VIDUSH SOMANY INSTITUTE OF TECHNOLOGY AND RESEARCH, KADI

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CT703D-N

BLOCKCHAIN TECHNOLOGY

LAB MANUAL

SEMESTER – 7

ENROLLMENT NO	
NAME	
BRANCH	

CERTIFICATE

This is to certify that Mr. / Ms. ______________________________ Of class _______________________ Enrollment No.: __________________________ has Satisfactorily completed the course in _____________________________ at Vidush Somany Institute Of Technology & Research,Kadi (Kadi Sarva Vishwavidyalaya) for ________ Year (B.E.) semester ______ of Computer Science & Engineering / Computer Engineering /Information Technology in the Academic year _______________.

Date of Submission: ______/______/______

Faculty Name with Signature **Head of Department**

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Practical 1

1.1 Understanding Block using https://tools.superdatascience.com/Blockchain/block

1.2 Understanding Blockchain using https://tools.superdatascience.com/Blockchain/Blockchain

1.3 Understanding Distributed Blockchain using https://tools.superdatascience.com/Blockchain/distributed

1.4 Understanding Tokens using https://tools.superdatascience.com/Blockchain/tokens

1.5 Understanding coin based transaction using https://tools.superdatascience.com/Blockchain/tokens

1.1 Understanding Block

Objective:

To understand the structure of a block and how mining ensures security using hashing and nonce.

Procedure:

1. Open the Block Simulator: https://tools.superdatascience.com/Blockchain/block
2. Enter any transaction/data into the block.
3. Observe how the block's hash changes with the data.
4. Click **Mine** to calculate a valid hash (with leading zeros).

Observation:

- The hash depends on both the data and nonce.
- Editing the block changes the hash immediately.
- Mining adjusts the nonce until a valid hash is found.

Conclusion:

A block is secured using hashing and mining. Even a small change in data invalidates the block unless it is mined again.

1.2 Understanding Blockchain

Objective:

To study how multiple blocks are linked to form a blockchain and how immutability is maintained.

Procedure:

1. Open the Blockchain Simulator: https://tools.superdatascience.com/Blockchain/Blockchain
2. Add transactions/data in one of the blocks.
3. Click **Mine** to validate it.
4. Edit an older block and observe how subsequent blocks turn invalid.
5. Re-mine blocks to restore validity.

Observation:

- Each block contains the hash of the previous block.
- Changing data in one block invalidates the entire chain.
- Re-mining is required to repair the chain.

Conclusion:
Blockchain ensures immutability because changing one block requires re-mining all following blocks, making tampering highly impractical.

1.3 Understanding Distributed Blockchain

Objective:
To understand how blockchain works in a distributed network and how consensus is achieved.

Procedure:
1. Open the Distributed Blockchain Simulator: https://tools.superdatascience.com/Blockchain/distributed
2. Edit the data in one node's blockchain.
3. Notice that this node differs from others (conflict).
4. Click **Consensus** to synchronize all nodes.

Observation:
- A single altered node creates conflict in the network.
- By applying consensus, the majority chain is accepted as the valid chain.
- The tampered chain is rejected.

Conclusion:
Distributed blockchain ensures trust among participants by maintaining a common, agreed version of the ledger through consensus mechanisms.

1.4 Understanding Tokens

Objective:
To explore how tokens can be created and transferred in blockchain-based systems.

Procedure:
1. Open the Token Simulator: https://tools.superdatascience.com/Blockchain/tokens
2. Create a token (e.g., "SanjayCoin").
3. Assign some tokens to a user account.
4. Transfer tokens from one account to another.

Observation:
- Tokens are recorded as transactions in blocks.
- Transfers are securely validated and stored on the blockchain.
- Tokens can represent currency, points, or assets.

Conclusion:
Tokens demonstrate blockchain's versatility, extending beyond cryptocurrency to represent any digital or physical asset.

1.5 Understanding Coin-based Transaction

Objective:
To study how coin-based transactions are performed and verified on blockchain.

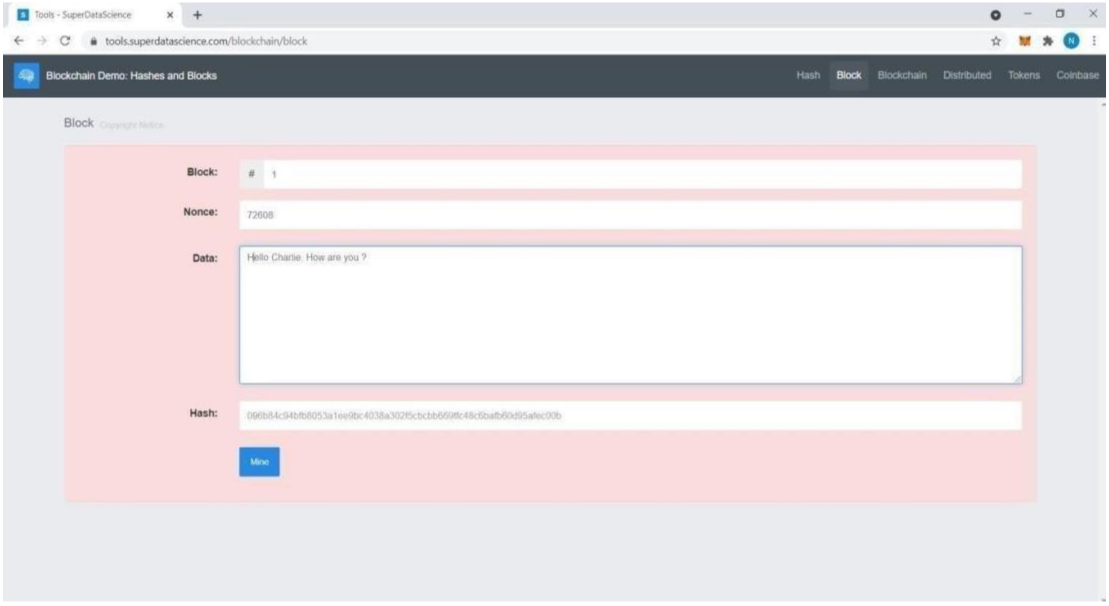
Procedure:
1. Open the Coin Transaction Simulator: https://tools.superdatascience.com/Blockchain/tokens
2. Create multiple users/wallets.
3. Perform coin transfers between users.
4. Observe how transactions are recorded into a block.
5. Mine the block to validate transactions.

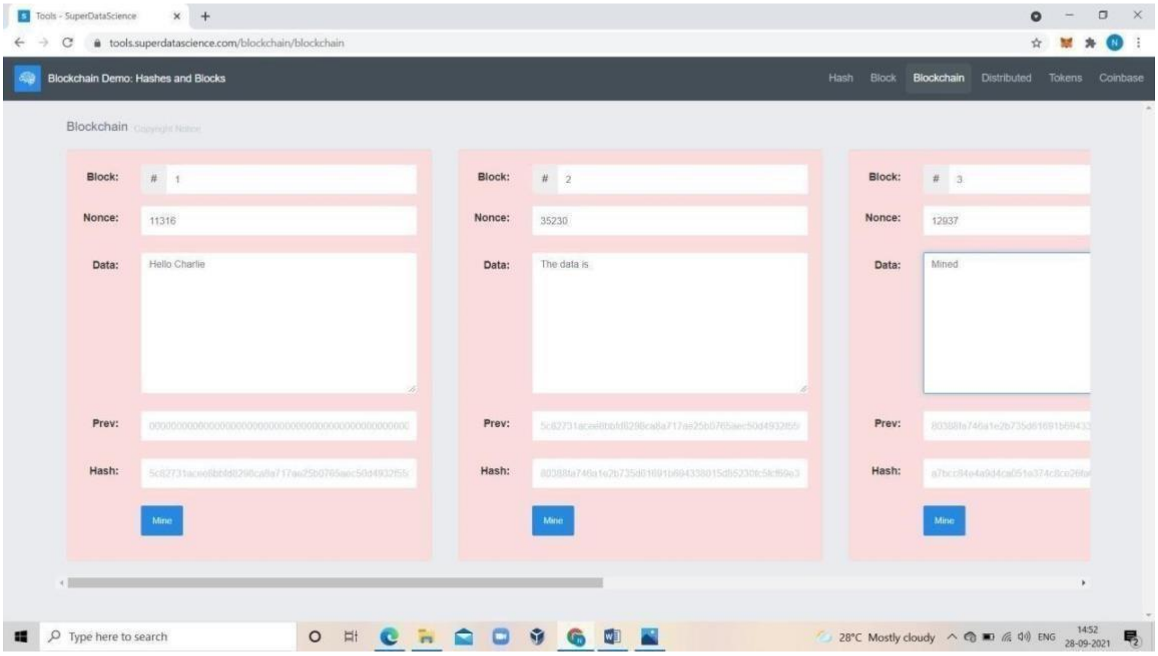
Observation:
- Transactions are added into the block before confirmation.

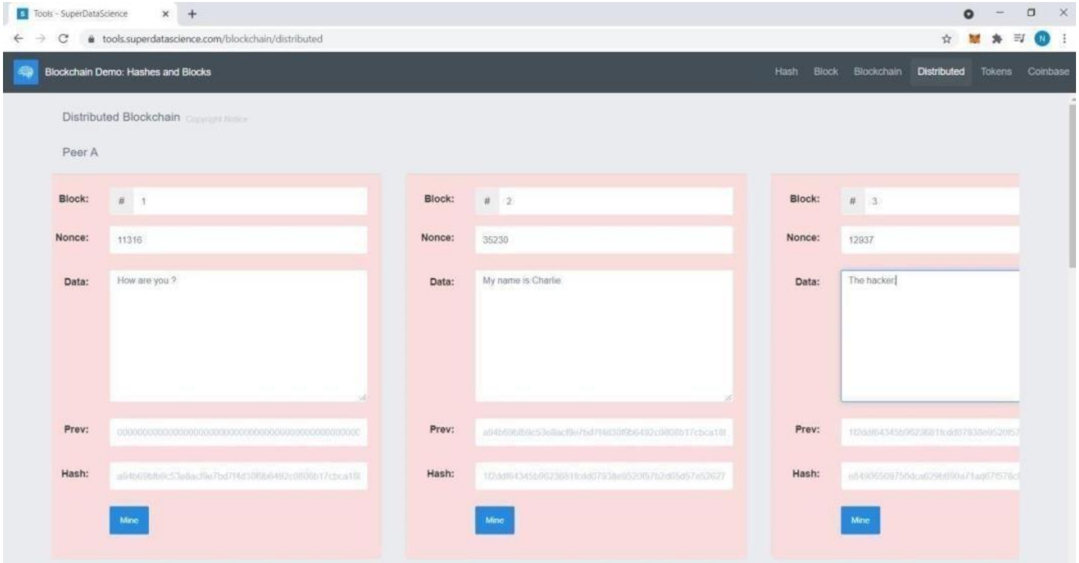
- Mining validates the transaction and secures it permanently.
- Each transfer is transparent and irreversible.

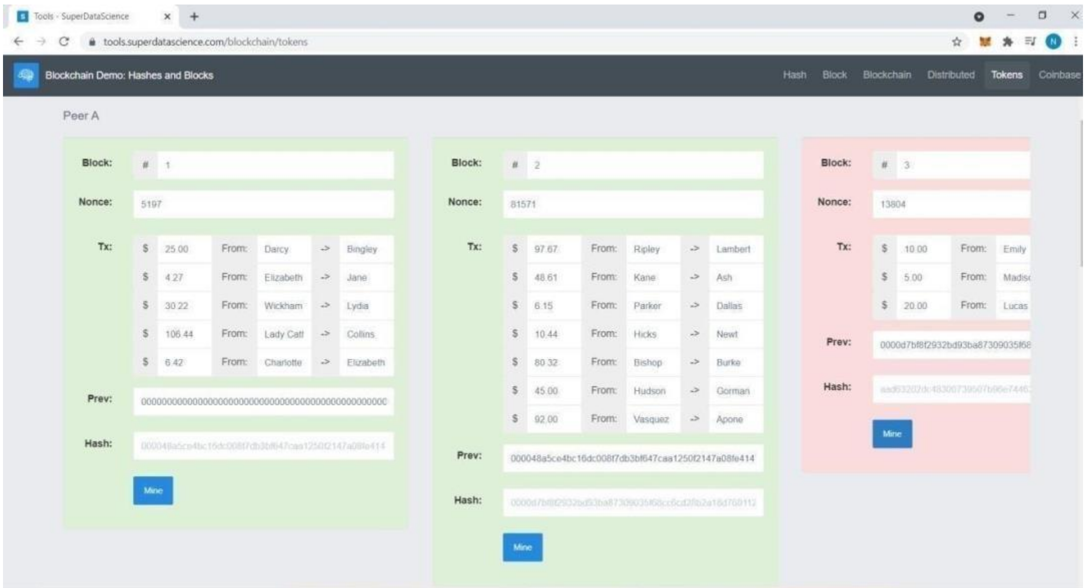
Conclusion:
Coin-based transactions illustrate how cryptocurrencies (like Bitcoin) enable peer-to-peer money transfer without intermediaries, secured by mining and blockchain technology.

Screenshots:






Blockchain Demo: Hashes and Blocks
Hash Block Blockchain Distributed Tokens Coinbase
Distributed Blockchain
Peer A
Block: # 1
Nonce: 11316
Data: How are you ?
Block: # 2
Nonce: 35230
Data: My name is Charlie
Block: # 3
Nonce: 12937
Data: The hacker
Prev:
Hash:
Mine


Blockchain Demo: Hashes and Blocks
Hash Block Blockchain Distributed Tokens Coinbase
Peer A
Block: # 1
Nonce: 5197
Tx:
$ 25.00 From: Darcy -> Bingley
$ 4.27 From: Elizabeth -> Jane
$ 30.22 From: Wickham -> Lydia
$ 106.44 From: Lady Catl -> Collins
$ 6.42 From: Charlotte -> Elizabeth
Block: # 2
Nonce: 81571
$ 97.67 From: Ripley -> Lambert
$ 48.61 From: Kane -> Ash
$ 6.15 From: Parker -> Dallas
$ 10.44 From: Hicks -> Newt
$ 80.32 From: Bishop -> Burke
$ 45.00 From: Hudson -> Gorman
$ 92.00 From: Vasquez -> Apone
Block: # 3
Nonce: 13804
$ 10.00 From: Emily
$ 5.00 From:
$ 20.00 From: Lucas
Prev:
Hash:
Mine

MCQ Questions

Q1. In a blockchain block, what is the purpose of the “Nonce”?
a) It stores the previous block’s hash
b) It is a random number adjusted to find a valid hash
c) It represents the number of tokens in the block
d) It verifies the identity of the user
Answer: ____

Q2. What happens if data inside an old block is modified in a blockchain?
a) The block remains valid
b) Only the modified block becomes invalid
c) The modified block and all following blocks become invalid
d) Nothing changes in the Blockchain
Answer: ____

Q3. In a distributed blockchain, how is the final version of the blockchain decided among nodes?
a) By the node with the highest balance
b) By using the majority consensus
c) By the first node to respond
d) By random selection of a node
Answer: ____

Q4. What do tokens on a blockchain represent?
a) Only cryptocurrency like Bitcoin
b) Physical or digital assets, points, or currency
c) Internet data packets
d) Computer memory storage units
Answer: ____

Q5. Which of the following best explains coin-based transactions on blockchain?
a) Coins are transferred between banks through blockchain
b) Coins can be transferred between users without intermediaries, secured by mining
c) Coins are physical money stored in blocks
d) Coins can only be used for gaming transactions
Answer: ____

Faculty Signature	
Date and Grade	

Practical 2

Using JavaScript Perform following
(Source: YouTube Channel: Simply Explained – Savjee)
2.1 Creating a Blockchain
2.2 Implementing Proof-of-Work
2.3 Miner rewards & transactions
2.4 Signing transactions
2.5 Angular frontend

Prerequisites

- **Node.js** (LTS) installed
- A new folder, then:

```
npm init -y
npm i elliptic
```

We'll use Node's built-in crypto for SHA-256 and elliptic for ECDSA signing.

2.1 Creating a Blockchain

Objective

Build the core classes: Block, Transaction, Blockchain.

Procedure

1. Create blockchain.js.
2. Implement hashing of block contents.
3. Link blocks using previousHash.
4. Add basic chain validation.

```
// blockchain.js
const crypto = require('crypto');
const EC = require('elliptic').ec;
const ec = new EC('secp256k1');

// ---------- UTIL ----------
const sha256 = (data) => crypto.createHash('sha256').update(data).digest('hex');

// ---------- MODELS ----------
class Transaction {
  constructor(fromAddress, toAddress, amount) {
    this.fromAddress = fromAddress || null;
    this.toAddress = toAddress;
    this.amount = amount;
    this.timestamp = Date.now();
  }

  calculateHash() {
    return sha256(this.fromAddress + this.toAddress + this.amount + this.timestamp);
  }

  signTransaction(signingKey) {
```

```
    if (signingKey.getPublic('hex') !== this.fromAddress) {
      throw new Error('You cannot sign transactions for other wallets!');
    }
    const sig = signingKey.sign(this.calculateHash(), 'base64');
    this.signature = sig.toDER('hex');
  }

  isValid() {
    // Mining reward (coinbase) has no fromAddress and is valid
    if (this.fromAddress === null) return true;
    if (!this.signature) return false;

    const pubKey = ec.keyFromPublic(this.fromAddress, 'hex');
    return pubKey.verify(this.calculateHash(), this.signature);
  }
}

class Block {
  constructor(timestamp, transactions, previousHash = '') {
    this.timestamp = timestamp;
    this.transactions = transactions; // array of Transaction
    this.previousHash = previousHash;
    this.nonce = 0;
    this.hash = this.calculateHash();
  }

  calculateHash() {
    return sha256(
      this.previousHash +
      this.timestamp +
      JSON.stringify(this.transactions) +
      this.nonce
    );
  }

  mineBlock(difficulty) {
    const target = '0'.repeat(difficulty);
    while (!this.hash.startsWith(target)) {
      this.nonce++;
      this.hash = this.calculateHash();
    }
  }

  hasValidTransactions() {
    return this.transactions.every(tx => tx.isValid());
  }
}

class Blockchain {
  constructor() {
```

```
    this.chain = [this.createGenesisBlock()];
    this.difficulty = 2;
    this.pendingTransactions = [];
    this.miningReward = 100;
  }

  createGenesisBlock() {
    return new Block(Date.now(), [], '0');
  }

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

  minePendingTransactions(rewardAddress) {
    const block = new Block(Date.now(), this.pendingTransactions,
this.getLatestBlock().hash);
    block.mineBlock(this.difficulty);
    this.chain.push(block);

    // Reset pending and add mining reward
    this.pendingTransactions = [
      new Transaction(null, rewardAddress, this.miningReward)
    ];
  }

  addTransaction(tx) {
    if (!tx.fromAddress || !tx.toAddress) throw new Error('Transaction must include from and
to');
    if (!tx.isValid()) throw new Error('Cannot add invalid transaction');
    this.pendingTransactions.push(tx);
  }

  getBalanceOfAddress(address) {
    let balance = 0;
    for (const block of this.chain) {
      for (const tx of block.transactions) {
        if (tx.fromAddress === address) balance -= tx.amount;
        if (tx.toAddress === address) balance += tx.amount;
      }
    }
    return balance;
  }

  isChainValid() {
    // Genesis is assumed valid; validate links, hashes, and tx signatures
    for (let i = 1; i < this.chain.length; i++) {
      const curr = this.chain[i];
      const prev = this.chain[i - 1];
```

```
      if (!curr.hasValidTransactions()) return false;
      if (curr.hash !== curr.calculateHash()) return false;
      if (curr.previousHash !== prev.hash) return false;
    }
    return true;
  }
}

// ---------- DEMO (run: node blockchain.js) ----------
if (require.main === module) {
  const myKey = ec.genKeyPair();
  const myWalletAddress = myKey.getPublic('hex');

  const chain = new Blockchain();

  const tx1 = new Transaction(myWalletAddress, 'addrB', 10);
  tx1.signTransaction(myKey);
  chain.addTransaction(tx1);

  console.log(' Mining block...');
  chain.minePendingTransactions(myWalletAddress);

  console.log('Balance (me):', chain.getBalanceOfAddress(myWalletAddress));
  console.log('Chain valid?', chain.isChainValid());
}

module.exports = { Blockchain, Block, Transaction, ec };
```

Observation / Expected Output

- Mining log appears, then your wallet balance becomes **100 − 10 = 90** after the reward comes in the *next* block.
- Chain valid? true.

2.2 Implementing Proof-of-Work

Objective

Require each block’s hash to start with a certain number of leading zeros (difficulty).

Procedure

- Already implemented in Block.mineBlock(difficulty).
- Increase difficulty and observe longer mining time.

Quick Test

```
# In blockchain.js, set: this.difficulty = 4;
node blockchain.js
```

Observation

- Mining takes noticeably longer.
- Hashes begin with 0000....

2.3 Miner Rewards & Transactions

Objective

Reward miners and process user transactions via a mempool (pendingTransactions).

Procedure

1. Create and sign user transactions.
2. Call minePendingTransactions(rewardAddress).
3. Observe reward credited in the *next* block.

Quick Test Snippet

```
// After initial mining in demo:
const { Blockchain, Transaction, ec } = require('./blockchain');
const chain = new Blockchain();

const minerKey = ec.genKeyPair();
const minerAddr = minerKey.getPublic('hex');

const aKey = ec.genKeyPair();
const aAddr = aKey.getPublic('hex');

const bAddr = ec.genKeyPair().getPublic('hex');

const tx = new Transaction(aAddr, bAddr, 25);
tx.signTransaction(aKey);
chain.addTransaction(tx);

console.log('⛏ Mining 1st block...');
chain.minePendingTransactions(minerAddr);

console.log('Miner balance after 1st mining (should be 0, reward queued):',
chain.getBalanceOfAddress(minerAddr));
console.log('⛏ Mining 2nd block...');
chain.minePendingTransactions(minerAddr);
console.log('Miner balance (should be 100):', chain.getBalanceOfAddress(minerAddr));
```

Observation

- Reward is realized after the *next* mining round (classic coinbase maturity behavior in this simple model).

2.4 Signing Transactions

Objective

Use ECDSA (secp256k1) to sign transactions and verify authenticity.

Procedure

- Already implemented in Transaction.signTransaction() and Transaction.isValid().
- Only the owner of fromAddress can sign.

Negative Test (Tampering)

```
const { Blockchain, Transaction, ec } = require('./blockchain');
const chain = new Blockchain();

const keyA = ec.genKeyPair();
const addrA = keyA.getPublic('hex');
const addrB = ec.genKeyPair().getPublic('hex');

const tx = new Transaction(addrA, addrB, 50);
//  Forget to sign: tx.signTransaction(keyA);
try {
  chain.addTransaction(tx);
} catch (e) {
  console.log('Expected error:', e.message);
}
```

Observation

- You should see: **“Cannot add invalid transaction”** (or signing error).
- If you sign with the wrong key, you’ll get: **“You cannot sign transactions for other wallets!”**

2.5 Angular Frontend (Minimal Sketch)

Objective

Expose simple blockchain actions over HTTP and build a tiny Angular UI to interact with them.

Procedure (Backend: Express)

1. Add Express server:

```
npm i express body-parser cors
```

2. Create server.js:

```
// server.js
const express = require('express');
const bodyParser = require('body-parser');
const cors = require('cors');
const { Blockchain, Transaction, ec } = require('./blockchain');

const app = express();
app.use(cors());
app.use(bodyParser.json());
```

```
const chain = new Blockchain();

app.get('/chain', (req, res) => res.json(chain));

app.post('/transaction', (req, res) => {
  const { fromPrivateKeyHex, toAddress, amount } = req.body;
  try {
    if (!fromPrivateKeyHex) {
      // Allow coinbase-like faucet by passing null fromAddress (demo only!)
      const tx = new Transaction(null, toAddress, amount);
      chain.pendingTransactions.push(tx);
      return res.json({ ok: true, message: 'Faucet tx added (unsigned, coinbase-like).' });
    }
    const key = ec.keyFromPrivate(fromPrivateKeyHex);
    const fromAddress = key.getPublic('hex');
    const tx = new Transaction(fromAddress, toAddress, amount);
    tx.signTransaction(key);
    chain.addTransaction(tx);
    res.json({ ok: true, message: 'Transaction added.' });
  } catch (e) {
    res.status(400).json({ ok: false, error: e.message });
  }
});

app.post('/mine', (req, res) => {
  const { rewardAddress } = req.body;
  chain.minePendingTransactions(rewardAddress);
  res.json({ ok: true, message: 'Block mined.' });
});

app.get('/balance/:address', (req, res) => {
  res.json({ address: req.params.address, balance:
chain.getBalanceOfAddress(req.params.address) });
});

app.listen(3000, () => console.log('API running at http://localhost:3000'));
```

Run:
node server.js

Procedure (Angular UI)

Create Angular app:

```
# in a separate folder
ng new mini-chain --routing=false --style=css
cd mini-chain
ng add @angular/material
```

Create a service src/app/chain.service.ts:

```
import { Injectable } from '@angular/core';
import { HttpClient } from '@angular/common/http';

@Injectable({ providedIn: 'root' })
export class ChainService {
  private base = 'http://localhost:3000';
  constructor(private http: HttpClient) {}

  getChain() { return this.http.get(`${this.base}/chain`); }
  getBalance(address: string) { return this.http.get(`${this.base}/balance/${address}`); }
  addTx(fromPrivateKeyHex: string|null, toAddress: string, amount: number) {
    return this.http.post(`${this.base}/transaction`, { fromPrivateKeyHex, toAddress, amount
});
  }
  mine(rewardAddress: string) { return this.http.post(`${this.base}/mine`, { rewardAddress
}); }
}
```

Simple component src/app/app.component.ts:

```
import { Component } from '@angular/core';
import { ChainService } from './chain.service';
import { ec as EC } from 'elliptic';
const ec = new EC('secp256k1');

@Component({
  selector: 'app-root',
  templateUrl: './app.component.html'
})
export class AppComponent {
  log: string[] = [];
  myKey = ec.genKeyPair();
  myPrivHex = this.myKey.getPrivate('hex');
  myAddr = this.myKey.getPublic('hex');
  toAddr = '';

  constructor(private api: ChainService) {}

  faucet() {
```

```
    this.api.addTx(null, this.myAddr, 50).subscribe(r => this.log.push(JSON.stringify(r)));
  }
  send() {
    if (!this.toAddr) return;
    this.api.addTx(this.myPrivHex, this.toAddr, 10).subscribe(r =>
this.log.push(JSON.stringify(r)));
  }
  mine() {
    this.api.mine(this.myAddr).subscribe(r => this.log.push(JSON.stringify(r)));
  }
  showBalance() {
    this.api.getBalance(this.myAddr).subscribe(r => this.log.push(JSON.stringify(r)));
  }
  showChain() {
    this.api.getChain().subscribe(r => this.log.push(JSON.stringify(r)));
  }
}
```

Minimal template src/app/app.component.html

```
<div style="max-width:800px;margin:24px auto;font-family:system-ui;">
  <h2>MiniChain (Demo)</h2>
  <p><b>Your Address:</b> {{ myAddr | slice:0:30 }}...</p>
  <button (click)="faucet()">Faucet +50</button>
  <input placeholder="To Address" [(ngModel)]="toAddr" style="width:100%;margin:8px
0;" />
  <button (click)="send()">Send 10</button>
  <button (click)="mine()">Mine</button>
  <button (click)="showBalance()">My Balance</button>
  <button (click)="showChain()">Show Chain</button>

  <h3>Log</h3>
  <pre>{{ log.join('\n') }}</pre>
</div>
```

Run Angular:

```
ng serve
# open http://localhost:4200
```

Observation

- Click **Faucet +50**, **Mine** → balance grows after the *next* mining round.
- **Send 10** to any address (paste another generated address if you create a second wallet in code).
- **Show Chain** prints blocks and transactions.

MCQ Questions

Q1. What is the purpose of the previousHash field in a block?
a) To link the block with its parent block, maintaining chain integrity
b) To calculate the nonce value during mining
c) To store the miner's reward transaction
d) To identify invalid transactions in a block
Answer: ____

Q2. What happens if someone tampers with a transaction inside a block?
a) Only that single transaction becomes invalid
b) The hash of the block changes, breaking the chain link
c) The mining reward becomes zero for the miner
d) The entire blockchain automatically corrects itself
Answer: ____

Q3. Which data structure is used to hold unconfirmed transactions before mining?
a) Hash table
b) Pending transaction pool (array/list)
c) Merkle tree
d) Digital signature log
Answer: ____

Q4. In this blockchain, what does the signTransaction() function ensure?
a) Transactions are added to the mempool faster
b) Only the owner of the wallet can authorize spending from it
c) Mining becomes easier by reducing difficulty
d) The miner always receives their reward first
Answer: ____

Q5. Why is the Angular frontend calling the backend API endpoints (/transaction, /mine, /balance, /chain)?
a) To directly mine blocks inside Angular
b) To act as a user interface for interacting with blockchain functions
c) To validate hashes in the frontend without backend help
d) To remove invalid transactions before mining
Answer: ____

Faculty Signature	
Date and Grade	

Practical 3

Introduction to Geth:
3.1 Introduction to geth
3.2 Creation of private Blockchain
3.2 Creation of Account
3.4 Mining using geth

3.1 Introduction to Geth

Objective:
To understand the basics of Geth (Go-Ethereum) and how it provides the command-line interface to run Ethereum nodes.

Procedure:

1. Install **Geth** from the official website: https://geth.ethereum.org/downloads (Supports Windows, Linux, Mac).
2. Verify installation:
   ```
   geth version
   ```

Note the client version, OS, and Ethereum protocol version.

Observation:

- geth command shows version details and confirms the installation.
- Geth can run in different modes: **full node, light node, fast sync**.

Conclusion:
Geth is the official Go implementation of Ethereum that allows us to run Ethereum nodes, create private blockchains, and interact with smart contracts.

3.2 Creation of Private Blockchain

Objective:
To set up a local Ethereum private blockchain for experimentation using Geth.

Procedure:
1 Create a working directory (e.g., mychain).
```
mkdir mychain && cd mychain
```
2 Create a genesis.json file (defines chain parameters):

```
{
  "config": {
    "chainId": 2025,
    "homesteadBlock": 0,
    "eip150Block": 0,
    "eip155Block": 0,
    "eip158Block": 0
  },
  "difficulty": "1",
  "gasLimit": "2100000",
  "alloc": {}
}
```

3. Initialize blockchain with this genesis file:
```
geth --datadir ./data init genesis.json
```

Check that genesis block is created inside the data folder.

Observation:

- A new private chain is created with its own genesis block.
- Difficulty is set low for easy mining in private networks.

Conclusion:

We successfully set up a private Ethereum blockchain using a custom genesis file in Geth.

3.3 Creation of Account

Objective:

To create a new Ethereum account (wallet address) in the private blockchain.

Procedure:

1. Create an account using the following command:
geth --datadir ./data account new

2. Enter a password (this secures the account).

3. Copy the generated public address.
    Example output: Address: {0x1234abcd...}

Observation:

- A keystore file is created under data/keystore.
- The public address is used to send/receive Ether.

Conclusion:

An Ethereum account is successfully created, which can hold Ether and interact with contracts in the private blockchain.

3.4 Mining using Geth

Objective:

To mine blocks in the private Ethereum network using Geth.

Procedure:

Start the Geth console with mining enabled:
geth --datadir ./data --networkid 2025 --http console

In the Geth JavaScript console, start mining:
miner.start(1) // *(Here, 1 = number of threads).*

Stop mining with:
miner.stop()

Check account balance after mining:
eth.getBalance(eth.accounts[0])

Observation:

- Mining starts and new blocks are generated quickly (since difficulty is low).
- Ether rewards are credited to the miner's account.

Conclusion:

Mining was successfully performed in the private Ethereum blockchain, demonstrating how Ether is generated as a reward for block creation.

MCQ Questions

Q1. What is the role of the genesis.json file when creating a private blockchain with Geth?
a) It stores all user accounts and private keys
b) It defines the initial block parameters and network configuration
c) It controls the mining speed of Ethereum mainnet
d) It automatically deploys smart contracts
Answer: ____

Q2. When you create a new account in Geth, where is the private key stored?
a) In the system clipboard
b) In a keystore file inside the data directory
c) In the genesis block configuration
d) On the Ethereum mainnet servers
Answer: ____

Q3. Which Geth console command is used to start mining?
a) eth.start()
b) miner.start()
c) eth.mine()
d) blockchain.mine()
Answer: ____

Q4. In a private Ethereum blockchain, why is the difficulty often set very low (e.g., "1") in the genesis file?
a) To reduce Ether transaction fees
b) To allow blocks to be mined quickly for testing purposes
c) To prevent creation of multiple accounts
d) To enable faster network synchronization with mainnet
Answer: ____

Q5. What does the eth.getBalance(eth.accounts[0]) command return in the Geth console?
a) The number of pending transactions
b) The total Ether mined in the entire chain
c) The balance of the first account in Wei
d) The total number of blocks in the chain
Answer: ____

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Practical 4

Introduction to Remix Ethereum:
4.1 Introduction to Metamask
4.2 Creation of account using Metamask
4.3 Introduction to Remix Ethereum
4.4 Introduction to solidity program structure, Compilation and deployment environment.
4.5 Write a smart contract in solidity to store and get Hello World
4.6 Write a smart contract in solidity to create a function setter and getter to set and get a value.
4.7 Write a smart contract in solidity to print the array of integers and its length.
4.8 Write a solidity code to print array elements and its position.

4.1 Introduction to MetaMask

Objective:
To understand MetaMask, a browser-based Ethereum wallet and gateway to blockchain applications.
Procedure:
1. Install MetaMask extension (Chrome/Brave/Firefox).
2. Create or import a wallet.
3. Switch networks (Ethereum mainnet, testnets, or local private blockchain).

Observation:
- MetaMask shows an Ethereum address, balance, and network status.
- It connects browser DApps to blockchain securely.

Conclusion:
MetaMask is a convenient wallet and interface to manage accounts and interact with Ethereum-based DApps.

4.2 Creation of Account using MetaMask

Objective:
To create a new Ethereum account in MetaMask.
Procedure:
1. Open MetaMask → Click "Create Account."
2. Provide an account name.
3. Copy the newly generated address.

Observation:
- A new account (public address) is displayed.
- Private keys are securely stored within MetaMask.

Conclusion:
We successfully created a new Ethereum account in MetaMask for use with Remix and smart contracts.

4.3 Introduction to Remix Ethereum

Objective:
To learn Remix IDE, a web-based environment for developing Solidity smart contracts.
Procedure:
1. Open Remix IDE.

2. Explore tabs: File Explorer, Solidity Compiler, Deploy & Run Transactions.

Observation:

- Remix provides code editor, compiler, and deployment tools in one place.

Conclusion:

Remix is a powerful IDE to write, compile, and deploy Solidity smart contracts quickly.

4.4 Solidity Program Structure, Compilation, and Deployment

Objective:

To understand Solidity program structure and deploy contracts in Remix.

Procedure:

1. Structure of Solidity code:
    - pragma solidity → compiler version
    - contract { } → main program
    - Functions: setter/getter, logic
2. Write code in Remix editor.
3. Compile using "Solidity Compiler."
4. Deploy via "Deploy & Run Transactions."

Observation:

- Compiler generates ABI and bytecode.
- Deployment creates a contract instance on blockchain.

Conclusion:

We learned Solidity program structure and successfully deployed contracts using Remix.

4.5 Smart Contract — Hello World

Objective:

To write a basic smart contract to store and retrieve a string.

Code:

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

contract HelloWorld {
   string public message = "Hello World";

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

Observation:

- After deployment, calling getMessage() returns **"Hello World."**

Conclusion:

A simple Solidity contract was created and deployed successfully.

4.6 Smart Contract — Setter and Getter

Objective:

To create functions for setting and getting a value.

Code:

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

contract Storage {
    uint256 private value;

    function setValue(uint256 _value) public {
        value = _value;
    }

    function getValue() public view returns (uint256) {
        return value;
    }
}
```

Observation:

- Using setValue(25) stores 25.
- Calling getValue() retrieves 25.

Conclusion:

The setter and getter contract demonstrates how to modify and access stored values.

4.7 Smart Contract — Array of Integers and Length

Objective:

To store an array of integers and print its length.

Code:

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

contract IntArray {
    uint[] public numbers;

    function addNumber(uint _num) public {
        numbers.push(_num);
    }

    function getNumbers() public view returns (uint[] memory) {
        return numbers;
    }

    function getLength() public view returns (uint) {
        return numbers.length;
    }
}
```

Observation:
- After adding numbers (10, 20, 30), getNumbers() returns [10,20,30].
- getLength() returns 3.

Conclusion:
We demonstrated array handling and dynamic length retrieval in Solidity.

4.8 Smart Contract — Array Elements and Position

Objective:
To display array elements along with their index positions.

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

contract ArrayWithIndex {
   uint[] public items;

   function addItem(uint _item) public {
      items.push(_item);
   }

   function getItem(uint index) public view returns (uint) {
      require(index < items.length, "Index out of range");
      return items[index];
   }

   function getAllItems() public view returns (uint[] memory) {
      return items;
   }
}
```

Observation:
- Adding [5, 15, 25], calling getItem(1) returns 15.
- getAllItems() returns [5,15,25].

Conclusion:
We created a Solidity program to fetch array elements by their index, demonstrating indexed storage in blockchain contracts.

MCQ Questions

Q1. What is the primary purpose of MetaMask in Ethereum development?
a) To compile Solidity code
b) To store and manage Ethereum accounts securely in the browser
c) To create genesis blocks for private blockchains
d) To mine Ether on the Ethereum mainnet
Answer: ____

Q2. Which tab in Remix IDE is used to compile Solidity smart contracts?
a) File Explorer
b) Solidity Compiler
c) Deploy & Run Transactions
d) Debugger
Answer: ____

Q3. In Solidity, which keyword specifies the compiler version to be used?
a) import
b) pragma
c) contract
d) version
Answer: ____

Q4. What will be the output of the following Solidity function if numbers = [5, 10, 15]?
```
function getLength() public view returns (uint) {
    return numbers.length;
}
```
a) 0
b) 2
c) 3
d) 15
Answer: ____

Q5. Why is the require statement used in the getItem(uint index) function of an array contract?
a) To check if the value is greater than zero
b) To prevent division by zero errors
c) To ensure the given index is within array bounds
d) To initialize the array with default values
Answer: ____

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Practical 5

Introduction to Ethereum-Ganache:
5.1 Creation of account using Ganache.
5.2 Introduction to solidity smart contract compilation and deployment environment.
5.3Write a smart contract in solidity to store and get Hello World

5.1 Creation of Account using Ganache

Objective:
To create Ethereum accounts in Ganache for testing smart contracts.
Procedure:
1. Download and install **Ganache** from https://trufflesuite.com/ganache.
2. Launch Ganache → choose **Quickstart (Ethereum)**.
3. Ganache automatically creates **10 accounts** with:
   - Public address
   - Private key
   - Initial Ether balance (default 100 ETH in test mode).

Observation:
- Each account has a unique public/private key pair.
- Balances are preloaded for testing transactions.

Conclusion:
Ganache successfully generated multiple test accounts with Ether for local blockchain development.

5.2 Introduction to Solidity Smart Contract Compilation and Deployment Environment

Objective:
To understand how Ganache integrates with Remix IDE for compiling and deploying Solidity contracts.
Procedure:
1. Open Remix IDE.
2. Write a Solidity program in the editor.
3. Compile the contract using the **Solidity Compiler tab**.
4. In the **Deploy & Run Transactions tab**:
   - Under “Environment,” select **Web3 Provider**.
   - Provide the Ganache RPC server (default: http://127.0.0.1:7545).
   - Connect MetaMask to Ganache and select one of the generated accounts.
5. Deploy the contract → Ganache records the transaction.

Observation:
- Compilation generates ABI and bytecode.
- Deployment transaction appears in Ganache’s transaction history with block number, gas used, and contract address.

Conclusion:
We connected Remix to Ganache and successfully compiled and deployed a smart contract on the local Ethereum blockchain.

5.3 Write a Smart Contract in Solidity to Store and Get “Hello World”

Objective:

To implement and deploy a simple Solidity smart contract for storing and retrieving a message.

Code (HelloWorld.sol):

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

contract HelloWorld {
    string public message;

    constructor() {
        message = "Hello World";
    }

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

    function setMessage(string memory newMessage) public {
        message = newMessage;
    }
}
```

Procedure:

1. Paste the code into Remix.
2. Compile using the Solidity compiler.
3. Deploy using Web3 Provider → Ganache account.
4. Interact with the contract:
    - Call getMessage() → should return **“Hello World.”**
    - Call setMessage("Welcome") → updates stored string.
    - Call getMessage() again → should return **“Welcome.”**

Observation:

- Contract successfully deployed on Ganache.
- Storage variable updated and retrieved correctly.

Conclusion:

A “Hello World” smart contract was implemented, deployed, and tested on the Ganache private Ethereum blockchain.

MCQ Questions

Q1. What is Ganache primarily used for in Ethereum development?
a) Mining Ether on the Ethereum mainnet
b) Creating a local blockchain for testing smart contracts
c) Generating ABI files for Solidity contracts
d) Providing a cloud-based Ethereum service
Answer: ____

Q2. By default, how many accounts with preloaded Ether does Ganache create in a new workspace?
a) 5
b) 10
c) 20
d) 50
Answer: ____

Q3. Which RPC URL is typically used to connect Remix or MetaMask to Ganache?
a) http://localhost:3030
b) http://127.0.0.1:8545
c) http://127.0.0.1:7545
d) http://localhost:9000
Answer: ____

Q4. When a smart contract is deployed using Remix connected to Ganache, where can the transaction details be viewed?
a) In the Solidity Compiler tab
b) In the MetaMask extension only
c) In Ganache's Transactions tab (GUI)
d) On the Ethereum mainnet explorer
Answer: ____

Q5. In the HelloWorld contract, what is the purpose of the constructor() function?
a) To print values of the array
b) To set the initial value of the message variable
c) To calculate the length of a string
d) To compile the contract automatically
Answer: ____

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NOTES