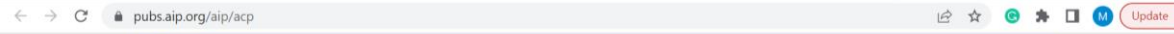





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It is with great pleasure to welcome you to Symposium on Advances of Sustainable Engineering (SIMASE) 2021 hosted by Rumah Publikasi Indonesia on August 18-19, 2021. The event aims to be a venue for engineers, researchers, scholars, and policy makers to explore the challenges and opportunities from the pandemic on civil engineering, mechanical engineering, manufacturing process and engineering materials, and electrical engineering. For civil engineers, they will play a significant part in the recovery since design and construction services will be needed in the future, and they need to develop new construction methods, materials, and technologies in order to build a sustainable and resilient infrastructure. For manufacturers and engineers, they need to start thinking about the long-term change of their operations and adapt to the "new normal" that has emerged because of the epidemic. We welcome all parties to share their research and thoughts in the symposium.

Finally, on behalf of the editors of SIMASE 2021, I would like to extend my most sincere gratitude to the organizing committee, co-hosting institutions, and most importantly, participants, speakers, presenters, and authors of the symposium. I do hope the proceedings bring significant contribution, particularly to the field of advances of sustainable engineering. I look forward to seeing you all at the upcoming symposium.

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# Issues

Select Decade

2020 ▾

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Issue

27 April - Volume 2648, Issue 1 ▾

Volume 2646, Issue 1

27 April 2023



ARTICLES

In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

PRELIMINARY

Preface: Proceedings of the Symposium on Advance of Sustainable Engineering 2021 (SIMASE 2021): Post Covid-19 Pandemic: Challenges and Opportunities in Environment, Science, and Engineering Research

AIP Conference Proceedings 2646, 010001 (2023) doi: <https://doi.org/10.1063/1.5012294>

View article

PDF

BIOLOGY

Comparison of potential compounds *Saussureamine D* and *Saussureamine E* from the plant *Saussurea costus* falc. as a inhibitor of SARS CoV-2 RNA-dependent RNA-polymerase (RDRP) in silico

Yani Suryani, Opek Tauparromotom, Adhitya Virakawati Damila, Fauzan Ahsan Hafidhin, Aep Kusnawan, Sorbini Abdul Wasylk, Gwang Adhitya Purba, Budiman Eko Wilowati

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Abstract ▾

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PDF

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A review of the motivation theories in learning

<p><b>Volume 2646, Issue 1</b></p> <p>27 April 2023</p> <p>All Issues</p>	<p><b>In this Issue</b></p> <p>PRELIMINARY</p> <p><b>BIOLOGY</b></p> <p>CHEMISTRY</p> <p>COMPUTER SCIENCE AND TECHNOLOGY</p> <p>ENGINEERING</p> <p>GENERAL PHYSICS</p>	<p>A review of the motivation theories in learning</p> <p>Introduction to Monte Carlo Simulation</p> <p>What is big data? A consensual definition and a review of key research topics</p>
	<p><b>The <math>\text{CH}_3\text{CO}_2\text{H}</math> effect on the quality of halai gelatin from gouramy (<i>Osphronemus gouramy</i>) bone</b></p> <p>Anggila Rahmi Hahani, Aulia Anul Wardah</p> <p>AP Conference Proceedings 2646, 020002 (2023) doi: <a href="https://doi.org/10.1003/c.0113735">https://doi.org/10.1003/c.0113735</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>	
	<p><b>Effect of silicon concentration on soybean plant</b></p> <p>Budy Prasetyo Tadiq Quomman, Salamat Gnanjar, Sghatufathi Ash Shidiq, Abraham Sunedikusumah</p> <p>AP Conference Proceedings 2646, 020003 (2023) doi: <a href="https://doi.org/10.1003/c.0113731">https://doi.org/10.1003/c.0113731</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>	
	<p><b>Diversity of sea cucumbers and brittle stars in intertidal zone, Karang Papak coastal, West Java, Indonesia</b></p> <p>E. Pasulih, R. A. S. D. R. Putri, W. T. Ardiansyah, S. K. Wardani, W. Setyia, Y. Suryani, I. Zulfahmi, Rumondang</p> <p>AP Conference Proceedings 2646, 020004 (2023) doi: <a href="https://doi.org/10.1003/c.0129634">https://doi.org/10.1003/c.0129634</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>	
	<p><b>Amphibian diversity (order of Anura) based on distance from water bodies in different communities in Situ Patengan area</b></p> <p>A. Widiana, Sodkin, A. Yulawati, R. M. Hasybi, I. F. Syarifati</p> <p>AP Conference Proceedings 2646, 020005 (2023) doi: <a href="https://doi.org/10.1003/c.0129635">https://doi.org/10.1003/c.0129635</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>	

<b>Volume 2646, Issue 1</b>	
27 April 2023 All Issues	
<b>In this Issue</b>	<a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a>
<b>PRELIMINARY</b>	
<b>BIOLOGY</b>	
CHEMISTRY	
COMPUTER SCIENCE AND TECHNOLOGY	
ENGINEERING	
GENERAL PHYSICS	
	<p><b>The effect of organic mulch and Trichoderma sp on radish</b></p> <p>Yati Setiati Rachmawati, Agus Dudiarni, Kandung Hamsan</p> <p>AIP Conference Proceedings 2646, 020006 (2023) doi: <a href="https://doi.org/10.1063/5.0125625">https://doi.org/10.1063/5.0125625</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>
	<p><b>The effect of banana stems compost and various tuber sizes of G4 potato seed on growth, yield and quality of potato Var. Granola</b></p> <p>Adiat Sudrajat, Soliya Haniati, Imam Khoirul Akom Lidiqian, Yati Setiati Rachmawati, M. Subandi</p> <p>AIP Conference Proceedings 2646, 020007 (2023) doi: <a href="https://doi.org/10.1063/5.0111136">https://doi.org/10.1063/5.0111136</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>
	<p><b>Identification and characterization of gut microbiota of <i>Coturnix coturnix japonica</i></b></p> <p>A Kusumanti, R. Rochmah, Y Suryani</p> <p>AIP Conference Proceedings 2646, 020008 (2023) doi: <a href="https://doi.org/10.1063/5.0112909">https://doi.org/10.1063/5.0112909</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>
	<p><b>Effects of feeding mixed tofu dregs and fish waste at various compositions and feeding time on the growth of black soldier fly (<i>Hermetia illucens</i>) larvae</b></p> <p>Ida Khasbi, Luh Wayan Ari Smitri, Ramadhani Elka Putra</p> <p>AIP Conference Proceedings 2646, 020009 (2023) doi: <a href="https://doi.org/10.1063/5.0115729">https://doi.org/10.1063/5.0115729</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>

## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Notes on terrestrial orchids in Mount Burangrang Nature Reserve, West Java

Tri Cahyanto, Triska Rosma, Dikri Zukarnoen, Muhammad Efendi, Ahtansyah Fadilah, Yuni Kusum  
AIP Conference Proceedings 2646, 020010 (2023) doi: <https://doi.org/10.1063/5.0114489>

[Abstract](#)

[View article](#)

[PDF](#)

### Bioconversion efficiencies of several food waste by black soldier fly, *Hermetia illucens* (L.) (diptera: Stratiomyidae) larvae for sustainable waste management

U. Juita, L. L. Fitri, A. D. Permiana

AIP Conference Proceedings 2646, 020011 (2023) doi: <https://doi.org/10.1063/5.0129590>

[Abstract](#)

[View article](#)

[PDF](#)

### Polyethylene terephthalate (PET) plastic biodegradation by sea water bacteria

D. A. Naswadi, A. Rasyid, Tarkotumirki, M. F. Fachrul

AIP Conference Proceedings 2646, 020012 (2023) doi: <https://doi.org/10.1063/5.0117587>

[Abstract](#)

[View article](#)

[PDF](#)

### Determining pollutant load capacity of nitrate and phosphate using the QUAL2Kw model

E. G. Play, W. Asteno, D. I. Hendrawan

AIP Conference Proceedings 2646, 020013 (2023) doi: <https://doi.org/10.1063/5.0117591>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Acid mine drainage processing with ex-situ bioremediation on batch reactor by sulphate reducing bacteria: A literature study

F. Terfiana, A. Rianadi, B. Iwanito, B. Subiantiyah

AIP Conference Proceedings 2646, 020014 (2023) doi: <https://doi.org/10.1063/5.0117227>

[Abstract](#)

[View article](#)

[PDF](#)

### Evaluation of wastewater quality of tempeh industry (case study of Tempeh Semanan Industrial Estate)

M. R. Pakpahan, R. Raniyat, D. Hendrawan

AIP Conference Proceedings 2646, 020015 (2023) doi: <https://doi.org/10.1063/5.0117588>

[Abstract](#)

[View article](#)

[PDF](#)

### Relation of traffic-related air pollution and people's duration of stay at sidewalk café/restaurant

M. C. Adisana, A. S. Wartaman, H. M. Toki

AIP Conference Proceedings 2646, 020016 (2023) doi: <https://doi.org/10.1063/5.0112637>

[Abstract](#)

[View article](#)

[PDF](#)

### Granular aerobic sludge cultivation in the sequencing batch reactor

Rizani Yolanda Salim, Roslailanti Hadisoubroto, Rathaningsih

AIP Conference Proceedings 2646, 020017 (2023) doi: <https://doi.org/10.1063/5.0117653>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Effect of ecolabel on environmental quality

D. Setiati, M. Zuhair, A. Masrini, Suparwo, Yulisa Sanjari

AIP Conference Proceedings 2646, 020018 (2023) doi: <https://doi.org/10.1063/5.0113032>

[Abstract](#)

[View article](#)

[PDF](#)

### Managing environmental ethics in the context of pro-environmental behaviour

D. Setiati, M. Zuhair, S. Nuraini, Suparwo, A. Masrini

AIP Conference Proceedings 2646, 020019 (2023) doi: <https://doi.org/10.1063/5.0113033>

[Abstract](#)

[View article](#)

[PDF](#)

### Impact of environmental awareness on environmental performance

A. Masrini, M. Zuhair, D. Setiati, Suparwo, A. Putra

AIP Conference Proceedings 2646, 020020 (2023) doi: <https://doi.org/10.1063/5.0113028>

[Abstract](#)

[View article](#)

[PDF](#)

### Environmental commitment management based on environmental attitude

A. Masrini, M. Zuhair, D. Setiati, Suparwo, Rahmawati

AIP Conference Proceedings 2646, 020021 (2023) doi: <https://doi.org/10.1063/5.0113029>

[Abstract](#)

[View article](#)

[PDF](#)



Volume 2646, Issue 1

27 April 2023

All Issues

In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

Effect of planting spaces and organic fermented cows's urine on growth and yield of Talenta varieties of com (*Zea mays saccharata*)

Muhammad Subandjo, Ikhsan Hapid Abdillah, Dikayani

AIP Conference Proceedings 2646, 020022 (2023) doi: <https://doi.org/10.1063/5.0115750>

Abstract

View article

PDF

Implementation YOLOv3 for symptoms of disease in shallots crop

A. Sunarudin, Adi Sunaryadi, Auliah Puzpaningrum, Aditya Rifay Fauza

AIP Conference Proceedings 2646, 020023 (2023) doi: <https://doi.org/10.1063/5.0113748>

Abstract

View article

PDF

CHEMISTRY

Inventory of PM<sub>2.5</sub> concentration at roadside using LVAS and particulate counter during the Covid-19 pandemic on Bandung urban road

Nadila Gine Salana, Yekob Astor

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Abstract

View article

PDF

Performance of food industry wastewater treatment plant (WWTP) by combining anaerobic, aerobic, and ozonation process

Ira Ryski Welyani, Imam Rozali Fathur, Assyifa Junitasari

AIP Conference Proceedings 2646, 030002 (2023) doi: <https://doi.org/10.1063/5.0114405>

Abstract

View article

PDF



Volume 2646, Issue 1

27 April 2023

All Issues

In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

Synthesis of hydroxyapatite from chicken eggshells and its applications as adsorbent of cadmium(II) metal ion in aqueous solution

Vina Amelia, M. Guswanda Putra, Eko Prabowo Hadisantoso, Fitriyani Rizka S., Yusuf Rohmatulloh

AIP Conference Proceedings 2646, 030003 (2023) doi: <https://doi.org/10.1063/5.0113179>

Abstract

View article

PDF

Extraction and identification of carotenoids from the skin of banana kepok (*Musa paradisiaca* L.)

Nunung Kumashih, Wulan Sari, Vina Amelia, Assyifa Junitasari

AIP Conference Proceedings 2646, 030004 (2023) doi: <https://doi.org/10.1063/5.0113916>

Abstract

View article

PDF

Analysis of groundwater pollution vulnerability using DRASTIC method development in Bandung city

Adi Mulyana Supriatna, Suprihanto Notodarmadjo, Ira Ryski Welyani, Assyifa Junitasari

AIP Conference Proceedings 2646, 030005 (2023) doi: <https://doi.org/10.1063/5.0125507>

Abstract

View article

PDF

Isolation and characterization of amylase from cassava skin (*Manihot utilisima* Pohl)

Tina Dewi Rosahdi, Rendi Pitriani, Asap Supriadin, Assyifa Junitasari

AIP Conference Proceedings 2646, 030006 (2023) doi: <https://doi.org/10.1063/5.0112764>

Abstract

View article

PDF



Volume 2646, Issue 1

27 April 2023

All Issues

In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

Determination nutrient content (C, N, P, K) on the citrus (*Citrus* sp.), pineapple (*Ananas comosus*), papaya (*Carica papaya* L.) peels eco-enzyme

Rumirah, Ida Yurudaty, Tina Dewi Rosahdi

AIP Conference Proceedings 2646, 030007 (2023) doi: <https://doi.org/10.1063/5.0112775>

Abstract

View article

PDF

Antioxidant activity of essential oil from basil (*Ocimum sanctum* L.)

Nunung Kumashih, Muhamad Latief, Asap Supriadin, Assyifa Junitasari

AIP Conference Proceedings 2646, 030008 (2023) doi: <https://doi.org/10.1063/5.0113011>

Abstract

View article

PDF

Lead (II) ion removal using a cellulose acetate-PEG membrane from water hyacinth (*Eichhornia crassipes*)

Vina Amelia, Nida Nadhifah, Teti Sudarti, Nisa Nur Khesanah

AIP Conference Proceedings 2646, 030009 (2023) doi: <https://doi.org/10.1063/5.0113181>

Abstract

View article

PDF

The effect of concentration and temperature on the activities of polyvinyl alcohol (PVA) as iron corrosion inhibitor in solution of NaCl

Teti Sudarti, Siti Robiah Pitriah, Yusuf Rohmatulloh, Asap Supriadin

AIP Conference Proceedings 2646, 030010 (2023) doi: <https://doi.org/10.1063/5.0113153>

Abstract

View article

PDF



<p><b>Volume 2646, Issue 1</b></p> <p>27 April 2023 <i>All Issues</i></p> <p><b>In this Issue</b></p> <p>PRELIMINARY</p> <p>BIOLOGY</p> <p><b>CHEMISTRY</b></p> <p>COMPUTER SCIENCE AND TECHNOLOGY</p> <p>ENGINEERING</p> <p>GENERAL PHYSICS</p>	<p>Effectiveness of ozonization process on reducing wastewater pollutant levels from integrated laboratory IPAL sedimentation process</p> <p>S. Jusiah, Y. Sumawandari, N. Windayanti, I. R. Father AIP Conference Proceedings 2646, 030811 (2023) doi: <a href="https://doi.org/10.1063/5.0114195">https://doi.org/10.1063/5.0114195</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Chemical oxygen demand reduction and pretreatment method of dairy industry sludge waste for lactic-acid fermentation purpose</p> <p>Yati Sugarti, Sani Normayanti, Lili Naulufhar, Rama Triyana, Angganni Widia Nola AIP Conference Proceedings 2646, 030812 (2023) doi: <a href="https://doi.org/10.1063/5.0112173">https://doi.org/10.1063/5.0112173</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Comparison of antibacterial power of garlic (<i>Allium sativum</i>) and shallot (<i>Allium ascalonicum</i> L.) against <i>Staphylococcus aureus</i> ATCC 6538</p> <p>Yulia Kambaliwati, Assyifa Juntesan, Tina Dewi Rusdiah AIP Conference Proceedings 2646, 030813 (2023) doi: <a href="https://doi.org/10.1063/5.0114268">https://doi.org/10.1063/5.0114268</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Detection of rat DNA content in snacks of public elementary school children in Bandung city with PCR (polymerase chain reaction) technique</p> <p>Ayuni Adawiyati, Fatya Shofiaturohmah, Yanti Suryani, Tri Cahyanto, Yuni Kulsarti, Desi Nurjanah, Neneng Windayanti, Rendi Arba Ulini, Huzatul Qodim AIP Conference Proceedings 2646, 030814 (2023) doi: <a href="https://doi.org/10.1063/5.0120768">https://doi.org/10.1063/5.0120768</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>
<p><b>Volume 2646, Issue 1</b></p> <p>27 April 2023 <i>All Issues</i></p> <p><b>In this Issue</b></p> <p>PRELIMINARY</p> <p>BIOLOGY</p> <p><b>CHEMISTRY</b></p> <p>COMPUTER SCIENCE AND TECHNOLOGY</p> <p>ENGINEERING</p> <p>GENERAL PHYSICS</p>	<p>The development of a simple distillation kit for green chemistry oriented organic liquid waste recycling</p> <p>Sani Sari, Maya Amelia, Neneng Windayanti, Dendi Mhaige AIP Conference Proceedings 2646, 030815 (2023) doi: <a href="https://doi.org/10.1063/5.0116596">https://doi.org/10.1063/5.0116596</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Composite of hydroxyapatite (HA) from eggshells and TiO<sub>2</sub></p> <p>E. N. Asyiah, F. S. Irwansyah, A. R. Nuriyanti, D. R. Eddy AIP Conference Proceedings 2646, 030816 (2023) doi: <a href="https://doi.org/10.1063/5.0113777">https://doi.org/10.1063/5.0113777</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Making of chemopoly game Android-based in atomic structure material</p> <p>Ade Dinaldi Fauziah, Feri Septi Irwansyah, Cucu Zenab Subarkah AIP Conference Proceedings 2646, 030817 (2023) doi: <a href="https://doi.org/10.1063/5.0116329">https://doi.org/10.1063/5.0116329</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Developing of gas stoichiometry learning kit based on green chemistry</p> <p>Yulia Sukmawandani, Fit Nur Aulia, Ida Fanda AIP Conference Proceedings 2646, 030818 (2023) doi: <a href="https://doi.org/10.1063/5.0114197">https://doi.org/10.1063/5.0114197</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>
<p><b>Volume 2646, Issue 1</b></p> <p>27 April 2023 <i>All Issues</i></p> <p><b>In this Issue</b></p> <p>PRELIMINARY</p> <p>BIOLOGY</p> <p><b>CHEMISTRY</b></p> <p>COMPUTER SCIENCE AND TECHNOLOGY</p> <p>ENGINEERING</p> <p>GENERAL PHYSICS</p>	<p>Determination of bioethanol in fermented products with redox titration</p> <p>Y. Hakim, Y. Sukmawandari, N. Windayanti AIP Conference Proceedings 2646, 030819 (2023) doi: <a href="https://doi.org/10.1063/5.0114198">https://doi.org/10.1063/5.0114198</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Analysis of the alcohol content of milk kefir with the addition of anti-yeast</p> <p>N. Windayanti, S. Rahmatullah, F. S. Irwansyah, W. A. Sitoresmi, S. Jusiah AIP Conference Proceedings 2646, 030820 (2023) doi: <a href="https://doi.org/10.1063/5.0113949">https://doi.org/10.1063/5.0113949</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p>Analysis of alcohol content based on fermentation temperature of milk kefir</p> <p>S. Rahmatullah, F. S. Irwansyah, W. Q. Alila, T. R. Putri AIP Conference Proceedings 2646, 030821 (2023) doi: <a href="https://doi.org/10.1063/5.0117196">https://doi.org/10.1063/5.0117196</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p> <hr/> <p><b>COMPUTER SCIENCE AND TECHNOLOGY</b></p> <p>Implementation of artificial neural network for predicting water drag of the aircraft floater</p> <p>Sigit Tri Adhapi, Ruzgon Fajar, S. Syamsuar, S. Sudyo AIP Conference Proceedings 2646, 040001 (2023) doi: <a href="https://doi.org/10.1063/5.0114019">https://doi.org/10.1063/5.0114019</a></p> <p><a href="#">Abstract</a> <a href="#">View article</a> <a href="#">PDF</a></p>

## Volume 2646, Issue 1

27 April 2023  
[All issues](#)

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

**COMPUTER SCIENCE AND TECHNOLOGY**

ENGINEERING

GENERAL PHYSICS

### A-star algorithm implementation for determining the nearest police personnel with the occurrence of the case

Ichsen Taufik, Faiz M. Kuffah, Oki Reval Julenda, Agung Wahana, Popon

AP Conference Proceedings 2646, 640002 (2023) doi: <https://doi.org/10.1063/5.0112728>

[Abstract](#)

[View article](#)

[PDF](#)

### Information and communication technology in educational management for sustainable development in Indonesia

Nughradin, Asri Komariah, Dedy Achmad Kumady, Mileniz Nurahma, Galena Ilma Lya Persapa, Nabila Salma Zaira, Rensha Dewi, Nabila Febrya Azwanda

AP Conference Proceedings 2646, 640003 (2023) doi: <https://doi.org/10.1063/5.0113634>

[Abstract](#)

[View article](#)

[PDF](#)

### Application-based archive management for accelerated process of shrinking and recovering active inactive data

Syahminan, Wi Setyaningsih, Dianawati Suryaningtyas

AP Conference Proceedings 2646, 640004 (2023) doi: <https://doi.org/10.1063/5.0129609>

[Abstract](#)

[View article](#)

[PDF](#)

### USDP method with COSO elements: E-internal control system's application

I. Tyason, I. Anshad, M. F. Inanto, E. Sarwoko

AP Conference Proceedings 2646, 640005 (2023) doi: <https://doi.org/10.1063/5.0114070>

[Abstract](#)

[View article](#)

[PDF](#)

### Amazing culture: Game of local wisdom based on unity engine

Anel Rahman Hakim, Romadhon, Prihatin Sulistyowati, Silvia Wadani, Sholihah

AP Conference Proceedings 2646, 640006 (2023) doi: <https://doi.org/10.1063/5.0112981>

[Abstract](#)

[View article](#)

[PDF](#)

### An interaction of problem based learning models and work motivation on students' competence in programmable logic control subject

Fendi Achmad, Mospayah, Edy Sulistyri, Agus Wiyono, Dedy Rahman Prihatin, Setya Chandra Wibawa, Supripto, Subuh Ismat Haryudo, Suarwanto, Daeng Rahmatullah

AP Conference Proceedings 2646, 640007 (2023) doi: <https://doi.org/10.1063/5.0127141>

[Abstract](#)

[View article](#)

[PDF](#)

### Effectiveness of IoT learning using SEAMOLEC platform through distance and open education

Ado Rahma Yuly, Handi Pradana, Dena Rouda Ramdania, Darma Wahyu Nurhidayah, Yudi Prihatnyana

AP Conference Proceedings 2646, 640008 (2023) doi: <https://doi.org/10.1063/5.0129756>

[Abstract](#)

[View article](#)

[PDF](#)

### Information system to support the implementation of good university governance

Endi Sarwoko, Iva Nurdiana Nurlanda, Sulistyri, Irma Tyason

AP Conference Proceedings 2646, 640009 (2023) doi: <https://doi.org/10.1063/5.0112742>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
[All issues](#)

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

**COMPUTER SCIENCE AND TECHNOLOGY**

ENGINEERING

GENERAL PHYSICS

### Electronic module for addition and subtraction of fractions based on numerical literacy

D. Triwahyuningtyas, N. R. Sesanti, I. B. Anggrawal

AP Conference Proceedings 2646, 640010 (2023) doi: <https://doi.org/10.1063/5.0112130>

[Abstract](#)

[View article](#)

[PDF](#)

### Using the linear sequential model method for Android-based encyclopedias

Prihatin Sulistyowati, Rofidatul Nuriati Putri, Anel Rahman Hakim

AP Conference Proceedings 2646, 640011 (2023) doi: <https://doi.org/10.1063/5.0112863>

[Abstract](#)

[View article](#)

[PDF](#)

### Development of Muvizu-based animation video with geometrical spatial shapes

Rahayu Katsadinata, Ahmad Farwad Reduan, Juwairah

AP Conference Proceedings 2646, 640012 (2023) doi: <https://doi.org/10.1063/5.0115267>

[Abstract](#)

[View article](#)

[PDF](#)

### Batik patterns with geometrical shapes using Android geometry pad

Ayuni Sri Rahmans, Rahayu Katsadinata, Yuyu Nurhayati Rahayu, Nunung Soebarningsih

AP Conference Proceedings 2646, 640013 (2023) doi: <https://doi.org/10.1063/5.0130812>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Geometric construction using compass and straightedge on GeoGebra

I. Maryono, Y. S. Kusumawati, J. A. Dahlan

AIP Conference Proceedings 2646, 040014 (2023) doi: <https://doi.org/10.1063/5.0112307>

[Abstract](#)

[View article](#)

[PDF](#)

### Design and verification of Cov-trek prototype based on systems modeling language (SysML) and modeling framework

I. Made Suartana, Ricky Eko Putra, Nurhasan, Sujanwardo

AIP Conference Proceedings 2646, 040015 (2023) doi: <https://doi.org/10.1063/5.0112733>

[Abstract](#)

[View article](#)

[PDF](#)

### Online learning based on the viewpoint of electrical engineering department students

Yuli Suto Nugroho, Faried Waddi, Supriatno, Agus Hartiyanto

AIP Conference Proceedings 2646, 040016 (2023) doi: <https://doi.org/10.1063/5.0112827>

[Abstract](#)

[View article](#)

[PDF](#)

### Quickly understanding of android-based application athlete's buddy to balancing the athlete physical nutrition

Setya Chandra Wibawa, Ety Sulitkyo, Bambang Supatniko, Annisa Rohmi Namsawati, Eko Handoyo, Joni Susilowibowo, Bachtiar S. Bachti

AIP Conference Proceedings 2646, 040017 (2023) doi: <https://doi.org/10.1063/5.0112841>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Maximum excess over sub-arrays distance to assess creative thinking

Yeni Andiyasari, Elchariadi, I. Gusli Putu Asto Budipahyanto, Bambang Yulianto, Supriatno, Shirdani C. Hidayati

AIP Conference Proceedings 2646, 040018 (2023) doi: <https://doi.org/10.1063/5.0123684>

[Abstract](#)

[View article](#)

[PDF](#)

### Improvement design of marketing communication program in shoe company using benchmarking method and analytical hierarchy process tools

N. C. Mahayanti, H. Amari, M. Rendra

AIP Conference Proceedings 2646, 040019 (2023) doi: <https://doi.org/10.1063/5.0123695>

[Abstract](#)

[View article](#)

[PDF](#)

### Optimization of channel distribution for capacitated vehicle routing problem (CVRP): A case study of BULOG in East Lombok Regency

A. R. Sopandi, E. Nagata, T. E. Lestari

AIP Conference Proceedings 2646, 040020 (2023) doi: <https://doi.org/10.1063/5.0123699>

[Abstract](#)

[View article](#)

[PDF](#)

### Decision making analysis in the selection of electric generators using AHP and TOPSIS methods

H. Aslami, I. Kurniawan, W. A. Kurniawan, A. S. Amin, B. I. Hakim

AIP Conference Proceedings 2646, 040021 (2023) doi: <https://doi.org/10.1063/5.0123705>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Technological perspective on innovation, development and change in response to Covid-19: A scientometric research

S. R. Muberoq, A. G. Abdullah, A. Setiawan, I. Widiaty, M. A. Dhina

AIP Conference Proceedings 2646, 040022 (2023) doi: <https://doi.org/10.1063/5.0112740>

[Abstract](#)

[View article](#)

[PDF](#)

### Implementation of Three JS on batik digital museum development

Isma Widiaty, Eki Nigraha, Rista Mingga, Sugeng Rifqi Muberoq, Handa Widya Kurniati

AIP Conference Proceedings 2646, 040023 (2023) doi: <https://doi.org/10.1063/5.0112849>

[Abstract](#)

[View article](#)

[PDF](#)

### Classification of heart disability based on electrocardiogram medical records using data mining classification methods

Sumarti, Donny Fernando, Ayu Purwana Sari, Felicia Felicia, Thoha Nurhadyan, Agung Triayudi

AIP Conference Proceedings 2646, 040024 (2023) doi: <https://doi.org/10.1063/5.0112808>

[Abstract](#)

[View article](#)

[PDF](#)

### Identification of supporting factors for technology components in SMEs in facing global competition

A. Ikwana, M. Mufti, Y. Mauludin, H. Aslami, R. Kurniawan

AIP Conference Proceedings 2646, 040025 (2023) doi: <https://doi.org/10.1063/5.0113183>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

**COMPUTER SCIENCE AND  
TECHNOLOGY**

ENGINEERING

GENERAL PHYSICS

### Factors affecting transfer shopping transactions in e-commerce

A. Ikhwana, I. S. Lestari, R. Kurniawati, D. S. Tapajani, Y. Mauludin

AIP Conference Proceedings 2646, 040035 (2023) doi: <https://doi.org/10.1063/5.0112196>

[Abstract](#)

[View article](#)

[PDF](#)

### Efficiency of material inventory using economic order quantity (EOQ) calculation techniques

K. Vorawati, W. Hadi, V. K. Ladusi, S. Sahara, Y. P. Putra, E. Andarwati

AIP Conference Proceedings 2646, 040027 (2023) doi: <https://doi.org/10.1063/5.0112838>

[Abstract](#)

[View article](#)

[PDF](#)

### The implementation of reverse logistics for the development of e-waste distribution centre for small electronic devices users

J. S. Iqbal

AIP Conference Proceedings 2646, 040028 (2023) doi: <https://doi.org/10.1063/5.0129400>

[Abstract](#)

[View article](#)

[PDF](#)

### Completion of the CVRP model for the case of distribution of leather raw materials in Garut using the sweep algorithm approach

D. S. Tapajani, A. Ikhwana, Y. Mauludin, R. Kurniawati, D. C. Hadinata

AIP Conference Proceedings 2646, 040029 (2023) doi: <https://doi.org/10.1063/5.0129649>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

**COMPUTER SCIENCE AND  
TECHNOLOGY**

ENGINEERING

GENERAL PHYSICS

### Analyzing sentiment and topic modelling of iPhone Xs post launch event through Twitter data

M. I. Fakhr, H. Irawan

AIP Conference Proceedings 2646, 040030 (2023) doi: <https://doi.org/10.1063/5.0129382>

[Abstract](#)

[View article](#)

[PDF](#)

### Object detection for pattern analysis of consumer behaviour to optimise store layout

H. Z. Santoso, H. Irawan, S. Widyanesti

AIP Conference Proceedings 2646, 040031 (2023) doi: <https://doi.org/10.1063/5.0129753>

[Abstract](#)

[View article](#)

[PDF](#)

### Agile project management maturity level: The case of Indonesia

L. Riko, A. M. Aamir

AIP Conference Proceedings 2646, 040032 (2023) doi: <https://doi.org/10.1063/5.0118279>

[Abstract](#)

[View article](#)

[PDF](#)

### WINNER: Technological innovation using renewable energy sources

I. Cahyadi, H. Akbar, M. Syamsuddin, N. Nuphanudin, H. Puspita

AIP Conference Proceedings 2646, 040033 (2023) doi: <https://doi.org/10.1063/5.0113008>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

**COMPUTER SCIENCE AND  
TECHNOLOGY**

ENGINEERING

GENERAL PHYSICS

### Application of AHP and SAW in the selection of electric generators in manufacturing companies

H. Aulani, E. J. Hayati, N. S. Suseno, W. Sutikawati, A. S. Amin

AIP Conference Proceedings 2646, 040034 (2023) doi: <https://doi.org/10.1063/5.0127185>

[Abstract](#)

[View article](#)

[PDF](#)

### The impact of brand awareness and perceived quality on smartphone customer loyalty

N. S. Suseno, H. Aulani

AIP Conference Proceedings 2646, 040035 (2023) doi: <https://doi.org/10.1063/5.0118164>

[Abstract](#)

[View article](#)

[PDF](#)

### Partial least squares structural equation models to assess the impact of digital technology and industry

N. Nugraha, O. Rukmana, K. I. M. Shari, A. A. Nurrahman

AIP Conference Proceedings 2646, 040036 (2023) doi: <https://doi.org/10.1063/5.0131099>

[Abstract](#)

[View article](#)

[PDF](#)

### The design of android application for 3D microteaching based on augmented reality

R. A. Arianti, A. A. Juntur, E. Kemasuddin

AIP Conference Proceedings 2646, 040037 (2023) doi: <https://doi.org/10.1063/5.0114921>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Ergonomic bench for college students in Indonesia

B. I. Putra, R. B. Jakaria, T. Saemano

AIP Conference Proceedings 2646, 040036 (2023) doi: <https://doi.org/10.1063/5.0123652>

[Abstract](#)

[View article](#)

[PDF](#)

### Digital literacy within the context of industry-driven education

Alfatar Rohdyah, Isma Widaty

AIP Conference Proceedings 2646, 040035 (2023) doi: <https://doi.org/10.1063/5.0133083>

[Abstract](#)

[View article](#)

[PDF](#)

### Smart watches in the industrial revolution 4.0 era

Selwa Fatma Supratman, Isma Widaty, Nani Rohaeni

AIP Conference Proceedings 2646, 040040 (2023) doi: <https://doi.org/10.1063/5.0123630>

[Abstract](#)

[View article](#)

[PDF](#)

### Subak system technology to promote sustainable development within the industry

T. Tarant, S. D. Sordani

AIP Conference Proceedings 2646, 040041 (2023) doi: <https://doi.org/10.1063/5.0113021>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Machine learning approach for scholarship candidate selection on Islamic State University in Indonesia

Mohamad Irfan, Wilidan Budawan Zulfar, Rina Anjar Ramadanti, Agung Wahana, Yana Adila Gerhana

AIP Conference Proceedings 2646, 040042 (2023) doi: <https://doi.org/10.1063/5.0133047>

[Abstract](#)

[View article](#)

[PDF](#)

### Review of artificial neural network applications for prediction of internal combustion engine performance

L. Sholahuddin, R. Fajar, S. Ismanboko

AIP Conference Proceedings 2646, 040043 (2023) doi: <https://doi.org/10.1063/5.0117389>

[Abstract](#)

[View article](#)

[PDF](#)

### Mathematical model of dengue transmission in the early-age group

Fadiah Iahli, Nur Fadlaturohmah, Endi, Euis Rohayati

AIP Conference Proceedings 2646, 040044 (2023) doi: <https://doi.org/10.1063/5.0123654>

[Abstract](#)

[View article](#)

[PDF](#)

### Detect the nearest coffee shop using Floyd-Warshall algorithm

Nur Lukman, Thareq Kemal Bachriar, Cecep Nurul Alam, Ichsan Taufik, Dena Rauda Ramdania

AIP Conference Proceedings 2646, 040045 (2023) doi: <https://doi.org/10.1063/5.0114214>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### The role of artificial intelligence in image recognition to support green campus in Telkom University

A. P. Zen, A. Nugroho, I. M. Minaj, C. R. Yungsih, D. A. Setiawoko

AIP Conference Proceedings 2646, 040046 (2023) doi: <https://doi.org/10.1063/5.0113002>

[Abstract](#)

[View article](#)

[PDF](#)

### Implementation of augmented reality as information technology in judicial system toward society 5.0 in Indonesia

Adnan Permama Zen, Isroni Muhammad Minaj, Awanto Nugroho, D. Triharondo, I. P. Wignia

AIP Conference Proceedings 2646, 040047 (2023) doi: <https://doi.org/10.1063/5.0113003>

[Abstract](#)

[View article](#)

[PDF](#)

### The development of Powtoon animation media on mathematical arithmetic operations

Hamdan Sugilar, Is. Sri Mandisewati, Asep Jihad, Tika Kartika Rochmawati, Rahayu Kariadinata

AIP Conference Proceedings 2646, 040048 (2023) doi: <https://doi.org/10.1063/5.0114211>

[Abstract](#)

[View article](#)

[PDF](#)

### Digital flow chart media which promotes the local cultural values for learning discourse writing

Diyason Prasandha, Bambang Hartono, Rohayu Priatwati, Septine Sukityaningrum, Mewa Febrian

AIP Conference Proceedings 2646, 040049 (2023) doi: <https://doi.org/10.1063/5.0120569>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



#### Graspable math to prove the pythagorean theorem

Jusroh, Agni Eira Tacik, Tuli Tutul Widesubulana, Rahayu Karadinata, Ida Nuraida  
AIP Conference Proceedings 2646, 040050 (2023) doi: <https://doi.org/10.1063/5.0112624>

[Abstract](#)

[View article](#)

[PDF](#)

#### Analysis of measurement results using the Donlon and Fischer methods

Endang Komaruddin, Yulati Sastri Wijaya, Ivan Hensel, Erwin Sulaiman, Imam Anif Rahardjo  
AIP Conference Proceedings 2646, 040051 (2023) doi: <https://doi.org/10.1063/5.0113385>

[Abstract](#)

[View article](#)

[PDF](#)

#### Development Matlab graphical user interface in statistics

Rahayu Karadinata, Ahmad Rifai Nurdiansyah, Yuyu Nurhayati Rahayu, Hamdan Sugilar, Iwan Gusawan  
AIP Conference Proceedings 2646, 040052 (2023) doi: <https://doi.org/10.1063/5.0117609>

[Abstract](#)

[View article](#)

[PDF](#)

#### Bootstrap confidence interval estimation on geometric process models for lifetime data analysis

A. S. Aswaddin, N. A. Aslari, R. Cahyandari, I. Wahyuni  
AIP Conference Proceedings 2646, 040053 (2023) doi: <https://doi.org/10.1063/5.0114151>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



#### Profile of online integrated science learning in schools: An observational study

Nurita Apriani Lestari, Tsabitama Irbu, Eko Haryono, Binar Kurnia Pratiwi, Utama Aan Dafa, Setya Chandra Wibawa, Agus Haryanto, Nurhasan  
AIP Conference Proceedings 2646, 040054 (2023) doi: <https://doi.org/10.1063/5.0113740>

[Abstract](#)

[View article](#)

[PDF](#)

#### The time optimization of bottleneck transport problems in the Islamic higher education enrollment using Mallia-Das algorithm

Dindin Jemaluddin, Ein Raita Widen, Rifaa Khasriyah  
AIP Conference Proceedings 2646, 040055 (2023) doi: <https://doi.org/10.1063/5.0114002>

[Abstract](#)

[View article](#)

[PDF](#)

#### Root square mean labeling of disjoint union of path and the middle graph of path

Rosnawati Ramdani, Astrid Yuni Fariasa, Dena Mithaja  
AIP Conference Proceedings 2646, 040056 (2023) doi: <https://doi.org/10.1063/5.0117163>

[Abstract](#)

[View article](#)

[PDF](#)

#### Combination of convolutional neural network and long short-term memory to enhance the sentiment analysis result with the Indonesian language

D. Yusuf, D. S. Mayawati, M. A. Ramdhani, J. Jumadi, W. B. Zulfikar  
AIP Conference Proceedings 2646, 040057 (2023) doi: <https://doi.org/10.1063/5.0112678>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



#### Design of android-based interactive multimedia in occupational health and safety laboratory

San Sari, Dinda Petehandawati, Ida Fariha  
AIP Conference Proceedings 2646, 040058 (2023) doi: <https://doi.org/10.1063/5.0112607>

[Abstract](#)

[View article](#)

[PDF](#)

#### The prediction analysis model using the simple linear regression methods

A. Jiliat, I. Nuraida, S. U. Wabigo  
AIP Conference Proceedings 2646, 040059 (2023) doi: <https://doi.org/10.1063/5.0113081>

[Abstract](#)

[View article](#)

[PDF](#)

### ENGINEERING

#### Weldability and shear strength of cylindrical resistance spot welding stainless steel 304

A. Sifa, B. Badruzaman, F. Dionisius, T. Endramawan, N. Alipah  
AIP Conference Proceedings 2646, 050001 (2023) doi: <https://doi.org/10.1063/5.0113847>

[Abstract](#)

[View article](#)

[PDF](#)

#### Effect of thermomechanic on thickness wall molds hot press using static simulation: Small plate product-rice husk composite

A. Sifa, F. Dionisius, A. Nurrohmah  
AIP Conference Proceedings 2646, 050002 (2023) doi: <https://doi.org/10.1063/5.0113848>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



#### Design improvement of baseplate motor of driving system rubber tyred gantry crane

Sroyoddin, A. N. V. Rifasari, R. A. H. Tanjung, M. I. Al Fatah, P. C. Utama, I. Basori  
AIP Conference Proceedings 2646, 050093 (2023) doi: <https://doi.org/10.1063/5.0117758>

[Abstract](#)

[View article](#)

[PDF](#)

#### Design improvement of tensioner bolt of driving system rubber tyred gantry crane

Sroyoddin, R. A. H. Tanjung, A. N. V. Rifasari, P. C. Utama, M. I. Al Fatah, I. Basori  
AIP Conference Proceedings 2646, 050094 (2023) doi: <https://doi.org/10.1063/5.0117760>

[Abstract](#)

[View article](#)

[PDF](#)

#### Electrochemical properties of graphene oxide/calcium carbonate/chitosan nanocoating of Ti-6Al-4V for biomedical implant

M. J. Surya, M. Handayani, F. Triawan, Y. N. Thaha, N. Diansono  
AIP Conference Proceedings 2646, 050095 (2023) doi: <https://doi.org/10.1063/5.0117687>

[Abstract](#)

[View article](#)

[PDF](#)

#### A review of structural health monitoring systems and application for railway bridges

Triya Fantiika, Wimpie A. N. Aspar, Dwi A. Purnomo, Willy Barasa, Sruang M. Harjono, Suci P. Primadityanti  
AIP Conference Proceedings 2646, 050096 (2023) doi: <https://doi.org/10.1063/5.0115833>

[Abstract](#)

[View article](#)

[PDF](#)

#### Virtual human modelling for work position improvement in cutting process

Winis Septiarni, Novia Rahmawati, Robby Sernaldi  
AIP Conference Proceedings 2646, 050097 (2023) doi: <https://doi.org/10.1063/5.0115853>

[Abstract](#)

[View article](#)

[PDF](#)

#### Current technology of biodiesel fuel filtration (water separator and contaminants) – Marine application – A short review

Agus Sartono, M. Taufiq Suryantono, Rizqon Fajar, Budi Rohmanito, Han Setiapraja, Teguh Wibowo  
AIP Conference Proceedings 2646, 050098 (2023) doi: <https://doi.org/10.1063/5.0115853>

[Abstract](#)

[View article](#)

[PDF](#)

#### A quick-release hanging hook design and 3D printing

Desista Dendi Ramadani, Mohammad Bayu Nur Akbar, Putri Angelica, Kushendaryah Saptaji, Cho Lik Chan, Fandi Triawan  
AIP Conference Proceedings 2646, 050099 (2023) doi: <https://doi.org/10.1063/5.0115279>

[Abstract](#)

[View article](#)

[PDF](#)

#### Self-tuning fuzzy based of exponential control switching in cascade control system for robot with differential drive

Putra Wisnu Agung Sucipto, Annisa Firasanti, Seta Samsiana, Eki Ahmed Zaki Hamidi  
AIP Conference Proceedings 2646, 050110 (2023) doi: <https://doi.org/10.1063/5.0127308>

[Abstract](#)

[View article](#)

[PDF](#)

#### Implementation of self balancing robot based on the proportional integral differential (PID) controller parameter

Eki Ahmed Zaki Hamidi, Mufid Rofli Erlendi, Ahmad Basuni, Muammar Wildan  
AIP Conference Proceedings 2646, 050111 (2023) doi: <https://doi.org/10.1063/5.0115865>

[Abstract](#)

[View article](#)

[PDF](#)

#### Electrically controlled converter kit for gas fuel conversion engine improvement

Kurnia F. A. Sukra, Han Sumartono, Muhammed N. Hidayat, Ramadhani D. Sumanudji  
AIP Conference Proceedings 2646, 050112 (2023) doi: <https://doi.org/10.1063/5.0115995>

[Abstract](#)

[View article](#)

[PDF](#)

#### The crispness of cassava crisps with random shape by compression test

Dana Giwanti, Fandi Triawan, Kushendaryah Saptaji, Lydia Anggraini  
AIP Conference Proceedings 2646, 050113 (2023) doi: <https://doi.org/10.1063/5.0115444>

[Abstract](#)

[View article](#)

[PDF](#)

#### Cold start ability test for diesel passenger cars using thirty percent palm biodiesel and precipitation in low temperature ambient

Ihwan Hariyono, Muhammad Ma'rif, Siti Yubaidah, Budi Rochmanito, Han Setiapraja, Rizqon Fajar, Mahasari Dewi Sukhtah  
AIP Conference Proceedings 2646, 050114 (2023) doi: <https://doi.org/10.1063/5.0115472>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



### Structural design of massage chair made of corrugated cardboard materials

Siti Zulaikah, Fandi Triawan, Datto Wibowo Djaman, Yusuf Romadhoni, Dede Sukayati

AIP Conference Proceedings 2646, 050016 (2023) doi: <https://doi.org/10.1063/5.0113449>

[Abstract](#) [View article](#) [PDF](#)

### Smartphone-based application to control TV using IoT technology

Nathan Rizq Evandi, Hanif Fakhruroja, Nanang Ismail

AIP Conference Proceedings 2646, 050016 (2023) doi: <https://doi.org/10.1063/5.0113757>

[Abstract](#) [View article](#) [PDF](#)

### Numerical study effect of throat shape to energy dissipation in water jet pump via entropy generation analysis

M. P. Helios, A. Maswan, A. M. Fathoni, H. Suhyanto, W. Aswapoodikul

AIP Conference Proceedings 2646, 050017 (2023) doi: <https://doi.org/10.1063/5.0113725>

[Abstract](#) [View article](#) [PDF](#)

### Development of autonomous robot using fuzzy inference system (FIS) for indoor ultraviolet (UV) disinfection

Adven Simamata, Tetra Kusuma Dewar, Muhamad Rasyan Fari, Kushendansyah Saptaji

AIP Conference Proceedings 2646, 050018 (2023) doi: <https://doi.org/10.1063/5.0113738>

[Abstract](#) [View article](#) [PDF](#)

### Application of house of quality in assessment of biodiesel – Diesel fuel blending technologies

Neharani Dewi Sukhatri, Feri Kusuma, Bina Restitute Barus, Khairi Anni, Andhas Rahman Winadit, Arie Rahmadi

AIP Conference Proceedings 2646, 050019 (2023) doi: <https://doi.org/10.1063/5.0114040>

[Abstract](#) [View article](#) [PDF](#)

### Strength investigation of petroleum storage tank structure under hydrostatic load using finite element method

Iham Andar Adi Satriya, Raden Wibawa Paraberya, Fadilah Hasim

AIP Conference Proceedings 2646, 050020 (2023) doi: <https://doi.org/10.1063/5.0113267>

[Abstract](#) [View article](#) [PDF](#)

### Machine learning for insulator: A systematic literature review

Niko Sordika, Yuda Sukmana, Lia Kamela

AIP Conference Proceedings 2646, 050021 (2023) doi: <https://doi.org/10.1063/5.0128229>

[Abstract](#) [View article](#) [PDF](#)

### Measurement of carbon fiber reinforced polymer electric conductivities by four-wire probe and two-wire probe

Henokh Budjanto, Bentang Anief Budiman, Ignatius Pulung Nurprasetyo

AIP Conference Proceedings 2646, 050022 (2023) doi: <https://doi.org/10.1063/5.0113266>

[Abstract](#) [View article](#) [PDF](#)

### Autonomous mobile robot localization using Markov decision algorithm

Gresh Haryono Sitompul, Muhamad Rasyan Fari, Ignatius Budi Hadiansoto, Iwan Setiawan

AIP Conference Proceedings 2646, 050023 (2023) doi: <https://doi.org/10.1063/5.0112716>

[Abstract](#) [View article](#) [PDF](#)

### Combination of polyaniline and graphene oxide as counter electrode composites in dye-sensitized solar cells

Risa Rahmawati Sunarya, Alvan Ikhlasu Falya, Veinardi Suendo, Rahmat Hidayat

AIP Conference Proceedings 2646, 050024 (2023) doi: <https://doi.org/10.1063/5.0115886>

[Abstract](#) [View article](#) [PDF](#)

### Developing hydrogen as energy for transportation means in Indonesia

Ganesha Tri Chandrasa, Soedibyo, Barman Tambunan, Eniya Lidiani Dewi, Rizqon Fajar

AIP Conference Proceedings 2646, 050025 (2023) doi: <https://doi.org/10.1063/5.0112933>

[Abstract](#) [View article](#) [PDF](#)

### Survey of road distress during the COVID-19 pandemic using unmanned aerial vehicles (UAVs)

Retho Utami, Yosob Astor, Farhan Anadzarum Gustaman, Muhammad Rizki Firdaus, Fadhliah Aulia Rahman, Sarah Nabillah Winata

AIP Conference Proceedings 2646, 050026 (2023) doi: <https://doi.org/10.1063/5.0112707>

[Abstract](#) [View article](#) [PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



### Spatial clustering and techno-economic analysis of electrification 3T villages using renewable energy microgrid system

Andra Laksono Putro, Widodo Wahyu Purwanto

AIP Conference Proceedings 2646, 050037 (2023) doi: <https://doi.org/10.1063/5.0113773>

[Abstract](#)

[View article](#)

[PDF](#)

### Design of machine layout simulation model using group technology concept at PT. Super Plastin

Pudji Astuti, Fani Puspitasari, Hasya Afifa Maharani

AIP Conference Proceedings 2646, 050028 (2023) doi: <https://doi.org/10.1063/5.0118681>

[Abstract](#)

[View article](#)

[PDF](#)

### A spatial data-driven decision analysis of pipe failure management in water supply system

W. Nugroho, C. Utomo, N. Triawan

AIP Conference Proceedings 2646, 050029 (2023) doi: <https://doi.org/10.1063/5.0139429>

[Abstract](#)

[View article](#)

[PDF](#)

### Estimation of lower-bound velocity of electric three-wheeled vehicle during frontal crash

M. Afia Prayogo, Djati Wibowo Djaman, Fandi Triawan, Bentang Anief Budiman

AIP Conference Proceedings 2646, 050030 (2023) doi: <https://doi.org/10.1063/5.0113859>

[Abstract](#)

[View article](#)

[PDF](#)

### Performance evaluation of lightning protection methods for transmission line in Indonesia

N. W. Prambodo, B. B. S. D. A. Harseno, Anton Junaldi

AIP Conference Proceedings 2646, 050031 (2023) doi: <https://doi.org/10.1063/5.0139209>

[Abstract](#)

[View article](#)

[PDF](#)

### Paratransit network analysis using geographic information system (GIS) in Indonesia

Mira Lestira Herson, Yackob Astor

AIP Conference Proceedings 2646, 050032 (2023) doi: <https://doi.org/10.1063/5.0114021>

[Abstract](#)

[View article](#)

[PDF](#)

### Rollover stability analysis of electric three-wheeled vehicle

Fah Endrasari, Djati Wibowo Djaman, Fandi Triawan, Bentang Anief Budiman

AIP Conference Proceedings 2646, 050033 (2023) doi: <https://doi.org/10.1063/5.0112852>

[Abstract](#)

[View article](#)

[PDF](#)

### Three phase current monitoring system using SCT013 sensor and Internet of Things platform

Asep Najmunnikhman, Kusnandar, Udin Komarudin, Dede Imron Aminulloh

AIP Conference Proceedings 2646, 050034 (2023) doi: <https://doi.org/10.1063/5.0113698>

[Abstract](#)

[View article](#)

[PDF](#)

### Multiyear observation of lightning characteristic in Java Island and its influence on overhead transmission line performance

B. B. S. D. A. Harseno, Bryono, A. S. Habibie, P. A. A. Pratiwina

AIP Conference Proceedings 2646, 050035 (2023) doi: <https://doi.org/10.1063/5.0129702>

[Abstract](#)

[View article](#)

[PDF](#)

### Primary design concept of mini compression test machine for food texture analyzer

Piki Angelica, Musafri Yetti, Fandi Triawan, Budi Hacksapito, Aditya Haroro, Asep Bayu Dini Nandiyanto

AIP Conference Proceedings 2646, 050036 (2023) doi: <https://doi.org/10.1063/5.0113402>

[Abstract](#)

[View article](#)

[PDF](#)

### Analysis of improvement of Transjakarta operational performance during the Covid-19 pandemic (case study: Corridor IX Pinang Ranti - Pluit)

A. Utami, W. K. R. Nisbe

AIP Conference Proceedings 2646, 050037 (2023) doi: <https://doi.org/10.1063/5.0112849>

[Abstract](#)

[View article](#)

[PDF](#)

### Work energy modeling link layer protocol on TinyOS and TinySec based wireless sensor networks with LEACH method

Milfar Rahman, Bambang Yulianto, Supriatno, Fandi Baskoro, Widi Anjowari

AIP Conference Proceedings 2646, 050038 (2023) doi: <https://doi.org/10.1063/5.0112752>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS

### Comparison of mixed fuel coal and palm shells on operation 135 MW circulating fluidized bed boiler steam powerplant

D. J. Damar, D. Domanhan

AIP Conference Proceedings 2646, 050035 (2023) doi: <https://doi.org/10.1063/5.0112176>

[Abstract](#) [View article](#) [PDF](#)

### Factors affecting the decision of local culinary selection based on consumer behavior

R. Kurniawati, R. Rubryansyah, A. Ikhwana, W. A. Kurniawan, H. Aulawi

AIP Conference Proceedings 2646, 050040 (2023) doi: <https://doi.org/10.1063/5.0129751>

[Abstract](#) [View article](#) [PDF](#)

### Identification of consumer preferences online transportation users using conjoint analysis

R. Kurniawati, T. I. Nurjaman, A. Ikhwana, Y. Mauluddin, B. L. Hakim

AIP Conference Proceedings 2646, 050041 (2023) doi: <https://doi.org/10.1063/5.0129749>

[Abstract](#) [View article](#) [PDF](#)

### Identification of dominant waste in the production process at the garment industry

Y. Mauluddin, E. Johar, D. S. Teptayan, R. Kurniawati, B. L. Hakim

AIP Conference Proceedings 2646, 050042 (2023) doi: <https://doi.org/10.1063/5.0114066>

[Abstract](#) [View article](#) [PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS

### Usefulness analysis of production machines seen from the aspects of operation and business scale

Y. Mauluddin, D. Permana, H. Aulawi, W. A. Kurniawan, B. L. Hakim

AIP Conference Proceedings 2646, 050043 (2023) doi: <https://doi.org/10.1063/5.0114065>

[Abstract](#) [View article](#) [PDF](#)

### Supply chain collaborative planning, forecasting, and replenishment

L. P. E. Yano, A. M. Aamer

AIP Conference Proceedings 2646, 050044 (2023) doi: <https://doi.org/10.1063/5.0126123>

[Abstract](#) [View article](#) [PDF](#)

### Redesign ironing board using Kansei engineering method

D. Saifin, M. Nahayu, I. Muldah

AIP Conference Proceedings 2646, 050045 (2023) doi: <https://doi.org/10.1063/5.0129629>

[Abstract](#) [View article](#) [PDF](#)

### Study of the economic potential of using biofuels in PLN diesel power plants

M. A. Rohmanta, P. Adhama, P. A. Wibowo

AIP Conference Proceedings 2646, 050046 (2023) doi: <https://doi.org/10.1063/5.0115170>

[Abstract](#) [View article](#) [PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS

### Quality control to improve customer satisfaction by using quality function deployment method

T. E. Lestari, E. Nagata, A. R. Sopandi

AIP Conference Proceedings 2646, 050047 (2023) doi: <https://doi.org/10.1063/5.0150750>

[Abstract](#) [View article](#) [PDF](#)

### Implementing SWOT analysis for green marketing tourism development

A. M. Ekasari, I. H. Agustina, I. Hindanayah, L. N. Shafira

AIP Conference Proceedings 2646, 050048 (2023) doi: <https://doi.org/10.1063/5.0112390>

[Abstract](#) [View article](#) [PDF](#)

### Identifying online capacity building platforms in the industry

I. Indrobrino, M. Biqis, S. Nurani

AIP Conference Proceedings 2646, 050049 (2023) doi: <https://doi.org/10.1063/5.0151502>

[Abstract](#) [View article](#) [PDF](#)

### Implementation of quality function deployment method in production process of manufacturing

E. Nagata, A. R. Sopandi, T. E. Lestari

AIP Conference Proceedings 2646, 050050 (2023) doi: <https://doi.org/10.1063/5.0114096>

[Abstract](#) [View article](#) [PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



Abstracts | Full Text | PDF

### Supply chain risk management analysis using SCOR method

W. A. Kurniawan, D. T. Alamanda, H. Aulawi, R. I. Hanafi, U. Cahyadi

AIP Conference Proceedings 2646, 050091 (2023) doi: <https://doi.org/10.1063/5.0113147>

Abstract

View article

PDF

### A framework for designing IoT-based smart warehouse infrastructures

I. Afifa, A. M. Aamer

AIP Conference Proceedings 2646, 050092 (2023) doi: <https://doi.org/10.1063/5.0129309>

Abstract

View article

PDF

### Smart home based on Internet of Things

Jaja Kuslita, Furqon Andika

AIP Conference Proceedings 2646, 050093 (2023) doi: <https://doi.org/10.1063/5.0112929>

Abstract

View article

PDF

### Analysis competitive product design of traditional culinary products "dodo/ Garut"

W. A. Kurniawan, D. T. Alamanda, H. Aulawi, Y. Ar-Ram, R. Kurniawati

AIP Conference Proceedings 2646, 050094 (2023) doi: <https://doi.org/10.1063/5.0113152>

Abstract

View article

PDF

### A system design of big data analytics for an IoT-enabled warehouse

S. S. Arumman, A. M. Aamer

AIP Conference Proceedings 2646, 050095 (2023) doi: <https://doi.org/10.1063/5.0129307>

Abstract

View article

PDF

### Real-time data integration in smart warehouse as a contemporary approach

C. R. Sahana, A. M. Aamer

AIP Conference Proceedings 2646, 050096 (2023) doi: <https://doi.org/10.1063/5.0122745>

Abstract

View article

PDF

### Performance evaluation of authorized service center: A case study of an SME company

S. S. Islam, M. W. M. Ajabar

AIP Conference Proceedings 2646, 050097 (2023) doi: <https://doi.org/10.1063/5.0113807>

Abstract

View article

PDF

### Technical skills: Industry requirements and the Indonesian national qualification framework (KKNI)

R. F. Hendrawan, A. Kerdosari

AIP Conference Proceedings 2646, 050098 (2023) doi: <https://doi.org/10.1063/5.0115122>

Abstract

View article

PDF

### The effect of organizational culture and compensation on employee engagement

H. Wiyanto, M. Akbar, A. Dharmawan

AIP Conference Proceedings 2646, 050099 (2023) doi: <https://doi.org/10.1063/5.0139601>

Abstract

View article

PDF

### The work system design on the connecting rod operator based on workload analysis

N. Hidayat, W. Kusumawati, S. Supriyadi, A. Nalwadi, Y. Napid

AIP Conference Proceedings 2646, 050100 (2023) doi: <https://doi.org/10.1063/5.0110695>

Abstract

View article

PDF

### Development of the food industry based on oranges

I. Gusti Bagus Udayana, Anak Agung Ngurah Mayun Wrayaya, Made Sri Yulertini, Luh Kartini, Ida Bagus Komang Maharadika, Anak Agung Made Somayanti, I. Gede Pasok Mangku, Yohanes Parindungan Siurmeang, Yuni Wibowo

AIP Conference Proceedings 2646, 050101 (2023) doi: <https://doi.org/10.1063/5.0130818>

Abstract

View article

PDF

### Preliminary study for berth allocation problem under uncertainty at PT Mustika Alam Lestari (MAL) port of Tanjung Priok, Jakarta

V. K. Ladosi, K. Vorawati, H. D. Hamdi

AIP Conference Proceedings 2646, 050102 (2023) doi: <https://doi.org/10.1063/5.0129643>

Abstract

View article

PDF

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS



Risk management approach to solve berth allocation problem (BAP) in port

V. K. Ladisi, J. Amnuada

AIP Conference Proceedings 2646, 050063 (2023) doi: <https://doi.org/10.1063/5.0129650>

[Abstract](#)

[View article](#)

[PDF](#)

Analysis berth allocation problem (BAP) at New Priok Container Terminal One (NPTC-1) North Jakarta Indonesia

W. Hadi, V. K. Ladisi, S. Sohesta, D. Sujadi

AIP Conference Proceedings 2645, 050064 (2023) doi: <https://doi.org/10.1063/5.0129547>

[Abstract](#)

[View article](#)

[PDF](#)

Quantitative and qualitative analysis to map potential energy needs in Garut district, West Java Province - Indonesia

B. I. Hakim, H. Subandi, Y. Mauluddin, H. Aswari

AIP Conference Proceedings 2646, 050065 (2023) doi: <https://doi.org/10.1063/5.0118148>

[Abstract](#)

[View article](#)

[PDF](#)

Supply chain strategies to minimize the risk of local potato products

T. Martini, N. A. Hamdani, I. Tjennisa, S. Nugraha, I. Nabhuani

AIP Conference Proceedings 2645, 050066 (2023) doi: <https://doi.org/10.1063/5.0139543>

[Abstract](#)

[View article](#)

[PDF](#)

Uplah karanji craftsmen work posture evaluation using quick exposure check

I. H. Lahay, E. Wolok, R. S. Ayuba

AIP Conference Proceedings 2646, 050067 (2023) doi: <https://doi.org/10.1063/5.0131844>

[Abstract](#)

[View article](#)

[PDF](#)

Planning of hydraulic tripod jack ATR 42-500 aircraft based on ergonomic aspects

B. Sumartono, W. T. Brawa, S. I. Yanti

AIP Conference Proceedings 2645, 050068 (2023) doi: <https://doi.org/10.1063/5.0131627>

[Abstract](#)

[View article](#)

[PDF](#)

Thermal growth prediction on 4 MW steam turbine casing using finite element method

Dewyda Febriansyah, Endra Dwi Purnomo, Budi Nollyantoro Fadjar, Rudas Harjadi, Guk Supriyadi Ali Nandar

AIP Conference Proceedings 2646, 050069 (2023) doi: <https://doi.org/10.1063/5.0131778>

[Abstract](#)

[View article](#)

[PDF](#)

Depth estimation model of shallow-tropical seawaters based on remote sensing data and BatNas

Moh. Dedo, Hani Susati, Milary Agung Widanaty, Anif Ismail, Hadi Sutoko

AIP Conference Proceedings 2646, 050070 (2023) doi: <https://doi.org/10.1063/5.0131639>

[Abstract](#)

[View article](#)

[PDF](#)

The readiness of electric vehicle in Indonesia based on the perceptions of key stakeholders

Andarie Hadi Pandyaswargo, Melinda Fitriani Nur Magritroh

AIP Conference Proceedings 2646, 050071 (2023) doi: <https://doi.org/10.1063/5.0131751>

[Abstract](#)

[View article](#)

[PDF](#)

A road test for heavy duty vehicles fueled by B30 palm oil

Hani Sumartono, Muhammad Mas'ud, Rudi Cahyo Nugroho, Naeep Suryana, Ithwan Haryono

AIP Conference Proceedings 2646, 050072 (2023) doi: <https://doi.org/10.1063/5.0132420>

[Abstract](#)

[View article](#)

[PDF](#)

Development of extrusion machine design for recycling plastic waste

Comytha Octomulyati Riechmud, Jolita Wita Rahmesanti, Desanta Dewa, Taufiq Gandra, Kushendaryah Sopitaj, Ignatius Budi Hachapoto

AIP Conference Proceedings 2646, 050073 (2023) doi: <https://doi.org/10.1063/5.0142708>

[Abstract](#)

[View article](#)

[PDF](#)

Ocean energy web as a media for increasing renewable energy literacy

D. Nasrudin, C. Rochman, M. Azzani, D. Muhiyattah, H. Y. Sutondji

AIP Conference Proceedings 2646, 050074 (2023) doi: <https://doi.org/10.1063/5.0141464>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Improving people's energy literacy through the nuclear energy web

D. Nasrudin, C. Rochman, R. P. Putra, D. Muhyasillah, H. Y. Suhendi

AIP Conference Proceedings 2646, 050073 (2023) doi: <https://doi.org/10.1063/5.0114561>

[Abstract](#)

[View article](#)

[PDF](#)

### Introducing wind energy as an alternative energy source through e-magazine

C. Rochman, D. Nasrudin, R. Hidayatulloh, D. Muhyasillah, H. Y. Suhendi

AIP Conference Proceedings 2646, 050076 (2023) doi: <https://doi.org/10.1063/5.0116361>

[Abstract](#)

[View article](#)

[PDF](#)

### Solar energy e-book as a media to improve renewable energy literacy

C. Rochman, D. Nasrudin, S. Fitrabini, D. Muhyasillah, H. Y. Suhendi

AIP Conference Proceedings 2646, 050077 (2023) doi: <https://doi.org/10.1063/5.0116378>

[Abstract](#)

[View article](#)

[PDF](#)

### Cooling estimation of high-speed train using ASHRAE guideline 23 approach

A. M. Fathoni, M. P. Helios, H. Subryanto, R. J. Komara, A. Marwan, B. Nuryadin, K. P. Sumarah, A. Ridhwan, I. G. A. Utariyani, H. Pujiwidodo, B. T. Prasetyo

AIP Conference Proceedings 2646, 050078 (2023) doi: <https://doi.org/10.1063/5.0112626>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Determination position of the portable air purifiers using computational fluid dynamics methods

Yudawan Fajar Kusuma, F. Andree Yohanes

AIP Conference Proceedings 2646, 050079 (2023) doi: <https://doi.org/10.1063/5.0112706>

[Abstract](#)

[View article](#)

[PDF](#)

### Effect of additional fin and thickness of basic plate of the ocean bottom unit (OBU) model using computational fluid dynamics methods

Yudawan Fajar Kusuma, Hozni Defiant, Fadiah Hasem, F. Andree Yohanes

AIP Conference Proceedings 2646, 050080 (2023) doi: <https://doi.org/10.1063/5.0112702>

[Abstract](#)

[View article](#)

[PDF](#)

### Study on the effect of the use essential bio-additives on the biodiesel characteristics (B20) and its performance using a 20 kVA generator

Siti Yubadiah, Egi Agustian, Ilwan Haryono, Hari Setiaprja, Anny Salsakaty

AIP Conference Proceedings 2646, 050081 (2023) doi: <https://doi.org/10.1063/5.0113132>

[Abstract](#)

[View article](#)

[PDF](#)

### Design of experiment (DoE) in reducing sugar optimization to produce third-generation bioethanol from *Chlorella pyrenoidosa*: Central composite design vs Box-Behnken design

H. B. Aditya, A. H. Setboying, A. S. Silionga, Yheni Mulyaningsih, Yhana Mulyaningsih, H. C. Theclany, Supriyanto

AIP Conference Proceedings 2646, 050082 (2023) doi: <https://doi.org/10.1063/5.0113548>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Application of North West Corner, least cost and Vogel's approximation method for optimizing transportation cost of biodiesel between biofuel company and blending terminal

A. Roschyntawati, R. Pujwat, D. P. Upahita, Y. N. R. Hendra, R. Fajar, M. I. A. Saputro, A. Kismanto

AIP Conference Proceedings 2646, 050083 (2023) doi: <https://doi.org/10.1063/5.0113524>

[Abstract](#)

[View article](#)

[PDF](#)

### Numerical modeling analysis of air flow distribution in HVAC general arrangements of Indonesia high speed train passengers coach

R. J. Komara, H. Subryanto, M. P. Helios, A. M. Fathoni, B. Nuryadin, B. T. Prasetyo, H. Pujiwidodo, I. G. A. Utariyani, H. Setiaprja

AIP Conference Proceedings 2646, 050084 (2023) doi: <https://doi.org/10.1063/5.0113576>

[Abstract](#)

[View article](#)

[PDF](#)

### Electrical energy management with peak clipping and load shifting methods based on fuzzy logic in office electricity consumers

Firsa Hartama, Ade Gafar Abdulrah, Dadang Lukman Hakim, Diky Zakaria

AIP Conference Proceedings 2646, 050085 (2023) doi: <https://doi.org/10.1063/5.0113134>

[Abstract](#)

[View article](#)

[PDF](#)

### Modeling of energy management with electric load curve using fuzzy logic system for office electricity consumers

Hans Dwi Septanto, Ade Gafar Abdulrah, Dadang Lukman Hakim, Diky Zakaria

AIP Conference Proceedings 2646, 050086 (2023) doi: <https://doi.org/10.1063/5.0113124>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Office electrical equipment activation management using fuzzy logic approach

A. R. San San Senauloh, Ade Gafar Abdullah, Dadang Lukman Hakim, Diky Zakaria

AIP Conference Proceedings 2646, 050087 (2023) doi: <https://doi.org/10.1063/5.0113126>

[Abstract](#) [View article](#) [PDF](#)

### Low cost PID temperature control training board

Diky Zakaria, Muhammad Husni Muttagir, Ade Gafar Abdullah, Nia Amelia, Wildan Arasid

AIP Conference Proceedings 2646, 050090 (2023) doi: <https://doi.org/10.1063/5.0113123>

[Abstract](#) [View article](#) [PDF](#)

### Development plastic simple recycler to produce alternative energy source using pyrolysis method

Syifa Sultan, Risa Rahmawati Sanarya, Sani Sari

AIP Conference Proceedings 2646, 050089 (2023) doi: <https://doi.org/10.1063/5.0113084>

[Abstract](#) [View article](#) [PDF](#)

### Computer numerical control batik machine with automatic conveyor

Izza Lusano Al Qushai, Nikolas Krisma Hadi Fernandez, Budi Hadsugoto, Santo Tjhan

AIP Conference Proceedings 2646, 050090 (2023) doi: <https://doi.org/10.1063/5.0113069>

[Abstract](#) [View article](#) [PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### A study of stabilization quanser linear inverted pendulum with MATLAB Simulink

Hikomo Aj Nursantoro, Kishendersyah Saptaji, Budi Hadsugoto

AIP Conference Proceedings 2646, 050091 (2023) doi: <https://doi.org/10.1063/5.0113768>

[Abstract](#) [View article](#) [PDF](#)

### Redefining public space as a public life adaptation to the Covid-19 pandemic based on people preferences in Jakarta

Nurhikmah Budi Hartanti, Achmad Hadi Pratomo

AIP Conference Proceedings 2646, 050092 (2023) doi: <https://doi.org/10.1063/5.0113116>

[Abstract](#) [View article](#) [PDF](#)

### Characteristic of biodiesel – Diesel oil blend in B40 and B50

K. Amri, M. D. Solikhah, F. T. Pratomo, Mathootani, A. G. Arsanji, A. Pamungkas

AIP Conference Proceedings 2646, 050092 (2023) doi: <https://doi.org/10.1063/5.0114026>

[Abstract](#) [View article](#) [PDF](#)

### The effect of height and building orientation on thermal comfort sensation using PMV

Putri Afifah, Fopi Puspitasari, Endri I. Poemomo

AIP Conference Proceedings 2646, 050094 (2023) doi: <https://doi.org/10.1063/5.0120291>

[Abstract](#) [View article](#) [PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Workload analysis using NASA-TLX and energy consumption of soy sauce operator

Ames Faridika, Pudi Astuti, Gunur Chandra Sakti

AIP Conference Proceedings 2646, 050095 (2023) doi: <https://doi.org/10.1063/5.0133444>

[Abstract](#) [View article](#) [PDF](#)

### Design and build a light electric vehicle powered by battery and fuel cell as a range extender

Kurnawan, Ganesha Tri Chandrasa, Didik Rosyono, Abdul Hamid Budiman

AIP Conference Proceedings 2646, 050096 (2023) doi: <https://doi.org/10.1063/5.0117792>

[Abstract](#) [View article](#) [PDF](#)

### Study on the potential and technology of pumped storage hydropower (PSH) in Indonesia

Muhammad Asdhvyoga Rahmanta, Fari Aditama

AIP Conference Proceedings 2646, 050097 (2023) doi: <https://doi.org/10.1063/5.0113767>

[Abstract](#) [View article](#) [PDF](#)

### The overview of sustainable development-oriented adaptive reuses implementation (Case study: Changes in buildings and areas of L.L.R.E Martadinata Road corridor area, Bandung, Indonesia)

Mohammad Ishtiaq, Adinda Putri Dachi, Asa Salfin, Ayudiah Khairani

AIP Conference Proceedings 2646, 050098 (2023) doi: <https://doi.org/10.1063/5.0127874>

[Abstract](#) [View article](#) [PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS



### Converting light ICE car to accelerate battery vehicle adoption in Indonesia

Yuli Astuti, Didik Rasyono, Panca Kurniawan, Suhreni Syde, Ganeshia Tri Chandrasa, Agus Suhendra  
AIP Conference Proceedings 2646, 050095 (2023) doi: <https://doi.org/10.1063/5.0114409>

[Abstract](#)

[View article](#)

[PDF](#)

### The application of screening criteria to determine enhanced oil recovery method in an oil field

R. T. Saputra, R. Setab, S. S. Riwati

AIP Conference Proceedings 2646, 050100 (2023) doi: <https://doi.org/10.1063/5.0117243>

[Abstract](#)

[View article](#)

[PDF](#)

### Relationship risk factors and vulnerability to COVID-19 in East Jakarta

Benny D. Subarto, Herika M. Taki, Fardomuan R. Sihombing, Komeng A. P. Wijaya, Gekisa M. Gunandar

AIP Conference Proceedings 2646, 050101 (2023) doi: <https://doi.org/10.1063/5.0131418>

[Abstract](#)

[View article](#)

[PDF](#)

### The importance of understanding reservoir fluid and reservoir description in pressure transient analyses

Heri Karyadi Octomo, Hananya Wrianta, Satryo Nurhanudin Wibowo, Omie Rotariant, Djumedi Agus Wibowo, Mohamad Romli

AIP Conference Proceedings 2646, 050102 (2023) doi: <https://doi.org/10.1063/5.0113765>

[Abstract](#)

[View article](#)

[PDF](#)

### Geotourism routes at UNESCO global geopark

S. R. P. Wulung, A. K. Yulawati, C. U. Abdulah, E. Fitriyani

AIP Conference Proceedings 2646, 050103 (2023) doi: <https://doi.org/10.1063/5.0113781>

[Abstract](#)

[View article](#)

[PDF](#)

### The effect of concentration and temperature on nickel extraction from laterite nickel ore using atmospheric pressure acid leaching method

Deborah Bianca Elisabeth Latsut, Rokmaniana Kurniawati, Wasek Dahani, Subandrio

AIP Conference Proceedings 2646, 050104 (2023) doi: <https://doi.org/10.1063/5.0113586>

[Abstract](#)

[View article](#)

[PDF](#)

### Potential geotourism of Pengantin cave, Rumpin, as a national nature reserve

Iryas Furgon, Novi Triary, Edy Sugarto, Hermes Fita Yuda, Mohammad Aprinyadi, Dyah Ayu Setyorini, Anil

AIP Conference Proceedings 2646, 050105 (2023) doi: <https://doi.org/10.1063/5.0120541>

[Abstract](#)

[View article](#)

[PDF](#)

### Material testing of aluminum alloy 6061 with heat treatment and aging method

Y. N. Rohmat, T. Endamawan, E. Haris, I. Basori, Y. Y. Fambudy, A. R. Ardo

AIP Conference Proceedings 2646, 050106 (2023) doi: <https://doi.org/10.1063/5.0129736>

[Abstract](#)

[View article](#)

[PDF](#)

### SCADA-based low-cost single phase AC generator control laboratory kit

Setyo Supratno, Aen Sujatmiko, Sumarto, Erjeng A. Juanda, Seto Samsona

AIP Conference Proceedings 2646, 050107 (2023) doi: <https://doi.org/10.1063/5.0116873>

[Abstract](#)

[View article](#)

[PDF](#)

### Urban heat island phenomenon in the early and peak periods of Covid-19 cases

E. Surtaji, B. Setiabudi Wicoko

AIP Conference Proceedings 2646, 050108 (2023) doi: <https://doi.org/10.1063/5.0116108>

[Abstract](#)

[View article](#)

[PDF](#)

### Layered natural filter technique for reducing iron content level of the borehole water on peat area

Dia Mudroo, Andi Subendi

AIP Conference Proceedings 2646, 050109 (2023) doi: <https://doi.org/10.1063/5.0112735>

[Abstract](#)

[View article](#)

[PDF](#)

### 3D models of underground geological structures based on rock resistivity

H. D. Ayu, A. Jufriadi, A. S. Arif, F. Raktomanto

AIP Conference Proceedings 2646, 050110 (2023) doi: <https://doi.org/10.1063/5.0115345>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS

The effect of tolerance variation in slope stability analysis using 3 dimensional finite element method

A. Y. Siregar, M. A. Azmi, I. Marwanza

AIP Conference Proceedings 2646, 050111 (2023) doi: <https://doi.org/10.1063/5.0113062>

[Abstract](#)

[View article](#)

[PDF](#)

The effect of titanium dioxide-coated copper catalytic converters to reduce noise level from four-stroke engines

Wajra Warju, Sudman Rizki Ariyanto, Muhammad Yandi Pratama, Bambang Yulianto, Sujarwanto Sujarwanto

AIP Conference Proceedings 2646, 050112 (2023) doi: <https://doi.org/10.1063/5.0114006>

[Abstract](#)

[View article](#)

[PDF](#)

Design and analysis of the effectiveness of an automated home control system using the Internet of Things

Ertan Rohadi, Moechammad Sarosa, Heri Susanto

AIP Conference Proceedings 2646, 050113 (2023) doi: <https://doi.org/10.1063/5.0113774>

[Abstract](#)

[View article](#)

[PDF](#)

Hardness, impact, and fire resistance properties on Sumberejo kenaf fiber reinforced epoxy composites on 0°/0°/0°/0° and 0°/90°/0°/90° fiber directions

R. A. Rahmudani, A. L. Jowono, S. Rosano

AIP Conference Proceedings 2646, 050114 (2023) doi: <https://doi.org/10.1063/5.0140104>

[Abstract](#)

[View article](#)

[PDF](#)

Current characteristics of full color running text design based on microcontroller HD-U60-75

W. Setya, M. F. Rozaldi

AIP Conference Proceedings 2646, 050115 (2023) doi: <https://doi.org/10.1063/5.0113401>

[Abstract](#)

[View article](#)

[PDF](#)

Design and analysis of planar monopole antenna for satellite communication

E. Rohadi, I. Sinjaktin, R. H. Romadhon

AIP Conference Proceedings 2646, 050116 (2023) doi: <https://doi.org/10.1063/5.0117266>

[Abstract](#)

[View article](#)

[PDF](#)

Distance detection systems for motorized vehicles on highways using rfid and ultrasonic sensors: Design and analysis

Ertan Rohadi, Moechammad Sarosa, Anun Madhira Addarani

AIP Conference Proceedings 2646, 050117 (2023) doi: <https://doi.org/10.1063/5.0113775>

[Abstract](#)

[View article](#)

[PDF](#)

Numerical simulation for floater design on the 17 passengers capacity of N219 amphibian in static and dynamic condition

Sayati Syamsuar, Erwardi, Bagyo Suwasono, Sutyo, Nina Kartika, Adityo Sukasmoro, Annissa Roshyentalawati, Handarto, Andi M. Kadir, Arief Setyawan, Ali Munazid

AIP Conference Proceedings 2646, 050118 (2023) doi: <https://doi.org/10.1063/5.0132289>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

**ENGINEERING**

GENERAL PHYSICS

Five hole probe fixed calibration with high response pressure sensor

Hanni Defanti, Fadilah Hasim, Shabrina Leksono, Dimas Sangaji, Sahran, A. A. Zaki

AIP Conference Proceedings 2646, 050119 (2023) doi: <https://doi.org/10.1063/5.0135651>

[Abstract](#)

[View article](#)

[PDF](#)

Floater model for wind tunnel testing

Avif Rahmadhi Hidayat, Zukhy Maslun, Sanjuthi, Rifal Indriawan, Satrio La Ndulu, Fadilah Hasim, Hanni Defanti

AIP Conference Proceedings 2646, 050120 (2023) doi: <https://doi.org/10.1063/5.0113145>

[Abstract](#)

[View article](#)

[PDF](#)

Thermal comfort analysis by adjusting the tipping window opening distance using PMV

Kholijah Laliq, Popi Puspitanari

AIP Conference Proceedings 2646, 050121 (2023) doi: <https://doi.org/10.1063/5.0120286>

[Abstract](#)

[View article](#)

[PDF](#)

Performance evaluation of various electronic circuit online & offline simulators: Case study of voltage divider

M. A. Kautsar, G. A. Nazranidin, S. Fuada, M. Hesenah, V. Fujiyanti, M. D. Hidayatullah, W. Pratna

AIP Conference Proceedings 2646, 050122 (2023) doi: <https://doi.org/10.1063/5.0112634>

[Abstract](#)

[View article](#)

[PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Plastic bottle recycler with automation using Raspberry Pi controller

Abdul Dwi Nur Cahyo, Nadhifa Moudidat, Fand Trawan, Muhamed Rausyan Fikri, Djab Wibowo Djaman, Rendi Andrias, Eka Febrian Sulanto

AIP Conference Proceedings 2646, 050123 (2023) doi: <https://doi.org/10.1063/5.0116352>

[Abstract](#)

[View article](#)

[PDF](#)

### Design of computer vision training kit with machine learning algorithm to overcome distance learning in pandemic COVID-19

D Kuswardhana, E. Hartman, F. Jabbar, F. Nashrullah

AIP Conference Proceedings 2646, 050124 (2023) doi: <https://doi.org/10.1063/5.0139406>

[Abstract](#)

[View article](#)

[PDF](#)

### Kinematic design of trans phalangeal prosthetic device with 1-DOF

Deswita Dewi Ramadani, Fand Trawan, Djab Wibowo Djaman, Kushendarsyah Saptan, Ertanto Yandri

AIP Conference Proceedings 2646, 050125 (2023) doi: <https://doi.org/10.1063/5.0113458>

[Abstract](#)

[View article](#)

[PDF](#)

### Augmented reality application in tourism

Wildan Azzad, Rishadian Yusuf, Diky Zakaria, Ach. Maulana Habibi Yusuf

AIP Conference Proceedings 2646, 050126 (2023) doi: <https://doi.org/10.1063/5.0113152>

[Abstract](#)

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## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

## GENERAL PHYSICS

### Trends of environmental literacy research: A systematic review of the literature

Muhammad Nur Hudha, Ida Hamdani, Anna Permainan, Ade Gafar Abdullah

AIP Conference Proceedings 2646, 050001 (2023) doi: <https://doi.org/10.1063/5.0113171>

[Abstract](#)

[View article](#)

[PDF](#)

### Effect of diameter on viscosity value with Stoke's method using Amrita OLabs

Yudi Digantera, Rera Denye Agustina, Elsy Nurfaidiah, Riko Purnama Putra, Shaleq Andhika, Ruki Hidayatulloh

AIP Conference Proceedings 2646, 050002 (2023) doi: <https://doi.org/10.1063/5.0112564>

[Abstract](#)

[View article](#)

[PDF](#)

### Relativistic quantum Stirling engine of massless boson in the 1D infinite potential well with two-level energies

Irza Agani Fahrul, Yohanes Dwi Saputra, Rajendra Salim

AIP Conference Proceedings 2646, 050003 (2023) doi: <https://doi.org/10.1063/5.0116283>

[Abstract](#)

[View article](#)

[PDF](#)

### Physical properties of briquettes composite from coffee husks (Coffea arabica L) and corn cob (Zea mays) for alternative fuel

H. Aliah, B. L. Rahmah, A. Saadib, R. N. Iman, D. G. Syarif, A. Setiawan, B. W. Nuryadin

AIP Conference Proceedings 2646, 050004 (2023) doi: <https://doi.org/10.1063/5.0114333>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Momentum transfer analysis of upper body during backhand drive stroke in tennis

Agus Rusdiana, Angga M. Syahid, Tian Kurniawan

AIP Conference Proceedings 2646, 060005 (2023) doi: <https://doi.org/10.1063/5.0113706>

[Abstract](#)

[View article](#)

[PDF](#)

### 3D biomechanical analysis of long drive swing between skilled and amateur golf players

Agus Rusdiana, Angga M. Syahid, Tian Kurniawan

AIP Conference Proceedings 2646, 060006 (2023) doi: <https://doi.org/10.1063/5.0113753>

[Abstract](#)

[View article](#)

[PDF](#)

### 3D kinematics analysis of track start movement in swimming

Agus Rusdiana, Angga M. Syahid, Tian Kurniawan

AIP Conference Proceedings 2646, 060007 (2023) doi: <https://doi.org/10.1063/5.0113767>

[Abstract](#)

[View article](#)

[PDF](#)

### Parcml web games on science learning: A systematic perspective of content design

Sudi Dwi Aji, Amelia Dwi Yasa, Citra Setia Dewi

AIP Conference Proceedings 2646, 060008 (2023) doi: <https://doi.org/10.1063/5.0113189>

[Abstract](#)

[View article](#)

[PDF](#)



## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Simple harmonic motion physical modelling based on macro Excel

I. Isrokatun, B. S. Purwono

AIP Conference Proceedings 2646, 060009 (2023) doi: <https://doi.org/10.1063/5.0113216>

[Abstract](#) [View article](#) [PDF](#)

### Electromagnetic induced: Design and build Android-based applications

W. Setya, K. Abdulloh, T. A. S. Putri

AIP Conference Proceedings 2646, 060010 (2023) doi: <https://doi.org/10.1063/5.0116414>

[Abstract](#) [View article](#) [PDF](#)

### The application of video based laboratory in vibrations and waves concept

Herry Yuniarti Suhendi, Diah Mulhayatillah, Dindin Nasrudin, Chaerul Rochman, Adam Malik, Ryan Andiansyah

AIP Conference Proceedings 2646, 060011 (2023) doi: <https://doi.org/10.1063/5.0115726>

[Abstract](#) [View article](#) [PDF](#)

### The use of photovoice to analyze the physics concepts on Rayleigh scattering phenomena

Utarna Alan Dato, Fathatur Naimah, Rana Ambarsari, Ali Nuruliyah, Nurita Apriana Lestari, Abdul Khokir, Nadi Supripto, Bambang Yulianto, Supriawanto

AIP Conference Proceedings 2646, 060012 (2023) doi: <https://doi.org/10.1063/5.0113756>

[Abstract](#) [View article](#) [PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Comparison of the optical properties of TZPBNE glasses with the variation on PbO/Na<sub>2</sub>O and Er<sub>2</sub>O<sub>3</sub>/Na<sub>2</sub>O

Mukhayyadin Niswati Rodhyatul Jauhariyah, Ahmad Marzuki, Asnawi, Tifin Sunardi, Maradik, Mita Anggaryanti, Lydie Ratnaswari, Agus Hartanto, Nurhasan

AIP Conference Proceedings 2646, 060013 (2023) doi: <https://doi.org/10.1063/5.0114068>

[Abstract](#) [View article](#) [PDF](#)

### Development of practical tools related to spring constant and Young's modulus using ultrasonic sensors

A. Malik, R. Priesta, T. A. S. Putri, W. Suklewati, Y. S. Latifah, H. Y. Suhendi

AIP Conference Proceedings 2646, 060014 (2023) doi: <https://doi.org/10.1063/5.0113044>

[Abstract](#) [View article](#) [PDF](#)

### Rainfall prediction in the district of Lima Puluh Kota using a Fourier transformation approach

Rizki Zakwandi, Wansono, Rena Denysa Agustina, Ade Yuli Nuryanti

AIP Conference Proceedings 2646, 060015 (2023) doi: <https://doi.org/10.1063/5.0113173>

[Abstract](#) [View article](#) [PDF](#)

### Kelvin wake pattern: An analysis of boat wakes by it mass

Rena Denysa Agustine, Riki Purnama Putra, Rizki Hidayatullah, Shadiq Andhika, Amanda Putri, Dedi Kurnandi, Dera Mharja

AIP Conference Proceedings 2646, 060016 (2023) doi: <https://doi.org/10.1063/5.0113922>

[Abstract](#) [View article](#) [PDF](#)

## Volume 2646, Issue 1

27 April 2023  
All Issues

### In this Issue

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

GENERAL PHYSICS

### Effect of coils frequency on the Tesla coil props

D. Mulhayatillah, M. F. Rozaki, Y. Setiawan, S. D. Nurdin, H. Y. Suhendi, D. Nasrudin

AIP Conference Proceedings 2646, 060017 (2023) doi: <https://doi.org/10.1063/5.0112777>

[Abstract](#) [View article](#) [PDF](#)

### Water content and nail head pulled-through strength of epoxy/Sumberejo kenaf fiber composite with fiber orientation 0°/0°/0°/0° and 0°/90°/0°/90°

Iva Zahrotin, Ariadne L. Juwono, Seto Roseno

AIP Conference Proceedings 2646, 060018 (2023) doi: <https://doi.org/10.1063/5.0113062>

[Abstract](#) [View article](#) [PDF](#)

### Application Visco-Ms to improve time measurement accuracy on viscosity test

Rizki Hidayatullah, Riki Purnama Putra, Shadiq Andhika, Rena Denysa Agustine, Dera Mharja

AIP Conference Proceedings 2646, 060019 (2023) doi: <https://doi.org/10.1063/5.0112960>

[Abstract](#) [View article](#) [PDF](#)

### Calculation of the electronic structure CsBX<sub>3</sub> (B = Pb and Sn, X = Cl, Br and I) using density functional theory (DFT) method as the active material of perovskite solar cells

Mochamad Rizki Azhar, Hasmah Adah, Peta Phtiana

AIP Conference Proceedings 2646, 060020 (2023) doi: <https://doi.org/10.1063/5.0118029>

[Abstract](#) [View article](#) [PDF](#)

**Volume 2646, Issue 1**

27 April 2023  
All Issues

**In this Issue**

PRELIMINARY

BIOLOGY

CHEMISTRY

COMPUTER SCIENCE AND  
TECHNOLOGY

ENGINEERING

**GENERAL PHYSICS**

Calculation of the optical absorbance properties of *Rivina humilis* molecules using density functional theory method as active material dye sensitized solar cell

[Siti Aschawati](#), [Hosniyah Aliah](#), [Prita Pritama](#)

*AIP Conference Proceedings* 2646, 060021 (2023) doi: <https://doi.org/10.1063/5.0118307>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Phonon properties calculation of inorganic perovskite CsSnX<sub>3</sub> (X=Cl, Br, I) in cubic phase using density functional theory (DFT)

[Elhylla Fitra Rahmani](#), [Hosniyah Aliah](#), [Prita Pritama](#)

*AIP Conference Proceedings* 2646, 060022 (2023) doi: <https://doi.org/10.1063/5.0118308>

[Abstract](#) ▾

[View article](#)

[PDF](#)

Using pendulum oscillation as Doppler effect experiment

[A. Y. Nuryantini](#), [R. Zakariandi](#), [M. A. Anayada](#)

*AIP Conference Proceedings* 2646, 060023 (2023) doi: <https://doi.org/10.1063/5.0113172>

[Abstract](#) ▾

[View article](#)

[PDF](#)

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## Relation of traffic-related air pollution and people's duration of stay at sidewalk café/restaurant

M. C. Adriana ✉; A. S. Wartaman; H. M. Taki



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# Relation of Traffic-related Air Pollution and People's Duration of Stay at Sidewalk Café/Restaurant

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**Abstract.** Air pollution is one of the main factors causing adverse health effects, such as cardiovascular disease, morbidity, and even mortality to humans. In the urban environment, transport is known to be the primary source of air pollution. This paper aims to assess people awareness of air pollution in open public spaces by investigating the relationship between people's dwell time and traffic-induced pollution at sidewalk café/restaurant. First, air pollution was analysed by descriptive statistics. Next, correlation and multivariate analysis were used to seek the relations between traffic, air pollution, and dwell time. The results show that pollution level doesn't significantly influence people duration of stay, but traffic does. It portrays the unawareness of people towards air quality in their surroundings. Furthermore, the unexpected result found in this study is that there are other significant pollution sources such as from cooking and smoking activities. Therefore, policies to improve air quality in urban areas are highly needed from the transport sector and eventually beyond it.

## INTRODUCTION

Open public space (OPS) has an essential role in urban society related health and well-being [1,2] as well as the quality of life [3,4]. The existence of open public space is able to promote physical activity [5], social interaction and integration [6], and mental health [7]. In the city, streets and its sidewalk are vital elements as public spaces because it offers one of the urban delights [8], where citizens can do various activities such as travel, shopping, playing, interaction, and recreational.

Nowadays, cities face great environmental challenges, one of them is poor air quality. Air pollution is well-known to cause adverse health effects to humans. Studies found that exposure to air pollution contributes to respiratory and cardiovascular morbidity, premature mortality [9], and cancer [10]. According to United Nations [11], air pollution has caused 4.2 million people deaths in 2016. In the urban environment, transport is found to be the primary source of air pollution through vehicle exhaust emission [12,13], which is proved by the clear connections between traffic volume and air pollution [14,15].

OPS is vital to the urban society but dwelling there can be harmful. People who spend time eating, drinking, resting and socializing at sidewalk café/restaurant have direct exposure to traffic-induced pollution without realizing it. Understanding people's behaviours in open public spaces can reflect their awareness of air pollution. Studies identify the relations of people awareness by asking their perception about air quality, however, it is rare to find studies that examined their actual behaviour related to air pollution. This study aims to assess people awareness by directly investigating people's behaviour in sidewalk café/restaurant. Duration of stay is an indicator of behaviour towards OPS quality [8] that can also portray exposure toward air pollution.

The study is taken place in London, a world-class city that is also the most polluted place in Europe [16]. Since 2009, the city government has implemented transport improvement programs to tackle the issue called London's Great

Outdoors and Better Street programs. However, the nitrogen dioxide (NO<sup>2</sup>) concentration and particulate matter number still exceed the EU limit [17,18].

The study is conducted by quantitatively measuring traffic flow, air pollution level, and people's dwell time in three different streets with has distinct traffic volumes but similar activity functions. The hypothesis in this research is pollution level affects people's duration of stay at sidewalk café/restaurant, on which if pollution level in A > pollution level in B, the dwell time in A < dwell time in B. The findings of this study may provide useful information to policymakers in such decision planning to optimize air quality management policies to create a better quality of life and sustainable cities.

## MATERIALS AND METHODS

### Study Area

This study focuses on three streets in Central London which categorized by different "movement" functions and similar "place" functions. Different "movement" functions are defined by traffic volume and "place" by activities or land use. Based on that, the roads chosen were: (1) Exhibition Road with low traffic, (2) The Cut with medium traffic, and (3) Upper Street with high traffic. All of those streets have distinct road layouts and have sidewalk cafes and restaurants (see table 1).

**TABLE 1.** Summary of road conditions

Street Name	Traffic Volume	Street Length (m)	Number of Lanes	Information
The cut	Medium	340	2	High street with residential access
Exhibition Road <sup>a</sup>	Low	590	1	Important route (A1)
Upper Street	High	340	4	High pedestrian use

<sup>a</sup>Vehicle restriction applied

### Data Collection

Data in this study are mainly primary data that is gathered through surveys. Data collection was conducted in the summer, considering the best weather for people to sit outside. Three sunny days were chosen to minimize the bias of data, considering the weather will influence people behaviour in outdoor places. The surveys were conducted on 6, 7, and 8 July 2016.

#### *Traffic and Duration of Stay*

Traffic and people's dwell time were collected through video recording by Tracsis Traffic Data Ltd. The camera started on those three days from 06:30 – 19:00. The cameras captured two cafes/restaurants at The Cut, two at Exhibition Road, and one at Upper Street.

#### *Air pollution data*

Air pollution measurement was carried out using TSI Model 3007 CPC equipment which can assess Particle Number Concentrations (PNC) with the size range of 0.01µm - 1.0µm, called ultrafine particles (UFP). PNC is highly potential to measure traffic-induced pollution because it contains 90% of UFP [19], the primary emission of road traffic [20,21]. UFP (<0.1 µm) is also more relevant to health risk [22], so it will have more advantage in examining the well-being of people using public space related to their exposure.

The measurement was conducted on the selected roadside environments on three different days. Background level was also measured from the 7<sup>th</sup> floor of Palestra Building for those three days. The measurement was supposed to be taken from 08:00 am until 07.00 pm, however, it was not possible due to the equipment limitations (see table 2).

**TABLE 2.** Summary of survey days and times

Date of	Sample Site	Video Recording Time	Café/Restaurant	Roadside Sampling Time	Background Sample Time
6 July 2016	The Cut	06:30 – 19:00	Café Nero Pret a Manger	09:48 – 12:11	08:51 – 13:45
				12:41 – 15:24	15:12 – 19:00
				16:00 – 19:00	
7 July 2016	Exhibition Road	06:30 – 19:00	Roots & Bulbs Café Fernandez& Wells	10:23 – 15:50	08:19 – 13:40
				16:28 – 19:00	14:58 – 19:00
8 July 2016	Upper Street	06:30 – 19:00	Costa	11:28 – 14:52	10:18 – 16:38
				15:05 – 17:54	17:12 – 19:00
				18:22 – 18:59	

## Data Analysis

Data were analysed using some software. First, air pollution data were analysed using R software to show the pattern of air pollution. R software is a powerful software in processing large data set such as air pollution data. Next, correlation analysis was applied using SPSS software to find the correlation between pollution, traffic volume, and duration of stay. Lastly, analysis was continued by multivariate regression analysis to predict the relationship between those three variables.

## RESULTS AND DISCUSSION

### Traffic and Air Pollution Results

Traffic data from video recording confirms the initial assumption which shows the different traffic levels on those three streets. Exhibition road has the lowest volume on average for only 36 Per car unit (PCU)/hour. Upper Street, as expected, has the highest traffic volume with an average of 1,307 PCU/hour. The Cut is the medium one, with an average volume of 685 PCU/hour.

### Air Pollution

The Cut has the lowest mean of PNC (26,458 particles  $\text{cm}^{-3}$ ) with medium traffic volume, and as expected, Upper Street with the highest traffic has the highest mean of PNC level (48,098 particles  $\text{cm}^{-3}$ ). Anomaly results are found at Exhibition Road with the lowest traffic but present the high PNC level (42,430 particles  $\text{cm}^{-3}$ ), slightly below Upper Street. Thus, indicate that there might be other factors affecting PNC level other than traffic (see table 3).

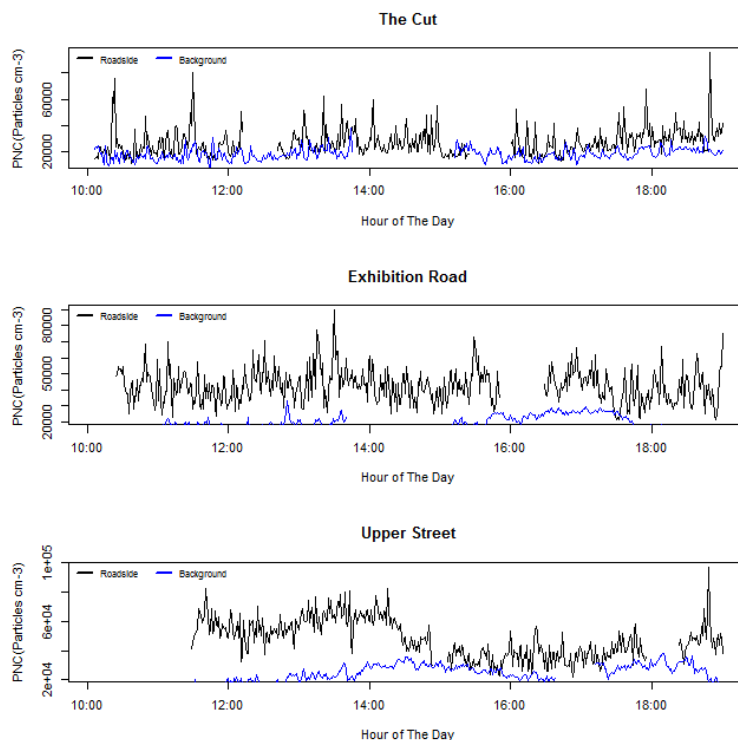
**TABLE 3.** Descriptive statistic of air pollution

Date	Site	Particle Number Concentrations (particles $\text{cm}^{-3}$ )		
		Mean	Median	Standard Deviation
06-Jul-16	The Cut	26458	22682	15532
07-Jul-16	Exhibition Road	42430	40224	16424
08-Jul-16	Upper Street	48098	46663	16018

Furthermore, to understand the genuine traffic contribution to the PNC, the background level of PNC should also be alleviated from roadside contribution [23]. The PNC gap at Exhibition Road is big although it has low traffic. Exhibition road has more cafes and restaurants along the road compared to The Cut and Upper Street which means more cooking activities occur. According to Dennekamp [21], cooking activities contribute high PNC (50,000 – 225,000 particles  $\text{cm}^{-3}$ ), higher than the vehicle traffic itself. In addition, more people smoking at Exhibition Road that also contributes to 62,500 - <75,000 particles  $\text{cm}^{-3}$ . Both activities can explain the cause of the high PNC in Exhibition Road.

Exhibition Road shows unexpected results in this study. As consequences, policies beyond transport sector are needed to improve air quality in urban areas. Pollution from cooking can be reduced by changing gas cooking into electric cooking which emits less UFP [24]. Moreover, regulation, in general, is needed to manage the public space.

The PNC gap at Upper Street is large which is caused by traffic activities. However, The Cut with medium traffic also shows the gap but insignificant. Traffic data shows that cars and light good vehicles volumes are approximately the same in both streets (The Cut: 460 car/hour; Upper Street: 545 car/hour and The Cut: 118 LGV/hour; Upper Street: 161 LGV/hour). The differences are found with bus and heavy goods vehicles (HGV) numbers. Average HGV passing The Cut is 37 HGV/hour, while it gets almost three times larger in Upper Street (101 HGV/hour). Lastly, The Cut has very low bus passing (0,75 bus/hour), whereas it reaches 166 bus/hour in the Upper Street (see table 4 and Fig. 1).



**FIGURE 1.** Time series of roadside and background PNC

**TABLE 4.** Number of bus and HGV in the cut and upper street

Time	Total Bus/hour		Total HGV/Hour	
	The Cut	Upper Street	The Cut	Upper Street
Average	0,75	166	37	101

Bus and HGV in the UK have been exclusively powered by diesel [25], which emit UFP from unburnt fuel and incomplete combustion [26]. Study found that bus itself emits significant UFP around 30,000 – 110,000 particles  $\text{cm}^{-3}$  [21]. While both buses and HGV have vital roles for people and goods movement, it is important to minimize the adverse impact by using more sustainable fuel such as biodiesel or even electric vehicles.

### Duration of Stay

There is a total of 310 samples collected during the video recording and air pollution measurement: (1) The Cut: 101; (2) Exhibition Road: 156; (3) Upper Street: 53. The average dwell time at The Cut is the lowest (35.2 minutes) and then followed by Exhibition Road by 45 minutes on average. Survey found that people at Upper Street spend the longest time by 46,2 minutes on average. Overall, the average duration of stay in all three places is 41,5 minutes (see table 5).

**TABLE 5.** Duration of stay

Location	Café/Restaurant	Average Duration of Stay (minutes)
The Cut	Café Nero	39.2
	Pret a Manger	31.2
Exhibition Road	Roots & Bulbs Café	36.4
	Fernandez & Wells	53.7
Upper Street	Costa	46.2

### Correlation Analysis

Spearman's correlation analysis shows a significant positive correlation between PNC level and dwell time. A similar correlation is also found between average traffic flow with people's duration of stay. In summary, traffic flow and PNC are positively associated with people's dwell time at sidewalk café/restaurant (see table 6).

**TABLE 6.** Correlation analysis of duration of stay

Variables	Dwell Time	<i>p</i> -value
PNC Level	0.143*	0.012
Average PCU/15 minutes	0.675**	0.000

Significant codes for *p*-value: \*\* *p*-value < 0.01; \* *p*-value < 0.05

### Multivariate Regression Analysis

Multivariate regression results present a significant positive impact of traffic flow on the duration of stay, which means the more crowded the traffic, the longer people dwell and vice versa. Meanwhile, PNC level doesn't significantly influence people's dwell time, which indicates the unawareness of air quality in their surrounding area. Some studies have tried to seek the relationship between perceived and actual levels of pollutants but it's not possible [27,28]. UFP are identified as tiny particles, much smaller than PM<sub>2.5</sub> and PM<sub>10</sub>. It is also more numerous and more toxic [21,29]. Due to its characteristics, UFP are invisible and odourless [30]. All these criteria of UFP may make it hard to be sensed by human sensory, just like many air pollutants such as PM<sub>2.5</sub> and PM<sub>10</sub>. Since they cannot feel it, they cannot perceive it, and as a result, they become unaware of it (see table 7).

**TABLE 7.** Correlation analysis of dwell time

Factors	Standardized $\beta$	Standard Error	t-value	<i>p</i> -value
PNC (Particles/cm <sup>-3</sup> )	0.04	0.000	0.94	0.349
Average PCU/hour	0.669**	0.013	15.73	0.000
N	310			
Adj. R <sup>2</sup>	0.454			
F-stat	129.44	<i>p</i> -value	0.000	

Significant codes for *p*-value: \*\* *p*-value < 0.01

### CONCLUSION

OPS is vital to the urban society, but dwelling there has a risk of traffic-induced pollution. The finding of this study proved that people are unaware of air quality in open public spaces which is performed by their duration of stay. An unexpected result found in this paper is that other significant pollution sources exist from cooking and smoking activities. Therefore, policies to improve air quality in the urban area is highly needed from the transport sector and eventually beyond it.

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# Relation of traffic-related air pollution and people's duration of stay at sidewalk café/restaurant

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**Abstract.** Air pollution is one of the main factors causing adverse health effects, such as cardiovascular disease, morbidity, and even mortality to humans. In the urban environment, transport is known to be the primary source of air pollution. This paper aims to assess people awareness of air pollution in open public spaces by investigating the relationship between people's dwell time and traffic-induced pollution at sidewalk café/restaurant. First, air pollution was analysed by descriptive statistics. Next, correlation and multivariate analysis were used to seek the relations between traffic, air pollution, and dwell time. The results show that pollution level doesn't significantly influence people duration of stay, but traffic does. It portrays the unawareness of people towards air quality in their surroundings. Furthermore, the unexpected result found in this study is that there are other significant pollution sources such as from cooking and smoking activities. Therefore, policies to improve air quality in urban areas are highly needed from the transport sector and eventually beyond it.

**Keyword:** Air Pollution, Road Traffic, Sidewalk Café/Restaurant, Awareness, London

## 1. Introduction

Open public space (OPS) has an essential role in urban society related health and well-being [1, 2] as well as the quality of life [3, 4]. The existence of open public space is able to promote physical activity [5], social interaction and integration [6], and mental health [7]. In the city, streets and its sidewalk are vital elements as public spaces because it offers one of the urban delights [8], where citizens can do various activities such as travel, shopping, playing, interaction, and recreational.

Nowadays, cities face great environmental challenges, one of them is poor air quality. Air pollution is well-known to cause adverse health effects to humans. Studies found that exposure to air pollution contributes to respiratory and cardiovascular morbidity, premature mortality [9], and cancer [10]. According to United Nations [11], air pollution has caused 4.2 million people deaths in 2016. In the urban environment, transport is found to be the primary source of air pollution through vehicle exhaust emission [12, 13], which is proved by the clear connections between traffic volume and air pollution [14, 15].

OPS is vital to the urban society but dwelling there can be harmful. People who spend time eating, drinking, resting and socializing at sidewalk café/restaurant have direct exposure to traffic-induced pollution without realizing it. Understanding people's behaviours in open public spaces can reflect their awareness of air pollution. Studies identify the relations of people awareness by asking their perception about air quality, however, it is rare to find studies that examined their actual behaviour related to air

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pollution. This study aims to assess people awareness by directly investigating people's behaviour in sidewalk café/restaurant. Duration of stay is an indicator of behaviour towards OPS quality [8] that can also portray exposure toward air pollution.

The study is taken place in London, a world-class city that is also the most polluted place in Europe [16]. Since 2009, the city government has implemented transport improvement programs to tackle the issue called London's Great Outdoors and Better Street programs. However, the nitrogen dioxide (NO<sub>2</sub>) concentration and particulate matter number still exceed the EU limit [17, 18].

The study is conducted by quantitatively measuring traffic flow, air pollution level, and people's dwell time in three different streets with has distinct traffic volumes but similar activity functions. The hypothesis in this research is pollution level affects people's duration of stay at sidewalk café/restaurant, on which if pollution level in A > pollution level in B, the dwell time in A < dwell time in B. The findings of this study may provide useful information to policymakers in such decision planning to optimize air quality management policies to create a better quality of life and sustainable cities.

## 2. Materials and Methods

### 2.1. Study area

This study focuses on three streets in Central London which categorized by different "movement" functions and similar "place" functions. Different "movement" functions are defined by traffic volume and "place" by activities or land use. Based on that, the roads chosen were: (1) Exhibition Road with low traffic, (2) The Cut with medium traffic, and (3) Upper Street with high traffic. All of those streets have distinct road layouts and have sidewalk cafes and restaurants.

**Table 1.** Summary of road conditions.

Street Name	Traffic Volume	Street Length (m)	Number of Lanes	Information
The cut	Medium	340	2	High street with residential access
Exhibition Road <sup>a</sup>	Low	590	1	Important route (A1)
Upper Street	High	340	4	High pedestrian use

<sup>a</sup>Vehicle restriction applied

### 2.2. Data collection

Data in this study are mainly primary data that is gathered through surveys. Data collection was conducted in the summer, considering the best weather for people to sit outside. Three sunny days were chosen to minimize the bias of data, considering the weather will influence people behaviour in outdoor places. The surveys were conducted on 6, 7, and 8 July 2016.

**2.2.1. Traffic and duration of stay.** Traffic and people's dwell time were collected through video recording by Tracsis Traffic Data Ltd. The camera started on those three days from 06:30 – 19:00. The cameras captured two cafes/restaurants at The Cut, two at Exhibition Road, and one at Upper Street.

**2.2.2. Air pollution data.** Air pollution measurement was carried out using TSI Model 3007 CPC equipment which can assess Particle Number Concentrations (PNC) with the size range of 0.01 µm - 1.0 µm, called ultrafine particles (UFP). PNC is highly potential to measure traffic-induced pollution because it contains 90% of UFP [19], the primary emission of road traffic [20, 21]. UFP (<0.1 µm) is also more relevant to health risk [22], so it will have more advantage in examining the well-being of people using public space related to their exposure.

The measurement was conducted on the selected roadside environments on three different days. Background level was also measured from the 7<sup>th</sup> floor of Palestra Building for those three days. The measurement was supposed to be taken from 08:00 am until 07.00 pm, however, it was not possible due to the equipment limitations.

**Table 2.** Summary of Survey Days and Times.

Date of	Sample Site	Video Recording Time	Café/Restaurant	Roadside Sampling Time	Background Sample Time
5 6 July 2016	The Cut	06:30 – 19:00	Café Nero Pret a Manger	09:48 – 12:11 12:41 – 15:24 16:00 – 19:00	08:51 – 13:45 15:12 – 19:00
7 July 2016	Exhibition Road	06:30 – 19:00	Roots & Bulbs Café Fernandez & Wells	10:23 – 15:50 16:28 – 19:00	08:19 – 13:40 14:58 – 19:00
8 July 2016	Upper Street	06:30 – 19:00	Costa	11:28 – 14:52 15:05 – 17:54 18:22 – 18:59	10:18 – 16:38 17:12 – 19:00

### 2.3. Data analysis

Data were analysed using some software. First, air pollution data were analysed using R software to show the pattern of air pollution. R software is a powerful software in processing large data set such as air pollution data. Next, correlation analysis was applied using SPSS software to find the correlation between pollution, traffic volume, and duration of stay. Lastly, analysis was continued by multivariate regression analysis to predict the relationship between those three variables.

## 3. Results and Discussion

### 3.1. Traffic and Air Pollution Results

Traffic data from video recording confirms the initial assumption which shows the different traffic levels on those three streets. Exhibition road has the lowest volume on average for only 36 Per car unit (PCU)/hour. Upper Street, as expected, has the highest traffic volume with an average of 1,307 PCU/hour. The Cut is the medium one, with an average volume of 685 PCU/hour.

### 3.2. Pollution

The Cut has the lowest mean of PNC (26,458 particles  $\text{cm}^{-3}$ ) with medium traffic volume, and as expected, Upper Street with the highest traffic has the highest mean of PNC level (48,098 particles  $\text{cm}^{-3}$ ). Anomaly results are found at Exhibition Road with the lowest traffic but present the high PNC level (42,430 particles  $\text{cm}^{-3}$ ), slightly below Upper Street. Thus, indicate that there might be other factors affecting PNC level other than traffic.

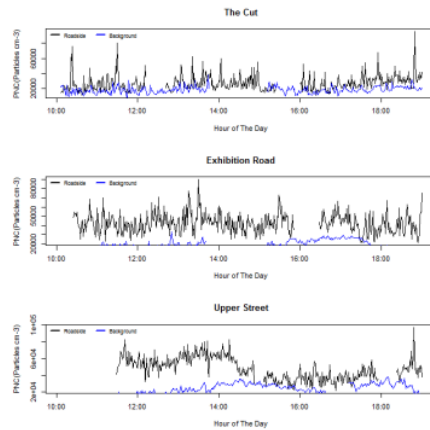
**Table 3.** Descriptive statistic of air pollution.

Date	Site	Particle Number Concentrations (particles $\text{cm}^{-3}$ )		
		Mean	Median	Standard Deviation
06-Jul-16	The Cut	26458	22682	15532
07-Jul-16	Exhibition Road	42430	40224	16424
08-Jul-16	Upper Street	48098	46663	16018

Furthermore, to understand the genuine traffic contribution to the PNC, the background level of PNC should also be alleviated from roadside contribution [23]. The PNC gap at Exhibition Road is big although it has low traffic. Exhibition road has more cafes and restaurants along the road compared to The Cut and Upper Street which means more cooking activities occur. According to Dennekamp [21], cooking activities contribute high PNC (50,000 – 225,000 particles  $\text{cm}^{-3}$ ), higher than the vehicle traffic itself. In addition, more people smoking at Exhibition Road that also contributes to 62,500 - <75,000 particles  $\text{cm}^{-3}$ . Both activities can explain the cause of the high PNC in Exhibition Road.

Exhibition Road shows unexpected results in this study. As consequences, policies beyond transport sector are needed to improve air quality in urban areas. Pollution from cooking can be reduced by changing gas cooking into electric cooking which emits less UFP [24]. Moreover, regulation, in general, is needed to manage the public space.

The PNC gap at Upper Street is large which is caused by traffic activities. However, The Cut with medium traffic also shows the gap but insignificant. Traffic data shows that cars and light good vehicles volumes are approximately the same in both streets (The Cut: 460 car/hour; Upper Street: 545 car/hour and The Cut: 118 LGV/hour; Upper Street: 161 LGV/hour). The differences are found with bus and heavy goods vehicles (HGV) numbers. Average HGV passing The Cut is 37 HGV/hour, while it gets almost three times larger in Upper Street (101 HGV/hour). Lastly, The Cut has very low bus passing (0,75 bus/hour), whereas it reaches 166 bus/hour in the Upper Street.



**Figure 1.** Time series of roadside and background PNC

**Table 4.** Number of bus and HGV in The Cut and Upper Street.

Time	Total Bus/hour		Total HGV/Hour	
	The Cut	Upper Street	The Cut	Upper Street
Average	0,75	166	37	101

Bus and HGV in the UK have been exclusively powered by diesel [25], which emit UFP from unburnt fuel and incomplete combustion [26]. Study found that bus itself emits significant UFP around 30,000 – 110,000 particles  $\text{cm}^{-3}$  [21]. While both buses and HGV have vital roles for people and goods movement, it is important to minimize the adverse impact by using more sustainable fuel such as biodiesel or even electric vehicles.

### 3.3. Duration of Stay

There is a total of 310 samples collected during the video recording and air pollution measurement: (1) The Cut: 101; (2) Exhibition Road: 156; (3) Upper Street: 53. The average dwell time at The Cut is the lowest (35.2 minutes) and then followed by Exhibition Road by 45 minutes on average. Survey found that people at Upper Street spend the longest time by 46,2 minutes on average. Overall, the average duration of stay in all three places is 41,5 minutes.

**Table 5.** Duration of stay.

Location	Café/Restaurant	Average Duration of Stay (minutes)
The Cut	Café Nero	39.2
	Pret a Manger	31.2

Exhibition Road	Roots & Bulbs Café	36.4
	Fernandez & Wells	53.7
Upper Street	Costa	46.2

### 3.4. Correlation Analysis

Spearman's correlation analysis shows a significant positive correlation between PNC level and dwell time. A similar correlation is also found between average traffic flow with people's duration of stay. In summary, traffic flow and PNC are positively associated with people's dwell time at sidewalk café/restaurant.

**Table 6.** Correlation analysis of duration of stay.

Variables	Dwell Time	p-value
PNC Level	0.143*	0.012
Average PCU/15 minutes	0.675**	0.000

Significant codes for p-value: \*\* p-value < 0.01; \* p-value < 0.05

### 3.5. Multivariate Regression Analysis

Multivariate regression results present a significant positive impact of traffic flow on the duration of stay, which means the more crowded the traffic, the longer people dwell and vice versa. Meanwhile, PNC level doesn't significantly influence people's dwell time, which indicates the unawareness of air quality in their surrounding area. Some studies have tried to seek the relationship between perceived and actual levels of pollutants but it's not possible [27, 28]. UFP are identified as tiny particles, much smaller than PM<sub>2.5</sub> and PM<sub>10</sub>. It is also more numerous and more toxic [21, 29]. Due to its characteristics, UFP are invisible and odourless [30]. All these criteria of UFP may make it hard to be sensed by human sensory, just like many air pollutants such as PM<sub>2.5</sub> and PM<sub>10</sub>. Since they cannot feel it, they cannot perceive it, and as a result, they become unaware of it.

**Table 7.** Correlation analysis of dwell time.

Factors	Standardized $\beta$	Standard Error	t-value	p-value
PNC (Particles/cm <sup>3</sup> )	0.04	0.000	0.94	0.349
Average PCU/hour	0.669**	0.013	15.73	0.000
N	310			
Adj. R <sup>2</sup>	0.454			
F-stat	129.44	p-value	0.000	

Significant codes for p-value: \*\* p-value < 0.01

## 4. Conclusion

OPS is vital to the urban society, but dwelling there has a risk of traffic-induced pollution. The finding of this study proved that people are unaware of air quality in open public spaces which is performed by their duration of stay. An unexpected result found in this paper is that other significant pollution sources exist from cooking and smoking activities. Therefore, policies to improve air quality in the urban area is highly needed from the transport sector and eventually beyond it.

## Acknowledgments

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