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HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Final Report

Fashion E-commerce test Website

Final Database Presentation

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Table Contents

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Project Context & Motivation

I. Project Context & Motivation

- **Market Trend:** The rapid shift from brick-and-mortar retail to digital-first fashion ecosystems.
- **Legacy Challenges:**
    - **Data Fragmentation:** Using Excel and paper leads to many mistakes because too slow to update data
    - **Inventory Desynchronization:** Website and Warehouse numbers do not match (discrepancy)
    - **Scalability Bottlenecks:** Inability to handle high-traffic seasonal sales.
- **Our Mission:** Building a high-performance "Operational Backbone" using Microsoft SQL Server to ensure 100% data integrity.

I. Project Context & Motivation

Core Technical Challenges:

- **Concurrency Control:** Preventing "Overselling" during simultaneous purchases via ACID transactions as well as triggers.
- **Search Performance:** Optimizing discovery for 50,000+ SKUs using indexing strategies.
- **Logic Coupling:** Decoupling business rules from the frontend and centralizing them within **T-SQL Stored Procedures** for security and consistency.

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System Architecture & Database Design

II. System Architecture & Database Design

Technology stack:

Database Level (The System Core)

- **MS SQL Server 2022:** Industrial-grade engine for robust transaction management and high security.
- **T-SQL Stored Procedures:** All critical business logic (Orders, Inventory, Vouchers) is encapsulated in the database to ensure **execution speed** and **data consistency**.

Application Level (The Logic Bridge)

- **Node.js & Express:** A non-blocking, event-driven runtime environment designed to handle high-concurrency e-commerce traffic.
- **EJS (Embedded JS):** Server-side rendering for dynamic and SEO-friendly content delivery.

Frontend Level (The User Interface)

- **Bootstrap 5:** Ensures a professional, **mobile-first**, and fully responsive design across all devices.

II. System Architecture & Database Design

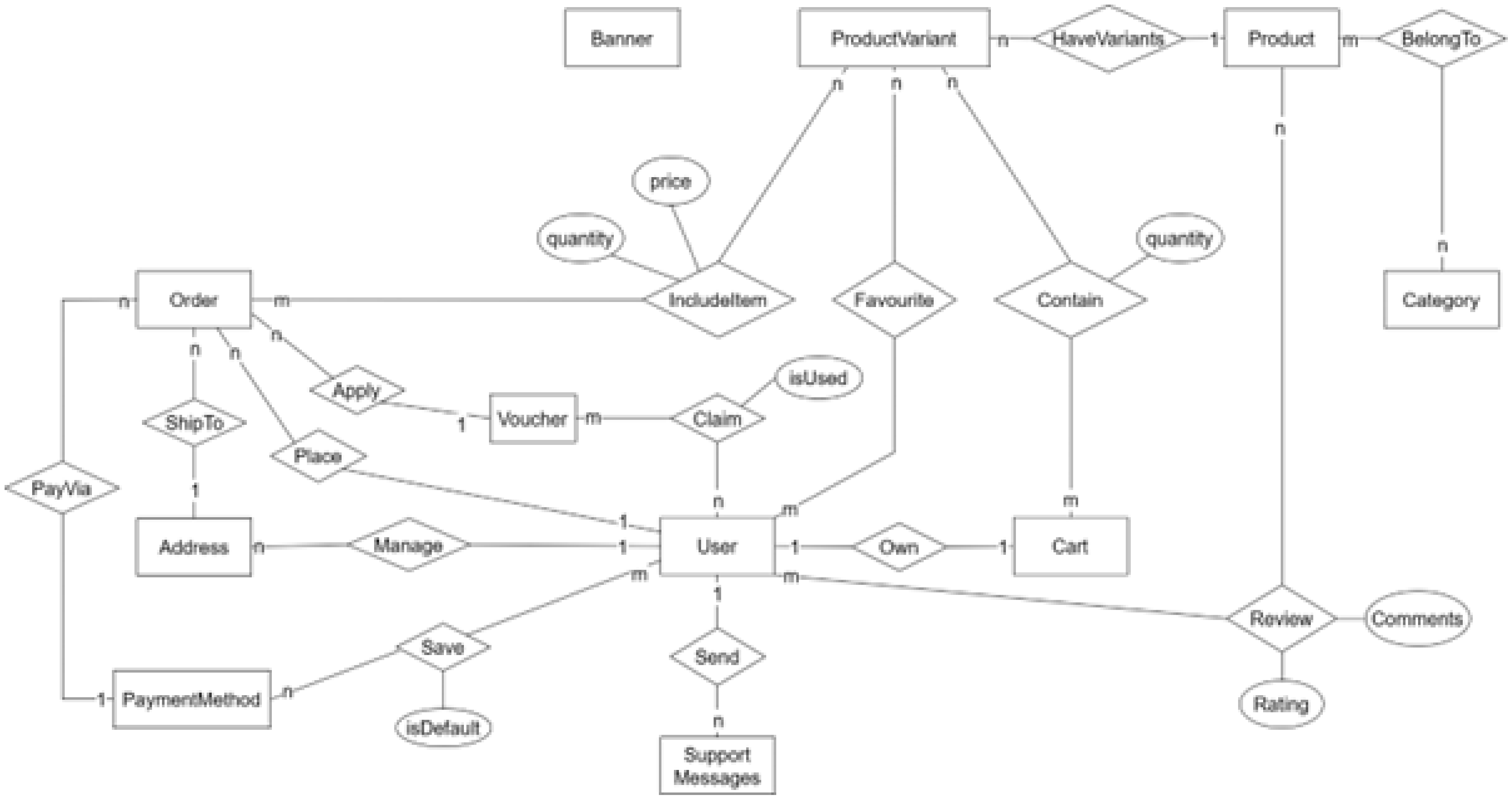
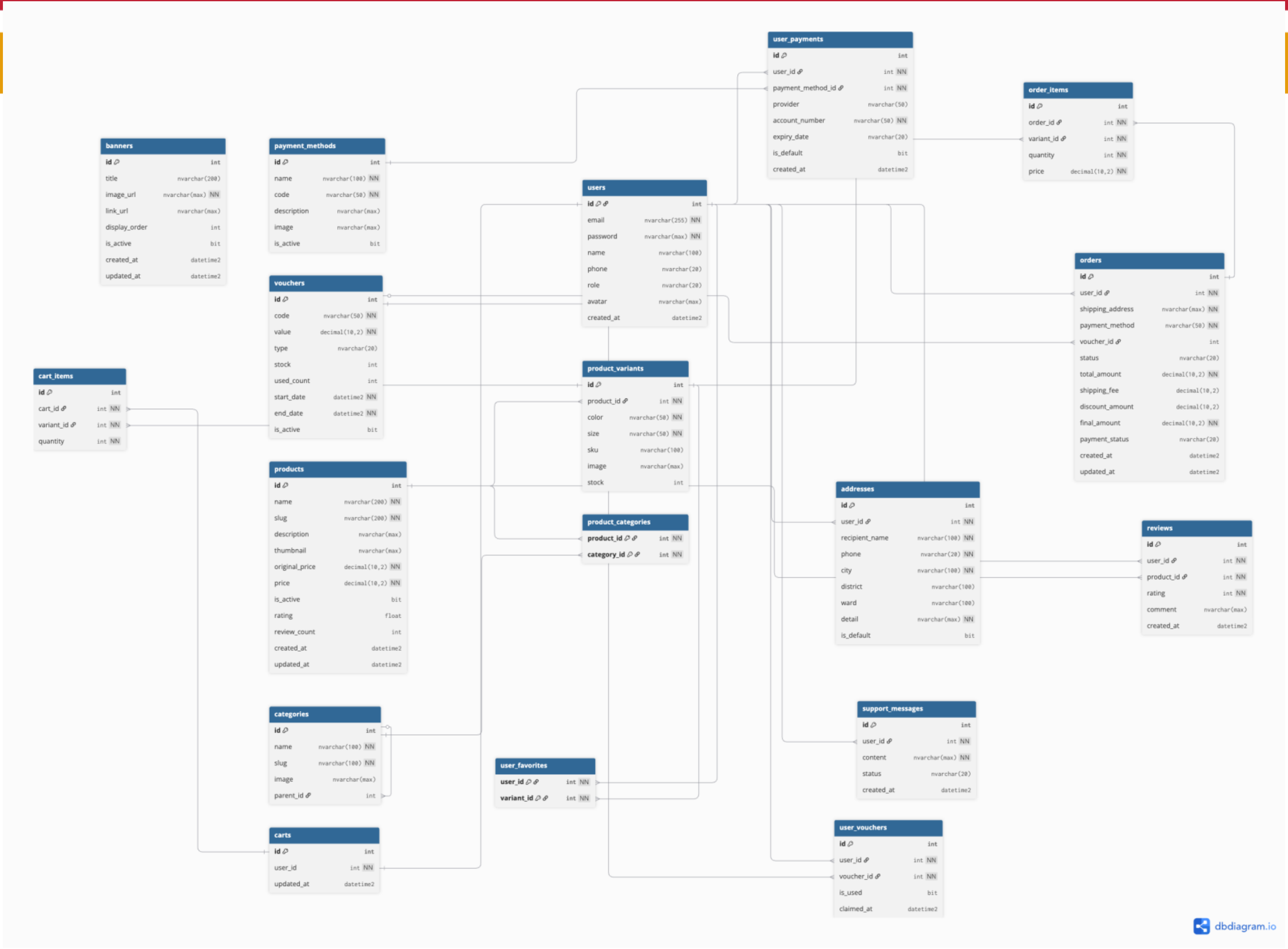


figure 2.1: ERD diagram

II. System Architecture & Database Design



user_payments: id int; user_id int NN; payment_method_id int NN; provider nvarchar(50); account_number nvarchar(50) NN; expiry_date nvarchar(20); is_default bit; created_at datetime2
order_items: id int; order_id int NN; variant_id int NN; quantity int NN; price decimal(10,2) NN
banners: id int; title nvarchar(200); image_url nvarchar(max) NN; link_url nvarchar(max); display_order int; is_active bit; created_at datetime2; updated_at datetime2
payment_methods: id int; name nvarchar(100) NN; code nvarchar(50) NN; description nvarchar(max); image nvarchar(max); is_active bit
users: id int; email nvarchar(255) NN; password nvarchar(max) NN; name nvarchar(100); phone nvarchar(20); role nvarchar(20); avatar nvarchar(max); created_at datetime2
orders: id int; user_id int NN; shipping_address nvarchar(max) NN; payment_method nvarchar(50) NN; voucher_id int; status nvarchar(20); total_amount decimal(10,2) NN; shipping_fee decimal(10,2); discount_amount decimal(10,2); final_amount decimal(10,2) NN; payment_status nvarchar(20); created_at datetime2; updated_at datetime2
vouchers: id int; code nvarchar(50) NN; value decimal(10,2) NN; type nvarchar(20); stock int; used_count int; start_date datetime2 NN; end_date datetime2 NN; is_active bit
cart_items: id int; cart_id int NN; variant_id int NN; quantity int NN
product_variants: id int; product_id int NN; color nvarchar(50) NN; size nvarchar(50) NN; sku nvarchar(100); image nvarchar(max); stock int
products: id int; name nvarchar(200) NN; slug nvarchar(200) NN; description nvarchar(max); thumbnail nvarchar(max); original_price decimal(10,2) NN; price decimal(10,2) NN; is_active bit; rating float; review_count int; created_at datetime2; updated_at datetime2
addresses: id int; user_id int NN; recipient_name nvarchar(100) NN; phone nvarchar(20) NN; city nvarchar(100) NN; district nvarchar(100); ward nvarchar(100); detail nvarchar(max) NN; is_default bit
product_categories: product_id int NN; category_id int NN
reviews: id int; user_id int NN; product_id int NN; rating int NN; comment nvarchar(max); created_at datetime2
categories: id int; name nvarchar(100) NN; slug nvarchar(100) NN; image nvarchar(max); parent_id int
support_messages: id int; user_id int NN; content nvarchar(max) NN; status nvarchar(20); created_at datetime2
user_favorites: user_id int NN; variant_id int NN
carts: id int; user_id int NN; updated_at datetime2
user_vouchers: id int; user_id int NN; voucher_id int NN; is_used bit; claimed_at datetime2
dbdiagram.io

figure 2.2: Relational Model

II. System Architecture & Database Design

figure 2.2: Relational Model

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Functional implementation map

- Customer module
- Admin module

III. Functional implementation map (Customer module)

Authentication & Profile:

Procedure Name	**Description & Implementation Note**
`register_user`	Creates new account with CHECK role constraints. Returns new User ID.
`login_user`	Validates credentials (email/password) and returns user profile + id.
`update_profile`	Updates personal info (Avatar, Phone, Password).
`get_my_addresses`	Returns list of all saved shipping addresses for the logged-in user.
`add_address`	Adds a new address. If `is_default` is true, automatically updates other addresses to false.
`update_address`	Updates existing address details.
`delete_address`	**Soft/Hard Delete**: Removes an address from the user's book.

III. Functional implementation map (Customer module)

Product Discovery & Browsing:

Procedure Name	Description & Implementation Note
`browse_products`	**Complex Search**: Handles Keywords, Category Slug, Attributes (Color/Size), Price Range. Implements Dynamic Sorting and Pagination.
`get_product_details`	**JSON Return**: Returns nested JSON object containing Product Info, Variants List, and Latest Reviews in a single query.
`get_trending_products`	Returns top-selling items based on last 30 days.

III. Functional implementation map (Customer module)

Shopping Cart System:

Procedure Name	Description & Implementation Note
`cart_add_item`	**Smart Upsert**: Uses MERGE statement. Validates stock limit (`Current + New <= Stock`) before adding.
`cart_update_item_quantity`	Modifies quantity. Deletes item if New Quantity <= 0.
`cart_remove_item`	Removes item from cart permanently.
`cart_view_details`	Lists items with calculated subtotals and real-time stock availability check.

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III. Functional implementation map (Customer module)

Checkout & Orders:

Procedure Name	Description & Implementation Note
`checkout`	**ACID Transaction**: Atomic operation handling Stock Deduction, Voucher Application, Address Snapshotting, and Order Creation. Uses `BEGIN TRANSACTION`.
`collect_voucher`	Validates code validity/usage limits and adds to user's wallet.
`view_my_vouchers`	Lists available vouchers with status (Ready, Expired, Out of Stock).
`view_order_history`	Lists all orders with status (Pending, Shipping, etc.).
`cancel_order`	**Restock Logic**: Allows user to cancel 'PENDING' orders. Automatically restores Product Stock and Vouchers. Uses UPDLOCK.

III. Functional implementation map (Customer module)

Engagement & Support:

Procedure Name	Description & Implementation Note
`view_wishlist`	Displays all products currently saved in the user's favorites list.
`add_to_wishlist`	Adds product variant to `user_favorites`.
`remove_from_wishlist`	Removes a product from the user's favorites list.
`submit_product_review`	Allows verified purchasers to rate (1-5) and comment. Updates aggregate Product Rating.
`send_support_message`	Creates a new support ticket in `support_messages` table.

III. Functional implementation map (Admin module)

Product Catalog Management:

Procedure Name	Description & Implementation Note
`create_product`	Inserts base product. Handles category linking via JSON array input (`OPENJSON`).
`upsert_variant`	**Upsert Logic**: Adds new variant (Size/Color) or updates existing one using `MERGE`.
`update_product`	Updates general info (Name, Price, Status).
`delete_product`	Soft-delete: Sets `is_active = 0`.
`delete_variant`	Hard-delete: Only allowed if variant has never been sold.

III. Functional implementation map (Admin module)

Marketing & Promotions:

Procedure Name	Description & Implementation Note
`upsert_voucher`	Creates/Updates discounts. Logic includes Quantity, Date Range, Type (Fixed/Percent).
`upsert_banner`	Manages Homepage Banners (Image URL, Link, Display Order).
`delete_voucher`	Deactivates voucher if used, or permanently deletes if unused.
`delete_banner`	Removes banner from the system.

III. Functional implementation map (Admin module)

Order Operations:

Procedure Name	Description & Implementation Note
`view_orders`	Filters orders by Status and Date Range.
`update_order_status`	**Workflow**: Updates status (e.g., Shipping -> Completed). Automated Restocking on 'RETURNED' status.

III. Functional implementation map (Admin module)

Reports & Analytics:

Procedure Name	Description & Implementation Note
`report_revenue_by_date`	Aggregates daily revenue for `COMPLETED` orders.
`report_best_sellers`	Returns top products by quantity sold and total revenue generated.
`report_revenue_by_category`	Insights into which product categories are driving sales.

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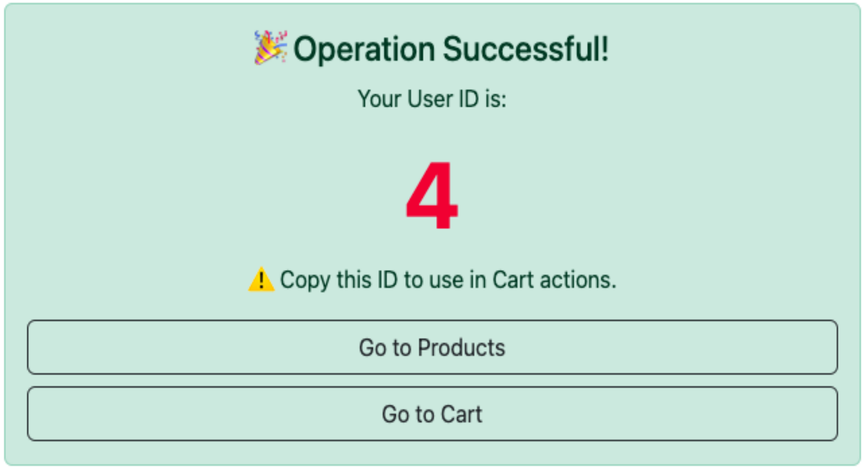
Scenario-based Testing

IV. Scenario-based Testing

- **Objective:** Validate end-to-end functionality via a "New User Journey."
- **Scope:** Account Creation -> Secure Authentication -> Profile Setup -> Transactional Shopping -> Order Management.

Test Data Setup:

- **New Email:** flow_test_@gmail.com
- **Password:** 123456
- **Name:** Test User
- **Phone:** 0988888888



🎉 Operation Successful!

Your User ID is:

4

⚠️ Copy this ID to use in Cart actions.

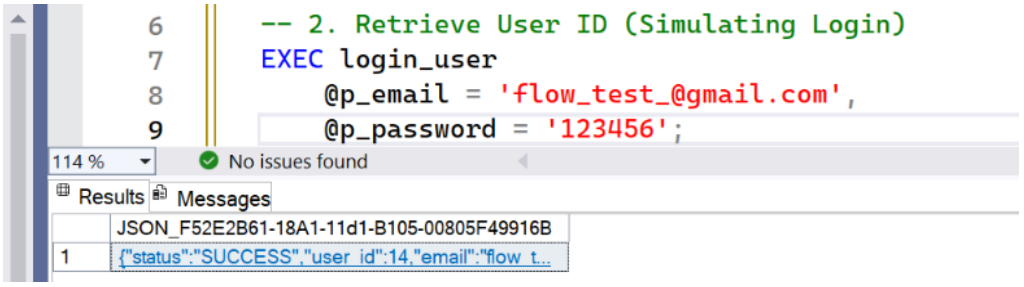
Step 1: User registration

```
-- 1. Register
-- (Using generated email to avoid conflict if run multiple times)
DECLARE @Email NVARCHAR(50) = 'flow_test_@gmail.com';
EXEC register_user @Email, '123456', 'Test User', '0988888888';
```

IV. Scenario-based Testing

Step 2: Log in

- **Action:** The user attempts to log in with the credentials created in Step 1.
- **Objective:** Verify login_user checks credentials correctly and returns a success status.

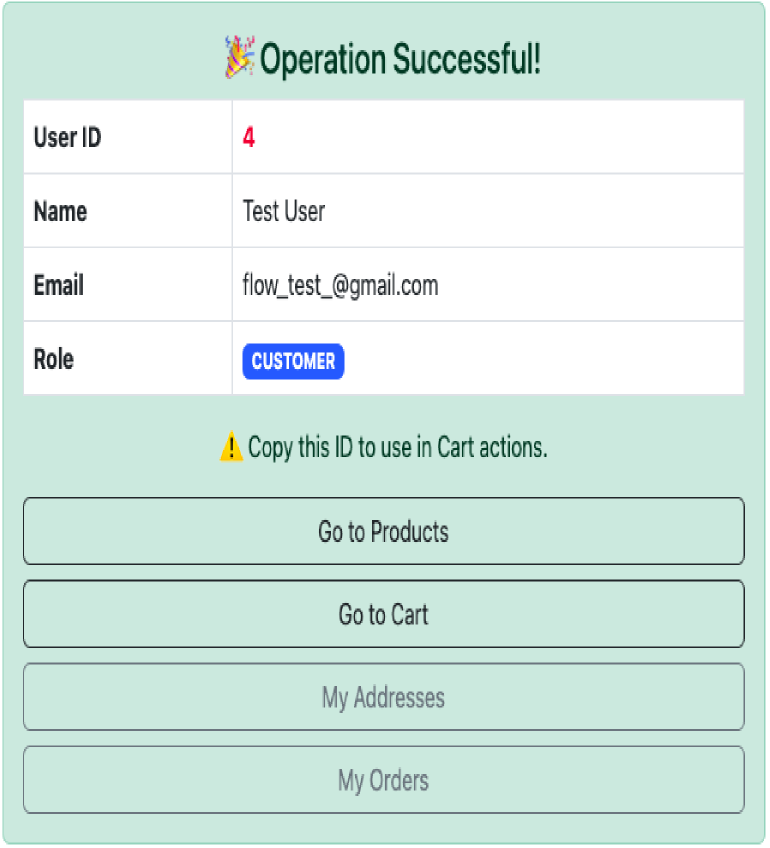


```
-- 2. Retrieve User ID (Simulating Login)
EXEC login_user
    @p_email = 'flow_test_@gmail.com',
    @p_password = '123456';
```

114 % No issues found

Results Messages

```
   JSON_F52E2B61-18A1-11d1-B105-00805F49916B
1  {"status":"SUCCESS","user_id":14,"email":"flow_t...
```



Operation Successful!

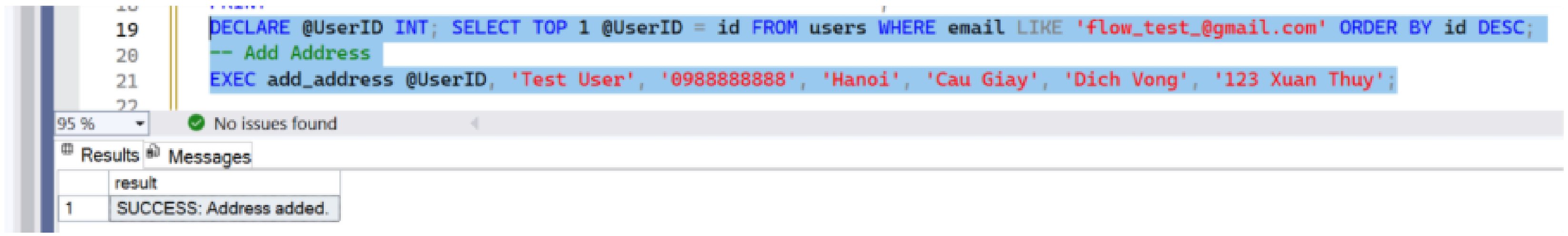
User ID	4
Name	Test User
Email	flow_test_@gmail.com
Role	CUSTOMER

Copy this ID to use in Cart actions.

IV. Scenario-based Testing

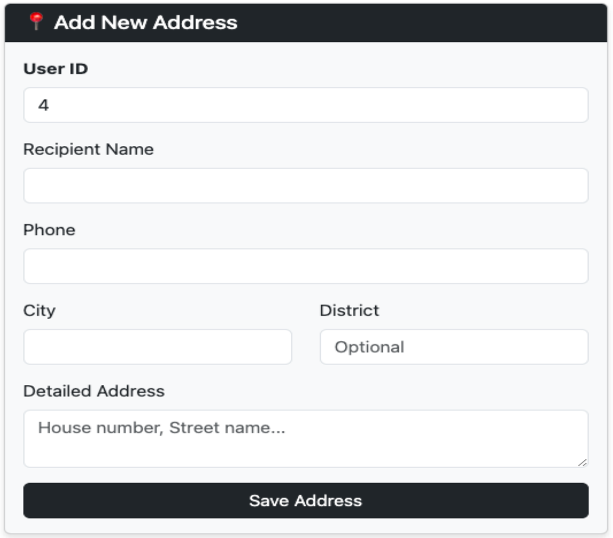
Step 3: Setup Shipping Address

- **Action:** Before buying, the user adds a shipping address to their profile.
- **Objective:** Verify add_address.



```
DECLARE @UserID INT; SELECT TOP 1 @UserID = id FROM users WHERE email LIKE 'flow_test_@gmail.com' ORDER BY id DESC;
-- Add Address
EXEC add_address @UserID, 'Test User', '0988888888', 'Hanoi', 'Cau Giay', 'Dich Vong', '123 Xuan Thuy';
```

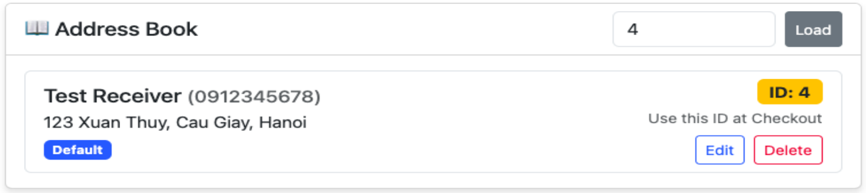
```
95 %    No issues found
Results  Messages
   result
1  SUCCESS: Address added.
```



Add New Address

User ID	4
Recipient Name	
Phone	
City	
District	Optional
Detailed Address	House number, Street name...

Save Address



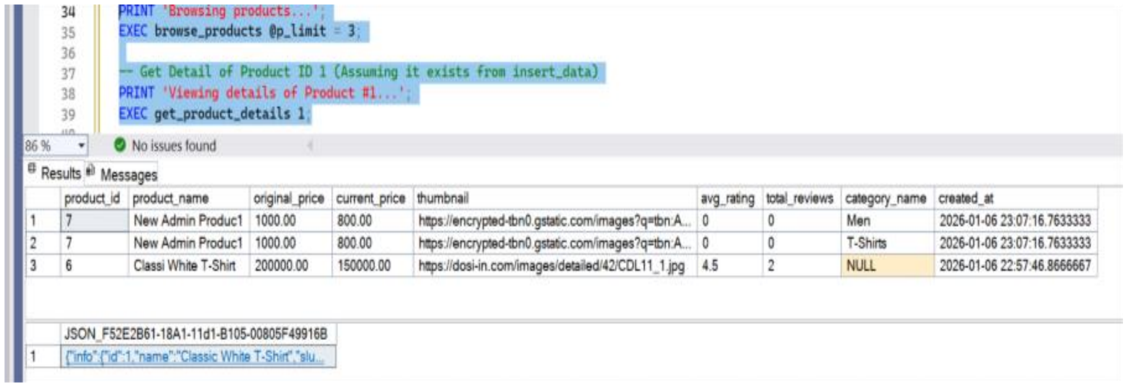
Address Book 4 Load

Test Receiver (0912345678) ID: 4
123 Xuan Thuy, Cau Giay, Hanoi Use this ID at Checkout
Default Edit Delete

IV. Scenario-based Testing

Step 4: Product Discovery

- **Action:** The user searches for 3 TOP items
- **Objective:** Verify browse_products returns relevant results.



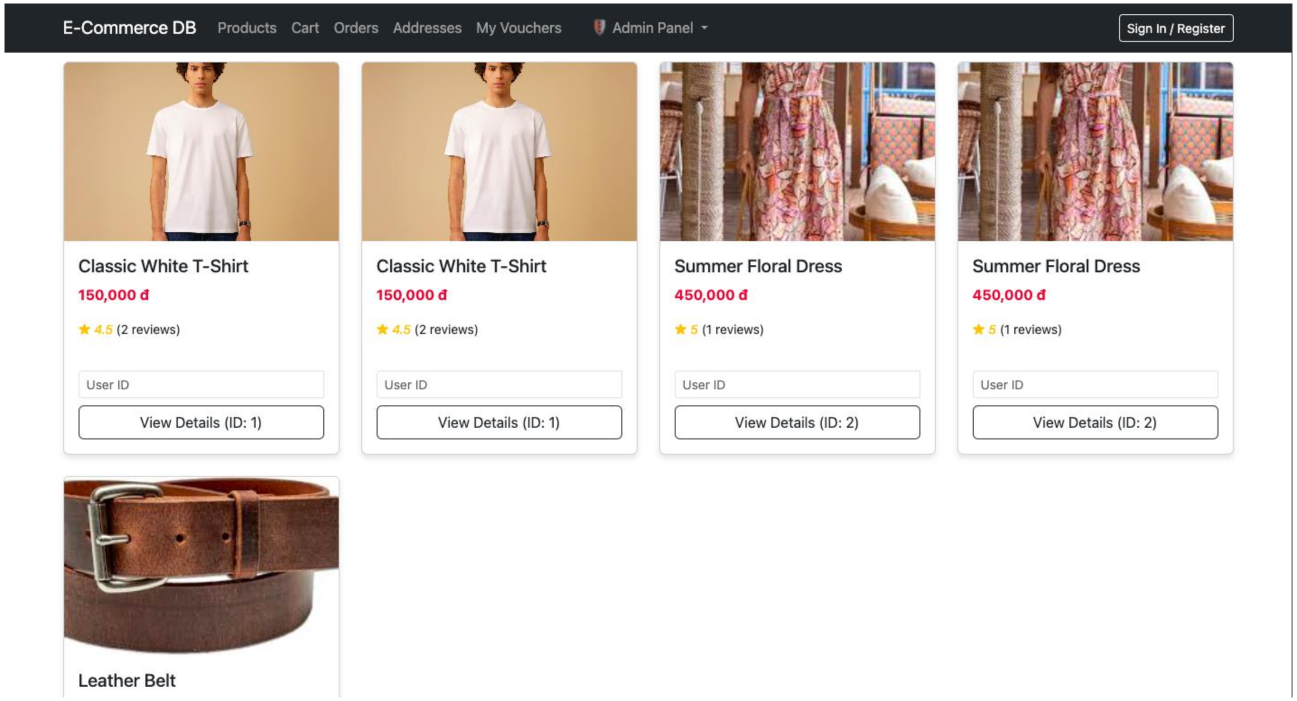
```
PRINT 'Browsing products...';
EXEC browse_products @p_limit = 3;

-- Get Detail of Product ID 1 (Assuming it exists from insert_data)
PRINT 'Viewing details of Product #1...';
EXEC get_product_details 1;
```

86 % No issues found

Results Messages

	product_id	product_name	original_price	current_price	thumbnail	avg_rating	total_reviews	category_name	created_at
1	7	New Admin Produc1	1000.00	800.00	https://encrypted-tbn0.gstatic.com/images?q=tbn:A...	0	0	Men	2026-01-06 23:07:16.7633333
2	7	New Admin Produc1	1000.00	800.00	https://encrypted-tbn0.gstatic.com/images?q=tbn:A...	0	0	T-Shirts	2026-01-06 23:07:16.7633333
3	6	Classi White T-Shirt	200000.00	150000.00	https://dosi-in.com/images/detailed/42/CDL11_1.jpg	4.5	2	NULL	2026-01-06 22:57:46.8666667

	JSON_F52E2B61-18A1-11d1-B105-00805F49916B
1	{"info":{"id":1,"name":"Classic White T-Shirt","slu...



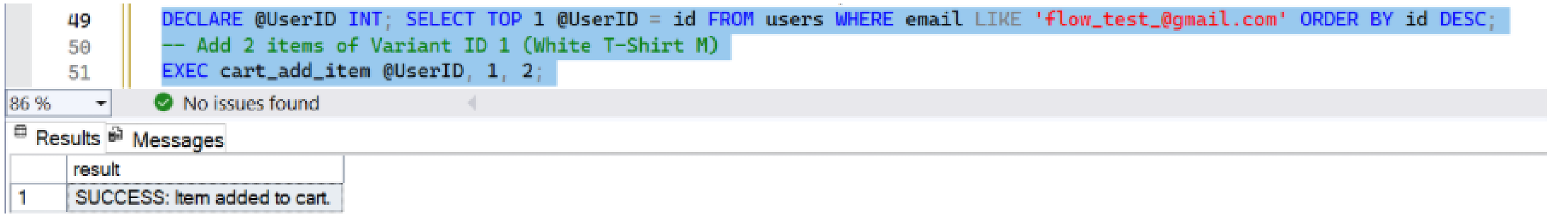
Classic White T-Shirt	Classic White T-Shirt	Summer Floral Dress	Summer Floral Dress
150,000 đ	150,000 đ	450,000 đ	450,000 đ
★ 4.5 (2 reviews)	★ 4.5 (2 reviews)	★ 5 (1 reviews)	★ 5 (1 reviews)
User ID	User ID	User ID	User ID
View Details (ID: 1)	View Details (ID: 1)	View Details (ID: 2)	View Details (ID: 2)

Leather Belt

IV. Scenario-based Testing

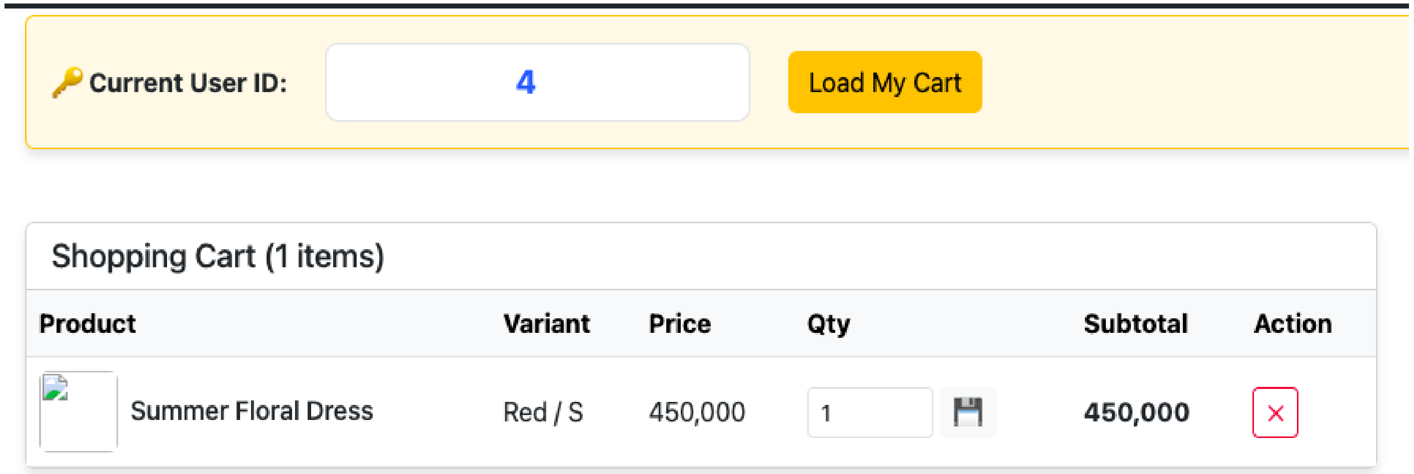
Step 5: Add to Cart

- **Action:** The user adds items with the first variant and quantity is 2
- **Objective:** Verify cart_add_item logic.



```
DECLARE @UserID INT; SELECT TOP 1 @UserID = id FROM users WHERE email LIKE 'flow_test_@gmail.com' ORDER BY id DESC;
-- Add 2 items of Variant ID 1 (White T-Shirt M)
EXEC cart_add_item @UserID, 1, 2;
```

```
86 %    No issues found
Results  Messages
   result
1  SUCCESS: Item added to cart.
```



Current User ID: 4

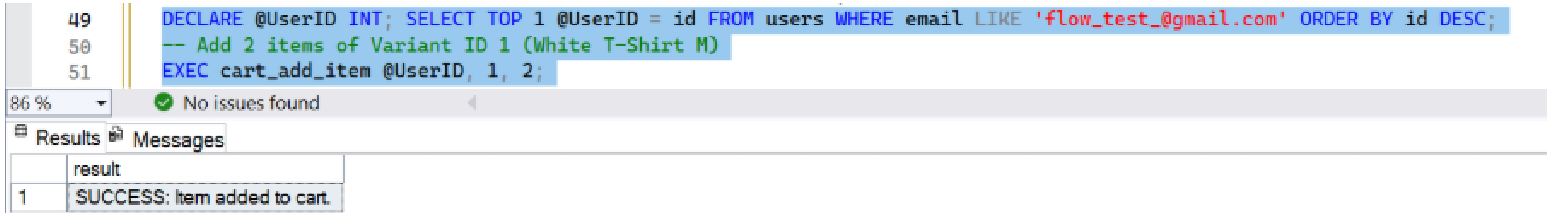
Shopping Cart (1 items)

Product	Variant	Price	Qty	Subtotal	Action
Summer Floral Dress	Red / S	450,000	1	450,000	×

IV. Scenario-based Testing

Step 6: Checkout Transaction

- **Action:** The user places the order using the address created in Step 3.
- **Objective:** Verify checkout creates the order, deducts stock, and clears the cart.

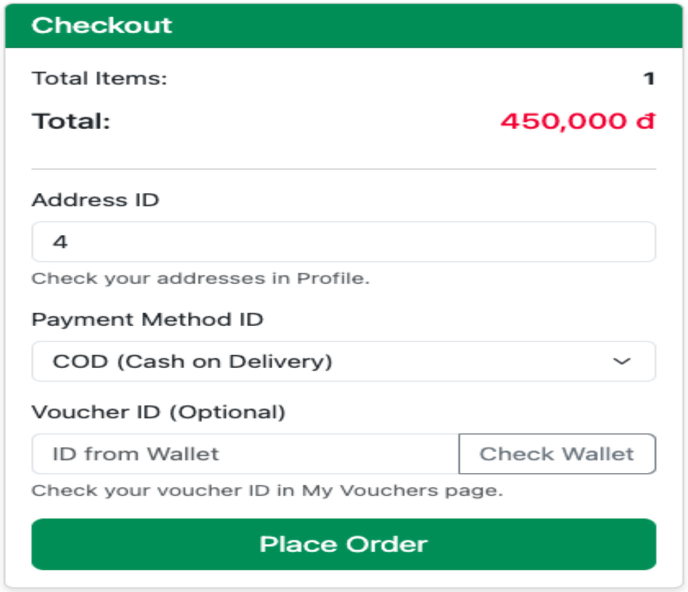


```
DECLARE @UserID INT; SELECT TOP 1 @UserID = id FROM users WHERE email LIKE 'flow_test_@gmail.com' ORDER BY id DESC;
-- Add 2 items of Variant ID 1 (White T-Shirt M)
EXEC cart_add_item @UserID, 1, 2;
```

86 % No issues found

Results Messages

	result
1	SUCCESS: Item added to cart.



Checkout

Total Items: 1

Total: 450,000 đ

Address ID: 4

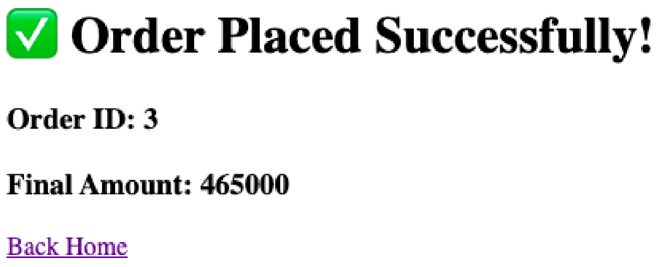
Check your addresses in Profile.

Payment Method ID: COD (Cash on Delivery)

Voucher ID (Optional): ID from Wallet | Check Wallet

Check your voucher ID in My Vouchers page.

Place Order



✅ **Order Placed Successfully!**

Order ID: 3

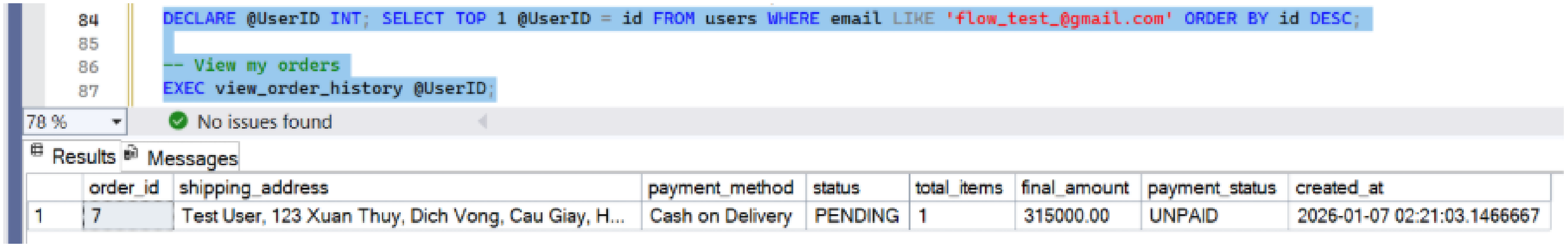
Final Amount: 465000

Back Home

IV. Scenario-based Testing

Step 7: Order Tracking

- **Action:** The user checks their order history to confirm the purchase.
- **Objective:** Verify view_order_history.

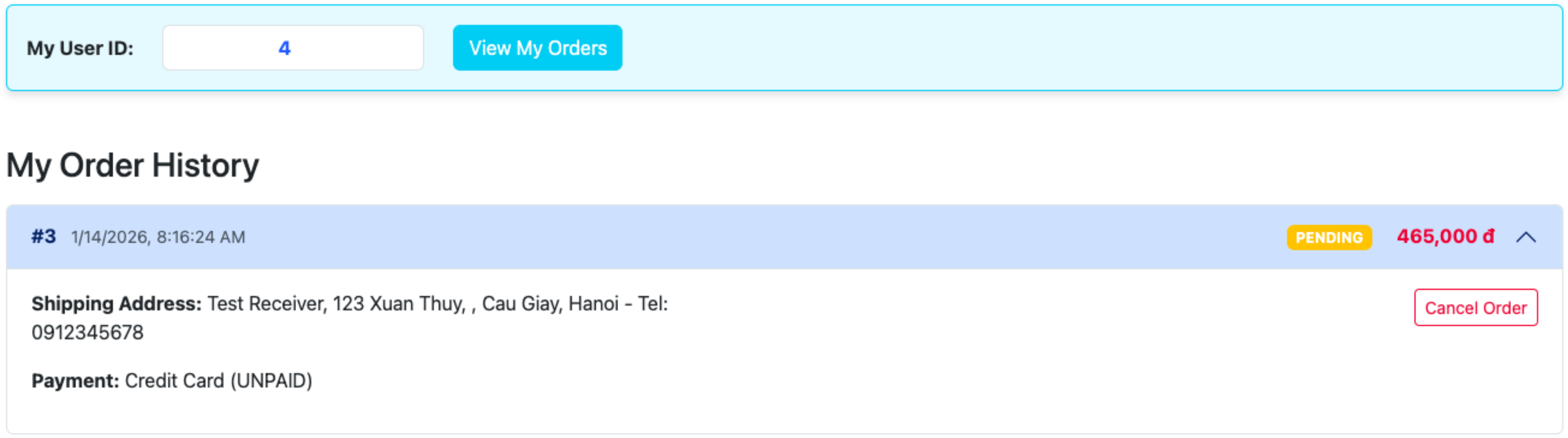


```
DECLARE @UserID INT; SELECT TOP 1 @UserID = id FROM users WHERE email LIKE 'flow_test_@gmail.com' ORDER BY id DESC;

-- View my orders
EXEC view_order_history @UserID;
```

78 % No issues found

Results Messages

	order_id	shipping_address	payment_method	status	total_items	final_amount	payment_status	created_at
1	7	Test User, 123 Xuan Thuy, Dich Vong, Cau Giay, H...	Cash on Delivery	PENDING	1	315000.00	UNPAID	2026-01-07 02:21:03.1466667



My User ID: 4 View My Orders

My Order History

#3 1/14/2026, 8:16:24 AM PENDING 465,000 đ

Shipping Address: Test Receiver, 123 Xuan Thuy, , Cau Giay, Hanoi - Tel: 0912345678

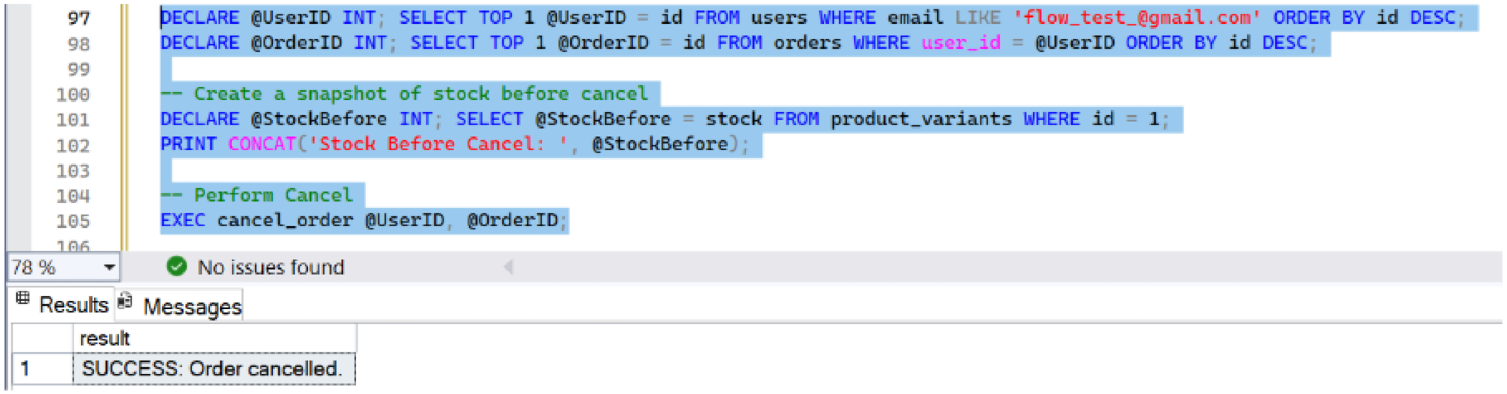
Payment: Credit Card (UNPAID)

Cancel Order

IV. Scenario-based Testing

Step 8: Order Cancellation

- **Action:** The user decides to cancel the order immediately.
- **Objective:** Verify cancel_order restores stock and updates status.

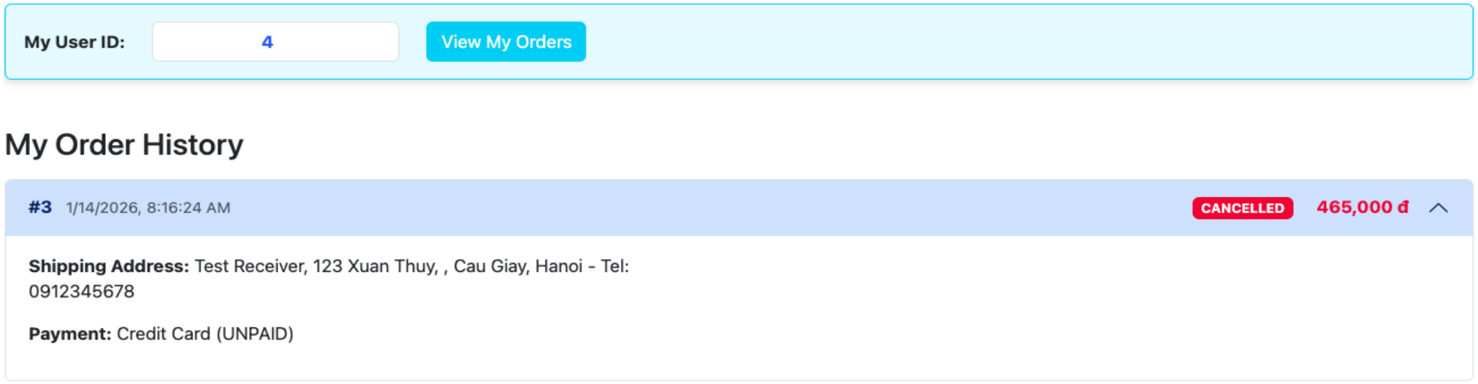


```
DECLARE @UserID INT; SELECT TOP 1 @UserID = id FROM users WHERE email LIKE 'flow_test_@gmail.com' ORDER BY id DESC;
DECLARE @OrderID INT; SELECT TOP 1 @OrderID = id FROM orders WHERE user_id = @UserID ORDER BY id DESC;

-- Create a snapshot of stock before cancel
DECLARE @StockBefore INT; SELECT @StockBefore = stock FROM product_variants WHERE id = 1;
PRINT CONCAT('Stock Before Cancel: ', @StockBefore);

-- Perform Cancel
EXEC cancel_order @UserID, @OrderID;
```

78 % — No issues found

Results | Messages

	result
1	SUCCESS: Order cancelled.



My User ID: 4 — View My Orders

My Order History

#3 1/14/2026, 8:16:24 AM — CANCELLED — 465,000 đ

Shipping Address: Test Receiver, 123 Xuan Thuy, , Cau Giay, Hanoi - Tel: 0912345678

Payment: Credit Card (UNPAID)

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Perfomance Optimization & Benchmarking

V. Perfomance Optimization & Benchmarking (Index)

1. Indexes supporting customer features

Table	Index Name	Columns (Key + Include)	Optimization Goal
Products	`idx_products_active_newest`	Key: `(is_active, created_at DESC)` Include: `name`, `price`, `thumbnail`, `rating`	**Homepage / Browse**: Allows instant retrieval of "Newest Active Products" without touching the main heap.
ProductCategories	`idx_product_categories_category_id`	Key: `(category_id)` Include: `product_id`	**Category Filter**: Accelerates "Show all Men's Shirts" queries.
Products	`idx_products_price`	Key: `(price)` Include: `name`, `thumbnail`	**Price Filter**: Optimizes "Price Range" searches and "Sort by Price".
Products	`idx_products_name`	Key: `(name)`	**Name Search**: Supports basic keyword search on product names.

V. Perfomance Optimization & Benchmarking (Index)

1. Indexes supporting customer features

ProductVariants	`idx_product_variants_product`	Key: `(product_id)` Include: `color`, `size`, `stock`	**Product Detail**: Fetches all available sizes/colors instantly when viewing a single product.
Reviews	`idx_reviews_product_created`	Key: `(product_id, created_at DESC)` Include: `rating`, `comment`	**Review Display**: Loads latest reviews for a product without sorting cost.
Orders	`idx_orders_user_created`	Key: `(user_id, created_at DESC)` Include: `status`, `total_amount`	**My Orders**: Instant access to user's order history sorted by newest.
CartItems	`idx_cart_items_cart_id`	Key: `(cart_id)` Include: `variant_id`, `quantity`	**Cart View**: Rapidly joins cart items with product info.

V. Perfomance Optimization & Benchmarking (Index)

2. Indexes supporting admin features

Table	Index Name	Columns (Key + Include)	Optimization Goal
Orders	`idx_orders_created_at`	Key: `(created_at)` Include: `status`, `final_amount`	**Revenue Reports**: Scans order dates for daily sales reports without full table scan.
Orders	`idx_orders_status`	Key: `(status)` Include: `user_id`, `total_amount`	**Order Mgmt**: Quickly filters "PENDING" or "SHIPPING" orders for fulfillment workflow.
SupportMessages	`idx_support_mes sages_user`	Key: `(user_id)` Include: `content`, `status`	**Support History**: Quick lookup of a specific user's ticket history.
ProductCategories	`idx_product_categories_cat`	Key: `(category_id)` Include: `product_id`	**Analytics (Cat)**: Optimized for "Revenue by Category" reporting queries.
OrderItems	`idx_order_items_variant_id`	Key: `(variant_id)` Include: `quantity`, `price`	**Best Sellers**: Aggregates sales data per variant efficiently.

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Triggers

VI. Triggers

Trigger Name	Table	Event	Description
`trg_prevent_negative_stock`	`product_variants`	AFTER UPDATE	**Inventory Safety Net.** Prevents stock from going below zero. If any UPDATE results in `stock < 0`, the trigger rolls back the transaction and raises an error. Protects against manual SQL updates bypassing checkout logic.
`trg_audit_order_status_change`	`orders`	AFTER UPDATE	**Order Status Monitor.** Prints status transitions to the Messages tab when order status or payment status changes. Output format: AUDIT: Order #ID status changed: OLD -> NEW | Payment: OLD -> NEW. Useful for real-time debugging during development.
`trg_address_single_default`	`addresses`	AFTER INSERT/ UPDATE	**Single Default Address.** Ensures only ONE address per user can be default. When `is_default=1` is set, automatically unsets all other addresses for the same user.
`trg_user_payment_single_default`	`user_payments`	AFTER INSERT/ UPDATE	**Single Default Payment.** Same logic as above for payment methods. Essential since no stored procedure manages this table.

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Conclusion and Future Work

VII. Conclusion and Future Work

1. Conclusion

Key Technical Deliverables

- **Stability:** Guaranteed by strict FK constraints and 3NF normalization.
- **Integrity:** Secured via encapsulation of Checkout & Inventory logic.
- **Performance:** Sub-second responsiveness (~10ms) powered by Covering Indexes.
- **Automation**: Database triggers enforce critical safety rules automatically, reducing the risk of human error.
- **Result:** A robust, secure, and scalable E-commerce backend.

VII. Conclusion and Future Work

2. Future Work

Future Enhancements & Upgrades

- **High-Speed Delivery:** Using **Redis** to reduce latency and handle flash-sale surges.
- **Fintech Integration:** Real-time processing with **VNPay/PayPal** for a seamless user experience.
- **Scalable Infrastructure:** Moving toward a **Microservices** architecture to support independent service growth.

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THANK YOU !