Bioengineering Research and Development (Private) Limited

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Mission Statement

At Bioengineering Research and Development (Private) Limited, we aim to advance innovation in biomaterials and biomedical engineering by pioneering cutting-edge solutions in 3D bioprinting, biocompatible scaffold fabrication, and water membrane development. We are committed to transforming healthcare and environmental sustainability through research-driven, high-quality, scalable technologies.

By integrating biotechnology, material science, and engineering, we aim to enhance tissue regeneration, medical device development, and water purification systems, ensuring a healthier and more sustainable future. Our dedication to scientific excellence, ethical innovation, and collaborative partnerships drives us to push the boundaries of bioengineering for the betterment of human life.

C.E.O

Muhammad Atiq Ur Rehman

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Executive Board

Bioengineering Research and Development (Private) Limited

Dr. Ing M. Atiq Ur Rehman

Dr. Muhammad Haseeb Nawaz

Engr. Aqsa Aizaz

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Our Products

We deliver innovative, high-quality solutions designed to advance research, enhance efficiency, and drive progress in bioengineering. Our commitment to cutting-edge technology and sustainability ensures reliability, performance, and a positive impact on the future.

3D Bioprinter: Our 3D bioprinter enables precise fabrication of biocompatible structures, revolutionizing tissue engineering and regenerative medicine.

3D Scaffolds: Our 3D scaffolds provide a biocompatible framework for tissue regeneration, supporting cell growth and biomedical applications.

Water Membranes: Our water membranes are designed for high-performance filtration and purification, ensuring clean and sustainable water solutions.

Hydrogels: Our hydrogels are advanced biomaterials designed for biomedical applications, offering excellent biocompatibility, moisture retention, and controlled drug delivery.

Orthopedic Implants: Our bioactive coatings for orthopedic implants enhance biocompatibility, promote osseointegration, and improve the longevity of medical implants.

Magnetic particles for Cancer Therapy: Our magnetic drug treatment for cancer utilizes magnetically responsive

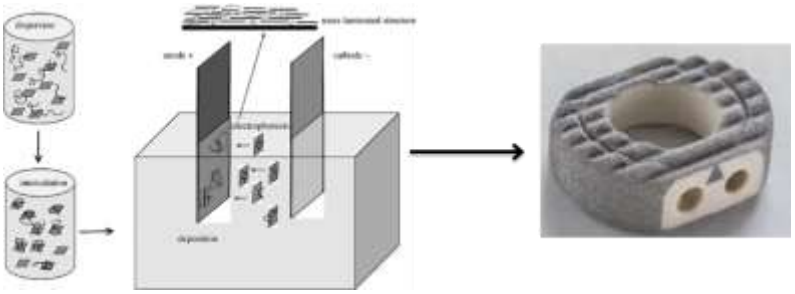
A. Wadood house near Qazi model school Frash,

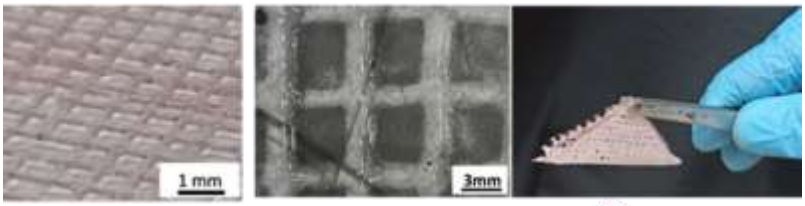
PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

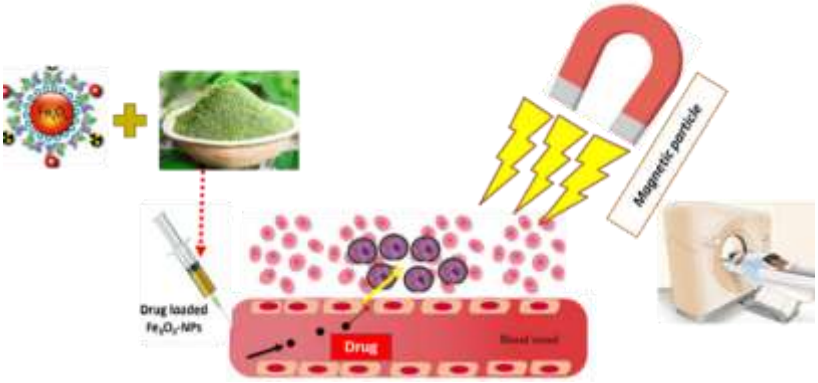
Contact # +923234663780

info@biomaterials.pk

nanoparticles to deliver targeted therapy, enhancing precision and minimizing side effects.







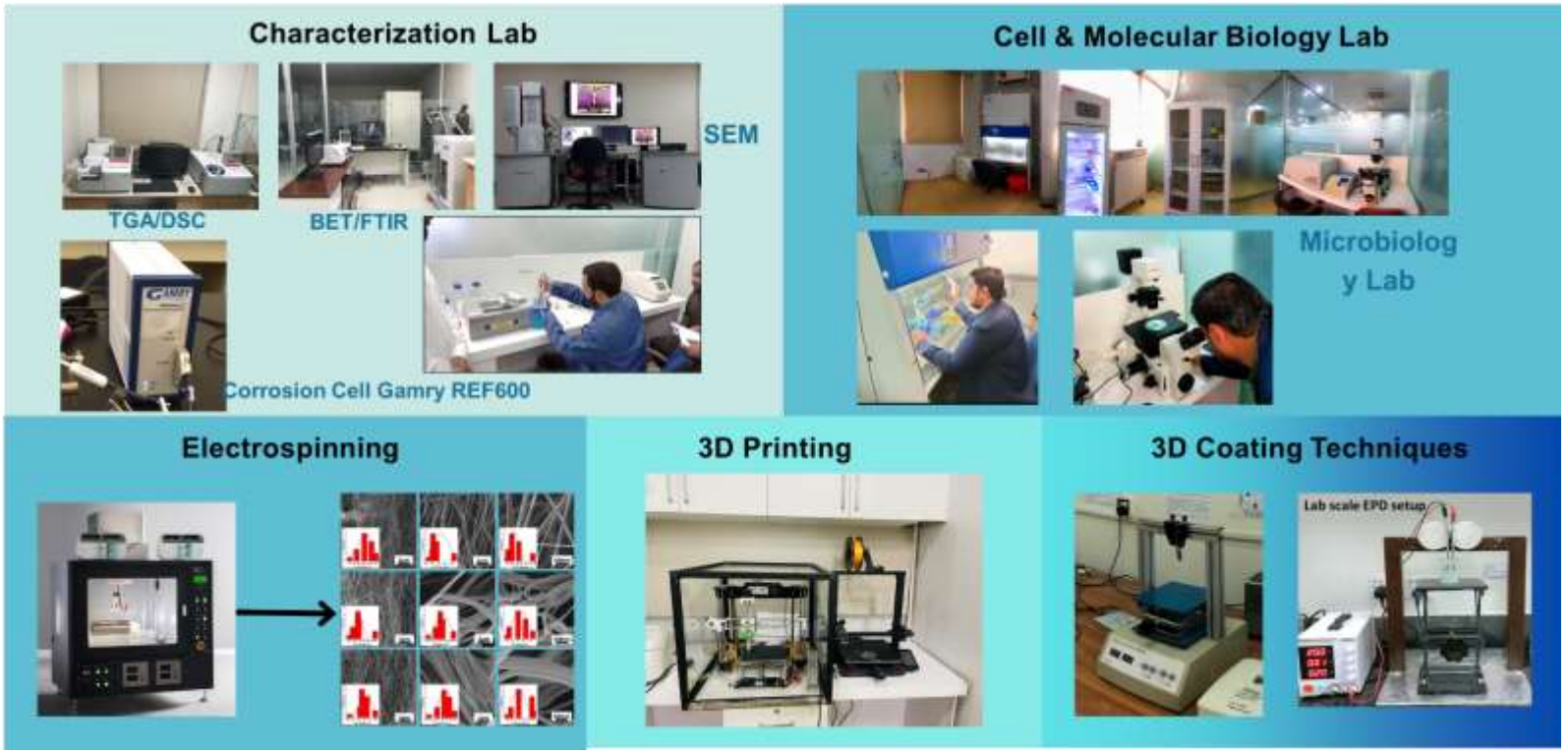
A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Our Facilities



A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Our Projects

1	3D PRINTED SCAFFOLDS	ISF PROJECT
2	WATER TREATMENT MEMBRANE	LAUNCHED
3	COATING ORTHOPEDIC IMPLANTS	FACILITY DESIGN & DEVELOPMENT
4	Electrospun Fibers	Research Stage
5	3D PRINTED BONE SCAFOLDS	RESEARCH STAGE
6	MAGNETIC DRUG THERAPY	ANIMAL TRAIL

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Our Services

- Cell & Molecular Biology
- Anti Microbial Efficacy Testing
- Characterization (SEM, FTIR & UV-Vis Spectroscopy)
- Drug Release Studies
- *In-vivo* CAM
- Biocompatibility and Biomarkers Evaluation
- Thermal Analysis
- Bio-fabrication (Additive manufacturing)
- Nanoparticles Synthesis
- Advance Characterization facilities
- Water Filtration

A. Wadood house near Qazi model school Frash,

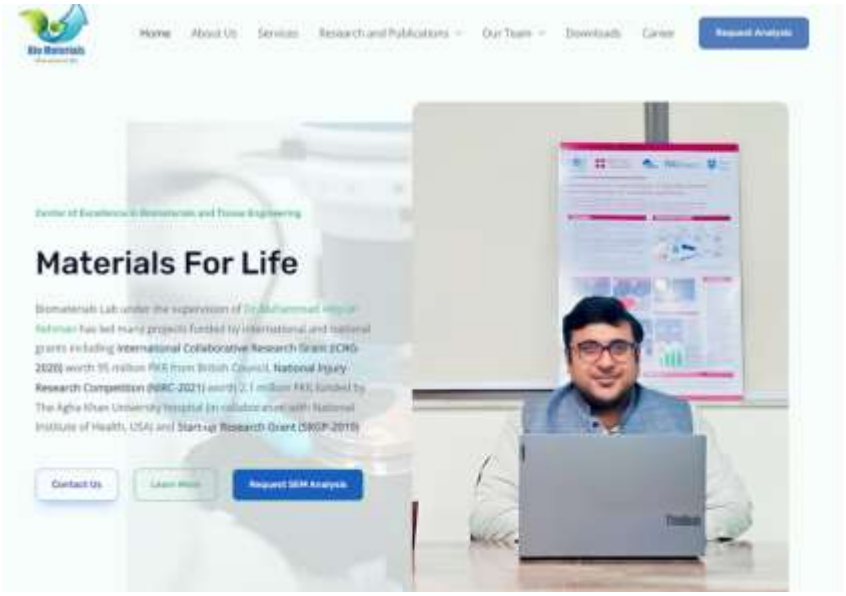
PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Our Presence

www.bioengineerings.com https://www.facebook.com/biomaterialsist/



A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Expertise and Achievements

At Bioengineering Research and Development (Private) Limited, we specialize in biomaterials innovation, focusing on the manufacturing of 3D bioprinters, fabrication of biocompatible 3D scaffolds, and developing high-performance water membranes. Our expertise lies in cutting-edge bioengineering, material science, and biotechnology solutions that drive advancements in healthcare, tissue engineering, and environmental sustainability. With a strong commitment to research and development, we continuously push the boundaries of innovation to create practical, scalable, and impactful solutions for global challenges.

Our achievements reflect our dedication to scientific progress. We have successfully secured project funding from the World Bank and the British Council, recognizing our contributions to bioengineering research and development. Additionally, our team consistently publishes 12 to 15 research papers annually, contributing to leading scientific journals and pushing forward the frontiers of biomaterials and biotechnology. Through these accomplishments, we continue to establish ourselves as a pioneering force in bioengineering, shaping the future of medical and environmental technologies.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

BioARTX 3D Inkjet Printer

User Manual

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Table of Contents

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

1. Introduction

1.1. Introduction to the BioARTX 3D Inkjet Printer

The **BioARTX X1 3D Inkjet Printer** is a state-of-the-art, highly specialized **bioprinting and material fabrication system** designed to address the challenges of **precision deposition, multi-material compatibility, and biosafe printing environments**. This revolutionary printer integrates advanced **inkjet deposition technology**, ensuring controlled and uniform droplet placement, making it an ideal tool for applications across **bioprinting, material science, drug formulation, electronics printing, and research**.

Unlike conventional **FDM, SLA, or DLP 3D printers**, which rely on extrusion or light-based curing mechanisms, the BioARTX **leverages microfluidic inkjet printing technology** to print complex structures using **biocompatible materials, functional inks, and specialty polymers**. The printer is uniquely equipped with **a precision syringe-based extrusion system**, allowing for easy replacement and adaptability for various inks.

The **BioARTX X1** stands out due to its enclosed printing environment, featuring **UV A, B, and C sterilization**, along with a **gamma irradiation option for extreme biosafety needs**. Additionally, the **HEPA filtration system** ensures that the printing chamber remains contamination-free. This makes it a perfect choice for laboratories, **pharmaceutical research, regenerative medicine, and custom material fabrication**.

Key Features and Innovations

The **BioARTX X1** is engineered for maximum flexibility and efficiency. Some of the key innovations and features include:

1.1.1. Advanced Inkjet-Based 3D Printing Technology

- **Drop-on-Demand (DoD) Printing:** Enables **controlled deposition of bioinks and functional materials**, ensuring high-resolution fabrication.
- **Syringe-Based Ink System:** The printer uses a disposable syringe for ink deposition, making it ideal for **multi-material applications**.
- **Adjustable Droplet Size:** Users can **control the droplet size dynamically**, ensuring precision in multi-layered constructs.

1.1.2. Multi-Material and Bioink Compatibility

- Supports a **wide variety of bioinks, conductive inks, and functional materials**.
- Enables **hybrid material deposition** for **pharmaceuticals, tissue engineering, electronics fabrication, and personalized medicine**.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- Customizable **temperature-controlled print bed** for enhanced material stability.

1.1.3. Sterile and Controlled Print Environment

- **Integrated UV A, B, and C sterilization system** for **decontaminating the print chamber** before and after printing.
- **External Gamma Irradiation Module** for additional biosafety in critical applications.
- **HEPA Filtration System** to prevent airborne contamination, ensuring clean printing conditions.

1.1.4. Precision Motion Control and Print Accuracy

- **High-Precision Linear Actuators:** The printer's motion system allows for **micron-level accuracy**, ensuring detailed prints.
- **Automated Bed Leveling and Calibration:** The system compensates for surface variations, enhancing print uniformity.
- **Real-Time Print Monitoring with Camera System:** Allows users to **observe and adjust the printing process remotely**.

1.1.5. User-Friendly Interface and Connectivity

- **Integrated Touchscreen Display:** Provides intuitive navigation and control.
- **Remote Access and Web-Based Control:** Users can **operate the printer from any device** through a network interface.
- **Custom G-Code Compatibility:** Enables advanced scripting for specialized research applications.

1.1.6. Comparison: BioARTX X1 vs. Other 3D Printing Technologies

The BioARTX X1 stands apart from traditional **Fused Deposition Modeling (FDM)** and **Stereolithography (SLA)** printers due to its **precision, material flexibility, and bio-safe environment**. Below is a comparative analysis:

BioARTX X1 vs. FDM (Fused Deposition Modeling) Printers

Feature	BioARTX 3D Inkjet Printer	FDM Printer
Print Mechanism	Inkjet drop-on-demand	Extrusion-based
Resolution	High (micron-level precision)	Moderate

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Material Variety	Supports bioinks, hydrogels, conductive inks, etc.	Limited to thermoplastics
Print Speed	High-speed controlled droplet deposition	Slower due to continuous filament extrusion
Sterilization	UV and Gamma sterilization	None
Waste Generation	Minimal	High

BioARTX X1 vs. SLA (Stereolithography) Printers

Feature	BioARTX 3D Inkjet Printer	SLA Printer
Print Mechanism	Inkjet drop-on-demand	UV laser curing liquid resin
Resolution	High	Very High
Material Compatibility	Bioinks, hydrogels, synthetic polymers	Limited to photopolymers
Sterilization	Built-in UV and Gamma	Requires chemical post-processing
Post-processing	Minimal	Extensive (chemical washing, UV curing)

1.1.7. Why Choose BioARTX X1?

The BioARTX X1 **is not just a 3D printer**; it is an **advanced fabrication platform** built for **scientific, medical, and engineering applications** that demand extreme precision, biosafety, and material flexibility. It offers:

- **Superior precision and droplet control**.
- **Advanced sterilization for bio-safe applications**.
- **Multi-material capability beyond plastics**.
- **User-friendly interface with real-time monitoring**.

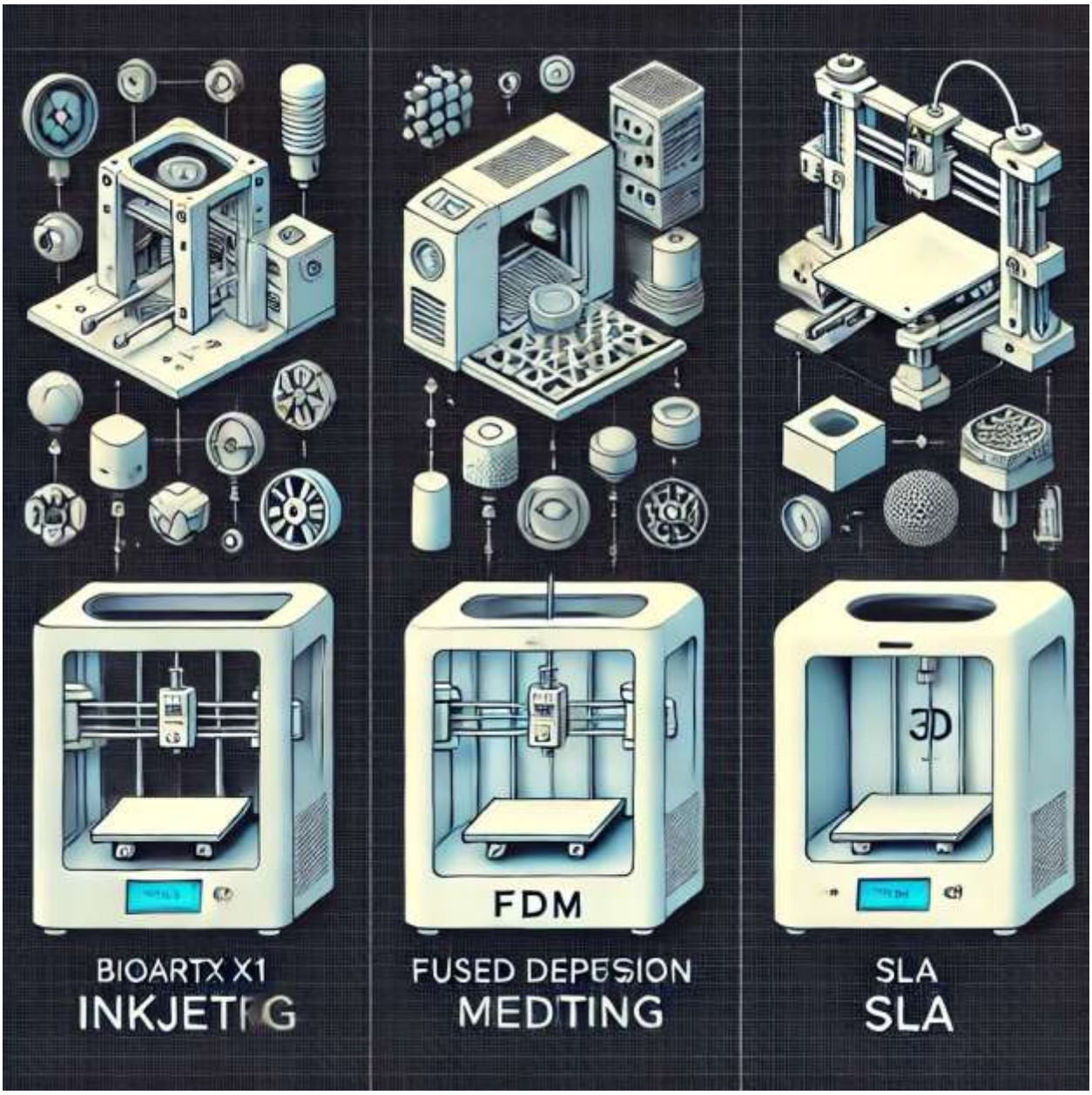
This makes it a **perfect solution for bioprinting, pharmaceuticals, electronics, and advanced material research**.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

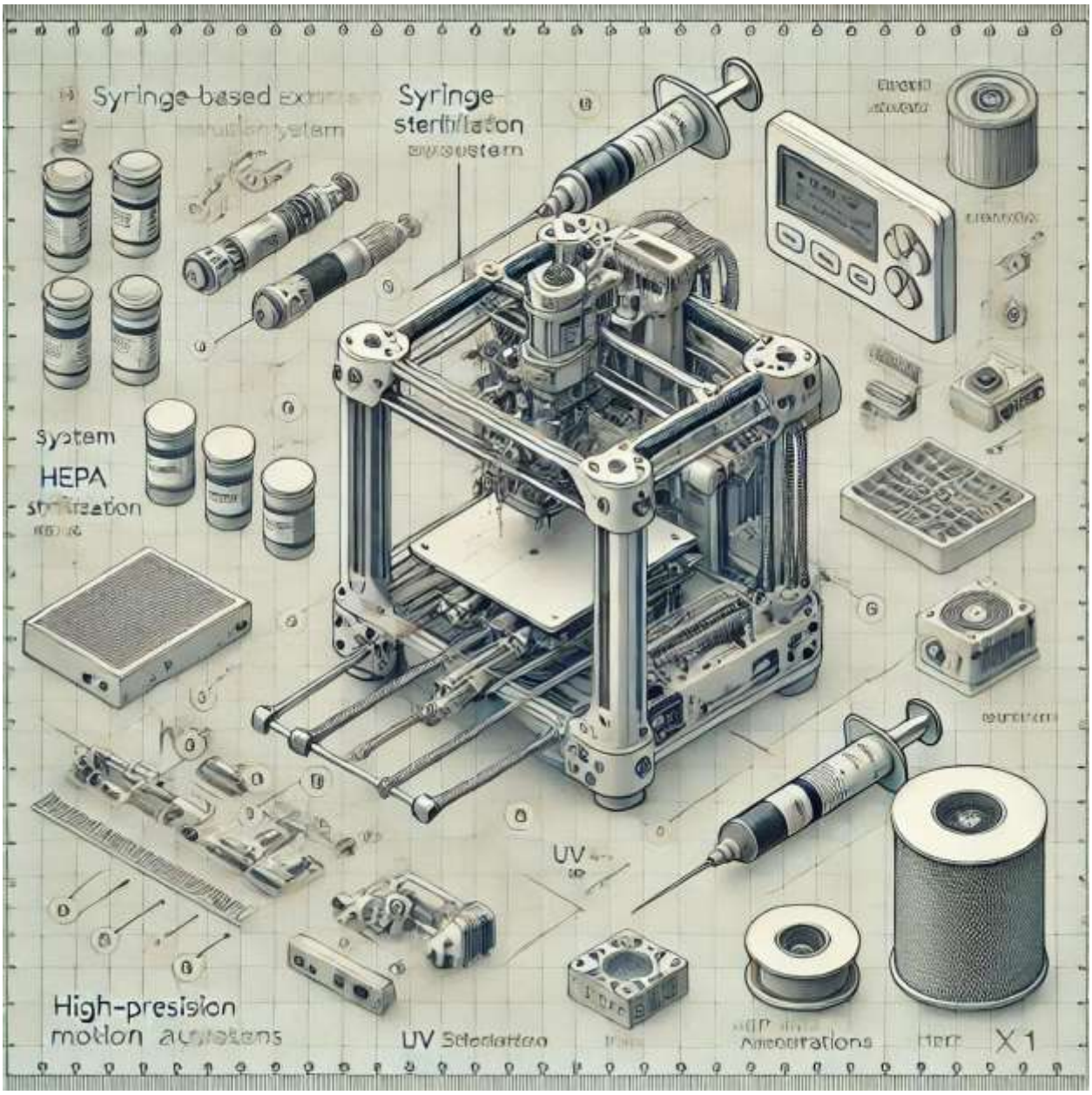


A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk



A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

2. Hardware and Components

The **BioARTX X1 3D Inkjet Printer** is a meticulously designed piece of technology, built with **precision, reliability, and efficiency** in mind. This section provides an in-depth exploration of each component, detailing its function, role in the overall system, and significance in ensuring **high-performance bioprinting**. Every part has been carefully selected to enhance the **functionality, print quality, and durability** of the printer. Each hardware component works in synergy to create a **seamless, high-precision bioprinting experience**, making the **BioARTX X1** a **leading-edge 3D inkjet printer** for biomedical, pharmaceutical, and material research applications.

2.1. Raspberry Pi 5 Control System

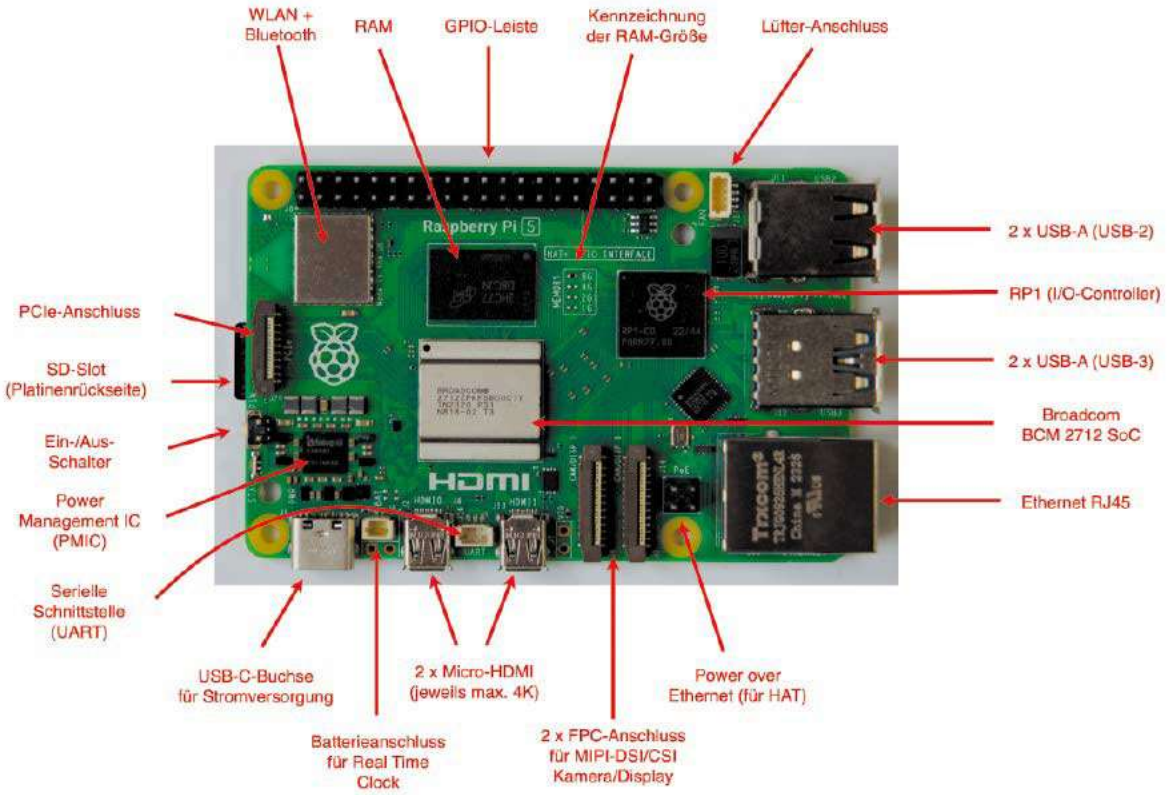
The **Raspberry Pi 5** serves as the **primary control unit** for the **BioARTX X1**, managing the coordination of different hardware components, data processing, and communication between firmware and user interface. It provides **high-speed computation and real-time control**, essential for precision 3D inkjet printing. Unlike conventional control boards, the Raspberry Pi 5 allows **advanced networking, remote monitoring, and custom firmware execution**, making it an essential component in a modern, high-performance 3D printing setup.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

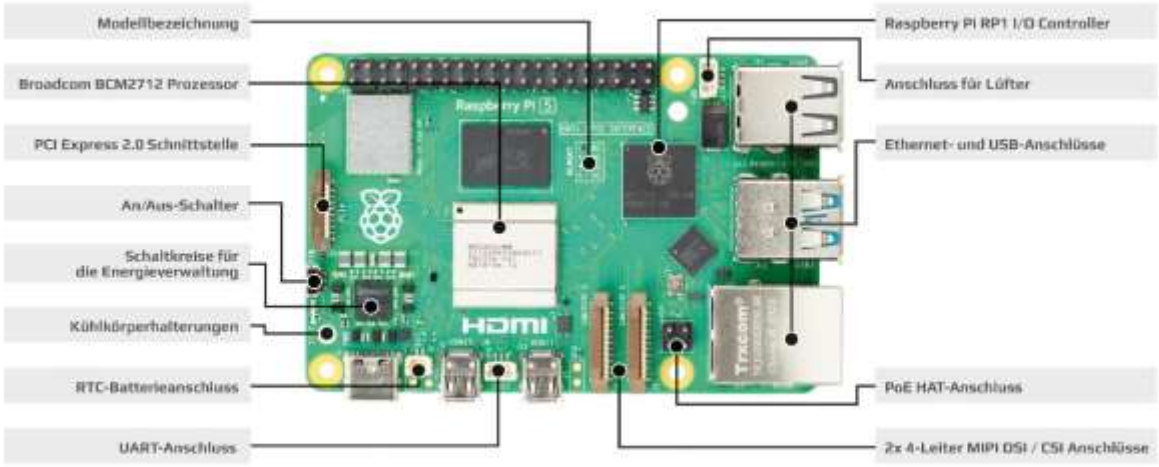


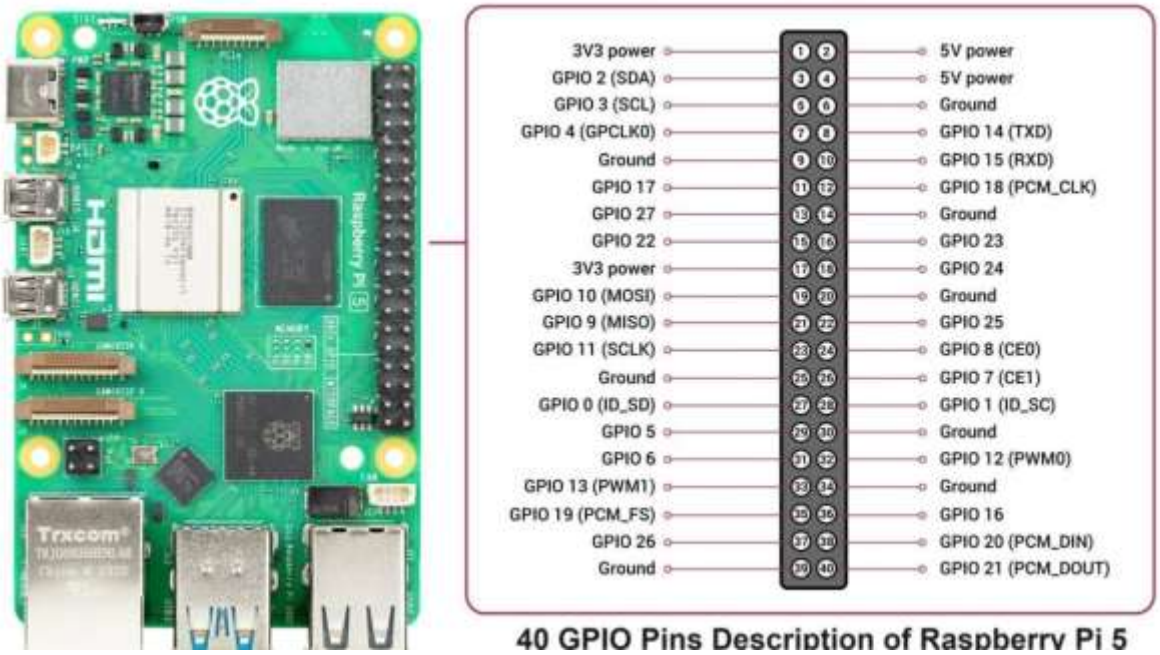
A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk





40 GPIO Pins Description of Raspberry Pi 5

2.1.1. Key Features of Raspberry Pi 5

- **Quad-core 64-bit ARM Cortex-A76 processor** (up to 2.4GHz) for efficient multi-tasking and high-speed data processing.
- **Increased RAM options (4GB or 8GB)**, allowing better handling of large G-code files and complex computations.
- **Improved I/O interfaces**, ensuring **seamless communication with stepper motor drivers, sensors, and touchscreen interfaces**.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

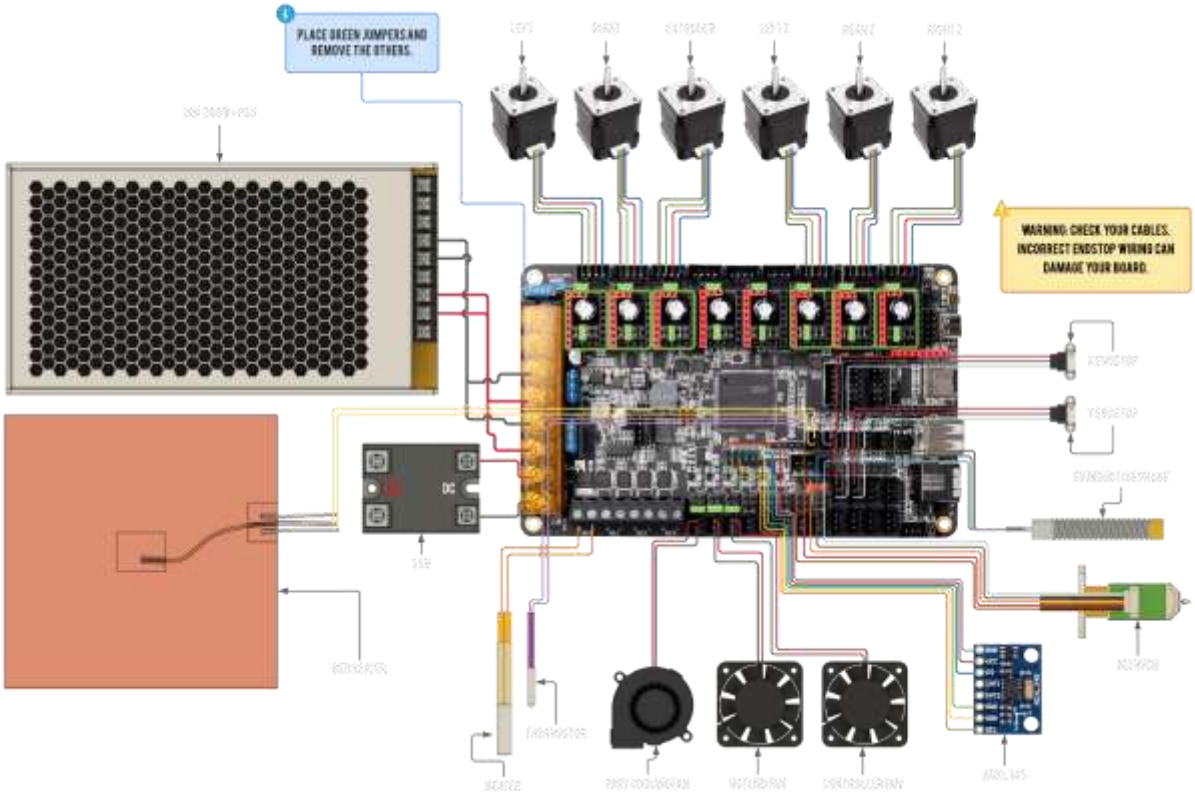
info@biomaterials.pk

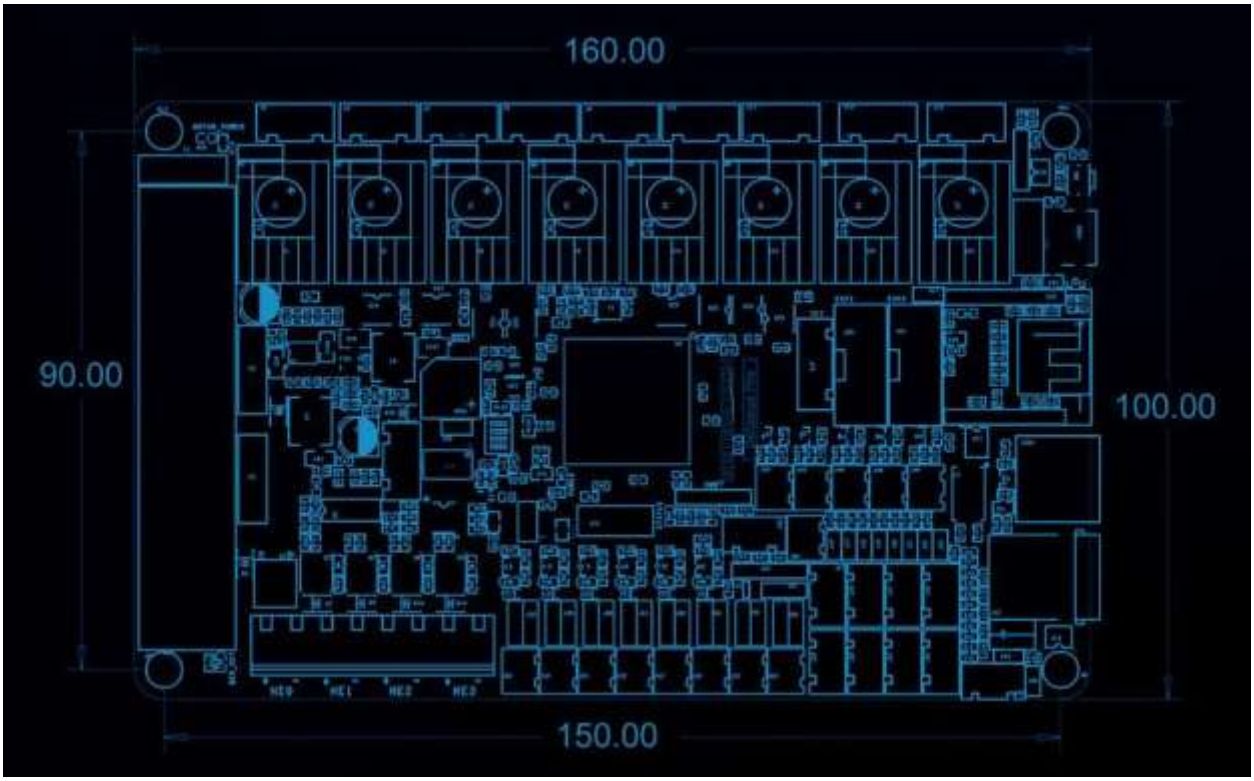
- **Dedicated GPU for enhanced graphics processing**, improving user interaction through the touchscreen interface.
- **Dual micro-HDMI support**, useful for monitoring printing in research environments.
- **Custom firmware compatibility**, ensuring smooth integration with **Klipper firmware**.
- **Power-efficient performance**, minimizing heat buildup during extended print jobs.
- **High-speed Ethernet connectivity**, allowing remote access to print settings and live monitoring of print progress.
- **Wi-Fi and Bluetooth compatibility**, ensuring a wireless control experience with ease of operation.
- **Expandable GPIO pins**, allowing further integration of **customized accessories and additional control mechanisms**.
- **Advanced thermal management system**, preventing overheating and ensuring stable long-term operation.
- **Hardware-level encryption support**, enhancing security for networked operations.
- **Real-time clock (RTC) integration**, allowing precise scheduling of print operations and time-sensitive research tasks.
- **Multiple USB 3.0 ports**, enabling direct connection to external storage for extensive print job logging.

The **Raspberry Pi 5** runs the **Klipper firmware**, optimized for handling complex movement algorithms and improving **precision and control** during printing. It works alongside the **BigTreeTech Octopus Pro** mainboard, acting as the **brain** of the operation. The combination of a **high-performance processor and real-time control firmware** ensures **flawless execution of intricate bioprinting designs**, making it one of the most sophisticated control systems available in the field of 3D printing.

2.2. BigTreeTech Octopus Pro Mainboard

The **BigTreeTech Octopus Pro** is a **high-performance 3D printing mainboard**, designed to handle multiple **stepper motor drivers, heating elements, and sensors**. Its robust architecture enables it to manage **the precise movements of the printhead and extrusion system** with minimal latency. Unlike basic 3D printer control boards, the **Octopus Pro is designed for advanced applications, offering flexibility, expandability, and superior processing power**.



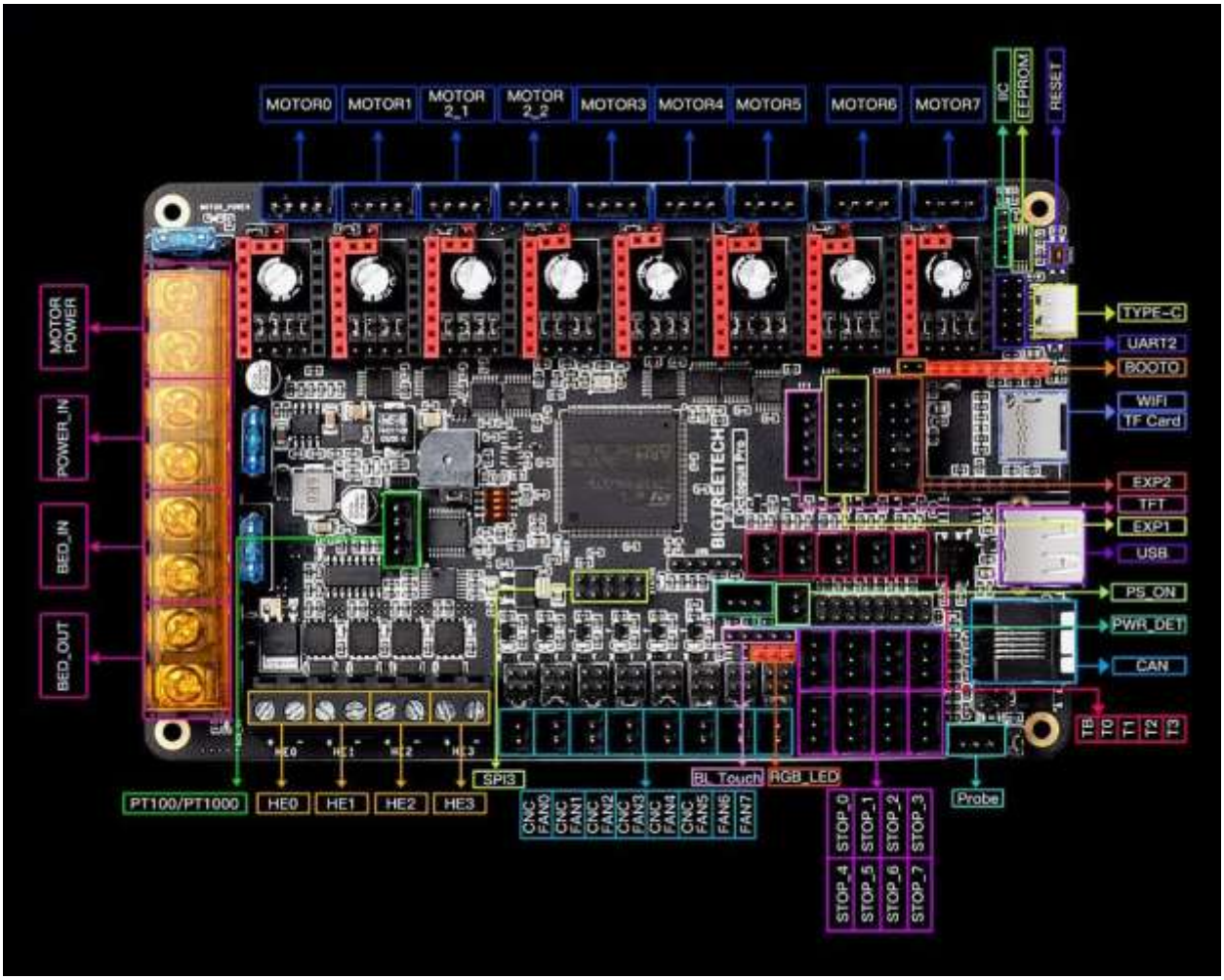


A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

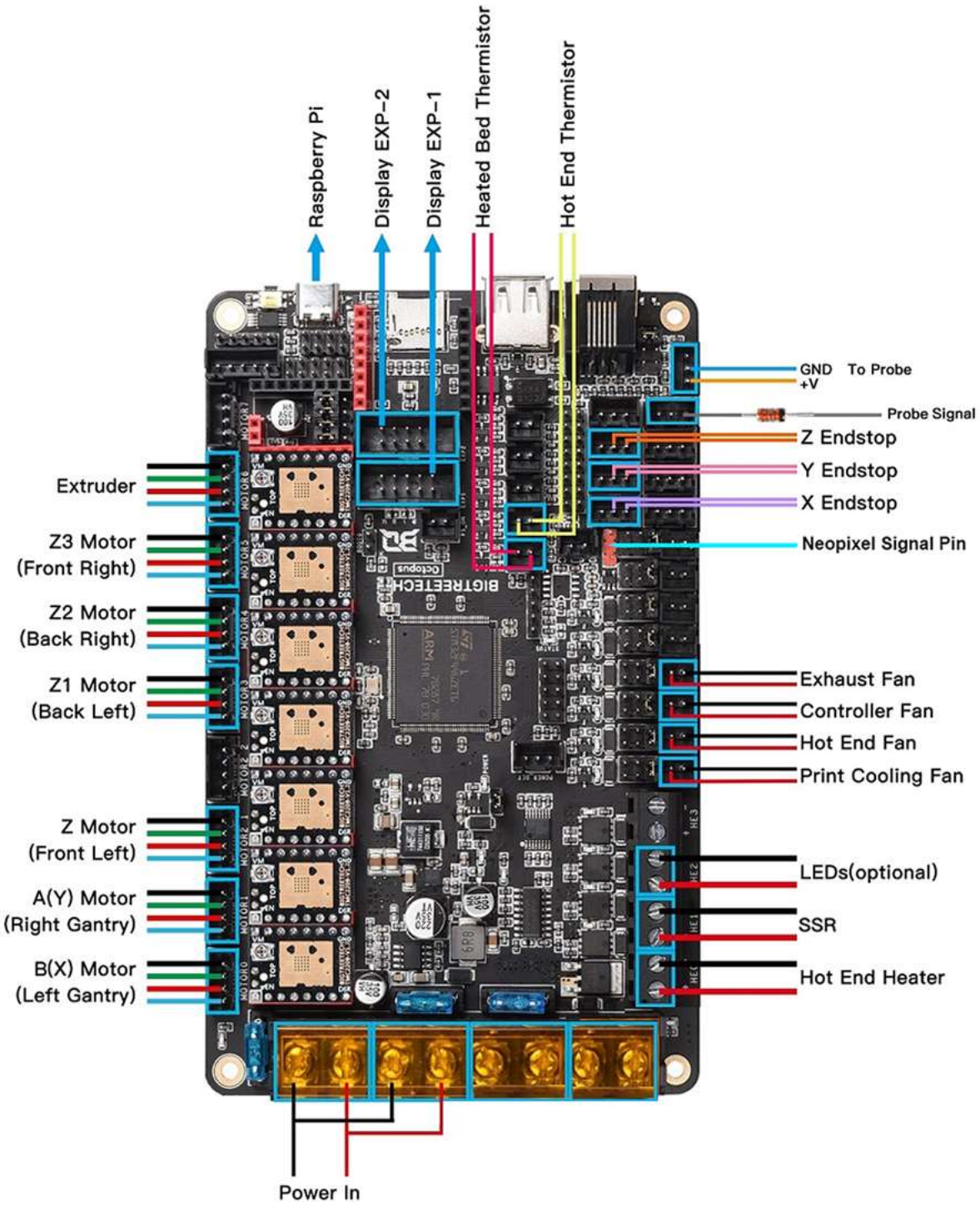


A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk



2.2.1. Technical Specifications

- **Supports up to 8 stepper motors**, ideal for complex multi-axis movement.
- **Multiple MOSFET outputs** for controlling heated beds, fans, and sterilization systems.
- **High-speed processing**, reducing lag between print commands and execution.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- **Dedicated ports for auto-bed leveling, filament sensors, and additional safety mechanisms**.
- **Seamless communication with the Raspberry Pi 5**, ensuring rapid execution of motion commands.
- **Advanced error correction algorithms**, improving print consistency and minimizing failures.
- **Extended support for additional peripherals**, including external sensors and heating elements.
- **Dedicated power input for high-power applications**, ensuring consistent performance under long printing durations.
- **Support for TMC drivers**, allowing silent and highly precise stepper motor movement.
- **Independent control over multiple heaters and cooling fans**, optimizing the print environment for temperature-sensitive materials.
- **Enhanced circuit protection**, preventing power surges from damaging sensitive electronics.
- **Multi-zone temperature monitoring**, allowing precise heat distribution across the print surface.
- **Integrated safety mechanisms**, including emergency stop features and thermal runaway protection.
- **Expandable UART and SPI interfaces**, enabling future upgrades and additional automation features.
- **Active power regulation**, improving energy efficiency while maintaining high-speed processing.
- **Built-in diagnostic LEDs**, allowing quick troubleshooting of motor and sensor activity.

This mainboard is a crucial component, as it integrates directly with the **motion control system**, allowing for precise, synchronized movement in **bioprinting applications**. The advanced **real-time monitoring and rapid data processing capabilities** provide a **smoother and more controlled printing process**, reducing print failures and improving efficiency in large-scale applications.

The **BigTreeTech Octopus Pro**, combined with **Raspberry Pi 5**, creates a **powerful, scalable, and future-proof control system**, ensuring **seamless performance in long-duration, high-precision bioprinting tasks**.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

2.3. 0.9° Nema 17 Stepper Motors (8 Units)

The **BioARTX X1** employs **eight high-precision Nema 17 stepper motors**, each rated at **0.9° step resolution**, making them twice as accurate as conventional **1.8° step motors**. These motors play a fundamental role in **ensuring high-resolution print movement**, reducing vibrations, and improving **print accuracy**.

2.3.1. Functions of the Stepper Motors

- **X and Y Axis Movement:** Controls the movement of the printhead, ensuring accurate droplet placement.
- **Z Axis Motion:** Adjusts the print bed, ensuring precise layer heights and leveling.
- **Bioink Extrusion System Control:** Regulates the bioink dispensing process, adjusting flow rate and pressure.
- **Additional Functional Components:** Drives components like the automated syringe replacement system.
- **Independent multi-motor coordination**, allowing fine-tuned control of multi-material deposition.
- **Active cooling for extended operation**, preventing thermal instability during long prints.

2.3.2. Stepper Motor Specifications

- **Torque Rating:** 46Ncm (65oz.in) for high-force, low-noise operation.
- **Step Angle:** 0.9° for precise, smooth motion.
- **2A Current per phase**, ensuring high-speed response with minimal overheating.
- **4-lead wiring**, allowing compatibility with most stepper drivers.
- **Custom driver support for silent operation**, minimizing vibration and noise.

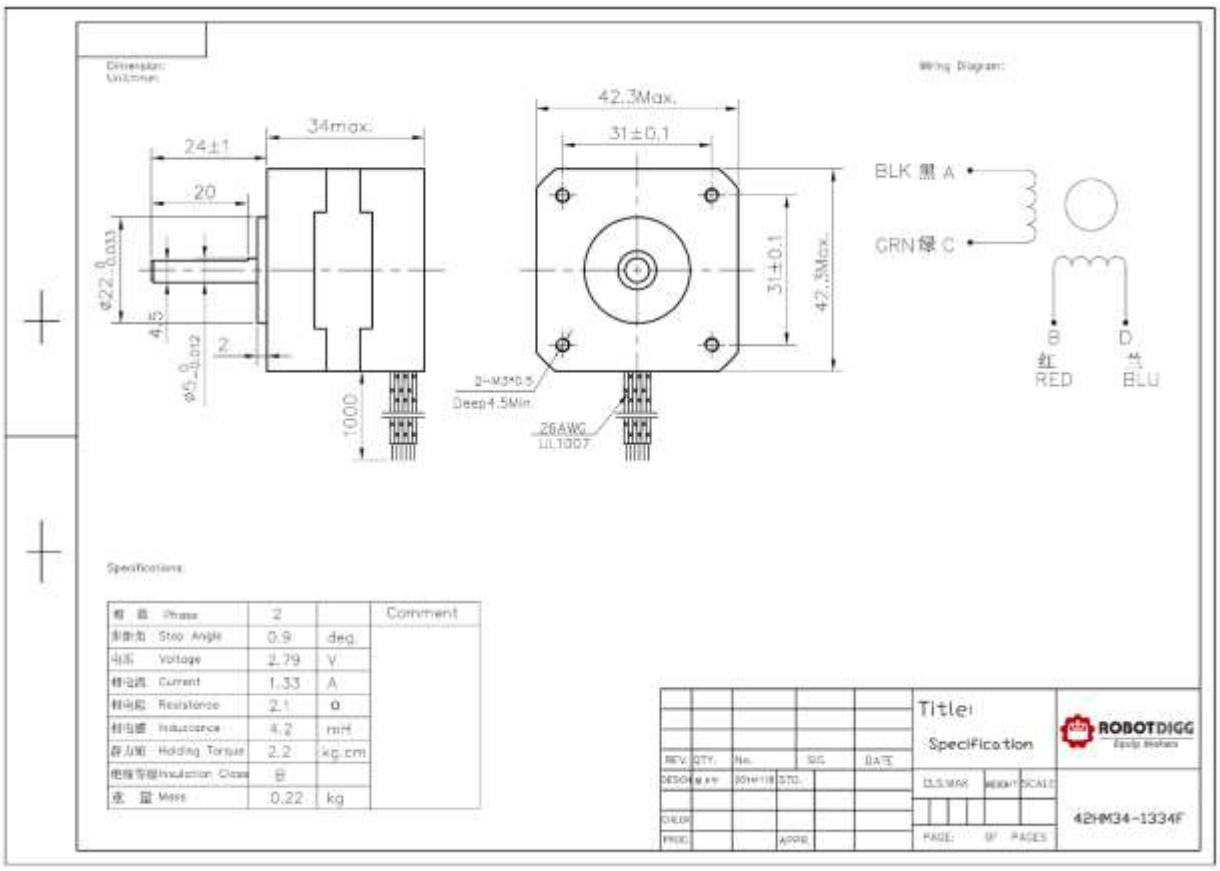
These motors are **essential** for ensuring **accurate bioink deposition**, **smooth movement**, and **precision control over the printing process**.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk



2.4. Ink and Bioink Extrusion System

The **inkjet extrusion system** is one of the most critical components of the **BioARTX X1**, designed to deposit materials with **micron-level precision**. The system consists of:

- **Syringe-based extrusion mechanism** for bioink printing.
- **Swappable hot-end extruder** for standard material printing.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- **Pressure-regulated extrusion control**, ensuring consistent droplet formation.
- **Automated material switching**, allowing multi-material transitions mid-print.
- **Fine pressure adjustments**, controlling viscosity-sensitive bioinks for high-detail printing.

2.4.1. Hot End Extruder

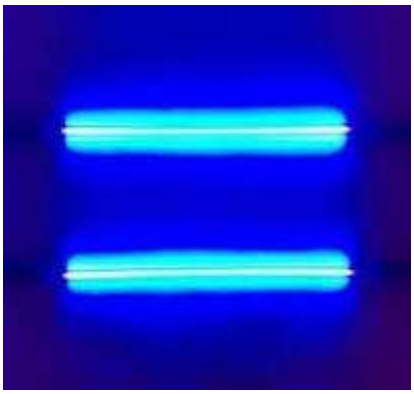
- Allows the printer to transition from **bioink-based printing** to **thermoplastic extrusion**.
- **High-temperature compatibility**, capable of handling various material types.
- **Quick-swappable design**, allowing seamless modification of print setups.
- **Integrated heat-break cooling**, ensuring stable extrusion conditions.

This modular extrusion system allows researchers and engineers to **adapt the printer for different materials**, making it highly **versatile and customizable**.

2.5. Sterilization System (UV A, B, C & Gamma)

Ensuring a **sterile printing environment** is crucial when dealing with bioinks. The **BioARTX X1** incorporates **multiple sterilization mechanisms**, each serving a specific function:

UV Sterilization (A, B, C)

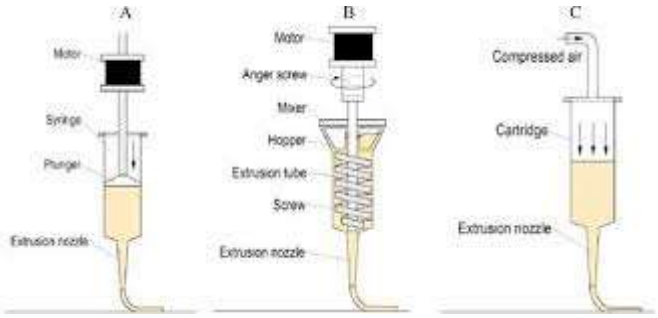
- **UV-A and UV-B lights** are integrated within the printing chamber for routine sterilization.
- **UVC Light Module** for intensive photocuring and deep sterilization.
- **Detachable UV system**, allowing flexibility in sterilization techniques.
- **Timed exposure cycles**, ensuring thorough decontamination without excess UV exposure.
- 

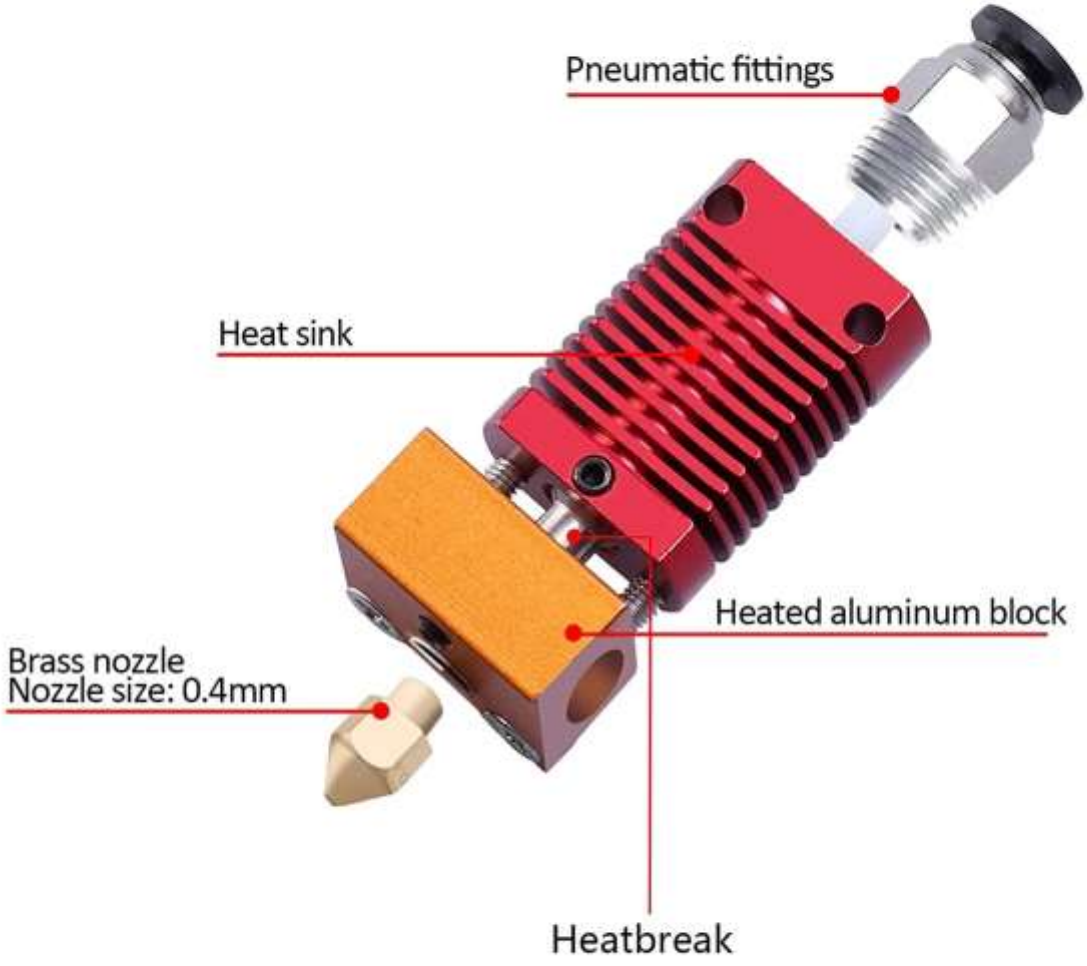
A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk





A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

Gamma Radiation System

- Used for high-biosafety applications where extreme sterilization is required.
- Located externally for **safety considerations** and **controlled exposure**.
- Only engaged in critical applications to avoid unnecessary exposure risks.
- **Regulated power settings**, ensuring optimal sterilization without damaging sensitive materials.

This **multi-tier sterilization system** ensures that the printer meets **biosafety standards**, preventing contamination in medical and pharmaceutical applications.

2.6. HEPA Filtration System

The **HEPA (High-Efficiency Particulate Air) filtration system** is a crucial element of the **BioARTX X1**, ensuring a **contamination-free printing environment**. The system is designed to **eliminate airborne contaminants**, preventing particles, bacteria, and other pollutants from interfering with sensitive bioinks and printed constructs.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

2.6.1. Key Features of the HEPA Filtration System

- **Industrial-grade filtration**, capable of capturing particles as small as **0.3 microns**.
- **Multi-stage filtration**, combining **pre-filters and activated carbon layers** to maximize air purity.
- **Continuous airflow regulation**, ensuring a stable and controlled printing chamber environment.
- **Automated filter status monitoring**, alerting users when filter replacement is necessary.
- **Low-noise operation**, maintaining a quiet research or laboratory setting.
- **Integration with sterilization systems**, working in tandem with **UV and Gamma** sterilization to ensure a fully sanitized workspace.
- **Electrostatic-enhanced filtration**, improving the removal of microscopic contaminants and biohazards.
- **Dedicated airflow ducts**, designed to evenly distribute filtered air throughout the chamber, preventing contamination hotspots.

This advanced **HEPA filtration system** ensures that prints remain sterile throughout the process, reducing the likelihood of contamination-related failures, making it **indispensable** for biomedical, pharmaceutical, and tissue engineering applications.

2.7. Camera Monitoring System

A **high-resolution camera system** is integrated into the **BioARTX X1**, allowing for **real-time monitoring, error detection, and quality control**. This feature ensures that prints can be tracked remotely, with footage available for **documentation, research analysis, and troubleshooting**.

2.7.1. Camera System Capabilities

- **Live-streaming support**, allowing users to **monitor prints in real-time** via an external device.
- **Timelapse recording**, providing a visual history of the printing process for quality control and research purposes.
- **Adjustable positioning**, enabling multiple viewing angles of the printing chamber.
- **Infrared (IR) night vision option**, allowing print monitoring even in low-light or enclosed environments.
- **High-definition (HD) imaging**, ensuring detailed visualization of fine-print structures.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- **Automatic snapshot capture at key intervals**, assisting in **print progress tracking**.
- **Error detection via image processing** (future feature), utilizing AI-based **pattern recognition to detect anomalies**.
- **Remote control functionality**, enabling **zoom and focus adjustments via an external device**.
- **Multi-camera support**, allowing multiple angles to be captured simultaneously for **comprehensive print analysis**.

This **camera system is an invaluable tool** for researchers and engineers, providing **visual evidence of print success, anomaly detection, and post-processing evaluations**. The ability to **remotely monitor and analyze print behavior** enhances productivity and ensures high **print reliability**.

2.8. Touchscreen Interface

The **BioARTX X1** features an advanced **7-inch capacitive touchscreen** that provides a user-friendly and highly interactive way to control and monitor printing operations. The touchscreen serves as the **primary interface** for users to access **print settings, system diagnostics, and monitoring features**.

2.8.1. Key Features of the Touchscreen Interface

- **High-resolution, full-color display**, ensuring clear visibility of settings and real-time progress.
- **Intuitive navigation menu**, providing an easy-to-use UI optimized for seamless operation.
- **Live print monitoring**, displaying real-time temperature, motion status, and bioink flow control.
- **Direct control of sterilization systems**, allowing immediate activation of UV and Gamma sterilization.
- **Emergency stop functionality**, ensuring user safety with instant print cancellation in critical situations.
- **Multi-touch gesture support**, enabling advanced user interaction and control.
- **Integrated logging system**, keeping records of previous print jobs for quality assurance.
- **On-screen troubleshooting assistant**, providing step-by-step guidance for resolving common issues.

- **Adjustable screen brightness and power-saving mode**, optimizing energy consumption for longer operation.
- **Firmware update capability via touchscreen**, allowing easy system upgrades without requiring a connected computer.
- **Customizable interface**, enabling users to personalize settings and workflows for improved efficiency.

3. SOFTWARE AND FIRMWARE

The **BioARTX X1 3D Inkjet Printer** integrates seamlessly with a robust software and firmware system, ensuring **high-precision, reliable, and adaptable 3D printing**. This section explores the **Klipper firmware** and the **Mainsail interface**, the core software components driving the printer. Together, they provide an advanced, user-friendly experience, offering enhanced performance, speed, and customizability.

3.1. Klipper Firmware

The **Klipper firmware** is the heart of the **BioARTX X1's** control system, providing real-time processing of movement algorithms, motion control, and device synchronization. It is an open-source 3D printer firmware known for its **speed**, **efficiency**, and **ability to harness the power of powerful external processors** like the **Raspberry Pi 5**.

3.1.1. Key Features of Klipper Firmware

- **High-speed motion control**, reducing printing time and improving accuracy by processing commands faster than traditional 3D printer firmware.
- **Distributed processing architecture**, allowing the **Raspberry Pi** to handle computational tasks while the **Octopus Pro** board controls hardware. This reduces strain on the controller, resulting in smoother and faster operation.
- **Pressure advance algorithm**, optimizing **extrusion flow** and reducing **blobbing** during prints. This feature is particularly crucial for high-precision applications like **bioprinting**.
- **Real-time motion planning**, ensuring that the **BioARTX X1** can maintain **high-quality prints** even during fast movements.
- **Automatic bed leveling and calibration**, reducing setup time and ensuring that the print bed remains stable and level during operations.
- **Advanced g-code processing**, enabling complex **multi-material prints** by adjusting extruder temperatures, flow rates, and speeds based on the print requirements.

- **Multiple extruder support**, allowing for seamless transitions between bioinks and standard materials without significant changes in workflow.
- **Advanced safety features**, including **thermal runaway protection**, **stepper motor stall detection**, and **motion safety checks**, ensuring safe operation of the printer in various environments.
- **Remote control capability**, allowing for remote management and monitoring via web-based interfaces like **Mainsail**.

Klipper enables the **BioARTX X1** to handle the demands of intricate, multi-material bioprinting while offering significant enhancements over traditional firmware. By offloading heavy computations to the **Raspberry Pi 5**, the system can run more **complex algorithms** at higher speeds without compromising on precision.

3.2. Mainsail Interface

The **Mainsail** interface is an intuitive, **web-based control platform** designed to provide users with a comprehensive view of the printer's status, settings, and performance. It offers a user-friendly **dashboard** for controlling the **BioARTX X1**, whether you are operating it locally or remotely.

3.2.1. Key Features of Mainsail Interface

- **Real-time print monitoring**, displaying **temperature** readouts, **motion tracking**, and **bioink extrusion** parameters.
- **User-friendly touchscreen compatibility**, allowing easy access to all settings directly from the printer's touchscreen or remote device.
- **G-code viewer**, providing a clear visualization of print paths, layer heights, and print speed.
- **Print job management**, with the ability to pause, cancel, or restart prints from the web interface.
- **Integrated webcam support**, enabling real-time timelapse recording and print progress tracking.
- **Advanced troubleshooting tools**, including error logs, diagnostics, and the ability to update firmware remotely.
- **Customizable settings and profiles**, allowing users to set specific print parameters (e.g., **speed**, **extrusion rates**, **temperature settings**) based on material and bioink type.
- **File management system**, making it easy to upload, organize, and execute print jobs directly from your device to the printer.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- **Multi-device control**, allowing for simultaneous operation on multiple devices (PCs, tablets, and smartphones) via the same web interface.
- **Real-time network monitoring**, tracking **printer performance** and **network health** to ensure stable printing operations.
- **Integrated notifications and alerts**, keeping users informed of print progress, failures, or issues with a variety of customizable alert options.

The **Mainsail interface** simplifies printer operation, making it easy to **configure settings, monitor progress**, and troubleshoot issues all in one place. Its ability to **interface with Klipper firmware** ensures a seamless flow between **g-code commands**, **motion planning**, and **material management**, enhancing the printer's overall usability.

3.3. Print Job Workflow and Customization

With **Klipper firmware** and **Mainsail** combined, the **BioARTX X1** offers an advanced **workflow management system** for 3D printing jobs.

3.3.1. Workflow Overview

1. **Model Preparation**: Users prepare a **3D model** of the object to be printed using software like **CAD programs** or **3D design tools**. The model is exported as a **stl** file and sliced into layers using slicing software (e.g., **Cura**, **PrusaSlicer**, etc.)
2. **G-code Generation**: The sliced file is converted into a **g-code file**, which contains instructions for the printer's movement, extrusion, and heating. The **Klipper firmware** processes this g-code.
3. **Printer Configuration**: Before starting the print, **Mainsail** allows users to fine-tune printer settings such as **temperature**, **flow rates**, and **motion parameters**, ensuring optimal results based on material and print requirements.
4. **Printing**: The printer begins the print job, with the **Klipper firmware** controlling the extruders, stepper motors, and temperature in real-time to achieve high precision.
5. **Monitoring**: Throughout the print, **Mainsail** provides real-time monitoring, alerting users if any issues arise, such as **print failures**, **material shortages**, or **temperature deviations**.
6. **Post-Processing**: After the print is complete, users can **review** the printed object, access detailed **timelapse footage**, and prepare for the next job.

3.3.2. Customization and Advanced Features

The combination of **Klipper** and **Mainsail** offers a highly customizable printing experience. Users can:

- **Adjust speed profiles** for different materials or complex prints.
- **Set up dual-material prints**, allowing for multi-material deposition within the same print job.
- **Create material-specific profiles**, optimizing settings for bioinks, conductive inks, and standard filaments.
- **Integrate additional hardware**, such as **auto-bed leveling sensors** or **filament sensors**, improving printer accuracy.
- **Automate workflows**, including multi-step post-processing tasks.

3.3.3. Advantages of Klipper and Mainsail in BioARTX X1

- **Enhanced Speed and Performance**: With **Klipper's processing power** and **Mainsail's efficient user interface**, the BioARTX X1 operates with **greater speed** while maintaining precision.
- **Seamless Multi-Material Printing**: The ability to easily switch between bioinks and other materials ensures **greater versatility**, especially for biomedical applications.
- **Advanced Diagnostics and Alerts**: **Klipper** and **Mainsail** work together to provide advanced troubleshooting tools, including **real-time alerts**, **temperature control**, and **automatic error detection**, improving the overall reliability of the printing process.
- **Remote and Real-Time Access**: With **Mainsail's web interface**, users can control and monitor the printer remotely, enabling **greater flexibility** in managing complex jobs.

3.4. Firmware Updates and System Maintenance

Both **Klipper firmware** and **Mainsail interface** support **easy firmware updates** via the touchscreen or remotely through the web interface. Regular updates help improve system performance, fix bugs, and add new features.

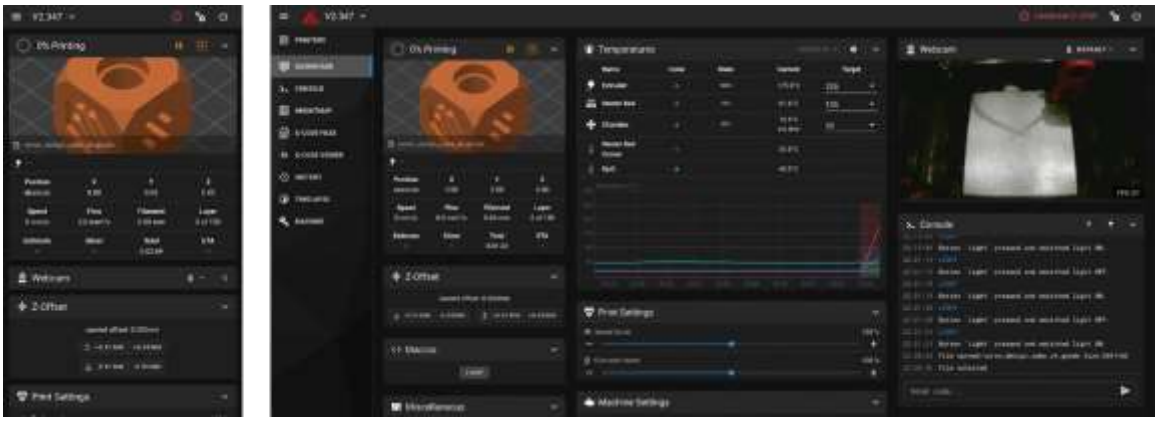
3.4.1. Firmware Update Process

- **Download firmware updates** from the official **Klipper GitHub repository** or directly through **Mainsail**.
- **Verify and install updates** via the touchscreen interface or remotely through the web.
- **Reboot the system** to apply the new firmware.

3.4.2. Routine Maintenance Tasks

- Regular **software and firmware updates**.
- Periodically checking **error logs** for system performance insights.

- **Cleaning and recalibrating** the printer to ensure accuracy and longevity.



Klipper firmware is an advanced instruction set and interface UI for modern 3D printers. It doesn't work inside the printer's microcontroller like marlin firmware but uses a separate more powerful computer, like a Raspberry Pi or other SBC, for better performance. This means better prints, quicker speeds, and easier ways to tweak your printer.

Mainsail and other web interfaces are packaged with Klipper to make the system more user friendly. Mainsail is a user-friendly interface that makes it easier to use Klipper's advanced features in easy and direct way through a web browser.

Here's what makes Mainsail so handy:

3.4.3. Keep an Eye on Your Printer

Watch your printer do its thing and check on important stuff like temperature, how much filament you're using, where everything's moving, and how far along your print is. It's all shown in real-time with neat charts and info.

3.4.4. Easy Printer Commands

Forget about typing in tricky commands. Mainsail lets you control your printer from your web browser. You can start, stop, or cancel your prints with a click. Change the heat settings with a slide or type in numbers if you need to be super exact. You can even move your printer around right from the screen, which is great for getting things just right.

3.4.5. Sort Out Your Files

Keep all your printing files in order with Mainsail. Upload your Gcode files, put them in folders to stay organized, and look back at your print history to see how long things took, how much filament you used, and when you printed them.

3.4.6. Watch Your Prints Live

Connect a camera to Mainsail and you can watch your prints live. This way, you can keep an eye on things from anywhere and catch any problems early.

3.4.7. Make Printing Easier with Macros

Set up custom macros to make controlling your printer easier. They can do the boring stuff for you, like leveling the bed, changing filament, or setting up your extruder, so you don't have to write long commands and forgot the G-code commands.

3.4.8. Tweak Your Printer Settings

With Mainsail, you can dive into Klipper and change your printer's settings and configuration to make it work just how you like. Plus, you can keep Klipper and Mainsail updated with the latest cool features and fixes.

3.4.9. Add More with Plugins

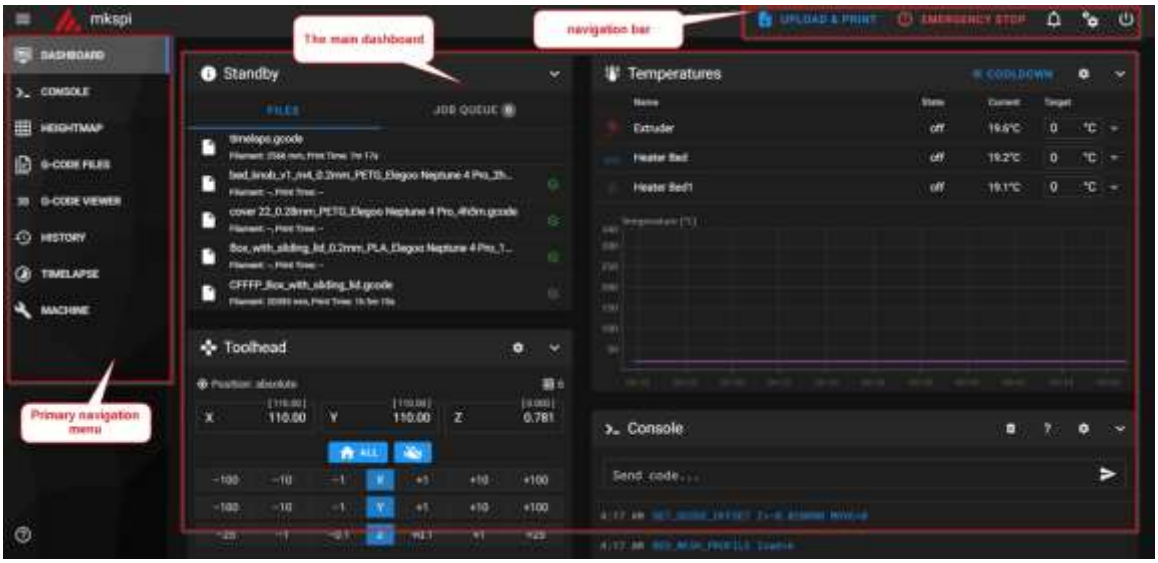
Make Mainsail even better with plugins and added components. There's a bunch you can add, like ones for making timelapses of your prints.

Navigating the Mainsail Interface: A Guided Tour

After successful installation, launch Mainsail in your web browser by entering the IP address of your mainsail interface on your browser. You'll be greeted by the intuitive Mainsail dashboard, your central hub for printer monitoring and control. Let's explore the key sections of this interface and understand mainsail features:

3.4.10. Dashboard Overview

The Mainsail interface comprises a primary navigation menu, a navigation bar with an emergency stop button, notifications, and a few other options. Additionally, the main dashboard that have essential components for controlling and monitoring your 3D printer.



The mainsail navigating menu

This side vertical menu allows you to access many features in the mainsail interface.

- **Mainsail dashboard**

This dashboard consists of many components. Let's take apart the Mainsail components and understand what each part does.

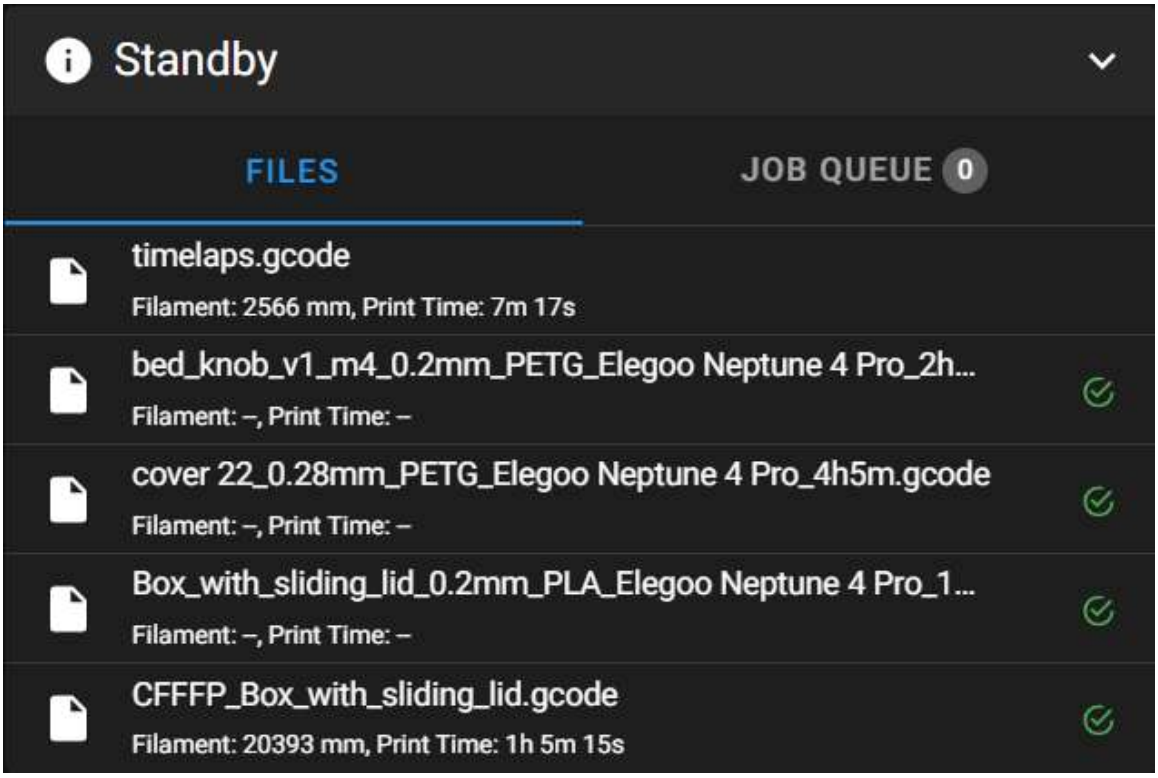
- **Standby component**

A. Wadood house near Qazi model school Frash,

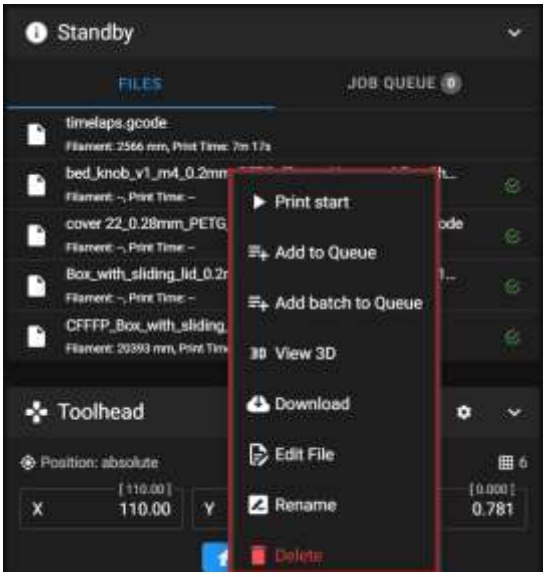
PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk



In this component, you can manage your G-code files and control the printing queue. Additionally, right-clicking provides more options, such as starting print a specific file.



- **Temperatures component**
  In this component, you can adjust the hotend and heat bed temperatures. Additionally, it displays graphs of temperature changes over time for better understanding.

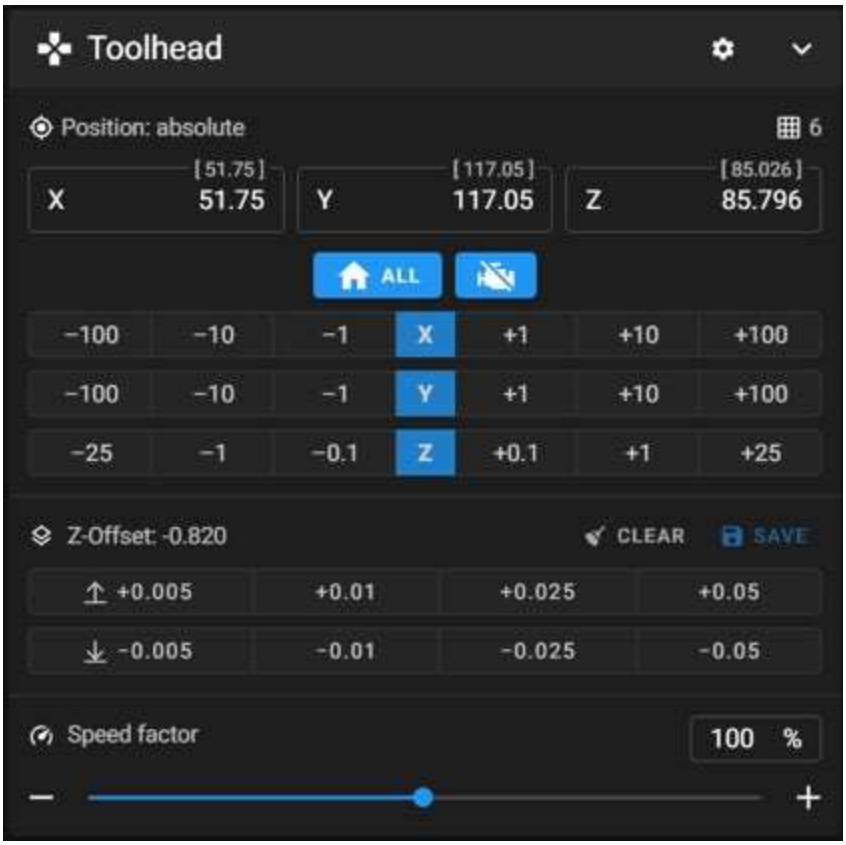
A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- **Toolhead component**



In this component, you can view the current absolute position of the printer head and use it to manually move the printer motors to specific positions in the X, Y, and Z directions. Additionally, you have the ability to disable the stepper motors, adjust the Z-Offset value, and control the printer speed in percentage.

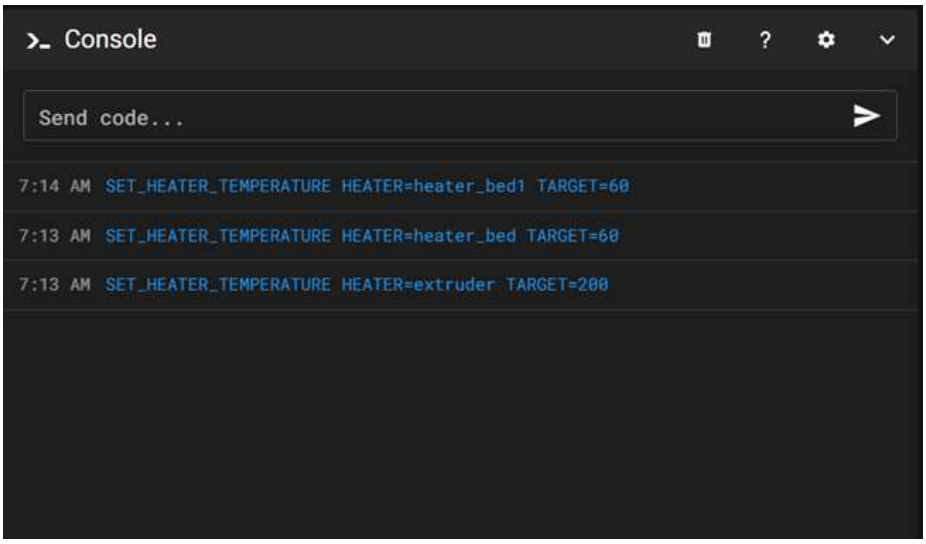
- **The console component**

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

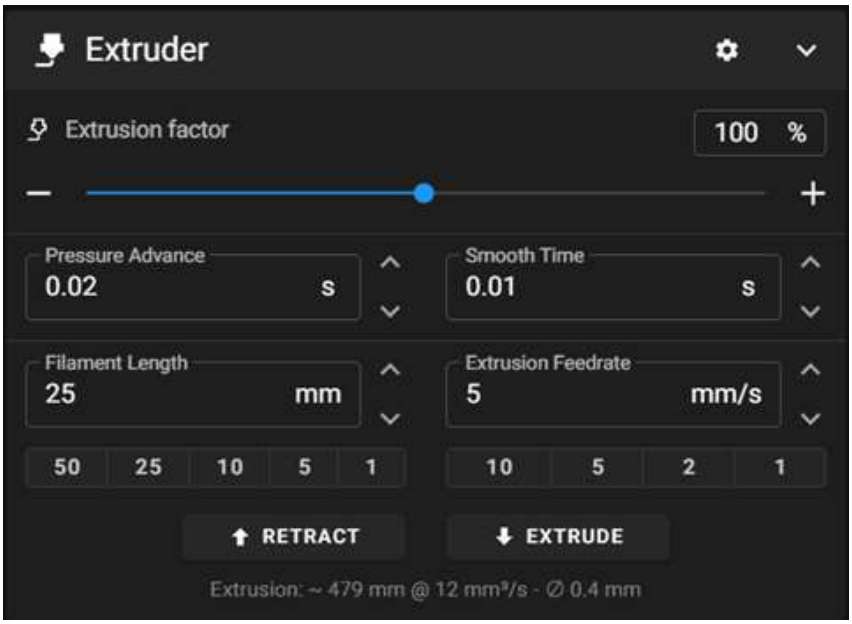
Contact # +923234663780

info@biomaterials.pk



In this component, you can directly communicate with your 3D printer using commands and G-codes. Additionally, it provides feedback from your 3D printer.

- **The Extruder component**



This component allows you to precisely control the extrusion process in your printer. It offers various options such as adjusting the Extrusion Factor, fine-tuning pressure advance values, setting smooth time, specifying filament length, and adjusting extrusion feed rate. Additionally, it enables you to extrude or retract a specific amount of material as needed.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

6.The macros component

With Macros Component, you can create and manage shortcuts that perform specific tasks with a single click! Bundle together a series of commands, such as starting automatic bed leveling or canceling a print. Once you've set up a macro, you can use it anytime—no more typing out lengthy instructions! Macros are perfect for repetitive tasks, saving you time and effort. And since mainsale and Klipper are open source, you have the flexibility to create your own custom macros.

For example: you can click on the G29 macros command and your 3D printer will start the auto bed leveling. It is easy to access and perform and can save your time.

- **The machine component**

In this component you have quick access to some important options related to your machine like adjusting the velocity, square corner velocity, acceleration and Max. Accel. to Decel.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- **The miscellaneous component**

In this component, you have the ability to adjust the printer's layer fan speed as a percentage, and you can also activate the printer's beeper to produce sounds at different frequencies. Additionally, you can manage the caselight and access information regarding the filament sensor status.

Now that we've completed exploring the Mainsail dashboard components, let's move on to discover the other navigation menu options available in Mainsail interface!

- **The console options**

This option opens a new page containing the console, enabling you to communicate directly with your 3D printer using commands. Additionally, Mainsail provides access to a command list, offering quick access to commonly used commands for your convenience.

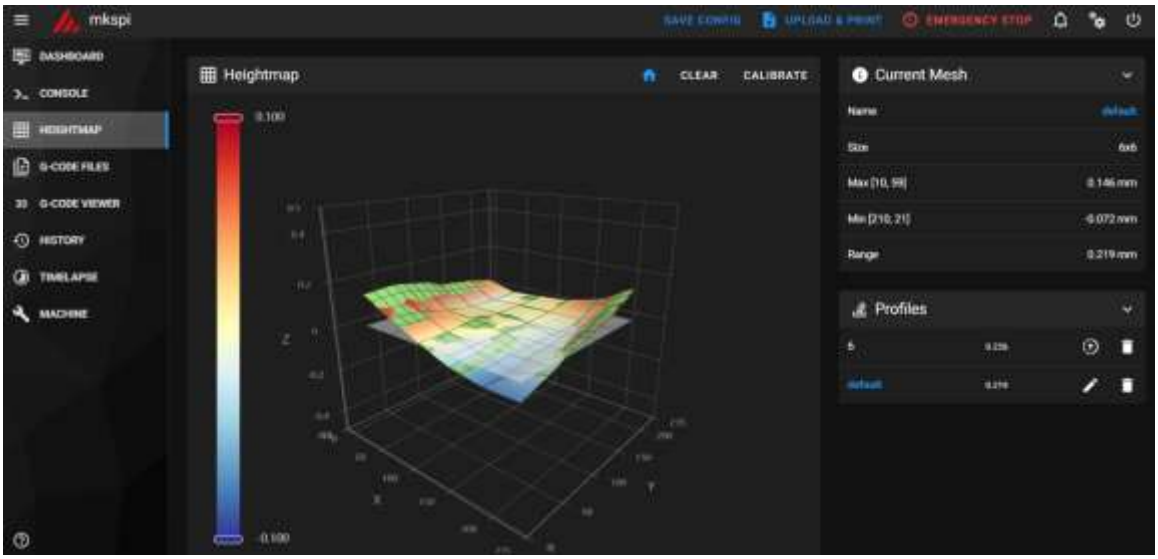
A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

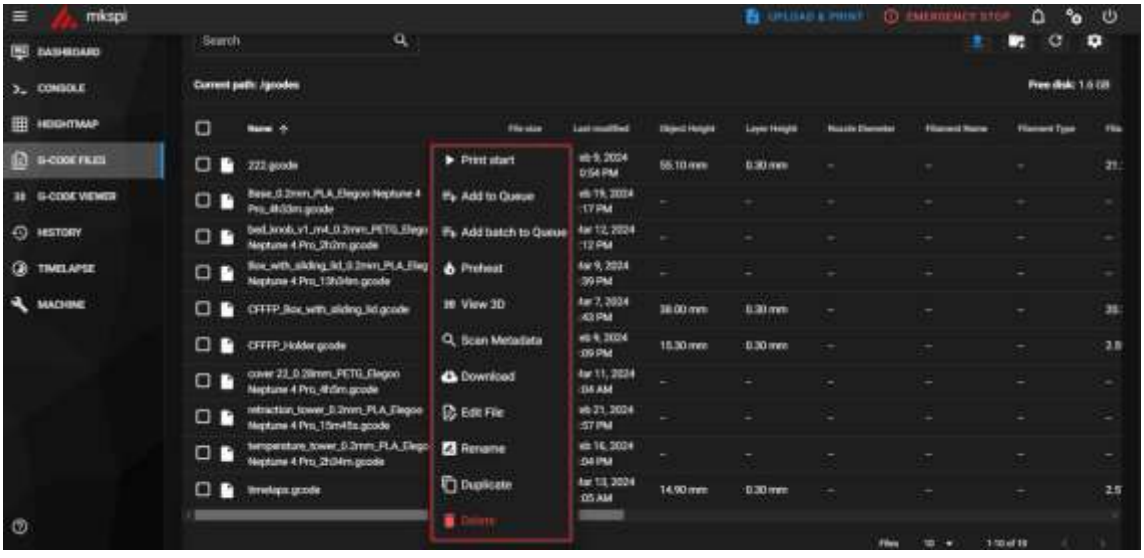
info@biomaterials.pk

- **Height map**



Selecting this option opens a new page providing crucial details about mesh bed leveling. Here, you can navigate through a 3D map representing your heatbed leveling, allowing you to visualize and understand the surface better. You also have the option to recalibrate your printing surface for improved results. Additionally, you can save multiple profiles, which proves useful if you use different printing metal sheets, enhancing flexibility and efficiency in your printing process.

- **G-code files**



In this component you can manage your G-code files that you have previously uploaded, you can arrange your files in folders or upload new files. You can also right-click on specific file for more options like print start or 3D view and mor

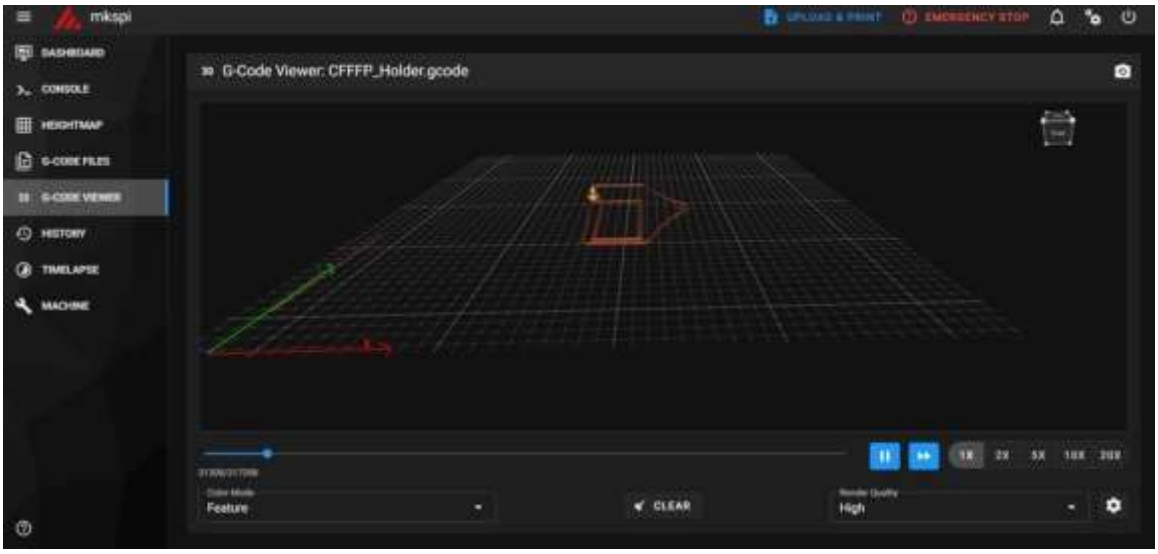
A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

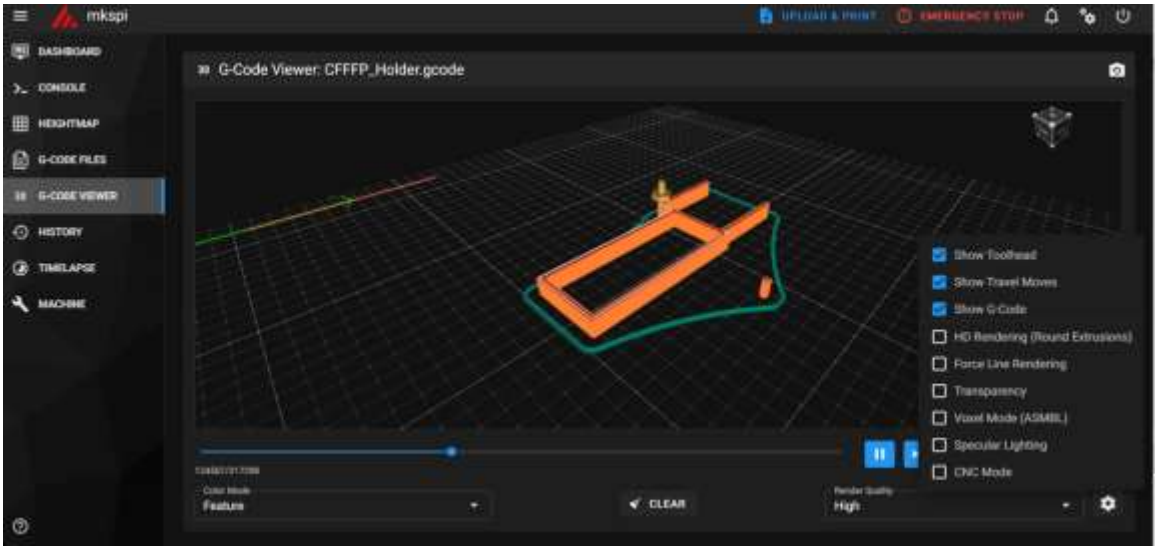
Contact # +923234663780

info@biomaterials.pk

- **G-code viewer**



This option enables you to simulate your G-codes in 3D before starting the actual printing process. This feature is incredibly useful as it allows you to test your files and identify potential issues to prevent failures. The simulation offers various options such as controlling the speed, displaying the toolhead, and showing travel moves, among others, providing you with a comprehensive overview of the printing process.



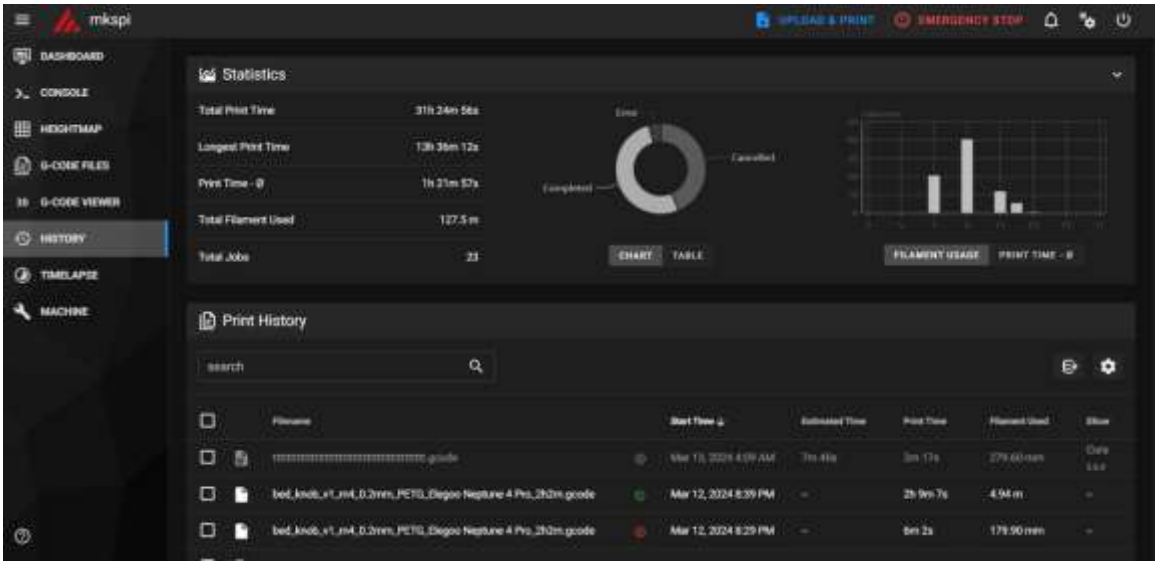
- **History**

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

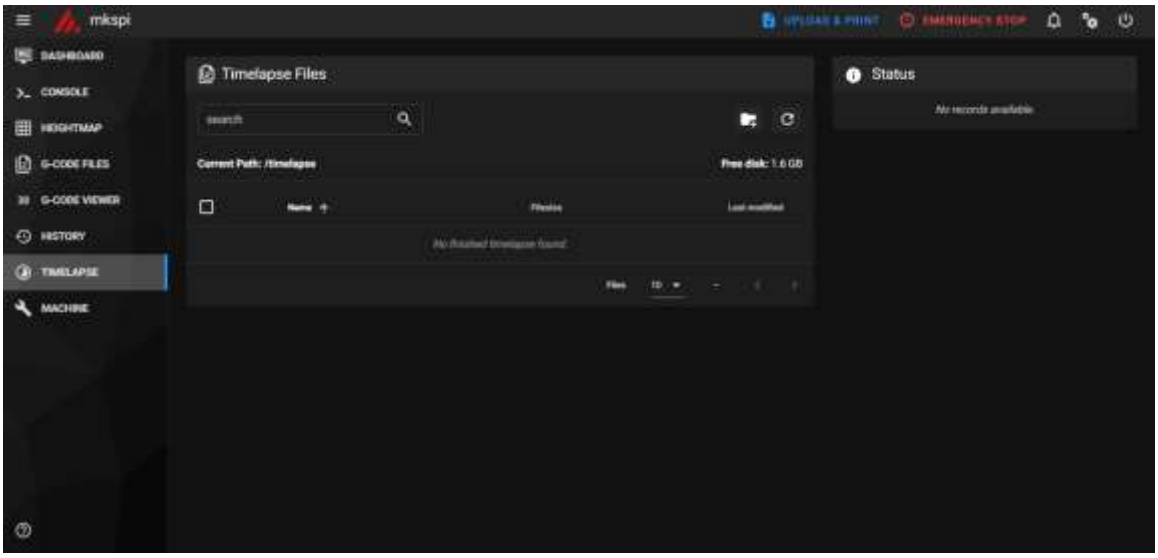
Contact # +923234663780

info@biomaterials.pk



In this option you can check out your past print jobs and see some useful statistics. This includes details like whether the print job was successful, how long it took, and how much filament was used. You can even choose to reprint a previous job if you need to. It's a handy way to keep track of your printing progress and learn from your past projects.

- **Timelapse**



When you select this option, it takes you to a page where all your recorded timelapse videos are stored. You can use the search function to find a specific timelapse video quickly, or create folders to organize your timelapse videos neatly. Additionally, you can right-click on any specific file for more options, such as downloading the file to share it on your social media platforms, for example. It's a convenient way to manage and share your timelapse recordings hassle-free.

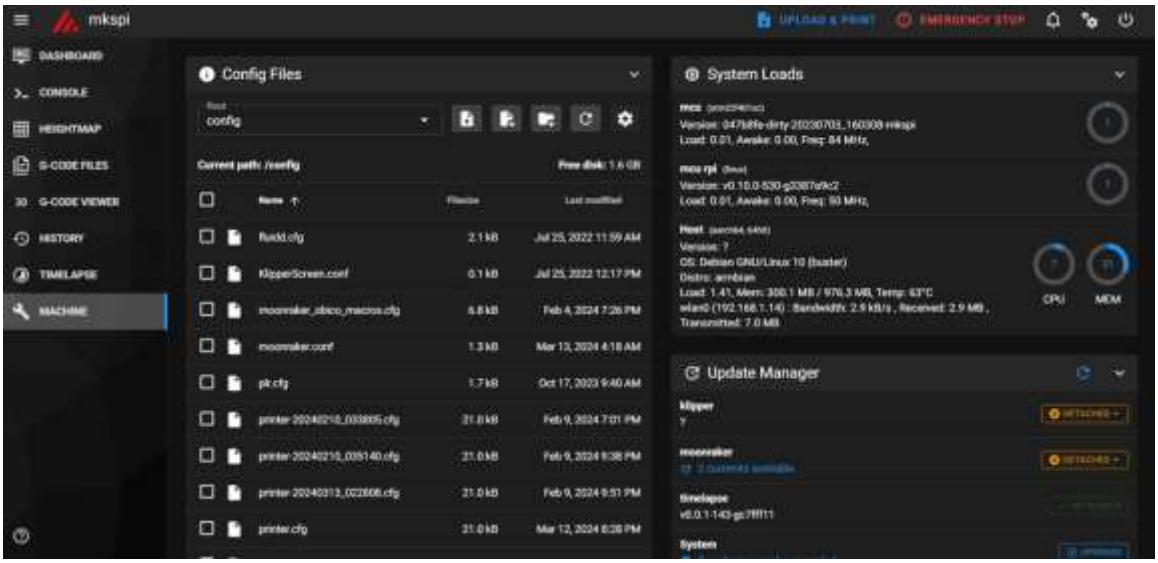
- **Machine**

A. Wadood house near Qazi model school Frash,

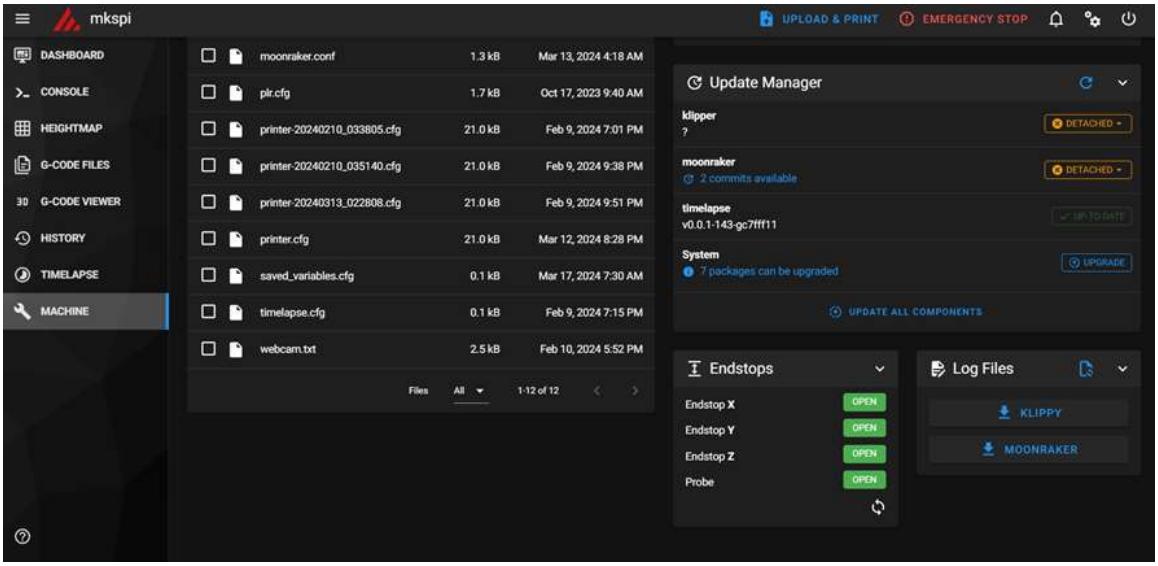
PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk



The "Machine" option has five parts that look like what you see on the main Mainsail dashboard. With this option, you can quickly check important info about your printer's hardware status using the System Loads part. The Update Manager helps you easily update Klipper, Moonraker, and other system packages. You can also tweak specific settings by opening and editing configuration files in the Configuration Files section. If you run into problems, the Log Files part provides helpful logs for figuring out what's wrong. Lastly, the End Stops section shows you if your printer's limit switches and z-probe are triggered and you can use it to test the functionality of these switches.



The **BioARTX X1 3D Inkjet Printer** is a meticulously designed piece of technology, built with **precision, reliability, and efficiency** in mind. This section provides an in-depth exploration of

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

each component, detailing its function, role in the overall system, and significance in ensuring **high-performance bioprinting**. Every part has been carefully selected to enhance the **functionality, print quality, and durability** of the printer. Each hardware component works in synergy to create a **seamless, high-precision bioprinting experience**, making the **BioARTX X1** a **leading-edge 3D inkjet printer** for biomedical, pharmaceutical, and material research applications.

3.4.11. 0.9° Nema 17 Stepper Motors (8 Units)

The **BioARTX X1** employs **eight high-precision Nema 17 stepper motors**, each rated at **0.9° step resolution**, making them twice as accurate as conventional **1.8° step motors**. These motors play a fundamental role in **ensuring high-resolution print movement**, reducing vibrations, and improving **print accuracy**.

Functions of the Stepper Motors:

- **X and Y Axis Movement:** Controls the movement of the printhead, ensuring accurate droplet placement.
- **Z Axis Motion:** Adjusts the print bed, ensuring precise layer heights and leveling.
- **Bioink Extrusion System Control:** Regulates the bioink dispensing process, adjusting flow rate and pressure.
- **Additional Functional Components:** Drives components like the automated syringe replacement system.
- **Independent multi-motor coordination**, allowing fine-tuned control of multi-material deposition.
- **Active cooling for extended operation**, preventing thermal instability during long prints.

Stepper Motor Specifications:

- **Torque Rating:** 46Ncm (65oz.in) for high-force, low-noise operation.
- **Step Angle:** 0.9° for precise, smooth motion.
- **2A Current per phase**, ensuring high-speed response with minimal overheating.
- **4-lead wiring**, allowing compatibility with most stepper drivers.
- **Custom driver support for silent operation**, minimizing vibration and noise.

These motors are **essential** for ensuring **accurate bioink deposition**, **smooth movement**, and **precision control over the printing process**.

3.4.12. Ink and Bioink Extrusion System

The **inkjet extrusion system** is one of the most critical components of the **BioARTX X1**, designed to deposit materials with **micron-level precision**. The system consists of:

- **Syringe-based extrusion mechanism** for bioink printing.
- **Swappable hot-end extruder** for standard material printing.
- **Pressure-regulated extrusion control**, ensuring consistent droplet formation.
- **Automated material switching**, allowing multi-material transitions mid-print.
- **Fine pressure adjustments**, controlling viscosity-sensitive bioinks for high-detail printing.

Hot End Extruder

- Allows the printer to transition from **bioink-based printing** to **thermoplastic extrusion**.
- **High-temperature compatibility**, capable of handling various material types.
- **Quick-swappable design**, allowing seamless modification of print setups.
- **Integrated heat-break cooling**, ensuring stable extrusion conditions.

This modular extrusion system allows researchers and engineers to **adapt the printer for different materials**, making it highly **versatile and customizable**.

3.4.13. Sterilization System (UV A, B, C & Gamma)

Ensuring a **sterile printing environment** is crucial when dealing with bioinks. The **BioARTX X1** incorporates **multiple sterilization mechanisms**, each serving a specific function:

UV Sterilization (A, B, C)

- **UV-A and UV-B lights** are integrated within the printing chamber for routine sterilization.
- **UVC Light Module** for intensive photocuring and deep sterilization.
- **Detachable UV system**, allowing flexibility in sterilization techniques.
- **Timed exposure cycles**, ensuring thorough decontamination without excess UV exposure.

Gamma Radiation System

- Used for high-biosafety applications where extreme sterilization is required.
- Located externally for **safety considerations** and **controlled exposure**.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

- Only engaged in critical applications to avoid unnecessary exposure risks.
- **Regulated power settings**, ensuring optimal sterilization without damaging sensitive materials.

This **multi-tier sterilization system** ensures that the printer meets **biosafety standards**, preventing contamination in medical and pharmaceutical applications.

3.4.14. HEPA Filtration System

The **HEPA (High-Efficiency Particulate Air) filtration system** is a crucial element of the **BioARTX X1**, ensuring a **contamination-free printing environment**. The system is designed to **eliminate airborne contaminants**, preventing particles, bacteria, and other pollutants from interfering with sensitive bioinks and printed constructs.

Key Features of the HEPA Filtration System

- **Industrial-grade filtration**, capable of capturing particles as small as **0.3 microns**.
- **Multi-stage filtration**, combining **pre-filters and activated carbon layers** to maximize air purity.
- **Continuous airflow regulation**, ensuring a stable and controlled printing chamber environment.
- **Automated filter status monitoring**, alerting users when filter replacement is necessary.
- **Low-noise operation**, maintaining a quiet research or laboratory setting.
- **Integration with sterilization systems**, working in tandem with **UV and Gamma** sterilization to ensure a fully sanitized workspace.
- **Electrostatic-enhanced filtration**, improving the removal of microscopic contaminants and biohazards.
- **Dedicated airflow ducts**, designed to evenly distribute filtered air throughout the chamber, preventing contamination hotspots.

3.4.15. Camera Monitoring System

A **high-resolution camera system** is integrated into the **BioARTX X1**, allowing for **real-time monitoring, error detection, and quality control**. This feature ensures that prints can be tracked remotely, with footage available for **documentation, research analysis, and troubleshooting**.

3.4.16. Touchscreen Interface

The **BioARTX X1** features an advanced **7-inch capacitive touchscreen** that provides a user-friendly and highly interactive way to control and monitor printing operations. The touchscreen serves as the **primary interface** for users to access **print settings, system diagnostics, and monitoring features**.

Key Features of the Touchscreen Interface:

- **High-resolution, full-color display**, ensuring clear visibility of settings and real-time progress.
- **Intuitive navigation menu**, providing an easy-to-use UI optimized for seamless operation.
- **Live print monitoring**, displaying real-time temperature, motion status, and bioink flow control.
- **Direct control of sterilization systems**, allowing immediate activation of UV and Gamma sterilization.
- **Emergency stop functionality**, ensuring user safety with instant print cancellation in critical situations.
- **Multi-touch gesture support**, enabling advanced user interaction and control.
- **Integrated logging system**, keeping records of previous print jobs for quality assurance.
- **On-screen troubleshooting assistant**, providing step-by-step guidance for resolving common issues.
- **Adjustable screen brightness and power-saving mode**, optimizing energy consumption for longer operation.
- **Firmware update capability via touchscreen**, allowing easy system upgrades without requiring a connected computer.
- **Customizable interface**, enabling users to personalize settings and workflows for improved efficiency.

4. SAFETY MEASURES

Safety Measures

Ensuring the safe operation of the **BioARTX X1 3D Inkjet Printer** is paramount. This section outlines the necessary safety precautions to take when operating the printer. It includes guidelines for handling bioinks, operating sterilization systems, and managing printer

components in a safe and efficient manner. Follow these procedures to minimize risks and ensure a safe working environment for both users and the printed objects.

4.1. General Safety Guidelines

Before operating the **BioARTX X1**, make sure to follow these general safety guidelines to protect yourself and others around you:

- **Always wear protective gear** such as gloves, lab coats, and safety glasses when handling bioinks or interacting with the printer's internal components.
- **Ensure proper ventilation** in the operating area. The printer should be placed in a room with **adequate airflow** to prevent the build-up of fumes from heated materials or bioinks.
- **Read the printer's user manual** thoroughly to understand its features, safety features, and any specific recommendations for safe operation.
- **Follow the instructions on material safety data sheets (MSDS)** for all bioinks and materials being used to ensure proper handling, storage, and disposal.
- **Check printer components** (e.g., electrical connections, cables, and motors) regularly to ensure they are in good condition and properly connected.
- **Power off the printer** when adjusting or repairs. Disconnect from the power source to prevent accidents from electrical shock or malfunction.

4.2. UV and Gamma Radiation Safety

The **BioARTX X1** uses **UV** and **Gamma sterilization systems** to ensure that prints meet sterility standards. These systems provide an effective way to kill bacteria and other microorganisms, but they must be handled with extreme care.

4.2.1. UV Radiation Safety

- **UV radiation can be harmful to skin and eyes**, so it is essential to never look directly at the UV light sources. Use protective **UV safety glasses** when working with or around the UV systems.
- **UV-C lights** used for photocuring and sterilization are the most dangerous and should only be operated when the printer's protective cover is securely closed. If UV-C lights need to be serviced, ensure that the printer is powered off and unplugged before performing any maintenance.
- **Minimize exposure to UV radiation** by ensuring that the **printer enclosure is intact** and that the **door is closed** when UV systems are active.

- **Install UV protective shields** to block potential exposure when servicing the printer or during troubleshooting.

4.2.2. Gamma Radiation Safety

- **Gamma radiation is highly dangerous** and requires **strict safety protocols**. The Gamma radiation source used for sterilization is located **externally**, and should only be activated when absolutely necessary and under supervision.
- Always ensure that **Gamma radiation areas** are **clearly marked** with appropriate warning signs and that unauthorized personnel do not enter these areas.
- **Use proper shielding** and wear **radiation safety clothing**, including lead aprons, when operating or servicing the Gamma system.
- Make sure that the **Gamma system is powered off** when it is not in use and is locked in a **secure area** to prevent accidental exposure.

4.3. Bioink Handling and Sterility

Handling **bioinks** requires care to avoid contamination or exposure to hazardous materials. Follow these safety measures when working with bioinks and biological materials.

4.3.1. General Bioink Handling

- **Always wear gloves** and other protective clothing when handling bioinks to avoid contact with skin and eyes. Bioinks can contain living cells or other sensitive components, so **avoid direct contact**.
- **Store bioinks properly**, as instructed in the material safety data sheets (MSDS). Keep them in a **cool, dry place** and ensure that they are used **before their expiration date**.
- **Dispose of bioinks properly**, following **hazardous waste disposal** guidelines. Dispose of expired or unused bioinks in **biohazard bags** and other approved containers.
- Ensure that any tools or syringes used with bioinks are **sterilized** after each use to avoid contamination between print jobs.

4.3.2. Maintaining Sterility in the Print Area

- **UV and Gamma sterilization** systems are essential for maintaining a **sterile printing environment**. Always ensure that the **printer enclosure is clean** before starting a print job.
- **Perform regular cleaning** of the printer's interior, especially the **extrusion system** and **print bed**, to remove any potential contaminants.

- Use **sterile gloves** when handling any materials that will come into contact with bioinks to prevent contamination.

4.4. Electrical and Mechanical Safety

The **BioARTX X1** has various **electrical and mechanical components** that need to be handled with caution.

4.4.1. Electrical Safety

- **Always disconnect the printer** from the power supply before performing maintenance or repairs on electrical components.
- If you notice any **frayed wires**, **damaged cables**, or **loose electrical connections**, stop using the printer immediately and have it inspected by a qualified technician.
- Ensure that **power cables** are **out of the way** to prevent tripping hazards and are not in contact with hot or moving parts.
- Avoid operating the printer with **wet hands** or in areas prone to moisture, as this can lead to electrical shock.

4.4.2. Mechanical Safety

- **Do not place hands or objects** near moving parts, such as the **stepper motors**, **extruder**, or **print bed**. Always wait for the printer to come to a complete stop before interacting with these parts.
- **Check the printer's stability** on its surface to ensure it is **level and secure** before starting the printing process.
- If the **syringe system** is used, **handle the syringes carefully** to avoid needle or material puncture injuries.

4.5. Emergency Procedures and Shutdown

In case of an emergency or malfunction, it is important to act quickly and correctly to prevent further issues or damage.

4.5.1. Emergency Shutdown

- **Immediately stop the printer** if you notice **smoke**, **burning smells**, or **unusual noises**. Disconnect the printer from the power supply by turning off the main power switch and unplugging it.
- In case of **power failure**, ensure that all critical settings and ongoing print jobs are safely paused or halted. Check that the **printer is properly ventilated** when restarting.

4.5.2. Fire Safety

- **Ensure the presence of fire extinguishers** in the printing area. Specifically, a **Class ABC** fire extinguisher is recommended for electrical and material-related fires.
- In the event of a fire, **turn off the printer**, remove any flammable materials, and use the fire extinguisher according to its instructions.

4.5.3. First Aid

- In case of bioink contact with skin or eyes, immediately rinse the affected area with **plenty of water** and seek medical attention if necessary.
- If exposure to **UV or Gamma radiation** occurs, seek medical attention immediately and inform the healthcare provider of the potential exposure.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

5. Maintenance and Troubleshooting

The **BioARTX X1 3D Inkjet Printer** is designed for **long-term reliability** and **consistent performance**. Regular maintenance and prompt troubleshooting are essential to ensure smooth operation, prevent downtime, and extend the printer's lifespan. This section provides guidelines for routine maintenance tasks, as well as tips for troubleshooting common issues that may arise during the printing process.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

5.1. Routine Maintenance

Proper maintenance is crucial to ensuring that the **BioARTX X1** operates efficiently and produces high-quality prints. Follow these steps for routine maintenance to keep your printer in optimal condition.

5.1.1. Cleaning the Print Bed

- Use a **soft cloth or scraper** to remove any debris from the print surface after each print job.
- For stubborn residues, use a mild, non-abrasive cleaner (such as isopropyl alcohol) to clean the surface.
- Avoid harsh chemicals that may damage the print surface.

5.1.2. Cleaning the Syringe System and Extruder

- After each use, **disconnect the syringe system** from the printer and rinse it with water or a suitable cleaning solution.
- **Clean the extruder** using the same method to prevent material buildup. It is recommended to run a small amount of **purge material** through the extruder to clear any residual bioink or filament.
- Make sure to **disassemble and clean** the syringe holder and any other parts that come into contact with bioinks.

5.1.3. Replacing the HEPA Filters

- Check the filters regularly and replace them every **6-12 months**, or as needed.
- Always ensure the **printer is powered off** and disconnected from the power supply before replacing the filters.

5.1.4. Calibration and Bed Leveling

- **Run the auto-leveling procedure** regularly to ensure the print bed is correctly calibrated.
- Periodically check the **extruder flow rate**, and adjust the settings in the **Mainsail interface** if needed.

5.1.5. Software and Firmware Updates

- **Check for software and firmware updates** periodically via the **Mainsail interface**.
- Follow the instructions in the interface to apply updates safely.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

5.2. Troubleshooting Common Issues

While the **BioARTX X1** is designed to be reliable, users may encounter occasional issues. Below are some common problems and their solutions.

5.2.1. Print Not Adhering to the Bed

- **Check the print bed level** and ensure it is calibrated correctly.
- Ensure the **bed temperature** is set appropriately for the material being printed.
- Clean the print bed to remove any residues that may affect adhesion.
- **Increase first layer extrusion** to ensure better adhesion.

5.2.2. Clogged Extruder or Syringe System

- **Clean the syringe system** and extruder after each print job to prevent material buildup.
- If clogging occurs, use a **cleaning filament** or run a purge cycle through the extruder to clear the blockage.
- **Inspect the syringe nozzle** for any signs of clogging and replace it if necessary.

5.2.3. Uneven Layer Height or Misalignment

- **Check the belt tension** and make sure it is properly adjusted.
- Ensure the **stepper motors** are functioning properly, and test the movement of the **X, Y, and Z axes**.
- Run the **auto-leveling procedure** to ensure the print bed is aligned properly.

5.2.4. Print Quality Issues (e.g., Blobbing, Stringing, Layer Shifting)

- **Check the filament** for moisture, as wet filament can cause extrusion issues. Dry the filament if necessary.
- Ensure that the **extruder temperature** and **print speed** are properly set for the material being used.
- If **blobbing** occurs, try adjusting the **retraction settings** in the **Mainsail interface**.

5.2.5. Printer Not Powering On

- **Check the power supply** to ensure it is properly connected and functioning.
- **Inspect the power cable** for any visible damage and replace it if needed.
- Ensure that the **Raspberry Pi** is correctly connected and the system is properly booted.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

5.2.6. Printer Stops Mid-Print

- Check the **power connection** to ensure there are no interruptions during the print.
- Ensure that the **Mainsail interface** is properly configured and that no **network issues** are causing disconnections.
- Inspect the **stepper motors** and **movement system** for any mechanical issues.

5.2.7. Poor Print Resolution or Layer Lines Visible

- Ensure that the **layer height** is set correctly for the desired print quality.
- **Increase the print resolution** if necessary and adjust the **print speed** to allow for finer detail.
- **Check the extruder calibration** and ensure the correct extrusion rate is set.

6. Advanced Features

The **BioARTX X1 3D Inkjet Printer** comes equipped with a range of advanced features that enhance its performance, flexibility, and ease of use. These features provide greater control over the printing process, enabling users to create high-precision prints using multiple materials, as well as ensuring that the printer can be customized to fit specific needs in various fields such as biomedical research, materials science, and more.

6.1. Multi-Material Printing

One of the key advanced features of the **BioARTX X1** is its ability to print with multiple materials, including **bioinks** and **standard filaments**.

6.1.1. Benefits of Multi-Material Printing

- **Enhanced versatility**, allowing users to print with a combination of bioinks and other materials such as **PLA**, **ABS**, or **nylon**.
- **Flexible applications** for a wide range of fields, including **bioprinting**, **medical modeling**, and **materials science**.
- Ability to create **complex structures** by combining different materials within a single print job, improving **design flexibility**.
- **Advanced control systems** for seamless transitions between materials during the printing process, ensuring **precise material deposition**.

6.2. Automatic Calibration and Bed Leveling

The **BioARTX X1** features **automatic calibration** and **bed leveling** to ensure optimal print quality and precision.

6.2.1. Key Features of Automatic Calibration and Bed Leveling

- **Auto-bed leveling sensor** that detects the distance between the print bed and the printhead for accurate alignment.
- **Automatic print bed calibration** that ensures the print surface remains level during printing, minimizing errors related to uneven surfaces.
- Regularly running the **auto-leveling procedure** improves print quality, especially when working with delicate bioinks and fine details.
- **Simplifies setup** for new users and reduces the chances of human error during manual calibration.

6.3. Touchscreen Interface with Intuitive Controls

The **BioARTX X1** is equipped with a **7-inch capacitive touchscreen** interface that allows for easy control and real-time monitoring of the printer's performance.

6.3.1. Features of the Touchscreen Interface

- **User-friendly controls**, offering a simple and intuitive experience for adjusting settings such as print speed, temperature, material type, and more.
- **Real-time monitoring** of print progress, temperature, extrusion rates, and other key parameters through the touchscreen display.
- **Access to printer diagnostics**, including **error logs**, **maintenance notifications**, and **system status** for quick troubleshooting.
- **Customization options** for configuring the interface to suit personal preferences and workflow needs.

6.4. Remote Control and Monitoring via Mainsail Interface

The **Mainsail interface** enables **remote control** and **monitoring** of the **BioARTX X1** through any device with internet access, providing flexibility and convenience for users.

6.4.1. Key Features of the Mainsail Interface:

- **Web-based interface** that can be accessed from any device, including **smartphones**, **tablets**, and **PCs**, allowing users to monitor and control the printer from a distance.

- **Real-time monitoring** of key parameters such as temperature, print progress, and material extrusion, ensuring continuous print quality.
- **Remote troubleshooting** and **error detection** via the Mainsail interface, with diagnostic information available in real time.
- **Remote pausing, resuming**, and **stopping prints**, providing full control without needing to be physically present at the printer.

6.5. Customizable Print Profiles and Settings

The **BioARTX X1** allows users to create and save **custom print profiles** tailored to specific materials and printing needs.

6.5.1. Benefits of Customizable Print Profiles

- **Control over print parameters**, including **speed**, **layer height**, **temperature**, and **material type** for each job.
- **Create unique profiles** for different bioinks, filaments, or multi-material jobs, ensuring the best results every time.
- Ability to **save and share** custom profiles for future use, improving workflow efficiency and repeatability.
- **Advanced settings** for fine-tuning **retraction**, **flow rates**, and other print-specific parameters.

6.6. Advanced Sterilization Systems

The **BioARTX X1** incorporates **advanced sterilization systems**, including **UV** and **Gamma radiation**, to ensure a **sterile printing environment** and minimize the risk of contamination.

6.6.1. UV Sterilization System Features

- Integrated **UV-A**, **UV-B**, and **UV-C lights** to disinfect both the print surface and the surrounding environment.
- **UVC light module** for **photocuring bioinks** and **sterilizing printed objects** post-print.
- **Removable UV module** for flexible sterilization options based on the specific print requirements.

6.6.2. Gamma Sterilization System Features

- **External Gamma radiation system** for high-level sterilization in **biosafe environments** where extreme cleanliness is required.
- **Controlled power settings** to adjust exposure based on sterilization needs.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

6.7. Modular Design for Customization

The **BioARTX X1** features a **modular design** that allows users to customize the printer based on their specific needs and applications.

6.7.1. Features of the Modular Design

- **Interchangeable extruders** and **syringe systems** to accommodate different material types, including bioinks, thermoplastics, and specialty filaments.
- **Removable sterilization components**, including **UV-C light modules** and **Gamma radiation systems**, for easier maintenance and adaptation to different workflow requirements.
- **Flexible upgrade options**, allowing users to enhance the printer's capabilities by adding new modules or swapping out existing ones.

7. Appendices

The **BioARTX X1 3D Inkjet Printer** comes with various appendices to provide additional information, technical specifications, and helpful resources for users. These sections aim to assist in ensuring proper setup, troubleshooting, and optimization of the printer for high-performance bioprinting. Below are some key appendices included in the manual:

7.1. Technical Specifications

The following are the **technical specifications** for the **BioARTX X1 3D Inkjet Printer**:

- **Print Technology**: 3D inkjet printing with bioinks and thermoplastic materials
- **Printing Method**: Drop-on-demand inkjet technology
- **Build Volume**: 300 x 300 x 300 mm
- **Layer Resolution**: 50 microns to 500 microns
- **Nozzle Diameter**: 0.4 mm
- **Print Speed**: 10-100 mm/s (depending on material and print settings)
- **Temperature Range**: Extruder temperature: 180°C - 300°C, Heated bed: 20°C - 120°C
- **Materials**: Compatible with bioinks, PLA, ABS, PETG, nylon, and custom filaments
- **Connectivity**: Wi-Fi, Ethernet, USB, Mainsail interface for remote control
- **Control System**: Raspberry Pi 5 with Klipper firmware

- **Power Supply**: 110V - 240V AC, 500W
- **Weight**: 15 kg

7.2. Maintenance Schedule

To ensure the **BioARTX X1** operates optimally, a regular maintenance schedule is essential. Below is the recommended maintenance schedule for the printer:

7.2.1. Daily Maintenance

- Clean the print bed and remove any debris after each print.
- Inspect the syringe system for any signs of clogging or wear.
- Check the printer's exterior for dust buildup.

7.2.2. Weekly Maintenance

- Clean the extruder and syringe system thoroughly after every 5-10 print jobs.
- Replace the **HEPA filter** if required.
- Perform a test print to ensure print quality.
- Check the belt tension and adjust if necessary.

7.2.3. Monthly Maintenance

- Perform a full system calibration, including auto-leveling and extruder flow rate check.
- Check for firmware and software updates and apply them.
- Inspect the power supply and connections for wear.
- Test the touch screen interface for responsiveness and calibration.

7.2.4. Every 6-12 Months

- Replace the **HEPA filter** and clean the filtration system.
- Inspect and replace any worn-out parts, such as the extruder nozzle or syringe holder.
- Perform a full printer inspection and maintenance check.

7.3. Troubleshooting Guide

This section provides a detailed **troubleshooting guide** for users to address common issues encountered during the operation of the **BioARTX X1**.

- **Problem**: Print not adhering to the bed
    - **Solution**: Check the print bed calibration and clean the surface. Ensure the bed temperature is set appropriately for the material.
- **Problem**: Clogged extruder or syringe system
    - **Solution**: Clean the syringe system and extruder thoroughly. Run a purge cycle or use cleaning filament to clear any clogs.
- **Problem**: Poor print quality (e.g., blobbing, stringing)
    - **Solution**: Check the extrusion temperature and retraction settings. Dry the filament if necessary to prevent moisture-related issues.
- **Problem**: Printer not powering on
    - **Solution**: Check the power supply connections and verify the power source. Ensure the Raspberry Pi is properly connected.
- **Problem**: Print misalignment or uneven layers
    - **Solution**: Check the belt tension, ensure the stepper motors are functioning, and run the auto-leveling procedure.

7.4. Glossary of Terms

Below are some key terms used in the **BioARTX X1** manual to help users understand the technology and features of the printer:

- **Bioink**: Specialized ink used for 3D printing biological materials, often containing living cells or biomaterials.
- **Extruder**: The component of the 3D printer that feeds and melts filament or bioink for deposition.
- **Stepper Motor**: A type of motor used for precise control of movement in 3D printers, typically used to drive the **X**, **Y**, and **Z** axes.
- **G-code**: A file format containing instructions for the 3D printer on how to move, extrude material, and build the object layer by layer.
- **Klipper**: Open-source firmware used for controlling the **BioARTX X1**, providing high-speed motion control and multi-material support.
- **Mainsail**: A web-based control interface for the **BioARTX X1**, used for remote monitoring and managing print jobs.

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

7.5. FAQs (Frequently Asked Questions)

Here are some commonly asked questions and answers about the **BioARTX X1**:

Q: How do I replace the syringe system?

- **A**: To replace the syringe system, **power off the printer** and follow the instructions in the manual for **disassembling and installing a new syringe**.

Q: How do I update the firmware?

- **A**: Firmware updates can be done through the **Mainsail interface**. Simply check for updates and follow the on-screen instructions to complete the update.

Q: What materials can I print with the BioARTX X1?

- **A**: The **BioARTX X1** supports a wide range of materials, including **bioinks**, **PLA**, **ABS**, **PETG**, **nylon**, and custom filaments.

Q: Can I use multiple extruders for different materials?

- **A**: Yes, the **BioARTX X1** supports multi-material printing and allows for easy switching between extruders for different materials during printing.

Start

|

Is the printer powering on?

|

+-- No --> Check power supply connections and verify the power source.

| Ensure the Raspberry Pi is properly connected.

| If issue persists, contact support.

+-- Yes --> Is the print bed properly calibrated?

|

+-- No --> Run the auto-leveling procedure.

| Clean the print bed surface.

| Recalibrate the bed.

+-- Yes --> Is the extruder/syringe system clogged?

```
|
+-- No --> Is the print adhering to the bed?
|       |
|       +-- No --> Check bed temperature settings.
|       |       Clean the print bed surface.
|       |       Recalibrate the bed.
|       |
|       +-- Yes --> Is the print quality poor (e.g., blobbing, stringing)?
|               |
|               +-- No --> Is there print misalignment or uneven layers?
|               |       |
|               |       +-- No --> Print successful! End.
|               |       |
|               |       +-- Yes --> Check belt tension.
|               |               Ensure stepper motors are functioning.
|               |               Run auto-leveling procedure.
|               |
|               +-- Yes --> Check extrusion temperature and retraction settings.
|                       Dry the filament if necessary.
|                       Adjust print settings as needed.
|
+-- Yes --> Clean the syringe system and extruder thoroughly.
        Run a purge cycle or use cleaning filament.
        If clog persists, replace the nozzle or syringe system.
```

End

A. Wadood house near Qazi model school Frash,

PO box Alipur, Frash village, Lehtrar Rd, Islamabad.

Contact # +923234663780

info@biomaterials.pk

8. Contact Information

For any **technical support, inquiries, or assistance** regarding the **BioARTX X1 3D Inkjet Printer**, please use the following contact details:

Customer Support:

- **Email:** info@bioengineerings.com
- **Phone:** +923161221778
- **Website:** www.bioengineerings.com
- **Live Chat:** Available on the website for real-time troubleshooting and assistance.

Technical Assistance:

For firmware updates, troubleshooting, and maintenance-related queries:

- **Support Forum:** www.bioengineerings.com
- **Documentation & Manuals:** Available in soft at website.

Sales & Business Inquiries:

For purchasing, bulk orders, and partnerships:

- **Sales Email:** managing_director@bioengineerings.com
- **Phone:** +923161221778

Physical Address:

Bioengineering Headquarters
Centre of Excellence in Biomaterials and Tissue Engineering, GCU KSK, Lahore.
Postal Code: 39020

Social Media & Community:

Stay updated with the latest news, firmware releases, and support discussions:

- **Twitter:** Muhammad Haseeb Nawaz
- **Facebook:** Biomaterials IST
- **LinkedIn:** Muhammad Haseeb Nawaz

For further assistance, please visit our official website or contact our support team for **personalized troubleshooting and guidance.**