Blockchain Experiment 3

Aim: Create a Cryptocurrency using Python and perform mining in the Blockchain created.

Theory:

1. Blockchain Overview

Blockchain is a **distributed and decentralized ledger** that stores information in a series of linked blocks.

Each block contains:

- Transaction data
- Timestamp
- Previous block's hash
- Its own unique hash (digital fingerprint)

Once data is recorded in a blockchain, it becomes **immutable** because altering one block would require recalculating all subsequent blocks.

2. Mining

Mining is the process of:

1. Collecting pending transactions into a block.
2. Performing a computational puzzle (Proof-of-Work) to find a valid hash.
3. Adding the new block to the blockchain.
   Broadcasting it to all connected peers.

Miners are rewarded with cryptocurrency for successfully mining a block.

3. Multi-Node Blockchain Network

In this lab, we simulate **three independent blockchain nodes** (5001, 5002, 5003).

Each node:

- Runs on a separate port.
- Maintains its own copy of the blockchain.
- Can connect with peers to share and validate blocks.

4. Consensus Mechanism

We use the **Longest Chain Rule**:

- If multiple versions of the chain exist, the **longest valid chain** is chosen.
- This ensures all nodes agree on a single transaction history.

5. Transactions & Mining Reward

Each transaction has:

- Sender
- Receiver
- Amount

When mining a block:

- Pending transactions are added to the block.
- A **reward transaction** is added automatically to pay the miner.

6. Chain Replacement

When /replace_chain is called:

1. Node requests chains from peers.
2. If it finds a longer and valid chain, it replaces its own.
3. This keeps the blockchain consistent across all nodes.

7. Cryptographic Hashing

Hashing is a fundamental security feature of blockchain technology.
A **hash** is a fixed-length output generated from input data using a cryptographic hash function such as SHA-256.

In a blockchain:

- Each block contains the hash of the previous block.
- Any small change in block data changes its hash completely.
- This creates a secure chain where blocks are cryptographically linked.

Because of hashing, tampering with one block breaks the entire chain, making the system highly secure and tamper-resistant.

8. Proof-of-Work (PoW) Algorithm

Proof-of-Work is a consensus technique that prevents misuse of the blockchain network.
In PoW:

- Miners must find a hash that satisfies a specific difficulty condition (e.g., starts with "0000").

- This requires trying many random values (nonces) until the correct hash is found.

- The first miner to solve the puzzle gets the right to add the block.

PoW ensures that adding a block requires real computational effort, which protects the network from spam and fraud.

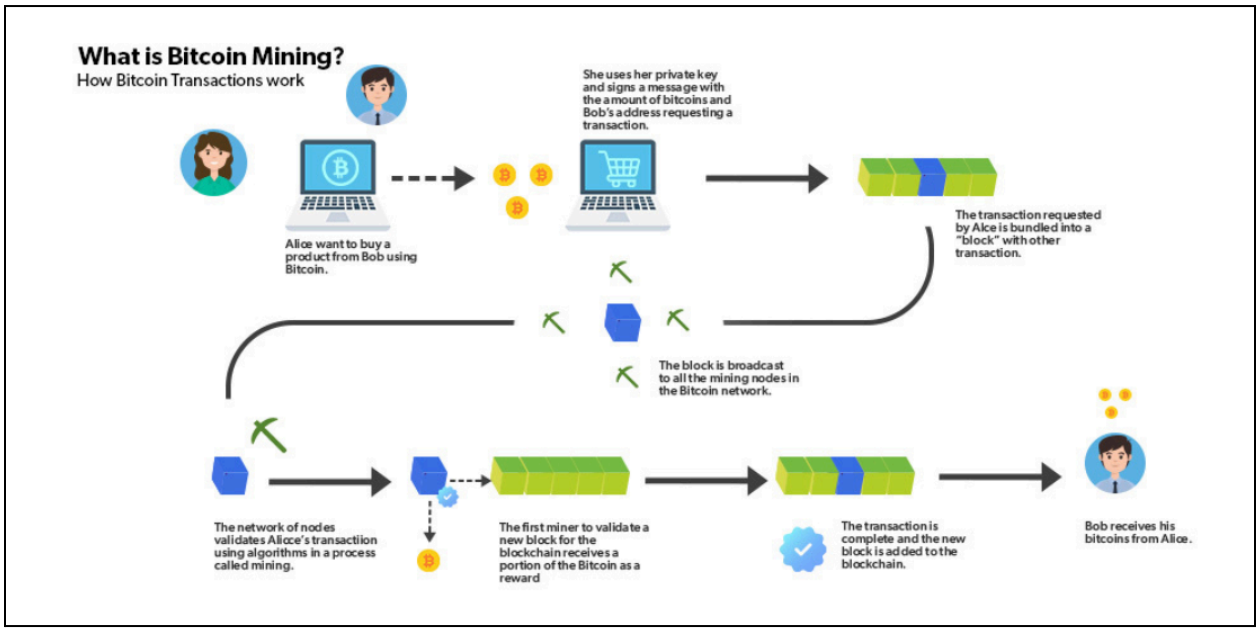
9. Block Structure

Each block in the blockchain consists of the following fields:

- **Index:** Position of the block in the chain
- **Timestamp:** Time of creation
- **Data:** List of verified transactions
- **Nonce:** Value used in PoW
- **Previous Hash:** Hash of the previous block
- **Hash:** Cryptographic hash of the current block

This structure ensures data integrity and traceability.

Mining:



Code:

```
import datetime
import hashlib
import json
from flask import Flask, jsonify, request
import requests
from uuid import uuid4
# Generate a unique id that is in hex
from urllib.parse import urlparse
# To parse url of the nodes

# Part 1 - Building a Blockchain

class Blockchain:

    def __init__(self):
        self.chain = []
                        self.transactions = []
# Adding transactions before they are added to a block
                    self.create_block(proof = 1, previous_hash = '0')
                            self.nodes = set()
# Set is used as there is no order to be maintained as the nodes can be from all around the globe

                def create_block(self, proof, previous_hash):
        block = {'index': len(self.chain) + 1,
                                            'timestamp': str(datetime.datetime.now()),
                'proof': proof,
                'previous_hash': previous_hash,
                  'transactions': self.transactions}
# Adding transactions to make the blockchain a cryptocurrency
                                self.transactions = []
# The list of transacction should become empty after they are added to a block
        self.chain.append(block)
        return block

    def get_previous_block(self):
        return self.chain[-1]

    def proof_of_work(self, previous_proof):
        new_proof = 1
        check_proof = False
        while check_proof is False:
                                    hash_operation = hashlib.sha256(str(new_proof**2 - previous_proof**2).encode()).hexdigest()
            if hash_operation[:4] == '0000':
                check_proof = True
            else:
                new_proof += 1
        return new_proof

    def hash(self, block):
            encoded_block = json.dumps(block, sort_keys = True).encode()
                                                return hashlib.sha256(encoded_block).hexdigest()

    def is_chain_valid(self, chain):
        previous_block = chain[0]
        block_index = 1
        while block_index < len(chain):
```

```
        block = chain[block_index]
                if block['previous_hash'] != self.hash(previous_block):
            return False
                previous_proof = previous_block['proof']
        proof = block['proof']
                hash_operation = hashlib.sha256(str(proof**2 - previous_proof**2).encode()).hexdigest()
        if hash_operation[:4] != '0000':
            return False
        previous_block = block
        block_index += 1
      return True

   # This method will add the trqnsaction to the list of trnsactions
         def add_transaction(self, sender, receiver, amount):
          self.transactions.append({'sender': sender,
                    'receiver': receiver,
                    'amount': amount})
                previous_block = self.get_previous_block()
          return previous_block['index'] + 1
# It will return the block index to which the transaction should be added

       # This function will add the node containing an address to the set of nodes created in init function
   def add_node(self, address):
            parsed_url = urlparse(address)
# urlparse will parse the url from the address
            self.nodes.add(parsed_url.netloc)
# Add is used and not append as it's a set. Netloc will only return '127.0.0.1:5000'

    # Consensus Protocol. This function will replace all the shorter chain with the longer chain in all the nodes on the network
   def replace_chain(self):
                network = self.nodes
# network variable is the set of nodes all around the globe
                longest_chain = None
# It will hold the longest chain when we scan the network
                max_length = len(self.chain)
# This will hold the length of the chain held by the node that runs this function
      for node in network:
                response = requests.get(f'http://{node}/get_chain')
# Use get chain method already created to get the length of the chain
          if response.status_code == 200:
              length = response.json()['length']
# Extract the length of the chain from get_chain fiunction
            chain = response.json()['chain']
                if length > max_length and self.is_chain_valid(chain):          # We check if the length is bigger and if the chain is valid then
                    max_length = length
# We update the max length
                    longest_chain = chain
# We update the longest chain
                if longest_chain:
# If longest_chain is not none that means it was replaced
                    self.chain = longest_chain
```

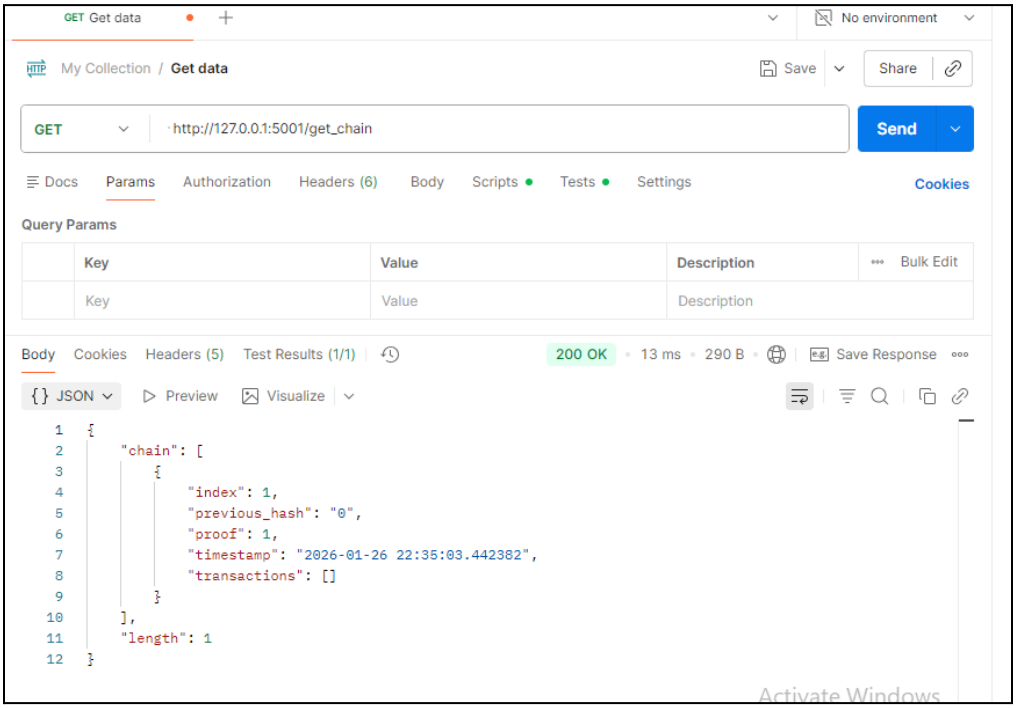
```
# Replace the chain of the current node with the longest chain
        return True
                                return False
# Return false if current chain is the longest one

# Part 2 - Mining our Blockchain

# Creating a Web App
app = Flask(__name__)

# Creating an address for the node on Port 5000. We will create some other nodes as well on different ports
node_address = str(uuid4()).replace('-', '')
#

# Creating a Blockchain
blockchain = Blockchain()

# Mining a new block
@app.route('/mine_block', methods = ['GET'])
def mine_block():
                        previous_block = blockchain.get_previous_block()
    previous_proof = previous_block['proof']
                                proof = blockchain.proof_of_work(previous_proof)
                        previous_hash = blockchain.hash(previous_block)
        blockchain.add_transaction(sender = node_address, receiver = 'Richard', amount = 1) # Hadcoins to mine the block (A Reward). So the node gives 1 hadcoin to Abcde for mining the block
      block = blockchain.create_block(proof, previous_hash)
     response = {'message': 'Congratulations, you just mined a block!',
            'index': block['index'],
            'timestamp': block['timestamp'],
            'proof': block['proof'],
                                'previous_hash': block['previous_hash'],
                                'transactions': block['transactions']}
    return jsonify(response), 200

# Getting the full Blockchain
@app.route('/get_chain', methods = ['GET'])
def get_chain():
    response = {'chain': blockchain.chain,
            'length': len(blockchain.chain)}
    return jsonify(response), 200

# Checking if the Blockchain is valid
@app.route('/is_valid', methods = ['GET'])
def is_valid():
                                is_valid = blockchain.is_chain_valid(blockchain.chain)
    if is_valid:
        response = {'message': 'All good. The Blockchain is valid.'}
    else:
        response = {'message': 'Houston, we have a problem. The Blockchain is not valid.'}
    return jsonify(response), 200

# Adding a new transaction to the Blockchain
@app.route('/add_transaction', methods = ['POST'])                    # Post method as we have to pass something to get
```

```
something in return
def add_transaction():
    json = request.get_json()
 # This will get the json file from postman. In Postman we will create a json file in which we will #pass the values for the keys in the json file
      transaction_keys = ['sender', 'receiver', 'amount']
          if not all(key in json for key in transaction_keys):
 # Checking if all keys are available in json
      return 'Some elements of the transaction are missing', 400
                                    index = blockchain.add_transaction(json['sender'], json['receiver'], json['amount'])
     response = {'message': f'This transaction will be added to Block {index}'}
    return jsonify(response), 201
    # Code 201 for creation

# Part 3 - Decentralizing our Blockchain

# Connecting new nodes
@app.route('/connect_node', methods = ['POST'])                    # POST request to register the new nodes from the json file
def connect_node():
    json = request.get_json()
                nodes = json.get('nodes')
# Get the nodes from json file
    if nodes is None:
        return "No node", 400
    for node in nodes:
        blockchain.add_node(node)
     response = {'message': 'All the nodes are now connected. The Hadcoin Blockchain now contains the following nodes:',
                                    'total_nodes': list(blockchain.nodes)}
    return jsonify(response), 201

# Replacing the chain by the longest chain if needed
@app.route('/replace_chain', methods = ['GET'])
def replace_chain():
                    is_chain_replaced = blockchain.replace_chain()
    if is_chain_replaced:
          response = {'message': 'The nodes had different chains so the chain was replaced by the longest one.',
                'new_chain': blockchain.chain}
    else:
        response = {'message': 'All good. The chain is the largest one.',
                                    'actual_chain': blockchain.chain}
    return jsonify(response), 200

# Running the app
app.run(host = '0.0.0.0', port = 5000)
```

Output:

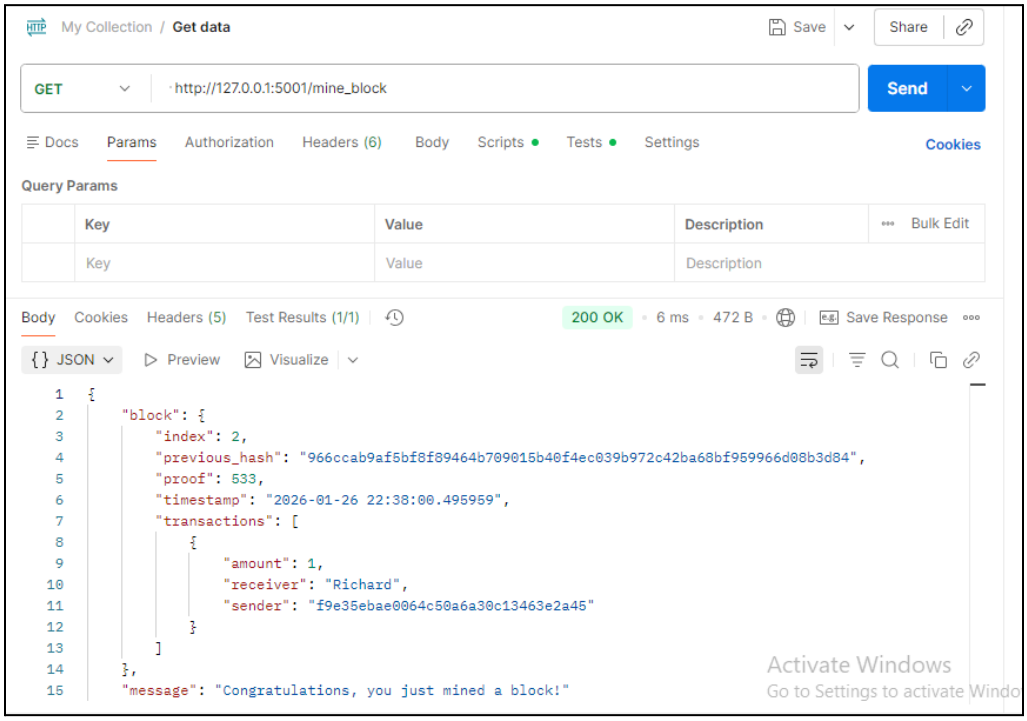
1. /get_chain (GET Request)

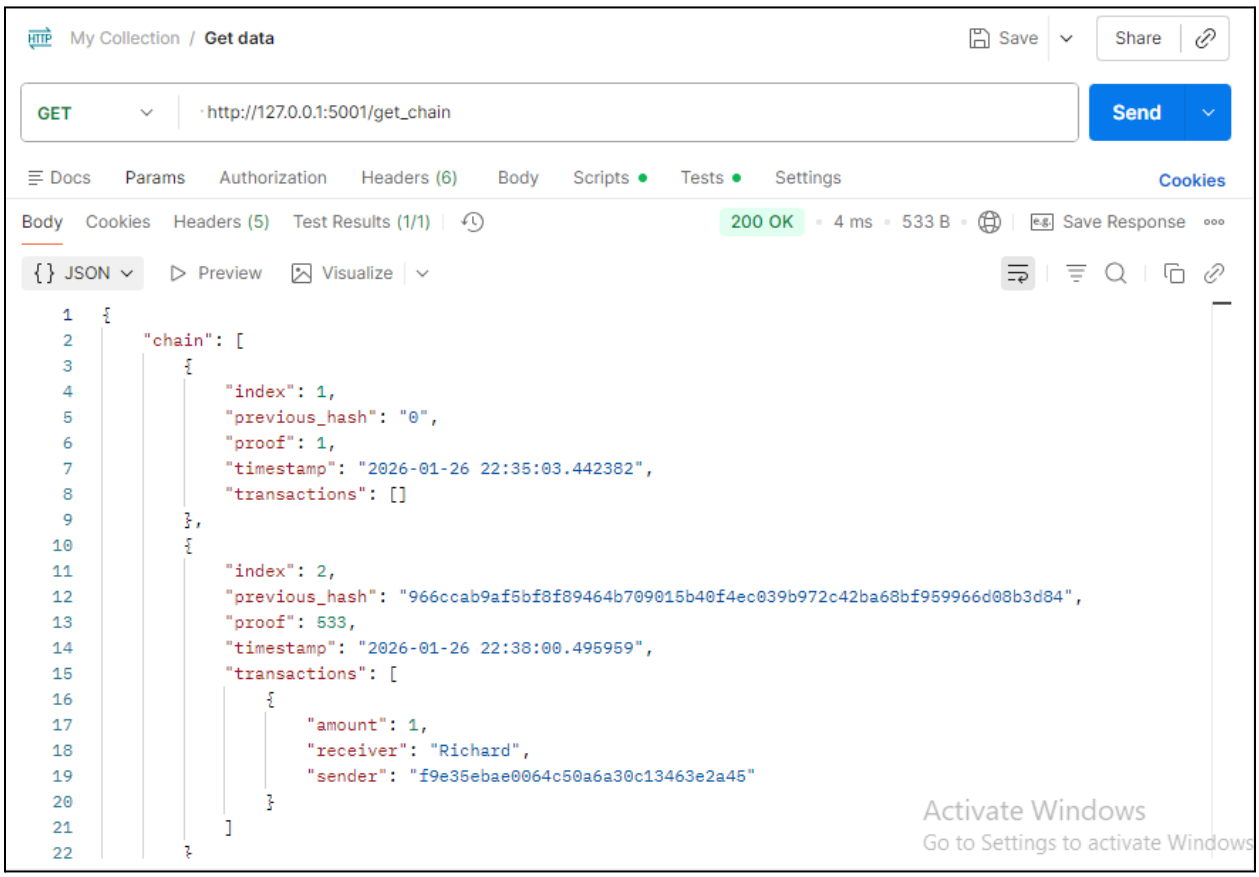
This GET request retrieves the complete blockchain from the node, showing all mined blocks and stored transactions.



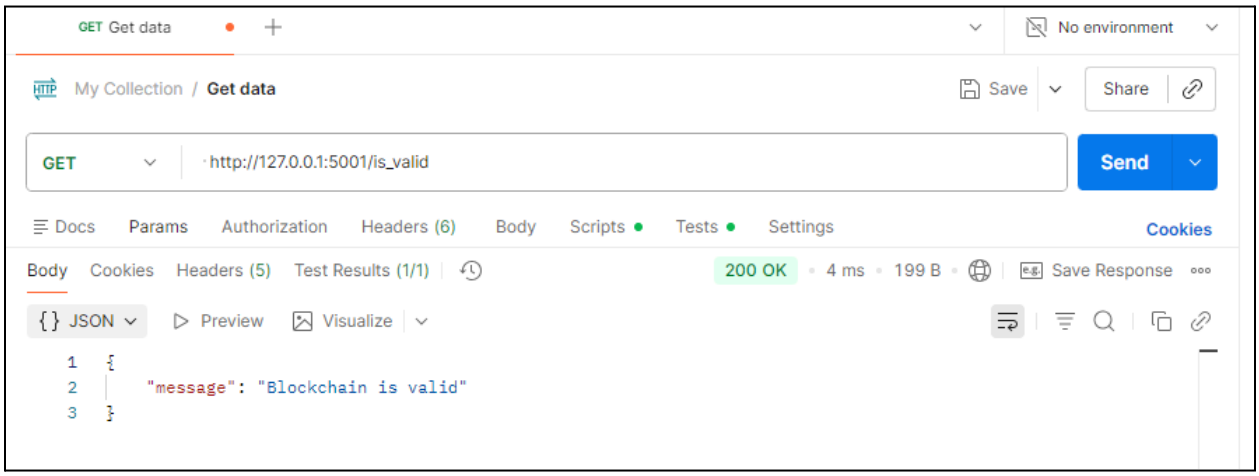
2. /mine_block (GET Request)

This GET request performs the mining process using Proof-of-Work and adds a new block to the blockchain.

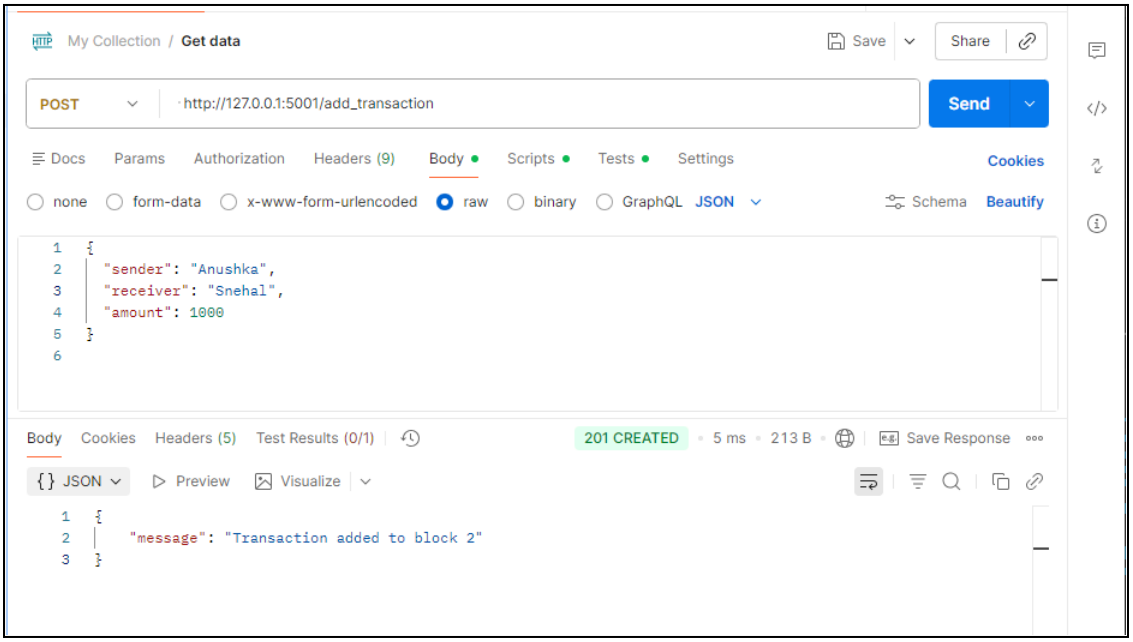

My Collection / Get data
Save
Share
GET
http://127.0.0.1:5001/mine_block
Send
Docs
Params
Authorization
Headers (6)
Body
Scripts
Tests
Settings
Cookies
Query Params
Key
Value
Description
Bulk Edit
Body
Cookies
Headers (5)
Test Results (1/1)
200 OK
6 ms
472 B
Save Response
JSON
Preview
Visualize
{
"block": {
"index": 2,
"previous_hash": "966ccab9af5bf8f89464b709015b40f4ec039b972c42ba68bf959966d08b3d84",
"proof": 533,
"timestamp": "2026-01-26 22:38:00.495959",
"transactions": [
{
"amount": 1,
"receiver": "Richard",
"sender": "f9e35ebae0064c50a6a30c13463e2a45"
}
]
},
"message": "Congratulations, you just mined a block!"
Activate Windows
Go to Settings to activate Windo


My Collection / Get data
Save
Share
GET
http://127.0.0.1:5001/get_chain
Send
Docs
Params
Authorization
Headers (6)
Body
Scripts
Tests
Settings
Cookies
Body
Cookies
Headers (5)
Test Results (1/1)
200 OK
4 ms
533 B
Save Response
JSON
Preview
Visualize
{
"chain": [
{
"index": 1,
"previous_hash": "0",
"proof": 1,
"timestamp": "2026-01-26 22:35:03.442382",
"transactions": []
},
{
"index": 2,
"previous_hash": "966ccab9af5bf8f89464b709015b40f4ec039b972c42ba68bf959966d08b3d84",
"proof": 533,
"timestamp": "2026-01-26 22:38:00.495959",
"transactions": [
{
"amount": 1,
"receiver": "Richard",
"sender": "f9e35ebae0064c50a6a30c13463e2a45"
}
]
}
Activate Windows
Go to Settings to activate Windows

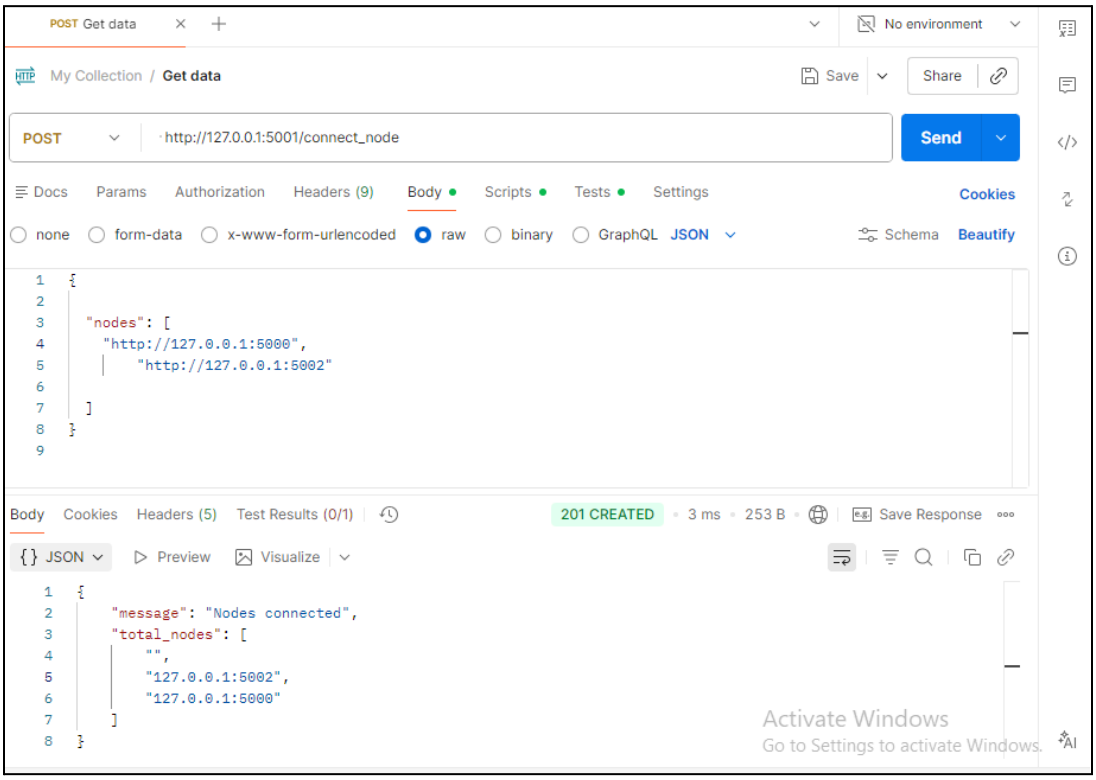
3. /is_valid (GET Request)
This GET request checks whether the current blockchain is valid and untampered.



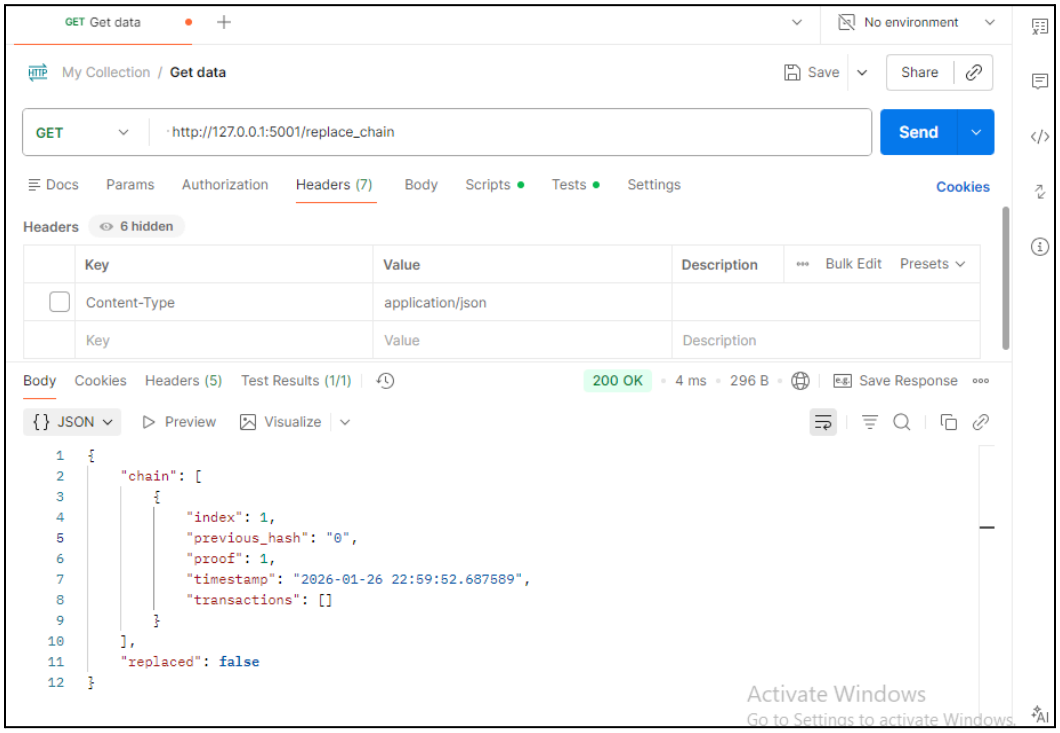
4. /add_transaction (POST Request)
This POST request submits a new transaction (sender, receiver, amount) to be added to the next mined block.



5. /connect_node (POST Request)
This POST request connects the current node with other peer nodes in the blockchain network.



6. **/replace_chain (GET Request)**
This GET request checks all connected peer nodes and replaces the current blockchain with the longest valid chain, ensuring network-wide consistency.



Conclusion:

In this experiment, a basic cryptocurrency system was designed and implemented using Python by applying fundamental blockchain principles such as block generation, cryptographic hashing, Proof-of-Work mining, transaction processing, and decentralized networking. A Flask-based framework was used to enable communication between multiple nodes, with each node maintaining its own copy of the blockchain ledger.

The mining process required solving the Proof-of-Work challenge, after which new blocks were added to the chain and miners received rewards. The system also supported transaction validation and inclusion of verified transactions into newly mined blocks. Through this implementation, the experiment offered hands-on insight into the functioning of blockchain technology, demonstrating how consensus, decentralization, and mining together enable the secure operation of cryptocurrencies in distributed environments.