IWAM
INTERNATIONAL WORKSHOP ADITIVE MANUFACTURING

# 2ND INTERNATIONAL WORKSHOP

# ADDITIVE MANUFACTURING AND SUSTAINABILITY

## BOOK OF ABSTRACTS

# IWAM 24

ipb INSTITUTO POLITÉCNICO DE BRAGANÇA

OCTOBER 4TH, 2024

# 2nd International Workshop on Additive Manufacturing and Sustainability

# IWAM 24

Bragança - Portugal

October 4th, 2024

**Title:** 2nd. International Workshop on Additive Manufacturing and Sustainability (IWAM): book of abstracts

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**Publisher:**

Instituto Politécnico de Bragança

Campus de Santa Apolónia

5300-253 Bragança - Portugal

**Publishing:** 2025

**ISBN:** 978-972-745-347-4

**Handle:** http://hdl.handle.net/10198/29735

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**WELCOME**

We are pleased to present the International Workshop on Additive Manufacturing and Sustainability Book of Abstracts. This compilation brings together researchers, professors, and innovators from around the world who are advancing additive manufacturing (AM) and sustainable practices.

As the global community prioritizes environmental responsibility, additive manufacturing has emerged as a transformative technology capable of revolutionizing industries while reducing ecological footprints. This workshop unites advanced research, innovative applications, and progressive strategies to examine how additive manufacturing can enhance sustainability.

Within these pages, you will find a diverse array of abstracts showcasing ground-breaking work in areas such as:

Sustainable materials and processes in AM,

Energy efficiency and waste reduction,

Circular economy and lifecycle analysis,

Each contribution reflects a commitment to addressing the challenges and opportunities at the intersection of technology and sustainability. We hope this collection not only informs but also inspires collaboration and innovation among participants.

We are profoundly grateful to the authors, reviewers, and organizers whose unwavering commitment has enabled the publication of this book. A special thank you to our sponsors and partners for their unwavering support in bringing this workshop to life.

We appreciate your participation in this wonderful adventure. Let's work together to advance sustainability and innovation!

Warm regards,

The IWAM 2024 Organizing Committee,

João Rocha

João E. Ribeiro

Jorge Santos

Rui Lima

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# Process Optimization of a Green Composite Containing a 3D Structure Produced via Additive Manufacturing

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This study employs Dynamic Mechanical Analysis (DMA) to optimize the manufacturing process of abrasive wheels with internal three-dimensional channel structures, created by incorporating polylactic acid (PLA) through additive manufacturing, which forms specific channels during the sintering step. DMA tests were conducted to evaluate the impact of varying load and temperature cycles, aiming to minimize defects such as cracks by controlling thermalexpansion and contraction, thereby preserving the integrity of the internal cooling channels. The findings suggest that removing the load, before cooling, enhances the effect of elastic recovery of the PLA structure, effectively preventing permanent deformations.

**Keywords**: Dynamic Mechanical Analysis (DMA); Abrasive Wheels; Polylactic Acid (PLA); Internal Cooling Channels.

# Artificial Intelligence for Additive Manufacturing: preliminary analysis of trends and challenges

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This preliminary study examines how artificial intelligence (AI) and additive manufacturing (AM) might function together within the contexts of Industry 4.0 and 5.0, with an emphasis on how AI might improve AM procedures. Using Scopus datasets on AM and AI, a bibliometric study was carried out. The most important uses of AI in AM are tentatively and heuristically identified to draw some conclusions about future developments.

The integration of AI into AM offers numerous advantages, including improved design optimization, process control, and quality assurance. AI algorithms can analyze vast amounts of data generated during AM processes, enabling real-time monitoring and adaptive decision-making. For instance, machine learning (ML) models can predict and prevent defects in 3D-printed components by analyzing sensor data and identifying patterns indicative of potential failures. Additionally, AI-driven generative design tools can create lightweight, complex geometries that are optimized for performance and material efficiency, pushing the boundaries of what is achievable with AM.

One of the most promising applications of AI in AM is in-process monitoring and control. Traditional AM processes often face challenges related to consistency and repeatability, particularly in metal additive manufacturing. AI can address these issues by continuously analyzing data from sensors, cameras, and other monitoring systems to detect anomalies and adjust parameters in real time. This not only improves the quality of printed parts but also reduces material waste and production costs. Furthermore, AI can facilitate the development of digital twins—virtual replicas of physical systems—that simulate and optimize AM processes before they are executed in the real world.

The bibliometric analysis of Scopus datasets reveals a growing interest in the convergence of AI and AM, with a significant increase in publications over the past decade. However, the field is still in its nascent stages, and several challenges remain. These include the need for more robust AI models that can handle the complexity and variability of AM processes, as well as the development of standardized datasets and benchmarks to facilitate research and collaboration. Ethical considerations, such as the impact of AI on employment and the potential for biased algorithms, must also be addressed as these technologies become more pervasive.

In conclusion, the integration of AI and AM holds immense potential to transform manufacturing in the context of Industry 4.0 and 5.0. By improving design, process control, quality assurance, and supply chain management, AI can address many of the challenges currently faced by AM and unlock new possibilities for innovation. However, realizing this potential will require continued research, collaboration, and investment in both AI and AM technologies. As the field continues

to evolve, adopting a human-centric approach that emphasizes sustainability, inclusivity, and ethics is crucial to ensuring that everyone benefits from these advancements.

**Keywords**: Artificial Intelligence (AI); Additive Manufacturing (AM); Industry 4.0 and 5.0; Process Optimization.

# Experimental Study of Green Nanofluids: Evaluation of Wettability, Viscosity, and Thermal Conductivity Properties

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Nanoparticles have gained significant attention for their diverse applications in fields such as medicine, electronics, and heat transfer due to their unique thermal, optical, and magnetic properties. However, conventional synthesis methods often involve toxic chemicals and high energy consumption. In this study, we report the green synthesis of magnetic iron oxide nanoparticles ($Fe_3O_4$ NPs) using *Chlorella vulgaris* extract as a bioreducing and stabilizing agent, offering an environmentally friendly alternative to conventional methods. The synthesized $Fe_3O_4$ NPs were incorporated into nanofluids using water as the base fluid with different NPs concentrations (0.01wt%, 0.05wt%, and 1wt%) to assess their performance in thermal systems. The thermophysical properties of all nanofluids, including wettability, viscosity, and thermal conductivity, were thoroughly investigated. The cumulative addition of $Fe_3O_4$ NPs to water significantly enhanced the corresponding wettability by reducing the contact angle on different substrates. At the same time, viscosity showed only a minor increase with higher NPs concentration on nanofluids. Notably, thermal conductivity improved by up to 11% at higher $Fe_3O_4$ NPs concentrations (1wt%), indicating the potential of these green-synthesized nanofluids for heat transfer applications in single-phase and two-phase systems. This study highlights the benefits of green synthesis methods and the applicability of these nanofluids in industrial thermal management.

**Keywords**: Green Synthesis; Magnetic Iron Oxide Nanoparticles; Nanofluids; Thermal Conductivity.

# Increasing motivation and learning in digital manufacturing: Blended Intensive Programs for STUDENTS

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This article deals with an approach to teaching digital manufacturing and in particular additive manufacturing through a set of tasks involving scanning and 3D printing. This pedagogical project stands out for incorporating international students from multiple international institutions and different background through the Blended Intensive Program (BIP), this program had students from various areas Science, Technology, Engineering, Arts and Mathematics (STEAM). Research results indicate that this approach produces excellent results in terms of student engagement and learning outcomes. The program effectively promotes students' creative skills, solving a set of tasks by group, combining theoretical training with practical experience in a competitive environment.

**Keywords**: Digital Manufacturing; Additive Manufacturing; Blended Intensive Program (BIP); Student Engagement.

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# 3D Print Technologies Applied in Robotics Prototyping

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This paper explores the use of 3D printing technology in industrial and educational environments, for robotics applications, emphasizing its versatility, cost-effectiveness, and rapid prototyping capabilities. Several projects are discussed, including the STC 4.0 HP Project, which combines 3D printing with robotic automation in the ceramics industry and creating educational robots for hands-on learning. 3D printing enables rapid iterations in these projects, allowing continuous improvements and adaptations. This technology's potential is further demonstrated by its application in creating custom accessories, such as sensor adapters, which can be reused and modified across multiple projects. The findings demonstrate how 3D printing promotes innovation and accessibility, particularly in robotics, making it an important tool in industry and education.

**Keywords**: 3D Printing Technology; Robotics Applications; Rapid Prototyping; Industrial and Educational Innovation.

# Study of Electro Discharge Machining (EDM) to manufacture holes in Selective Laser Melted (SLM) parts.

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This study evaluates the performance of the Electro Discharge Machining (EDM) process on parts manufactured using Selective Laser Melting (SLM) technology. To achieve this purpose, holes were drilled into 17-4 PH stainless steel specimens produced by SLM, measuring the machining time and tool wear. The tests were repeated on specimens of the same material produced using conventional methods, and the results were compared. The findings indicate that SLM parts demonstrate superior performance. This study aims to enhance understanding of the capabilities and limitations of SLM in conjunction with EDM, to optimize the parameters of both processes for specific industrial applications.

**Keywords**: Electro Discharge Machining (EDM); Selective Laser Melting (SLM); 17-4 PH Stainless Steel; Process Optimization.

# Utilisation of feedstock material in additive manufacturing technology of ceramics by UV laser vat-photopolymerisation (VPP-UVL/C)

**S. Peláez-Peláez[1,*], A. Martínez-Sánchez[1], S. Giganto[1], P. Rodríguez-González[1], S. Martínez-Pellitero[1]**

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Additive manufacturing (AM) represents a revolution in the industry by enabling the production of parts with complex geometries and a high degree of customisation, optimising the use of materials and reducing waste. Moreover, it has significant benefits in terms of sustainability, reducing waste and reducing the carbon footprint by up to 70%. In the field of ceramic materials, the use of AM technologies has gained relevance by combining the advantages of additive manufacturing with the properties of ceramics, however, research on sustainability is very limited.

Among the AM techniques for ceramics, UV laser vat-photopolymerisation (VPP-UVL) stands out for its precision and finish quality, but in terms of sustainability it presents major challenges such as post-process optimisation, emission assessment and material sustainability. In particular, this work focuses on the optimisation of material usage through the design and development of a functional prototype of the feed deposit for the Ceramaker 900-FLEX machine of 3DCeram Sinto Group, aimed at the production of small parts and/or short batches, optimising its use and reducing waste, especially important in materials with an expiry date.

**Keywords**: Additive Manufacturing (AM); Sustainability; Ceramic Materials; Vat-Photopolymerisation (VPP-UVL).

# MEX and VPP-UVL Technologies for Printing Complex Alumina Parts

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This study explores the advantages and disadvantages of manufacturing complex-shaped alumina parts through Material Extrusion (MEX) compared to Vat Photopolymerization via Ultraviolet Laser exposure (VPP-UVL), by evaluating key printing parameters and post-processing techniques. For the MEX printing technique, optimal printing parameters, such as nozzle temperature and print speed, were determined along with their influence on surface quality and dimensional accuracy of the parts. It is concluded that, although challenges such as interlayer bonding and porosity exist, alumina extrusion 3D printing can replace VPP-UVL printed parts in certain industrial applications.

**Keywords**: Material Extrusion (MEX); Vat Photopolymerization (VPP-UVL); Alumina Parts; Printing Parameters.

# Design of a novel bi-phasic biomimicking auxetic 3d printed structure with fluids that biomimic the hysteretic behaviour of articular cartilage for medical phantoms

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This study aims to develop a novel bi-phasic, 3D-printed structure for medical phantoms that biomimics the dynamic, hysteretic behaviour of soft tissues. Traditional medical phantoms are effective at simulating static mechanical biological tissue properties but often fail to replicate the complex biomechanical characteristics of biological tissues, such as viscoelasticity, anisotropy, and fluid-solid interactions. By utilizing 3D printing and embedding fluid components, this research seeks to overcome these limitations. The designed structure will more accurately simulate biological tissues' response under mechanical load, including energy dissipation through hysteresis. This advancement in medical phantom technology offers potential for more realistic testing and validation of medical devices, imaging techniques, and treatments related to biological tissues, ultimately improving patient care.

**Keywords**: 3D-Printed Medical Phantoms; Biomechanical Biomimicry; Viscoelasticity; Hysteresis.

# Developing optical mimicking phantoms of the head tissues – a new approach for transcranial photobiomodulation research

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Transcranial photobiomodulation (tPBM) has gained relevance in the recent decade, due to positive results in clinical trials for several neurological pathologies (e.g., stroke, traumatic brain injury, dementia related diseased). Nonetheless, the uncertainty around the ideal light parameters causes some resistance in the incorporation of this therapy into mainstream practice. To establish optimal stimulation parameters, it is important to first understand how light interacts with the relevant tissue, but using biological tissues for this research involves several ethical considerations and may be wasteful. Thus, to provide better alternatives for tPBM research, optical mimicking phantoms were developed using low-cost and sustainable materials. Agarose was used as matrix to which titanium dioxide ($TiO_2$); India ink; organometallic compounds; and laser-ablated gold and zinc were added.

The transmittance and reflectance spectra of the phantoms and porcine tissues (i.e., skin, muscle, cranium, brain, and cerebellum) were characterized using an integrating sphere, and later compared to find similarities between the two. Overall, it was possible to establish similarities between the porcine tissues' and the phantoms' optical properties, but it was noted that finding a phantom that could replicate both the reflectance and absorbance spectra of a given tissue might be a difficult task. Further research is needed to explore various concentrations and combinations of materials to better replicate the optical properties of biological tissues.

**Keywords**: Transcranial Photobiomodulation (tPBM); Optical Mimicking Phantoms; Agarose Matrix; Tissue Optical Properties.

# Optimization of PDMS Curing in SLA Resin Molds: Techniques and Approaches

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Cardiovascular diseases are the leading cause of death worldwide, with ischemic heart diseases and cerebrovascular diseases accounting for 85.6% of total cardiovascular deaths. Among these conditions, atherosclerosis, stenosis, and aneurysms stand out. In recent years, significant efforts have been invested in research to improve the diagnosis and treatment of these pathologies. In this pursuit, in silico and in vitro approaches have gained prominence, providing a better understanding of blood flow behavior in veins, facilitating the research of new devices, and contributing to prevention and diagnosis. However, these studies still require experimental validation.

One of the main challenges of in vitro experiments lies in the difficulty of manufacturing biomodels that accurately reproduce veins and allow for the visualization of blood flow. Recently, significant advances have been achieved using polydimethylsiloxane (PDMS). This material enables the development of transparent models, which are low-cost compared to glass and offer flexibility. Various techniques have been applied to these models, including Magnetic Resonance Imaging (MRI), Laser Doppler, Digital Image Correlation, Particle Tracking Velocimetry (PTV), and Particle Image Velocimetry (PIV), with the latter being the most widely used for validating numerical simulations.

Current techniques for manufacturing biomodels involve additive manufacturing and the use of PDMS. SLA and MSLA printers, which offer superior finish and quality compared to FDM printers, are becoming increasingly popular. However, a common challenge in using commercial SLA resins is the inhibition of PDMS curing, which hinders effective mold replication. To overcome these obstacles, various techniques have been employed, such as painting the molds, which creates a protective layer between the mold and the PDMS, as well as chemical and thermal treatments. Each of these approaches has its advantages and disadvantages. For example, painting can alter the dimensions of the mold, chemical treatment can weaken the structure, and thermal treatment can compromise dimensions if not performed at appropriate temperatures.

In this work, we will address the appropriate thermal treatment for two commercial resins that

enable the development of molds for producing PDMS biomodels suitable for experimental testing. The correct choice of manufacturing and treatment methods is essential to ensure the accuracy and effectiveness of biomodels, allowing them to be used in various in vitro studies and contributing to advancements in cardiovascular disease research.

**Keywords**: Cardiovascular Biomodels; Polydimethylsiloxane (PDMS); Additive Manufacturing; Thermal Treatment.

# Development of a hydrophone for measuring the propagation of acoustic waves in biological tissues

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Understanding the propagation of acoustic waves in biological tissues is essential to enhance ultrasound-based therapies. Current measurement methods primarily focus on capturing acoustic waves at the tissue surface, which limits our ability to comprehend how these waves propagate internally. This limitation arises because the interaction between the wave and the tissue alters its characteristics along the propagation path due to factors such as attenuation, dispersion, and reflection. As a result, the signals detected by the transducer reflect a complex combination of these interferences, making the precise interpretation of the measurements and the in-depth analysis of acoustic propagation challenging.

This work focus on the development of a tailorable hydrophone design to measure the propagation of acoustic waves in biological tissues more effectively. The device features a PZT ceramic disc, and an aluminium needle designed to penetrate tissues, allowing for more localised and accurate measurements. The selection of materials has been meticulously executed to optimise acoustic wave transmission, ensuring effective acoustic impedance matching both within the hydrophone and with the biological tissues. This approach offers a more reliable and efficient solution for evaluating the penetration of acoustic waves in biological tissues, enhancing research and the development of innovative therapies.

**Keywords**: Acoustic Wave Propagation; Biological Tissues; Tailorable Hydrophone; PZT Ceramic Disc

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# Development of wood and cork derivative panels for sustainable construction

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Sustainability in civil construction is essential to ensure the development of buildings that respect the environment and promote the efficient use of natural resources. This concept encompasses practices such as the use of recyclable materials, waste reduction, energy efficiency, and water conservation. The adoption of sustainable methods in civil construction not only minimizes environmental impacts but can also result in more cost-effective and durable buildings in the long term. Furthermore, it contributes to the creation of healthier environments for occupants, promoting well-being and quality of life. The importance of sustainability in this sector is, therefore, undeniable, as it aligns urban progress with environmental preservation, ensuring a more balanced and sustainable future for generations to come.

The use of wood as a raw material is inherently sustainable, as it is a renewable material that captures CO2 from the atmosphere, among other ecological advantages of each material used in the wall. The project in question aims to create a wall panel made of wood, equipped with mechanical properties and fire resistance. The panels are being produced with the following compositions: MDF+cork+MDF and OSB+cork+OSB, using waterproof MDF.

The main objective of the project is to develop a sustainable wall panel for modular construction, taking advantage of the benefits of wood. Cork plays a fundamental role in this context, as it is an abundant material in Portugal and possesses various sustainable characteristics. Cork is obtained from the bark of cork oak trees, which regenerates in approximately nine years, contributing to the preservation of the protected fauna and flora in cork oak forests. Additionally, cork is lightweight, impermeable to liquids and gases, elastic and compressible, has thermal and acoustic insulation properties, burns slowly, and is highly resistant to friction. It is a completely biodegradable, renewable, and recyclable material.

For the development of the panel, a pressing process is carried out, as shown in Figure 1, in which the previously mentioned materials are distributed proportionally and subjected to pressing. This procedure results in the formation of a board, which will then undergo rigorous testing to evaluate its mechanical properties and fire resistance.

**Figura 1 -** Thermal hydraulic press.

The specimens will be subjected to three-point bending tests and cone calorimetry tests. Through the three-point bending test, the maximum bending stress, modulus of elasticity, and maximum bending force are determined. Therefore, the mechanical properties of the specimens are evaluated and approved according to the standards. The cone calorimetry test, following the ISO 5660-1 standard, analyzes the fire reaction of a material under controlled heat, maintaining a constant heat flux. This method evaluates the material's flammability and its performance in fires, aiding in classification according to fire behavior certification standards. Results from the mechanical tests and fire reaction of the developed panels will be presented.

**Keywords**: Sustainable Construction; Wood-Based Panels; Cork Insulation; Fire Resistance.

# Valorisation of Olive Mill Wastewaters for Industrial Applications

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Olive mill wastewaters (OMWW) are a byproduct of the olive oil production process, posing significant environmental challenges due to their high organic load and chemical complexity. This research aims to explore the potential industrial application of OMWW as a cutting fluid in metalworking processes, thus transforming a problematic waste into a valuable resource. To achieve this, a comprehensive mechanical, chemical, and biological characterization of OMWW was conducted, alongside tribological tests to evaluate its performance in comparison to conventional industrial cutting fluids. Preliminary results indicate that OMWW exhibits competitive tribological properties, suggesting its viability as an eco-friendly alternative. This study contributes to both the valorisation of agro-industrial waste and the development of sustainable manufacturing practices.

**Keywords**: Olive Mill Wastewaters (OMWW); Cutting Fluid; Tribological Properties; Sustainable Manufacturing.

# Progress on fire safety of sustainable timber construction

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Sustainable timber construction is gaining momentum as a key strategy for reducing the environmental impact of the building industry. Using eco-friendly materials like wood, natural fibres, and innovative bio-based composites, along with advancements in pre-fabrication, has made it possible to design more sustainable and energy-efficient building solutions. However, fire safety is still a significant concern that limits the scalability of modern timber construction and new eco-materials and meeting the legal and technical fire performance requirements becomes challenging.

This work explores how design practices and test methods to assess and improve the fire behaviour of eco-materials and building elements contribute to developing efficient and fire-resilient timber solutions. Key advancements include innovative fire-retardant treatments, the development of bio-based composite materials, progress on pre-fabrication systems and improvements in design codes and calculation methods towards a performance-based approach. It also discusses future research and development directions. This will ultimately contribute to the ongoing challenge of fostering an innovative, efficient, and sustainable construction sector.

**Keywords**: Sustainable Timber Construction; Fire Safety; Bio-Based Composites; Fire-Retardant Treatments.

# Effects of extensive green roofs on rainwater drainage from a metalworking industry building

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This study examines how extensive green roofs impact the sizing of the rainwater drainage system for a metalworking building in northeastern Portugal. If the roof, measuring approximately 4,700 $m^2$, is constructed of sheet metal, the calculated flow rate that must be drained is 5,860.51 L/min. In contrast, if the roof is green and extensive, the calculated flow rate drops to 3,255.84 L/min. This represents a 44.44% retention of rainwater, which necessitates changes in the components of the drainage system. Additionally, the green roof delays the release of unretained water into the urban drainage system, thereby contributing to sustainable urban drainage and helping to mitigate urban flooding.

**Keywords**: Rainwater drainage systems; Green roofs; Portuguese regulations; Sustainability; Urban flooding mitigation.

# Extraction of natural fibers for the manufacture of 3D filaments by FDM material extrusion

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The study aimed to extract hemp fibers for the NaturFab project, in order to mechanically strengthen PLA in filaments for 3D printing. In order to find the best extraction method, several chemical treatments were carried out to separate the fibers from the plant, using solutions of 2 g/l of sodium hydroxide (NaOH) + 2 g/l of sodium carbonate ($NaCO_3$) and another solution of 6% NaOH, both at 80 ºC. After obtaining the first fiber sample, tensile tests were carried out to compare the strength of the hemp fibers with those of commercial flax. Hemp showed inferior performance compared to flax fibers, with a more fragile behavior after treatment with 6% NaOH. However, a solution of NaOH and $NaCO_3$ with polyglycolic detergent facilitated extraction and improved fiber strength, but further tests should be carried out to verify its effectiveness.

**Keywords**: Hemp Fiber Extraction; Chemical Treatments; PLA Reinforcement; Tensile Strength.

# Strategies for Modifying PDMS Wettability and Potential Applications

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Polydimethylsiloxane (PDMS) has garnered significant attention across various fields due to its excellent properties, but its inherent hydrophobicity poses challenges for applications that require controlled wettability. This review provides an overview of key traditional strategies for modifying PDMS surface wettability, focusing on methods such as oxygen plasma treatment, surfactant addition, UV-ozone treatment, and nanomaterial incorporation. These methods are commonly chosen due to their availability, simplicity, and lower cost. Oxygen plasma treatment is widely used to enhance PDMS hydrophilicity by introducing polar functional groups. Surfactant addition is a versatile approach for altering surface properties, influenced by the type and concentration of surfactant. UV-ozone treatment increases surface energy by inducing oxidation, while nanomaterial incorporation, including nanoparticles and nanotubes, offers a promising route for adjustable wettability through controlled interactions. This review discusses recent advancements in each technique, their mechanisms, advantages, and limitations, as well as future trends in PDMS surface modification for applications like microfluidics and biomedical devices.

**Keywords**: Polydimethylsiloxane (PDMS); Surface Wettability; Hydrophilicity Modification; Nanomaterial Incorporation.

# Microfabrication of a capillary-driven microfluidic device: Surface wettability

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## Abstract

Polydimethylsiloxane (PDMS) is commonly used in microfluidic devices due to its optical clarity, biocompatibility, and ease of fabrication. However, its inherent hydrophobicity limits its effectiveness in applications that rely on fluid transport. Surface modification techniques have been explored to address this limitation, with the objective of enhancing the wettability of PDMS surfaces. This study investigates the use of surfactants, namely PEO, incorporated in bulk in the PDMS mixture to improve its hydrophilicity. Water contact angle (WCA) measurements were used to assess the effectiveness of these modifications. Initial results indicated that PDMS modified with PEO demonstrated a significant reduction in WCA, suggesting improved hydrophilicity immediately after fabrication.

**Keywords**: Polydimethylsiloxane (PDMS); Surface Modification; Hydrophilicity; Surfactants (PEO).

# Microfabrication of a capillary flow-driven microfluidic plasma separator

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In microfluidic devices used for biomedical applications, inadequate surface wetting leads to the inefficient flow of fluids through channels. In this work, it was developed a capillary driven flow geometry, with the fluid flow facilitated by a PDMS surface wettability modification. Different designs of microfluidic devices for passive blood plasma separation were developed and fabricated using 3D printing and replica molding. Bulk surface modification with polyethylene oxide (PEO) was applied o PDMS mixture. Contact angle (CA) measurements were obtained and capillarity flow tests performed. The addition of the surfactant, such as PEO, modify the PDMS surface to hydrophilic. The results obtained, particularly with the 2.5% PEO bulk surface modification, were encouraging to be applied for plasma separation devices.

**Keywords**: Microfluidic Devices; Surface Wettability Modification; Polyethylene Oxide (PEO); Blood Plasma Separation.

# Development and fabrication of a microfluidic device for mechanical characterization of malaria-infected red blood cells

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This work reports the design and fabrication of a polymeric microfluidic device, with a hyperbolic contraction, to promote extensional flow and allow the single cell mechanical characterization, *in vitro*, of healthy and malaria-infected red blood cells (RBCs). The obtained results show an extensional flow profile of the velocity across the microchannel for both healthy and infected RBCs, while the ability of the cells to deform was significantly reduced for the malaria infected samples.

**Keywords**: Microfluidic Device; Extensional Flow; Red Blood Cells (RBCs); Malaria Infection.

# 3D Hollow microneedles fabrication for microfluidic applications

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The development of 3D hollow microneedles has garnered significant attention for their potential in microfluidic applications, particularly in drug delivery, diagnostics, and biomedical research. These microneedles offer a minimally invasive approach for fluid extraction and precise delivery of therapeutic agents, bypassing traditional barriers in the skin. This study focuses on fabrication of 3D hollow microneedles, exploring the 3D printing method to achieve optimal mechanical strength, biocompatibility, and fluid dynamics. By optimizing design and printing parameters, this work demonstrates how 3D hollow microneedles can enhance microfluidic device performance, presenting a way for advanced applications in healthcare and bioengineering.

**Keywords**: 3D Hollow Microneedles; Microfluidics; Drug Delivery; 3D Printing.

# Study, design, and manufacturing of 3D-printed orthoses

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This study highlights the growing presence of three-dimensional (3D) printing in everyday life, particularly in the manufacture of customized medical devices. In the field of additive manufacturing (AM), Material Extrusion (MEX), ISO/ASTM 52900:2023, (fused deposition modeling (FDM)) has become a widely used technique due to its affordability, accessibility, and ability to create personalized solutions.

In this case, a 3D-printed hand orthosis was designed to assist a woman suffering from tendinitis in her thumb. The orthosis was designed to reduce pain and provide support to improve her daily functionality. Material Extrusion (MEX), FDM technology was used to build the device layer by layer, resulting in a lightweight yet durable structure tailored to the patient's needs.

One of the key benefits of 3D printing in orthotic design is the ability to create customized, patient-specific solutions at a lower cost than traditional manufacturing. In addition, rapid prototyping allows for quick modifications based on patient feedback, improving comfort and effectiveness.

This study reinforces the potential of 3D printing in medical applications and demonstrates how FDM-printed orthotics can help alleviate pain and improve quality of life for people with musculoskeletal conditions. As the technology continues to evolve, personalized healthcare solutions will become more accessible and efficient.

**Keywords:** 3D Printing in Orthotics, Material Extrusion (MEX), Fused Deposition Modeling (FDM), Customized Hand Orthosis, Additive Manufacturing in Healthcare

# Linear transformations in an engineering course – Matrices and dynamic representations

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## ABSTRACT

Several studies point to the importance of teachers creating learning environments that involve students more in the construction and communication of knowledge. On the other hand, digital technologies can be used as didactics tools to improve learning. To promote the development of skills in the area of linear algebra, more specifically in the context of linear transformations, we chose to propose an activity involving Geogebra. This software allows symbolic representations of multiple linear transformations of the plane, either through the matrix route or through its analytical expression, while also allowing the observation of the image of particular objects through this transformation. The experiment was carried out with students of an engineering course who were attending the Linear Algebra and Analytical Geometry curricular unit. The students also answered a questionnaire to evaluate their learning and assess the relevance of Geogebra in the acquisition of concepts. Their feedback shows that this software encourages creativity and promotes experimental research, having been considered an excellent ally in understanding concepts related to linear transformations and their properties.

**Keywords:** Geogebra, linear transformations, linear algebra, higher education.

# Awareness of sustainability practices in construction: Learning in a real context

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As part of the Higher Professional Technical Course in Civil Construction at a Polytechnic Higher Education Institution, a teaching experience was proposed in which the Technical Installations and Sustainability Practices in Construction course units were taught interconnectedly. The students mobilized the knowledge acquired in the first-course unit to carry out practical work on more sustainable solutions in buildings as part of the second-course unit. This experience allowed the students to apply their knowledge in scenarios close to their professional reality and to reflect on the complex issues of sustainability in construction.

**Keywords:** Hydraulics, Sustainability in construction, Higher education.

# Development of a helmet device for transcranial optomechanical stimulation to treat Alzheimer's disease

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Alzheimer's disease (AD) is a neurodegenerative condition with enormous social and economic impact at a global scale. Given the inefficacy of the pharmacological treatments developed so far in decelerating/blocking AD pathology, the study and development of so-called alternative (i.e., nonpharmacological) and non-invasive therapies has become one of the major focuses of biomedical research on AD in recent years. Indeed, several researchers have demonstrated the therapeutic potential of optical and mechanical (i.e., optomechanical) stimuli in brain lesions. Among them, photobiomodulation (PBM, the application of modulated red/NIR light for therapeutic purposes) and transcranial ultrasound stimulation (TUSS) are at the forefront of clinical interventions with the potential to improve associated neuropathology and symptomatology of AD (e.g., reduction of protein aggregates deposition in the brain, increased functional connectivity and synchronization of neuronal activity, cognitive improvements), both at the preclinical and clinical levels. However, currently available devices lack a customizable parameterization of PBM and TUSS stimulation, typically offering standard protocols. Moreover, these devices are often limited to a short operating window, which hinders the assessment of different levels of stimulation associated with promising preclinical results. In this sense, we propose the development of a multi-modal, smart, noninvasive, and customized device to deliver transcranial stimulation through tailored light and ultrasonic stimuli for the treatment of Alzheimer's disease. To propose an optimized solution of the device, the plan includes testing different actuating components (*e.g.*, LEDs for light, single-element piezoelectric transducers for ultrasound), designs (*e.g.*, helmet, cap), manufacturing techniques (*e.g.*, additive manufacturing), actuation spots, and materials, as well as to determine the load and stress conditions when employing different designs by using CAE/CAM software simulation (e.g. SolidWorks), among others studies. If successful, this project can open unexplored paths that can revolutionize Alzheimer's therapeutics.

**Keywords:** Alzheimer's disease, neuroprotection, optomechanical stimuli, photobiomodulation, transcranial ultrasound stimulation.

# Acoustic stimulation based on piezoelectric materials enhanced anti-proliferative activity of triple-negative breast cancer cells

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Triple-negative breast cancer is highly aggressive with poor prognosis in terms of disease-free and overall survival, due to its lack of effective treatments. Hence, there is a pressing need to develop new therapies, among which ultrasound (US) stands out owing to its safety, non-invasiveness, and low cost. This work aims to develop and optimize a dynamic cell culture platform based on the application of acoustic stimuli and assess its effectiveness in reducing the proliferation of a triple-negative breast cancer cell line.

The developed system, consisting of piezoelectric ceramic actuators that were properly characterized, was tested for dynamic cell culture of highly aggressive neoplastic breast cells, the MDA-MB-231 cell line, and compared with static culture. The cellular assays revealed that US stimulation at the highest frequency tested significantly reduced metabolic activity and cell proliferation, with three daily stimulations leading to a greater reduction in cell proliferation.

**Keywords**: Triple-Negative Breast Cancer; Ultrasound Therapy; Dynamic Cell Culture; Piezoelectric Actuators.

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# Study of the effect of the physical characteristics of bacterial nanocellulose on the proliferation of triple negative breast cancer cells

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The incidence of breast cancer, that already is the most prevalent cancer type, has been increasing. The tumor microenvironment, particularly the mechanical properties of the extracellular matrix (ECM), plays a critical role in cancer progression. This has spurred scientific efforts to create substrates capable of mimicking ECM conditions to better understand cell behavior and develop new therapies. Bacterial nanocellulose (BNC), composed of fibers with diameter within the lower range of natural ECM fibers (20-100 nm), is a promising material for such studies.

This project aims to develop *in vitro* scaffolds with varying architectures and stiffness to study their effect on the proliferation of highly aggressive human breast cancer cells (MDA- MB-231). Alginate-based structures, including microspheres, fabrics, and meshes, were created and characterized using SEM, FTIR, and TGA techniques and then added to the static culture of BNC. While BNC membranes with diverse architectures and mechanical properties were successfully produced, the cells exhibited low metabolic activity, indicating potential cytotoxicity of the developed material.

**Keywords**: Breast Cancer; Extracellular Matrix (ECM); Bacterial Nanocellulose (BNC); *In Vitro* Scaffolds.

# Collaborative work between Polytechnic Higher Education students: Manufacturing processes, Safety and Sustainability

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The link with the real working environment, combined with the sharing of knowledge and collaboration between students from different courses, was the basis of a teaching experience involving students from the Mechanical Technology I course unit of the Mechanical Engineering degree course and the Safety and Environment course unit of the Higher Professional Technical Course in Sustainable Technologies in Mechanics and Vehicles, at a Polytechnic Higher Education Institution in the north of Portugal. The final objective was to carry out collaborative work on metalworking processes, the safety at work related to these processes, and waste management.

**Keywords:** Collaborative work, mechanics, safety, environment, higher education.

# Learning linear algebra with the MathE platform: an experience in a Mechanical Engineering course

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Linear algebra is part of the curriculum of most engineering courses. However, many students' difficulties in this area and the heterogeneity of their mathematical knowledge pose significant challenges for teachers. In this context, more personalized and interactive learning is needed to help overcome individual difficulties and promote autonomy in constructing knowledge. Technological platforms such as MathE are important tools in this process, as they facilitate the development of skills in searching, selecting, and analyzing the information provided. Therefore, as part of the Linear Algebra and Analytical Geometry course unit of a Mechanical Engineering degree course, we proposed that students use the Self Need Assessment component of the MathE platform to take two tests: one at a basic level and the other at an advanced level on the topics of Vector Spaces (VS) and Linear Transformations (LT). After submitting each test consisting of seven multiple-choice questions, the students were asked how they had performed. We also asked them to present their solutions to get them to identify and correct their own mistakes based on the feedback provided by the platform and the teacher. When complemented with other approaches, the MathE platform can be a valuable tool to increase students' autonomy in overcoming their difficulties, thus promoting the learning of linear algebra.

**Keywords:** Linear algebra, MathE platform, higher education

# Enhancing Realism in 3D Mapping Through Drone-Based Photogrammetry and Animated Elements

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Over time, society has increasingly adopted technology across various sectors and at different levels. Technological advancements have enabled the substitution of traditional models with animated 3D representations that offer higher levels of realism. This study explores the integration of drone-based photogrammetry with 3D modeling and animation techniques to produce realistic representations of outdoor environments, mapping the IPB-ESTIG campus, highlighting the integration of drones, software tools like Unity, and animation techniques for creating immersive environments. The objective was to provide a dynamic representation of the campus using photogrammetric methods and incorporating animated elements such as people and birds, allowing users to interact with the simulated environment. The challenges, methods, and results of this project demonstrate the viability of integrating photogrammetry, modeling, and animation to develop realistic 3D campus models and a more immersive experience in applications like urban planning, architecture, and environmental monitoring.

**Keywords**: Drone Photogrammetry; 3D Modeling; Animation Techniques; Immersive Environments.

# A Review of Best Methods for 3D Scanning and Modeling of Terrain and Buildings Using Drones and Photogrammetry

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Recent advancements in drone technology and photogrammetry have revolutionized the field of 3D terrain and building modelling. Drones equipped with photogrammetric software provide efficient, accurate, and cost-effective solutions for capturing high-resolution 3D models of both natural and urban environments. This literature review consolidates research on best practices for terrain and building scanning using drones and photogrammetry, focusing on methodologies, integration of technologies, challenges, and future directions. Additionally, the review explores applications in urban planning, environmental monitoring, disaster management, and heritage preservation.

**Keywords**: Drone Technology; Photogrammetry; 3D Modelling; Urban Planning.

# Mechanical analysis of specimens generated by 3D topological optimization

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This study investigates the use of topologically optimized filling in additive manufacturing to enhance the strength-to-mass ratio of 3D printed parts. The research utilized SolidWorks modeling, adhering to the ASTM 695-15 standard, with optimization focused on various symmetries and preserved regions to maximize structural efficiency. The specimens were printed using Anycubic Kobra 2 Neo 3D printers and ABS filament, and the optimized models were compared to those with standard fillings (grid and triangular) through compression testing. The results showed that while the optimized filling achieved only 50% of the strength of the standard-filled models, the grid pattern outperformed the others, demonstrating superior performance and ductility. Ultimately, the study concluded that the optimization process did not surpass the performance of the standard meshes generated by 3D printing slicers.

**Keywords**: Topologically optimized filling; Additive manufacturing; Strength-to-mass ratio; Compression testing.