



**MANIPAL INSTITUTE OF TECHNOLOGY**  
**MANIPAL**  
*(A constituent unit of MAHE, Manipal)*

## **MID-TERM REPORT**

### **Creating Storybooks and Unit Testing for Medical Device Interface**

**SUBMITTED  
BY**

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# EMPLOYMENT OFFER LETTER



January 31, 2025

Jay Dhaval Patel  
Roll No: 210905294  
Institute's name: MIT, Manipal

Subject: Offer of Employment from Baxter Innovations and Business Solutions Pvt. Ltd.

Dear Jay,

Further to our conversation, we are pleased to offer you the position of Intern Trainee in Medical Products & Therapies (MPT) under Infusion Systems. You will be based at Bangalore. As discussed, this offer will be subject to following terms and conditions:

1. You will be on a fixed term contract from February 3, 2025, to June 30, 2025. Your title during this period would be Intern Trainee. During this period, you will receive a Total Annual Compensation of INR 4,02,391 (Four Lakhs Two Thousand and Three Hundred Ninety One Only) The detailed Compensation Structure is mentioned in Annexure A and you will be governed by the same guidelines as that of an employee.
2. Post the completion of your fixed term contract, you will be offered a full-time position of Eng I, Software starting July 14, 2025. You will receive a Total Compensation of Rs. 1,200,809/- (Rupees Twelve Lakhs Eight Hundred and Nine only) per annum. This includes a variable pay component of Rs. 118,957/- (Rupees One Lakh Eighteen Thousand Nine Hundred Fifty-Seven Only). This will be disbursed to you as per the prevailing rules and guidelines of Baxter Innovations and Business Solutions Pvt. Ltd. The detailed Compensation Structure is mentioned in Annexure B.
3. This offer is valid provided you join us on or before February 3, 2025. Once you join the Company you will receive our Appointment Letter illustrating the standard terms and conditions of service with Baxter Innovations and Business Solutions Pvt. Ltd. This offer is also valid subject to your successful completion of your current engineering course.
4. As part of the joining formalities, you are requested to update, and upload requested information and documents on BaxLaunch Portal.

We are glad that very soon you will be part of our team. We look forward to your long and meaningful association with us.

Warm Regards,

For Baxter Innovations and Business Solutions Pvt. Ltd.

A handwritten signature in blue ink, appearing to read "Arnab", with a horizontal line underneath.

Chakraborty, Arnab  
Manager, HR R&D

## ABSTRACT

The advancement of healthcare technology has led to the development of integrated platforms that streamline medical device management, improve patient safety, and enhance clinical workflows. This project focuses on improving the distribution of configuration files and firmware updates to connected medical devices, ensuring secure and seamless synchronization across systems. By automating these processes, the project aims to reduce manual intervention, minimize errors, and enhance overall system efficiency.

In addition to backend improvements, the project involves the development of interactive UI component libraries to enhance the consistency and maintainability of the front-end system. **Storybooks** are created to document and visualize these components, making them reusable and ensuring a standardized user experience. Furthermore, **Unit Testing** using **Vitest** are implemented to validate the reliability of UI components, detect potential issues early in the development cycle, and maintain long-term code integrity.

The system architecture is designed as a modular and scalable framework, leveraging modern web technologies for a seamless and efficient user experience. The front-end is built using **Vue.js**, **TypeScript**, and **Vuetify**, allowing for a dynamic, responsive, and visually consistent user interface. These technologies enable component-based development, making the UI more reusable and maintainable. On the backend, **C# and .NET Core** are used to handle business logic, data processing, and secure API interactions, ensuring high performance and reliability. The backend also supports cloud-based deployment, secure authentication mechanisms, and real-time data synchronization, allowing healthcare providers to manage and monitor devices effectively.

The project follows a structured methodology, beginning with system analysis, followed by iterative development, integration, and rigorous testing. Over the course of five months, key milestones include better configuration management, UI component development, and automated testing implementation. The outcomes contribute to a more efficient, scalable, and secure system that supports real-time monitoring, data-driven decision-making, and optimized resource utilization in healthcare environments.

## TABLE OF CONTENTS

Employment Offer Letter.....	2
Abstract .....	3
1. Introduction .....	5
1.1 General Introduction to the Topic .....	5
1.2 Organization .....	5
1.3 Area of Computer Science .....	6
1.4 Hardware and Software Requirements .....	6
2. Problem Definition .....	8
3. Objectives .....	8
4. Background.....	9
5. Methodology.....	10
6. Implementation Details .....	10
7. Progress till date & Remaining work .....	14
8. References .....	14
9. Project Details .....	15

# **1. INTRODUCTION**

## **1.1 GENERAL INTRODUCTION TO THE TOPIC**

Infusion Platforms are a modern system used in hospitals to safely deliver fluids and medicines to patients. It is designed to make sure that patients get the right amount of medicine at the right time. The platform includes devices which control how fast and how much fluid is given to a patient. It is used in many treatments, such as providing nutrients, delivering medications, or giving blood products. One of the main goals of the platform is to reduce human errors and improve patient safety. It also helps hospital staff by making the process easier and more efficient. The system keeps track of treatments and allows updates, making it adaptable to the hospital's needs.

To complement these infusion platforms, integrated connectivity solutions have been developed. These solutions provide hospitals with the ability to manage devices across multiple beds, rooms, floors, facilities, thus offering a centralized view of infusion activities. Through secure data transmission and real-time reporting, they enable healthcare administrators to monitor device usage, optimize resource allocation, and streamline clinical operations. Moreover, the data collected supports advanced analytics, offering valuable insights that aid in decision-making, risk reduction, and continuous improvement of patient outcomes.

In today's healthcare landscape, where precision, efficiency, and safety are paramount, such integrated systems play a vital role in delivering high-quality care while reducing operational complexities.

## **1.2 ORGANIZATION**

Baxter International Inc. [1] is a global healthcare company specializing in medical devices and therapies across various domains, including Anaesthesia and Critical Care, Bio-surgery, Drug Delivery, Infusion Systems, IV Access, Nutrition, Renal Therapies, and Pharmacy Workflow. Founded in 1931 by Drs. Ralph Falk and Don Baxter, the company was a pioneer in the commercial production of prepared IV solutions. Over the decades, Baxter has played a key role in advancing healthcare, particularly in IV therapy, nutrition, respiratory support, hospital beds, and integrated care solutions. With a strong legacy of innovation and dedication to patient care, Baxter continues to make significant contributions to the healthcare industry. Its diverse product portfolio and global reach reflect its commitment to improving and sustaining lives while driving advancements in medical technology.

### 1.3 AREA OF COMPUTER SCIENCE

The development and functioning of modern infusion platforms and their supporting connectivity systems rely on several key areas of computer science:

1. **Embedded Systems:**

The infusion devices themselves run on embedded systems, which are specialized computing systems designed to perform dedicated functions. These systems manage real-time tasks like controlling the delivery of fluids and monitoring patient data.

2. **Networking & Communication Protocols:**

For seamless communication between medical devices and hospital record systems, strong knowledge of networking principles and secure communication protocols is essential. This ensures data is reliably transmitted without loss or corruption.

3. **Cybersecurity:**

Protecting sensitive patient data and maintaining the integrity of medical devices require robust cybersecurity measures. This includes encryption, authentication, secure firmware updates, and regular vulnerability assessments.

4. **Software Engineering:**

The user interface, system software, and backend services are built following best practices in software development, focusing on reliability, maintainability, and scalability. This involves design patterns, testing strategies, and version control systems.

5. **Data Analytics:**

Infusion platforms collect a significant amount of data related to therapy sessions. Analyzing this data helps improve treatment efficiency, detect anomalies, and optimize device usage. Skills in data processing, visualization, and statistical analysis are applied here.

6. **Human-Computer Interaction (HCI):**

Designing intuitive and user-friendly interfaces for healthcare professionals is essential. This area ensures that medical staff can interact with the systems easily and without errors, enhancing overall safety and usability.

### 1.4 HARDWARE AND SOFTWARE REQUIREMENTS

#### 1.4.1 Hardware Requirements

**Infusion Device Components:**

Each infusion device is built with embedded processors or microcontrollers that handle real-time tasks such as controlling fluid delivery and monitoring device performance. These devices are equipped with display units—typically LCD screens or touch panels—that allow healthcare professionals to interact with the system easily. Additionally, they contain input components such as buttons and scanners to facilitate accurate data entry and patient identification.

**Communication & Networking Infrastructure:**

To ensure seamless integration with hospital networks and electronic medical record systems, the hardware includes communication modules like Wi-Fi, Bluetooth, or Ethernet interfaces. On the enterprise level, dedicated servers and networking equipment such as routers and switches are required to manage the continuous flow of data between devices and hospital IT systems.

**Power & Safety Systems:**

Infusion devices are powered by rechargeable batteries to guarantee uninterrupted operation, even during power outages. Safety-critical components, including sensors and actuators, are integrated to monitor the fluid flow and promptly trigger alarms or stop the flow of fluids through devices in case of major irregularities.

**1.4.2 Software Requirements****Embedded Device Software:**

The infusion devices run on embedded firmware, often using a real-time operating system (RTOS) to ensure timely responses to user inputs and safety events. This software manages essential functions like drug library access, dosage control, and alarm handling, ensuring the accuracy and reliability of fluid delivery.

**Middleware & Integration Systems:**

To connect infusion devices with hospital systems, middleware software is employed. This software supports healthcare communication standards and protocols, enabling smooth interoperability with electronic health records (EHR) and reducing manual data entry errors.

**Device Management & Security Tools:**

Enterprise-level software tools are used to remotely configure, monitor, and update devices. These tools provide role-based access control, ensuring that only authorized personnel can make changes. Security features such as data encryption, authentication, and audit logging are incorporated to protect sensitive patient information and comply with healthcare regulations.

**Data Analytics & Compliance Software:**

Finally, advanced software solutions are utilized to collect and analyze usage data from infusion devices. These tools offer insights into device performance, treatment efficiency, and compliance metrics, assisting healthcare organizations in optimizing clinical workflows and maintaining regulatory standards.

## **2. PROBLEM DEFINITION**

In modern healthcare environments, managing and monitoring infusion devices across multiple hospitals and facilities requires efficient digital solutions. Hospitals deploy numerous infusion devices, each of which continuously generates critical data related to medication delivery, device usage, and patient safety. This data is often aggregated and presented through centralized dashboards to provide healthcare administrators with actionable insights. However, ensuring that this information is displayed in a clear, user-friendly, and consistent manner is essential for effective decision-making.

To meet these needs, a standardized library of reusable UI components is necessary. Creating storybooks for these components helps in building a well-organized, scalable, and maintainable user interface. It allows developers and designers to visualize and test individual components in isolation before integrating them into the larger dashboard system. Furthermore, incorporating unit testing ensures the reliability and correctness of these components, reducing the chances of errors in critical healthcare settings. Moreover, rigorous unit testing of each component helps to safeguard against potential failures, especially in environments where accuracy and reliability are non-negotiable.

The goal of the project is to streamline the development process, improve UI consistency, and enhance the overall usability of the platform that displays infusion device reports. By providing a reliable interface, healthcare organizations can better monitor device performance, analyze treatment patterns, and support clinical and operational decision-making efficiently.

## **3. OBJECTIVE(S)**

### **3.1 Development of Configuration Distribution Mechanism**

Focused on designing and enhancing a system to securely distribute various configuration files to connected medical devices, ensuring seamless synchronization and operational consistency across the network. This helps hospitals manage multiple devices efficiently while maintaining standard settings across all units.

### **3.2 Remote Software & Firmware Update Distribution**

Assist in building a process for distributing firmware and software updates over the network, aimed at keeping devices up to date without requiring manual intervention, improving efficiency and security. It minimizes device downtime and ensures the latest features and security patches are applied consistently.



### 3.3 Creation of Interactive UI Components using Storybook and TypeScript

Develop interactive storybooks for Vue.js UI components used in monitoring and analysis dashboards, promoting reusable, well-documented, and consistent front-end design practices with TypeScript [3]. This improves the development process by offering a clear reference for developers and enhancing user interface reliability.

### 3.4 Implementation of Unit Tests using Vitest

Create unit tests using Vitest to ensure the reliability and correctness of UI components, leading to better maintainability, scalability, and reduced chances of bugs in production systems. It supports early detection of issues, ensuring smooth performance and long-term stability of the interface.

## 4. BACKGROUND

The increasing reliance on technology in healthcare has led to the development of sophisticated platforms that enhance patient care, streamline clinical workflows, and improve overall operational efficiency. Modern medical devices require secure communication, seamless data synchronization, and reliable software management to function effectively within a connected healthcare environment. Ensuring that these devices receive accurate configurations, timely software updates, and proper security credentials is essential to maintaining their efficiency and safety. Without an automated and structured approach, managing these aspects can become complex and prone to human error.

In addition to backend improvements, the need for intuitive and well-documented user interfaces has grown significantly. Healthcare professionals interact with digital platforms to monitor device activity, analyze reports, and make informed decisions. A well-structured, reusable UI component library ensures consistency in the interface, reduces development time, and simplifies future updates. Creating a comprehensive and interactive UI documentation system allows for better usability and maintainability, ensuring that developers and designers can work efficiently while preserving design standards.

Furthermore, as healthcare systems become more data-driven, the importance of **robust testing methodologies** cannot be overlooked. Unit testing plays a crucial role in maintaining system reliability by catching errors early in the development cycle, reducing potential risks, and ensuring that the software meets high-quality standards. By implementing automated testing frameworks, the project aims to improve software stability, optimize performance, and facilitate smoother updates and deployments.

This project is designed to address these challenges by implementing **secure configuration distribution, structured UI development, and automated testing strategies**. By leveraging modern web technologies and backend frameworks, the project aims to enhance the overall efficiency, security, and usability of the system, ultimately contributing to a more streamlined and effective healthcare technology platform.

## 5. METHODOLOGY

To successfully achieve the objectives of the project, a systematic approach must be followed. The process is divided into carefully planned stages to ensure secure configuration distribution, effective UI development, and robust testing.

The first step involves understanding the existing system architecture and identifying how configuration files, and firmware updates are currently managed. Based on this analysis, enhancements are proposed to streamline and automate the distribution process. Secure communication protocols are integrated to ensure that all distributed files and updates are transmitted reliably and safely across devices.

For the development of UI component libraries, the process begins with gathering requirements and understanding the data to be visualized on dashboards. Reusable UI components are designed and documented using storybooks, allowing developers to preview, test, and maintain a consistent interface across the platform.

To ensure quality, unit testing frameworks are set up in parallel. Tests are written for each UI component to validate functionality and catch potential issues early in the development cycle. Continuous integration pipelines are utilized to automate testing, ensuring that code changes do not introduce bugs.

Regular reviews and iterations are carried out, incorporating feedback from stakeholders and making improvements as needed. This iterative approach allows flexibility while ensuring progress aligns with the project's overall goals of enhancing efficiency, security, and user experience.

## 6. IMPLEMENTATION DETAILS

The project is developed using a **monorepo architecture managed by Nx**, which allows multiple projects to be bundled together within a single repository. This approach improves maintainability, promotes code reuse, and streamlines dependency management across different parts of the system.

**Configuration Distribution and Management** - The backend is developed with **C# & .NET** chosen for its cross-platform compatibility, strong security features, and efficient API handling, ensuring reliable data transmission and device synchronization, which provides a robust, scalable, and high-performance environment

**UI Development and Component Storybooks** - The frontend is developed with **Vue.js**, **TypeScript**, and **Vuetify**, forming a modern, efficient, and scalable UI framework.

- **Vue.js** is used for its lightweight nature, reactive components, and easy integration with state management solutions, making the interface highly responsive and modular.

- **TypeScript** enhances code quality by introducing strong typing, reducing runtime errors, and improving developer productivity.
- **Vuetify**, a material design component library, ensures a consistent, visually appealing UI while reducing development time by providing pre-built UI elements.

**Storybook** is a tool that allows developers to **document, test, and visually inspect components in isolation**, ensuring that each UI element behaves as expected before being integrated into the main application. This approach significantly enhances collaboration between developers and designers, speeds up the development process, and reduces UI inconsistencies.

**Unit Testing for UI Components** - Unit testing is implemented using **Vitest**, a fast and lightweight testing framework optimized for Vue.js applications.

- **Vitest** is chosen over other testing frameworks because of its **built-in TypeScript support, fast execution speed, and seamless integration with Vue 3**.
- The tests focus on verifying that **UI components render correctly, function as expected, and handle different user interactions properly**.

By implementing **unit tests for UI components**, the project ensures **high reliability, reduces regression issues, and improves code maintainability**.

Automated testing ensures that new changes do not introduce bugs or inconsistencies, maintaining software reliability throughout the development lifecycle. Containerization using **Docker** enables the creation of portable and scalable deployments, allowing seamless application distribution across different environments. **Kubernetes** is used for orchestration, efficiently managing the deployment, scaling, and the operation of containerized applications to enhance system reliability and performance. Additionally, **version control** and **dependency management** are optimized within Nx, ensuring that updates to one project do not negatively impact others within the monorepo, thereby improving maintainability and development efficiency.

## Architecture of the Product

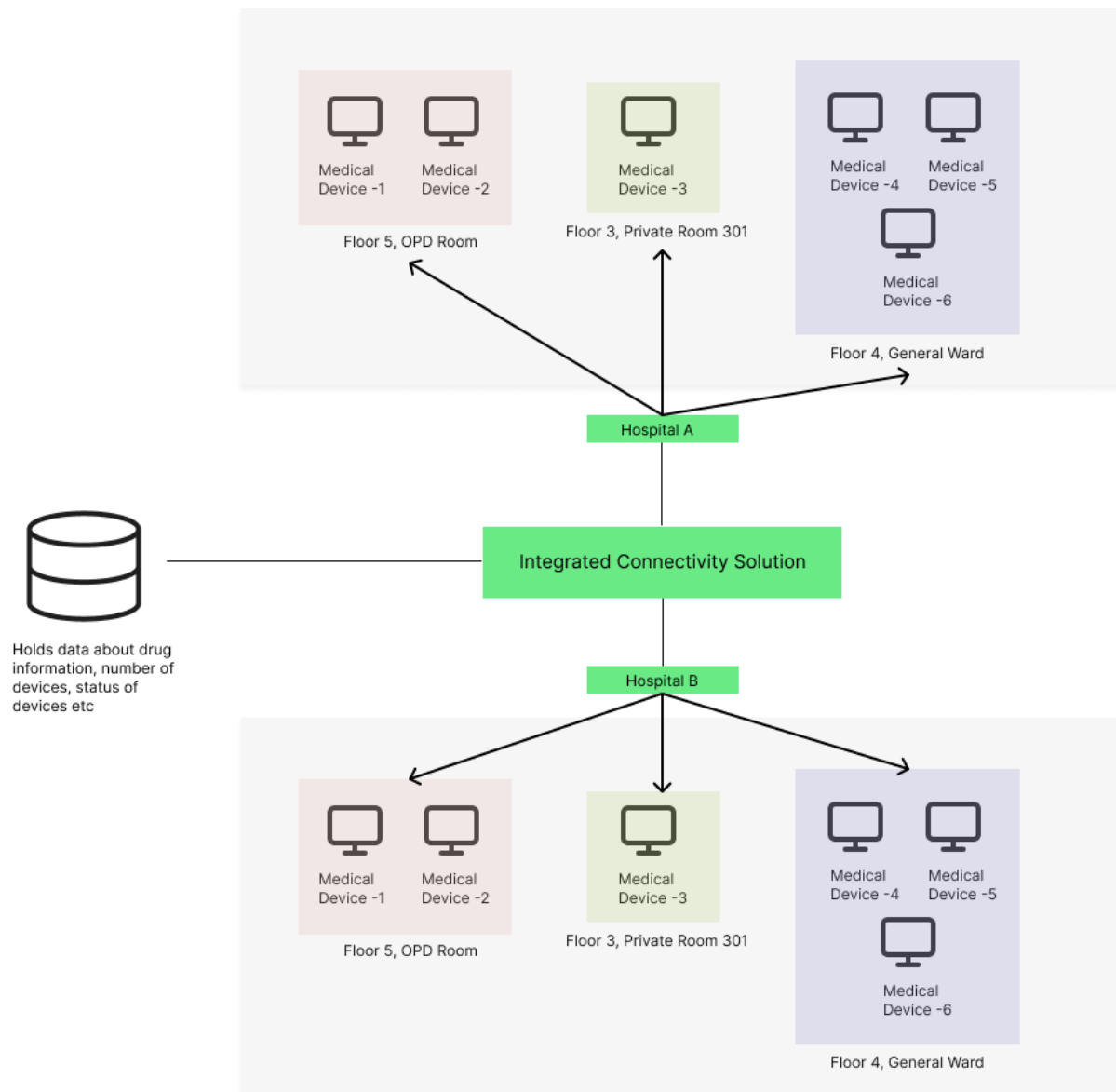


Figure-1: System level architecture of the product

The system is built to streamline and improve the management of infusion devices within healthcare settings, focusing on enhancing patient safety and clinical workflows. It is composed of three main layers, each with specific responsibilities:

**a) Device Layer** - This layer consists of smart infusion devices installed in hospital environments. Each device is embedded with advanced software to control the precise delivery of fluids and medications. Importantly, these devices support wireless communication, allowing them to connect with centralized systems. Key features originating here include:

- **Automatic Programming:** Infusion parameters are transmitted directly from hospital systems to the device, eliminating manual input errors.
- **Automated Documentation:** Infusion data is captured and recorded without requiring manual entry, ensuring accuracy and saving time.

**b) Connectivity & Integration Layer** - Acting as the bridge between devices and hospital systems, this layer is crucial for secure and efficient data exchange. It enables communication between infusion devices and electronic medical records (EMR) systems. The layer also supports vital functionalities such as:

- **Wireless List of Accessible Drugs:** Ensures that medication databases on all devices are always current, without the need for manual updates.
- **Over-the-Air Firmware Updates:** Allows software updates for devices to be pushed remotely, keeping systems up-to-date and compliant.
- **Alarm Routing:** Alerts and alarms from devices are transmitted to clinical staff in real-time, allowing quick response to critical situations.
- **Asset Tracking:** Keeps real-time records of the location and operational status of each infusion device, optimizing hospital resource management.

**c) Enterprise Layer** - This layer provides healthcare professionals with user-friendly dashboards and data visualization tools. It aggregates and analyzes infusion data collected from various devices and locations within the healthcare network. Key features include:

- **Graphical Reports & Dashboards:** Offer at-a-glance information about infusion data, device utilization, and treatment outcomes. The resulting graphical reports offer at-a-glance information, helping staff track device usage, monitor patient treatments, and identify trends.
- **Drill-Down Capabilities:** Allow staff to analyze specific data points, facilitating continuous improvement and informed decision-making.
- **Centralized Monitoring:** Enables hospitals to oversee operations across departments and locations, ensuring uniformity and efficiency.

## 7. PROGRESS TILL DATE AND REMAINING WORK

- *February 2025*
  - Onboarding and Orientation
  - Introduction to various Baxter verticals.
  - Foundations of HTML, CSS, JavaScript, Vue.js, TypeScript, Vuetify.
- *March 2025*
  - Made a small project as Proof of Concept in Vue.js and TypeScript.
  - Hands-on exercises with storybooks in Vue.js.
  - Familiarization with existing codebase.
- *April 2025*
  - Submission of mid-term report & evaluation (3 Months project)
  - Develop interactive storybooks to document and visualize UI components available in the existing codebase.
- *May 2025*
  - Implement unit tests for the UI components documented in the storybooks.
  - Automated testing and integrate it into the development workflow.
- *June 2025*
  - Document testing processes, methodologies, and outcomes for future reference.
  - Submission of final project report & evaluation. (5 Months project)

## 8. REFERENCES

- [1] Baxter India. [Online] Available: <https://www.baxter.in/>
- [2] Storybook for Vue & Vite. [Online] Available: <https://storybook.js.org/docs/get-started/frameworks/vue3-vite>
- [3] TypeScript Documentation. [Online] Available: <https://www.typescriptlang.org/docs/>

## 9. PROJECT DETAILS

<i>Student Details</i>			
<b>Student Name</b>	<b>Jay Patel</b>		
Register Number	210905294	Section / Roll No	CSE B
Email Address	jay.patel2@learner.manipal.edu	Phone No (M)	9909926646
<i>Project Details</i>			
<b>Project Title</b>	<b>Creating Storybooks and Unit Testing for Medical Device Interface</b>		
Project Duration	5 months	Date of reporting	03/02/2025
<i>Organization Details</i>			
<b>Organization Name</b>	<b>Baxter International Inc.</b>		
Full postal address with pin code	9th Floor, Crescent-2, Prestige Shantiniketan Campus - Whitefield, Thigaralapalya, Hoodi, Bengaluru, Karnataka, 560067		
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