T-Swap Audit Report

Version 1.0

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Protocol Summary

This project is meant to be a permissionless way for users to swap assets between each other at a fair price. You can think of T-Swap as a decentralized asset/token exchange (DEX). T-Swap is known as an Automated Market Maker (AMM) because it doesn't use a normal "order book" style exchange, instead it uses "Pools" of an asset. It is similar to Uniswap. To understand Uniswap, please watch this video: Uniswap Explained

Disclaimer

Ameer Hamza makes all effort to find as many vulnerabilities in the code in the given time period, but holds no responsibilities for the findings provided in this document. A security audit by the team is not an endorsement of the underlying business or product. The audit was time-boxed and the review of the code was solely on the security aspects of the Solidity implementation of the contracts.

Risk Classification

		Impact		
		High	Medium	Low
	High	H	H/M	M

		Impact		
Likelihood	Medium	H/M	M	M/L
	Low	M	M/L	L

We use the CodeHawks severity matrix to determine severity. See the documentation for more details.

Audit Details

- Commit Hash: 1ec3c30253423eb4199827f59cf564cc575b46db

Scope

```
./src/
#-- PoolFactory.sol
#-- TSwapPool.sol
```

Roles

- Liquidity Providers: Users who have liquidity deposited into the pools. Their shares are represented by the LP ERC20 tokens. They gain a 0.3% fee every time a swap is made.
- Users: Users who want to swap tokens.

Executive Summary

I learned what automated market makers are and what is uniswap v1. I also learned constant product formula which helped me learn what are invariants in this protocol. It was fun learning and breaking stuff :)

Issues found

Severity	Number of issues found
High	5
Medium	0
Low	2
Informational	3
Gas	0
Total	10

Findings

High

[H-1] `TSwapPool::deposit` is missing deadline check causing transactions to complete even after the deadline

Description The `deposit` function accepts a deadline parameter, which according to the documentation is "The deadline for the transaction to be completed by". However, this parameter is never used. As a consequence, operations that add liquidity to the pool might be executed at unexpected times, in market conditions where deposit rate is unfavorable.

Impact Transactions could be sent when market conditions are unfavorable to deposit, even when adding a deadline parameter.

Proof of Concepts The `deadline` parameter is unused.

Recommended mitigation Consider making the following change to the function

```
    function deposit(
        uint256 wethToDeposit,
        uint256 minimumLiquidityTokensToMint,
        uint256 maximumPoolTokensToDeposit,
        uint64 deadline
    )
        external
+       revertIfDeadlinePassed(uint64 deadline)
        revertIfZero(wethToDeposit)
        returns (uint256 liquidityTokensToMint)
    {
```

[H-2] Incorrect fee calculation in `TSwapPool::getInputAmountBasedOnOutput` causes protocol to take too many tokens from users, resulting in lost fees

Description The `getInputAmountBasedOnOutput` function is intended to calculate the amount of tokens a user deposit given an amount of tokens of output tokens. However, the function currently miscalculates the resulting amount. When calculating the fee, it scales the amount by 10_000 instead of 1_000.

Impact Protocol takes more fees than expected from users.

Recommended mitigation

```
    function getInputAmountBasedOnOutput(
        uint256 outputAmount,
        uint256 inputReserves,
        uint256 outputReserves
    )
        public
        pure
        revertIfZero(outputAmount)
        revertIfZero(outputReserves)
        returns (uint256 inputAmount)
    {
-       return ((inputReserves * outputAmount) * 10_000) / ((outputReserves - outputAmount) * 997);
+       return ((inputReserves * outputAmount) * 1_000) / ((outputReserves - outputAmount) * 997);
    }
```

[H-3] Lack of slippage protection in `TSwapPool::swapExactOutput` causes users to potentially receive way fewer tokens

Description The `swapExactOutput` function doesn't include any sort of slippage protection. This function is similar to what is done in `TSwapPool::swapExactInput`, where the function specifies a `minOutputAmount`, the `swapExactOutput` function should specify a `maxInputAmount`.

Impact If market conditions change before the transaction processes, the user could get a much worse swap.

Proof of Concepts 1. The price of 1 WETH right now is 1,000 USDC 2. User inputs a `swapExactOutput` looking for 1 WETH 1. inputToken = USDC 2. outputToken = WETH 3. outputAmount = 1 4. deadline = whatever 3. The function doesn't offer a maxInput amount 4. As the transaction is pending in the mempool, the market changes! And the price was huge -> WETH is now 10,000 USDC. 10x more than the user expected 5. The transaction completes, but the user sent the protocol 10,000 USDC instead of the expected 1,000 USDC

Recommended mitigation We should include a `maxInputAmount` so the user only has to spend up to specific amount, and can predict how much they will spend on the protocol.

```
    function swapExactOutput(
        IERC20 inputToken,
+       uint256 maxInputAmount,
.
.
.

        inputAmount = getInputAmountBasedOnOutput(outputAmount,
           inputReserves, outputReserves);

+       if(inputAmount>maxInputAmount){
+           revert();
+       }

        _swap(inputToken, inputAmount, outputToken, outputAmount);
```

[H-4] `TSwapPool::sellPoolTokens` mismatches input and output tokens causing users to receive the incorrect amount of tokens

Description The `sellPoolTokens` function is intended to allow users to easily sell pool tokens and receive WETH in exchange. Users indicate how many pool tokens they're willing to sell in the `poolTokenAmount` parameter. However, the function currently miscalculates the swapped amount.

This is due to the fact that the `swapExactOutput` function is called, whereas the `swapExactInput` function is the one that should be called. Because users specify the exact amount of input tokens, not output.

Impact Users will swap the wrong amount of tokens, which is a severe disruption of protocol functionality.

Recommended mitigation

Consider changing the implementation to use `swapExactInput` instead of `swapExactOutput`. Note that this would also require changing the `sellPoolTokens` function to accept a new parameter (i.e. `minWethToReceive` to be passed to `swapExactInput`)

```
    function sellPoolTokens(
        uint256 poolTokenAmount,
+        uint256 minWethToReceive
    ) external returns (uint256 wethAmount) {
-        return swapExactOutput(i_poolToken, i_wethToken,
   poolTokenAmount, uint64(block.timestamp));
```

```
6 +         return swapExactInput(i_poolToken, poolTokenAmount,
      i_wethToken, minWethToReceive, uint64(block.timestamp));
7       }
```

Additionally, it might be wise to add a deadline to the function, as there is currently no deadline. (MEV not covered)

[H-5] In `TSwapPool::_swap` the extra tokens given to users after every `swapCount` breaks the protocol invariant of `x * y = k`

Description The protocol follows a strict invariant of `x * y = k`. Where: - `x`: The balance of the pool token - `y`: The balance of WETH - `k`: The constant product of the two balances

This means, that whenever the balances change in the protocol, the ratio between the two amounts should remain constant, hence the `k`. However, this is broken due to the extra incentive in the `_swap` function. Meaning that over time the protocol funds will be drained.

The following block of code in `TSwapPool::_swap` is responsible for the issue.

```

        swap_count++;
        if (swap_count >= SWAP_COUNT_MAX) {
            swap_count = 0;
            outputToken.safeTransfer(msg.sender, 1
                _000_000_000_000_000_000);
        }
```

Impact A user could maliciously drain the protocol of funds by doing a lot of swaps and collecting the extra incentive given out by the protocol.

Most simply put, the protocol's core invariant is broken.

Proof of Concepts 1. A user swaps 10 times, and collects the extra incentive of `1_000_000_000_000_000_000` tokens 2. That user continue to swap untill all the protocol funds are drained

Proof Of Code

Place the following into `TSwapPool.t.sol`

```
    function testInvariantBroken() public {
        vm.startPrank(liquidityProvider);
        weth.approve(address(pool), 100e18);
        poolToken.approve(address(pool), 100e18);
        pool.deposit(100e18, 100e18, 100e18, uint64(block.timestamp));
        vm.stopPrank();

        uint256 outputWeth = 1e17;

```

```
        vm.startPrank(user);
        poolToken.approve(address(pool), type(uint256).max);
        poolToken.mint(user, 100e18);
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
        pool.swapExactOutput(
            poolToken,
            weth,
            outputWeth,
            uint64(block.timestamp)
        );
```

```
61          pool.swapExactOutput(
62              poolToken,
63              weth,
64              outputWeth,
65              uint64(block.timestamp)
66          );
67
68          int256 startingY = int256(weth.balanceOf(address(pool)));
69          int256 expectedDeltaY = int256(-1) * int256(outputWeth);
70
71          pool.swapExactOutput(
72              poolToken,
73              weth,
74              outputWeth,
75              uint64(block.timestamp)
76          );
77
78          vm.stopPrank();
79
80          uint256 endingY = weth.balanceOf(address(pool));
81          int256 actualDeltaY = int256(endingY) - int256(startingY);
82          assertEq(actualDeltaY, expectedDeltaY);
83      }
```

Recommended mitigation Remove the extra incentive mechanism. If you want to keep this in, we should account for the change in the x * y = k protocol invariant. Or, we should set aside tokens in the same way we do with fees.

```
1 -         swap_count++;
2 -         if (swap_count >= SWAP_COUNT_MAX) {
3 -             swap_count = 0;
4 -             outputToken.safeTransfer(msg.sender, 1
      _000_000_000_000_000_000);
5 -         }
```

Low

[L-1] `TSwapPool::LiquidityAdded` event has parameters out of order

Description When the `LiquidityAdded` event is emitted in the `TSwapPool::_addLiquidityMintAndTrans` function, it logs values in an incorrect order. The `poolTokensToDeposit` value should go in the third parameter position, whereas the `wethToDeposit` value should go second.

Impact Event emission is incorrect, leading to off-chain functions potentially malfunctioning.

Recommended mitigation

```
- emit LiquidityAdded(msg.sender, poolTokensToDeposit, wethToDeposit);
+ emit LiquidityAdded(msg.sender, wethToDeposit, poolTokensToDeposit);
```

[L-2] Default value returned by `TSwapPool::swapExactInput` results in incorrect return value given

Description The `swapExactInput` function is expected to return the actual amount of tokens bought by caller. However, while it declares the named return value `output` it is never assigned a value, nor uses an explicit return statement.

Impact The return value will always be 0, giving incorrect information to the caller.

Recommended mitigation

```
    {
        uint256 inputReserves = inputToken.balanceOf(address(this));
        uint256 outputReserves = outputToken.balanceOf(address(this));

-       uint256 outputAmount = getOutputAmountBasedOnInput(inputAmount, inputReserves, outputReserves);
+       output = getOutputAmountBasedOnInput(inputAmount, inputReserves, outputReserves);

-       if (outputAmount < minOutputAmount) {
-           revert TSwapPool__OutputTooLow(outputAmount, minOutputAmount);
+       if (output < minOutputAmount) {
+           revert TSwapPool__OutputTooLow(output, minOutputAmount);
        }

-       _swap(inputToken, inputAmount, outputToken, outputAmount);
+       _swap(inputToken, inputAmount, outputToken, output);
    }
```

Informationals

[I-1] `PoolFactory::PoolFactory__PoolDoesNotExist` is not used and should be removed

```
- error PoolFactory::PoolFactory__PoolDoesNotExist(address tokenAddress);
```

[I-2] Lacking zero address checks in `PoolFactory::constructor`

Description

It's always better to perform zero address checks when setting an address to a storage variable

Recommended mitigation

```
    constructor(address wethToken){
+       if (wethToken == address(0)){
+           revert();
+       }
        i_wethToken = wethToken;
    }
```

[I-3] `PoolFactory::createPool` should use `.symbol()` instead of `.name()`

Description

`PoolFactory::createPool` function uses `.name()` to get token's symbol, which is incorrect and can cause confusion

Impact Users interacting with protocol can confuse name with symbol leading to incorrect representation of token

Recommended mitigation

```
-       string memory liquidityTokenSymbol = string.concat("ts", IERC20(tokenAddress).name());
+       string memory liquidityTokenSymbol = string.concat("ts", IERC20(tokenAddress).symbol());
```