INDEX

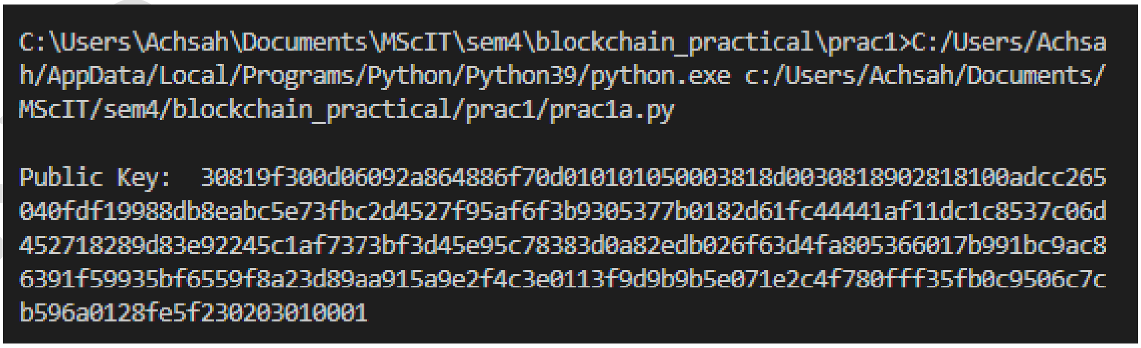
Table of Contents

PRACTICAL -1 WRITE THE FOLLOWING PROGRAMS FOR BLOCKCHAIN IN PYTHON

A) A simple client class that generates the private and public keys by using the built-in Python RSA algorithm and test it.

```
import binascii

import Crypto
from Crypto.PublicKey import RSA
from Crypto.Signature import PKCS1_v1_5


class Client:
    def __init__(self):
        random = Crypto.Random.new().read
        self._private_key = RSA.generate(1024, random)
        self._public_key = self._private_key.publickey()
        self._signer = PKCS1_v1_5.new(self._private_key)

    @property
    def identity(self):
        return 
binascii.hexlify(self._public_key.exportKey(format="DER")).decode(
            "ascii"
        )


Dinesh = Client()
print("\n Public Key:",Dinesh.identity)
```

Output

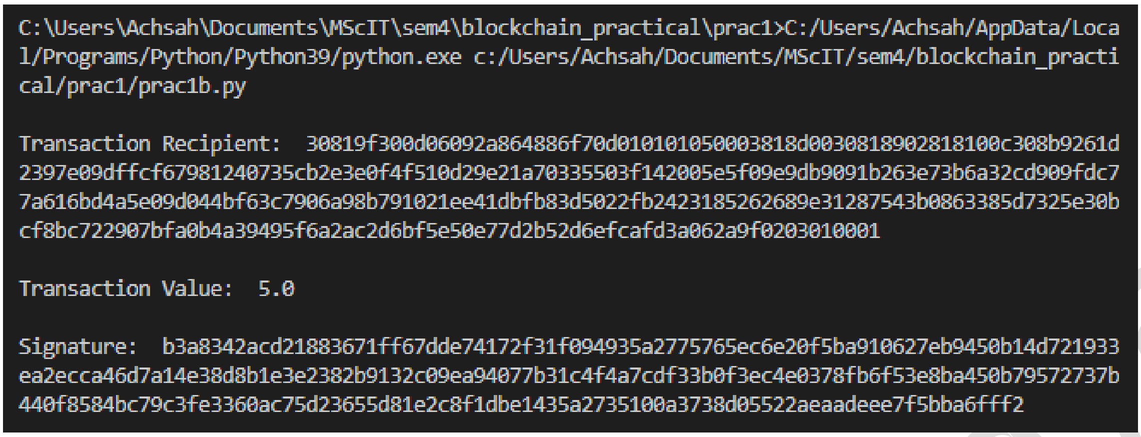


```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac1>C:/Users/Achsa
h/AppData/Local/Programs/Python/Python39/python.exe c:/Users/Achsah/Documents/
MScIT/sem4/blockchain_practical/prac1/prac1a.py

Public Key:  30819f300d06092a864886f70d010101050003818d0030818902818100adcc265
040fdf19988db8eabc5e73fbc2d4527f95af6f3b9305377b0182d61fc44441af11dc1c8537c06d
452718289d83e92245c1af7373bf3d45e95c78383d0a82edb026f63d4fa805366017b991bc9ac8
6391f59935bf6559f8a23d89aa915a9e2f4c3e0113f9d9b9b5e071e2c4f780fff35fb0c9506c7c
b596a0128fe5f230203010001
```

B) A transaction class to send and receive money and test it.

```
import binascii
import collections
import datetime
from client import Client
from Crypto.Hash import SHA
from Crypto.Signature import PKCS1_v1_5


class Transaction:
    def __init__(self, sender, recipient, value):
        self.sender = sender
        self.recipient = recipient
        self.value = value
        self.time = datetime.datetime.now()

    def to_dict(self):
        identity = "Genesis" if self.sender == "Genesis" else
self.sender.identity
        return collections.OrderedDict(
            {
                "sender": identity,
                "recipient": self.recipient,
                "value": self.value,
                "time": self.time,
            }
        )

    def sign_transaction(self):
        private_key = self.sender._private_key
        signer = PKCS1_v1_5.new(private_key)
        h = SHA.new(str(self.to_dict()).encode("utf8"))
        return binascii.hexlify(signer.sign(h)).decode("ascii")


Dinesh = Client()
Ramesh = Client()


t = Transaction(Dinesh, Ramesh.identity, 5.0)
print("\nTransaction Recipient:\n", t.recipient)
# print("\nTransaction Sender:\n", t.sender)
print("\nTransaction Value:\n", t.value)


signature = t.sign_transaction()
print("\nSignature:\n", signature)
```

Output

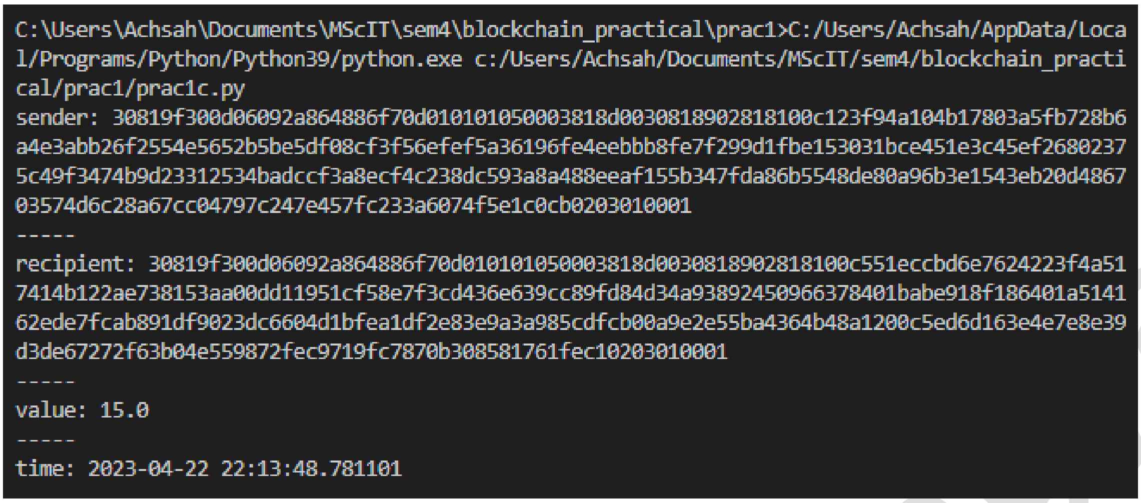


```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac1>C:/Users/Achsah/AppData/Loca
l/Programs/Python/Python39/python.exe c:/Users/Achsah/Documents/MScIT/sem4/blockchain_practi
cal/prac1/prac1b.py

Transaction Recipient:  30819f300d06092a864886f70d010101050003818d0030818902818100c308b9261d
2397e09dffcf67981240735cb2e3e0f4f510d29e21a70335503f142005e5f09e9db9091b263e73b6a32cd909fdc7
7a616bd4a5e09d044bf63c7906a98b791021ee41dbfb83d5022fb2423185262689e31287543b0863385d7325e30b
cf8bc722907bfa0b4a39495f6a2ac2d6bf5e50e77d2b52d6efcafd3a062a9f0203010001

Transaction Value:  5.0

Signature:  b3a8342acd21883671ff67dde74172f31f094935a2775765ec6e20f5ba910627eb9450b14d721933
ea2ecca46d7a14e38d8b1e3e2382b9132c09ea94077b31c4f4a7cdf33b0f3ec4e0378fb6f53e8ba450b79572737b
440f8584bc79c3fe3360ac75d23655d81e2c8f1dbe1435a2735100a3738d05522aeaadeee7f5bba6fff2
```

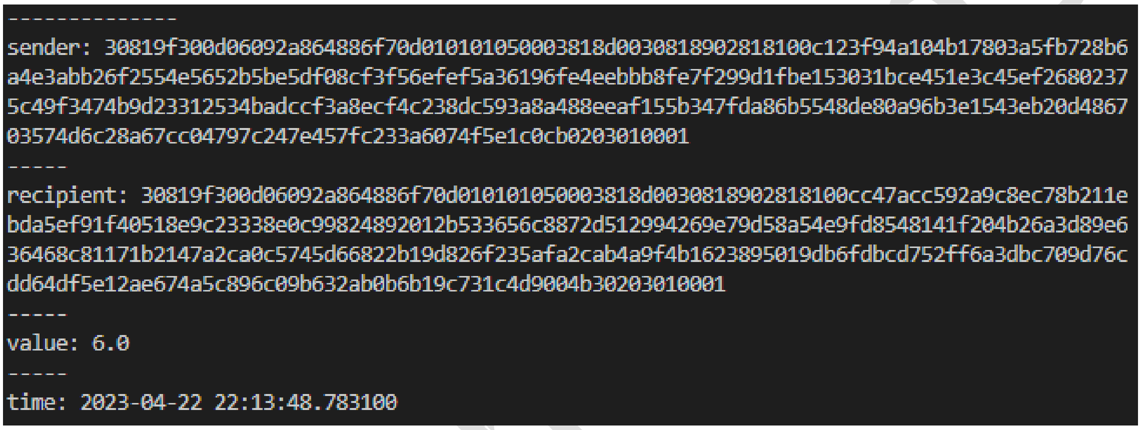
C) Create multiple transactions and display them.

```
from client import Client
from transaction_class import Transaction

Dinesh = Client()
Ramesh = Client()

t = Transaction(Dinesh, Ramesh.identity, 5.0)
print("\nTransaction Recipient:\n", t.recipient)
# print("\nTransaction Sender:\n", t.sender)
print("\nTransaction Value:\n", t.value)


signature = t.sign_transaction()
print("\nSignature:\n", signature)


Dinesh = Client()
Ramesh = Client()
Seema = Client()
Vijay = Client()

t1 = Transaction(Dinesh, Ramesh.identity, 15.0)
t1.sign_transaction()
transactions = [t1]
t2 = Transaction(Dinesh, Seema.identity, 6.0)
t2.sign_transaction()
transactions.append(t2)
t3 = Transaction(Ramesh, Vijay.identity, 2.0)
t3.sign_transaction()
transactions.append(t3)
t4 = Transaction(Seema, Ramesh.identity, 4.0)
t4.sign_transaction()
transactions.append(t4)


for transaction in transactions:
    Transaction.display_transaction(transaction)
    print("---------------")
```

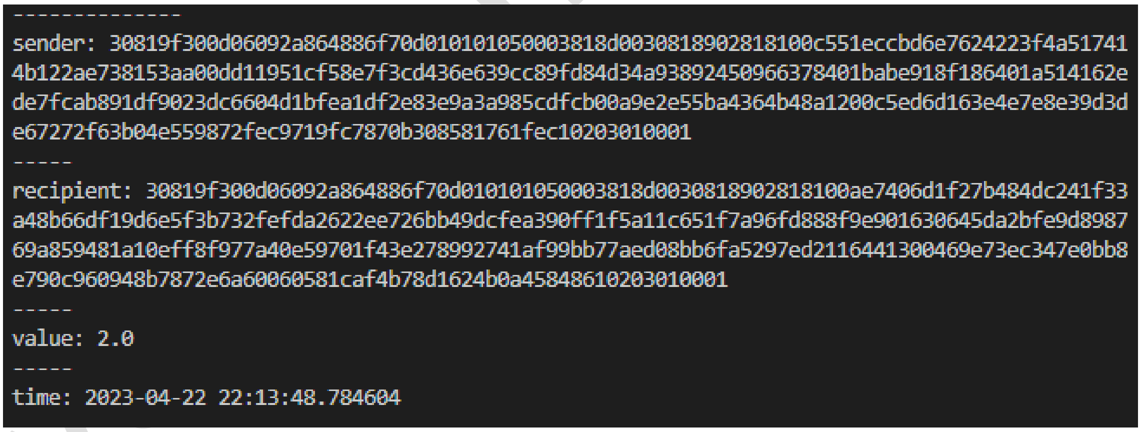
Output



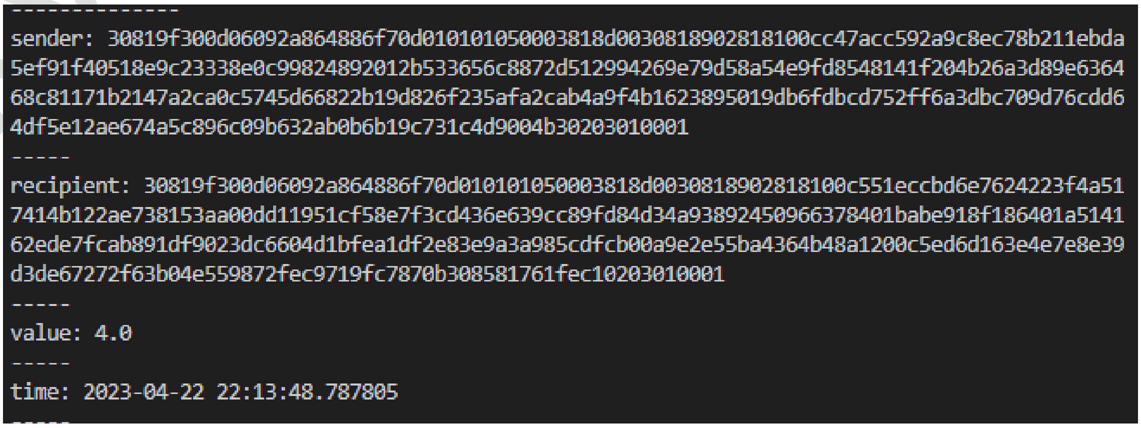
```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac1>C:/Users/Achsah/AppData/Loca
l/Programs/Python/Python39/python.exe c:/Users/Achsah/Documents/MScIT/sem4/blockchain_practi
cal/prac1/prac1c.py
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100c123f94a104b17803a5fb728b6
a4e3abb26f2554e5652b5be5df08cf3f56efef5a36196fe4eebbb8fe7f299d1fbe153031bce451e3c45ef2680237
5c49f3474b9d23312534badccf3a8ecf4c238dc593a8a488eeaf155b347fda86b5548de80a96b3e1543eb20d4867
03574d6c28a67cc04797c247e457fc233a6074f5e1c0cb0203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100c551eccbd6e7624223f4a51
7414b122ae738153aa00dd11951cf58e7f3cd436e639cc89fd84d34a93892450966378401babe918f186401a5141
62ede7fcab891df9023dc6604d1bfea1df2e83e9a3a985cdfcb00a9e2e55ba4364b48a1200c5ed6d163e4e7e8e39
d3de67272f63b04e559872fec9719fc7870b308581761fec10203010001
-----
value: 15.0
-----
time: 2023-04-22 22:13:48.781101
```



```
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100c123f94a104b17803a5fb728b6
a4e3abb26f2554e5652b5be5df08cf3f56efef5a36196fe4eebbb8fe7f299d1fbe153031bce451e3c45ef2680237
5c49f3474b9d23312534badccf3a8ecf4c238dc593a8a488eeaf155b347fda86b5548de80a96b3e1543eb20d4867
03574d6c28a67cc04797c247e457fc233a6074f5e1c0cb0203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100cc47acc592a9c8ec78b211e
bda5ef91f40518e9c23338e0c99824892012b533656c8872d512994269e79d58a54e9fd8548141f204b26a3d89e6
36468c81171b2147a2ca0c5745d66822b19d826f235afa2cab4a9f4b1623895019db6fdbcd752ff6a3dbc709d76c
dd64df5e12ae674a5c896c09b632ab0b6b19c731c4d9004b30203010001
-----
value: 6.0
-----
time: 2023-04-22 22:13:48.783100
```



```
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100c551eccbd6e7624223f4a51741
4b122ae738153aa00dd11951cf58e7f3cd436e639cc89fd84d34a93892450966378401babe918f186401a514162e
de7fcab891df9023dc6604d1bfea1df2e83e9a3a985cdfcb00a9e2e55ba4364b48a1200c5ed6d163e4e7e8e39d3d
e67272f63b04e559872fec9719fc7870b308581761fec10203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100ae7406d1f27b484dc241f33
a48b66df19d6e5f3b732fefda2622ee726bb49dcfea390ff1f5a11c651f7a96fd888f9e901630645da2bfe9d8987
69a859481a10eff8f977a40e59701f43e278992741af99bb77aed08bb6fa5297ed2116441300469e73ec347e0bb8
e790c960948b7872e6a60060581caf4b78d1624b0a45848610203010001
-----
value: 2.0
-----
time: 2023-04-22 22:13:48.784604
```

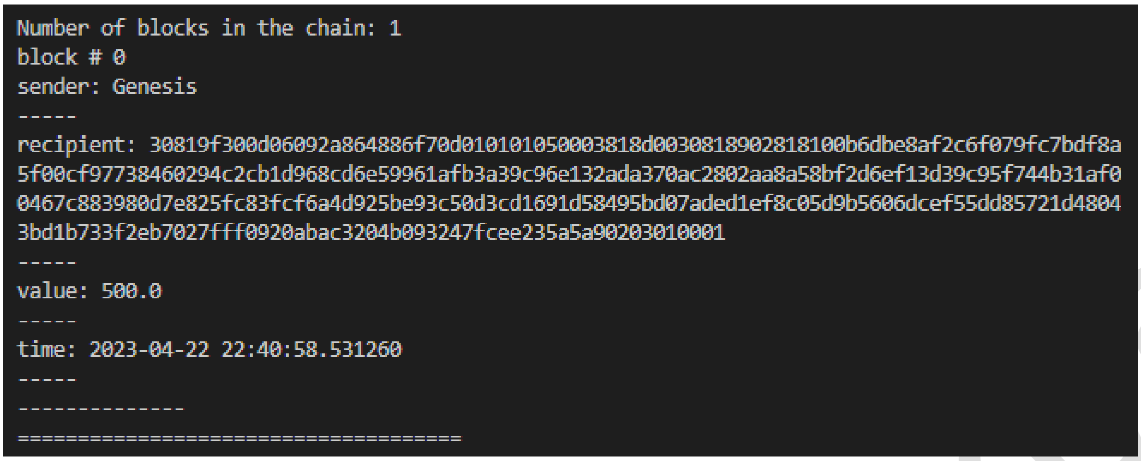


```
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100cc47acc592a9c8ec78b211ebda
5ef91f40518e9c23338e0c99824892012b533656c8872d512994269e79d58a54e9fd8548141f204b26a3d89e6364
68c81171b2147a2ca0c5745d66822b19d826f235afa2cab4a9f4b1623895019db6fdbcd752ff6a3dbc709d76cdd6
4df5e12ae674a5c896c09b632ab0b6b19c731c4d9004b30203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100c551eccbd6e7624223f4a51
7414b122ae738153aa00dd11951cf58e7f3cd436e639cc89fd84d34a93892450966378401babe918f186401a5141
62ede7fcab891df9023dc6604d1bfea1df2e83e9a3a985cdfcb00a9e2e55ba4364b48a1200c5ed6d163e4e7e8e39
d3de67272f63b04e559872fec9719fc7870b308581761fec10203010001
-----
value: 4.0
-----
time: 2023-04-22 22:13:48.787805
-----
```

D) Create a blockchain, a genesis block and execute it.

```
from client import Client
from transaction_class import Transaction


class Block:
    def __init__(self, client):
        self.verified_transactions = []
        self.previous_block_hash = ""
        self.Nonce = ""
        self.client = client


def dump_blockchain(blocks):
    print(f"\nNumber of blocks in the chain: {len(blocks)}")

    for i, block in enumerate(blocks):
        print(f"block # {i}")
        for transaction in block.verified_transactions:
            Transaction.display_transaction(transaction)
            print("--------------")

    print("=====================================")


Dinesh = Client()
t0 = Transaction("Genesis", Dinesh.identity(), 500.0)

block0 = Block(Dinesh)
block0.previous_block_hash = ""
NONCE = None

block0.verified_transactions.append(t0)
digest = hash(block0)
last_block_hash = digest

TPCoins = [block0]
dump_blockchain(TPCoins)
```

Output

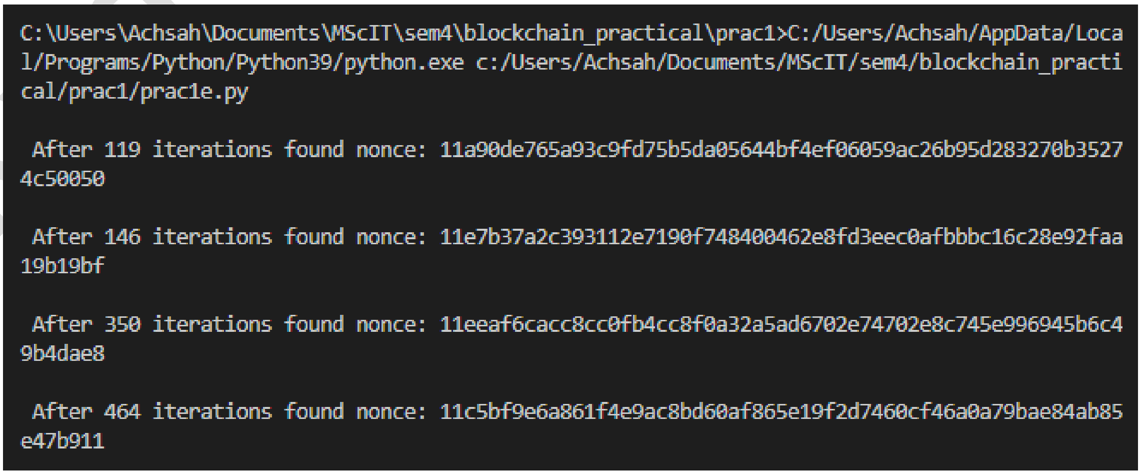


```
Number of blocks in the chain: 1
block # 0
sender: Genesis
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100b6dbe8af2c6f079fc7bdf8a
5f00cf97738460294c2cb1d968cd6e59961afb3a39c96e132ada370ac2802aa8a58bf2d6ef13d39c95f744b31af0
0467c883980d7e825fc83fcf6a4d925be93c50d3cd1691d58495bd07aded1ef8c05d9b5606dcef55dd85721d4804
3bd1b733f2eb7027fff0920abac3204b093247fcee235a5a90203010001
-----
value: 500.0
-----
time: 2023-04-22 22:40:58.531260
-----
--------------
=====================================
```

E) Create a mining function and test it.

```
import hashlib


def sha256(message):
    return hashlib.sha256(message.encode("ascii")).hexdigest()


def mine(message, difficulty=1):
    assert difficulty >= 1
    prefix = "1" * difficulty
    for i in range(1000):
        digest = sha256(str(hash(message)) + str(i))
        if digest.startswith(prefix):
            print(f"after {str(i)} iterations found nonce: {digest}")
            # return print(digest)


mine("test message", 2)
```

Output

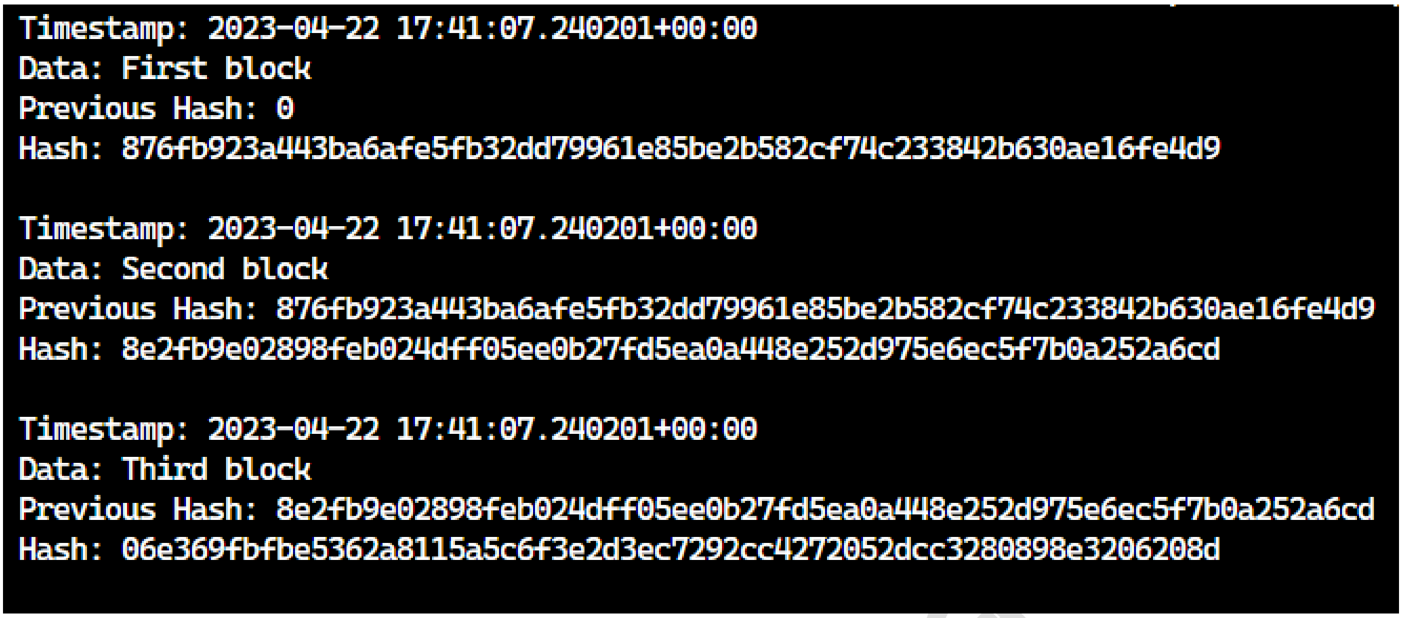


```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac1>C:/Users/Achsah/AppData/Loca
l/Programs/Python/Python39/python.exe c:/Users/Achsah/Documents/MScIT/sem4/blockchain_practi
cal/prac1/prac1e.py

 After 119 iterations found nonce: 11a90de765a93c9fd75b5da05644bf4ef06059ac26b95d283270b3527
4c50050

 After 146 iterations found nonce: 11e7b37a2c393112e7190f748400462e8fd3eec0afbbbc16c28e92faa
19b19bf

 After 350 iterations found nonce: 11eeaf6cacc8cc0fb4cc8f0a32a5ad6702e74702e8c745e996945b6c4
9b4dae8

 After 464 iterations found nonce: 11c5bf9e6a861f4e9ac8bd60af865e19f2d7460cf46a0a79bae84ab85
e47b911
```

F) Add blocks to the miner and dump the blockchain.

```
import datetime
import hashlib

# Create a class with two functions


class Block:
    def __init__(self, data, previous_hash):
        self.timestamp = datetime.datetime.now(datetime.timezone.utc)
        self.data = data
        self.previous_hash = previous_hash
        self.hash = self.calc_hash()

    def calc_hash(self):
        sha = hashlib.sha256()
        hash_str = self.data.encode("utf-8")
        sha.update(hash_str)
        return sha.hexdigest()


# Instantiate the class

blockchain = [Block("First block", "0")]

blockchain.append(Block("Second block", blockchain[0].hash))
blockchain.append(Block("Third block", blockchain[1].hash))

# Dumping the blockchain

for block in blockchain:
    print(
        f"Timestamp: {block.timestamp}\nData: {block.data}\nPrevious Hash:
{block.previous_hash}\nHash: {block.hash}\n"
    )
```

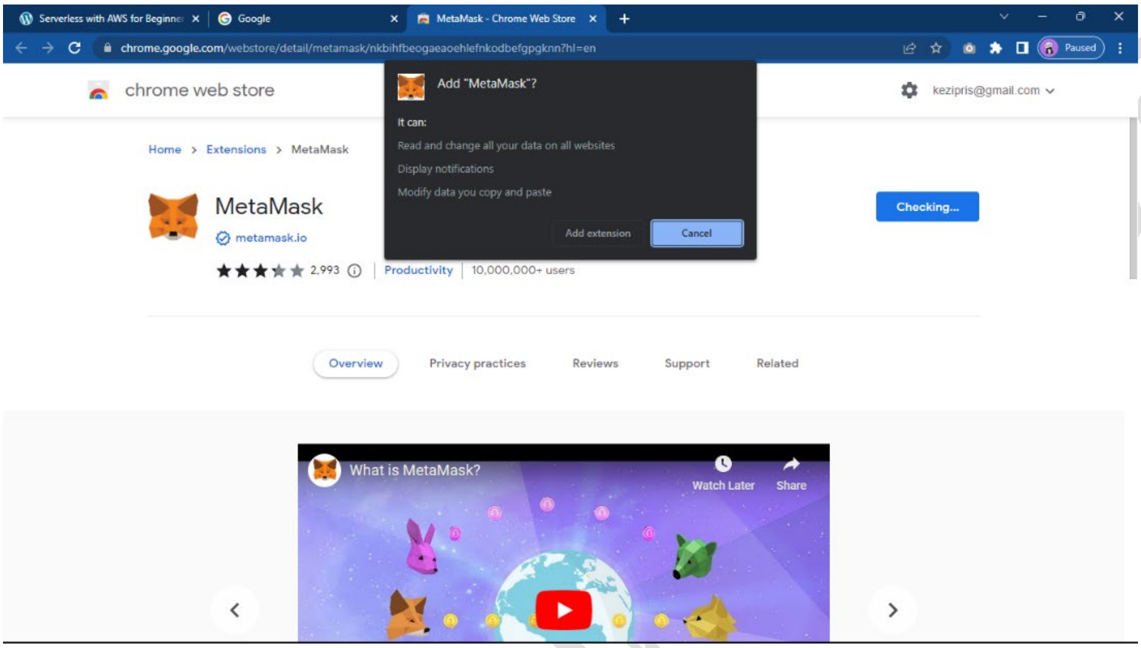
Output



```
Timestamp: 2023-04-22 17:41:07.240201+00:00
Data: First block
Previous Hash: 0
Hash: 876fb923a443ba6afe5fb32dd79961e85be2b582cf74c233842b630ae16fe4d9

Timestamp: 2023-04-22 17:41:07.240201+00:00
Data: Second block
Previous Hash: 876fb923a443ba6afe5fb32dd79961e85be2b582cf74c233842b630ae16fe4d9
Hash: 8e2fb9e02898feb024dff05ee0b27fd5ea0a448e252d975e6ec5f7b0a252a6cd

Timestamp: 2023-04-22 17:41:07.240201+00:00
Data: Third block
Previous Hash: 8e2fb9e02898feb024dff05ee0b27fd5ea0a448e252d975e6ec5f7b0a252a6cd
Hash: 06e369fbfbe5362a8115a5c6f3e2d3ec7292cc4272052dcc3280898e3206208d
```

PRACTICAL-2 INSTALL AND CONFIGURE GO ETHEREUM AND THE MIST BROWSER. DEVELOP AND TEST A SAMPLE APPLICATION(METAMASK & REMIX)

Step 1-> Install MetaMask extension for chrome from Chrome Web Store



chrome.google.com/webstore/detail/metamask/nkbihfbeogaeaoehlefnkodbefgpgknn?hl=en

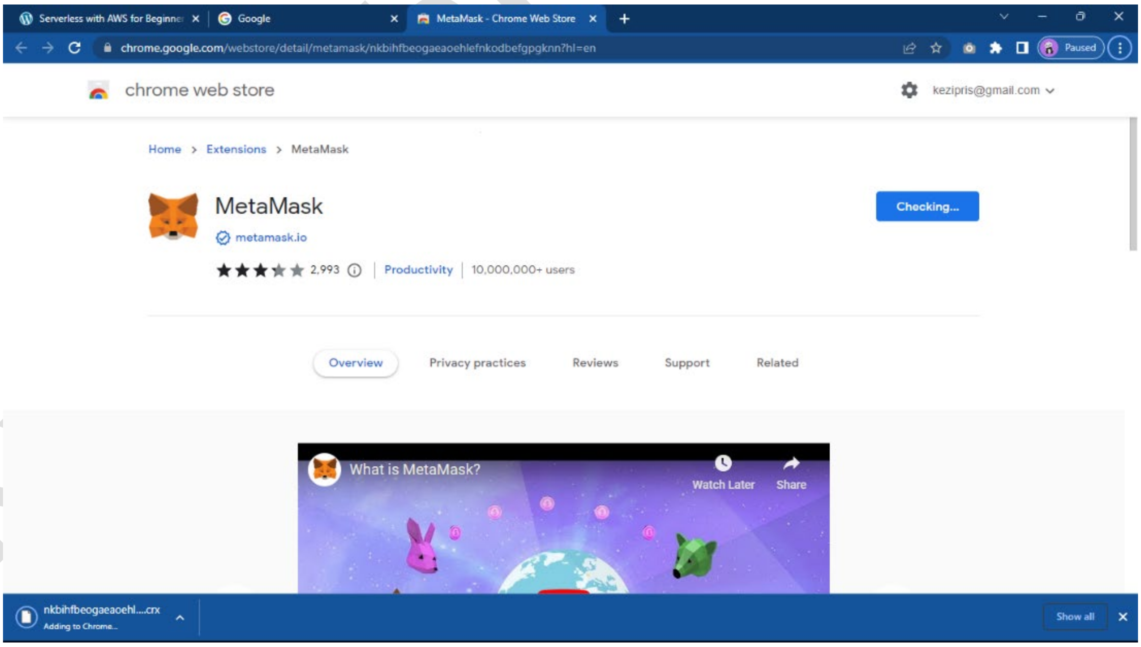
Add "MetaMask"?

It can:

Read and change all your data on all websites

Display notifications

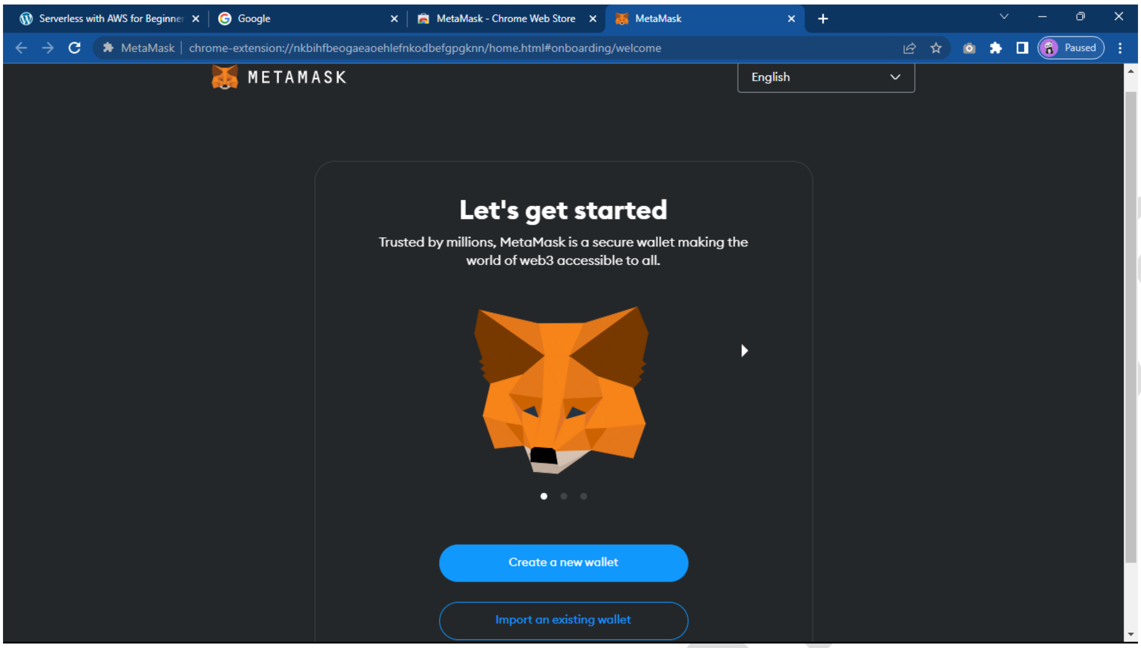
Modify data you copy and paste



chrome.google.com/webstore/detail/metamask/nkbihfbeogaeaoehlefnkodbefgpgknn?hl=en

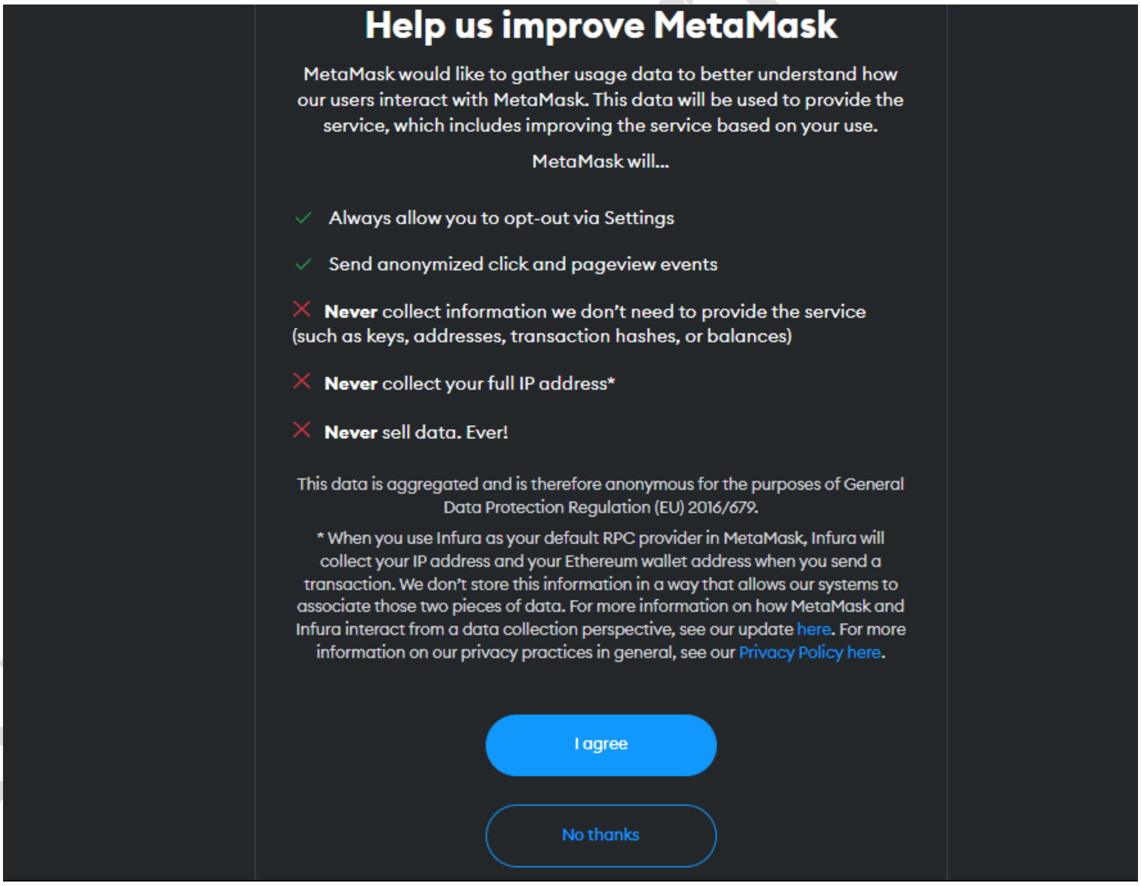
nkbihfbeogaeaoehl....crx
Adding to Chrome...

Step 2-> Click on Metamask Extension in Extensions. Below page will open in a new tab. Click on Create a New Wallet. Click on I agree.


Serverless with AWS for Beginner
Google
MetaMask - Chrome Web Store
MetaMask
MetaMask | chrome-extension://nkbihfbeogaeaoehlefnkodbefgpgknn/home.html#onboarding/welcome
Paused
METAMASK
English
Create a new wallet
Import an existing wallet

Let's get started

Trusted by millions, MetaMask is a secure wallet making the world of web3 accessible to all.



Help us improve MetaMask

MetaMask would like to gather usage data to better understand how our users interact with MetaMask. This data will be used to provide the service, which includes improving the service based on your use.

MetaMask will...

✓ Always allow you to opt-out via Settings

✓ Send anonymized click and pageview events

✗ **Never** collect information we don't need to provide the service (such as keys, addresses, transaction hashes, or balances)

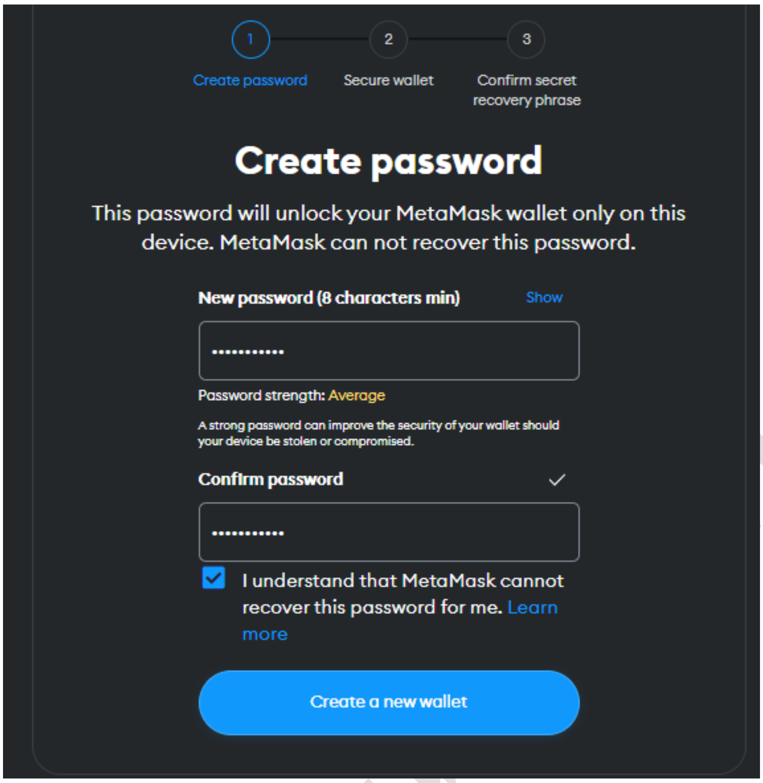
✗ **Never** collect your full IP address*

✗ **Never** sell data. Ever!

This data is aggregated and is therefore anonymous for the purposes of General Data Protection Regulation (EU) 2016/679.

* When you use Infura as your default RPC provider in MetaMask, Infura will collect your IP address and your Ethereum wallet address when you send a transaction. We don't store this information in a way that allows our systems to associate those two pieces of data. For more information on how MetaMask and Infura interact from a data collection perspective, see our update here. For more information on our privacy practices in general, see our Privacy Policy here.

Step 3-> Create a password. This password can be used only on the device it was created on. Create a Strong password and click on Create a new Wallet button



1 Create password — 2 Secure wallet — 3 Confirm secret recovery phrase

Create password

This password will unlock your MetaMask wallet only on this device. MetaMask can not recover this password.

New password (8 characters min) Show

···········

Password strength: Average

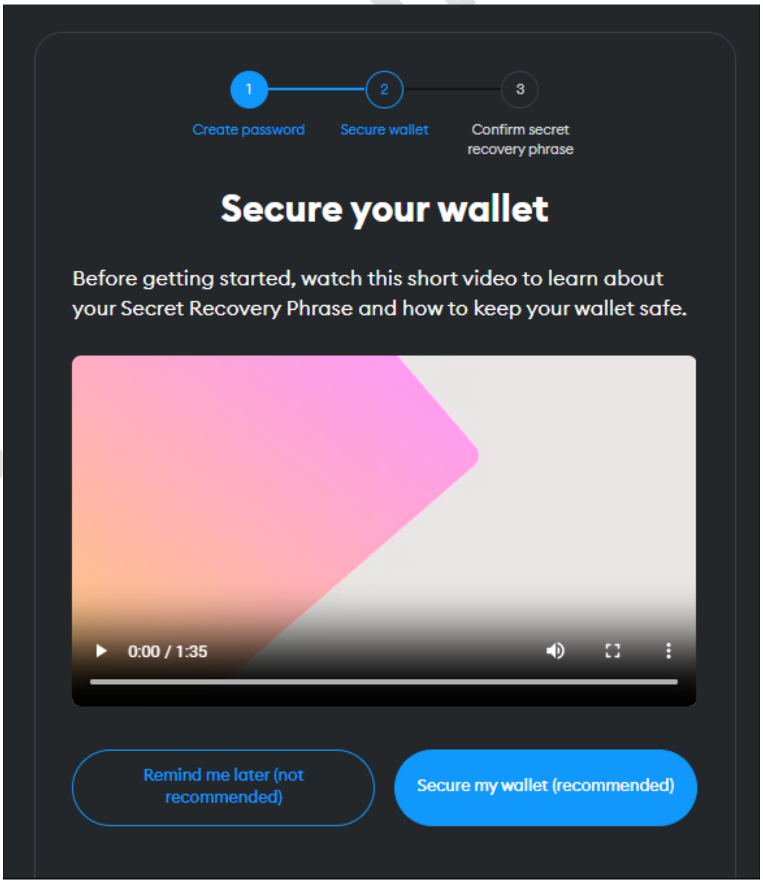
A strong password can improve the security of your wallet should your device be stolen or compromised.

Confirm password ✓

···········

☑ I understand that MetaMask cannot recover this password for me. Learn more

Create a new wallet



1 Create password — 2 Secure wallet — 3 Confirm secret recovery phrase

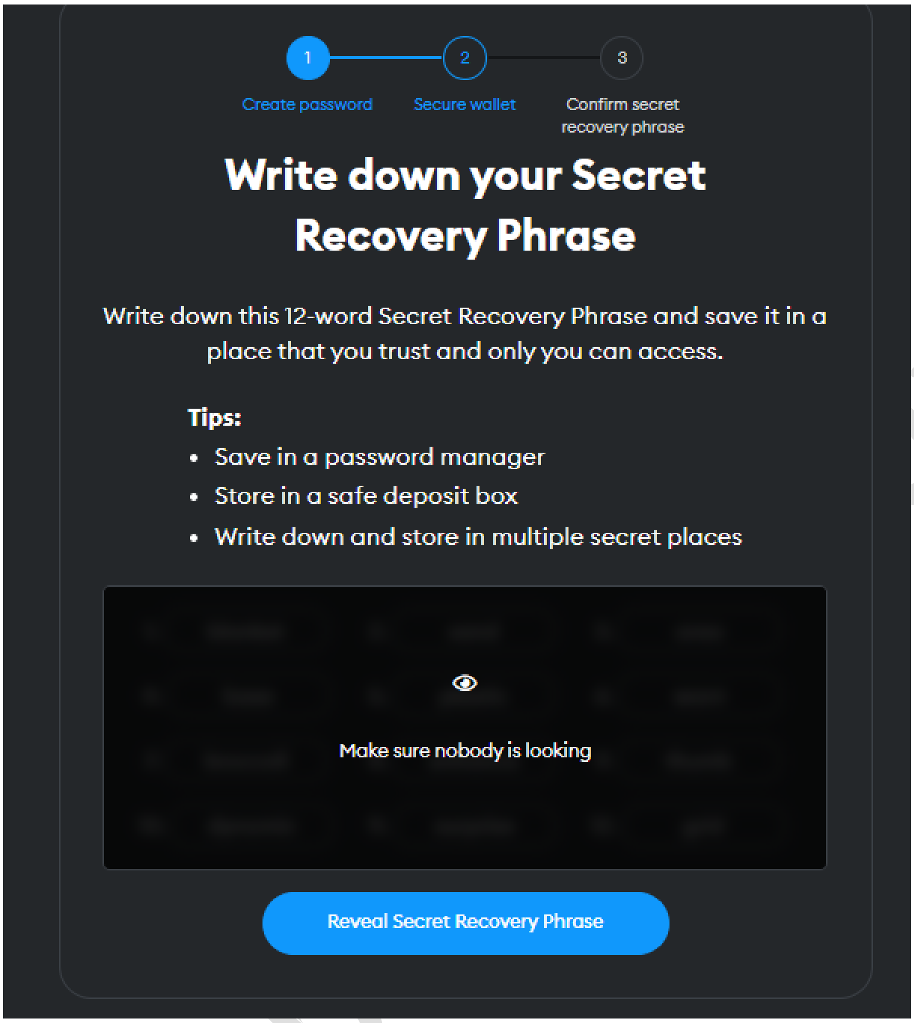
Secure your wallet

Before getting started, watch this short video to learn about your Secret Recovery Phrase and how to keep your wallet safe.

Remind me later (not recommended)

Secure my wallet (recommended)

Step 4-> Click on Secure my wallet button, following window will appear



Write down your Secret Recovery Phrase

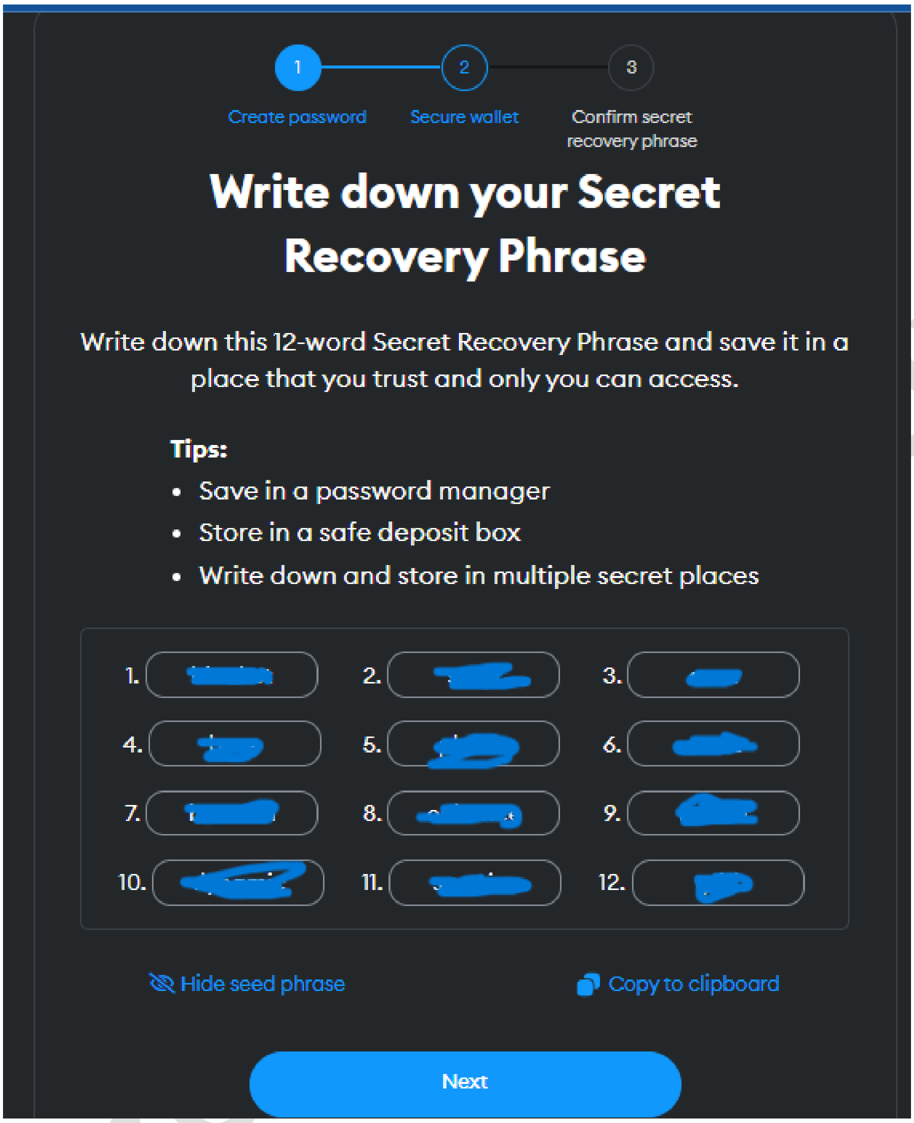
Write down this 12-word Secret Recovery Phrase and save it in a place that you trust and only you can access.

Tips:

- Save in a password manager
- Store in a safe deposit box
- Write down and store in multiple secret places

Make sure nobody is looking

Step 5-> Click on Reveal Secret Recovery Phrase button and save the words in the same sequence



Write down your Secret Recovery Phrase

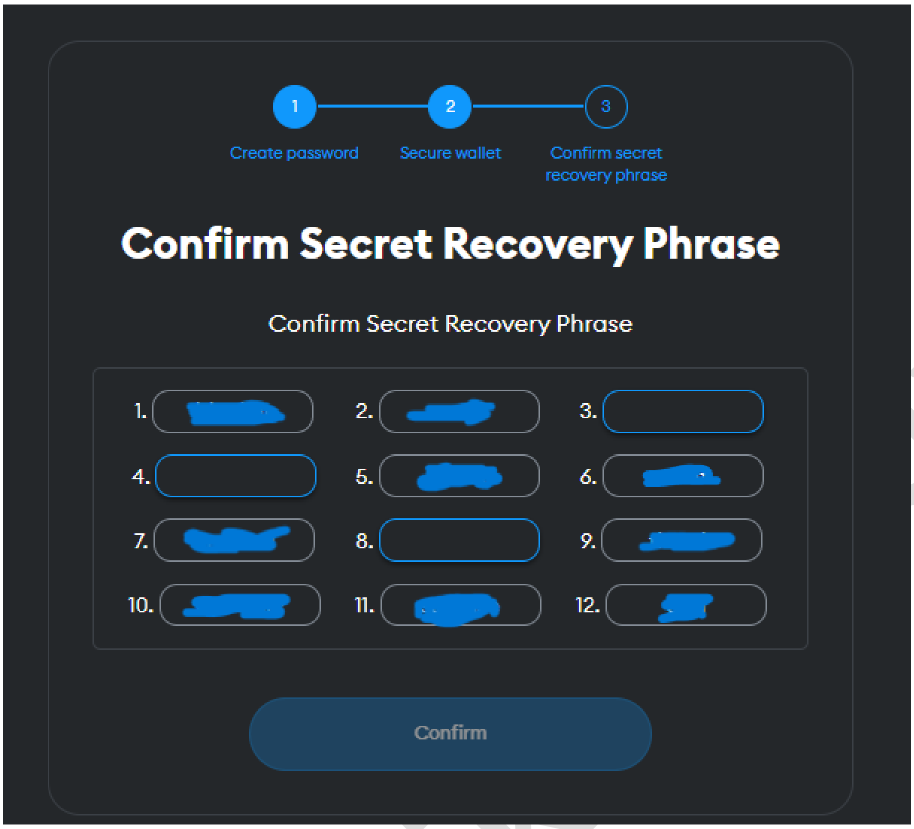
Write down this 12-word Secret Recovery Phrase and save it in a place that you trust and only you can access.

Tips:

- Save in a password manager
- Store in a safe deposit box
- Write down and store in multiple secret places

1. [redacted]	2. [redacted]	3. [redacted]
4. [redacted]	5. [redacted]	6. [redacted]
7. [redacted]	8. [redacted]	9. [redacted]
10. [redacted]	11. [redacted]	12. [redacted]

Step 6-> Enter the respective words in the empty positions and click Confirm.

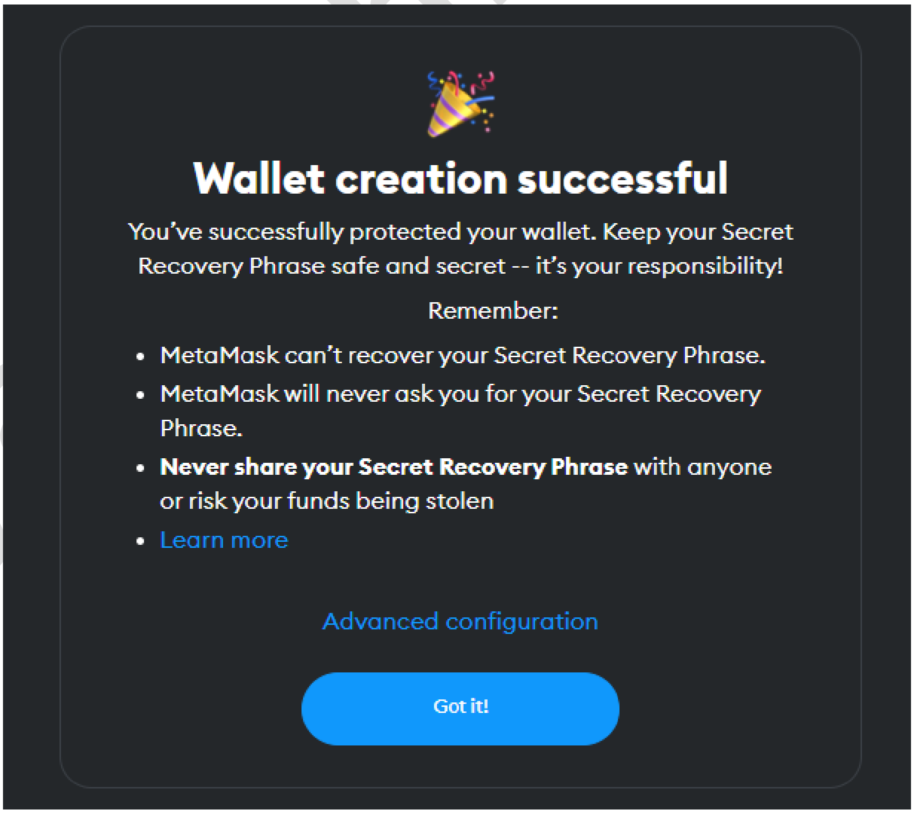


Confirm Secret Recovery Phrase

Confirm Secret Recovery Phrase

1. [redacted]	2. [redacted]	3.
4.	5. [redacted]	6. [redacted]
7. [redacted]	8.	9. [redacted]
10. [redacted]	11. [redacted]	12. [redacted]

Step 7-> Click Got it!



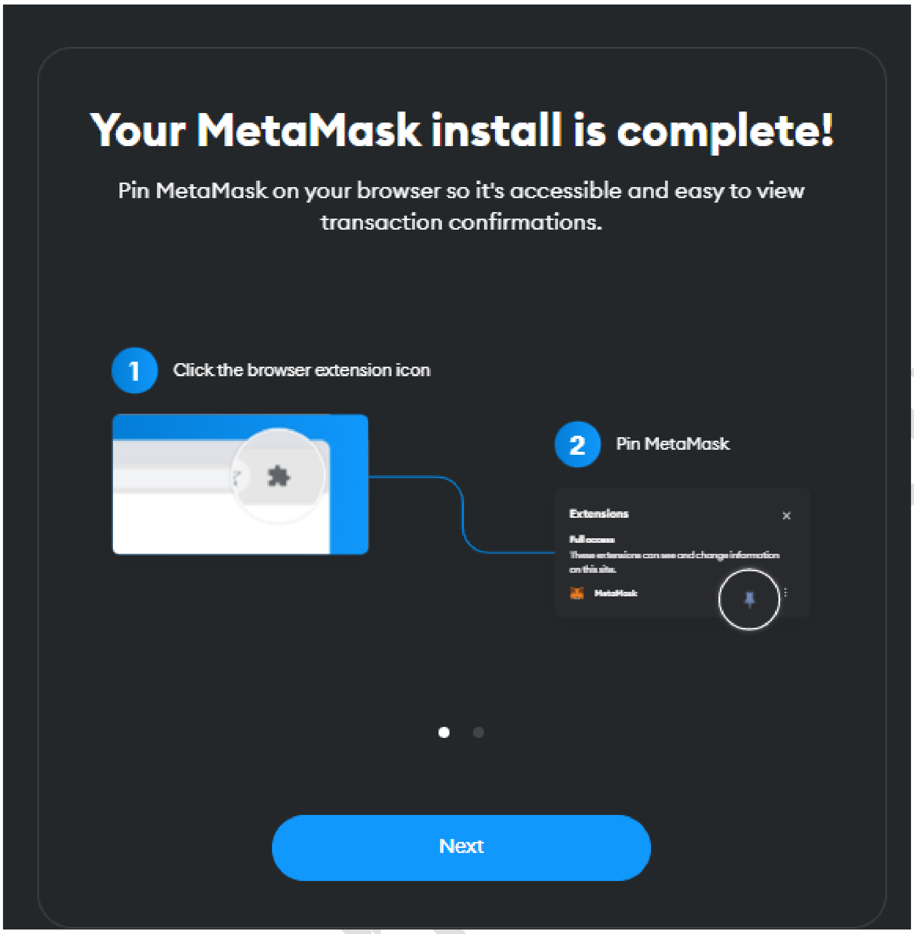
Wallet creation successful

You've successfully protected your wallet. Keep your Secret Recovery Phrase safe and secret -- it's your responsibility!

Remember:

- MetaMask can't recover your Secret Recovery Phrase.
- MetaMask will never ask you for your Secret Recovery Phrase.
- **Never share your Secret Recovery Phrase** with anyone or risk your funds being stolen
- Learn more

Step 8-> Click on Next



Your MetaMask install is complete!

Pin MetaMask on your browser so it's accessible and easy to view transaction confirmations.

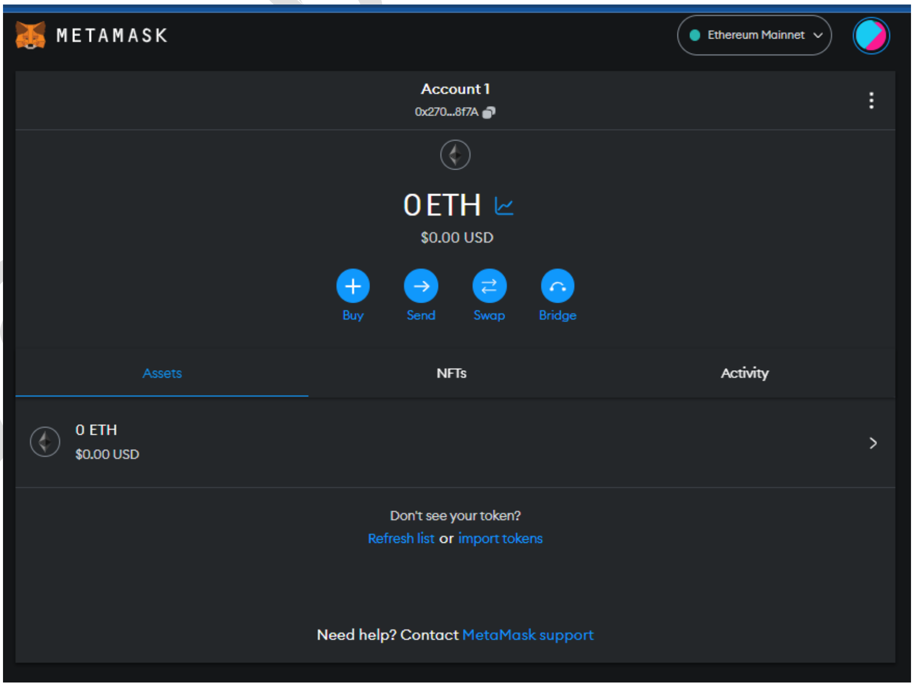
1 Click the browser extension icon

2 Pin MetaMask

Extensions
Full access
These extensions can see and change information on this site.
MetaMask

Next

Step 9-> Following will be the Dashboard



Account 1
0x270...8f7A

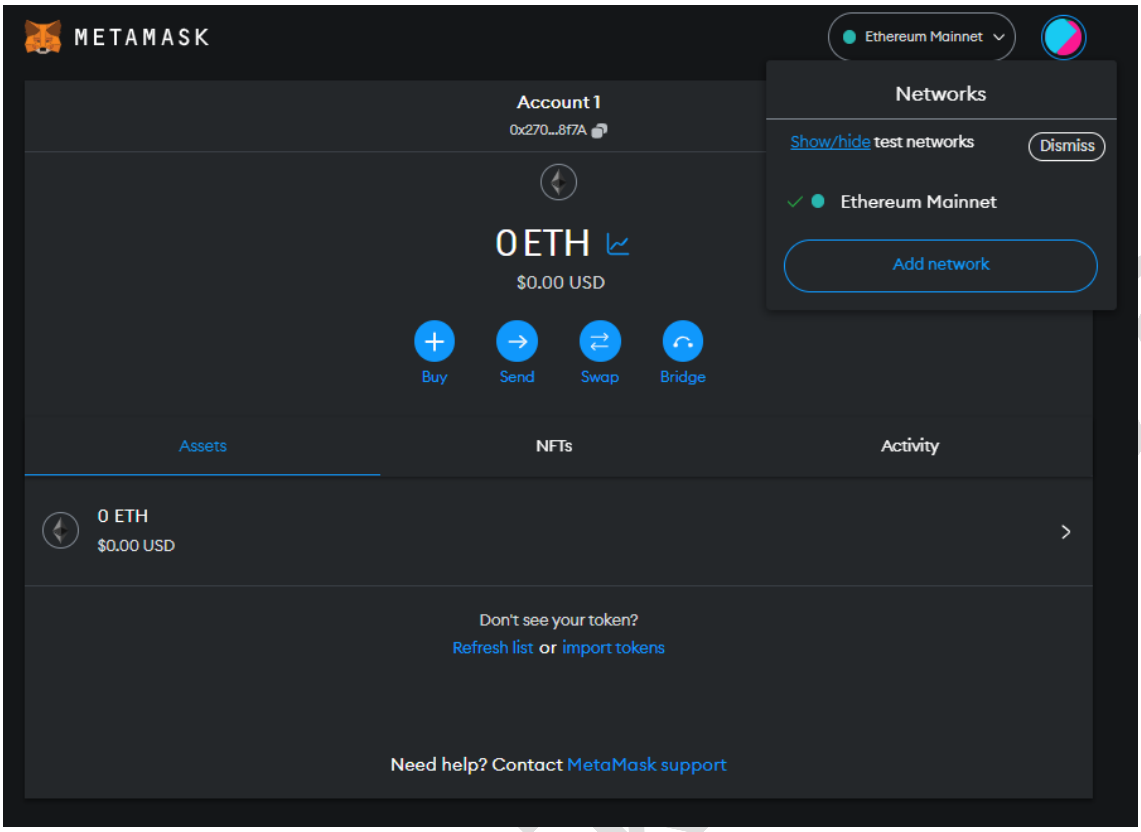
0 ETH
$0.00 USD

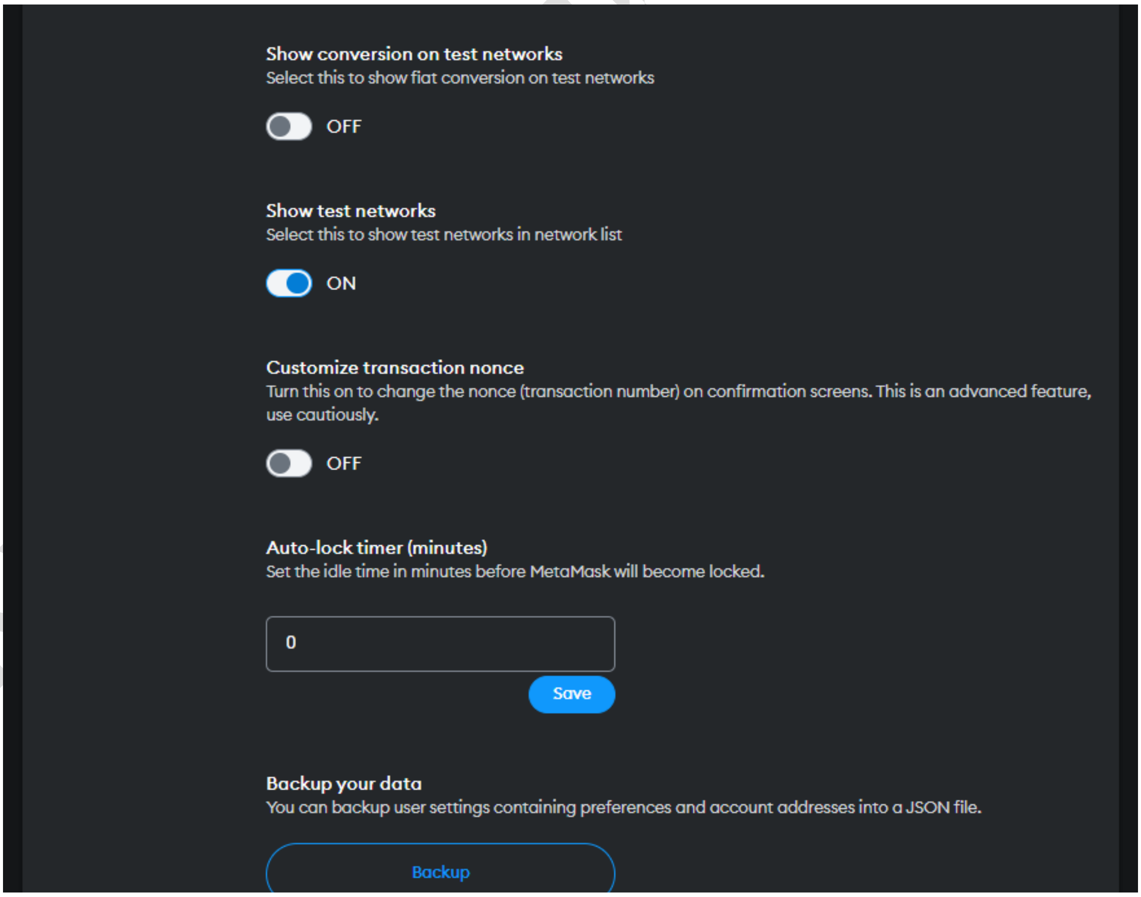
0 ETH
$0.00 USD

Don't see your token?
Refresh list or import tokens

Need help? Contact MetaMask support

Step 10-> Click on Ethereum Mainnet button. Next click on Show/hide test networks.





Show conversion on test networks
Select this to show fiat conversion on test networks

OFF

Show test networks
Select this to show test networks in network list

ON

Customize transaction nonce
Turn this on to change the nonce (transaction number) on confirmation screens. This is an advanced feature, use cautiously.

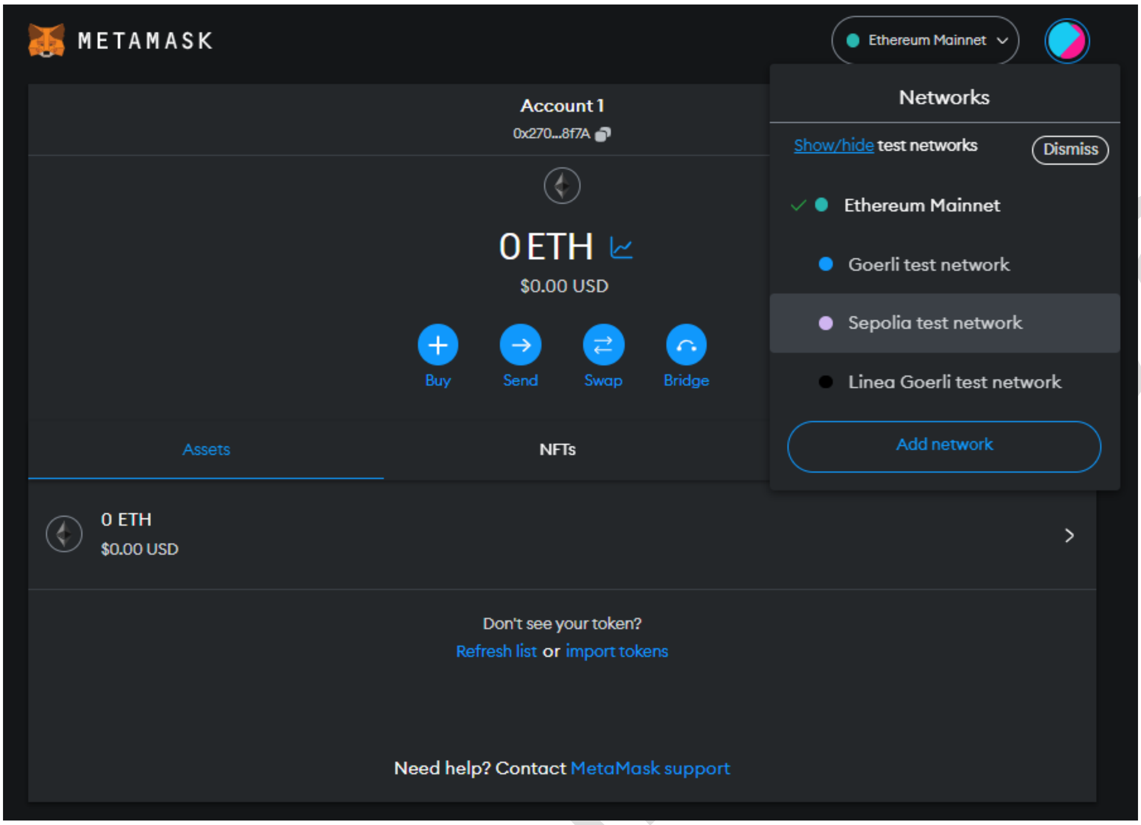
OFF

Auto-lock timer (minutes)
Set the idle time in minutes before MetaMask will become locked.

0

Backup your data
You can backup user settings containing preferences and account addresses into a JSON file.

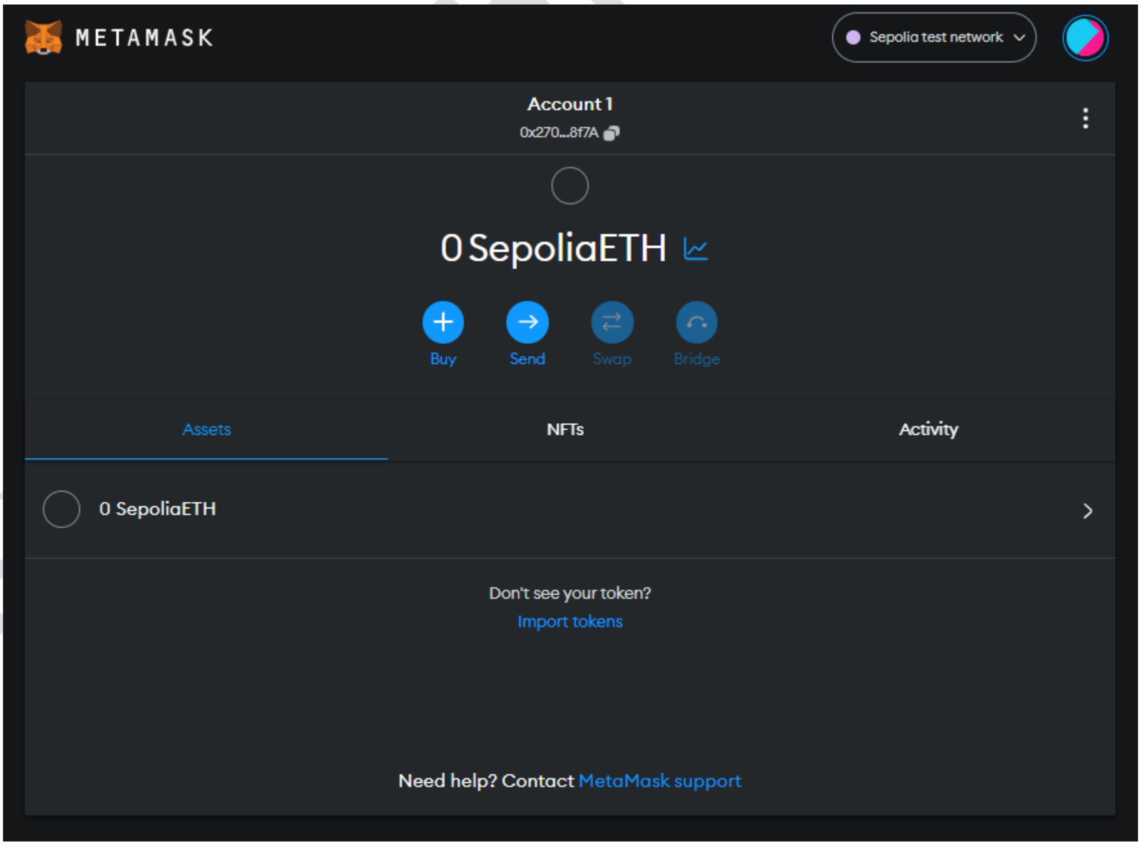
Step 11-> Check if tesnets are shown by clicking on Etherum Mainnet button. Click on Sepolia test network.



Don't see your token?

Refresh list or import tokens

Need help? Contact MetaMask support

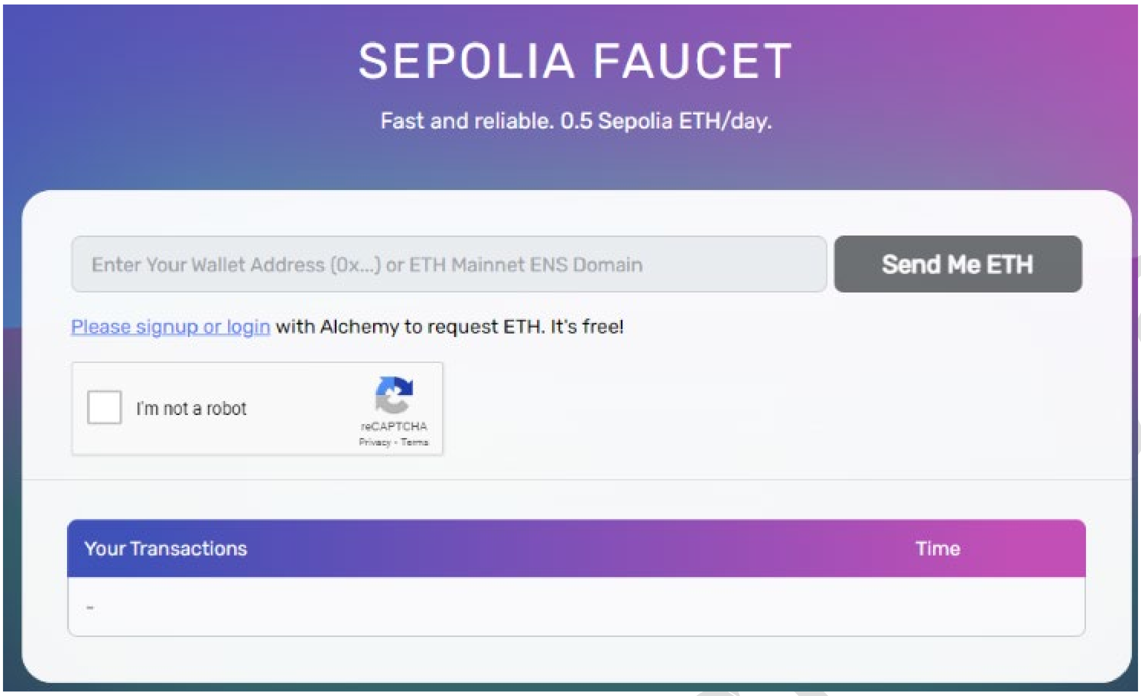


Don't see your token?

Import tokens

Need help? Contact MetaMask support

Step 12-> Go to https://sepoliafaucet.com/ and Click on Alchemy Login button.

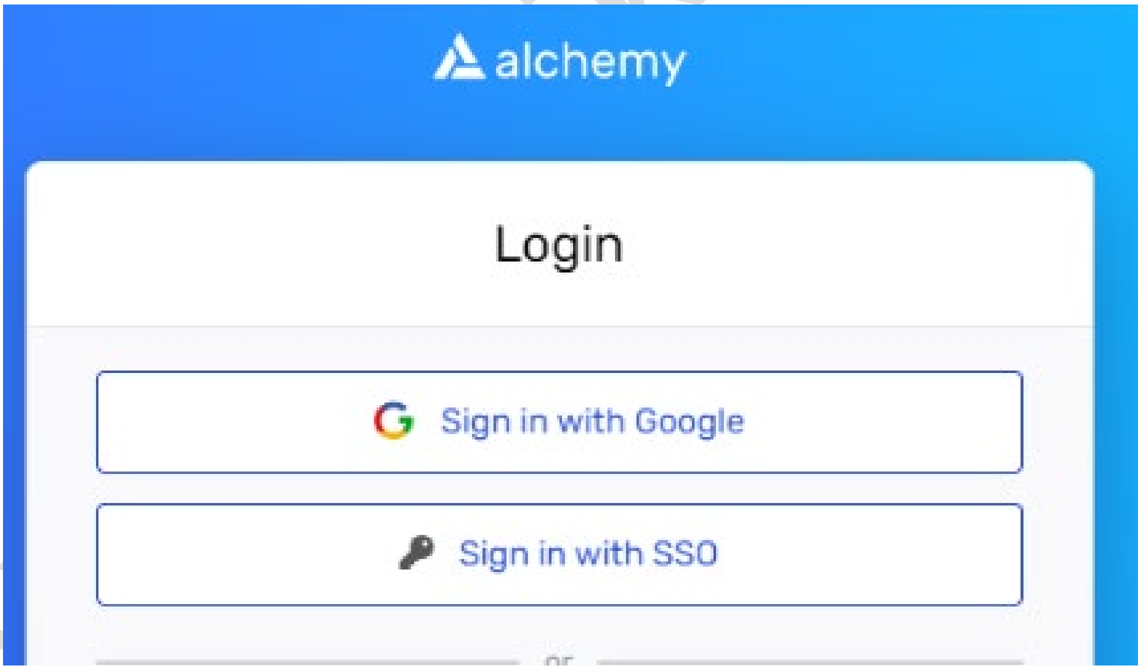


SEPOLIA FAUCET

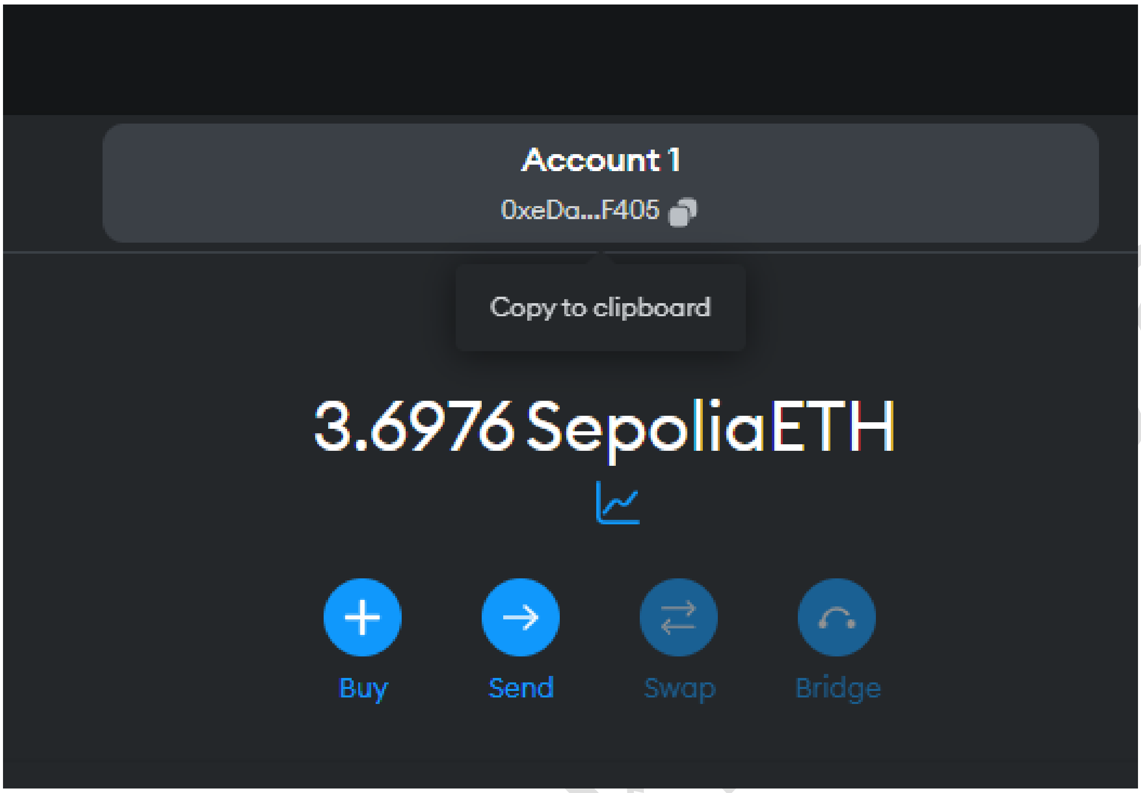
Fast and reliable. 0.5 Sepolia ETH/day.

Please signup or login with Alchemy to request ETH. It's free!

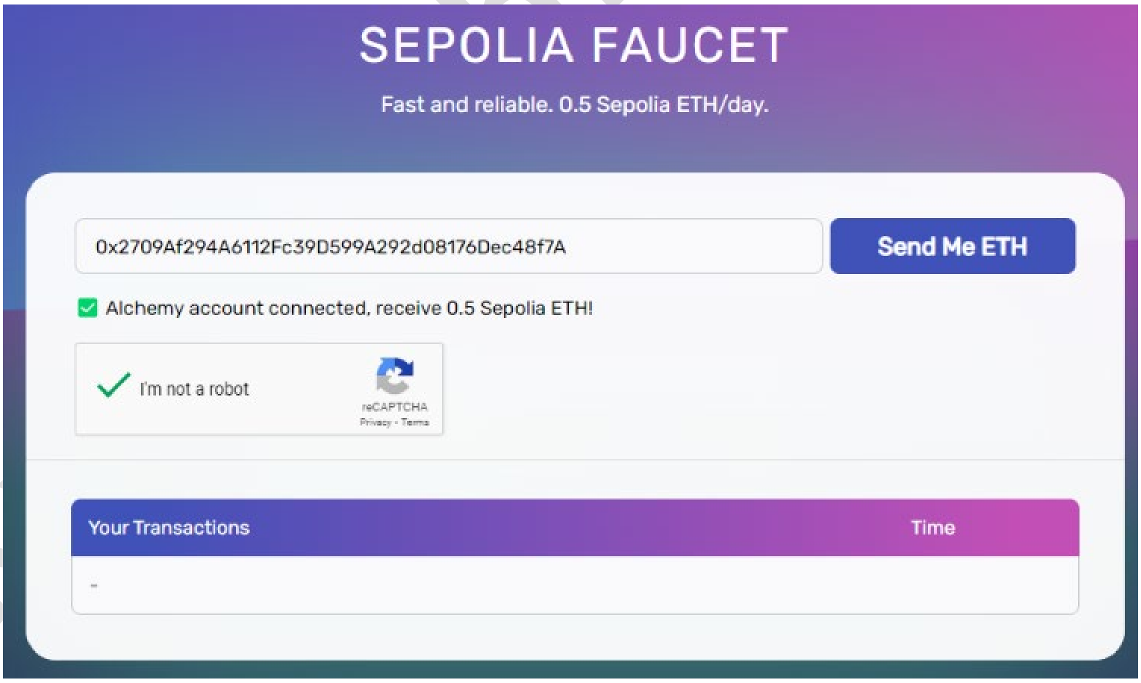
Step 13-> Login to a gmail account in another browser tab and click on Sign in with Google



Step 14-> Now go to MetaMask and copy the account address.



Step 15-> Paste the address and click on Send Me ETH.



SEPOLIA FAUCET

Fast and reliable. 0.5 Sepolia ETH/day.

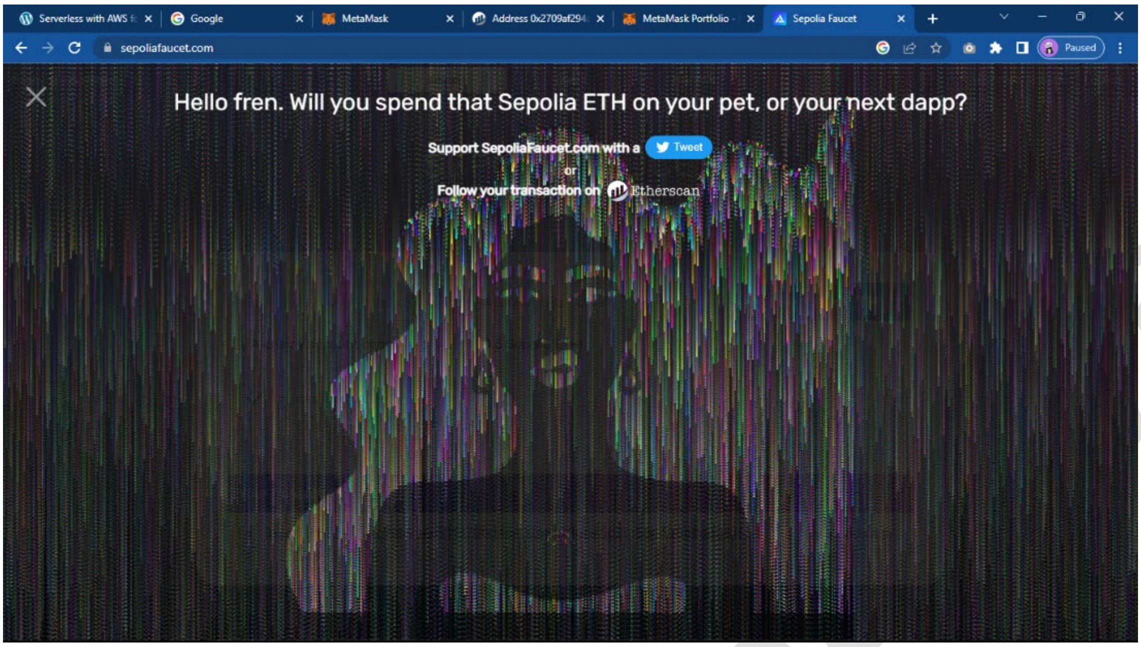
0x2709Af294A6112Fc39D599A292d08176Dec48f7A

☑ Alchemy account connected, receive 0.5 Sepolia ETH!

✓ I'm not a robot

Your Transactions	Time
-	

Step 16-> Your ETH transfer is succesfull. You should see a similar animation.



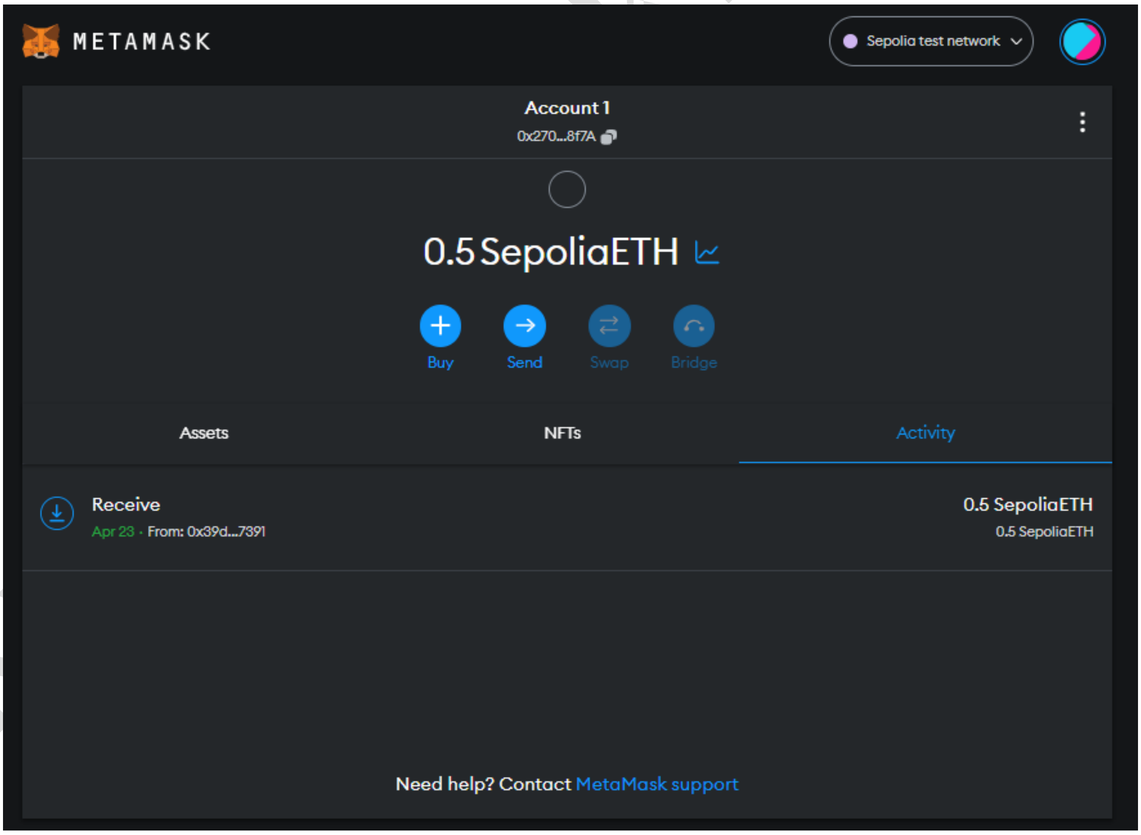
Hello fren. Will you spend that Sepolia ETH on your pet, or your next dapp?

Support SepoliaFaucet.com with a Tweet

or

Follow your transaction on Etherscan

Step 17-> Check your MetaMask account for Sepolia test network. 0.5 ETH will be added.



Account 1

0x270...8f7A

0.5 SepoliaETH

Receive — 0.5 SepoliaETH

Apr 23 · From: 0x39d...7391 — 0.5 SepoliaETH

Need help? Contact MetaMask support

PRACTICAL-3 IMPLEMENT AND DEMONSTRATE THE USE OF THE FOLLOWING IN SOLIDITY

1. To execute Solidity scripts go to ->https://remix.ethereum.org/

2. Open contracts folder and starting writing scripts. The scripts are compiled using Solidity compiler.

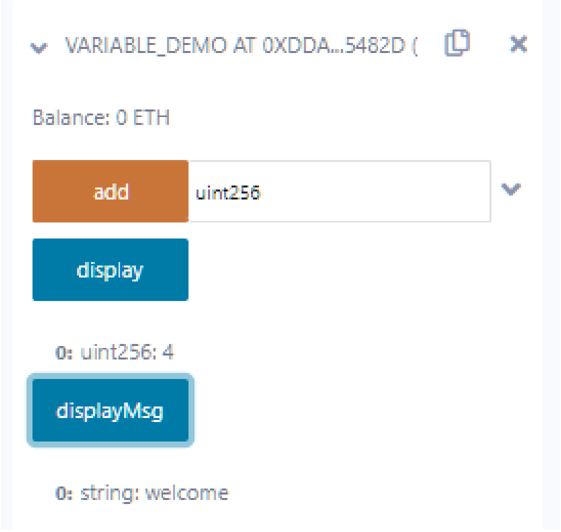
3. The following scripts were compiled using 0.5.0+commit.1d4f565a Solidity compiler

4. Deploy the scripts to execute code

A)Variable, Operators, Loops, Decision Making, Strings, Arrays, Enums, Structs, Mappings, Conversions, Ether Units, Special Variables

1. Variable

```
pragma solidity ^0.5.0;

contract variable_demo {
    uint256 sum = 4; //state variable
    uint256 x;
    address a;
    string s = "welcome";

    function add(uint256) public {
        uint256 y = 2; //local variable sum = sum+x+y:
        sum = sum + x + y;
    }

    function display() public view returns (uint256) {
        return sum;
    }

    function displayMsg() public view returns (string memory) {
        return s;
    }
}
```



Balance: 0 ETH

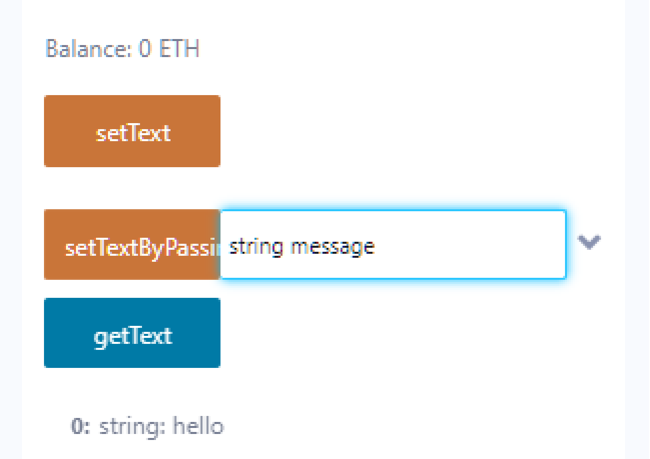
0: uint256: 4

0: string: welcome

FIGURE 1 -DISPLAYING VARIABLE VALUE

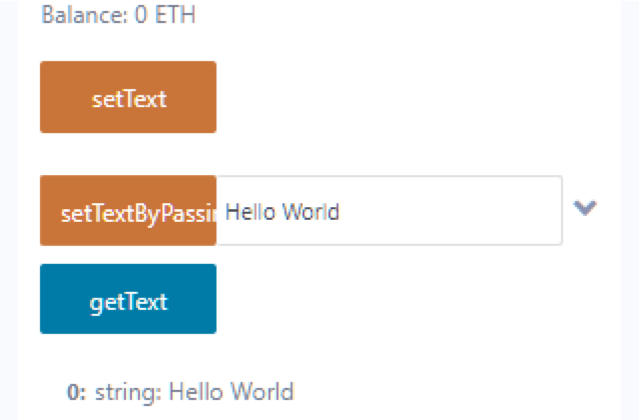
2. Strings

```
pragma solidity ^0.5.0;

contract LearningStrings {
    string text;

    function getText() public view returns (string memory) {
        return text;
    }

    function setText() public {
        text = "hello";
    }

    function setTextByPassing(string memory message) public {
        text = message;
    }
}
```



```
0: string: hello
```

Figure 2 - Before setting new string value



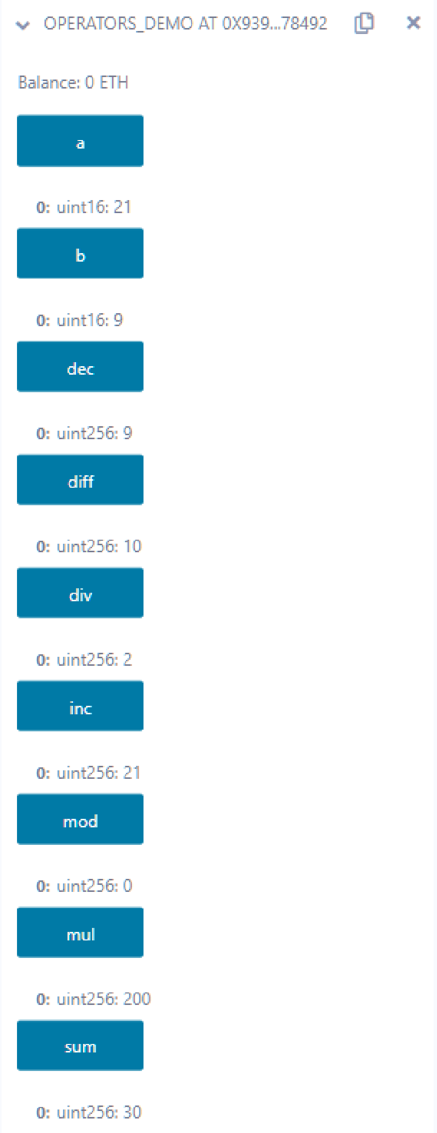
Hello World

```
0: string: Hello World
```

Figure 3 - After setting string value

3. Operators

```
pragma solidity ^0.5.0;

contract SolidityTest {
    uint16 public a = 20;
    uint16 public b = 10;
    uint256 public sum = a + b;
    uint256 public diff = a - b;
    uint256 public mul = a * b;
    uint256 public div = a / b;
    uint256 public mod = a % b;
    uint256 public dec = --b;
    uint256 public inc = ++a;
}
```



OPERATORS_DEMO AT 0X939...78492

Balance: 0 ETH

a

0: uint16: 21

b

0: uint16: 9

dec

0: uint256: 9

diff

0: uint256: 10

div

0: uint256: 2

inc

0: uint256: 21

mod

0: uint256: 0

mul

0: uint256: 200

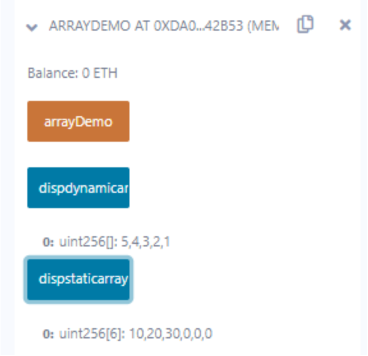
sum

0: uint256: 30

FIGURE 4 - ALL OPERATORS OF SOLIDITY DISPLAYED

4. Array

```
pragma solidity ^0.5.0;
contract arraydemo
{
    //Static Array
    uint[6] arr2=[10,20,30];
    function dispstaticarray() public view returns(uint[6] memory)
    {
        return arr2;
    }
    //Dynamic Array
    uint x=5;
    uint [] arr1;
    function arrayDemo() public
    {
        while(x>0)
        {
            arr1.push(x);
            x=x-1;
        }
    }
    function dispdynamicarray() public view returns(uint[] memory)
    {
        return arr1;
    }
}
```



ARRAYDEMO AT 0XDA0...42B53 (MEM

Balance: 0 ETH

0: uint256[]: 5,4,3,2,1

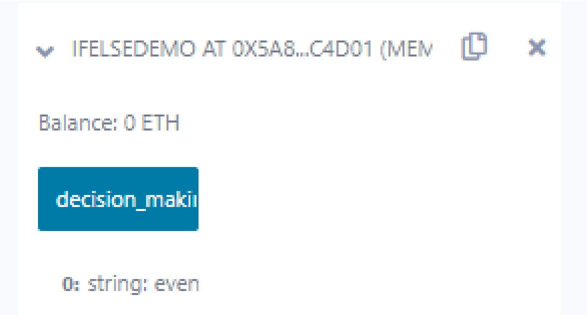
0: uint256[6]: 10,20,30,0,0,0

FIGURE 5 - ARRAY DISPLAYED

5. Decision Making

If Else

```
pragma solidity ^0.5.0;

contract ifelsedemo

{

    uint i=10;

    function decision_making() public view returns(string memory)

    {

        if(i%2==0)

        {

            return "even";

        }

        else

        {

            return "Odd";

        }

    }

}
```



IFELSEDEMO AT 0X5A8...C4D01 (MEM

Balance: 0 ETH

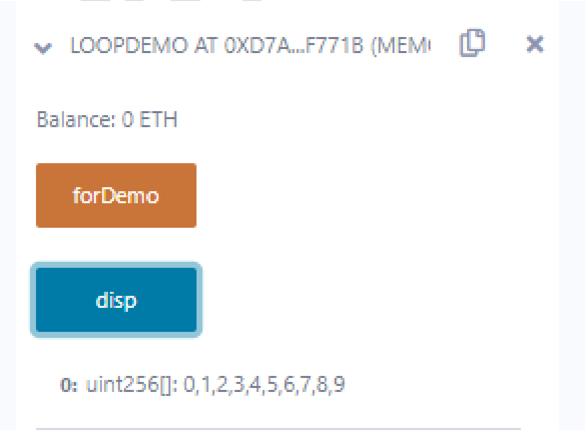
0: string: even

FIGURE 6 - IF ELSE OUTPUT

6. Loops

For Loop

```
pragma solidity ^0.5.0;

contract loopDemo

{

    uint [] data;

    function forDemo() public returns(uint[] memory)

    {

        for(uint i=0; i<10; i++){

            data.push(i);

        }

        return data;

    }

    function disp() public view returns(uint[] memory)

    {

        return data;

    }

}
```

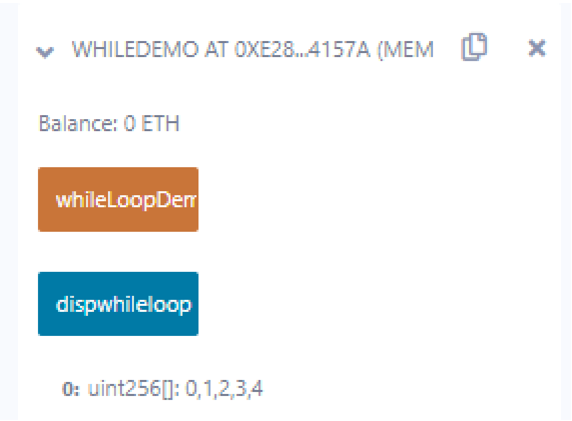


```
0: uint256[]: 0,1,2,3,4,5,6,7,8,9
```

FIGURE 7 - APPENDING VALUES TO ARRAY USING FOR LOOP

While Loop

```
pragma solidity ^0.5.0;

contract whiledemo

{

    uint [] data;

    uint x=0;



    function whileLoopDemo() public

    {

        while(x<5)

        {

            data.push(x);

            x=x+1;

        }

    }



    function dispwhileloop() public view returns(uint[] memory)

    {

        return data;

    }

}
```



WHILEDEMO AT 0XE28...4157A (MEM

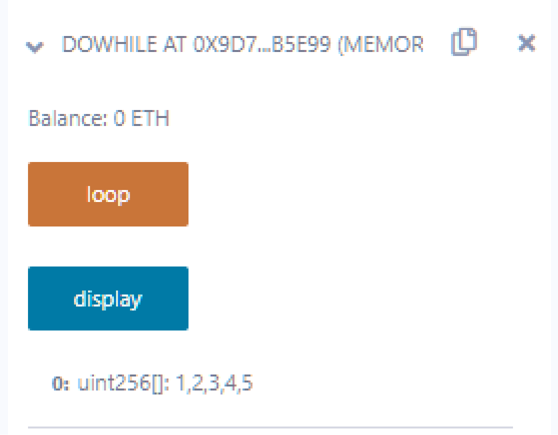
Balance: 0 ETH

0: uint256[]: 0,1,2,3,4

FIGURE 8 - APPENDING VALUES TO ARRAY USING WHILE LOOP

Do While

```
pragma solidity ^0.5.0;

// Creating a contract
contract DoWhile {
    // Declaring a dynamic array
    uint256[] data;

    // Declaring state variable
    uint8 j = 0;

    // Defining function to demonstrate
    // 'Do-While loop'
    function loop() public returns (uint256[] memory) {
        do {
            j++;
            data.push(j);
        } while (j < 5);
        return data;
    }
    function display() public view  returns(uint256[] memory){
        return data;
    }
}
```

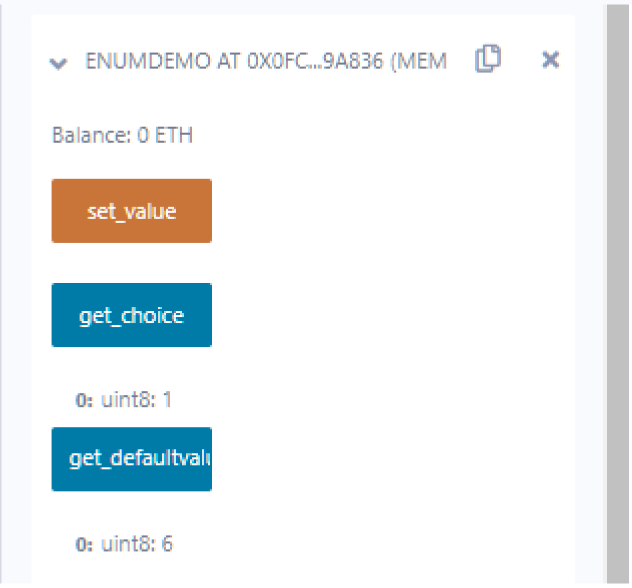


```
0: uint256[]: 1,2,3,4,5
```

FIGURE 9 APPENDING VALUES TO ARRAY USING DO WHILE LOOP

7. Enums

```
pragma solidity ^0.5.0;

contract enumdemo {
    enum week_days {
        Monday,
        Tuesday,
        Wednesday,
        Thursday,
        Friday,
        Saturday,
        Sunday
    }

    week_days week;
    week_days choice;
    week_days constant default_value = week_days.Sunday;

    function set_value() public {
        choice = week_days.Tuesday;
    }

    function get_choice() public view returns (week_days) {
        return choice;
    }

    function get_defaultvalue() public view returns (week_days) {
        return default_value;
    }
}
```



Balance: 0 ETH

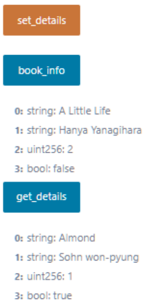
```
0: uint8: 1
```

```
0: uint8: 6
```

FIGURE 10 – ACCESSING ENUM VALUES

8. Structs

```
pragma solidity ^0.5.0;

contract structdemo {
    struct Book {
        string name;
        string author;
        uint256 id;
        bool availability;
    }
    Book book2;
    Book book1 = Book("A Little Life", "Hanya Yanagihara", 2, false);

    function set_details() public {
        book2 = Book("Almond", "Sohn won-pyung", 1, true);
    }

    function book_info()
        public
        view
        returns (
            string memory,
            string memory,
            uint256,
            bool
        )
    {
        return (book1.name, book1.author, book1.id, book1.availability);
    }

    function get_details()
        public
        view
        returns (
            string memory, string memory, uint256, bool
        )
    {
        return (book2.name, book2.author, book2.id, book2.availability);
    }
}
```



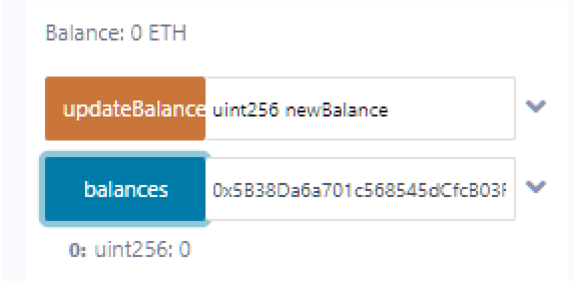
```
0: string: A Little Life
1: string: Hanya Yanagihara
2: uint256: 2
3: bool: false
```

```
0: string: Almond
1: string: Sohn won-pyung
2: uint256: 1
3: bool: true
```

FIGURE 11- STRUCTURE DATATYPE IN SOLIDITY

9. Mappings

```
pragma solidity ^0.5.0;

contract LedgerBalance {
    mapping(address => uint256) public balances;

    function updateBalance(uint256 newBalance) public {
        balances[msg.sender] = newBalance;
    }
}

contract Updater {
    function updateBalance() public returns (uint256) {
        LedgerBalance ledgerBalance = new LedgerBalance();
        return ledgerBalance.balances(address(this));
    }
}
```

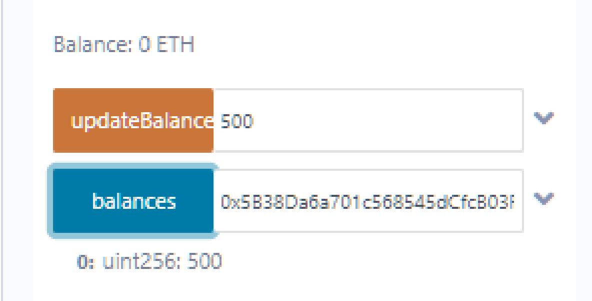


Balance: 0 ETH

0x5B38Da6a701c568545dCfcB03F

0: uint256: 0

FIGURE 12 - BEFORE UPDATING BALANCE



Balance: 0 ETH

500

0x5B38Da6a701c568545dCfcB03F

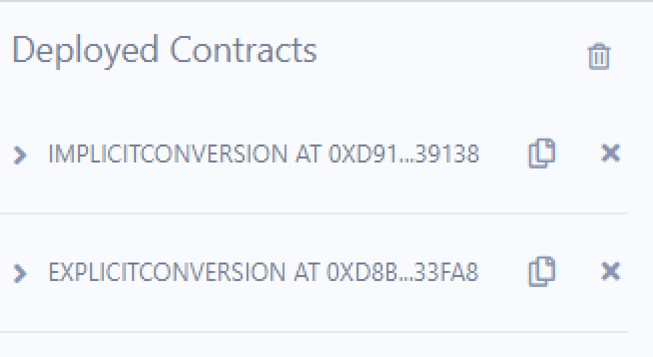
0: uint256: 500

FIGURE 13 - AFTER UPDATING BALANCE

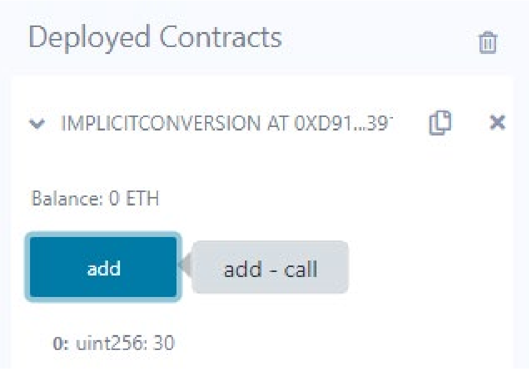
10. Conversions

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract ImplicitConversion {
    function add() public pure returns (uint256) {
        uint256 a = 10;
        uint256 b = 20;
        return a + b;
    }
}

contract ExplicitConversion {
    function convert() public pure returns (bytes memory) {
        string memory str = "Hello World";
        bytes memory b = bytes(str);
        return b;
    }
}
```

Step 1-> Deploy both contracts

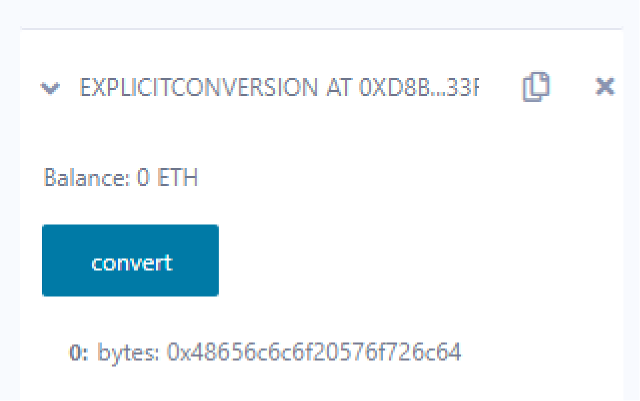

Deployed Contracts
IMPLICITCONVERSION AT 0XD91...39138
EXPLICITCONVERSION AT 0XD8B...33FA8

Step 2-> Open Implicit Conversion and click on add button to sum and display value



0: uint256: 30

Step 3-> Open Explicit Conversion and click on convert button

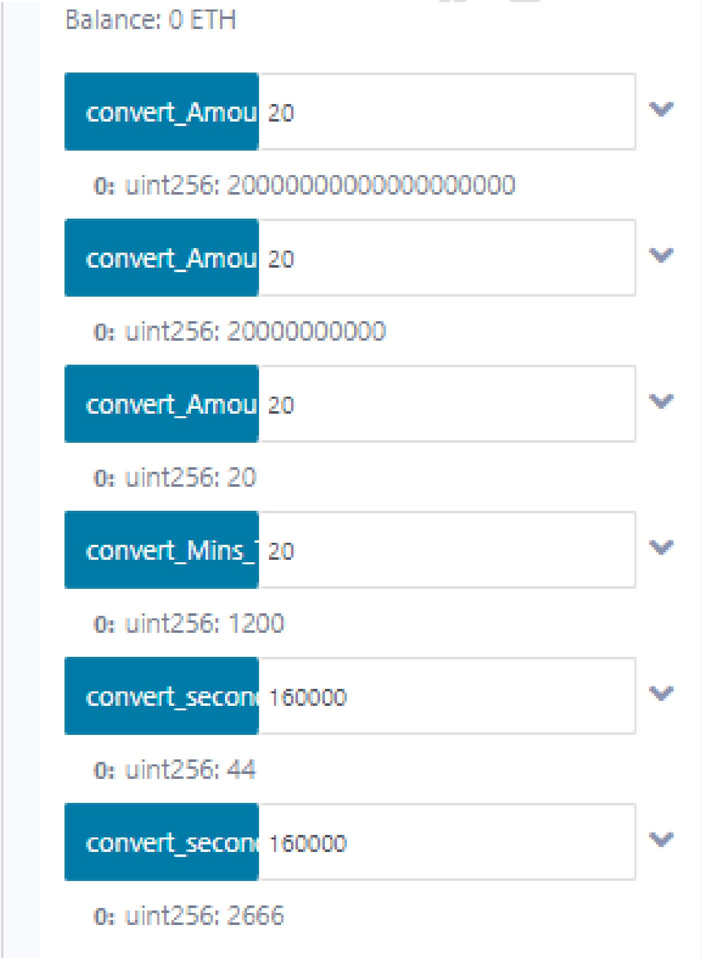


Balance: 0 ETH

0: bytes: 0x48656c6c6f20576f726c64

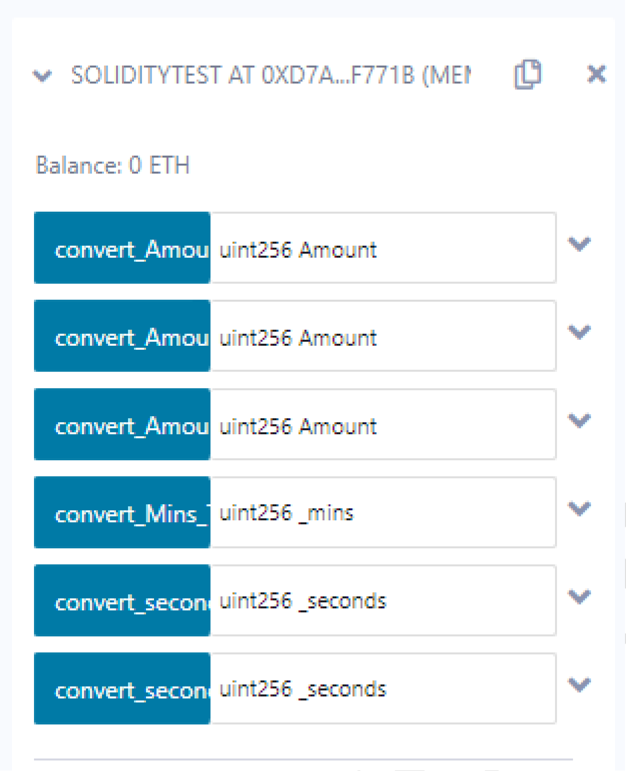
11. Ether Units

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract SolidityTest {
    function convert_Amount_to_Wei(uint256 Amount)
        public
        pure
        returns (uint256)
    {
        return Amount * 1 wei;
    }

    function convert_Amount_To_Ether(uint256 Amount)
        public
        pure
        returns (uint256)
    {
        return Amount * 1 ether;
    }

    function convert_Amount_To_Gwei(uint256 Amount)
        public
        pure
        returns (uint256)
    {
        return Amount * 1 gwei;
    }

    function convert_seconds_To_mins(uint256 _seconds)
        public
        pure
        returns (uint256)
    {
        return _seconds / 60;
    }

    function convert_seconds_To_Hours(uint256 _seconds)
        public
        pure
        returns (uint256)
    {
        return _seconds / 3600;
    }

    function convert_Mins_To_Seconds(uint256 _mins)
        public
        pure
        returns (uint256)
    {
        return _mins * 60;
    }
}
```



```
Balance: 0 ETH

convert_Amou 20
0: uint256: 20000000000000000000
convert_Amou 20
0: uint256: 20000000000
convert_Amou 20
0: uint256: 20
convert_Mins_ 20
0: uint256: 1200
convert_secon 160000
0: uint256: 44
convert_secon 160000
0: uint256: 2666
```

Step 1-> Provide values to each function and click on them



SOLIDITYTEST AT 0XD7A...F771B (MEI

Balance: 0 ETH

convert_Amou uint256 Amount

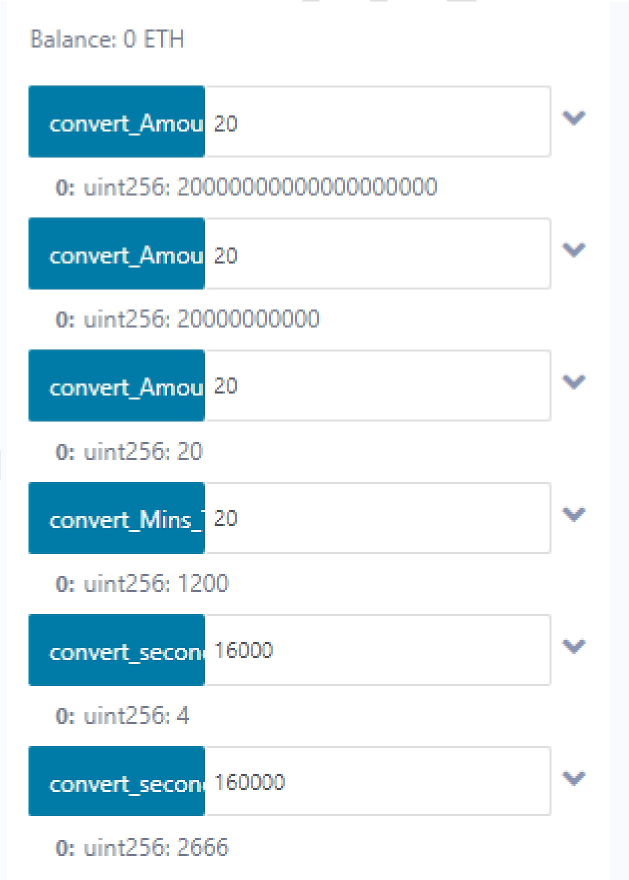
convert_Amou uint256 Amount

convert_Amou uint256 Amount

convert_Mins_1 uint256 _mins

convert_secon uint256 _seconds

convert_secon uint256 _seconds



Balance: 0 ETH

convert_Amou 20

0: uint256: 20000000000000000000

convert_Amou 20

0: uint256: 20000000000

convert_Amou 20

0: uint256: 20

convert_Mins_1 20

0: uint256: 1200

convert_secon 16000

0: uint256: 4

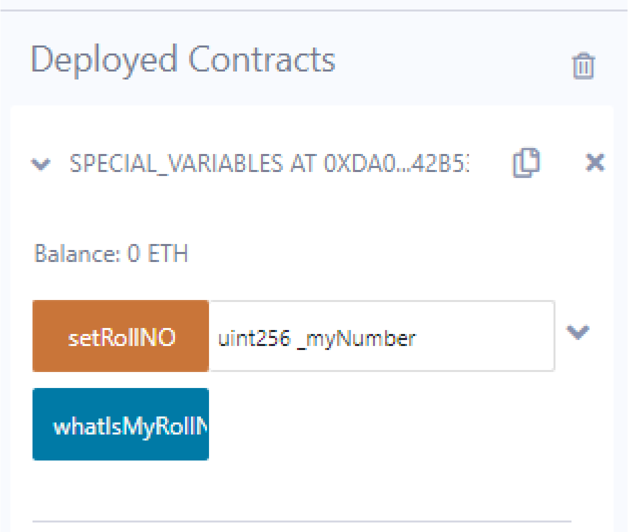
convert_secon 160000

0: uint256: 2666

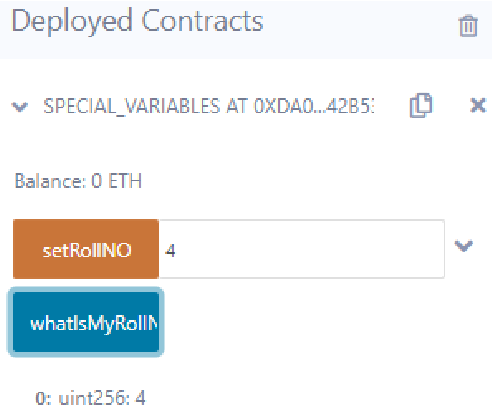
12. Special Variables

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract Special_Variables {
    mapping(address => uint256) rollNo;

    function setRollNO(uint256 _myNumber) public {
        rollNo[msg.sender] = _myNumber;
    }

    function whatIsMyRollNumber() public view returns (uint256) {
        return rollNo[msg.sender];
    }
}
```

Step 1-> Deploy contract Special Variables



Step 2-> Input a number for setRollNO function and click on it & whatIsMyRollNumber button

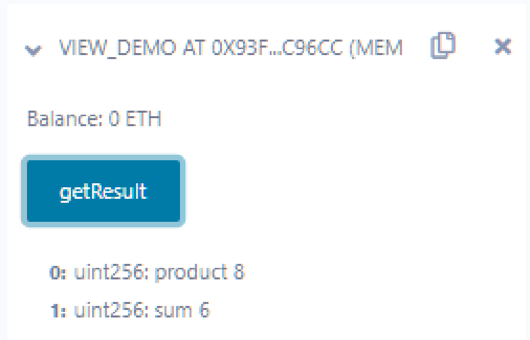


0: uint256: 4

B)Functions, Function Modifiers, View functions, Pure Functions, Fallback Function, Function Overloading, Mathematical functions, Cryptographic functions

1. View Functions

```
pragma solidity ^0.5.0;

contract view_demo {
    uint256 num1 = 2;
    uint256 num2 = 4;

    function getResult() public view returns (uint256 product, uint256 sum) {
        product = num1 * num2;
        sum = num1 + num2;
    }
}
```



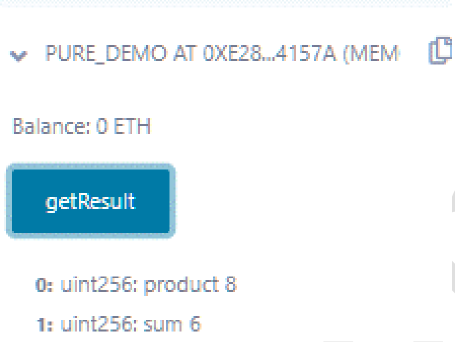
Balance: 0 ETH

```
0: uint256: product 8
1: uint256: sum 6
```

FIGURE 14 - VIEW FUNCTION DEMO

2. Pure Functions

```
pragma solidity ^0.5.0;

contract pure_demo {
    function getResult() public pure returns (uint256 product, uint256 sum) {
        uint256 num1 = 2;
        uint256 num2 = 4;
        product = num1 * num2;
        sum = num1 + num2;
    }
}
```



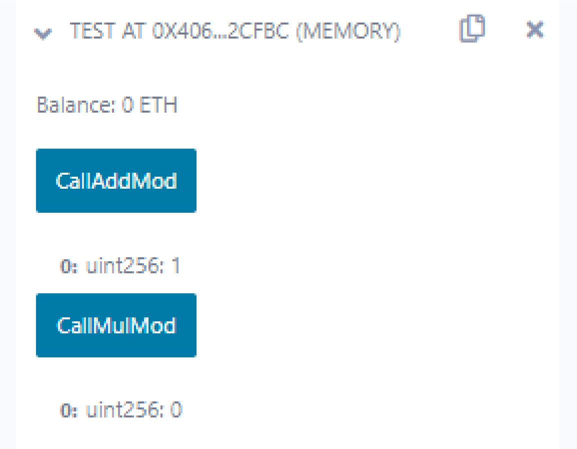
Balance: 0 ETH

```
0: uint256: product 8
1: uint256: sum 6
```

FIGURE 15 – PURE FUNCTION OUTPUT

3. Mathematical Functions

```
pragma solidity ^0.5.0;

contract Test{

    function CallAddMod() public pure returns(uint){

        return addmod(7,3,3);

    }

    function CallMulMod() public pure returns(uint){

        return mulmod(7,3,3);

    }

}
```



TEST AT 0X406...2CFBC (MEMORY)

Balance: 0 ETH

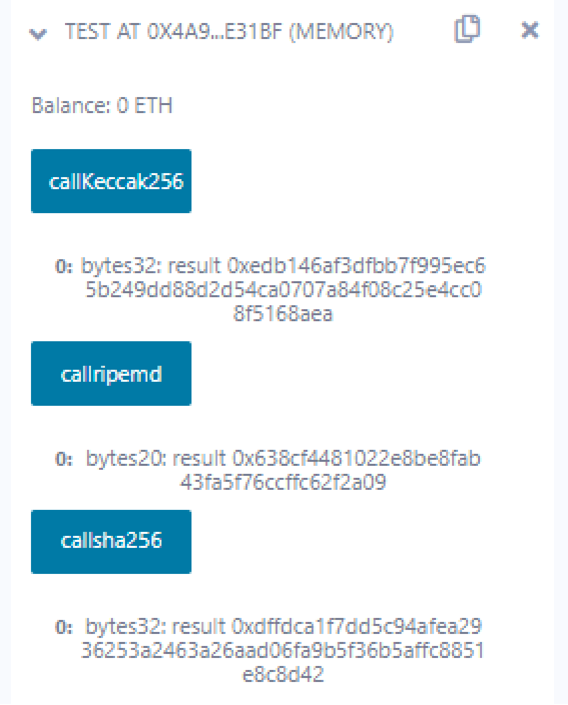
0: uint256: 1

0: uint256: 0

FIGURE 16 - MATHEMATICAL FUNCTIONS IN SOLIDITY

4. Cryptographic Functions

```
pragma solidity ^0.5.0;

contract Test{

    function callKeccak256() public pure returns(bytes32 result){

        return keccak256("BLOCKCHAIN");

    }

    function callsha256() public pure returns(bytes32 result){

        return sha256("BLOCKCHAIN");

    }

    function callripemd() public pure returns (bytes20 result){

        return ripemd160("BLOCKCHAIN");

    }

}
```



Balance: 0 ETH

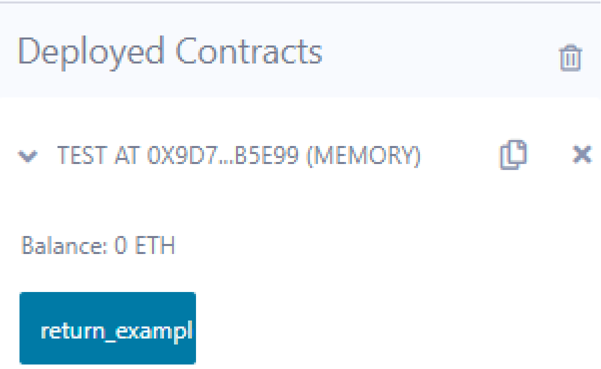
```
0: bytes32: result 0xedb146af3dfbb7f995ec6
   5b249dd88d2d54ca0707a84f08c25e4cc0
   8f5168aea

0: bytes20: result 0x638cf4481022e8be8fab
   43fa5f76ccffc62f2a09

0: bytes32: result 0xdffdca1f7dd5c94afea29
   36253a2463a26aad06fa9b5f36b5affc8851
   e8c8d42
```

FIGURE 17 – CRYPTOGRAPHY ALGORITHMS IN SOLIDITY

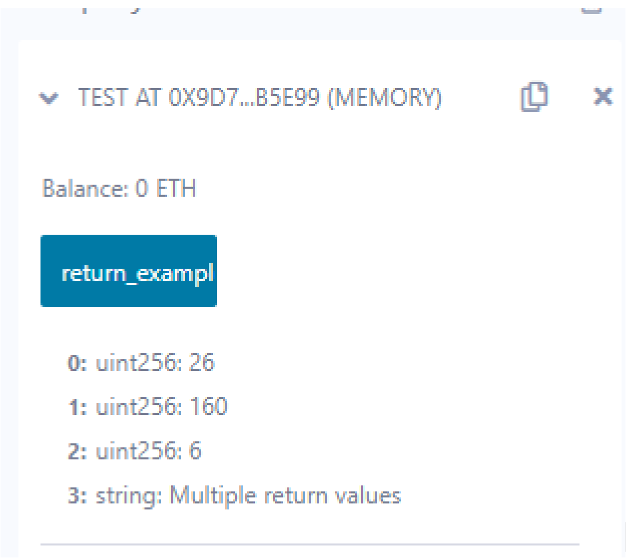
5. Functions

```
// SPDX-License-Identifier: MIT
pragma solidity >=0.4.22 <0.9.0;

contract Test {
    function return_example()
        public
        pure
        returns (
            uint256,
            uint256,
            uint256,
            string memory
        )
    {
        uint256 num1 = 10;
        uint256 num2 = 16;
        uint256 sum = num1 + num2;
        uint256 prod = num1 * num2;
        uint256 diff = num2 - num1;
        string memory message = "Multiple return values";
        return (sum, prod, diff, message);
    }
}
```

Step 1-> Deploy Test Contract



Step 2-> Click on return_example button to display all values



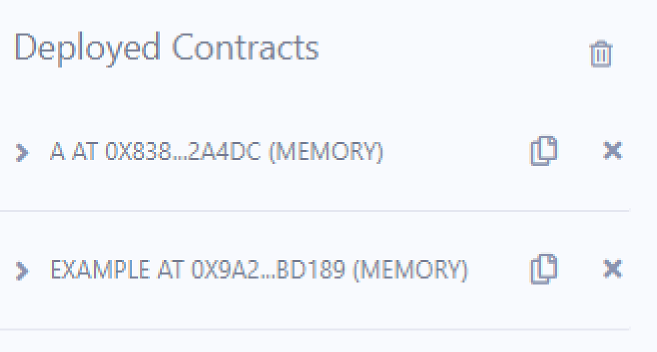
Balance: 0 ETH

```
0: uint256: 26
1: uint256: 160
2: uint256: 6
3: string: Multiple return values
```

6. Fallback Function

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.5.12;

contract A {
    uint256 n;

    function set(uint256 value) external {
        n = value;
    }

    function() external payable {
        n = 0;
    }
}

contract example {
    function callA(A a) public returns (bool) {
        (bool success, ) = address(a).call(abi.encodeWithSignature("setter()"));
        require(success);
        address payable payableA = address(uint160(address(a)));
        return (payableA.send(2 ether));
    }
}
```

Step 1-> Deploy both A & example contracts

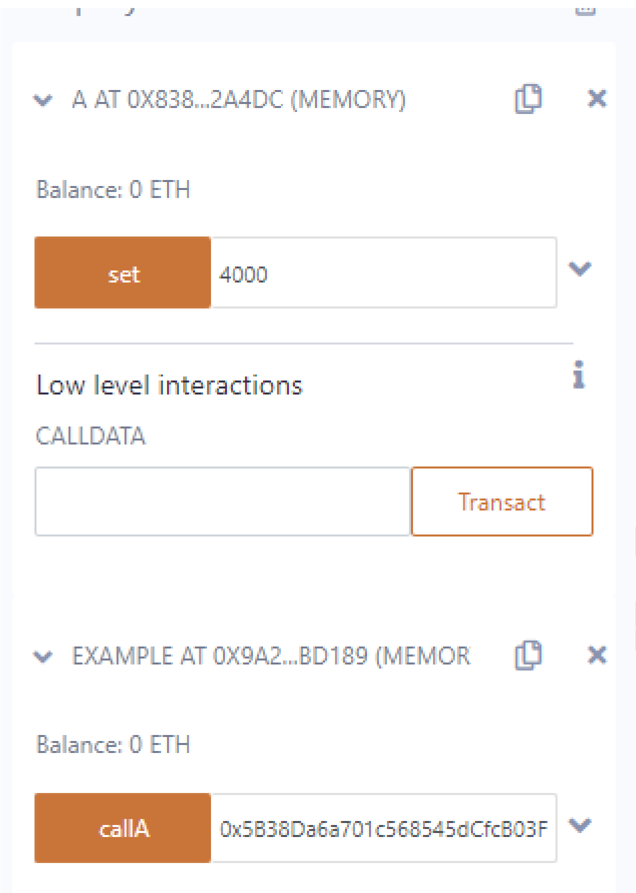


Deployed Contracts

› A AT 0X838...2A4DC (MEMORY)

› EXAMPLE AT 0X9A2...BD189 (MEMORY)

Step 2-> Provide values to both deployed contracts accordingly(use any address)



A AT 0X838...2A4DC (MEMORY)

Balance: 0 ETH

set 4000

Low level interactions

CALLDATA

Transact

EXAMPLE AT 0X9A2...BD189 (MEMOR

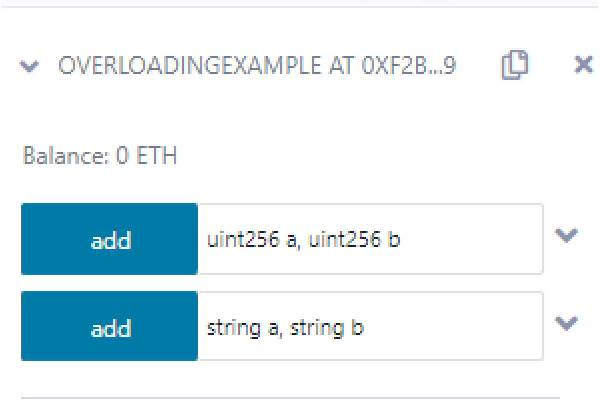
Balance: 0 ETH

callA 0x5B38Da6a701c568545dCfcB03F

7. Function Overloading

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract OverloadingExample {
    function add(uint256 a, uint256 b) public pure returns (uint256) {
        return a + b;
    }

    function add(string memory a, string memory b)
        public
        pure
        returns (string memory)
    {
        return string(abi.encodePacked(a, b));
    }
}
```

Step 1-> Deploy Overloading Example contract



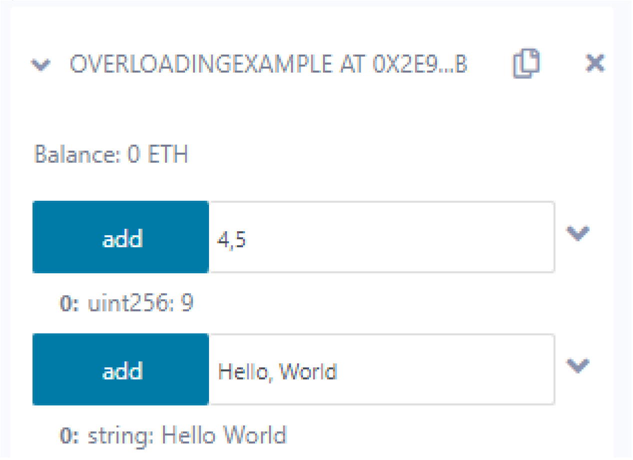
OVERLOADINGEXAMPLE AT 0XF2B...9

Balance: 0 ETH

add | uint256 a, uint256 b

add | string a, string b

Step 2-> Give integer and string values to both add functions as below



OVERLOADINGEXAMPLE AT 0X2E9...B

Balance: 0 ETH

add | 4,5

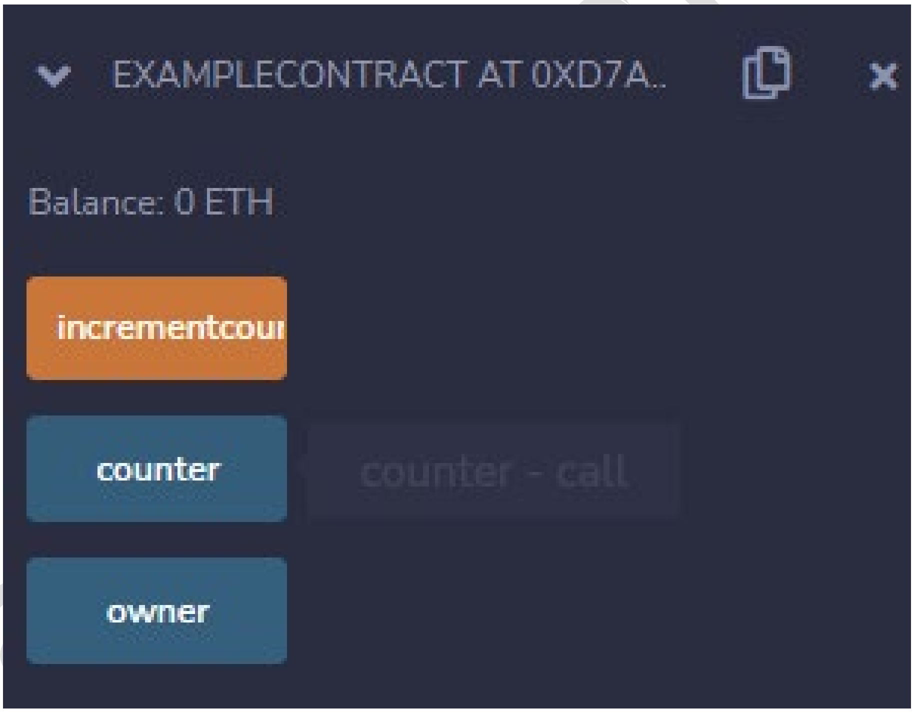
0: uint256: 9

add | Hello, World

0: string: Hello World

8. Function modifiers

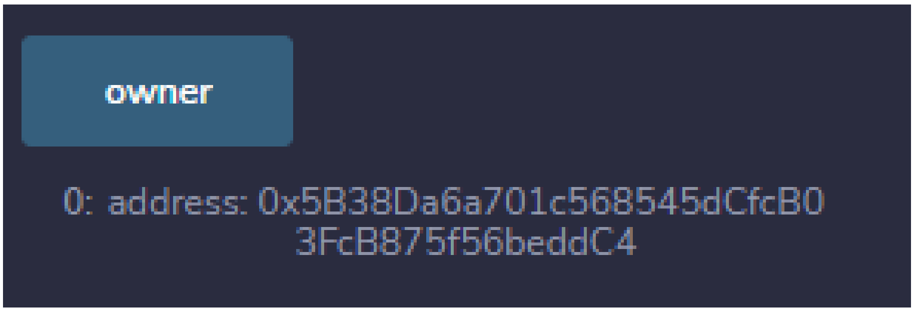
```
// SPDX-License-Identifier: MIT
pragma solidity ^0.5.0;

contract ExampleContract {
    address public owner = 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4;
    uint256 public counter;

    modifier onlyowner() {
        require(msg.sender == owner, "Only the contract owner can call");
        _;
    }

    function incrementcounter() public onlyowner {
        counter++;
    }
}
```



EXAMPLECONTRACT AT 0XD7A..

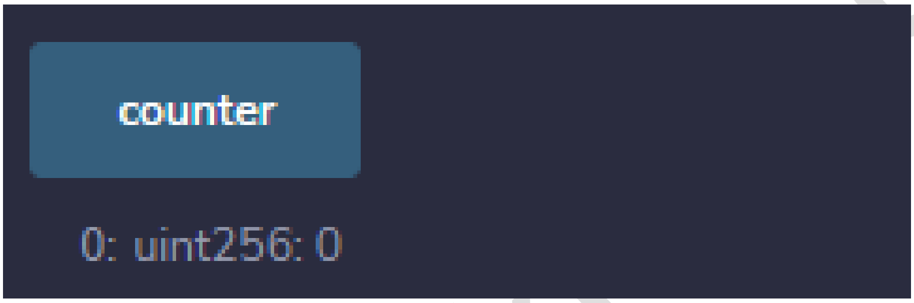
Balance: 0 ETH

Step 1-> Click on owner button



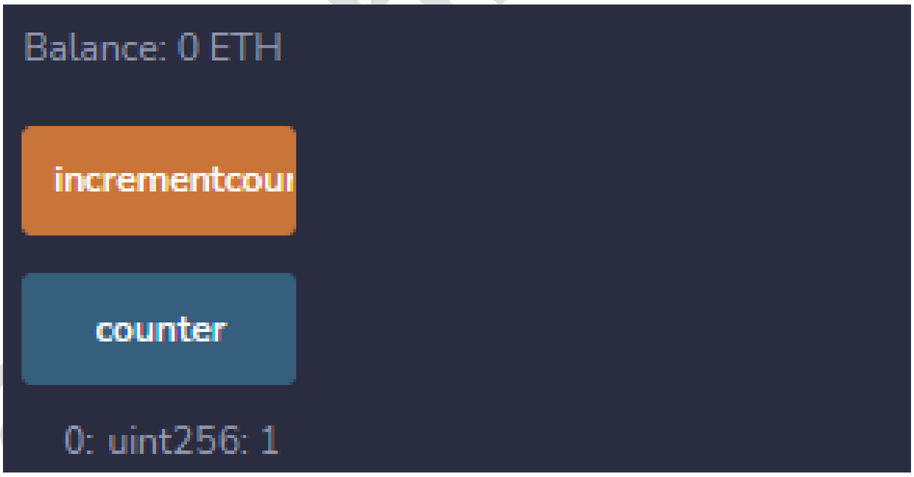
```
0: address: 0x5B38Da6a701c568545dCfcB0
3FcB875f56beddC4
```

Step 2-> Click on counter button initially it is 0.



```
0: uint256: 0
```

Step 3-> Then click on increment counter button and again click on counter button, the counter has been increased



```
Balance: 0 ETH
```

```
0: uint256: 1
```

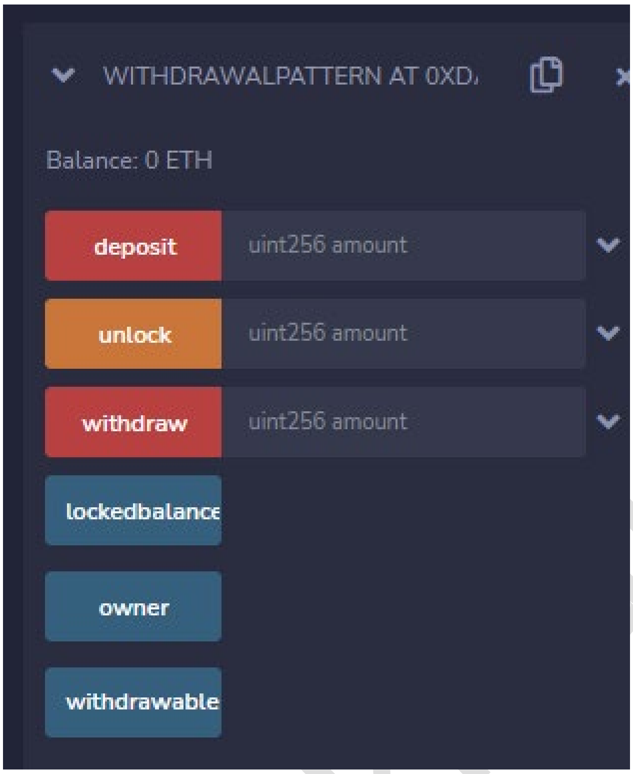
PRACTICAL-4 IMPLEMENT AND DEMONSTRATE THE USE OF THE FOLLOWING IN SOLIDITY

A) Withdrawal Pattern, Restricted Access

1) Withdrawal Pattern

```
// SPDX-License-Identifier: MIT
pragma solidity 0.8.18;

contract WithdrawalPattern {
    address public owner;
    uint256 public lockedbalance;
    uint256 public withdrawablebalance;

    constructor() {
        owner = msg.sender;
    }

    modifier onlyowner() {
        require(msg.sender == owner, "Only the owner can call this function");
        _;
    }

    function deposit(uint256 amount) public payable {
        require(amount > 0, "Amount must be greater than zero");
        lockedbalance += amount;
    }

    function withdraw(uint256 amount) public payable onlyowner {
        require(
            amount <= withdrawablebalance,
            "Insufficient withdrawable balance"
        );
        withdrawablebalance -= amount;
        payable(msg.sender).transfer(amount);
    }

    function unlock(uint256 amount) public onlyowner {
        require(amount <= lockedbalance, "Insufficient locked balance");
        lockedbalance -= amount;
        withdrawablebalance += amount;
    }
}
```

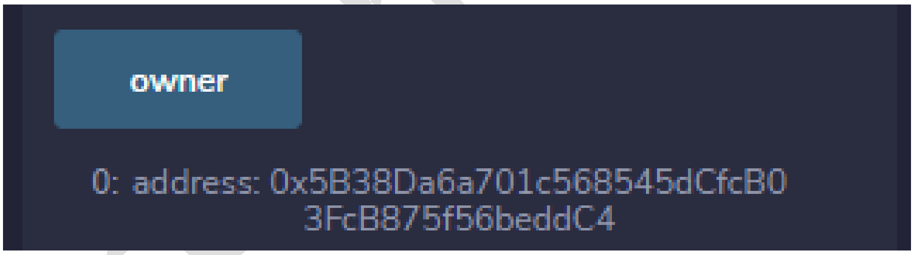
Outputs:



Balance: 0 ETH

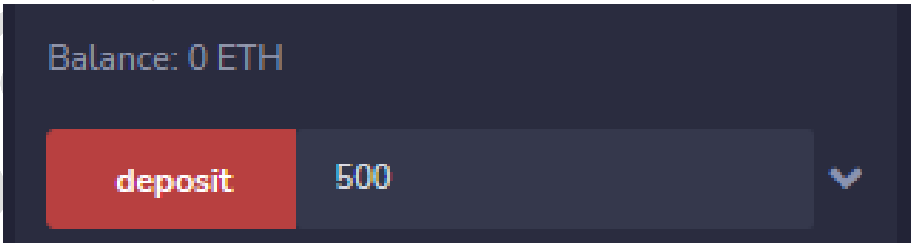
Flow of execution

Step 1-> Click on owner



```
0: address: 0x5B38Da6a701c568545dCfcB0
3FcB875f56beddC4
```

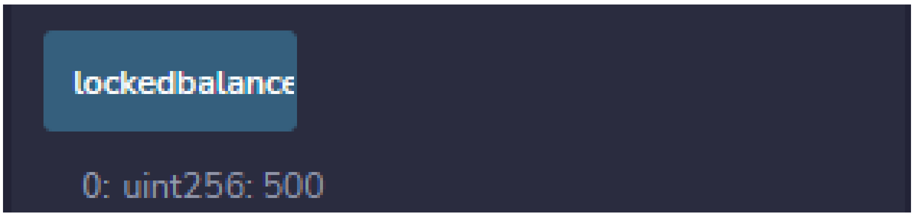
Step 2-> Enter an amount and click on deposit



Balance: 0 ETH

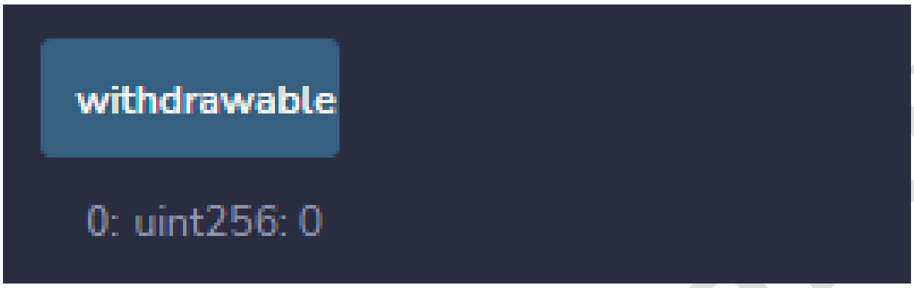
500

Step 3-> Click on locked balance button to display the locked amount in the account



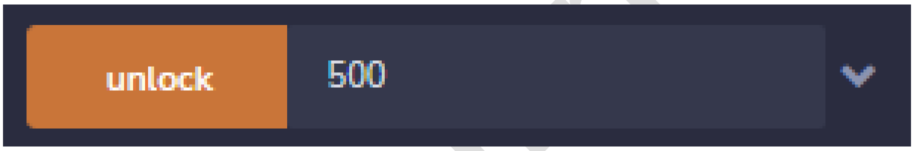
```
0: uint256: 500
```

Step 4-> Click on withdrawable balance button

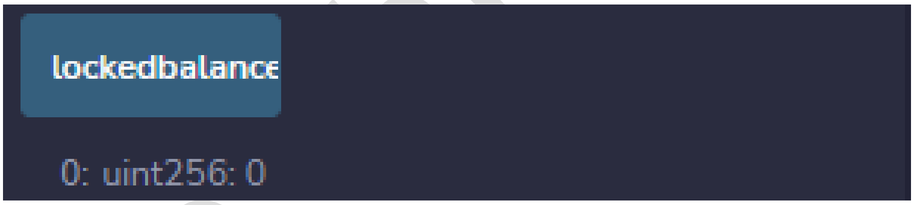


```
0: uint256: 0
```

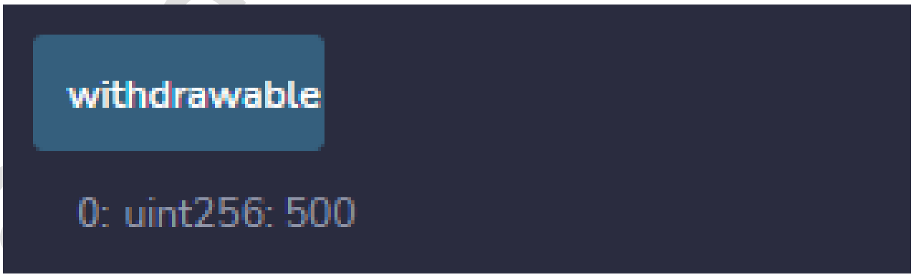
Step 5-> Click on unlock button and enter any amount to transfer amount to withdrawable balance. Check locked balance and withdrawable balance.



500

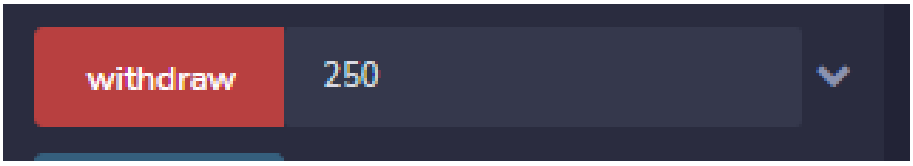


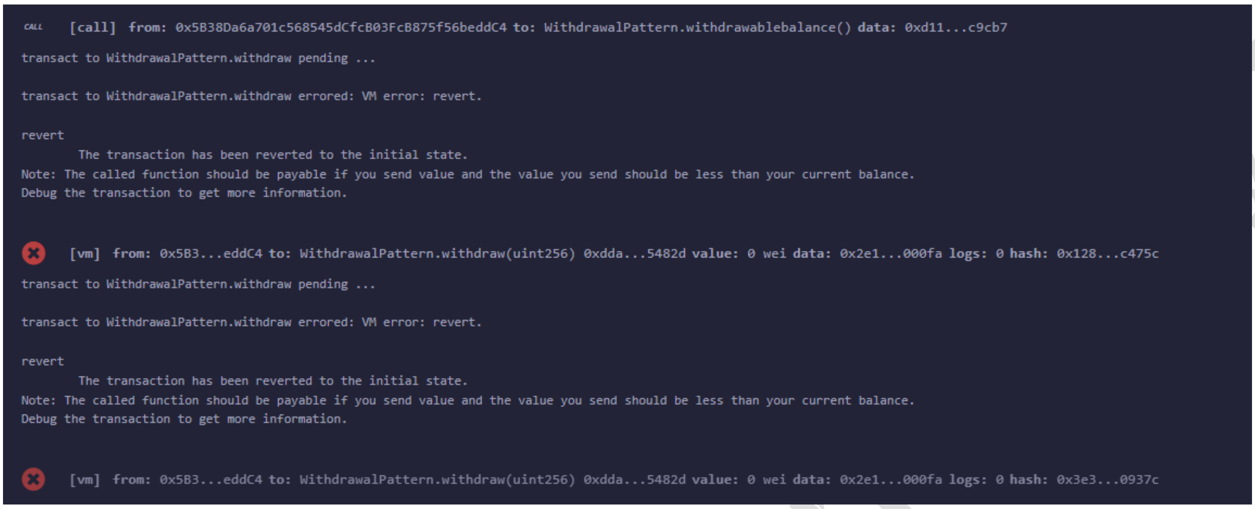
```
0: uint256: 0
```



```
0: uint256: 500
```

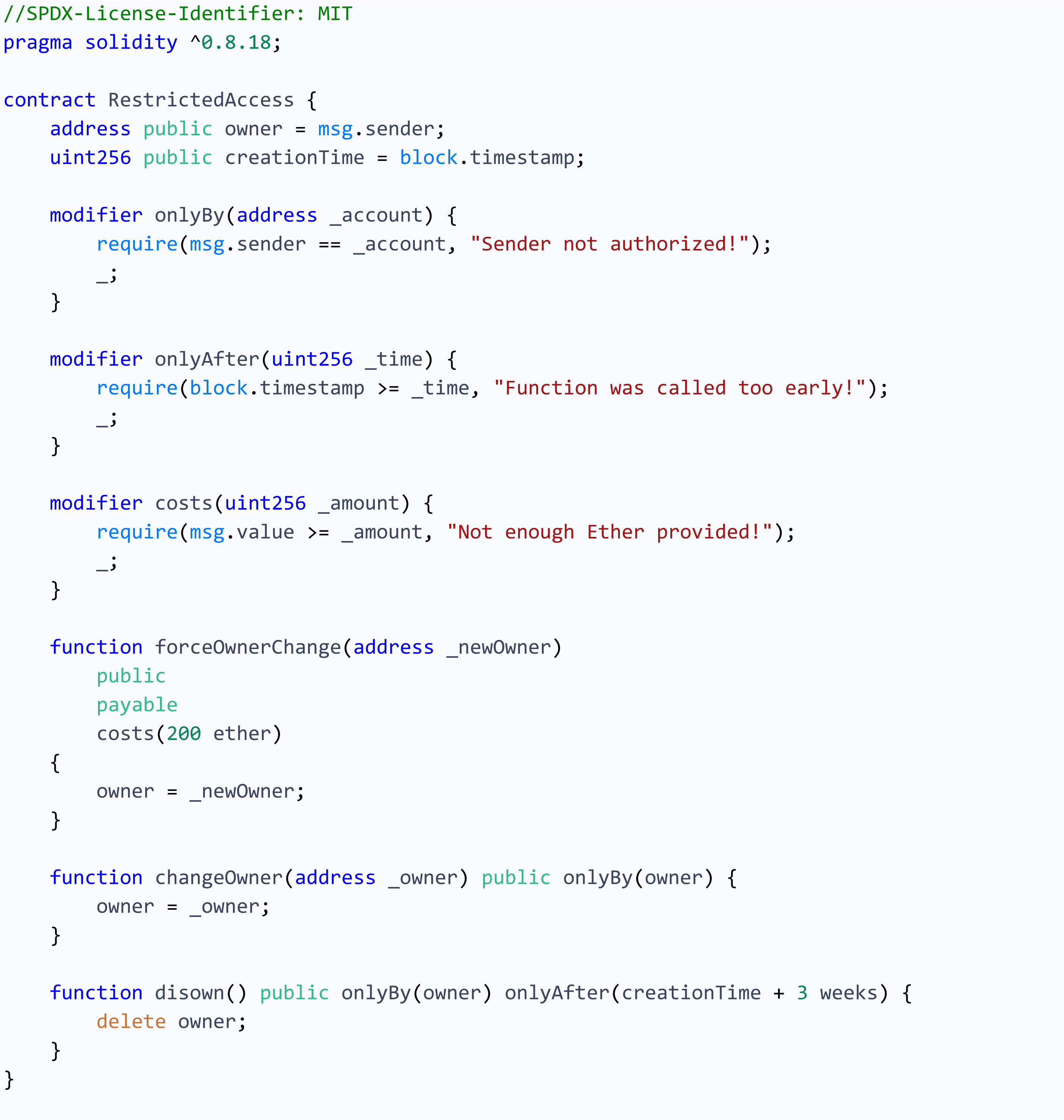
Step 6-> Enter any amount you want to withdraw and Click the withdraw button. You should get an error and the transaction should be reverted.





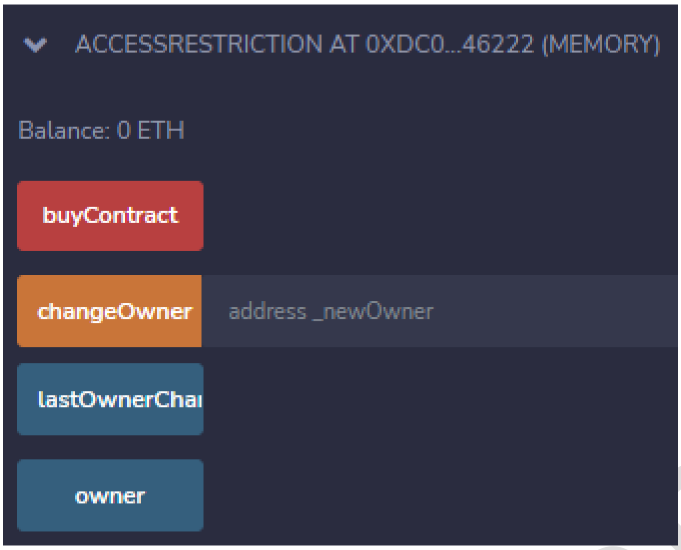
```
CALL   [call]  from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: WithdrawalPattern.withdrawablebalance() data: 0xd11...c9cb7
transact to WithdrawalPattern.withdraw pending ...

transact to WithdrawalPattern.withdraw errored: VM error: revert.

revert
        The transaction has been reverted to the initial state.
Note: The called function should be payable if you send value and the value you send should be less than your current balance.
Debug the transaction to get more information.


       [vm]  from: 0x5B3...eddC4 to: WithdrawalPattern.withdraw(uint256) 0xdda...5482d value: 0 wei data: 0x2e1...000fa logs: 0 hash: 0x128...c475c
transact to WithdrawalPattern.withdraw pending ...

transact to WithdrawalPattern.withdraw errored: VM error: revert.

revert
        The transaction has been reverted to the initial state.
Note: The called function should be payable if you send value and the value you send should be less than your current balance.
Debug the transaction to get more information.


       [vm]  from: 0x5B3...eddC4 to: WithdrawalPattern.withdraw(uint256) 0xdda...5482d value: 0 wei data: 0x2e1...000fa logs: 0 hash: 0x3e3...0937c
```

2) Restricted Access



```
//SPDX-License-Identifier: MIT
pragma solidity ^0.8.18;

contract RestrictedAccess {
    address public owner = msg.sender;
    uint256 public creationTime = block.timestamp;

    modifier onlyBy(address _account) {
        require(msg.sender == _account, "Sender not authorized!");
        _;
    }

    modifier onlyAfter(uint256 _time) {
        require(block.timestamp >= _time, "Function was called too early!");
        _;
    }

    modifier costs(uint256 _amount) {
        require(msg.value >= _amount, "Not enough Ether provided!");
        _;
    }

    function forceOwnerChange(address _newOwner)
        public
        payable
        costs(200 ether)
    {
        owner = _newOwner;
    }

    function changeOwner(address _owner) public onlyBy(owner) {
        owner = _owner;
    }

    function disown() public onlyBy(owner) onlyAfter(creationTime + 3 weeks) {
        delete owner;
    }
}
```

Output

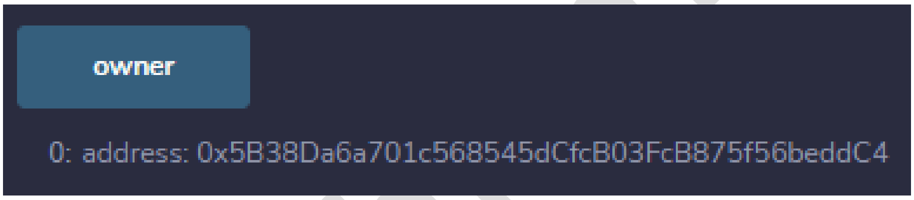


ACCESSRESTRICTION AT 0XDC0...46222 (MEMORY)

Balance: 0 ETH

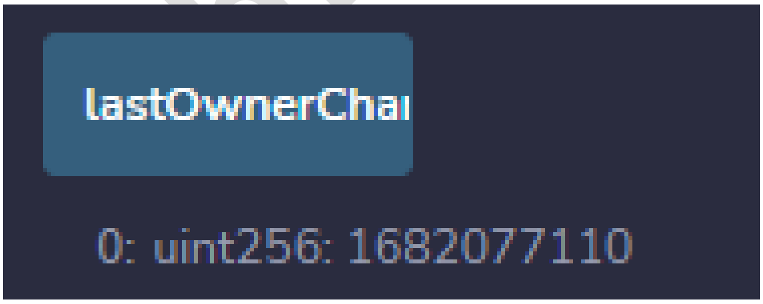
Flow of execution

Step 1-> Click on owner to create an owner object



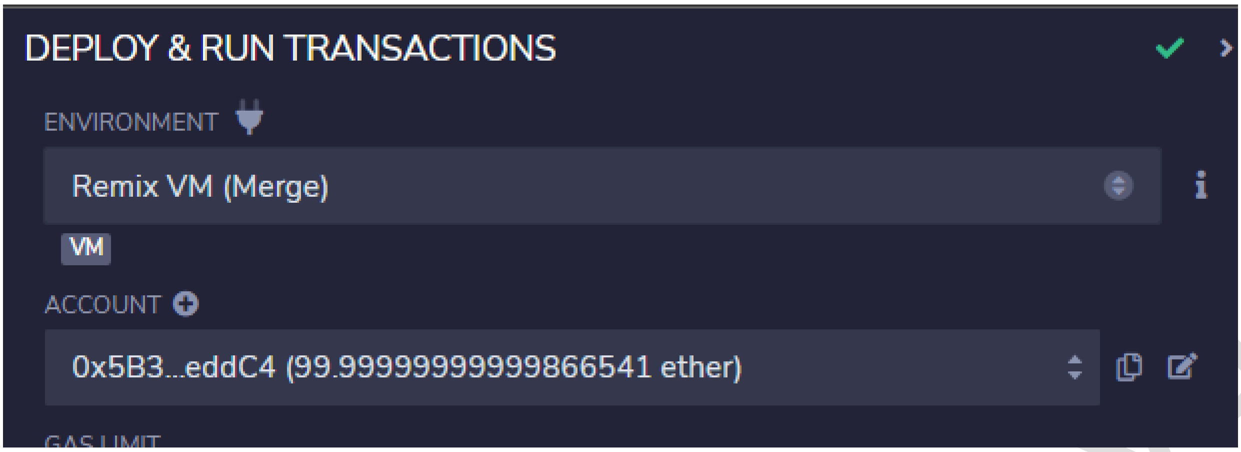
```
0: address: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
```

Step 2-> Click on lastOwnerChange button



```
0: uint256: 1682077110
```

Step 3-> Change the address of the account from Account dropdown in Deploy tab of Remix IDE.



DEPLOY & RUN TRANSACTIONS

ENVIRONMENT

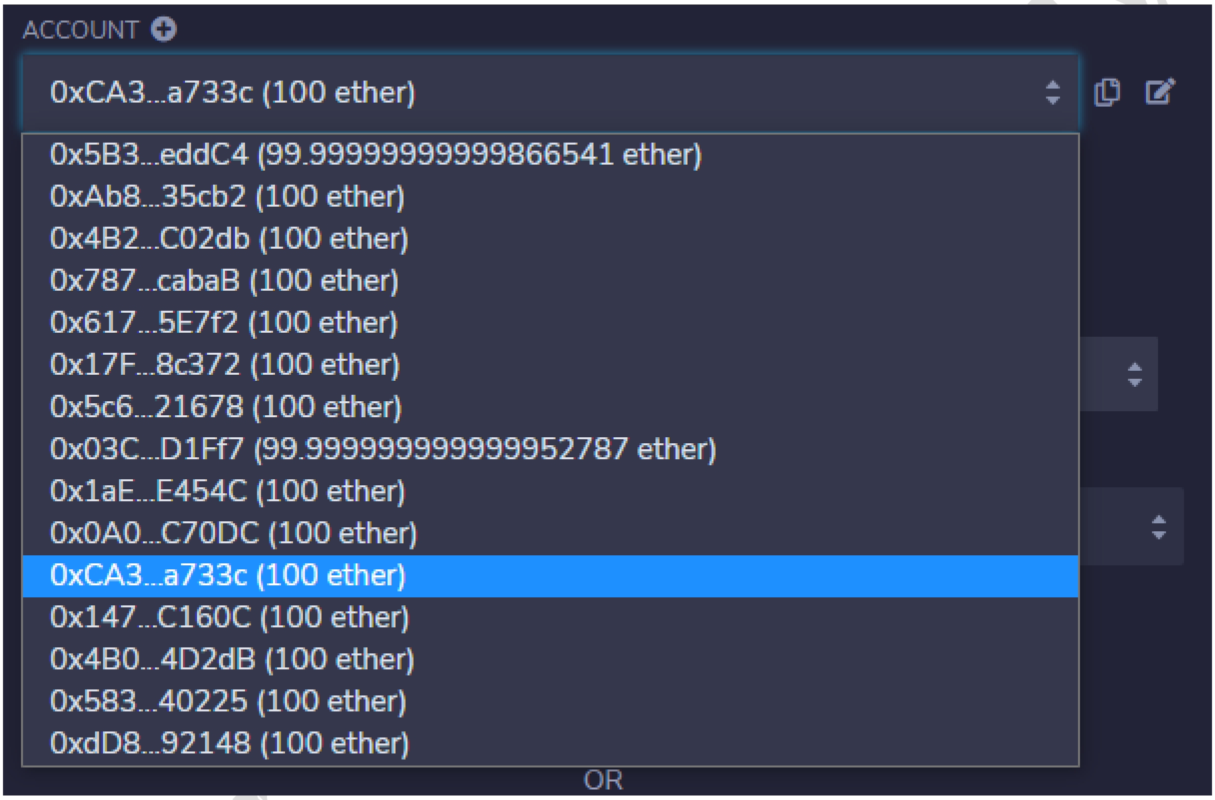
Remix VM (Merge)

VM

ACCOUNT

0x5B3...eddC4 (99.99999999999866541 ether)

GAS LIMIT



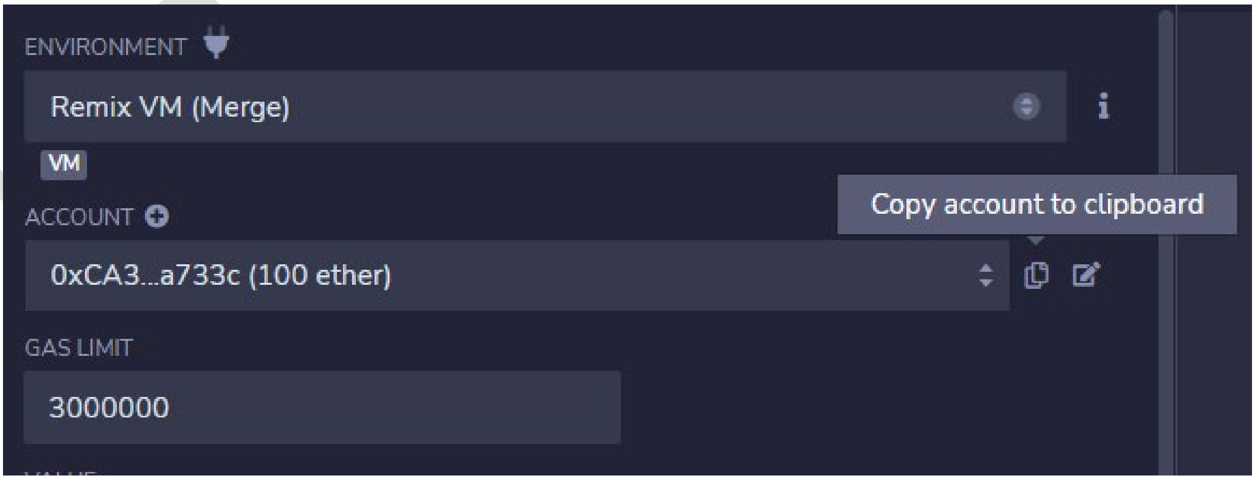
ACCOUNT

0xCA3...a733c (100 ether)

0x5B3...eddC4 (99.99999999999866541 ether)
0xAb8...35cb2 (100 ether)
0x4B2...C02db (100 ether)
0x787...cabaB (100 ether)
0x617...5E7f2 (100 ether)
0x17F...8c372 (100 ether)
0x5c6...21678 (100 ether)
0x03C...D1Ff7 (99.999999999999952787 ether)
0x1aE...E454C (100 ether)
0x0A0...C70DC (100 ether)
0xCA3...a733c (100 ether)
0x147...C160C (100 ether)
0x4B0...4D2dB (100 ether)
0x583...40225 (100 ether)
0xdD8...92148 (100 ether)

OR

Step 4-> Copy the address



ENVIRONMENT

Remix VM (Merge)

VM

ACCOUNT

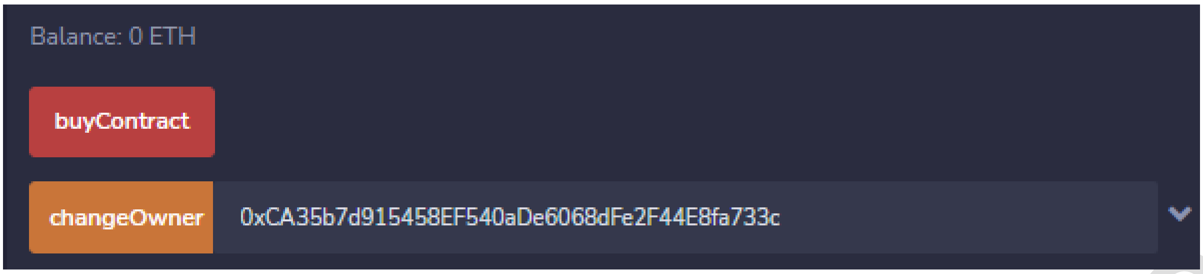
Copy account to clipboard

0xCA3...a733c (100 ether)

GAS LIMIT

3000000

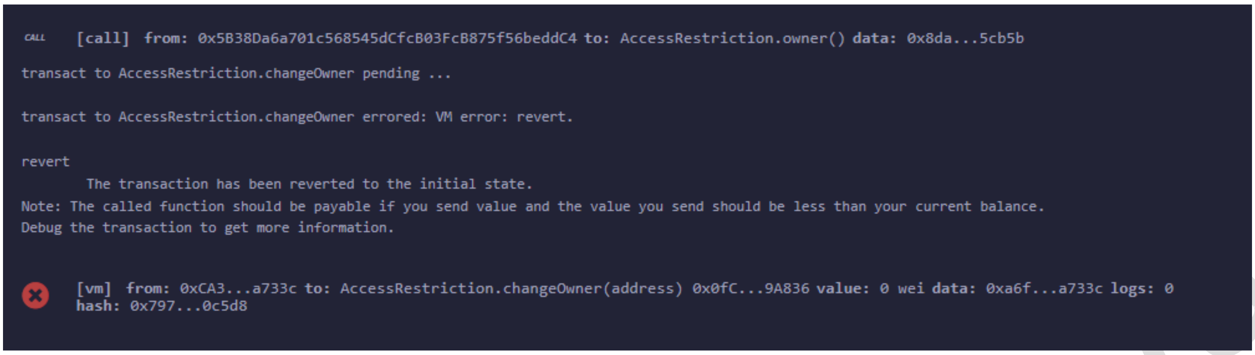
Step 5-> Paste the address in changeOwner input and click on changeOwner.



Balance: 0 ETH

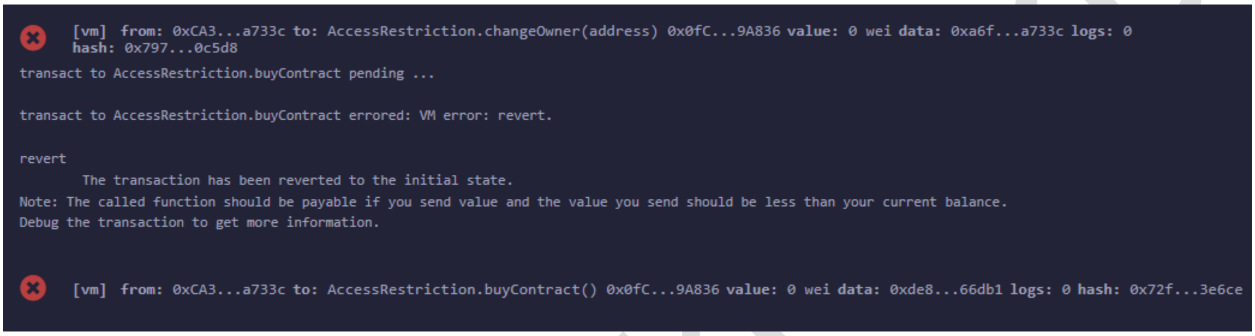
0xCA35b7d915458EF540aDe6068dFe2F44E8fa733c

Step 6-> You should get an error as following



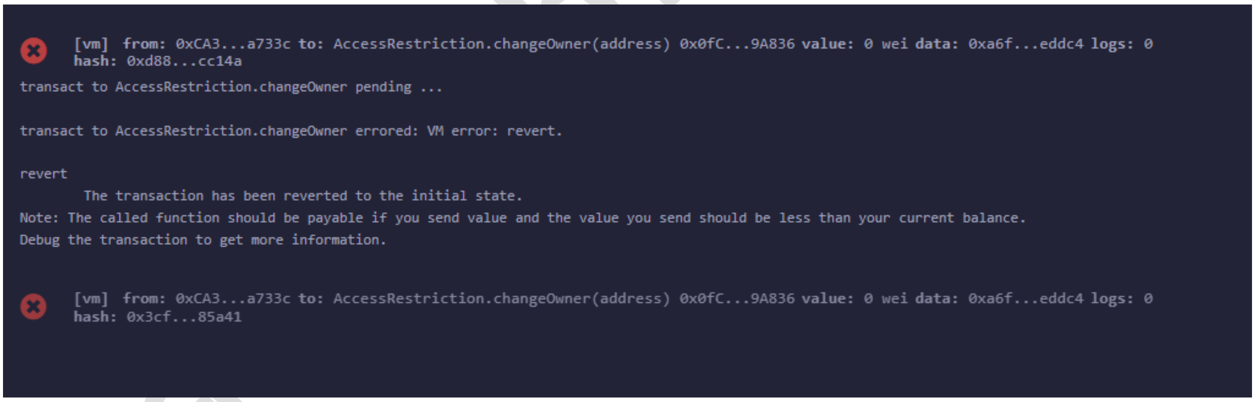
```
CALL   [call]  from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: AccessRestriction.owner() data: 0x8da...5cb5b

transact to AccessRestriction.changeOwner pending ...

transact to AccessRestriction.changeOwner errored: VM error: revert.

revert
        The transaction has been reverted to the initial state.
Note: The called function should be payable if you send value and the value you send should be less than your current balance.
Debug the transaction to get more information.

       [vm]  from: 0xCA3...a733c to: AccessRestriction.changeOwner(address) 0x0fC...9A836 value: 0 wei data: 0xa6f...a733c logs: 0
       hash: 0x797...0c5d8
```

Step 7-> If you click on buycontract it should give an error as follows



```
       [vm]  from: 0xCA3...a733c to: AccessRestriction.changeOwner(address) 0x0fC...9A836 value: 0 wei data: 0xa6f...a733c logs: 0
       hash: 0x797...0c5d8
transact to AccessRestriction.buyContract pending ...

transact to AccessRestriction.buyContract errored: VM error: revert.

revert
        The transaction has been reverted to the initial state.
Note: The called function should be payable if you send value and the value you send should be less than your current balance.
Debug the transaction to get more information.

       [vm]  from: 0xCA3...a733c to: AccessRestriction.buyContract() 0x0fC...9A836 value: 0 wei data: 0xde8...66db1 logs: 0 hash: 0x72f...3e6ce
```

Step 8-> Now, paste the actual address of the account in the changeowner input and click on changeowner



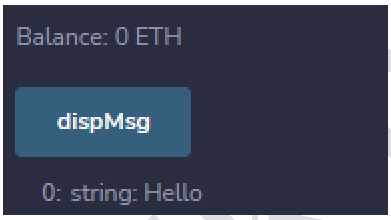
```
       [vm]  from: 0xCA3...a733c to: AccessRestriction.changeOwner(address) 0x0fC...9A836 value: 0 wei data: 0xa6f...eddc4 logs: 0
       hash: 0xd88...cc14a
transact to AccessRestriction.changeOwner pending ...

transact to AccessRestriction.changeOwner errored: VM error: revert.

revert
        The transaction has been reverted to the initial state.
Note: The called function should be payable if you send value and the value you send should be less than your current balance.
Debug the transaction to get more information.

       [vm]  from: 0xCA3...a733c to: AccessRestriction.changeOwner(address) 0x0fC...9A836 value: 0 wei data: 0xa6f...eddc4 logs: 0
       hash: 0x3cf...85a41
```

B) Contracts, Inheritance, Constructors, Abstract Contracts, Interfaces

1) Contracts

```
pragma solidity ^0.5.0;

contract Contract_demo {
    string message = "Hello";

    function dispMsg() public view returns (string memory) {
        return message;
    }
}
```

Output



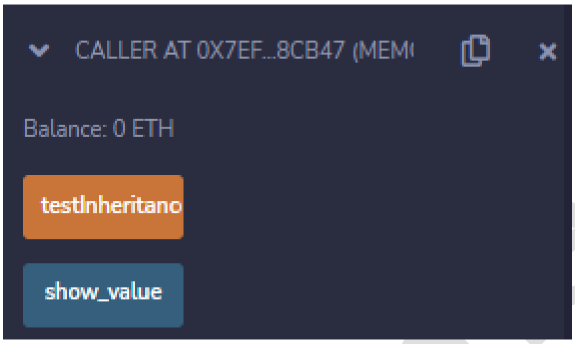
Balance: 0 ETH

```
0: string: Hello
```

2) Inheritance

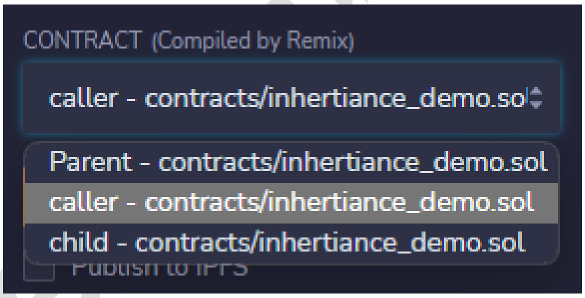
```
pragma solidity >=0.4.22 <0.6.0;

contract Parent {
    uint256 internal sum;

    function setValue() external {
        uint256 a = 10;
        uint256 b = 20;
        sum = a + b;
    }
}

contract child is Parent {
    function getValue() external view returns (uint256) {
        return sum;
    }
}

contract caller {
    child cc = new child();

    function testInheritance() public returns (uint256) {
        cc.setValue();
        return cc.getValue();
    }

    function show_value() public view returns (uint256) {
        return cc.getValue();
    }
}
```

Outputs

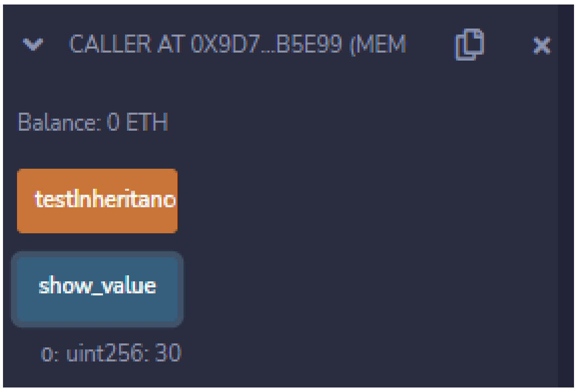


Flow of execution

Step 1-> Select caller contract to deploy in Contract and deploy


CONTRACT (Compiled by Remix)
caller - contracts/inhertiance_demo.sol
Parent - contracts/inhertiance_demo.sol
caller - contracts/inhertiance_demo.sol
child - contracts/inhertiance_demo.sol
Publish to IPFS

Step 2-> Click test Inheritance and then click on show_value to view value



0: uint256: 30

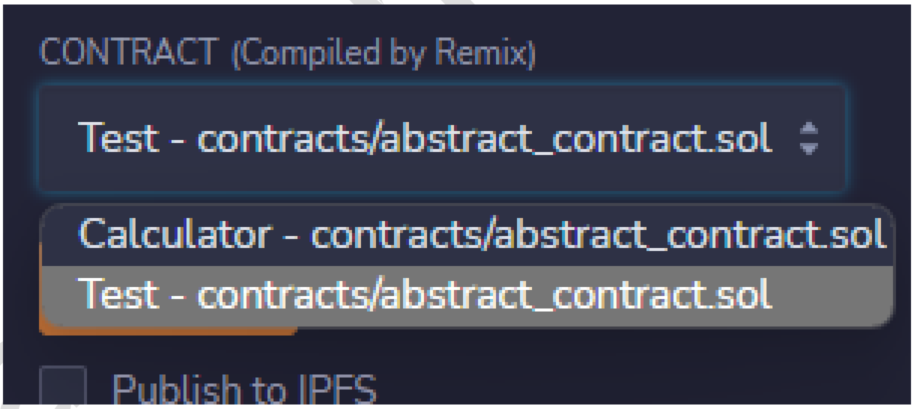
3) Abstract Contracts

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.5.17;

contract Calculator {
    function getResult() external view returns (uint256);
}

contract Test is Calculator {
    constructor() public {}

    function getResult() external view returns (uint256) {
        uint256 a = 1;
        uint256 b = 2;
        uint256 result = a + b;
        return result;
    }
}
```

Outputs

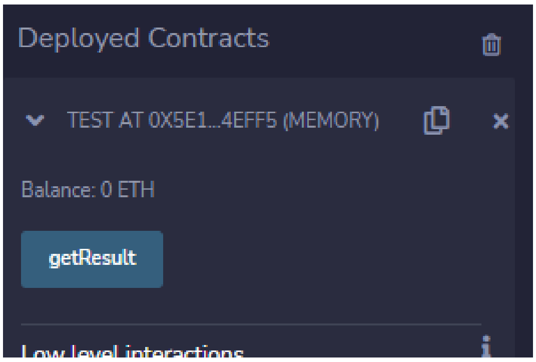
Flow of execution

Step 1-> Select Test contract and deploy

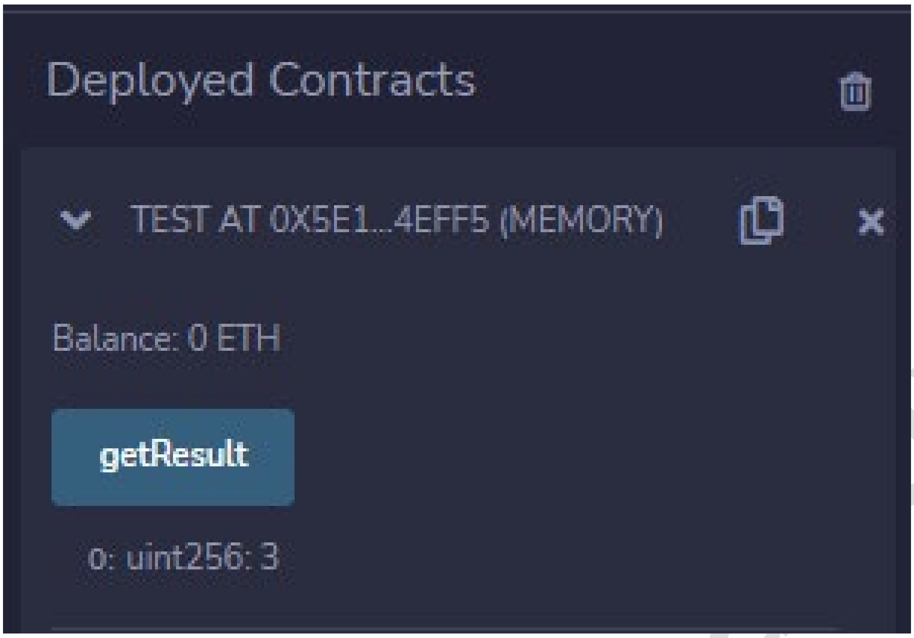


CONTRACT (Compiled by Remix)
Test - contracts/abstract_contract.sol
Calculator - contracts/abstract_contract.sol
Test - contracts/abstract_contract.sol
Publish to IPFS

Step 2-> The contact will deploy as below



Step 3-> Click on getResult to get sum of a+b



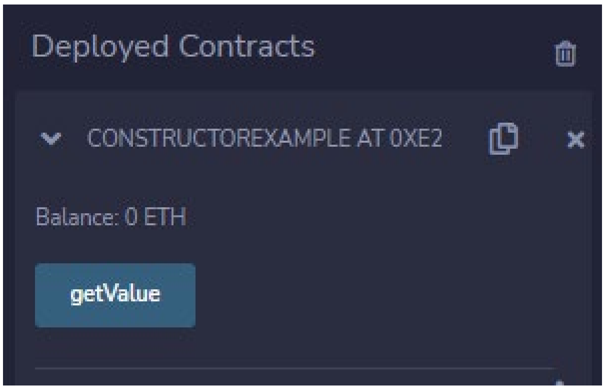
Balance: 0 ETH

0: uint256: 3

4) Constructors

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.5.0;

// Creating a contract
contract constructorExample {
    string str;

    constructor() public {
        str = "GeeksForGeeks";
    }

    function getValue() public view returns (string memory) {
        return str;
    }
}
```

Outputs



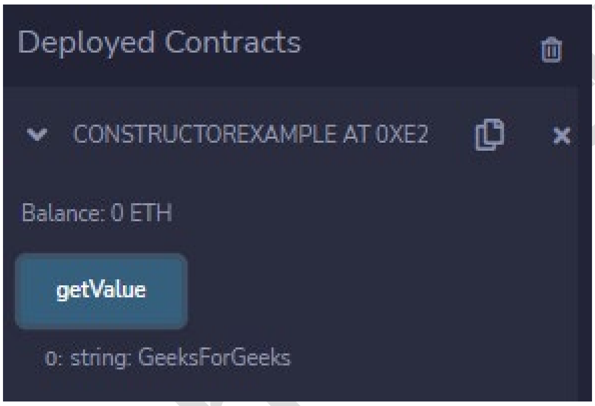
Deployed Contracts

CONSTRUCTOREXAMPLE AT 0XE2

Balance: 0 ETH

Flow of execution

Step 1-> Click on getValue to print string



Deployed Contracts

CONSTRUCTOREXAMPLE AT 0XE2

Balance: 0 ETH

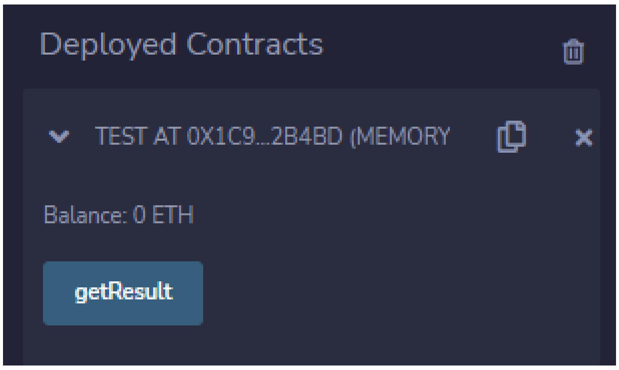
0: string: GeeksForGeeks

5) Interfaces

```
pragma solidity ^0.5.0;

interface Calculator {
   function getResult() external view returns(uint);
}
contract Test is Calculator {
   constructor() public {}
   function getResult() external view returns(uint){
      uint a = 1;
      uint b = 2;
      uint result = a + b;
      return result;
   }
}
```

Outputs

Flow of execution

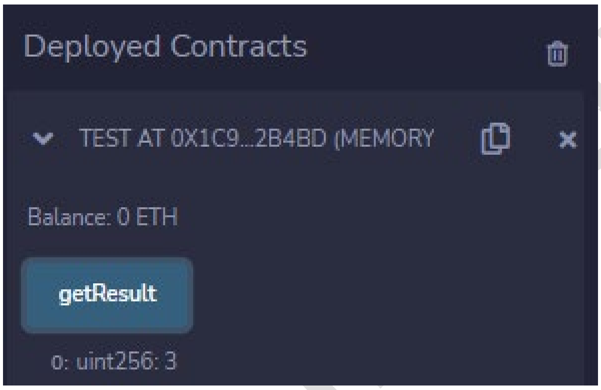


Deployed Contracts

TEST AT 0X1C9...2B4BD (MEMORY

Balance: 0 ETH

Step 1-> Click on getResult to display sum



Deployed Contracts

TEST AT 0X1C9...2B4BD (MEMORY

Balance: 0 ETH

0: uint256: 3

C) Libraries, Assembly, Events, Error handling.

1) Libraries

myLib.sol Code

```
// SPDX-License-Identifier: MIT
pragma solidity >=0.7.0 <0.9.0;

library myMathLib {
    function sum(uint256 a, uint256 b) public pure returns (uint256) {
        return a + b;
    }

    function exponent(uint256 a, uint256 b) public pure returns (uint256) {
        return a**b;
    }
}
```

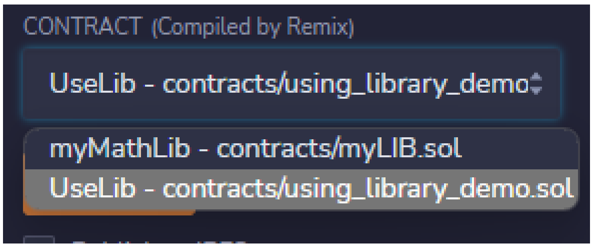
using_library.sol Code

```
// SPDX-License-Identifier: MIT
pragma solidity >=0.7.0 <0.9.0;

import "contracts/myLIB.sol";

contract UseLib {
    function getsum(uint256 x, uint256 y) public pure returns (uint256) {
        return myMathLib.sum(x, y);
    }

    function getexponent(uint256 x, uint256 y) public pure returns (uint256) {
        return myMathLib.exponent(x, y);
    }
}
```

Outputs

Flow of execution

Step 1-> Change contract to UseLib and deploy.



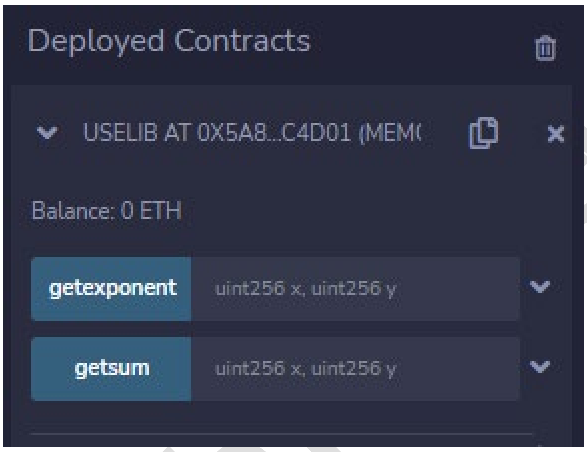
CONTRACT (Compiled by Remix)

UseLib - contracts/using_library_demo

myMathLib - contracts/myLIB.sol

UseLib - contracts/using_library_demo.sol

Step 2-> The deployed contract should be same as below

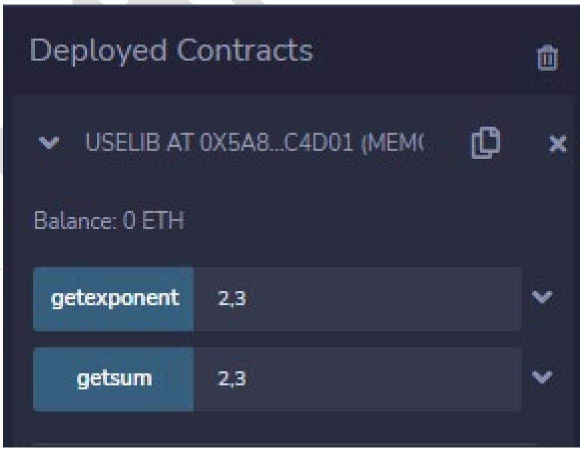


Deployed Contracts

USELIB AT 0X5A8...C4D01 (MEM(

Balance: 0 ETH

Step 3-> Input values to both getexponent and getsum functions as below



Deployed Contracts

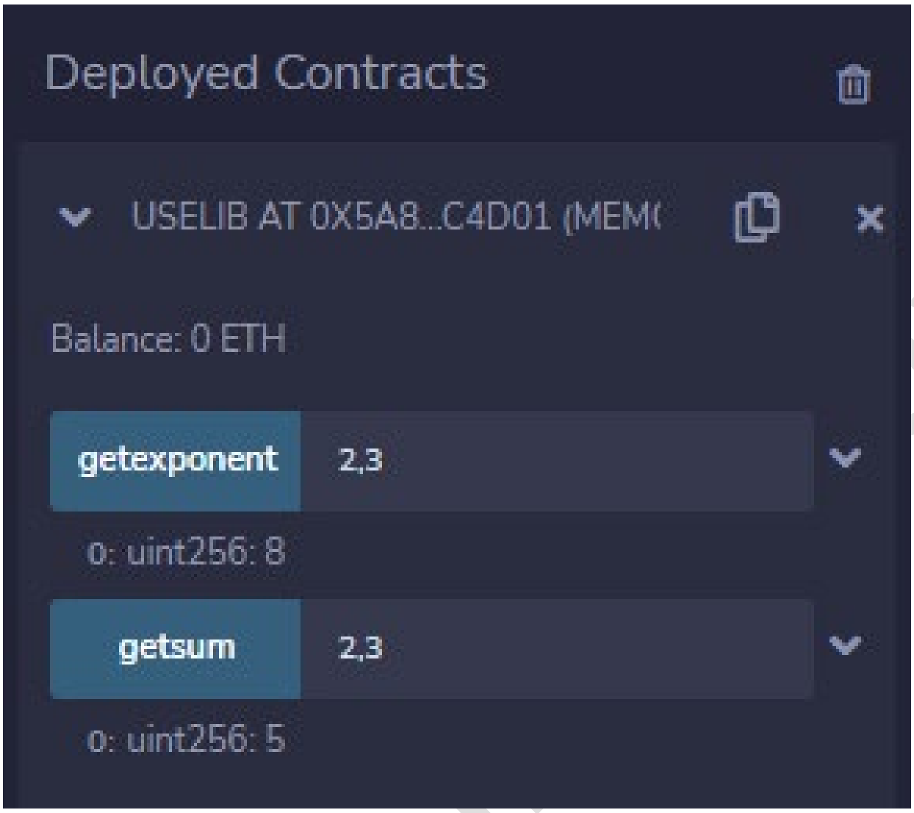
USELIB AT 0X5A8...C4D01 (MEM(

Balance: 0 ETH

getexponent: 2,3

getsum: 2,3

Step 4-> Execute both functions. You will get below output


Deployed Contracts

USELIB AT 0X5A8...C4D01 (MEM(

Balance: 0 ETH

getexponent 2,3

0: uint256: 8

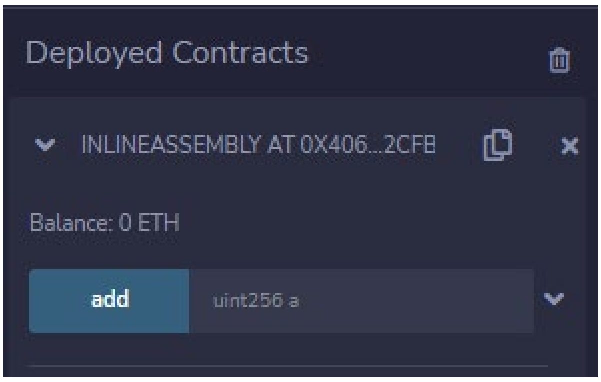
getsum 2,3

0: uint256: 5

2) Assembly

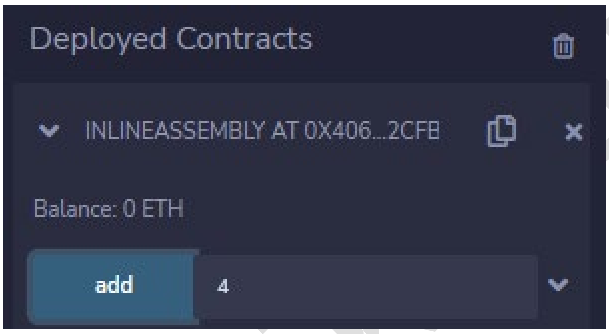
```
// SPDX-License-Identifier: GPL-3.0
pragma solidity >=0.4.16 <0.9.0;

contract InlineAssembly {
    // Defining function
    function add(uint256 a) public view returns (uint256 b) {
        assembly {
            let c := add(a, 16)
            mstore(0x80, c)
            {
                let d := add(sload(c), 12)
                b := d
            }

            b := add(b, c)
        }
    }
}
```

Outputs

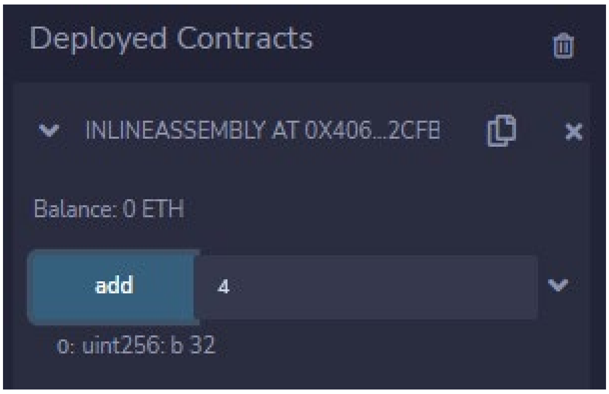


Flow of execution

Step 1-> Input a number for add function



Step 2-> Click add to output sum

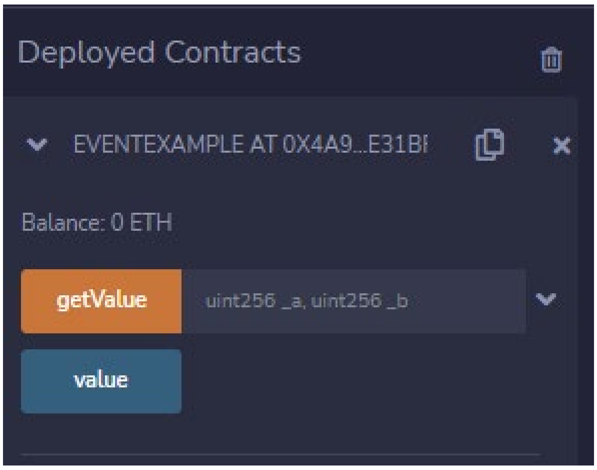


0: uint256: b 32

3) Events

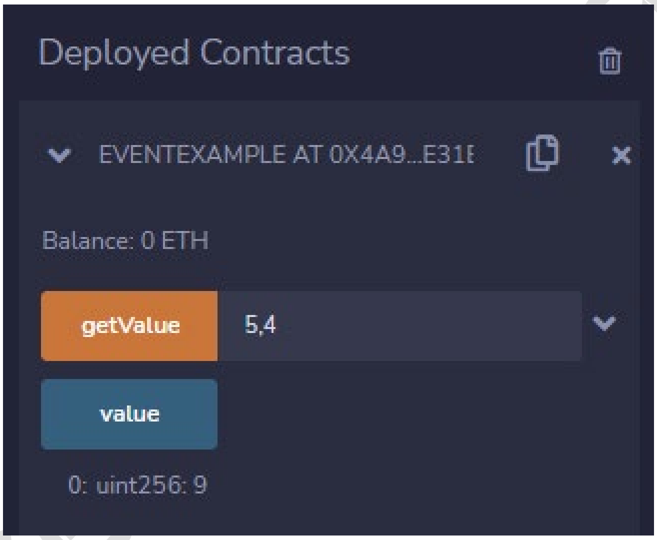
```
// SPDX-License-Identifier: MIT
pragma solidity ^0.5.0;

// Creating a contract
contract eventExample {
    // Declaring state variables
    uint256 public value = 0;

    // Declaring an event
    event Increment(address owner);

    // Defining a function for logging event
    function getValue(uint256 _a, uint256 _b) public {
        emit Increment(msg.sender);
        value = _a + _b;
    }
}
```

Outputs

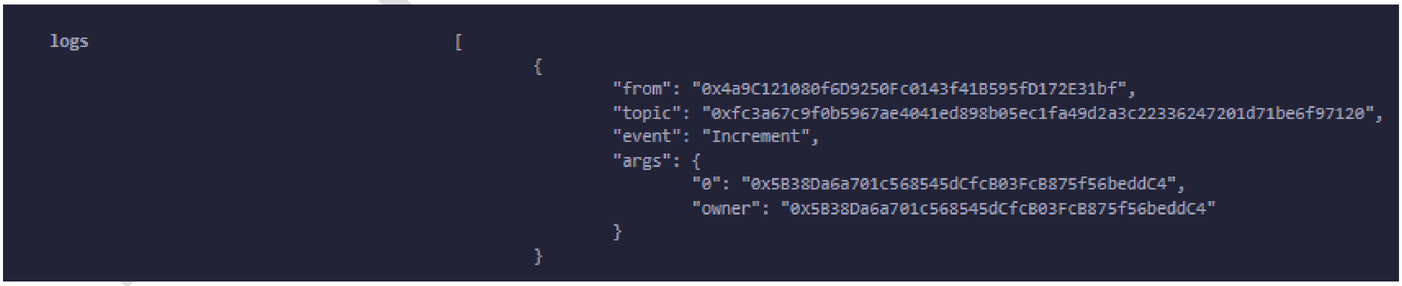


Flow of execution

Step 1-> Provide values to getValue function and click on it.



Step 2-> In the terminal check for logs

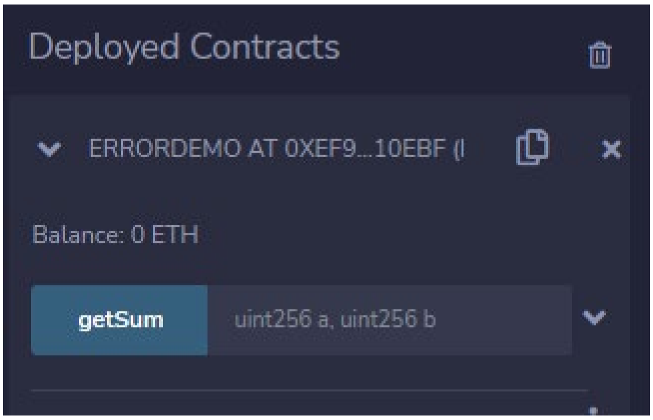


```
logs                                    [
                                                {
                                                        "from": "0x4a9C121080f6D9250Fc0143f41B595fD172E31bf",
                                                        "topic": "0xfc3a67c9f0b5967ae4041ed898b05ec1fa49d2a3c22336247201d71be6f97120",
                                                        "event": "Increment",
                                                        "args": {
                                                                "0": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4",
                                                                "owner": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4"
                                                        }
                                                }
```

4) Error Handling

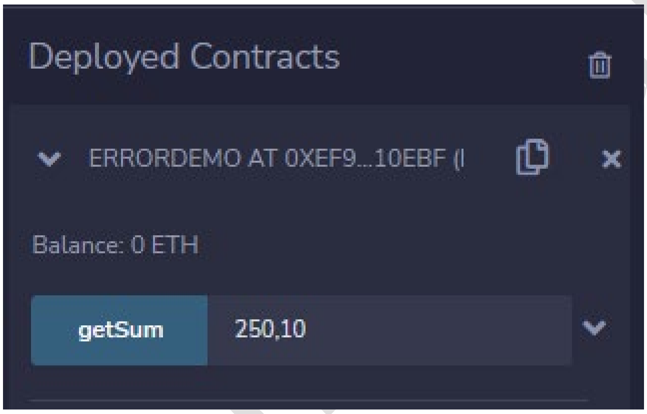
```
// SPDX-License-Identifier: MIT
pragma solidity ^0.5.17;

contract ErrorDemo {
    function getSum(uint256 a, uint256 b) public pure returns (uint256) {
        uint256 sum = a + b;
        // require(sum < 255, "Invalid");
        assert(sum<255);
        return sum;
    }
}
```

Output

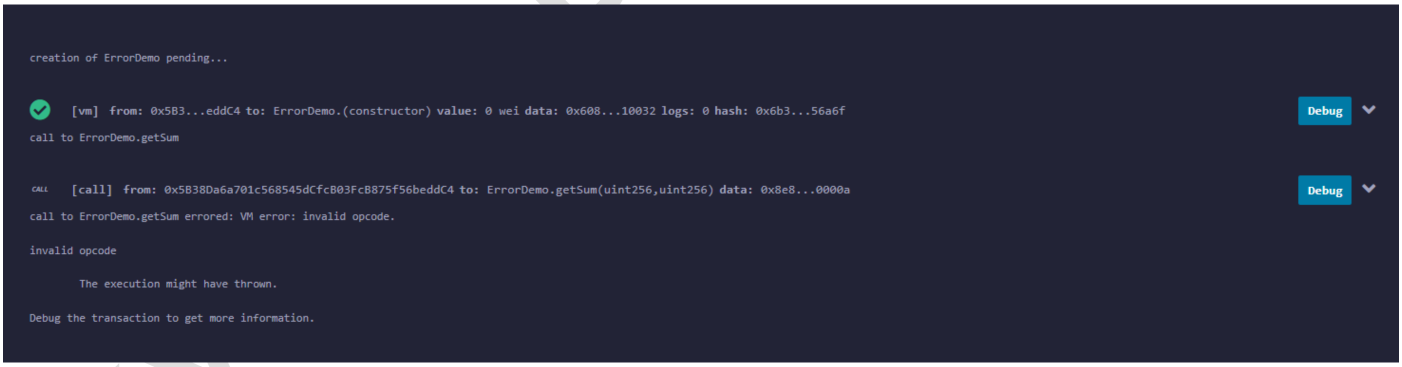


Flow of execution

Step 1-> Provide some values and press on getSum



Step 2-> Check terminal panel

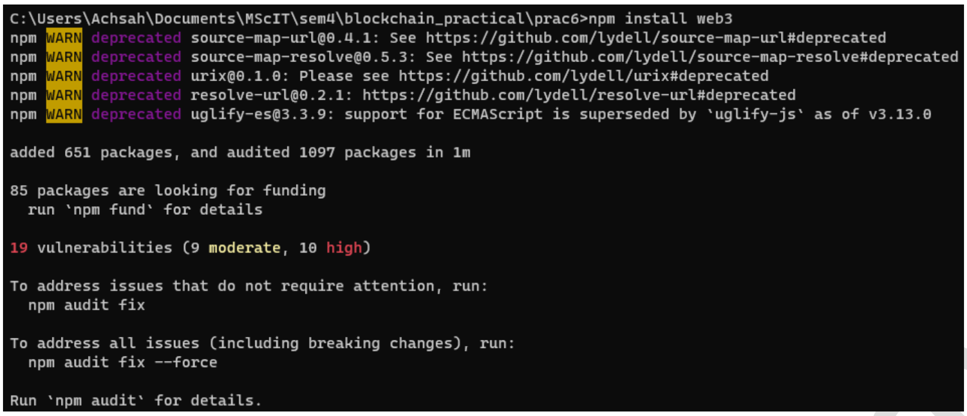


```
creation of ErrorDemo pending...

[vm] from: 0x5B3...eddC4 to: ErrorDemo.(constructor) value: 0 wei data: 0x608...10032 logs: 0 hash: 0x6b3...56a6f
call to ErrorDemo.getSum

CALL [call] from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: ErrorDemo.getSum(uint256,uint256) data: 0x8e8...0000a
call to ErrorDemo.getSum errored: VM error: invalid opcode.

invalid opcode

        The execution might have thrown.

Debug the transaction to get more information.
```

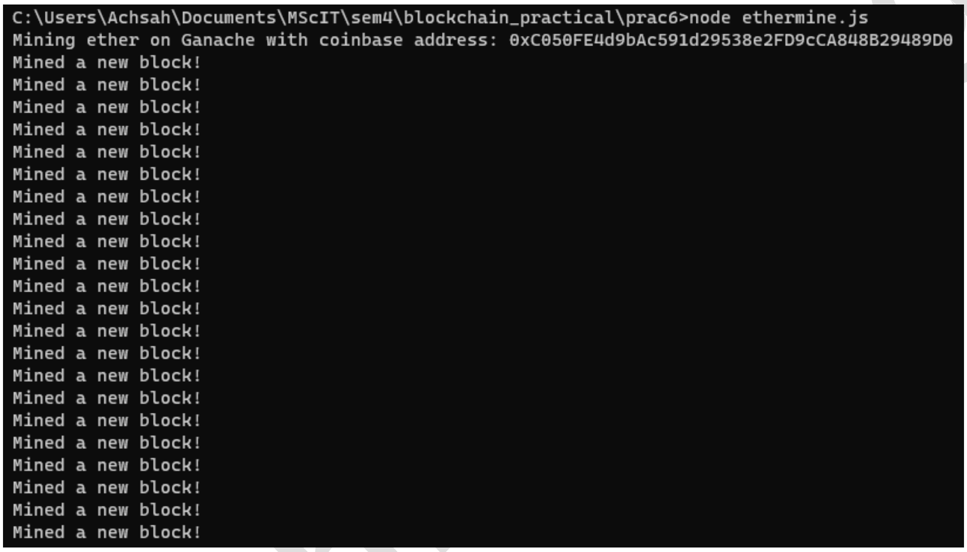
PRACTICAL-5 WRITE A PROGRAM TO DEMONSTRATE MINING OF ETHER

```
const Web3 = require('web3');

const web3 = new Web3(new
Web3.providers.HttpProvider('http://127.0.0.1:7545')); // Replace with your
Ganache HTTP provider


async function mine() {
    const accounts = await web3.eth.getAccounts();
    const coinbaseacc1 = accounts[0];
    const coinbaseacc2 = accounts[1];
    console.log(`Mining ether on Ganache with coinbase address:
${coinbaseacc1}`);

    while (true) {
        try {
            await web3.eth.sendTransaction({
                from: coinbaseacc1,
                to: coinbaseacc2,
                value: 50,
            });
            console.log(`Mined a new block!`);
        } catch (err) {
            console.error(err);
        }
    }
}

mine();
```

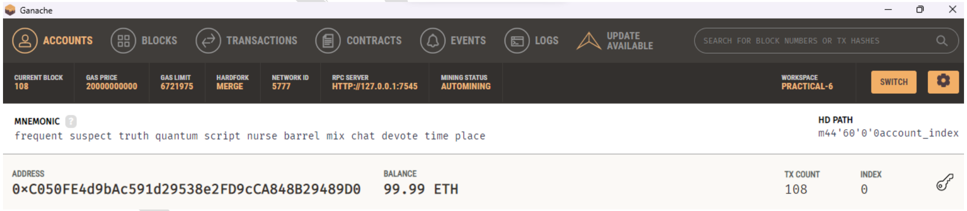
Output



```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac6>npm install web3
npm WARN deprecated source-map-url@0.4.1: See https://github.com/lydell/source-map-url#deprecated
npm WARN deprecated source-map-resolve@0.5.3: See https://github.com/lydell/source-map-resolve#deprecated
npm WARN deprecated urix@0.1.0: Please see https://github.com/lydell/urix#deprecated
npm WARN deprecated resolve-url@0.2.1: https://github.com/lydell/resolve-url#deprecated
npm WARN deprecated uglify-es@3.3.9: support for ECMAScript is superseded by `uglify-js` as of v3.13.0

added 651 packages, and audited 1097 packages in 1m

85 packages are looking for funding
  run `npm fund` for details

19 vulnerabilities (9 moderate, 10 high)

To address issues that do not require attention, run:
  npm audit fix

To address all issues (including breaking changes), run:
  npm audit fix --force

Run `npm audit` for details.
```



```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac6>node ethermine.js
Mining ether on Ganache with coinbase address: 0xC050FE4d9bAc591d29538e2FD9cCA848B29489D0
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
Mined a new block!
```



CURRENT BLOCK 108 | GAS PRICE 20000000000 | GAS LIMIT 6721975 | HARDFORK MERGE | NETWORK ID 5777 | RPC SERVER HTTP://127.0.0.1:7545 | MINING STATUS AUTOMINING | WORKSPACE PRACTICAL-6

MNEMONIC
frequent suspect truth quantum script nurse barrel mix chat devote time place

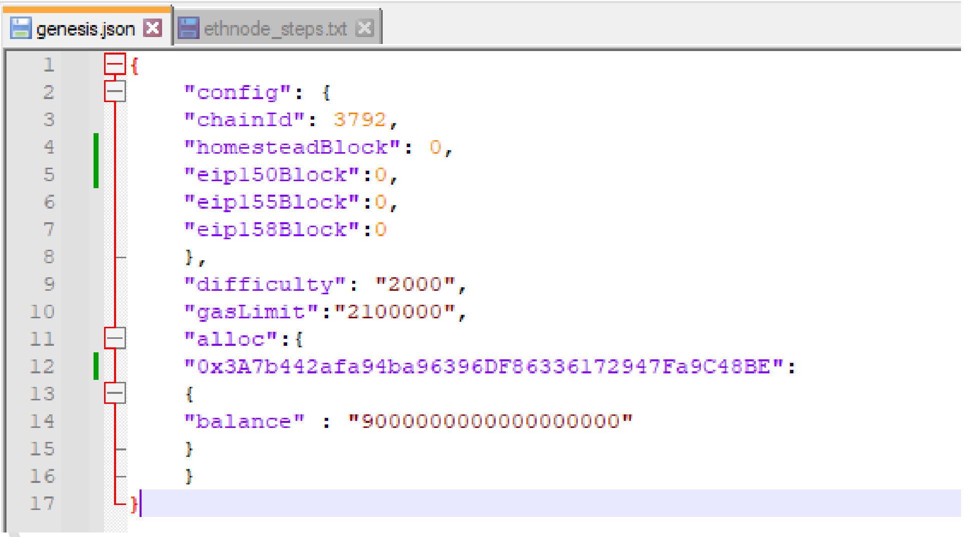
HD PATH
m44'60'0'0account_index

ADDRESS	BALANCE	TX COUNT	INDEX
0×C050FE4d9bAc591d29538e2FD9cCA848B29489D0	99.99 ETH	108	0

PRACTICAL-6 DEMONSTRATE THE RUNNING OF THE BLOCKCHAIN NODE

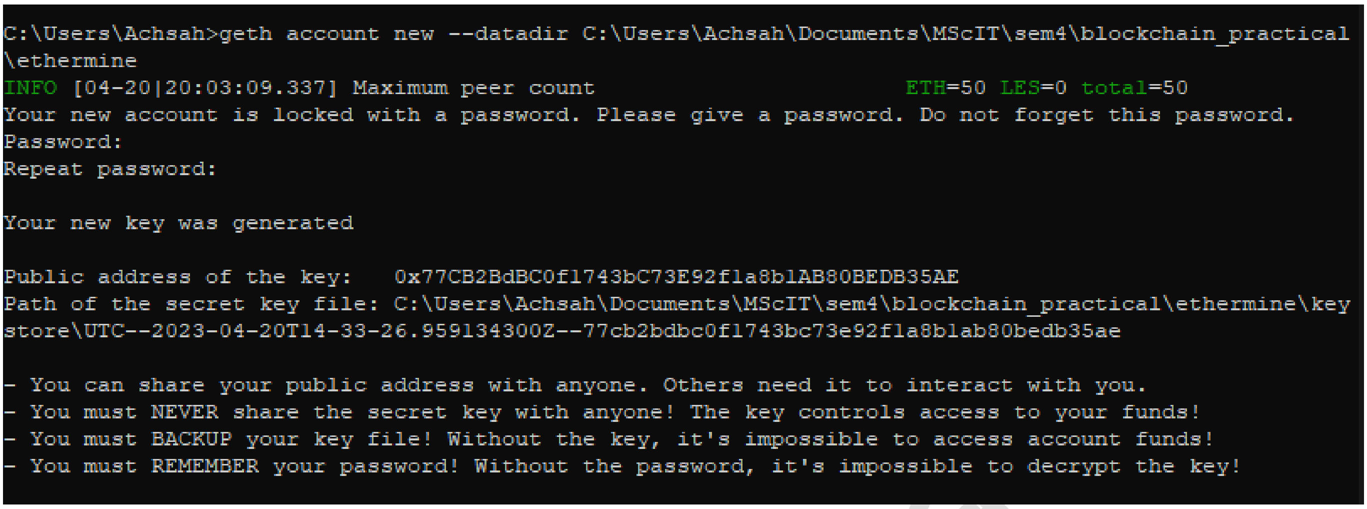
Step 1-> Create a folder named ethermine and a JSON file named genesis.json and write the following lines in it.

```
{
    "config": {
        "chainId": 3792,
        "homesteadBlock": 0,
        "eip150Block": 0,
        "eip155Block": 0,
        "eip158Block": 0
    },
    "difficulty": "2000",
    "gasLimit": "2100000",
    "alloc": {
        "0x0b6C4c81f58B8d692A7B46AD1e16a1147c25299F": {
            "balance": "9000000000000000000"
        }
    }
}
```



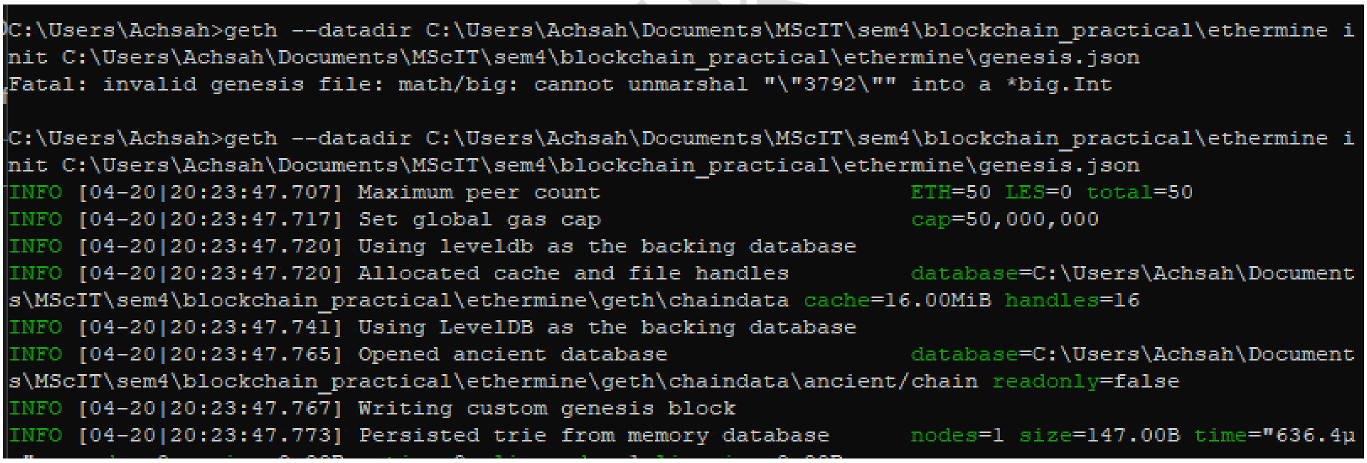
```
{
    "config": {
    "chainId": 3792,
    "homesteadBlock": 0,
    "eip150Block":0,
    "eip155Block":0,
    "eip158Block":0
    },
    "difficulty": "2000",
    "gasLimit":"2100000",
    "alloc":{
    "0x3A7b442afa94ba96396DF86336172947Fa9C48BE":
    {
    "balance" : "9000000000000000000"
    }
    }
}
```

Step 2-> Run command geth account new –datadir C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine testnet-blockchain



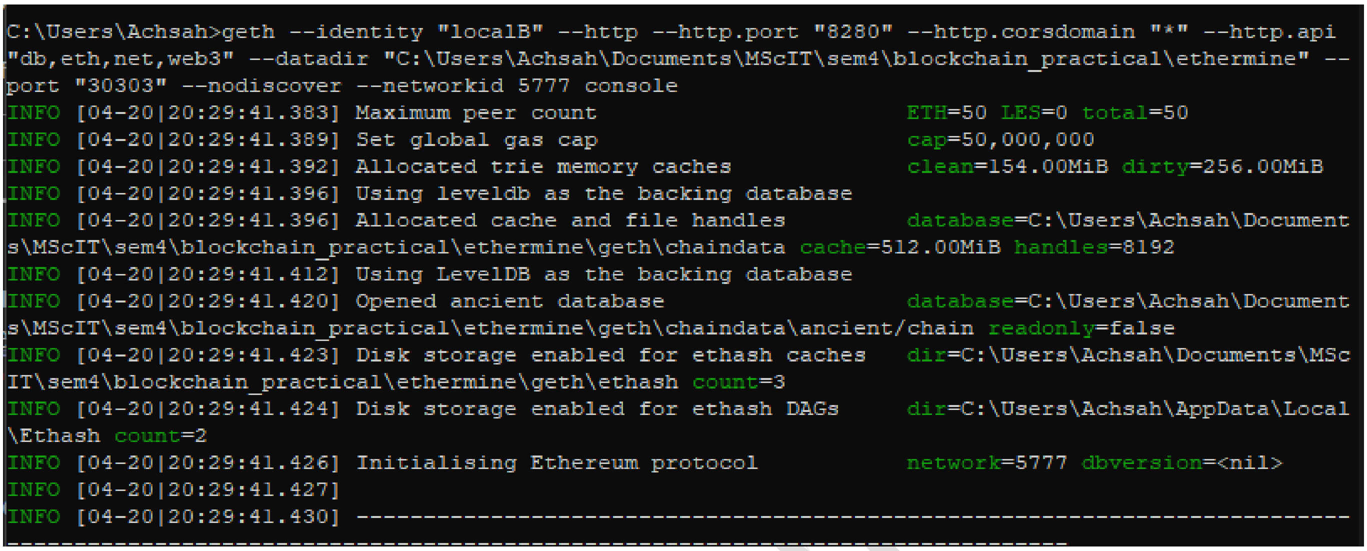
```
C:\Users\Achsah>geth account new --datadir C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical
\ethermine
INFO [04-20|20:03:09.337] Maximum peer count                       ETH=50 LES=0 total=50
Your new account is locked with a password. Please give a password. Do not forget this password.
Password:
Repeat password:

Your new key was generated

Public address of the key:   0x77CB2BdBC0f1743bC73E92f1a8b1AB80BEDB35AE
Path of the secret key file: C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine\key
store\UTC--2023-04-20T14-33-26.959134300Z--77cb2bdbc0f1743bc73e92f1a8b1ab80bedb35ae

- You can share your public address with anyone. Others need it to interact with you.
- You must NEVER share the secret key with anyone! The key controls access to your funds!
- You must BACKUP your key file! Without the key, it's impossible to access account funds!
- You must REMEMBER your password! Without the password, it's impossible to decrypt the key!
```

Step 3-> Run command geth --datadir C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine



```
C:\Users\Achsah>geth --datadir C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine i
nit C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine\genesis.json
Fatal: invalid genesis file: math/big: cannot unmarshal "\"3792\"" into a *big.Int

C:\Users\Achsah>geth --datadir C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine i
nit C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine\genesis.json
INFO [04-20|20:23:47.707] Maximum peer count                       ETH=50 LES=0 total=50
INFO [04-20|20:23:47.717] Set global gas cap                       cap=50,000,000
INFO [04-20|20:23:47.720] Using leveldb as the backing database
INFO [04-20|20:23:47.720] Allocated cache and file handles         database=C:\Users\Achsah\Document
s\MScIT\sem4\blockchain_practical\ethermine\geth\chaindata cache=16.00MiB handles=16
INFO [04-20|20:23:47.741] Using LevelDB as the backing database
INFO [04-20|20:23:47.765] Opened ancient database                  database=C:\Users\Achsah\Document
s\MScIT\sem4\blockchain_practical\ethermine\geth\chaindata\ancient/chain readonly=false
INFO [04-20|20:23:47.767] Writing custom genesis block
INFO [04-20|20:23:47.773] Persisted trie from memory database      nodes=1 size=147.00B time="636.4µ
```

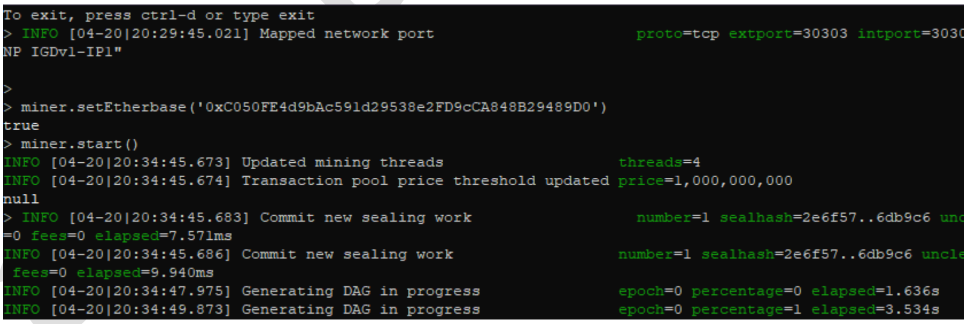
Step 4-> Run command geth --identity "localB" --http --http.port "8280" --http.corsdomain "*" --http.api "db,eth,net,web3" --datadir "C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine" --port "30303" --nodiscover --networkid 5777 console. This command will enable geth console.



```
C:\Users\Achsah>geth --identity "localB" --http --http.port "8280" --http.corsdomain "*" --http.api
"db,eth,net,web3" --datadir "C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\ethermine" --
port "30303" --nodiscover --networkid 5777 console
INFO [04-20|20:29:41.383] Maximum peer count                       ETH=50 LES=0 total=50
INFO [04-20|20:29:41.389] Set global gas cap                       cap=50,000,000
INFO [04-20|20:29:41.392] Allocated trie memory caches             clean=154.00MiB dirty=256.00MiB
INFO [04-20|20:29:41.396] Using leveldb as the backing database
INFO [04-20|20:29:41.396] Allocated cache and file handles         database=C:\Users\Achsah\Document
s\MScIT\sem4\blockchain_practical\ethermine\geth\chaindata cache=512.00MiB handles=8192
INFO [04-20|20:29:41.412] Using LevelDB as the backing database
INFO [04-20|20:29:41.420] Opened ancient database                  database=C:\Users\Achsah\Document
s\MScIT\sem4\blockchain_practical\ethermine\geth\chaindata\ancient/chain readonly=false
INFO [04-20|20:29:41.423] Disk storage enabled for ethash caches   dir=C:\Users\Achsah\Documents\MSc
IT\sem4\blockchain_practical\ethermine\geth\ethash count=3
INFO [04-20|20:29:41.424] Disk storage enabled for ethash DAGs     dir=C:\Users\Achsah\AppData\Local
\Ethash count=2
INFO [04-20|20:29:41.426] Initialising Ethereum protocol           network=5777 dbversion=<nil>
INFO [04-20|20:29:41.427]
INFO [04-20|20:29:41.430] -----------------------------------------------------------------------
---------------------------------------------------------------------------------
```

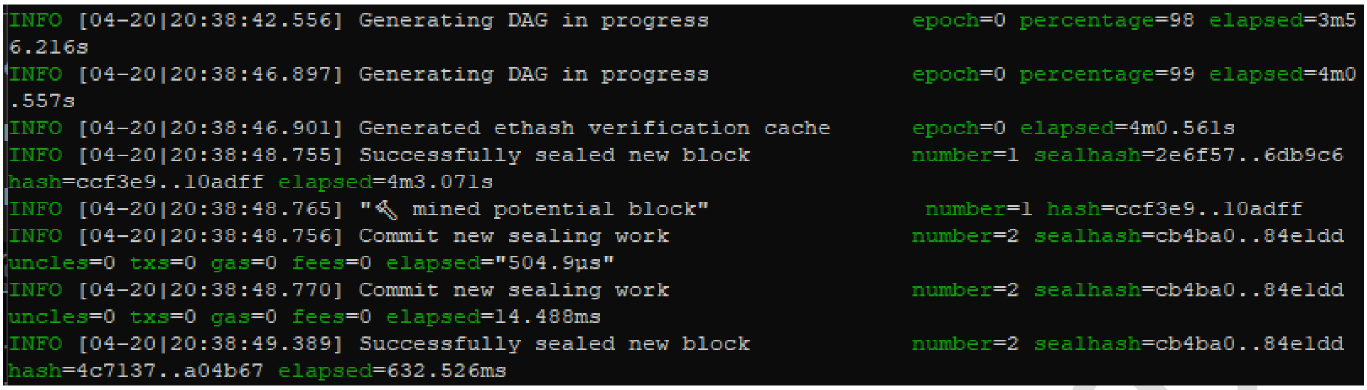
Step 5-> Run the command miner.setEtherbase('0xC050FE4d9bAc591d29538e2FD9cCA848B29489D0') in the geth console

Step 6-> Run the command miner.start() to start mining



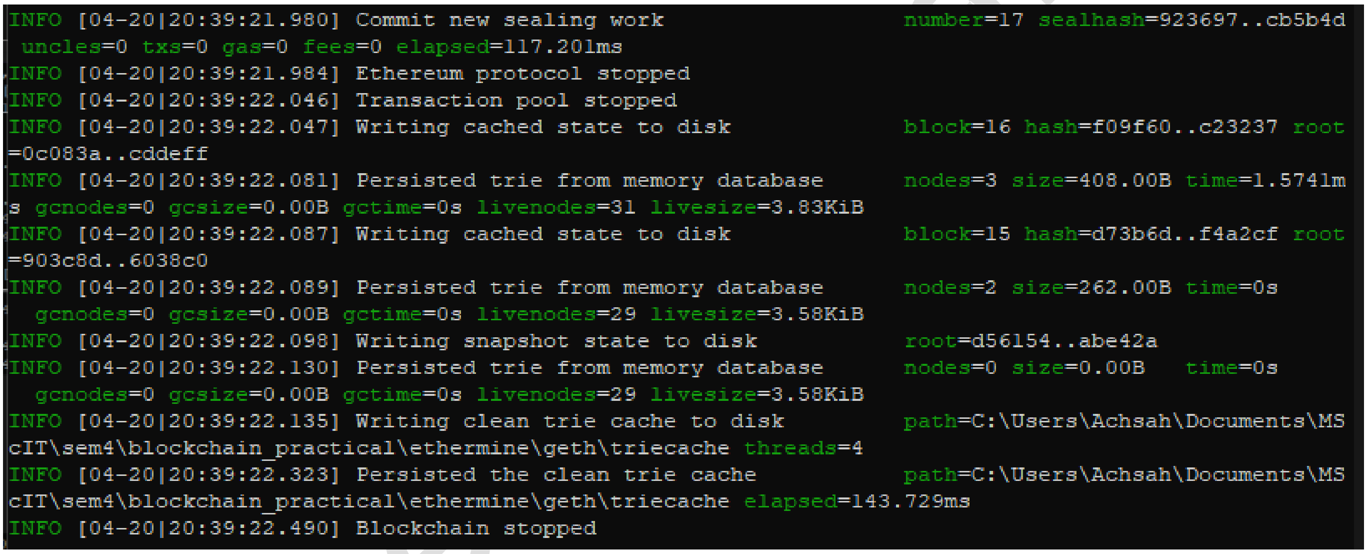
```
To exit, press ctrl-d or type exit
> INFO [04-20|20:29:45.021] Mapped network port                     proto=tcp extport=30303 intport=3030
NP IGDv1-IP1"

>
> miner.setEtherbase('0xC050FE4d9bAc591d29538e2FD9cCA848B29489D0')
true
> miner.start()
INFO [04-20|20:34:45.673] Updated mining threads                 threads=4
INFO [04-20|20:34:45.674] Transaction pool price threshold updated price=1,000,000,000
null
> INFO [04-20|20:34:45.683] Commit new sealing work                 number=1 sealhash=2e6f57..6db9c6 unc
=0 fees=0 elapsed=7.571ms
INFO [04-20|20:34:45.686] Commit new sealing work                number=1 sealhash=2e6f57..6db9c6 uncle
 fees=0 elapsed=9.940ms
INFO [04-20|20:34:47.975] Generating DAG in progress             epoch=0 percentage=0 elapsed=1.636s
INFO [04-20|20:34:49.873] Generating DAG in progress             epoch=0 percentage=1 elapsed=3.534s
```

Step 7-> Below screenshots are the mining processes running on your local machine.



```
INFO [04-20|20:38:42.556] Generating DAG in progress               epoch=0 percentage=98 elapsed=3m5
6.216s
INFO [04-20|20:38:46.897] Generating DAG in progress               epoch=0 percentage=99 elapsed=4m0
.557s
INFO [04-20|20:38:46.901] Generated ethash verification cache      epoch=0 elapsed=4m0.561s
INFO [04-20|20:38:48.755] Successfully sealed new block            number=1 sealhash=2e6f57..6db9c6
hash=ccf3e9..10adff elapsed=4m3.071s
INFO [04-20|20:38:48.765] "🔨 mined potential block"                number=1 hash=ccf3e9..10adff
INFO [04-20|20:38:48.756] Commit new sealing work                  number=2 sealhash=cb4ba0..84e1dd
uncles=0 txs=0 gas=0 fees=0 elapsed="504.9µs"
INFO [04-20|20:38:48.770] Commit new sealing work                  number=2 sealhash=cb4ba0..84e1dd
uncles=0 txs=0 gas=0 fees=0 elapsed=14.488ms
INFO [04-20|20:38:49.389] Successfully sealed new block            number=2 sealhash=cb4ba0..84e1dd
hash=4c7137..a04b67 elapsed=632.526ms
```

Step 8-> To stop the mining press Ctrl+D



```
INFO [04-20|20:39:21.980] Commit new sealing work                  number=17 sealhash=923697..cb5b4d
 uncles=0 txs=0 gas=0 fees=0 elapsed=117.201ms
INFO [04-20|20:39:21.984] Ethereum protocol stopped
INFO [04-20|20:39:22.046] Transaction pool stopped
INFO [04-20|20:39:22.047] Writing cached state to disk             block=16 hash=f09f60..c23237 root
=0c083a..cddeff
INFO [04-20|20:39:22.081] Persisted trie from memory database      nodes=3 size=408.00B time=1.5741m
s gcnodes=0 gcsize=0.00B gctime=0s livenodes=31 livesize=3.83KiB
INFO [04-20|20:39:22.087] Writing cached state to disk             block=15 hash=d73b6d..f4a2cf root
=903c8d..6038c0
INFO [04-20|20:39:22.089] Persisted trie from memory database      nodes=2 size=262.00B time=0s
  gcnodes=0 gcsize=0.00B gctime=0s livenodes=29 livesize=3.58KiB
INFO [04-20|20:39:22.098] Writing snapshot state to disk           root=d56154..abe42a
INFO [04-20|20:39:22.130] Persisted trie from memory database      nodes=0 size=0.00B   time=0s
  gcnodes=0 gcsize=0.00B gctime=0s livenodes=29 livesize=3.58KiB
INFO [04-20|20:39:22.135] Writing clean trie cache to disk         path=C:\Users\Achsah\Documents\MS
cIT\sem4\blockchain_practical\ethermine\geth\triecache threads=4
INFO [04-20|20:39:22.323] Persisted the clean trie cache           path=C:\Users\Achsah\Documents\MS
cIT\sem4\blockchain_practical\ethermine\geth\triecache elapsed=143.729ms
INFO [04-20|20:39:22.490] Blockchain stopped
```

PRACTICAL-7 CREATE YOUR OWN BLOCKCHAIN AND DEMONSTRATE ITS USE

Create a javascript folder with the following code in any folder of your choice.

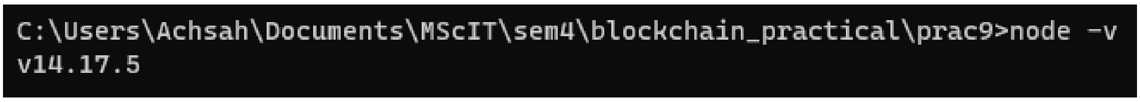
JavaScript Code

```
const SHA256 = require("crypto-js/sha256");
class Block {
  constructor(index, timestamp, data, previousHash = "") {
    this.index = index;
    this.timestamp = timestamp;
    this.data = data;
    this.previousHash = previousHash;
    this.hash = this.calculateHash();
  }

  calculateHash() {
    return SHA256(
      this.index +
        this.previousHash +
        this.timestamp +
        JSON.stringify(this.data)
    ).toString();
  }
}

class Blockchain {
  constructor() {
    this.chain = [this.createGenesisBlock()];
  }

  createGenesisBlock() {
    return new Block(0, "21/04/2023", "Genesis Block", "0");
  }

  getLatestBlock() {
    return this.chain[this.chain.length - 1];
  }

  addBlock(newBlock) {
    newBlock.previousHash = this.getLatestBlock().hash;
    newBlock.hash = newBlock.calculateHash();
    this.chain.push(newBlock);
  }
  isChainValid() {
    for (let i = 1; i < this.chain.length; i++) {
      const currentBlock = this.chain[i];
      const previousBlock = this.chain[i - 1];

      if (currentBlock.hash !== currentBlock.calculateHash()) {
        return false;
      }

      if (currentBlock.previousHash !== previousBlock.hash) {
        return false;
      }
    }

    return true;
  }
}

//Blockchain Implementation

let myCoin = new Blockchain();
myCoin.addBlock(new Block(1, "22/04/2023", { amount: 4 }));
myCoin.addBlock(new Block(2, "22/04/2023", { amount: 8 }));
//console.log('Is blockchain valid? ' + myCoin.isChainValid());
console.log(JSON.stringify(myCoin, null, 4));
```

Output

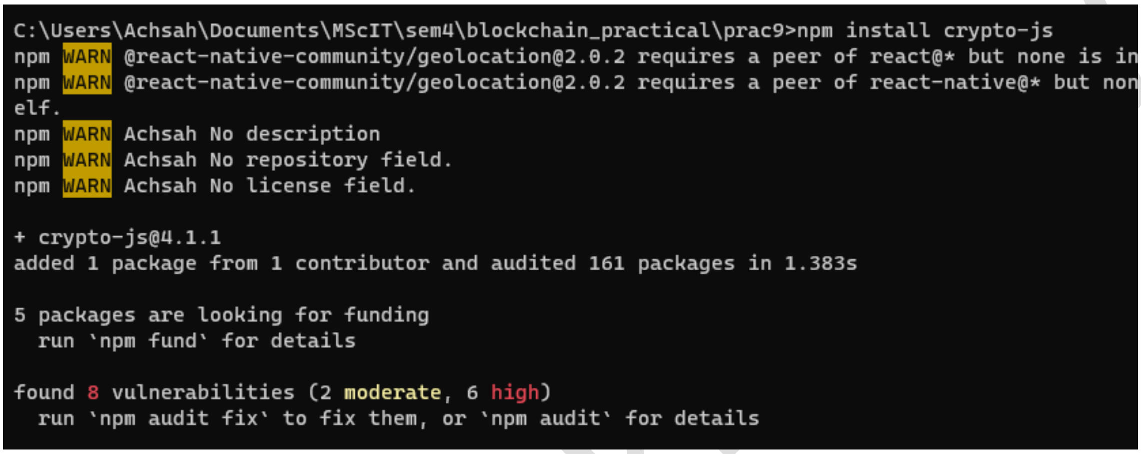
Flow of execution

Step 1-> Make sure you have installed nodejs in your system



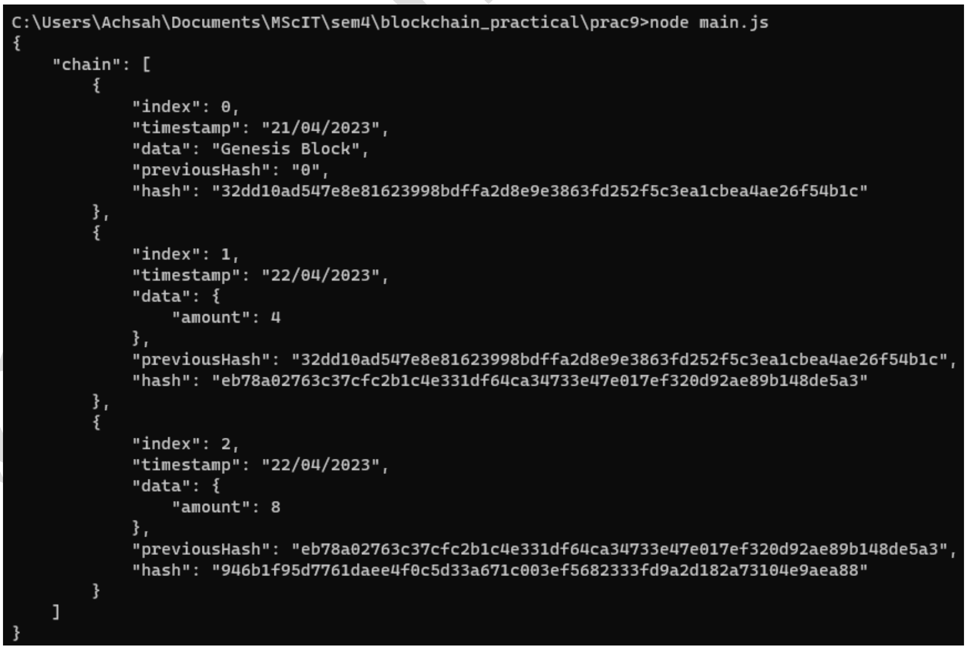
```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac9>node -v
v14.17.5
```

Step 2-> We need crypto –js node module to make our own blockchain. So install it as following



```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac9>npm install crypto-js
npm WARN @react-native-community/geolocation@2.0.2 requires a peer of react@* but none is in
npm WARN @react-native-community/geolocation@2.0.2 requires a peer of react-native@* but non
elf.
npm WARN Achsah No description
npm WARN Achsah No repository field.
npm WARN Achsah No license field.

+ crypto-js@4.1.1
added 1 package from 1 contributor and audited 161 packages in 1.383s

5 packages are looking for funding
  run `npm fund` for details

found 8 vulnerabilities (2 moderate, 6 high)
  run `npm audit fix` to fix them, or `npm audit` for details
```

Step 3-> Run the above code in command line using command: node main.js



```
C:\Users\Achsah\Documents\MScIT\sem4\blockchain_practical\prac9>node main.js
{
    "chain": [
        {
            "index": 0,
            "timestamp": "21/04/2023",
            "data": "Genesis Block",
            "previousHash": "0",
            "hash": "32dd10ad547e8e81623998bdffa2d8e9e3863fd252f5c3ea1cbea4ae26f54b1c"
        },
        {
            "index": 1,
            "timestamp": "22/04/2023",
            "data": {
                "amount": 4
            },
            "previousHash": "32dd10ad547e8e81623998bdffa2d8e9e3863fd252f5c3ea1cbea4ae26f54b1c",
            "hash": "eb78a02763c37cfc2b1c4e331df64ca34733e47e017ef320d92ae89b148de5a3"
        },
        {
            "index": 2,
            "timestamp": "22/04/2023",
            "data": {
                "amount": 8
            },
            "previousHash": "eb78a02763c37cfc2b1c4e331df64ca34733e47e017ef320d92ae89b148de5a3",
            "hash": "946b1f95d7761daee4f0c5d33a671c003ef5682333fd9a2d182a73104e9aea88"
        }
    ]
}
```