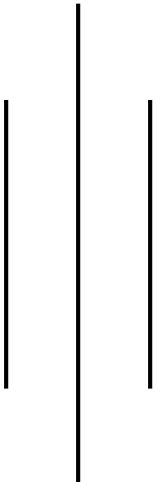


## E-COMMERCE

### TRIBHUVAN UNIVERSITY AMRIT SCIENCE CAMPUS

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Lastly, we are grateful to **Tribhuvan University, Institute of Science and Technology**, for providing us with this opportunity to apply our academic knowledge to practical application through this project.

## Abstract

This project report presents the development and implementation of our **E-commerce Website**. The platform provides a modern and user-friendly online shopping experience.

The system was built using **React** for the frontend and **Next.js** for the backend, with **Prisma ORM** and **PostgreSQL** for efficient database management. **Zustand** is used for state management. Deployment is handled by **Vercel** for the application and **Neon** for the database.

Key features include a **product catalog, search and filter, cart and checkout system, caching strategies, and indexing**. This project demonstrates our understanding of full-stack web development, system design, database integration, and deployment in a real-world scenario.

**Keywords:** React, Next.js, Prisma ORM, PostgreSQL, Zustand, Vercel, Neon, E-commerce

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# 1. Introduction

## 1.1 Background

The rapid growth of the internet and digital technologies has fundamentally transformed how businesses operate and how consumers shop. Traditional shopping methods are increasingly being replaced by **e-commerce platforms** that provide convenience, variety, and speed. In Nepal, too, the adoption of online shopping is rising as customers demand platforms that are secure, user-friendly, and optimized for performance.

Our project, the **E-commerce Website**, is developed to meet these needs. It allows users to **browse, search, filter, and purchase products online** with ease. By integrating modern frameworks such as **React** and **Next.js**, and efficient tools like **Prisma ORM** and **PostgreSQL**, the website demonstrates how academic knowledge can be applied to build practical, real-world solutions.

## 1.2 Objectives

The primary objectives of this project are:

- To **design and implement** a responsive and user-friendly e-commerce website.
- To integrate a **secure and scalable backend** using Next.js and Prisma ORM.
- To provide efficient **data management** using PostgreSQL.
- To implement **client-side caching** and personalization to improve performance.
- To ensure **fast indexing and optimized fetching** for product data.
- To deploy the system on **Vercel (frontend & backend)** and **Neon (database)** for global accessibility.

## 1.3 Scope

The scope of this project includes the **development of a full-stack e-commerce platform** that provides:

- **Frontend interface** for customers to browse, search, and purchase products.
- **Backend services** to handle authentication, orders, and database queries.
- **Database management** using PostgreSQL with Prisma ORM for structured data storage.
- **State management** using Zustand for cart and session handling.
- **Caching** mechanisms for personalized and faster user experiences.
- **Deployment** on cloud-based services ensuring scalability and availability.

## 1.4 Methodology

The development process followed a **semi-waterfall model** with iterative improvements. The phases included:

1. **Requirement Analysis** – Identified the core needs of users: browsing products, searching efficiently, and completing secure checkouts.
2. **Design** – Created wireframes, UI mockups, and the system architecture including database schema.
3. **Development** – Implemented frontend (React), backend (Next.js), and database (Prisma + PostgreSQL).
4. **Testing** – Performed unit, integration, performance, and security testing to ensure reliability.
5. **Deployment** – Hosted the frontend and backend on **Vercel**, and the database on **Neon**.

## 1.5 Market Analysis

The global e-commerce market continues to grow at a rapid pace. According to recent studies:

- The global e-commerce industry is projected to exceed **\$8 trillion by 2027**.
- Customers increasingly prefer **mobile-friendly, fast, and personalized platforms**.
- In Nepal, the growth of **digital wallets, online banking, and delivery services** has created favorable conditions for e-commerce adoption.

Our project leverages these market trends by focusing on **user experience, caching, personalization, and indexing**, making it competitive and future-ready.

## **2. Features and Functionality**

The **E-commerce Website** provides the following features:

### **2.1 Intuitive Homepage Design**

- Clean, responsive, and visually appealing interface.
- Featured products section for promotions.
- Easy navigation through categories.

### **2.2 Product Catalog**

- Products displayed with **images, descriptions, and prices**.
- Supports categorization for efficient browsing.

### **2.3 Search and Filtering**

- Search products by **name, category, or keyword**.
- Filters by price, category, and relevance.

### **2.4 Shopping Cart and Checkout**

- Add/remove products to cart.
- Real-time updates using **Zustand state management**.
- Smooth and secure checkout process.

### **2.5 Caching and Personalization**

- **Client-side caching** improves load times.
- **Personal caching** stores frequently accessed products for each user.

### **2.6 Admin Panel**

- Admins can **add, edit, or remove products**.
- User and order management features.
- Performance monitoring and indexing for database queries.

### **3. Tools and Technologies**

**3.1 Frontend: React** – Used to build the user interface with a component-based design, ensuring responsiveness and smooth navigation for product browsing, cart, and checkout pages.

**3.2 Backend: Next.js** – Handles server-side rendering for performance and SEO, and provides API routes for authentication, product fetching, and order management.

**3.3 Database: Prisma ORM with PostgreSQL** – Prisma simplifies database queries and schema management, while PostgreSQL stores structured data such as users, products, and orders with indexing for faster searches.

**3.4 State Management: Zustand** – Manages global state like shopping cart and user session in a lightweight and efficient way.

**3.5 Hosting: Vercel & Neon** – Vercel hosts the frontend and backend with automatic deployment, while Neon provides cloud hosting for the PostgreSQL database.

**3.6 Version Control: Git & GitHub** – Used to track changes in the source code, collaborate in development, and integrate with Vercel for continuous deployment.

## 4. System Design

### 4.1 Architecture

- **React frontend** handles user interaction.
- **Next.js backend** provides API endpoints and business logic.
- **Prisma ORM** communicates with **PostgreSQL database**.
- **Zustand** manages application state (cart, user session).
- Deployment: **Vercel** (web app) + **Neon** (database).

### 4.2 Database Design

- **Users table** (user\_id, name, email, password, role).
- **Products table** (product\_id, name, category, price, stock).
- **Orders table** (order\_id, user\_id, total\_price, status).
- **Cart table** (cart\_id, user\_id, product\_id, quantity).
- **Categories table** (category\_id, category\_name).

### 4.3 User Interface Design

- **Responsive layout** using React.
- **Minimalist design** for fast navigation.
- **Mobile-first approach** ensures smooth experience across devices.

## 5. Implementation

This chapter details the implementation of the e-commerce platform, highlighting key features and technologies used in the frontend, backend, and database layers.

### 5.1 Frontend (React)

**Component-Based Architecture:** The UI is built using reusable React components, ensuring modularity, reusability, and easier maintenance.

- **State Management with Zustand:** Provides a lightweight and efficient solution for managing global state, including cart items, authentication status, and user preferences.
- **Responsive Design with Tailwind CSS:** Tailwind's utility-first classes are used to ensure the platform adapts seamlessly to various screen sizes and devices.
- **Routing (Next.js):** Client-side routing powered by Next.js ensures fast and smooth navigation.
- **Lazy Loading:** Components and images are loaded on demand to improve performance, especially on mobile devices.
- **API Integration (Axios/Fetch):** The frontend communicates with backend API routes for data fetching and submission.

### 5.2 Backend (Next.js)

**API Routes:** Next.js API routes handle authentication, product management, checkout processes, and order tracking.

- **Server-Side Rendering (SSR):** Improves SEO and initial load speed by rendering product pages and categories on the server.
- **Authentication Logic:** JWT-based authentication ensures secure login, signup, and session handling.
- **Business Logic:** Core functionalities such as cart management, order processing, and user accounts are implemented in backend routes.
- **Middleware:** Used for request validation, authentication checks, and logging.
- **Payment Gateway Integration:** APIs (Stripe or local providers like eSewa/Khalti) are connected for secure checkout and payment processing.
- **Security Practices:** Includes input validation, HTTPS, rate limiting, and protection against SQL injection and XSS attacks.

### 5.3 Database (Prisma + PostgreSQL)

**Prisma Schema:** Defines models for users, products, orders, reviews, and relationships between entities. Prisma migrations manage schema evolution.

- **Relational Database (PostgreSQL):** Stores transactional and relational data such as product catalogs, user accounts, and order histories efficiently.
- **Indexed Queries:** Frequently queried fields like product titles, categories, and user IDs are indexed for faster searches and lookups.
- **Data Integrity:** Enforced through foreign keys, constraints, and relational mapping (e.g., one-to-many between users and orders).
- **Scalability:** PostgreSQL provides ACID compliance and can handle high transaction volumes.

## 6. Testing

To ensure the reliability, performance, and usability of our E-commerce Website, we carried out the following testing approaches:

- **Unit Testing** – Individual React components (such as product cards, cart items) and Next.js API routes were tested to confirm correct functionality in isolation.
- **Integration Testing** – Verified smooth interaction between the **frontend, backend, and database** by testing workflows like adding products to the cart and placing an order.
- **Performance Testing** – Measured page loading speed and API response times. Client-side caching and indexing were tested to ensure faster performance under multiple user requests.
- **Security Testing** – Checked authentication flow, login system, and protected API endpoints. SQL safety and input validation were tested to prevent common vulnerabilities.
- **User Acceptance Testing (UAT)** – The website was tested by peers to ensure it was **easy to use, responsive, and met the expected requirements**, with feedback used to improve the interface and flow.

## 7. Deployment

The deployment process ensured that the website is accessible, secure, and scalable for real users:

- **Frontend & Backend** – Deployed together on **Vercel**, which provides fast global delivery, automatic builds from GitHub, and continuous deployment.
- **Database** – Hosted on **Neon**, a cloud-based PostgreSQL platform offering scalability and backups for data reliability.
- **SSL (HTTPS)** – Enabled by default on Vercel to secure communication between client and server.
- **Caching** – Implemented client-side and personal caching strategies to improve response time and reduce server load.

## 8. Future Scope

To enhance the platform and make it more competitive, the following improvements can be implemented in the future:

- **AI-based Product Recommendations** – Suggest products based on user behavior and purchase history to personalize shopping.
- **Mobile Application (Android & iOS)** – Extend the platform to native mobile apps for better accessibility and user convenience.
- **Integration with Digital Wallets** – Add popular Nepali payment options such as **eSewa, Khalti, and FonePay** for seamless transactions.
- **Admin Analytics Dashboard** – Provide admins with real-time insights on sales, traffic, and customer behavior.
- **Multi-language & Multi-currency Support** – Expand reach by supporting different languages and currencies for diverse users.

## 9. Conclusion

The **E-commerce Website project** successfully demonstrates how modern web development frameworks and tools can be used to design and implement a scalable, user-friendly, and secure platform.

By combining **React, Next.js, Prisma ORM, PostgreSQL, Zustand, Vercel, and Neon**, we have created a complete system capable of handling **product browsing, searching, caching, checkout, and database operations**.

The project reflects both **academic learning and practical application**, providing a foundation for future enhancements such as AI, analytics, and mobile applications.

## References

- React Documentation ([react.dev](https://react.dev))
- Next.js Documentation ([nextjs.org](https://nextjs.org))
- Prisma ORM Documentation ([prisma.io](https://prisma.io))
- PostgreSQL Official Documentation ([postgresql.org](https://postgresql.org))
- Zustand State Management Docs
- Vercel Deployment Docs
- Neon Database Hosting Docs

## Appendix (Screenshots)

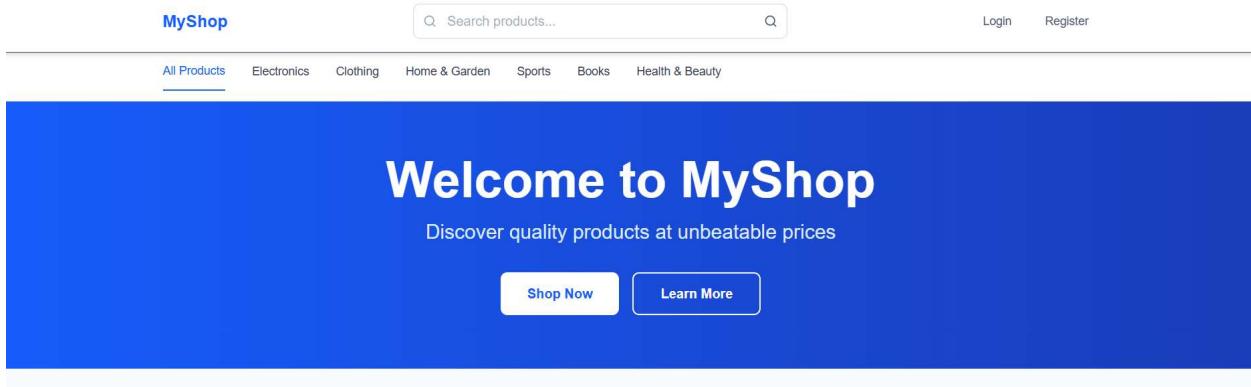


Fig: Home page

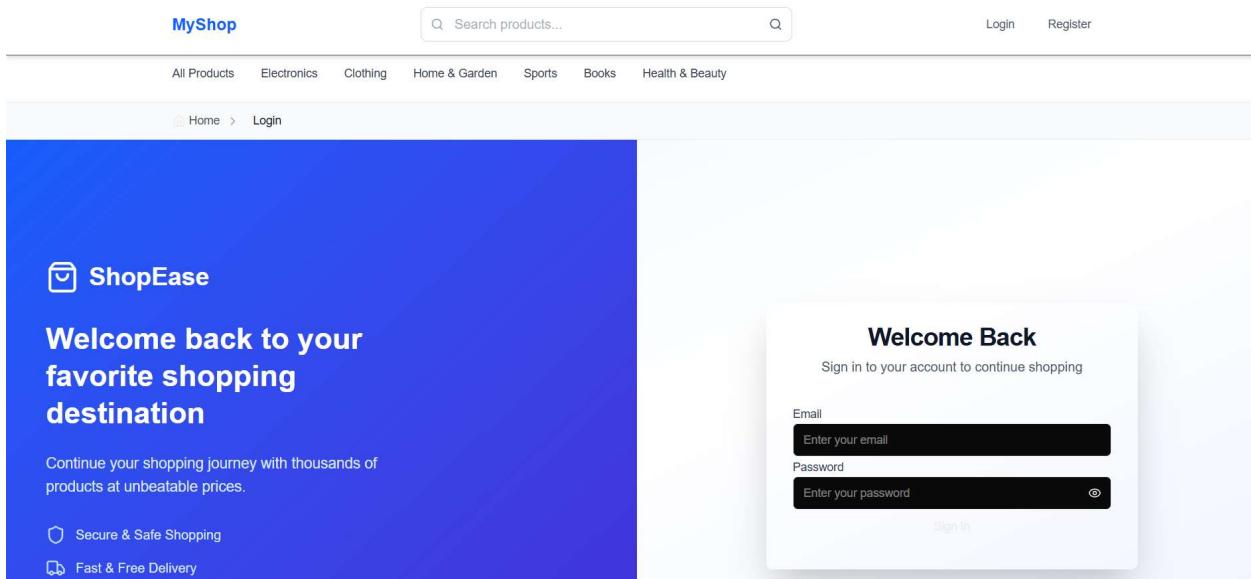


Fig: Login Page

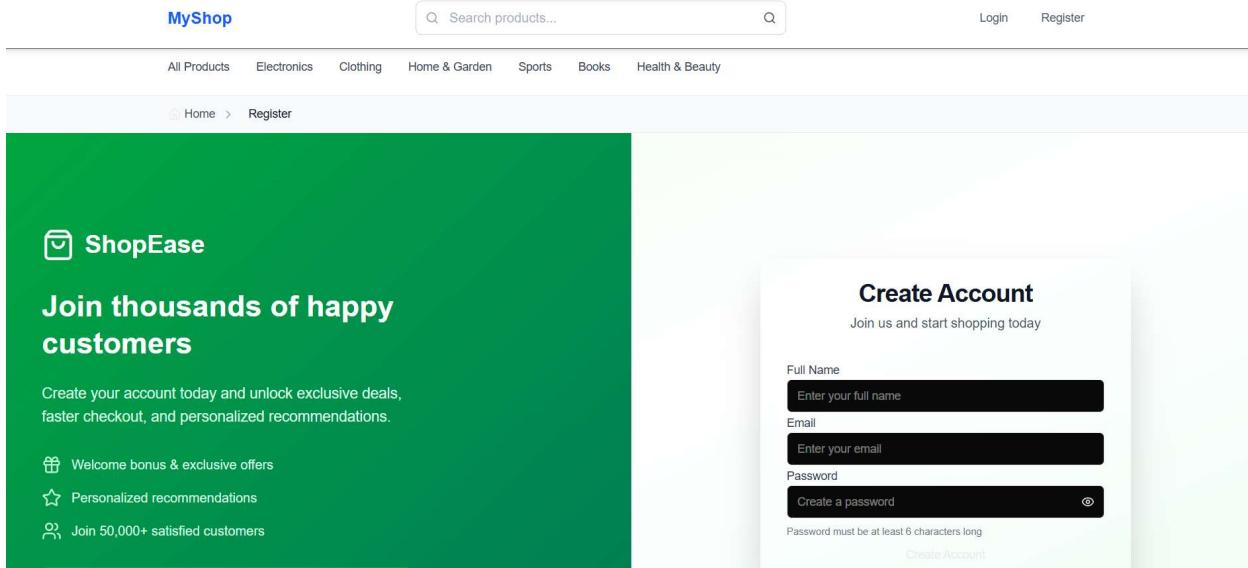


Fig: Register Page

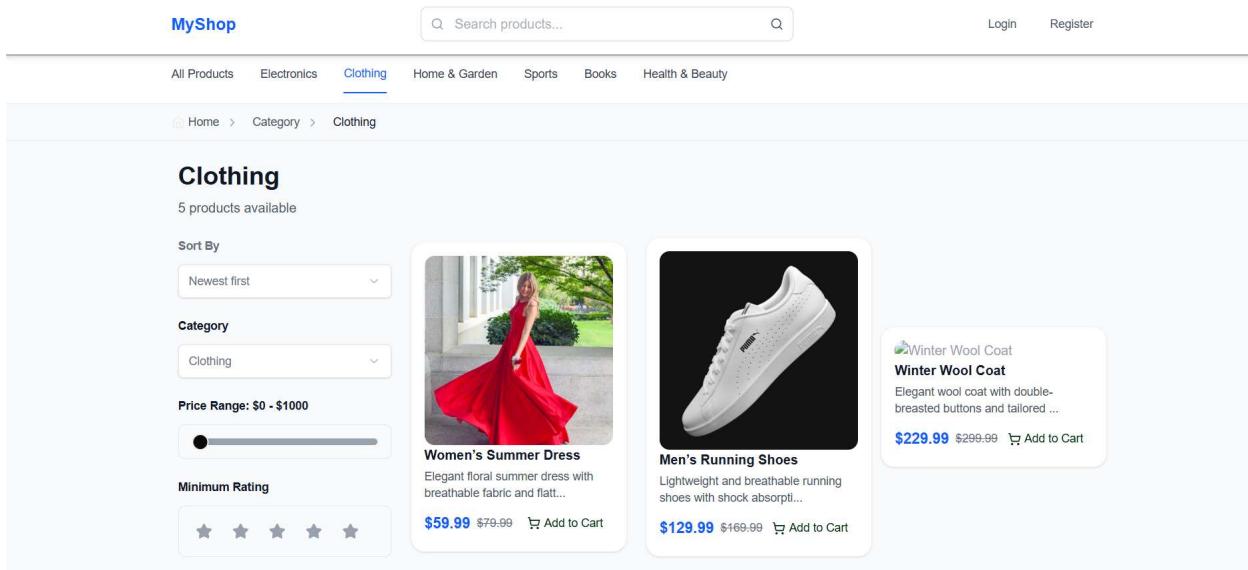


Fig: Product Page

 **Shopping Cart** ×

2 items in your cart



**Luxury Wristwatch**  
**\$499.99**

- 1 + ×



**Hydrating Face Serum**  
**\$49.99**

- 1 + ×

---

Subtotal (2 items)	\$549.98
Shipping	Free
<b>Total</b>	<b>\$549.98</b>

Proceed to Checkout

Continue Shopping

Fig: Card Page

## Secure Checkout

Complete your order safely and securely

 SSL Encrypted  Secure Payment  Trusted by 50k+ customers

### Shipping Information

Where should we deliver your order?

Full Name \*

John Doe

Email Address \*

dolkhalarju9800@gmail.com

Primary Phone \*

+1 (555) 123-4567

Alternate Phone

+1 (555) 987-6543

Company Name (Optional)

Your Company Inc.

Street Address \*

123 Main Street

### Order Summary

2 items in your cart



Luxury Watch

Quantity: 1

\$499.99



Hydrating Face Serum

Quantity: 1

\$49.99

Subtotal

\$549.98

Tax

\$44.00

Total

\$593.98

Fig: Checkout Page