science & technology

**Register now!**

241st ECS Meeting
Vancouver, BC, Canada. May 29 – June 2, 2022

**ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University**



ICEAT 2019 Committee

Organizing Committee

General Chair

- Aster Rahayu (Universitas Ahmad Dahlan, Indonesia)

General Co-Chair

- Yun Arifatul Fatimah (Universitas Muhammadiyah Magelang, Indonesia)
- Andri Pranolo (Universitas Ahmad Dahlan, Indonesia)

Technical Program Committee

- Andri Pranolo (Universitas Ahmad Dahlan, Indonesia)
- Rafał Dreżewski (AGH University of Science and Technology, Poland)
- Shi-Jinn Horng (National Taiwan University of Science and Technology, Taiwan)
- E.P. Nowicki (University of Calgary, Canada)
- Husni Thamrin (Universitas Muhammadiyah Surakarta, Indonesia)
- Dwi Anggraini (Universitas Muhammadiyah Malang, Indonesia)
- Gunawan Ariyanto (Universitas Muhammadiyah Surakarta, Indonesia)
- Zulfatman (Universitas Muhammadiyah Malang, Indonesia)
- Slamet Riyadi (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Yun Arifatul Fatimah (Universitas Muhammadiyah Magelang, Indonesia)
- Aster Rahayu (Universitas Ahmad Dahlan, Indonesia)
- Pedro Hokama (University of Campinas, Brasil)
- Wolfgang Keller (University of Colorado, Colorado, US)
- Hari Prasetyo (Universitas Muhammadiyah Surakarta, Indonesia)
- Eko Setiawan (Universitas Muhammadiyah Surakarta, Indonesia)
- Ilyas Mas'udin (Universitas Muhammadiyah Malang, Indonesia)
- Siti Mahsanah (Universitas Ahmad Dahlan, Indonesia)
- Herry Purnama (Universitas Muhammadiyah Surakarta, Indonesia)
- Dan Mugisidi (UHAMKA Jakarta, Indonesia)
- Lukas G. Swan (Dalhousie University, Canada)
- Sudarisman (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Aris Widyo Nugroho (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Muji Setiyo (Universitas Muhammadiyah Magelang, Indonesia)
- Marwan Effendy (Universitas Muhammadiyah Surakarta, Indonesia)
- Tri Widayatno (Universitas Muhammadiyah Surakarta, Indonesia)
- Tri Yuni Hendrawati (Universitas Muhammadiyah Jakarta, Indonesia)
- Denny Vitasari (Universitas Muhammadiyah Surakarta, Indonesia)
- Nurul Hidayati Fithriyah (Universitas Muhammadiyah Jakarta, Indonesia)
- Haryanto (Universitas Muhammadiyah Purwokerto, Indonesia)
- Agus Setyo Munthohar (Universitas Muhammadiyah Yogyakarta, Indonesia)



- Rahma Yanda (Gifu University, Japan)
- Alwis Nazir (Universitas Islam Negeri Sultan Syarif Kasim, Indonesia)
- Roman Volianskyi (Dniprovsky State Technical University, Ukraine)
- Sri Sunarjono (Universitas Muhammadiyah Surakarta, Indonesia)
- Nurul Hidayati (Universitas Muhammadiyah Surakarta, Indonesia)
- Samin (Universitas Muhammadiyah Malang, Indonesia)
- Jazaul Ikhsan (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Ade FAH Alhashimy (Universitas Muhammadiyah Sumatera Utara, Indonesia)
- Gunawan (Universitas Muhammadiyah Surabaya, Indonesia)
- Wisnu Setiawan (Universitas Muhammadiyah Surakarta, Indonesia)
- Alfian Ma'arif (Universitas Ahmad Dahlan, Indonesia)
- Novrianti (Gifu University, Japan)

PAPER • OPEN ACCESS

Lists of Editors

To cite this article: 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 011003

View the [article online](#) for updates and enhancements.

You may also like

- [List of Editors](#)
- [Message from the Editor](#)
Paul Thomas
- [Lists of committees](#)



The Electrochemical Society
Advancing solid state & electrochemical science & technology

241st ECS Meeting

Vancouver, BC, Canada. May 29 – June 2, 2022



ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University



Register now!



ICEAT 2019 Editors

- Dan Mugisidi (UHAMKA Jakarta, Indonesia)
- Ade FAH Alhashimy (Universitas Muhammadiyah Sumatera Utara, Indonesia)
- Agus Setyo Munthohar (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Rafał Dreżewski (AGH University of Science and Technology, Poland)
- Yun Arifatul Fatimah (Universitas Muhammadiyah Magelang, Indonesia)
- Agus Aktawan (Universitas Ahmad Dahlan, Indonesia)
- Andri Pranolo (Universitas Ahmad Dahlan, Indonesia)
- Novrianti (Gifu University, Japan)
- Leonel Hernandez (ITSA University, Colombia)
- Lukas G. Swan (Dalhousie University, Canada)
- Pedro Hokama (University of Campinas, Brasil)
- Aster Rahayu (Universitas Ahmad Dahlan, Indonesia)
- Alfian Ma'arif (Universitas Ahmad Dahlan, Indonesia)
- Jazaul Ikhsan (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Aris Widy Nugroho (Universitas Muhammadiyah Yogyakarta, Indonesia)
- Tri Widayatno (Universitas Muhammadiyah Surakarta, Indonesia)
- Ahmad Azhari (Universitas Ahmad Dahlan, Indonesia)
- Adhi Prahara (Universitas Ahmad Dahlan, Indonesia)
- Rahma Yanda (Gifu University, Japan)
- Alwis Nazir (Universitas Islam Negeri Sultan Syarif Kasim, Indonesia)
- Roman Volianskyi (Dniprovsy State Technical University, Ukraine)



PAPER • OPEN ACCESS

Proceeding Copyright

To cite this article: 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 011004

View the [article online](#) for updates and enhancements.

You may also like

- [Statement from the 1987 Como meeting of the International Commission on Radiological Protection](#)
- [The activities of EFOMP in education and training: past, present and future](#)
S Christofides
- [Statement from the 1987 Como meeting of the International Commission on Radiological Protection](#)



The Electrochemical Society
Advancing solid state & electrochemical science & technology

241st ECS Meeting

Vancouver, BC, Canada. May 29 – June 2, 2022



ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University



Register now!



The 2019 3rd International Conference on Engineering and Applied Technology (ICEAT)

30-31 October 2019, Sorong, Indonesia

THE PROCEEDINGS PUBLICATION LICENCE:

Licence terms and conditions

By submitting your paper to the conference organizer, you, as author/representative of all the authors, grant a royalty free license to IOP Publishing Limited (IOP) to use the copyright in the paper for the full term of copyright in all ways otherwise restricted by copyright, including the right to reproduce, distribute and communicate the article to the public under the terms of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/3.0/>) and to make any other use which IOP may choose world-wide, by all means, media and formats, whether known or unknown at the date of submission, to the conference organizer.

This license does not transfer the copyright in the paper as submitted which therefore remains with the authors or their employer, as appropriate. IOP encourages authors to use the paper in any way provided that, where possible, he/she displays citation information and the IOP Proceedings License Notice, for electronic use, best efforts are made to include a link to the online abstract in the journal and no author offers the paper to another publisher (prior to withdrawal or rejection) or includes it in another publisher's website.

However, a re-written and extended version of the paper may be published in another journal provided such re-use is within generally accepted ethical scientific limits and provided further citation information and the IOP Proceedings License Notice is displayed if possible, and for electronic use best efforts are made to include a link to the online abstract in the journal.

By granting this license, the author warrants that the paper he/she is submitting is his/her original work, has not been published previously (other than in a research thesis or dissertation which fact has been notified to the conference organizer in writing), all named authors participated sufficiently in the conception and writing of the paper, have received a final version of the paper, agree to its submission and take responsibility for it, and the submission has been approved as necessary by the authorities at the establishment where the research was carried out.

By granting this license, the author also warrants that he/she acts on behalf of, and with the knowledge of, all authors of the paper, that the paper does not infringe any third party rights, it contains nothing libelous, all factual statements are, to the best of the authors' knowledge, true or based on valid research conducted according to accepted norms, and all required permissions have been obtained.



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

The 2019 3rd International Conference on Engineering and Applied Technology (ICEAT)

30-31 October 2019, Sorong, Indonesia

The IOP Proceedings License Notice

Published under licence in **IOP Conference Series: Materials Science and Engineering** by IOP Publishing Ltd.



Content from this work may be used under the terms of the Creative Commons Attribution 3.0 license. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Editor : Dan Mugisidi, Ade Fah Alhashimy, Agus Setyo Munthohar, Rafał Dreżewski, Yun Arifatul Fatimah, Aster Rahayu, Agus Aktawan, Andri Pranolo, Leonel Hernandez, Lukas G. Swan, Pedro Hokama, Jazaul Ikhsan, Aris Widy Nugroho, Tri Widayatno, Ahmad Azhari, Adhi Prahara.

Publisher : IOP Publishing Ltd.

Secretariat : Fakultas Teknologi Industri
Universitas Ahmad Dahlan
Jl. Ringroad Selatan, Tamanan, Banguntapan, Bantul Regency,
Special Region of Yogyakarta 55191
Email: info2019@ast-ptm.or.id

The 2019 3rd International Conference on Engineering and Applied Technology (ICEAT)

30-31 October 2019, Sorong, Indonesia

Statement of Peer Review

All papers published in this volume of IOP Conference Series: Materials Science and Engineering has been peer reviewed through processes administered by the Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

PAPER • OPEN ACCESS

Peer review statement

To cite this article: 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 011006

View the [article online](#) for updates and enhancements.

You may also like

- [Peer review statement](#)
- [Peer review statement](#)
- [Peer review statement](#)

**The Electrochemical Society**
Advancing solid state & electrochemical science & technology

**Register now!**

241st ECS Meeting
Vancouver, BC, Canada. May 29 – June 2, 2022

**ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University**



Peer review statement

All papers published in this volume of *IOP Conference Series: Materials Science and Engineering* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.



PAPER • OPEN ACCESS

Sponsor

To cite this article: 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 011005

View the [article online](#) for updates and enhancements.

You may also like

- [Organizers and Sponsors Organized & Hosted by](#)
- [3rd International Congress on Ceramics \(ICC3\)](#)
Koichi Niihara, Tatsuki Ohji and Yoshio Sakka
- [Organizers and Sponsors](#)

**The Electrochemical Society**
Advancing solid state & electrochemical science & technology

**Register now!**

241st ECS Meeting
Vancouver, BC, Canada. May 29 – June 2, 2022

**ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University**



Organizers and Sponsors

Organized by

AST PTM (Applied Science and Technology of Muhammadiyah Higher Education),
Indonesia

Hosted by

Universitas Muhammadiyah Sorong, Indonesia

Technical Co-Sponsored by

IOPscience, IOP

Supported by

Majelis Pendidikan Tinggi Penelitian dan Pengembangan, PP Muhammadiyah, Indonesia
Universitas Ahmad Dahlan, Indonesia
Universitas Muhammadiyah Yogyakarta, Indonesia
Universitas Muhammadiyah Surakarta, Indonesia
Universitas Muhammadiyah Malang, Indonesia
Universitas Muhammadiyah Purwokerto, Indonesia
Universitas Muhammadiyah Magelang, Indonesia
Universitas Muhammadiyah Jakarta, Indonesia
Universitas Muhammadiyah Banjarmasin, Indonesia
Universitas Muhammadiyah Sidoarjo, Indonesia
Universitas Muhammadiyah Surabaya, Indonesia
Universitas Muhammadiyah Jember, Indonesia
Universitas Muhammadiyah Gresik, Indonesia
Universitas Muhammadiyah Prof. Dr. Hamka, Indonesia
Universitas Muhammadiyah Makassar, Indonesia





2019 3rd INTERNATIONAL CONFERENCE ON
ENGINEERING AND APPLIED TECHNOLOGY

Certificate

Certified that

Reni Umilasari
(Universitas Muhammadiyah Jember)

has presented a paper entitled
“Chromatic Number Local Irregularity of Vertex Shackle Product of Graphs”

in The 2019 3rd International Conference on Engineering and Applied Technology (ICEAT)
held on October 29th – October 30th, 2019 in Sorong, West Papua, Indonesia



Muhammad Taufiq Tamam, S.T., M.T.



Aster Rahayu, Ph.D.

Organized by :



AST PTM



UMSORONG

Supported by :



UAD



UMY



UMS



UMM



UMP



UMMAG



UMJ



UMBJM



UMSIDA



UMSBY



UMJEMBER



UMGRESIK



UMHAMKA



UMMAKASAR

NOTICE: Ukraine: Read IOP Publishing's statement.

Table of contents

Volume 821

2020

◀ Previous issue Next issue ▶

2019 3rd International Conference on Engineering and Applied Technology (ICEAT) 30 October - 1 November 2019, Sorong, Indonesia

Accepted papers received: 23 February 2020

Published online: 28 May 2020

Open all abstracts

Paper

OPEN ACCESS 011001

Preface

+ Open abstract  View article  PDF

OPEN ACCESS 011002

Lists of committees

+ Open abstract  View article  PDF

OPEN ACCESS 011003

Lists of Editors

+ Open abstract  View article  PDF

OPEN ACCESS 011004

Proceeding Copyright

+ Open abstract  View article  PDF

OPEN ACCESS 011005

Sponsor

+ Open abstract  View article  PDF

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS

011006

Peer review statement

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012001

Growth response of red chilli plants to flowering phase against the application of *Trichoderma* and *Pseudomonas fluorescens* and P fertilizers

Sutarman

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012002

Utilization of *trichoderma* sp. and *pseudomonas fluorescens* as biofertilizer in shade-resistant soybean

A Miftahurrohmat and Sutarman

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012003

Analysis of academic service cybersecurity in university based on framework COBIT 5 using CMMI

I Riadi, I T R Yanto and E Handoyo

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012004

Fuzzy feed forward neural network (FFNN) model for the Jakarta Islamic index (JII) forecasting

N Irsalinda, Y S Astuti and Sugiyarto

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012005

Transformation of function, form, zoning, circulation and material of Rumoh Aceh "Study of Aceh traditional architecture in Montasik sub-district, Aceh Besar"

F Azzahra and Sahriyadi

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012006

Spatial behavior pattern of visitors in City Park Case study: Flora and Bungkul Park, Indonesia

V Dharmawan and N Rachmaniyah

This site uses cookies. By continuing to use this site, you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS

012007

The effect of adhesive type and speed pan granulator on the properties of urea slow release fertilizer

R B Pamungkas, B Jos, M Djaeni and N S Afridha

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012008

Preparation of suppressor column for capillary ion chromatography with conductivity detection

A Rahayu, J A Fajri, L W Lim and T Takeuchi

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012009

Optimization condition of fluoride adsorption using activated clay

Z Mustakim, F Y Purwaningtyas, E B Leksono, Sarto and A Prasetya

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012010

Biomass Gasification of Sengon Sawdust to Produce Gas Fuel

Maryudi, A Aktawan, Sunardi, K Indarsi and E S Handayani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012011

Biodiesel from microalgae *Nannochloropsis oculata* and *Tetraselmis chuii* by sonication technique and K_2CO_3 catalyst

H Purnama, Harland and N Hidayati

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012012

Financial feasibility study of batching plant investment on Sigli -Banda Aceh highway construction project

H A Rani, R S Bonenehu and M H Mubarak

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012013

The insulation properties of foam concrete with the use of foam-agent and fly-ash

E Rommel, L Prasetyo1, Y Rusdianto, R Karimah, A.S. Riyanto and S.A. N Cahyo

[+ Open abstract](#) [View article](#) [PDF](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS

012014

Steel column planning using the *American Institute of Steel Construction (AISC) 2010* method

Wahyuni, K C S Zein and Muchlis

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012015

Effect of coconut-shell ash as filler and plastic bottle as substitution of porous asphalt mixture

T Syammaun, Meillyta and R Yati

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012016

Design mixed formula of hot mix asphalt mixture very thin overlay using crumb rubber

S Sunarjono, P A Wijaya, N Hidayati and A Magfirona

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012017

Laterite Soil Behavior - Geotextile (Study of Laterite Soil, Tanah Laut District)

I Setiawan, I Muzaidi and M Fitriansyah

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012018

Laboratory study: durability characteristics of Asphalt concrete binder course utilizing Bantak and Clereng as aggregate and Asbuton Lawele as fine aggregate (using Marshall Methods)

E Ruhaidani, D P Hardiani, E Anggarini and Y Perdana

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012019

Mechanical properties of self-compacting concrete incorporated with high volume fly ash

M Solikin and T Mulyanto

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012020

Feasibility test on the performance of LoRa technology incorporated in the wireless sensor network

R P Astutik and H A Winarno

[+ Open abstract](#)[View article](#)[PDF](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS

012021

Water content analysis effect on dielectric breakdown voltage in 500 kv transformer oil using coefficient correlation method

M A Auliq and A B Nugroho

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012022

The first proposed of fiber to the home (FTTH) protection unit for clients scattered placement

H Ramza, S A C Aziz, Z N, Mastang and M S Ab-Rahman

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012023

Identification parameter system for mathematical modeling BLDC motor using transfer function models

I Anshory, I Robandi and Wirawan

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012024

Identification of earthquake types based on seismogram data

D N K Hardani, D A Megapiengga and M T Tamam

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012025

Harmonisa in defibrillator equipment (DC Shock)using simulink Matlab

P Harahap and B Oktrialdi

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012026

River water level forecasting for flood warning system using deep learning long short-term memory network

A Faruq, S S Abdullah, A Marto, M A A Bakar, Samin and A Mubin

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012027

Stator slotted design of axial flux permanent magnet generator for low-speed turbine

M Irfan, R F Ariyanto, L Syafaah, A Faruq, Nurhadi and N Subeki

[+ Open abstract](#) [View article](#) [PDF](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS

012028

Immunostimulating effect of sweet potato fiber extract on IgM production by HB4C5 cells

I D Kumalasari, T Sugahara and K Nishi

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012029

The comparison of ergonomic risk assessment results using job strain index and OCRA methods

D P Restuputri, I Masudin and A R C Putri

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012030

Predictions of new students interest in entering the XXX University with statistic modeling

E D Priyana

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012031

Green productivity application for improving productivity and environmental performance through the selection of the best solution scenario in the agroindustry

A Mubin

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012032

Computational thinking digital media to improve digital literacy

I Yuliana, L P Octavia and E Sudarmilah

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012033

IT balanced scorecard (IT BSC) based strategic framework for assessing the impacts of Business Strategic-IT alignment

S Balafif and T Haryanti

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012034

Attribute analysis with classification algorithm on election participation

A S Fitrani, M A Rosid, F Muharram and F L Kodriyah

[+ Open abstract](#)[View article](#)[PDF](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.

OPEN ACCESS

012035



Application of fuzzy preference relations method in AHP to improve judgment matrix consistency

M Hamka and Harjono

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012036

Classification of EEG signals uses the coefficient of wavelet transform and K-nearest neighbor

H Hindarto, A Muntasa and A Efiyanti

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012037

Fire spread simulation using cellular automata in forest fire

H D Bhakti, H Ibrahim, F Fristella and M Faisal

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012038

Local irregularity chromatic number of vertex shackle product of graphs

R Umilasari, L Susilowati and Slamini

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012039

Consumable Fish Classification Using k-Nearest Neighbor

S Winiarti, F I Indikawati, A Oktaviana and H Yuliansyah

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012040

The insertion of confidential information into digital images using blowfish cryptography and end of file steganography

E Aribowo and A Suryadi

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012041

Data security improvements on cloud computing using cryptography and steganography

N R D P Astuti, E Aribowo and E Saputra

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012042

Correlation of risk factors for coronary heart disease in type 2 diabetes mellitus using the chi-square method

This releases cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



L Syafaah, D Arisnanda, M Irfan and R H Hendaryati

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012043

Application of genetic algorithm concept on course scheduling

R Ansari and N Saubari

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012044

First time user experience of academic information system: An evaluation of usability

A Setiawan and A Primadewi

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012045

Redesign and modification of torque measurement instrument for centrifugal pump

E Widodo, F Nurwenda, A Akbar, Mulyadi, N Fediyanto and A Fahrudin

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012046

Energy analysis desalination of single slope solar still

M A Siregar and W S Damanik

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012047

Simulation of air flow loss in triangle pipe construction

S Lubis, C A Siregar and F Abdilah

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012048

Engineering of motorcycle exhaust gases to reduce air pollution

A M Siregar, C A Siregar and M Yani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012049

Implementation and design gas leakage detection system using ATmega8 microcontroller

N Evalina and H A Azis

[+ Open abstract](#) [View article](#) [PDF](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS

012050

Design of control system expand valve on water heating process air jacket

F I Pasaribu and I Roza

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012051

Workability of coconut fiber concrete with rice husk ash as a sand replacement

F V Riza, D Karnelia and J Hadipramana

[+ Open abstract](#)[View article](#)[PDF](#)**JOURNAL LINKS**[Journal home](#)[Journal scope](#)[Information for organizers](#)[Information for authors](#)[Contact us](#)[Reprint services from Curran Associates](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.




PAPER • OPEN ACCESS

Local irregularity chromatic number of vertex shackle product of graphs

To cite this article: R Umilasari *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 012038

View the [article online](#) for updates and enhancements.



EXTENDED ABSTRACT DEADLINE: DECEMBER 18, 2020

239th ECS Meeting
with the 18th International Meeting on Chemical Sensors (IMCS)

May 30-June 3, 2021

SUBMIT NOW →

The banner features a blue and red color scheme with a background of network icons and a stylized 'ECS' logo. A small '18th' logo is also present on the right side.

Local irregularity chromatic number of vertex shackle product of graphs

R Umilasari^{1,*}, L Susilowati² and Slamin³

¹ Department of Informatics Engineering, Universitas Muhammadiyah Jember, Jember, Indonesia

² Department of Mathematics, Faculty of Sciences and Technology, Universitas Airlangga, Surabaya, Indonesia

³ Department of Informatics, Faculty of Computer Science, Universitas Jember, Jember, Indonesia

*Email: reni.umilasari@unmuhjember.ac.id

Abstract. Local irregular vertex labeling is one of graph labeling type that can be used as a tool for graph coloring. A mapping l is called local irregular vertex labeling if there are: (i) a mapping $l: V(G) \rightarrow \{1, 2, \dots, k\}$ as vertex irregular k -labeling and a weight $w: V(G) \rightarrow N$, for every $uv \in E(G)$, $w(u) \neq w(v)$ where $w(v) = \sum_{\{u \in N(v)\}} l(u)$; and (ii) $opt(l) = \min\{\max\{l_i\}\}$. Thus, the labeling l induces a proper vertex coloring of G where the vertex v is assigned the color $w(v)$. The local irregular chromatic number of G , denoted by $\chi_{lis}(G)$ is the minimum cardinality of the largest label over all such local irregular vertex labeling. In this paper, we determine the local irregular chromatic number of a vertex shackle product of graphs. The vertex shackle products of graphs, denoted by $Shack(G, v, k)$, is the graph constructed from k copies of connected graph G and v as the linkage vertex.

1. Introduction

A graph labeling is an assignment of integers to the vertices or edges, or both that first introduced in 1964. That is why labelling is one of interest topic in graph theory because until now there are some kinds of graph labelling. Let G be a simple connected graph, finite and undirected graph with vertex set V and edge set E . A labeling in G is a mapping from the set of elements in a graph (vertices, edges, or both) to a set of numbers (usually positive integers) [1]. There are many types of labelings that have been studied such as magic and anti-magic labelling, distance irregular labelling, and many others [2].

A vertex coloring is an assignment of labels or colors to each vertex of a graph such that no edge connects by two identically colored vertices. The most common type of vertex coloring seeks to minimize the number of colors for a given graph. A vertex coloring also called as the chromatic number of a graph, it is the minimum number of colors needed to produce a proper coloring of a graph [3]. In formal definition, the chromatic number denoted by $\chi(G)$ is the smallest positive integer k such that G is vertex k -colorable (and thus G has k -coloring) [4]. One of topic advance of chromatic number is chromatic number local irregular which be introduced by Kristiana *et al.* [5] and written as $\chi_{lis}(G)$. If $G = (V, E)$ be a connected grap, then local irregularity vertex coloring of G is $l: V(G) \rightarrow \{1, 2, \dots, k\}$ and $w: V(G) \rightarrow N$ where $w(u) = \sum_{\{v \in N(u)\}} l(v)$ such that $opt(l) = \min\{\max\{l_i\}\}$ and for every $uv \in E(G)$, $w(u) \neq w(v)$. The result that have been found before about chromatic number



local irregular are chromatic number local irregular of path, cycle, complete, bipartite, star, friendship, and corona product graphs [6]. Figure 1 shows a graph with local chromatic number $\chi_{lis}(G) = 3$.

A shackle product graph is divided into two type. That is vertex shackle and edge shackle product graphs. Both of them are formed from k copies of graph G . A vertex shackle product of graph, denoted by $Shack(G, v, k)$ is the graph constructed from k copies of connected graph G and v as the linkage vertex. Whereas edge shackle products graphs is denoted by $Shack(G, e, k)$ means that the graph is constructed from any G graph of k copies and e as the linkage edge [7]. In this paper we show the local irregular chromatic number of vertex shackle products of graphs. There are some definitions and prepositions that are used in this paper as presented below:

Definition 1. [1] l is called local irregularity vertex coloring if there is a function $l: V(G) \rightarrow \{1, 2, \dots, k\}$ as vertex irregular k -labeling, $w: V(G) \rightarrow N$ where $w(u) = \sum_{v \in N(u)} l(v)$ and

- i. $opt(l) = \min\{\max\{l_i\}; l_i, \text{vertex irregular labeling}\}$
- ii. For every $uv \in E(G)$, $w(u) \neq w(v)$.

Definition 2. [1] The minimum cardinality of local irregularity vertex labeling of G is called local irregular chromatic number, written by $\chi_{lis}(G)$.

Proposition 1. [1] $opt(l_i) = 1$ if each pair of two adjacent vertices in G have different degrees.

Proposition 2. [1] $opt(l_i) \geq 2$ if two adjacent vertices in G have the same degree.

Lemma 1. [1] For every G be simple and connected graph, $\chi_{lis}(G) \geq \chi(G)$

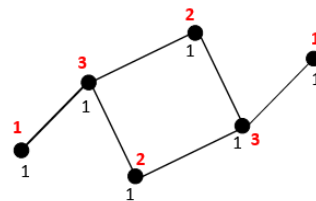


Figure 1. Graph G with $\chi_{lis}(G) = 3$

2. Result

We begin this section with some observations regarding to the chromatic number and local irregularity chromatic number of vertex shackle product of graphs such as path, cycle, star, complete and wheel graph.

Observation 1. The chromatic number of vertex shackle products of path

$$\chi_{lis}(Shack(P_n, v, m)) = \chi_{lis}(P_n)$$

This is due to the definition of vertex shackle graphs that the vertex shackle of k paths with n vertices is also a path with kn vertices. Furthermore, Kristiana *et al.* [1] showed that

$$\chi_{lis}(Shack(P_n, v, m)) = \chi_{lis}(P_n) = \begin{cases} 2, & \text{for } m \times n = 2, 3 \\ 3 & \text{for } m \times n \geq 4, 5, \dots \end{cases}$$

Observation 2. If $Shack(C_n, v, m)$ is the vertex shackle of m cycles C_n for $m \geq 2$ and $n \geq 3$ then

$$\chi(Shack(C_n, v, m)) = \begin{cases} 2, & \text{for } n \text{ even} \\ 3, & \text{for } n \text{ odd} \end{cases}$$

Observation 3. If $Shack(S_n, v, m)$ is the vertex shackle of m stars S_n for $m \geq 2$ and $n \geq 3$, then $\chi(Shack(S_n, v, m)) = 2$

Observation 4. If $Shack(K_n, v, m)$ is the vertex shackle of m complete graphs K_n for $m \geq 2$ and $n \geq 3$, then $\chi(Shack(K_n, v, m)) = n$.

Observation 5. If $Shack(W_n, v, m)$ is the vertex shackle of m wheel W_n for $m \geq 2$ and $n \geq 3$ then

$$\chi(Shack(W_n, v, m)) = \begin{cases} 3, & \text{for } n \text{ even} \\ 4, & \text{for } n \text{ odd} \end{cases}$$

We now ready to determine the local irregularity chromatic number of vertex shackle of m cycles as presented in the following theorem.

Theorem 1. If $Shack(C_n, v, m)$ is the vertex shackle of m cycles C_n for $m \geq 2$ and $n \geq 3$ then

$$\chi_{lis}(Shack(C_n, v, m)) = \begin{cases} 3, & \text{for } n \text{ even} \\ 4, & \text{for } n \text{ odd} \end{cases}$$

Proof. Let C_n be a cycle on $n \geq 3$ vertices and $Shack(C_n, v, m)$ be the vertex shackle of m cycles C_n for $m \geq 2$. Then the vertex set of $Shack(C_n, v, m)$ is $V(Shack(C_n, v, m)) = \{a_{i,j}, 1 \leq i \leq n-1, 1 \leq j \leq m, a_{n,m}\}$ and the edge set of $Shack(C_n, v, m)$ is $E(Shack(C_n, v, m)) = \{a_{i,j}a_{i+1,j}, 1 \leq i \leq n-1, 1 \leq j \leq m\} \cup \{a_{n-1,m}a_{n,m}\}$.

By **Proposition 2** we have $opt(l_i(Shack(C_n, v, m))) = 2$. To show the proof we can divide it into two cases below.

Case 1: for n even.

The vertex shackle of cycles $Shack(C_n, v, m)$ has chromatic number $\chi(Shack(C_n, v, m)) = 2$ for n even and $\chi(Shack(C_n, v, m)) = 3$ for n odd. Based on **Lemma 1** the lower bound is $\chi_{lis}(Shack(C_n, v, m)) = 3 \geq \chi(Shack(C_n, v, m)) = 2$. The upper bound shall be proved by defining $l: V(Shack(C_n, v, m)) \rightarrow \{1, 2\}$ using the following formula.

$$l(a_{i,j}) = \begin{cases} 1, & \text{for } 1 \leq i \leq n-1, i \text{ odd} \\ 2, & \text{for } 2 \leq i \leq n-2, i \text{ even} \end{cases}$$

$$l(a_{n,m}) = 1$$

Therefore, $opt(l) = 2$ and the labeling gives vertex-weight as follows:

$$w(a_{i,j}) = \begin{cases} 2, & \text{for } 2 \leq i \leq n-2, i \text{ even} \\ 4, & \text{for } 1 \leq i \leq n-1, i \text{ odd} \\ 8, & \text{for } i = 1 \text{ linkage vertex}, j = 2, 3, \dots \end{cases}$$

$$w(a_{n,m}) = 2$$

We conclude that $|w(V(Shack(C_n, v, m)))| = 3$. Based on **Definition 1** the upper bound is $\chi_{lis}(Shack(C_n, v, m)) \leq 3$. Hence, $\chi_{lis}(Shack(C_n, v, m)) = 3$ for n even.

Case 1: for n odd.

Based on **Lemma 1** the lower bound is $\chi_{lis}(Shack(C_n, v, m)) = 4 \geq \chi(Shack(C_n, v, m)) = 3$ for n odd. The upper bound shall be proved by defining $l: V(Shack(C_n, v, m)) \rightarrow \{1, 2\}$ using some formula below.

$$l(a_{i,j}) = \begin{cases} 1, & \text{for } 1 \leq i \leq n-2, i \text{ odd} \\ 2, & \text{for } 2 \leq i \leq n-1, i \text{ even} \end{cases}$$

$$l(a_{n,m}) = 1$$

Therefore, $opt(l) = 2$ and the labeling gives vertex-weight as follows:

$$w(a_{i,j}) = \begin{cases} 2, & \text{for } 2 \leq i \leq n-3, i \text{ even} \\ 4, & \text{for } 1 \leq i \leq n-2, i \text{ odd} \\ 3, & \text{for } i = n-1, 1 \leq j \leq m \\ 6, & \text{for } i = 1 \text{ linkage vertex}, j = 2, 3, \dots \end{cases}$$

$$w(a_{n,m}) = 3$$

Therefore $|w(V(Shack(C_n, v, m)))| = 4$. Based on **Definition 1**, the upper bound is $\chi_{lis}(Shack(C_n, v, m)) \leq 4$. Hence, $\chi_{lis}(Shack(C_n, v, m)) = 4$ for n odd. This case completes the proof. \square

The following theorem presents the local irregularity chromatic number of vertex shackle of m stars for $m \geq 2$.

Theorem 2. If $Shack(S_n, v, m)$ is the vertex shackle of m star S_n for $m \geq 2$ and $n \geq 3$ then $\chi_{lis}(Shack(S_n, v, m)) = 3$

Proof. Let S_n be a star on $n \geq 3$ vertices and $Shack(S_n, v, m)$ be the vertex shackle of m stars S_n for $m \geq 2$. Then the vertex set of $Shack(S_n, v, m)$ is $V(Shack(S_n, v, m)) = \{a_{i,j}, b_j; 1 \leq i \leq n-1, 1 \leq j \leq m\} \cup \{a_{n,m}\}$ and the edge set of $Shack(S_n, v, m)$ is $E(Shack(S_n, v, m)) = \{a_{i,j}b_j; 1 \leq i \leq n-1, 1 \leq j \leq m\} \cup \{a_{n,m}b_m\}$. Based on **Observation 3**, vertex shackle of stars $Shack(S_n, v, m)$ has $\chi(Shack(S_n, v, m)) = 2$ and by **Lemma 1**, the lower bound is $\chi_{lis}(Shack(S_n, v, m)) = 2 \geq \chi(Shack(S_n, v, m)) = 2$. However, the lower bound cannot be reached. The upper bound shall be proved by defining $l: V(Shack(S_n, v, m)) \rightarrow \{1\}$. By using **Proposition 1**, we know that $opt(l_i)(Shack(S_n, v, m)) = 1$ and the labeling gives vertex-weight as follows:

$$\begin{aligned} w(a_{i,j}) &= 1, \text{ for } 1 \leq i \leq n-1, 1 \leq j \leq m \\ w(a_{i,j}) &= 2, \text{ for } i = n, 1 \leq j \leq m-1, a_{i,j} \text{ is linkage vertex} \\ w(a_{n,m}) &= 1 \\ w(b_j) &= n \end{aligned}$$

Therefore $|w(V(Shack(S_n, v, m)))| = 3$. By **Definition 1** the upper bound is $\chi_{lis}(Shack(S_n, v, m)) \leq 3$. Then it proven that $\chi_{lis}(Shack(S_n, v, m)) = 3$. \square

The local irregularity chromatic number of vertex shackle of m complete graphs for $m \geq 2$ is presented in the following theorem.

Theorem 3. If $Shack(K_n, v, m)$ is the vertex shackle of m complete graphs K_n , for $m \geq 2$ and $n \geq 3$, then $\chi_{lis}(Shack(K_n, v, m)) = n$.

Proof. Let K_n be a complete graph on $n \geq 3$ vertices and $Shack(K_n, v, m)$ be the vertex shackle of m complete graphs K_n for $m \geq 2$. Then the vertex set of $Shack(K_n, v, m)$ is $V(Shack(K_n, v, m)) = \{a_{i,j}; 1 \leq i \leq n-1, 1 \leq j \leq m\} \cup \{a_{n,m}\}$ and the edge set of $Shack(K_n, v, m)$ is $E(Shack(K_n, v, m)) = \{a_{i,j}a_{i,j}; 1 \leq i \leq n-1, 1 \leq j \leq m\} \cup \{a_{i,j}a_{n,m}\}$.

The vertex shackle of m complete graphs $Shack(K_n, v, m)$ has $\chi(Shack(K_n, v, m)) = n$ as **Observation 4**. Based on **Lemma 1**, the lower bound is $\chi_{lis}(Shack(K_n, v, m)) = n \geq \chi(Shack(K_n, v, m)) = n$. The lower bound cannot be reached. The upper bound will be proved by defining $l: V(Shack(K_n, v, j)) \rightarrow \{1, 2, 3, \dots, n; 1 \leq j \leq m\}$. By **Proposition 1**, we can conclude that $opt(l_i)(Shack(K_n, v, m)) = n$ and the labeling gives vertex-weight as much as n different vertex weight. Therefore $|w(V(Shack(K_n, v, m)))| = n$. By **Definition 1**, the upper bound is $\chi_{lis}(Shack(K_n, v, m)) \leq n$. Hence, $\chi_{lis}(Shack(K_n, v, m)) = n$. \square

Finally, we close this section with the local irregularity chromatic number of vertex shackle of m wheels for $m \geq 2$ as shown below.

Theorem 4. If $Shack(W_n, v, m)$ is the vertex shackle of m wheels for $m \geq 2$ and $n \geq 3$, then

$$\chi_{lis}(Shack(W_n, v, m)) = \begin{cases} 4, & \text{for } n \text{ even} \\ 5, & \text{for } n \text{ odd} \end{cases}$$

Proof. Let W_n be a wheel on $n \geq 3$ rim vertices and $Shack(W_n, v, m)$ be the vertex shackle of m wheels W_n for $m \geq 2$. Then the vertex set of $Shack(W_n, v, m)$ is $V(Shack(W_n, v, m)) = \{a_{i,j}, b_j, a_{n,m}, 1 \leq i \leq n-1, 1 \leq j \leq m\}$ and the edge set of $Shack(W_n, v, m)$ is $E(Shack(W_n, v, m)) = \{a_{i,j}a_{i+1,j}, a_{i,j}b_j, 1 \leq i \leq n-1, 1 \leq j \leq m\} \cup \{a_{n-1,m}a_{n,m}\} \cup \{b_m a_{n,m}\}$. By **Proposition 2**, we have $opt(l_i)(Shack(W_n, v, m)) = 2$. We divide the proof into two cases below.

Case 1: for n even.

The vertex shackle of wheels $Shack(W_n, v, m)$ has chromatic number $\chi(Shack(W_n, v, m)) = 3$ for n even and $\chi(Shack(W_n, v, m)) = 4$ for n odd. Based on **Lemma 1**, the lower bound is $\chi_{lis}(Shack(W_n, v, m)) = 4 \geq \chi(Shack(W_n, v, m)) = 3$. The upper bound will be proved by defining $l: V(Shack(W_n, v, m)) \rightarrow \{1, 2\}$ using the following formula.

$$\begin{aligned} l(a_{i,j}) &= \begin{cases} 1, & \text{for } 1 \leq i \leq n-1, i \text{ odd}, 1 \leq j \leq m \\ 2, & \text{for } 2 \leq i \leq n-2, i \text{ even}, 1 \leq j \leq m \end{cases} \\ l(a_{n,m}) &= 1 \\ l(b_j) &= 1, \text{ for } 1 \leq j \leq m \end{aligned}$$

Therefore, $opt(l) = 2$ and the labeling gives vertex-weight as follows:

$$\begin{aligned} w(a_{i,j}) &= \begin{cases} 3, & \text{for } 2 \leq i \leq n, i \text{ even}, 1 \leq j \leq m \\ 5, & \text{for } 1 \leq i \leq n-1, i \text{ odd}, 1 \leq j \leq m \\ 10, & \text{for } i = 1 \text{ linkage vertex}, j = 2, 3, \dots \end{cases} \\ w(b_j) &= \frac{n}{2}(1+2), 1 \leq j \leq m \end{aligned}$$

We conclude that $|w(V(Shack(W_n, v, m)))| = 4$. By **Definition 1**, the upper bound is $\chi_{lis}(Shack(W_n, v, m)) \leq 4$. It means $\chi_{lis}(Shack(W_n, v, m)) = 4$ for n even.

Case 2: for n odd.

Based on **Lemma 1** the lower bound is $\chi_{lis}(Shack(W_n, v, m)) = 5 \geq \chi(Shack(W_n, v, m)) = 4$ for n odd. Then the upper bound will be proved by defining $l: V(Shack(W_n, v, m)) \rightarrow \{1, 2\}$ using the following formula.

$$\begin{aligned}
l(a_{i,j}) &= \begin{cases} 1, & \text{for } 1 \leq i \leq n-2, i \text{ odd}, 1 \leq j \leq m \\ 2, & \text{for } 2 \leq i \leq n-1, i \text{ even}, 1 \leq j \leq m \end{cases} \\
l(a_{n,m}) &= 1 \\
l(b_j) &= 1, \text{ for } 1 \leq j \leq m
\end{aligned}$$

Therefore, $\text{opt}(l) = 2$ and the labeling gives vertex-weight as follows:

$$\begin{aligned}
w(a_{i,j}) &= \begin{cases} 2, & \text{for } 2 \leq i \leq n-1, i \text{ even}, 1 \leq j \leq m \\ 4, & \text{for } 1 \leq i \leq n-2, i \text{ odd}, 1 \leq j \leq m \\ 3, & \text{for } i = n, i \text{ odd}, 1 \leq j \leq m \\ 10, & \text{for } i = 1 \text{ linkage vertex}, j = 2, 3, \dots \end{cases} \\
w(b_j) &= \frac{n-1}{2} (1+2) + 12, \text{ for } 1 \leq i \leq n-1, 1 \leq j \leq m
\end{aligned}$$

We also can conclude that $|w(V(\text{Shack}(W_n, v, m)))| = 5$. By **Definition 1**, the upper bound is $\chi_{lis}(\text{Shack}(W_n, v, m)) \leq 5$ prove that $\chi_{lis}(\text{Shack}(W_n, v, m)) = 5$ for n odd. Therefore, this case completes the proof. Figure 2 shows the example of local irregular chromatic number of the vertex shackle product of W_4 .

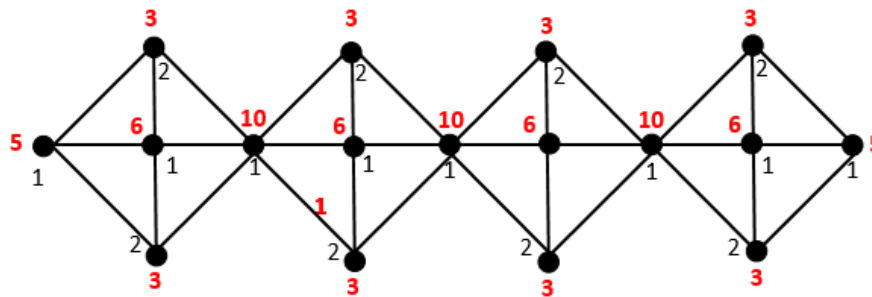


Figure 2. Graph G with $\chi_{lis}(\text{Shack}(W_4, v, 4)) = 4$

3. Conclusion

We conclude this paper with an open problem regarding to the local irregular chromatic number of the vertex shackle product of graphs as follows. **Problem 1.** For any connected graph G with n vertices, find the local irregular chromatic number of vertex shackle and edge shackle product of k copies of graph G.

Acknowledgments

We gratefully acknowledge the support from Universitas Muhammadiyah Jember and DRPM Kemristekdikti through World Class Research grant year 2019.

References

- [1] Slamin 2017 On distance irregular labeling of graphs *Far East Journal Mathematical Sciences* **102**:05 pp 919-32.
- [2] Gallian J A 2016 A dynamic survey of graph labelling *Electron J. Combin.* #DS6.
- [3] Amurugam S, Premalatha K, and Martin B 2017 Local anti-magic vertex coloring of a graph *Graphs and Combinatorics* **33** pp 275-85.
- [4] Chartrand G and Lesniak L 2000 *Graph and Digraph Third Edition* Chapman & Hall/First CRC Press Reprint (Florida) p 220.
- [5] Kristiana A I, Utoyo M I, Dafik, Slamin, Alfarisi R, and Agustin I H 2019 Local irregularity vertex coloring of graph *International Journal of Civil Engineering and Technology* **10**:4 pp 451-61.

- [6] A.I. Kristiana, M.I. Utoyo, Dafik, R. Alfarisi, I.H. Agustin and E. Waluyo 2019 On the chromatic number local irregularity of related wheel graph *Journal of Physics: Conf. Series* **1211** (2019) 012003.
- [7] Inayah N, Simanjuntak R, Salman A N M, and Syuhada K I A 2013 Super (a,d) -H Antimagic Total Labellings for Shackle of a Connected Graph H *Australasian Journal of Combinatorics* vol **57** pp 127-28.