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**ITS**  
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Teknologi  
Sepuluh Nopember

# JWGEA 2024

**22-26 July 2024**  
**KMUTT, Bangkok**

## **Proceedings Book**

**2024 Joint Workshop for Global  
Engineers in Asia**

# JWGEA 2024

## Joint Workshop for Global Engineers in Asia

King Mongkut's University of Technology Thonburi  
Bangkok, 22 - 26 July 2024

### MESSAGE FROM THE CHAIRMAN

Joint Workshop for Global Engineer in Asia (JWGEA) is a collaboration among four universities from four different countries in order to promote research and student's international network. The four members are King Mongkut's University of Technology Thonburi (KMUTT) Thailand, Institut Teknologi Sepuluh Nopember (ITS) Indonesia, Ritsumeikan University (RU) Japan, and Universiti Teknologi Malaysia (UTM). Since 2015, the workshop has been organized every year and each partner takes turns serving as a host. This year, 2024, King Mongkut's University of Technology Thonburi is very proud to serve as the host and welcome all of the members to the beautiful Bang Mod campus in Bangkok. This year, we prepare many cultural activities such as Khon (Thai dance drama) and take participants to Wat Pho (Thai temple regarding as the first university) We would like to thank Prof. Asai Shizuyo, Prof. Maria Anityasari, Prof. Chew Tin Lee as the key founder and continuing support of this workshop. Also, We are so very grateful to help the internationalized team from each university: Dr. Ain Naadia Binti Mazlan, Prof. Norahim bin Ibrahim, Prof. Niza Sarmin, Ms. Nastiti Primadyastuti, Dr. Astria Nur Irfansyah, etc. Also, KMUTT international affair staffs and faculty, Prof. Chawin Chantarasenawong, Ms. Sasima Juwasophi and many more.

Best Wishes,

*Poj Tangamchit*

Assoc.Prof.Dr.Poj Tangamchit  
(JWGEA 2024 Chairman)



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Bangkok, 22 - 26 July 2024

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## JOINT WORKSHOP FOR GLOBAL ENGINEER IN 2024 PROGRAM GUIDELINES

### INTRODUCTION

The 2024 Joint Workshop for Global Engineers in Asia or JWGEA 2024 is hosted by King Mongkut's University of Technology Thonburi (KMUTT) Thailand in collaboration with Institut Teknologi Sepuluh Nopember (ITS) Indonesia, Ritsumeikan University (RU) Japan, and Universiti Teknologi Malaysia (UTM), Malaysia to provide an opportunity for students to exchange their research views with international partners. The workshop is aimed to create an international environment for participants to build their network of research and, at the same time, facilitate cultural exchange among them.

### ACTIVITIES

- Parallel research presentation
- Cultural Activities
- Student Brainstorming
- Student Debate
- Bangkok Sightseeing

### CONTACT

[jwgea2024@gmail.com](mailto:jwgea2024@gmail.com)

# JWGEA 2024

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### JOINT WORKSHOP FOR GLOBAL ENGINEER IN 2024 PROGRAM GUIDELINES

#### City tour guide: Wat pho

\*\* Important dress code:

Shoulders must be covered: it is important to have your shoulders covered when entering a temple. Avoid wearing tank tops, strapless shirts, or any other type of top that exposes your shoulders.

Legs should be covered down to your knees: When it comes to your lower body, it is crucial to have your legs covered down to at least your knees. Shorts, short skirts, or dresses that fall above the knee are not suitable for temple visits.

Avoid overly revealing clothing: This means no low-cut tops, sheer fabrics, or clothing that hugs your body. Remember, modesty is key when visiting temples in Thailand.

Wearing shoes or sandals that can easily be slipped on or off when visiting temples in Thailand. Most Thai temples will require you to take off your shoes, so wearing shoes that can be effortlessly slipped off makes the process much more convenient.

Wat Pho is a Buddhist temple complex in the Phra Nakhon District, Bangkok, Thailand. It is on Rattanakosin Island, directly south of the Grand Palace. Known also as the Temple of the Reclining Buddha, its official name is Wat Phra Chetuphon Wimon Mangkhalaram Rajwaramahawihan. The temple is first on the list of six temples in Thailand classed as the highest grade of the first-class royal temples. It is associated with King Rama I who rebuilt the temple complex on an earlier temple site. It became his main temple and is where some of his ashes are enshrined. The temple was later expanded and extensively renovated by Rama III. The temple complex houses the largest collection of Buddha images in Thailand, including a 46 m long huge reclining Buddha. The temple is considered the earliest centre for public education in Thailand, and the illustrations and inscriptions placed in the temple for public instructions has been recognised by UNESCO in its Memory of the World Programme. It houses a school of Thai medicine, and is also known as the birthplace of traditional Thai massage which is still taught and practiced at the temple.

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### TENTATIVE AGENDA

#### joint Workshop for Global Engineers in Asia (JWGEA) 2024

Sunday, 21 July 2024

Time	Agenda
All-day	Airport pickup – Check in at Heliconia house KMUTT

# JWGEA 2024

## Joint Workshop for Global Engineers in Asia

King Mongkut's University of Technology Thonburi  
Bangkok, 22 - 26 July 2024

### TENTATIVE AGENDA

#### joint Workshop for Global Engineers in Asia (JWGEA) 2024

Monday, 22 July 2024

Time	Agenda
09.00 - 09.30	Vspace LX building 14th floor <ul style="list-style-type: none"><li>• Opening Ceremony</li><li>• KMUTT Introduction</li><li>• Welcome speech by vice president of internationalization Assoc.Prof.Dr. Chawin Chantharasenawong</li><li>• Group Photo</li></ul>
09.30 - 10.20	Introduction of each university (15 mins each) <ul style="list-style-type: none"><li>• Ritsumeikan University: Prof. Ito Takamoto</li><li>• Universiti Teknologi Malaysia: Prof. Norahim Ibrahim</li><li>• Institut Teknologi Sepuluh Nopember: Prof. Astria Nur Irfansyah</li><li>• Student grouping</li></ul>
10.20 - 10.30	Break
10.30 - 12.30	Ice breaking activity
12.30 - 13.30	Lunch break
13.30 - 15.00	Cultural Activity 1: by International Affair
15.00 - 15.15	Break
15.20 - 16.30	Cultural Activity 2: by International Affair
-	Dinner on your own

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### TENTATIVE AGENDA

#### joint Workshop for Global Engineers in Asia (JWGEA) 2024

Tuesday, 23 July 2024

Time	Agenda
09.00 - 10.30	Parallel session 1
10.30 - 10.40	Break
10.40 - 12.00	Parallel session 2
12.00 - 13.00	Lunch break
13.00 - 14.50	Activity 1: Student Brainstorming (Will AI dominate the world?)
14.50 - 15.00	Break
15.00 - 17.30	Seminar on sustainable mobility and transport (Theme: battery & hydrogen utilization)
-	Dinner on your own



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### TENTATIVE AGENDA

#### joint Workshop for Global Engineers in Asia (JWGEA) 2024

Wednesday, 24 July 2024

Time	Agenda
09.00 - 10.30	Parallel session 3
10.30 - 10.45	Break
10.45 - 12.30	Parallel session 4
12.30 - 13.30	Lunch break
13.30 - 15.00	Activity 2: Student Debating
15.00 - 15.15	Break
15.20 - 16.30	Closing Ceremony
16.30 - 17.00	Photo Session
17.00 - ...	Dinner Party

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### TENTATIVE AGENDA

#### joint Workshop for Global Engineers in Asia (JWGEA) 2024

Thursday, 25 July 2024

Time	Agenda
All-day	City Tour <ul style="list-style-type: none"><li>Morning - Wat Pho (Buddhist temple)</li></ul> <u>City tour Wat Pho</u> <ul style="list-style-type: none"><li>Afternoon - Free Style (come back to KMUTT by yourself)</li></ul>

Friday, 26 July 2024

Time	Agenda
-	Check out - Airport drop off

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### PARALLEL RESEARCH PRESENTATION & FEEDBACK SCHEDULE AND GROUPING

#### Rules for Presentation

1 The time allocation for each student presenter is 15 minutes including:

- 12 minutes presentation
- 3 minutes feedback

Student presenter is encouraged to give feedback to the other.

2 Each reviewer is required to give feedback to each student presenter.

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**DAY 1 (23 JULY 2024)**

**SESSION 1 (09:00 -10:30GMT + 7:00) - ROOM 1 (CB2402)**

### Presenter

- S1-R1-1  
MUHAMMAD FARIS AIMAN BIN MOHD YAINI  
UNIVERSITI TEKNOLOGI MALAYSIA  
NUTRITIONAL EVALUATION OF FERMENTED SOYBEAN WASTE AS ADDITIVE SOURCE AND ITS IMPACT ON CHICKEN GROWTH PERFORMANCE
- S1-R1-2  
SYARIFAH MUTHIA PUTRI INSTITUT  
TEKNOLOGI SEPULUH NOPEMBER  
DEMAND SIDE MANAGEMENT TO OVERCOMES POWER DEGRADATION DUE TO PV INTERMITTENT AT RESIDENTIAL CHARGING STATIONS
- S1-R1-3  
LING BEI EN  
UNIVERSITI TEKNOLOGI MALAYSIA  
CHARACTERIZATION OF ROTTEN JICAMA BIOPLASTIC FILLED WITH TEA TREE OIL AS ANTIMICROBIAL AGENT
- S1-R1-4  
PORNPAWIT KARPHERD  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
CARBON FOOTPRINT AND LIFE CYCLE COST ANALYSIS OF DIFFERENT MANAGEMENT SCENARIOS FOR SUPERMARKET FOOD WASTE IN THAILAND
- S1-R1-5  
AHMAD MUHAIMIN BIN MOHD ZULI  
UNIVERSITI TEKNOLOGI MALAYSIA  
ANALYSIS OF FERTILIZERS MADE FROM MULTIPLE ORGANIC WASTE COMPOSTS

### Reviewer

- POJ TANGAMCHIT  
KING MONGKUT'S UNIVERSITY  
OF TECHNOLOGY THONBURI
- NORAHIM IBRAHIM  
UNIVERSITI TEKNOLOGI MALAYSIA

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**DAY 1 (23 JULY 2024)**

**SESSION 1 (09:00 - 10:30GMT + 7:00) - ROOM 2 (CB2403)**

### Presenter

- S1-R2-1  
SIRAWICH SONTISAKA  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
TOBACCO WASTE TO BIOCHAR PRODUCTION OBTAINED  
BY HYDROTHERMAL AND CONVENTIONAL PYROLYSIS  
PROCESSES
- S1-R2-2  
WAN ADDEAN LUQMAN BIN MOHD SUHAIMI  
UNIVERSITI TEKNOLOGI MALAYSIA  
EVALUATION OF DRIED BLACK SOLDIER FLY LARVAE AS  
POTENTIAL ADDITIVE FEED SOURCE FOR POULTRY  
PRODUCTION
- S1-R2-3  
YANISA DOUNGKUMCHAN  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
SOLID ACID CATALYST DEVELOPMENT FROM RUBBER  
TIRE WASTE FOR BIOFUEL AND BIOCHEMICAL  
PRODUCTION
- S1-R2-4  
NIK AHMAD NA'IM BIN JOHN ISMAIL  
UNIVERSITI TEKNOLOGI MALAYSIA  
CHARACTERIZATION AND APPLICATION OF SOYBEAN  
WASTE FROM BEAN CURD INDUSTRY AS POTENTIAL  
POULTRY FEED MATERIAL
- S1-R2-5  
WIDHOWATI KESOEMA WARDHANI  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
TOXICITY OF EMERGING MICROPOLLUTANTS (EMPS)  
POTENTIALLY FOUND IN SEPTIC TANK OF MOJO,  
SURABAYA, INDONESIA

### Reviewer

- DIEW KOOLPIRUCK  
KING MONGKUT'S UNIVERSITY  
OF TECHNOLOGY THONBURI
- SRITHAR RAJOO  
UNIVERSITI TEKNOLOGI MALAYSIA

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**DAY 1 (23 JULY 2024)**

**SESSION 2 (10:40- 12:00GMT + 7:00) - ROOM 1 (CB2402)**

### Presenter

- S2-R1-1  
JEESICA HERMAYANTI PRATAMA  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
EXPLORING CHALLENGES AND FUTURE PERSPECTIVES OF MICROBIAL FUEL CELL OPERATION FOR PALM OIL MILL EFFLUENT WASTEWATER TREATMENT
- S2-R1-2  
TAN CHUEN LIN  
UNIVERSITI TEKNOLOGI MALAYSIA  
SIMULATION STUDY OF COPPER IONS ADSORPTION FROM WASTEWATER BY USING RAW RICE HUSKS
- S2-R1-3  
EVTRIYANDANI  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
ESTABLISH THE ECONOMY CIRCULAR FOR PAPER INDUSTRY IN INDONESIA
- S2-R1-4  
NAPAT NAOWARANGSEE  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI  
POSTURE MONITORING TO PREVENT PRESSURE ULCERS IN BEDRIDDEN ELDERLY PATIENTS USING 3D HUMAN SKELETON ANALYSIS AND MACHINE LEARNING
- S2-R1-5  
FONG YI KA  
UNIVERSITI TEKNOLOGI MALAYSIA  
INVESTIGATING THE IMPORTANCE OF VENTILATION METHODS IN THE OPERATING ROOM: A COMPREHENSIVE REVIEW

### Reviewer

- POJ TANGAMCHIT  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI
- NORAHIM IBRAHIM  
UNIVERSITI TEKNOLOGI MALAYSIA

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### Presenter

- S2-R2-1  
NUTTAWUT SRIBUNGNGAWINSTITUT  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
THE DEVELOPMENT OF POLY(LACTIC ACID) BLENDED  
WITH POLY(ETHYLENE GLYCOL) ELECTROSPUN FIBERS  
FOR TISSUE ENGINEERING
- S2-R2-2  
RAMADHAN SANYOTO SUGIHARSO WIDODO  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
SYNERGISTIC GANS: TRANSFER LEARNING FOR  
ANNOTATED LEFT ATRIUM MR IMAGE GENERATION  
USING PAIRED AND UNPAIRED MODELS
- S2-R2-3  
NATTAPORN SAE-SUE  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
MESOPOROUS BIOACTIVE GLASS NANOPARTICLES  
CONTAINING CHITOSAN/COLLAGEN SCAFFOLD FOR  
CARDIAC TISSUE ENGINEERING
- S2-R2-4  
MAVELYN CLARISSA TANIA  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
STRESS DETECTION USING RADAR TECHNOLOGY WITH  
HEART RATE VARIABILITY ANALYSIS
- S2-R2-5  
PIYAWADEE LUANGCHUANG  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
STUDY OF SELF-HEALING THERMOPLASTIC  
POLYURETHANE/METAL-CROSSLINKED  
EPOXIDIZED NATURAL RUBBER BLENDS FOR COMPLEX  
3D PRINTED STRUCTURES

### Reviewer

- DIEW KOOLPIRUCK  
KING MONGKUT'S UNIVERSITY  
OF TECHNOLOGY THONBURI
- SRITHAR RAJOO  
UNIVERSITI TEKNOLOGI MALAYSIA

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**DAY 2 (24 JULY 2024)**

**SESSION 3 (09:00- 10:30GMT + 7:00) - ROOM 1 (CB2402)**

### Presenter

- S3-R1-1  
NISMAT HAJJIM AYU PERMATA BAKTI  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
SURFACE ELECTROMYOGRAPHY FOR EVALUATING EFFECT OF AGING ON LOWER LIMB COORDINATION
- S3-R1-2  
JIRAYU HEMWAT  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI  
LASER POLISHING OF EXTRUSION ADDITIVELY MANUFACTURED 316L STAINLESS STEEL
- S3-R1-3  
WISDA MULYASARI  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
IS IT IMPORTANT TO USE THE MACROERGONOMIC APPROACH TO THE SAFETY CULTURE MATURITY MODEL?
- S3-R1-4  
MR.PANITHAN DOLRASRI  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI  
MAXIMIZING THERMAL PERFORMANCE OF NATURAL CONVECTION-BASED HEAT SINKS USING TOPOLOGY OPTIMIZATION
- S3-R1-5  
ZHANG XINMIAO  
RITSUMEIKAN UNIVERSITY  
DICE FOR PRICE

### Reviewer

- JIRAVIT PRADVIDHAYA  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI
- ITO TAKAMOTO  
RITSUMEIKAN UNIVERSITY



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**SESSION 3 (09:00- 10:30GMT + 7:00) - ROOM 2 (CB2403)**

### Presenter

- S3-R2-1  
WELLA HEWAGE HASARINDA AMILA  
KARIYAWASAM  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
EXPERIMENTAL ANALYSIS OF THERMAL RUNAWAY IN  
RANDOMLY DEGRADED LITHIUM-ION BATTERIES  
SUBJECTED TO THERMAL ABUSE
- S3-R2-2  
NATCHAPOL LERTPINITAMORNKUL  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
DEVELOPMENT OF CHAMBER FOR EVALUATING THERMAL  
RUNAWAY FIRE PROPAGATION IN BATTERY
- S3-R2-3  
OMOTO TOMOHISA  
RITSUMEIKAN UNIVERSITY  
TRANSFORMERS COLONY - THE METABOLIC SYSTEM FOR  
POSTHUMANISM -
- S3-R2-4  
MOHAMAD ZAKI AZIZI  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
THE INFLUENCE OF DIGITAL TRANSFORMATIONAL  
CAPABILITY ON INNOVATION PERFORMANCE IN THE  
AUTOMOTIVE COMPONENTS INDUSTRY: THE MEDIATING  
ROLE OF ORGANIZATIONAL AMBIDEXTERITY
- S3-R2-5  
NATAVUDH KHUN-IN  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
DIGITAL TWIN FOR UR5 ROBOT
- S3-R2-6  
IMAMURA / RYUSEI  
RITSUMEIKAN UNIVERSITY  
SUPER-RESOLUTION TECHNIQUES FOR ENHANCEMENT  
OF DIGIT IMAGES AND TEXT IMAGES

### Reviewer

- PARICHART NARUPHONTJIRAKUL  
KING MONGKUT'S UNIVERSITY  
OF TECHNOLOGY THONBURI
- ASTRIA NUR IRFANSYAH  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER



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**DAY 2 (24 JULY 2024)**

**SESSION 4 (10:45 - 12:30GMT + 7:00) - ROOM 1 (CB2402)**

### Presenter

- S4-R1-1  
HARMINI  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
A SMART MAXIMUM POWER POINT TRACKING (MPPT)  
ULTRA-HIGH STEP-UP DC-DC CONVERTER FOR PROTON  
EXCHANGE MEMBRANE FUEL CELL SYSTEM
- S4-R1-2  
WANRUDEE CHANAKAEW  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
DESIGN OF MAXILLOFACIAL PLATE WITH CONDYLE  
RECONSTRUCTION
- S4-R1-3  
SUGIMOTO RIKU  
RITSUMEIKAN UNIVERSITY  
FEM ANALYSIS OF LATTICE STRUCTURE MODEL  
SIMULATING HARMONIC STRUCTURE AND  
PRECIPITATION STRENGTHENED STRUCTURE
- S4-R1-4  
PONGPAT PHETCHANASONGKHRAM  
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY  
THONBURI  
MICROSTRUCTURE AND MECHANICAL PROPERTIES OF  
HYPOEUTECTIC AL-SI ALLOY WITH SC AND ZR ADDITIONS
- S4-R1-5  
GUNAWAN  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
STRATEGIES FOR DEVELOPING HUB PORTS TO ENHANCE  
THE INTERNATIONAL CONTAINER SHIPPING IN  
INDONESIA
- S4-R1-6  
YEW YUN RU  
UNIVERSITI TEKNOLOGI MALAYSIA  
THE ENERGIES OF THE CAYLEY GRAPH ASSOCIATED TO A  
DIHEDRAL GROUP

### Reviewer

- JIRAVIT PRADVIDHAYA  
KING MONGKUT'S UNIVERSITY  
OF TECHNOLOGY THONBURI
- ITO TAKAMOTO  
RITSUMEIKAN UNIVERSITY

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**DAY 2 (24 JULY 2024)**

**SESSION 4 (10:45 - 12:30GMT + 7:00) - ROOM 2 (CB2403)**

### Presenter

- S4-R2-1  
IZZATI JUSNI  
UNIVERSITI TEKNOLOGI MALAYSIA  
LAPLACIAN ENERGY OF GRAPHS ASSOCIATED TO SOME GENERALIZED QUATERNION GROUPS
- S4-R2-2  
BERNADUS DANIEL SASMITO ATMODIHARJO  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
GROUND STATION PHASED ARRAY ANTENNA DESIGN FOR SINGLE LEO SATELLITE WITH NON-EQUATORIAL ORBIT
- S4-R2-3  
CHE ANNURIANY FHIRZANA BINTI CHE ANUAR  
UNIVERSITI TEKNOLOGI MALAYSIA  
THE WIENER INDEX OF A VARIANT OF CAYLEY GRAPH FOR DIHEDRAL GROUP
- S4-R2-4  
EKO HANDOYO  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
SERO - THE SOFTWARE ECOSYSTEMS REFERENCE ONTOLOGY
- S4-R2-5  
SITI AISYAH BINTI SULAIMAN  
UNIVERSITI TEKNOLOGI MALAYSIA  
THE SOMBOR INDEX OF THE CAYLEY GRAPH OF A CRYSTALLOGRAPHIC POINT GROUP
- S4-R2-6  
NURUL HAIFA DAYANA BINTI NURULAZMI  
UNIVERSITI TEKNOLOGI MALAYSIA  
THE PRIME POWER CAYLEY GRAPH OF A QUATERNION GROUP AND ITS ZAGREB INDEX

### Reviewer

- PARICHART NARUPHONTJIRAKUL  
KING MONGKUT'S UNIVERSITY  
OF TECHNOLOGY THONBURI
- ASTRIA NUR IRFANSYAH  
INSTITUT TEKNOLOGI SEPULUH NOPEMBER

# NUTRITIONAL EVALUATION OF FERMENTED SOYBEAN WASTE AS ADDITIVE SOURCE AND ITS IMPACT ON CHICKEN GROWTH PERFORMANCE

Muhammad Faris Aiman Bin Mohd Yaini

<sup>1</sup>Faculty of Science (Biology), University Technology Malaysia  
[muhammadfarisaiman@graduate.utm.my](mailto:muhammadfarisaiman@graduate.utm.my)

## Abstract

The purpose of my research is to evaluate the use of fermented soybean waste as additive feed source and its impact on crossbred village chickens' performance. This study has three objectives. The first is to determine the chemical composition and nutritional content of fermented soybean waste. The second is to evaluate the growth performance of chickens fed with fermented soybean waste. The third objective is to assess the nutrient digestibility of chickens when fermented soybean waste is added to their diet. The soybean waste used is sourced from tofu factories. Utilizing soybean waste in this manner is highly beneficial for sustainability as it helps alleviate waste management issues. As we know, waste disposal poses numerous disadvantages such as the emission of greenhouse gases and water pollution if not handled properly. Fermenting soybean waste using effective microorganisms and molasses enhances its nutritional content. In my study, there are four treatments with varying percentages of fermented soybean waste: 5%, 10%, 15%, and a control group. These are used for comparison to determine the percentage that has the most significant impact on chicken growth. Each treatment is mixed with commercial feed according to the chicken's dietary requirements, except for the control group, which receives only commercial feed.

**Keywords:** Fermented soybean waste, Sustainability, Nutritional content, Growth performance, Nutrient digestibility

# DEMAND SIDE MANAGEMENT TO OVERCOMES POWER DEGRADATION DUE TO PV INTERMITTENT AT RESIDENTIAL CHARGING STATIONS

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## Abstract

Intermittent PV is a crucial problem in centralized PV infrastructure for residential charging station. This problem can be overcome by using one of the smart grid concepts, namely DMS (Demand Side Management) through load scheduling. Some of the load scheduling that has been carried out is scheduling based on electricity prices, battery SoC value, and load flexibility. This load scheduling does not take into intermittent problems in renewable energy. Hence, it still depends on grid conventional. This research proposes a EV charging scheduling based on PV power reduction due to intermittency for centralized PV at residential charging stations. EV charging scheduling uses genetic algorithms and PSO which can work effectively to obtain optimal scheduling. The simulation results verify that the peak load can be reduced align with the intermittent PV value. This research will result in mitigating intermittent PV in centralized PV at residential charging stations. It can produce an independent and sustainable electricity system.

**Keywords:** Demand Side Management, Load Scheduling, Intermittent, Genetic Algorithm, Particle Swarm Optimization

## Characterization of Rotten Jicama Bioplastic Filled with Tea Tree Oil as Antimicrobial Agent

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### Abstract

This research investigated the use of rotten jicama starch as a sustainable resource for producing bioplastic, incorporating tea tree oil (TTO) as antimicrobial agent. This approach aims to prevent resource competition with the food industry where the addition of TTO to the bioplastic is intended to mitigate bacterial contamination in the rotten jicama, thus hindering bacterial growth. The objective is to determine the optimal content of sorbitol and TTO and to characterize the tensile strength, FTIR, biodegradability, and antimicrobial properties of rotten and fresh jicama starch bioplastic, with the latter serving as a control. As result, the tensile properties of the rotten jicama film fell within the range of 4.5MPa for stress and 66% for elongation at break. FTIR spectra also indicated the presence of an O-H functional group and demonstrated that the addition of sorbitol can enhance the mechanical properties of jicama starch. The Kirby Bauer Test evaluated the inhibitory effect of rotten films on both gram-positive and gram-negative bacteria. Surprisingly, only films with 45phr TTO were effective against tested bacteria. This research offers insights into rotten starch-based bioplastics as eco-friendly alternatives to traditional plastics, addressing concerns about competition within the food industry while promoting sustainability.

**Keywords:** Jicama, Tea Tree Oil, Sorbitol, Bioplastic, Antimicrobial property

# Carbon Footprint and Life Cycle Cost Analysis of Different Management Scenarios for Supermarket Food Waste in Thailand

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## Abstract

Food waste has become a significant global concern in the pursuit of sustainability. Many organizations have attempted to utilize and valorize this food waste, and numerous studies have focused on household utilization and valorization. However, research on supermarket food waste (SFW) remains limited.

This study aims to investigate the quantity and management practices of SFW in Bangkok, Thailand. The categories and quantities of SFW generated in Bangkok supermarkets are collected and classified according to the method provided by the Ministry of Public Health.

Furthermore, the study assesses the carbon footprint and life cycle cost (LCC) of various SFW management scenarios to illustrate the trade-offs between carbon footprint and life cycle cost. Mathematical models are employed to calculate both the carbon footprint and the LCC. The carbon footprint calculation follows the IPCC 2006 guidelines and T-VER, while the analysis of LCC considers investment, operation, and maintenance costs.

The results of SFW analysis indicate that fruits and vegetables constitute the largest portion of SFW, accounting for approximately 69%. In terms of packaging materials, polypropylene makes up about 75%. The carbon footprint and LCC comparing landfill and energy-recovery incineration scenarios reveal that incineration has a significantly lower carbon footprint and life cycle cost.

**Keywords:** Supermarket food waste, carbon footprint, life cycle cost, landfill, energy-recovery incineration

## **Analysis of fertilizers made from multiple organic waste composts**

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### **Abstract**

Fertilizer markets faced disarray and volatility arising from the sudden hold up of economic during early pandemic. This uncertainty led at times to sharp increases in fertilizer prices and many instances of lower prices as market participants were adjusting to the new normal searching for new alternatives such as organic wastes. This study project delves into a thorough analysis of multiple organic waste composts generated by MAEKO automatic composting machine, including black soldier fly exuviae, frass, dead flies, banana peels, and okara. The objective is to assess their suitability as organic fertilizers. The composts will undergo comprehensive evaluations encompassing nutritional composition, moisture levels, and various other characteristics. Additionally, the study aims to investigate the impact of each compost on the growth performance of *Solanum melongena* (eggplant), serving as the experimental crop. Experiments will be conducted to explore the effects of varying compost on several plant growth parameters including number of leaves, leaves length and width, plant height, number of flowers and fruits, and chlorophyll content. Moreover, the study intends to elucidate the impact of each compost on soil fertility before and after transplanting. Soil parameters measured in this objective are nitrogen, phosphorus, potassium content, and soil pH. Anticipated results aim to provide valuable insights into the potential utilization of black soldier fly, okara, and banana peels waste as sustainable and effective organic fertilizers. Such findings hold practical implications for the advancement of eco-friendly agricultural practices and waste management strategies

**Keywords:** Black soldier fly, okara, compost, growth performance, soil fertility



## **Tobacco Waste to Biochar Production obtained by Hydrothermal and Conventional Pyrolysis Processes**

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### **Abstract**

This research aims to convert industrial waste biomaterials from tobacco waste by using hydrothermal and conventional pyrolysis processes. Tobacco leaf waste was utilized as the primary material for biochar production. The hydrothermal and conventional pyrolysis processes conducted at a temperature of 300 °C for 30 minutes under controlled thermal chemical reaction conditions handled. Comprehensive analyses were handled to evaluate analyze characteristics of biochars produced.

The hydrothermal process (HTL) resulted in a heating value of 22.97 MJ/kg on the dry ash free, whereas the pyrolysis process (PTL) showed a higher heating value of 29.10 MJ/kg on the dry ash free.

These findings indicate that while the pyrolysis process yields a biochar with a higher heating value, both processes produce biochar with comparable fixed carbon contents. This study contributes to the effective methods for converting industrial tobacco waste into valuable biochar, adding potential applications in various environmental and industrial sectors.

**Keywords:** Biochar, Tobacco Waste, Hydrothermal Process, Pyrolysis

# EVALUATION OF DRIED BLACK SOLDIER FLY LARVAE AS POTENTIAL ADDITIVE FEED SOURCE FOR POULTRY PRODUCTION

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## Abstract

This research is addressing the issue in finding a more sustainable and alternative feed source in poultry production. The latest and popular innovation is incorporating dried black soldier fly larvae due to their high protein content and the ability to consume organic waste. The conventional feed source such as soybean meal and fishmeal are associated with environmental challenges and limited availability. Despite the exceptional nutrient content, the ability to upcycle organic waste and the growing demand for poultry meat there is still an insufficient understanding on the impact of using BSF on growth performance. In this research, there are 3 main objectives. The chickens will be separated into 4 treatments each with different BSF inclusion (0%, 5%, 10% and 15% respectively). The first objective is to evaluate the growth performance by comparing the weight of chickens on a 3 day basis. The second is to determine the nutrient digestibility by analyzing the daily weight and nutrient content of the chicken feces with the feed given. The third objective is evaluating the meat yield between the meat and the carcass. This study hopes to aid in solving the issue with high cost for poultry meat by finding a cheaper alternative protein source for the chicken feed. This will alleviate the demand for frequent imports of key ingredients to make the chicken feed which increases the price substantially. Thus, offering a solution to promote more sustainable practices in the poultry industry

**Keywords:** Poultry Feed, Sustainable, Alternative source, Black Soldier Fly, Reduce cost

## Solid acid catalyst development from rubber tire waste for biofuel and biochemical production

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### Abstract

The growth of the vehicle industry increases the demand for rubber tires, resulting in significant rubber tire waste that negatively impacts the environment. Utilizing rubber tire waste is a method to mitigate environmental concerns, aligning with the Bio-Circular-Green-Economy (BCG). Many researchers have developed a way to utilize rubber tires in new applications such as catalysts and adsorbents. One approach involves pyrolyzing rubber tires at high temperatures to form carbon, which is then functionalized into a solid acid catalyst. Despite its promise, this process is complex and energy-intensive due to the pyrolysis involved. This research aims to develop a solid acid catalyst from rubber tire waste using a simpler method with lower energy consumption via sulfonation. The study examined the effects of synthesis conditions (temperature and acid concentration) on catalyst efficiency and stability during esterification of levulinic acid and methanol, compared to a commercial catalyst (Amberlyst-15). The TW-SO<sub>3</sub>H catalyst, synthesized at 150°C and 98% H<sub>2</sub>SO<sub>4</sub> concentration, demonstrated high performance (98% conversion) and product selectivity, surpassing Amberlyst-15 by up to 10%. This research addresses the environmental impact of tire waste and supports sustainable catalyst development, contributing to eco-friendly waste management strategies.

**Keywords:** rubber tire waste; sulfonation; solid acid catalyst; levulinic acid; esterification

# CHARACTERIZATION AND APPLICATION OF SOYBEAN WASTE FROM BEAN CURD INDUSTRY AS POTENTIAL POULTRY FEED MATERIAL

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## Abstract

Costing is one of the main factor that leads to unpredictable price of commodities in poultry industry, which is issued by the elevated of feed price since COVID-19. The high price may influence products cost as the feeding cost contribute more than 50% of overall costing. Thus, there is an urge to develop an alternative to commercial feed that are cheaper and contains a better nutritional content. This study utilizes an industrial-processed waste; okara, treated with fermentation and introduced to chicken's diet to analyse growth performance and nutrient digestibility. The sample was sent to lab for proximate analysis to obtain the nutritional content. The formulated feed was fed to 3 treatment groups (0%, 5%, 10% and 15%) and a group consist of 50 free range broilers and were assigned randomly. The treatment was conducted in 8 weeks and given ad libitum. The parameters for growth performance such as weight, feed intake, and Feed Conversion Ratio (FCR) are measured. After 4 weeks of introducing new feed, the chickens dung was collected and weighted to measure the digestibility test. After the treatment, 3 chickens from each group was sacrificed to record the meat and bone weight for meat yield analysis.

**Keywords:** fermentation, okara, industrial-processed waste, free range broilers, growth performance.

**TOXICITY OF EMERGING MICROPOLLUTANTS (EMPs)  
POTENTIALLY FOUND IN SEPTIC TANK OF MOJO, SURABAYA,  
INDONESIA**

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**Abstract**

Emerging Micro-pollutants (EMPs) are pollutants that are typically detected in small quantities and are referred to as "emerging" because they were not previously considered in existing environmental quality standards. Some EMPs originate from everyday products consumed. Among several types originating from over-the-counter drugs, paracetamol and caffeine are the most popular to consume. It should be noted because those are organic compounds, the septic tank process supposed to be able to degrade them. Nevertheless, residues can still be detected. Therefore, it is important to understand the potential toxicity that may be present in septic tanks in Surabaya, Indonesia. Furthermore, if EMPs do affect the effectiveness of septic tank degradation, their contents could be carried to other environments, endangering aquatic species and humans. This is possibly due to UNICEF's statement in 2022 that 70% of household water sources in Indonesia are contaminated with feces, partly due to septic tank leaks. Currently, there are no clear standards regarding the quality of EMPs in Indonesia, research about it is still scarce and conducting this research topic might add new information. This study will be conducted on a laboratory scale to know the toxicity or the effect of EMPs to indigenous bacteria of septic tank.

**Keywords:** Caffeine, Emerging Micropollutants (EMPs), Paracetamol, Septic Tank, Toxicity.

# EXPLORING CHALLENGES AND FUTURE PERSPECTIVES OF MICROBIAL FUEL CELL OPERATION FOR PALM OIL MILL EFFLUENT WASTEWATER TREATMENT

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## Abstract

Indonesia produces 30 million tons of palm oil annually, making it the world's largest producer and exporter. Indonesia's palm oil-dependent agricultural sector remains vital because of its abundant raw materials, technological advances, and market opportunities. In contrast, this industry produced 98.3 million m<sup>3</sup> of palm oil mill effluent (POME) from 2015-2022. POME improperly managed in aquatic and terrestrial ecosystems poses serious environmental risks because of its high acidic pH and biological and chemical oxygen demand. The conventional method for POME wastewater treatment must be replaced with a more efficient and cost-effective treatment because of the high contamination and large water volumes. Microbial fuel cells (MFCs), which use live microorganisms as catalysts to convert organic fuels into electricity, are becoming popular sustainable bioenergy systems. Integrated POME treatment with anaerobic digestion is projected to produce biogas and electricity simultaneously. Each MFC and biogas production strategy from POME has been studied extensively; therefore, power optimization and novel hybrid system development will improve energy generation efficiency. This study examined POME's renewable energy potential for Indonesia's biogas and electricity development prospects. Finally, the technical constraints and economic viability of POME wastewater treatment using MFCs are studied to explore the sustainability of wastewater treatment technology.

**Keywords:** POME, anaerobic digestion, MFC, renewable energy, wastewater treatment.

## SIMULATION STUDY OF COPPER IONS ADSORPTION FROM WASTEWATER BY USING RAW RICE HUSKS

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### Abstract

Green bio-adsorption is a common practice in wastewater treatments. The adsorption capabilities of raw rice husks to remove copper ions from wastewater are studied. The adsorption capacity of raw rice husks can be determined empirically through experiments, but it can be time-intensive and expensive due to the inherent complexities of the adsorption process and the significant labor and resources required. Simulation using the Fixed-bed Adsorption Simulation Tool, FAST is promoted as an effective prediction approach that offers a more efficient and cost-effective means of generating simulated result, providing a viable solution to the challenges associated with traditional experimental methods. The objectives of this study were to evaluate the performance of raw rice husks as a substitute for conventional absorbent and its absorption equilibrium and to predict the simulation parameters compared to the existing empirical results. This paper uses the Fixed-bed Adsorption Simulation Tool, FAST. This paper studies the effects of contact time, initial ions concentration, and adsorbent dosage on the adsorption process via raw rice husks. The contact time is 2 hours, with 1- 50 ppm initial copper ions concentration and 0.025-0.15 grams adsorbent dosages. Simulated results forecast that percentage adsorption increases with contact time and will reach adsorption equilibrium after 10 minutes with an optimum of 99.8% adsorption. The percentage adsorption is decreased with adsorbate concentration, where an optimum of 90% adsorption occurs at 1 ppm. The adsorption capacity is increased with adsorbent dosages. The optimum adsorption percentage of 99.6%, occurs at 0.15 grams. Langmuir Isotherm shows the best fit model in predicting the trendline of the breakthrough curve.

**Keywords:** Simulation, bio-adsorption; wastewater treatment; raw rice husks; copper ions

# ESTABLISH THE ECONOMY CIRCULAR FOR PAPER INDUSTRY IN INDONESIA

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## Abstract

Indonesia is one of the top ten global paper manufacturers and a sector that influences economic growth. Until the 4<sup>th</sup> quarter of 2023, the paper industry grew by 2.8% with a contribution to GDP of 3.5% with an export value reaching 8.4 billion USD. As This large business has a limited supply of raw material and increasing world awareness of environmental problems, causing a promotion to circular economy (CE) development in paper industry. By reviewing literature regarding to CE practices in the paper industry, this research identifies barriers and opportunities of the CE implementation. The results provide brief to the potential of circular economy strategies to promote economic development and environmental sustainability of paper industry in Indonesia. The potential for developing a circular economy in the paper industry will be discussed in two main parts, the potential for both a pre and post consumer paper for circular economy. The pre consumer circular economy potential of the paper industry focuses on the design/re-design paper products that are more environmentally friendly, material and raw material efficiency, the use of new and renewable energy (EBT) and the utilization of waste. The post consumer circular economy potential focuses on recycling paper.

**Keywords:** Manufacture, Material Efficiency, Recycle, Economic Growth, Sustainability



# Posture Monitoring to Prevent Pressure Ulcers in Bedridden Elderly Patients Using 3D Human Skeleton Analysis and Machine Learning

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## Abstract

Pressure ulcers are a serious issue for bedridden elderly patients, and regular repositioning is crucial to prevent them. However, due to a shortage of caregivers, repositioning may not happen as often as needed. Modern technology, especially image processing, offers a promising solution. We propose a system that uses a trilateral filter to retrieve depth information from 2D images, eliminating the need for a 3D camera. This RGB-D camera system can recognize patients' posture by analyzing their 3D skeleton, even when covered with a blanket, by focusing on just four key joints. If a patient stays in the same position for more than a set time (e.g., two hours), the system sends an alert to caregivers to reposition the patient and prevent pressure ulcers.

This new method of using skeleton analysis for patient care shows great promise for healthcare applications. By leveraging this technology, caregivers can ensure timely repositioning, reducing the risk of pressure ulcers. After redesigning the RGB-D camera system, intensive testing will be conducted in healthcare facilities to validate its effectiveness and reliability. This innovative approach could revolutionize patient care for bedridden individuals, improving their comfort and health outcomes.

**Keywords:** Posture monitoring, 3D human skeleton analysis, RGB-D camera, Trilateral filter, Depth information

## Investigating the Importance of Ventilation Methods in the Operating Room: A Comprehensive Review

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### Abstract

An operating room is a designated space where complex surgical procedures such as cataract surgery, appendectomy surgery, etc. are performed under aseptic conditions. The study aims to review the most suitable type of ventilation system to be used to reduce the concentrations of airborne contaminants in operating rooms. It is identified that mechanical ventilation is most suitable to be used due to it can ensure the rate of air change per hour (ACH) in range of 20-25 times constantly. Among the few types of mechanical ventilation which is mixing ventilation, vertical laminar airflow ventilation, and horizontal laminar airflow systems, vertical laminar airflow is the most suitable ventilation system to be used. Studies indicate that this system can maintain airflow velocities ranging from 0.25m/s to 0.38m/s, meeting the standard guidelines outlined in Deutsches Institut für Normung (DIN) 194604 standard. Another research shows that by increasing the surface area of vertical downward ventilation system from 4.3 m<sup>2</sup> to 5.7 m<sup>2</sup>, it can lead to a reduction in airborne contaminant concentration from 41% to 39%. By integrating an additional air curtain with ceiling-mounted air diffusers fitted with high-efficiency particulate air (HEPA) filters, it has an efficiency to remove particles up to 33.3%.

**Keywords:** Operating room, air change per hour, vertical laminar airflow, airborne contaminants.

# The Development of Poly(lactic acid) blended with Poly(ethylene glycol) Electrospun Fibers for Tissue Engineering

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## Abstract

Immune rejection poses a significant challenge for biomaterial implants, making the reduction of immune reactions crucial for success. This study aims to fabricate electrospun fibers from poly(lactic acid) (PLA) blended with poly(ethylene glycol) (PEG) in varying ratios (PLA:PEG), specifically 90:10 (B90), 80:20 (B80), 70:30 (B70), and 60:40 (B60). The blends were dissolved in chloroform: methanol (3:1) before electrospinning. Scanning electron microscopy (SEM) revealed nano- to microscale fibers with random arrangements. Bead formation and thread defects were prominent in B60. Fiber diameter analysis showed a significant decrease with lower PLA content. SEM imaging indicated that B90, B80, and B70 exhibited better fiber morphology. However, the potential of these fibers to reduce protein adsorption and other bioactive scaffold properties remains to be evaluated.

**Keywords:** Bioactive scaffold, Immune rejection, Electrospinning fiber, Poly(lactic acid) (PLA), poly(ethylene glycol) (PEG)

# SYNERGISTIC GANS: TRANSFER LEARNING FOR ANNOTATED LEFT ATRIUM MR IMAGE GENERATION USING PAIRED AND UNPAIRED MODELS

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## Abstract

Cardiovascular illnesses, which are the leading cause of death globally, need the use of advanced imaging techniques. The need for annotated medical imaging datasets in cardiology poses challenges for constructing deep learning models due to high collection costs, privacy concerns, and the limited availability of specific data. The study presents a novel approach for generating left atrium images with Generative Adversarial Network (GAN) models by employing transfer learning from a pre-trained U-Net model to Pix2Pix (paired GAN), subsequently transfers to CycleGAN (unpaired GAN) models to overcome dataset constraints. Our technique leverages the high fidelity of Pix2Pix and the adaptability of CycleGAN to create more annotations, even without extensive annotated datasets. The proposed methodology involves transfer learning between GAN models, enhancing the quality of generated annotations based on the evaluation method with Structural Similarity Index Measure (SSIM) and Peak Signal to Noise Ratio (PSNR), and improving the stability of the training process. The proposed method shows that the Pix2Pix model exhibits an average SSIM of 0.92 and PSNR of 29.03 compared to the actual and generated outputs. The CycleGAN model exhibits an average SSIM of 0.84 and a PSNR of 25.74 compared to the real input and generated output.

**Keywords:** Left Atrium, Paired GAN, Transfer Learning, Unpaired GAN, U-Net

# MESOPOROUS BIOACTIVE GLASS NANOPARTICLES CONTAINING CHITOSAN/COLLAGEN SCAFFOLD FOR CARDIAC TISSUE ENGINEERING

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## Abstract

Chitosan is a natural polymer and conductive hydrogel that is interested in the field of cardiac tissue engineering due to its structural similarity to the glycosaminoglycan in the heart. It can be combined with other types of hydrogels, such as collagen, to provide optimal physicochemical properties. However, there are some limitations such as weak mechanical strength and low angiogenesis induction, which a key to successful implantation. To overcome these limitations, mesoporous bioactive glass nanoparticles (MBGNs), bioceramic materials that exhibit various properties, such as biocompatibility, biodegradability, great bioactivity, and enhanced mechanical properties of the hydrogel, were used. MBGNs can be incorporated with various therapeutic ions. Zinc ( $Zn^{2+}$ ) displays several biological properties, including promoting angiogenesis and having anti-bacterial effects. Hence, the purpose of this research is to apply Zn-doped MBGNs into the chitosan/collagen scaffold to improve angiogenesis induction and mechanical properties. The Zn-MBGNs should have a spherical shape, monodispersity, and homogeneity, with a size in the range of 100 to 200 nm. From the definition of mesopore, Zn-MBGNs should have pore sizes ranging from 2 to 50 nm. After that, Zn-MBGNs will be applied to the chitosan/collagen scaffold.

**Keywords:** Chitosan, Collagen, Bioactive glass, Scaffold, Cardiac tissue engineering

# Stress Detection using Radar Technology with Heart Rate Variability Analysis

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## Abstract

Stress is an uneasiness feeling that arises when a person is exposed to an event that disrupts daily activities. Identifying stress can be done through questionnaires and interviews, but this could lead to subjective results based on the individual's interpretation or the psychologist's expertness, leading to inaccuracies. The existing method to improve stress diagnosis is Heart Rate Variability (HRV) analysis obtained from Electrocardiography (ECG) or Photoplethysmography (PPG). HRV has a deep connection with subconscious states identifying sympathetic and parasympathetic nerve activity that can be used to detect stress. However, ECG and PPG can only measure heart rate when worn, often causing discomfort and a sense of being monitored, which can affect stress levels. Radar technology can be used to detect heartbeats from a certain distance based on chest movement, allowing for non-contact measurements. The radar output signal is filtered and decomposed to separate the heartbeat and breathing signals from noise. Frequency domain analysis was performed to obtain the ratio of high and low frequency distribution. The ratio is used in the machine learning system to generate a stress score. Using this method, accurate stress level detection can be performed.

**Keywords:** Stress, Monitoring, Radar, and Heart Rate Variabilit

## Study of Self-healing Thermoplastic Polyurethane/Metal-crosslinked Epoxidized Natural Rubber Blends for Complex 3D Printed Structures

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### Abstract

The proposed study aims to develop self-healing TPU/metal-crosslinked ENR (SMC-ENR) blends by employing ligand modeling in ENR and ionic bonding in TPU matrices. We will vary the degree of epoxide groups in ENR molecules (25% and 50% mol) to induce a chemical crosslinking process using three metal ions: ferric chloride (FeCl<sub>3</sub>), magnesium chloride (MgCl<sub>2</sub>), and stannous chloride (SnCl<sub>2</sub>.H<sub>2</sub>O), in a 1:1 mmol ratio with DAP. The formation of metal compounds with DAP will impede metal crosslinks of metal atoms to ENR molecules, facilitating new crosslinking into the rubber matrix upon damage. Additionally, SMC-ENR will be blended with TPU to evaluate healing efficiency post-filament fabrication and 3D printing. Different TPU:SMC-ENR ratios (100:0, 0:100, 80:20, 70:30, 60:40, 50:50 phr) will be explored, focusing on co-continuous phase morphologies for enhanced printing capability. Both TPU and SMC-ENR phases will undergo complete self-healing evaluation using three imidazolium chemicals (1-butylimidazole, 2-butylimidazole, and 1-tert butylimidazole) with varying concentrations. These chemicals support ionic grafting on TPU and ENR molecular chains through hydroxyl functional groups. The resulting material properties, pertaining to self-healing propagation under mechanical and dynamical damage, will be utilized to print complexed network structures suitable for sprint, shoe, and lightweight helmet applications.

**Keywords:** metal crosslink, self-healing, 3D printing, epoxidized natural rubber, thermoplastic polyurethane

# **SURFACE ELECTROMYOGRAPHY FOR EVALUATING EFFECT OF AGING ON LOWER LIMB COORDINATION**

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## **Abstract**

Lower limb coordination is essential in body movements such as walking and running. The aging process has a significant influence on the lower limb coordination. A study is conducted to recognize the correlation between aging and lower limb coordination. The data acquisition process was carried out using Surface Electromyography (sEMG) and continued with signal processing using Discrete Wavelet Transform (DWT). This research will compare the signals that appear in six muscles that affect lower limb movement in “S-Walking” and “Q-Walking” which are lateral femoral, medial femoral, semitendinosus, lateral gastrocnemius, and medial gastrocnemius between two age parties, young (20-30 years old) and elderly (60-70 years old). The results will compare the correlation between interval and age in both parties. This result will help in understanding the effect of aging on lower limb coordination.

**Keywords:** Muscle Aging, Lower Limb Coordination, Electromyography, Discrete Wavelet Transform



## LASER POLISHING OF EXTRUSION ADDITIVELY MANUFACTURED 316L STAINLESS STEEL

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### Abstract

The surface quality of metal parts produced by additive manufacturing methods often exhibits poorer surface roughness compared to conventionally manufactured part. Laser polishing process is a very promising technique for achieving a smoother metal surface without the requirement for direct contact between a tool and the surface of the part. The procedure is based on the concepts of surface re-melting and quick solidification of the laser-molten layer. In this study, 316L stainless steel produced by extrusion additive manufacturing was polished using a nanosecond pulse laser under various processing conditions to improve its surface roughness. Experiments were conducted to examine the impact of laser scanning speed, laser pulse repetition rate, overlap percentage, and argon gas shield on the roughness and morphology of the polished surface. The results show that applying suitable polishing conditions can improve the roughness of laser-polished surfaces by up to 55%. Furthermore, argon gas shielding can help to mitigate oxidation during laser polishing. The findings of this study provide specific laser polishing conditions for post-processing extrusion additive manufacturing, where surface roughness is a critical concern, to smooth the rough 3D-printed surfaces.

**Keywords:** Nanosecond pulse laser, Additive manufacturing, Metal 3D-print, Surface roughness

## IS IT IMPORTANT TO USE THE MACROERGONOMIC APPROACH TO THE SAFETY CULTURE MATURITY MODEL?

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### Abstract

Macroergonomics aims to create entirely "harmonious" work systems that increase many areas of organisational efficiency and effectiveness. In macroergonomics, all work system components must collaborate to ensure safety. As a result, while the previous SLR only examined validity and reliability, a study of measurement variables is required to create an SCMM measuring instrument utilising a macroergonomic method.

This project will conduct a systematic literature review (SLR) of SCMM publishing papers during the last 22 years (2001-2023). This SLR tries to classify the variables used in SCMM measurement into sociotechnical (macroergonomic) work subsystems, study fields, models, and measurement methods. This paper applied the SLR methodology to 53 SCMM articles in the last two decades, from 2001 to 2023.

Data was collected by searching for published articles in Scopus, Google Scholar, and Semantic Scholar, UK. Health and Safety Executive (HSE), ProQuest, and Occupational Safety and Health Resource based on article title, abstract, and keywords. Filtering was done by using keywords and evaluating the content's suitability by examining the article's abstract and overall content (Output 53 articles). The results found valuable gaps in the use of the five sociotechnical work subsystems in measuring performance. The SLR found 18 organisation variables, 3 Job and task variables, 7 human variables, 5 environmental variables, and 7 tools and technological variables. The results indicate that the primary research areas in SCMM are healthcare and oil and gas, with ten publications. Besides, the SLR results indicated that the Hudson Model was the most utilised method, and the most used method was a questionnaire.

**Keywords:** Safety Culture Maturity Model, Macroergonomic, System sociotechnical, Safety Culture, Safety Culture Maturity,

## Maximizing thermal performance of natural convection-based heat sinks using topology optimization

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### Abstract

Thermal-fluidic topology optimization offers a powerful approach for designing heat sinks. Nevertheless, its application faces high computational cost, especially for natural convection heat transfer mode. This work presents a design of heat sink by using topology optimization coupled with experiment to address the challenge. A simplified model based on a dimensionless form is employed to reduce computational cost. A parametric study has been conducted to explore the impact of Grashof number and target volume fraction on design. Moreover, comparison of design methodology with conventional approach have been comparing. Findings demonstrate good agreement between numerical simulations and experiments. In addition, topological-optimized models show outstanding heat transfer performance at low Grashof number for natural convection heat transfer scenario while the effect of target volume fraction is neglectable. Notably, the simplified model reduces computational cost by 5%. Additionally, the topological-optimized model is better than the result of conventional design by 16%. This work highlights the potential of the simplified model and identifies crucial design parameters for natural convection heat sink optimization, demonstrating the superiority of topology-optimized designs over conventional methods.

**Keywords:** Topology optimization, Thermal-fluidic optimization, Heat sink design, Natural convection heat transfer, Computational cost reduction

## DICE FOR PRICE

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### Abstract

The Dynamic Integrated Climate-Economy model, referred to as the DICE model, is a neoclassical integrated assessment model developed by 2018 Nobel Laureate William Nordhaus. The model integrates in the neoclassical economics, carbon cycle, climate science, and estimated impacts allowing the weighing of subjectively guessed costs and subjectively guessed benefits of taking steps to slow climate change. My research is moving from DICE MODEL to SDICE MODEL. In other words, by adding probability to the DICE MODEL that is being considered in discrete time, it becomes an SDICE MODEL that can be considered in continuous time. Specifically, we use Hamiltonian stochastic differential equations to calculate the DICE MODEL from the Ito formula.

**Keywords:** environmental finance, climate change, Hamiltonian stochastic differential equation, continuous time, DICE MODEL

## Experimental Analysis of Thermal Runaway in Randomly Degraded Lithium-Ion Batteries Subjected to Thermal Abuse

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### Abstract

The occurrence of thermal runaway in lithium-ion batteries poses a significant challenge to the safety of their applications. This study investigated the thermal runaway effect of a degraded battery. Thermal runaway was triggered by thermal abuse using a 600W electric heater in a closed chamber. Batteries were manufactured four years prior, were used for the experiment and they were charged and discharged at a 0.5 C rate and rested for 24 hours before the experiment. The battery surface temperature was measured at three points evenly distributed along the axial direction, and the average value was chosen for analysis. In 6 out of 21 tests where the safety cap remained attached, the maximum temperature ranged from 600 to 700 °C, with visual images showing burning of emitted particles around the safety cap. In the remaining 15 tests where the safety cap was blown away, the maximum temperature ranged from 350 to 550 °C with visual images showing the burning of battery material throughout the top of the battery. Thermal runaway behaviour of degraded batteries, particularly the maximum explosion temperature, was found to be unpredictable and unrepeatable. Further testing is essential to establish a common range and develop appropriate safety measures accordingly.

**Keywords:** lithium-ion batteries, thermal runaway, thermal abuse experiment, degraded batteries

## Development of Chamber for Evaluating Thermal Runaway Fire Propagation in Battery

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### Abstract

Thermal runaway of Lithium-ion battery incidents pose a significant threat to the safety, particularly in electric vehicles. The chamber has been designed to evaluate the fire propagation of Lithium-ion battery multiple cells with a volume of 0.5 m<sup>3</sup> and dimensions of 763 mm in length, 1130 mm in diameter, and 9 mm in thickness. It is made of stainless-steel grade 304L, which has excellent corrosion resistance, making it ideal for this application and has been designed in accordance with the American Society of Mechanical Engineers code for designing pressure vessels (ASME BPVC.VIII.1, BPVC.II.D.M, B16.5). The chamber has been theoretically modeled and subjected to finite element analysis to ensure that it can work at the maximum working pressure of 1.0 MPa. The results show that the stress occurring from pressure does not exceed the yield stress value of stainless steel (107 MPa). The designed chamber provides a safe and controlled environment to evaluate the propagation of thermal runaway fires in battery cells and modules equipped with a thermal abuse heater and a temperature, pressure, gas concentration data acquisition system, along with a fire extinguishing system.

**Keywords:** pressure vessel; ASME code; thermal runaway; closed test chamber; finite element method

## **Transformers Colony - The Metabolic System for Posthumanism -**

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### **Abstract**

In recent years, the advancement of AI has prompted a reevaluation of the concepts of humanity and happiness, leading to what I perceive as a return to humanism through AI, defining it as post-humanism. In this era, I propose envisioning a space where humans, AI, and robots coexist as a graduation project. My proposal suggests building a student dormitory on the site of the former Nakagin Capsule Tower building. The design utilizes regular hexagonal prisms as the fundamental unit, integrating residential and public units that can be constructed by robots. Spaces will adapt to individuals' needs as AI observes and responds to human behaviors. For example, someone immersed in research might find a creative neighbor moving in to provide study advice. In the post-humanism era, the focus shifts to individual activities, fostering encounters that spur entrepreneurship, creativity, and innovation. Human uncertainty emerges as the most valuable data resource for AI. Thus, AI and humans forge a mutually beneficial relationship through learning and data exchange. In today's rapidly changing world, I believe that the symbiosis of people and AI can inspire architecture to create spaces that enhance human experience.

**Keywords:** AI, Post Humanism, Neo Metabolism, Robot construction

## **The Influence of Digital Transformational Capability on Innovation Performance in the Automotive Components Industry : The Mediating Role of Organizational Ambidexterity**

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### **Abstract**

The automotive components industry faces a profound digital transformation. Firms' digital transformational capability – leveraging digital technologies for business model innovation – has emerged as critical. However, its relationship with innovation performance and the potential mediating role of organizational ambidexterity remain underexplored.

This study examines how digital transformational capability influences innovation performance in the automotive components industry, exploring organizational ambidexterity's mediating effect. Four hypotheses were tested using partial least squares structural equation modeling (PLS-SEM): Digital transformational capability affects organizational ambidexterity and innovation performance; organizational ambidexterity affects innovation performance; and organizational ambidexterity mediates their relationship. Findings reveal digital transformational capability and organizational ambidexterity significantly influence innovation performance. Furthermore, organizational ambidexterity partially mediates this relationship. Results offer insights for industry leaders on fostering digital transformation and ambidexterity to enhance innovation capabilities. The study contributes by empirically examining these constructs' interplay in the automotive components context.

**Keywords** : Organizational Ambidexterity, Digital Transformational Capability, Innovation Performance, Competitive Advantage, Automotive Components Industry.



## DIGITAL TWIN FOR UR5 ROBOT

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### Abstract

This project aims to develop a digital twin system for controlling a UR5 robotic arm in its actual physical form and a simulated model. The system utilizes the ROS framework as a middleware for communication between the UR5 Robot and the UR5 Model. The main objective is to synchronize the motion of both the physical robotic arm and the simulated model, explicitly focusing on pick and place tasks. By implementing this system, the movement coordination between the physical and virtual representations of the UR5 can be observed, allowing for analysis and verification of their simultaneous motion capabilities. In the case of the UR5 Model, we will add a table as the base of the UR5 Model, with dimensions matching those of the UR5 Robot used in this project. This table serves as a reference point for the UR5 Model's movements, mimicking the real-world environment. We will then configure various settings to ensure its efficient use through MoveIt. Additionally, we will connect this custom UR5 Model to the UR5 Robot to achieve our objectives in this project.

The successful outcomes of this project include the installation of the model, commanding the model to move using JointTrajectory or Position & Orientation, creation of a new UR5 Model with a pedestal or a UR5 Model related to the UR5 Robot, utilization of MoveIt to configure the newly created UR5 model, commanding the UR5 Model using a Python script with movement commands in a loop, simultaneous movement of the UR5 Robot and UR5 Model, and visualization of the movement and characteristics of the UR5 Model in RViz. These achievements demonstrate the feasibility and effectiveness of our digital twin system for controlling the UR5 robotic arm.

**Keywords:** Digital twin / MATLAB / MoveIt / ROS / RViz / UR5 Model / UR5 Robot

## **Super-Resolution techniques for enhancement of digit images and text images**

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### **Abstract**

The quality and resolution of digital images are limited by camera resolution and distance between the object and the camera. Super-resolution (SR) is a technique to enhance the image resolution and quality by software. In this research, we apply super-resolution techniques based on deep learning technology to enhance the degraded digits and characters in images of analog meters. In the field of deep learning, it is known that the amount and quality of training data are related to the network output. This relationship between performance and data suggests that datasets containing digits and characters are effective for this research. Therefore, we train a super-resolution network using TextOCR dataset, which consists of 28,134 images containing a variety of digits and characters. On the experiment, we use RCAN, one of the outperforming SR model based on convolutional neural network (CNN) for image super resolution. For quantitative evaluation of its performance, we use PSNR, SSIM, and LPIPS which can evaluate the enhanced images by comparing them with corresponding clean images. As a result, we achieved significant improvement in the sharpening effect of the characters and quantitative results compared to the model trained with a general natural images dataset.

**Keywords:** Deep Learning, CNN, Super-Resolution, text enhancement, Sharpening

## **A Smart Maximum Power Point Tracking (MPPT) Ultra-High Step-Up DC-DC Converter for proton Exchange Membrane Fuel Cell System**

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### **Abstract**

The goal of this research is to create a smart ultra-high step-up dc-dc converter for a proton exchange membrane fuel cell system (PEMFC) using Maximum Power Point Tracking (MPPT). The ultra-high step-up dc-dc converter increases the FC output voltage to match the DC Bus voltage. This converter is controlled by smart MPPT algorithm and regulates the voltage of PEMFC to extract the maximum power output. The converter consists of two stage boost converters, a multiplier cell, a couple inductor, and a clamp circuit. The main advantages of the converter include its high voltage gain, low voltage stress on its power switches, and requiring a smaller inductor on low voltage side of the converter. Consequently, the recently developed smart MPPT algorithm offers quick MPP tracking for various fuel cell parameters. The low voltage gain of the quadratic converters has been solved that it can increase the input voltage to 9 times. This converter to convert from 45 volt of FC to 400 volt of the dc bus. The proposed system of ultra-high step-up dc-dc converter is applied to guarantee the continuity of meeting load needs with the capacity of FC is 6.000 Watt

**Keywords:** a smart Maximum Power Point Tracking (MPPT), ultra-high step-up dc-dc converter, Proton Exchange Membrane Fuel Cell system (PEMFC).

## Design of Maxillofacial plate with Condyle Reconstruction

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### Abstract

Large mandibular defects present a significant challenge for surgeons, often resulting in the loss of the condylar component, which is vital for mandibular function. The mechanical performance of current reconstruction plates is still uncertain, and there is a growing need for effective condylar components. This study investigates the mechanical performance of various personalized 3D-printed mandibular plates , including commercial plates, solid plates, and mesh plates with relative densities ranging from 0.3 to 0.7 under muscle biting forces. Finite Element Analysis (FEA) is used to evaluate the behavior of these plates under simulated incisor biting conditions. Additionally, the study examines the wear resistance properties of 3D-printed CoCrMo and Ti6Al4V, both biocompatible materials, in different post-processing conditions for the condylar component, which is an active joint. The results indicate that mesh plates demonstrate superior mechanical performance. Furthermore, the specific wear rate of the UHMWPE disc shows no significant difference between 3D-printed CoCrMo and Ti6Al4V pins when compared to conventionally cast pins.

**Keywords:** Mandibular reconstruction ,Finite Element Analysis , Patient-specific Temporomandibular joint (TMJ) , Wear resistance

# **FEM analysis of lattice structure model simulating harmonic structure and precipitation strengthened structure**

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## **Abstract**

In these days, the lattice structure is attracting attention due to its excellent heat dissipation and light weight. However, it is unclear how the strength properties change depending on the lattice structure pattern. The purpose of this study is to find a lattice structure with high specific strength. In my research, I create lattice models simulating harmonic structure and precipitation strengthened structure, and test them using FEM analysis. I use BCC, FCC and cementite model to create the lattice structure. In FEM analysis, I perform stress based uniaxial compression test. Now, we finished test of lattice models simulating harmonic structure. I find a high stress concentration point in every lattice structure models from FEM analysis. In specific strength, I can't find specific differences between the lattice structure models. As for future plan, I will make precipitation strengthened lattice structure and compare with harmonic lattice structure.

**Keywords:** Lattice structure, harmonic structure, Specific strength, precipitation strengthened structure, FEM analysis

## MICROSTRUCTURE AND MECHANICAL PROPERTIES OF HYPOEUTECTIC AL-SI ALLOY WITH SC AND ZR ADDITIONS

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### Abstract

The Al-Si alloy group is one of the most commonly used for casting due to its superior fluidity. However, these alloys do not exhibit very good mechanical properties because of the large  $\alpha$ -Al grains and the coarse, plate-like structure of the eutectic Si. The addition of minor alloying elements is necessary to improve the mechanical properties. This study investigates the effects of scandium (Sc) and zirconium (Zr) additions as minor alloying elements on the microstructure and mechanical properties of Al-7Si-0.3Mg alloy. The macrostructure and microstructure were examined by optical microscopy and scanning electron microscopy. The mechanical properties were investigated by analyzing hardness and tensile properties. The results demonstrated that the addition of Sc and Zr reduces the primary  $\alpha$ -Al grains in Al-7Si-0.3Mg alloy. Moreover, Sc impacts the eutectic Si structure, transforming the coarse plate-like into a finer fibrous structure. As a result, it substantially improved the hardness and tensile properties. More importantly, the addition of Sc and Zr reduces the sensitivity to microstructure changes due to variations in cooling rates during solidification.

**Keywords:** A356 alloy, Scandium, Zirconium, Grain refinement, Eutectic modification

## **Strategies for Developing Hub Ports to Enhance the International Container Shipping in Indonesia**

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### **Abstract**

In International trade, the distribution of goods via sea freight, particularly container ships, remains irreplaceable. The use of container shipping in Indonesia is increasingly evolving. Indonesia, as a major country with a strategic location in Asia, still depends on foreign ports for the distribution of goods via International container ship routes. To establish a hub port in Indonesia is constrained by various factors, both technical and or regulatory. This article offers a study using a scenario analysis approach, exploring various potential strategies to achieve a comprehensive result for the best strategy that should be implemented in developing a hub port in Indonesia. This research aims to assess the development strategy for hub ports in Indonesia, particularly on the island of Java. The results of this study are expected to serve as a reference for stakeholders in developing their business strategies and as a reference for the government in future regulatory formulation and implementation.

**Keywords :** scenario planning, hub port, container shipping, strategic planning, shipping transport

# THE ENERGIES OF THE CAYLEY GRAPH ASSOCIATED TO A DIHEDRAL GROUP

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## Abstract

The energy of a simple graph was first inspired by the Hückel Molecular Orbital theory. It was used by chemists to estimate the energy associated with  $\pi$ -electron orbitals of molecules which are the conjugated hydrocarbons. In this research, the energy and the minimum degree energy of the Cayley graph associated to the dihedral group of order 6 with subsets of order at most three have been computed by using some concepts and properties in graph theory, group theory, and linear algebra. First, the Cayley graph is presented and is mapped onto the adjacency matrix and the minimum degree matrix, respectively to obtain the adjacency eigenvalues and the minimum degree eigenvalues. Finally, the energy and the minimum degree energy of the Cayley graph are obtained by using the adjacency eigenvalues and minimum degree eigenvalues. The results show an interesting relationship between the energy and the minimum degree energy of the Cayley graph of  $D_6$  and the order of the subset. Specifically, for subsets of order one, the energy and the minimum degree energy are the same, while for subsets of order two, the minimum degree energy is twice of the energy, and for subsets of order three, it triples the energy.

**Keywords:** Cayley graph, energy of graph, dihedral group, graph theory, group theory



# LAPLACIAN ENERGY OF GRAPHS ASSOCIATED TO SOME GENERALIZED QUATERNION GROUPS

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## Abstract

The energy of a graph was first defined by Gutman in 1978. It is used in chemistry to approximate the total  $\pi$ -electron energy of molecules. In 2006, Gutman and Zhou introduced the Laplacian energy of a graph which represents the summation of the absolute values of the Laplacian eigenvalues of the graph. In this research, the Laplacian energy is computed for the conjugacy class graph and conjugate graph associated to generalized quaternion groups of certain order. The conjugacy class graph of a finite group is a graph whose vertices are non-central conjugacy classes of the group, and two vertices are connected by an edge if and only if the cardinalities of their conjugacy classes are not coprime. Meanwhile, the conjugate graph is a graph whose vertices are the elements of the group and two vertices are adjacent if they are conjugates. The computation of the Laplacian energy is done by using the definitions of Laplacian energy, conjugacy class graph and conjugate graph.

**Keywords:** Laplacian energy, conjugate graph, conjugacy class graph, graph theory, group theory

# Ground Station Phased Array Antenna Design for Single LEO Satellite with Non-Equatorial Orbit

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## Abstract

This research project aims to develop a rectangular phased array antenna tailored for Ground Stations, facilitating communication with single Low Earth Orbit (LEO) satellites in non-equatorial orbits. Leveraging MATLAB, innovative techniques such as non-uniform array configuration, electrical scanning, and sub-array deployment were employed throughout the design and optimization phases. The significance of this work lies in its contribution to addressing the growing demand for cost-effective ground station infrastructure amidst the increasing utilization of LEO satellites. By offering a more affordable solution tailored specifically for LEO satellite communication, this research supports enhanced accessibility to space-based services and promotes the broader integration of satellite technologies into various industries and applications. Through meticulous design and optimization, this project aims to achieve narrow beamwidth, high gain performance characteristics essential for establishing reliable communication links with LEO satellites, thereby advancing the capabilities of ground station infrastructure for space communication.

**Keywords:** Phased Array, Antenna, LEO Satellite, Ground Station, SubArray

# THE WIENER INDEX OF A VARIANT OF CAYLEY GRAPH FOR DIHEDRAL GROUP

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## Abstract

A Wiener index is a topological index of a molecule described as the sum of the lengths of the shortest paths among all pairs of vertices in the chemical graph. Based on the chemical application of graph theory, this index is used to calculate the number of bonds between pairs of atoms in molecules by computing the total distance between all pairs by creating a distance matrix. Meanwhile, a Cayley graph is a graph that encodes the abstract structure of a group. An example of the applications of Cayley graph is in solving the Rubik's Cube. Various transformations and configurations of the cube constitute a subgroup within a permutation group, derived from the distinct horizontal and vertical rotations of the puzzle. In other words, each position of the cube corresponds to a vertex of the Cayley graph. One of the important groups that is always associated to graph theory is the dihedral group since this group represents the symmetries of a regular polygon including rotations and reflections. This is due to the applications of this group in various fields including computer graphics, crystallography, and chemistry. In chemistry, the dihedral groups are used to characterize the symmetry of molecules. Therefore, in this research, a variant of Cayley graph namely the prime power Cayley graph is constructed for the dihedral group, and the Wiener index of this graph is computed.

**Keywords:** Wiener Index, Cayley Graph, Group Theory, Dihedral Group.

## SERO - THE SOFTWARE ECOSYSTEMS REFERENCE ONTOLOGY

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### Abstract

The Scientists and practitioners do not have a common language for software ecosystem modeling. This leads to inconsistent models, information loss, ambiguous models, and an overall loss to the research community. By comparing and integrating four frameworks from the literature, we develop a reference ontology that describes the fundamental concepts of ecosystems within the software industry. Using the reference ontology, researchers can develop a software ecosystem modeling language that can be used to create rich, standard, and well-formed models.

**Keywords:** software ecosystem, ontology, modeling language, software industry, information science.

## The Sombor Index of the Cayley Graph of a Crystallographic Point Group

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### Abstract

Crystallography is the science that studies the forms, structures, and arrangements of crystals. It is the experimental determination of the arrangement of atoms in crystalline solids, which is important in materials science, solid-state physics, and many other fields. From a mathematical perspective, symmetry-related phenomena can be described using a variety of mathematical objects. For example, a group can be used to describe the symmetry elements in a crystal. Crystallographic point groups are fundamental in crystallography for describing the symmetry properties of crystals. A crystallographic point group is a set of symmetry operations that keep at least one point fixed in a crystal lattice. They are represented by specific symbols and classified according to the symmetry elements they contain, such as rotation axes, mirror planes, and inversion centers. Furthermore, theoretical description of symmetry breaking can be analyzed based on group theory and graph theory by using a Cayley graph. A Cayley graph of crystallographic point groups consists of a finite number of vertices and edges depending on the groups' generators. In this research, the Sombor index of the Cayley graph of a crystallographic point group under hexagonal crystal system is computed. This index is a numerical invariant that is important for understanding the topological characteristics of chemical structures, as well as for studying various molecular properties and behaviours.

**Keywords:** Crystallography, Crystallographic point group, Cayley graph, Sombor index

# THE PRIME POWER CAYLEY GRAPH OF A QUATERNION GROUP AND ITS ZAGREB INDEX

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## Abstract

Graph theory provides a powerful framework for understanding and analyzing relationships in various real-life scenarios, from social networks to transportation systems to biological interactions. A graph is a mathematical structure that consists of two sets which are a set of vertices (or nodes) and a set of edges connecting pairs of vertices. For example, in social networks like Facebook or Twitter, each person is a node in the graph, and connections between them (friendships, followers) are the edges. Graph theory helps these platforms suggest friends or recommend people to follow based on the connections in the graph. Meanwhile, a quaternion group is derived based on the quaternion number system, which extends the complex number. Quaternions are useful in calculations involving rotations in three dimensions, such as in three-dimensional computer graphics, computer vision, magnetic resonance imaging and crystallography. In this study, a variant of graph of groups namely the prime power Cayley graph of a quaternion group is constructed and its Zagreb index is determined. A Zagreb index is one of the topological indices which are used in chemical graph theory to characterize the structural features of molecular graphs. This index is calculated based on the degrees of vertices in the graph.

**Keywords:** Graph theory, Quaternion group, Zagreb index, Topological Indices.