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完善合约代码

CPAMM.sol

```
// SPDX-License-Identifier: MIT
pragma solidity 0.8.16;

import "@openzeppelin/contracts/token/ERC20/IERC20.sol";

contract CSAMM {
    // 表示 dx 和 dy
    IERC20 immutable token0;
    IERC20 immutable token1;

    //用于存储持有币在合约的数量，对应 X 和 Y
    uint256 public reserve0;
    uint256 public reserve1;

    uint256 public totalSupply;
    //balanceOf 每个地址在流动性中持有的 share
    mapping(address => uint256) public balanceOf;

    constructor(address _token0, address _token1) {
        token0 = IERC20(_token0);
        token1 = IERC20(_token1);
    }

    // 可以进行复用，用于更新余额表
    function _update() private {
        reserve0 = token0.balanceOf(address(this));
        reserve1 = token1.balanceOf(address(this));
    }

    function _sqrt(uint256 y) internal pure returns (uint256 z) {
        if (y > 3) {
            z = y;
            uint256 x = y / 2 + 1;
            while (x < z) {
                z = x;
                x = (y / x + x) / 2;
            }
        } else if (y != 0) {
```

```
            z = 1;
        }
    }

    function _min(uint256 _x, uint256 _y) private pure returns (uint256)
{
        return _x > _y ? _y : _x;
    }

    // 添加流动性，增加 shared 到目的地址
    function _mint(address _to, uint256 _amount) private {
        // 此处补全
        balanceOf[_to] += _amount;
        totalSupply += _amount;
    }

    function _burn(address _from, uint256 _amount) private {
        // 此处补全
        balanceOf[_from] -= _amount;
        totalSupply -= _amount;
    }

    function swap(
        address _tokenIn,
        uint256 _amountIn
    ) external returns (uint256 amountOut) {
        // 此处补全
        // 前两个进行验证
        require(_amountIn > 0, "Invalid Amount");
        // 为交易所支持的币
        require(
            _tokenIn == address(token0) || _tokenIn == address(token1),
            "Invalid token"
        );
        // 判断是换的那种币
        bool isToken0 = _tokenIn == address(token0);
        (IERC20 tokenIn, IERC20 tokenOut) = isToken0
            ? (token0, token1)
            : (token1, token0);

        (uint256 reserveIn, uint256 reserveOut) = isToken0
            ? (reserve0, reserve1)
            : (reserve1, reserve0);
        //转币到合约
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        tokenIn.transferFrom(msg.sender, address(this), _amountIn);
        // 计算输出的数量
        amountOut = (_amountIn * reserveOut) / (reserveIn + _amountIn);
        // 转币给用户
        tokenOut.transfer(msg.sender, amountOut);
        // 更新自己的余额表
        _update();
    }

    function addLiquidity(
        uint256 _amount0,
        uint256 _amount1
    ) external returns (uint256 shares) {
        // 此处补全
        // 避免输入无效值
        require(_amount0 > 0 && _amount1 > 0, "Invalid amount");
        // 把 token0 和 token1 转入到合约
        token0.transferFrom(msg.sender, address(this), _amount0);
        token1.transferFrom(msg.sender, address(this), _amount1);
        // 计算并 mint share 给用户（改）
        // 已经添加过流动性，验证是否满足比例
        if (reserve0 > 0 || reserve1 > 0) {
            require(_amount0 * reserve1 == _amount1 * reserve0, "dy !=
y/x");
        }
        // 还未被添加过，取平平方
        if (totalSupply == 0) {
            shares = _sqrt(_amount0 * _amount1);
            // 已经添加过
        } else {
            // 选择较小的值，比较安全
            shares = _min(
                (_amount0 * totalSupply) / reserve0,
                (_amount1 * totalSupply) / reserve1
            );
        }
        require(shares > 0, "share is zero");
        _mint(msg.sender, shares);
        // 更新余额表
        _update();
    }

    // 根据 share，将币转回给用户
    function removeLiquidity(
```
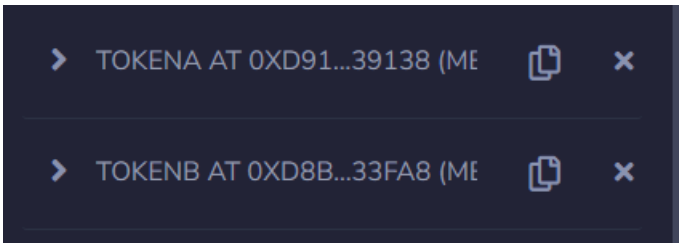
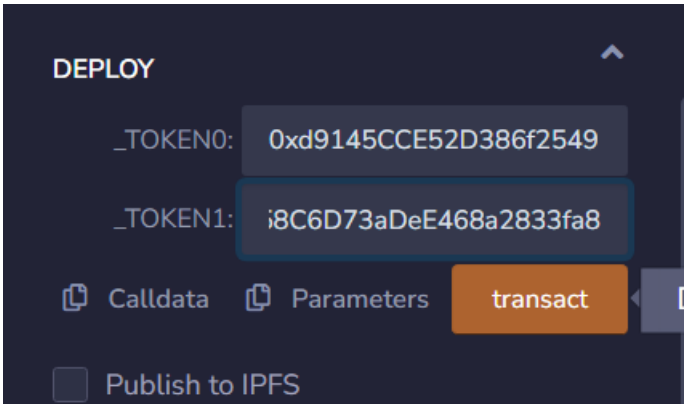

```
        uint256 _shares
    ) external returns (uint256 amount0, uint256 amount1) {
        // 此处补全
        require(_shares > 0, "Invalid shares");
        // 计算 dx 和 dy 的数量
        amount0 = (_shares * reserve0) / totalSupply;
        amount1 = (_shares * reserve1) / totalSupply;
        // 销毁用户的 share
        _burn(msg.sender, _shares);
        // 把两个币转回给用户
        token0.transfer(msg.sender, amount0);
        token1.transfer(msg.sender, amount1);
        // 更新余额表
        _update();
    }
}
```

实验过程

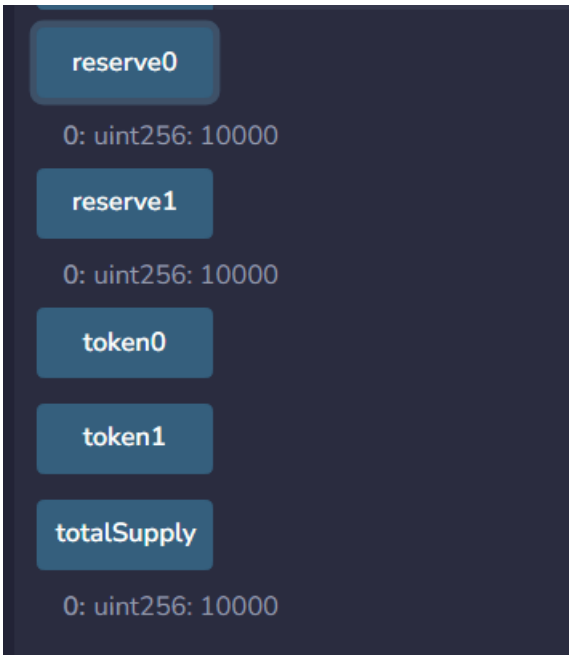
1. 部署 tokenA 和 tokenB



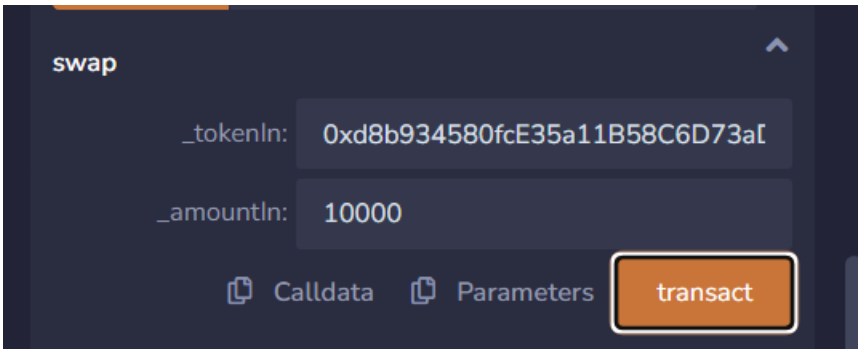
2. 部署 cpamm



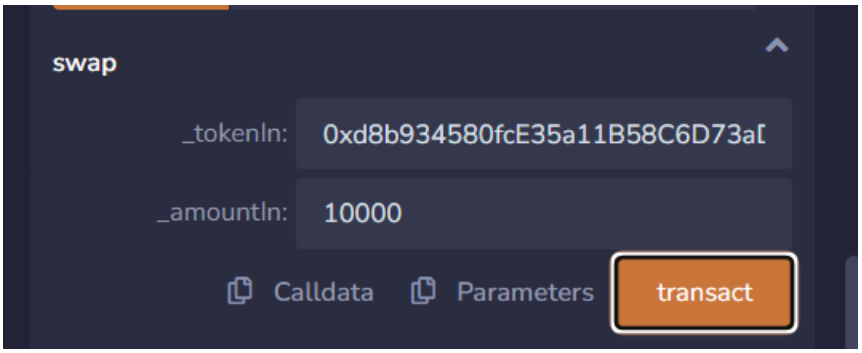
3. 查看状态



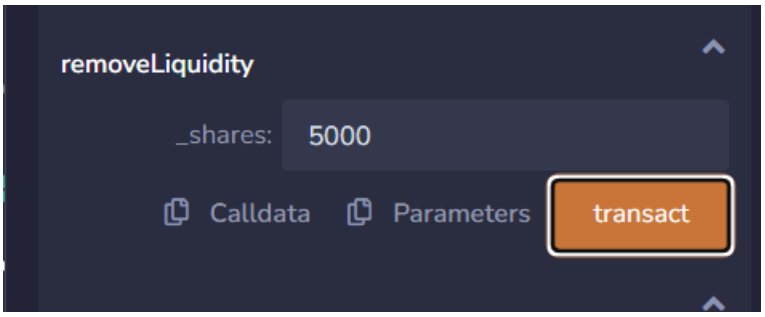
4. 买 10000tokenA



5. 查看状态（梁老师的好像是错的？为什么是反的）



6. 移除流动性



7. 查看状态


reserve0
0: uint256: 10000
reserve1
reserve1 - call
0: uint256: 2500