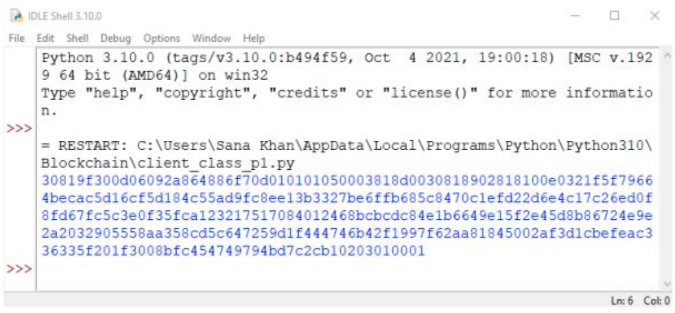
Practical 01

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

Code:

```
#import libraries
import hashlib
import random
import string
import json
import binascii
import numpy as np
import pandas as pd
import pylab as pl
import logging
import datetime
import collections
# following imports are required by PKI
import Crypto
import Crypto.Random
from Crypto.Hash import SHA
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')
Sana = Client()
print(Sana.identity)
```

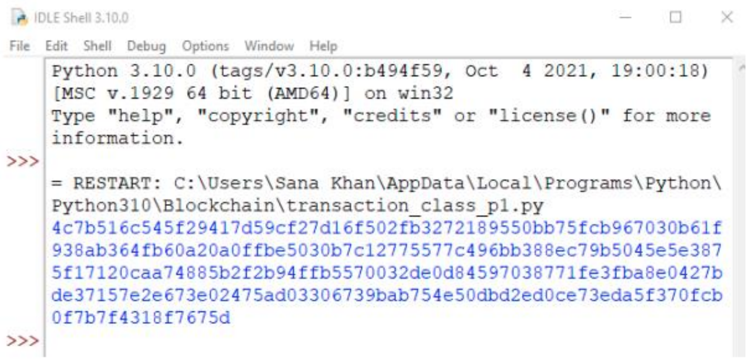


```
Python 3.10.0 (tags/v3.10.0:b494f59, Oct  4 2021, 19:00:18) [MSC v.192
9 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more informatio
n.
>>>
= RESTART: C:\Users\Sana Khan\AppData\Local\Programs\Python\Python310\
Blockchain\client_class_p1.py
30819f300d06092a864886f70d010101050003818d0030818902818100e0321f5f7966
4becac5d16cf5d184c55ad9fc8ee13b3327be6ffb685c8470c1efd22d6e4c17c26ed0f
8fd67fc5c3e0f35fca12321751708401246 8bcbcdc84e1b6649e15f2e45d8b86724e9e
2a2032905558aa358cd5c647259d1f444746b42f1997f62aa81845002af3d1cbefeac3
36335f201f3008bfc454749794bd7c2cb10203010001
>>>
```

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

Code:

```
import hashlib
import random
import string
import json
import binascii
import numpy as np
import pandas as pd
import pylab as pl
import logging
import datetime
import collections
import Crypto
import Crypto.Random
from Crypto.Hash import SHA
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')
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):
 if self.sender == "Genesis":
 identity = "Genesis"
 else:
 identity = 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')
Sana = Client()
Sarah = Client()
t = Transaction(
 Sana,
 Sarah.identity,
 5.0
)
signature = t.sign_transaction()
print (signature)
```



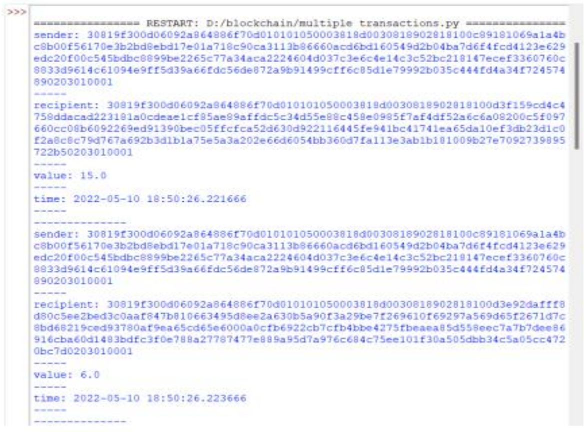
```
Python 3.10.0 (tags/v3.10.0:b494f59, Oct  4 2021, 19:00:18)
[MSC v.1929 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more
information.
>>>
= RESTART: C:\Users\Sana Khan\AppData\Local\Programs\Python\
Python310\Blockchain\transaction_class_p1.py
4c7b516c545f29417d59cf27d16f502fb3272189550bb75fcb967030b61f
938ab364fb60a20a0ffbe5030b7c12775577c496bb388ec79b5045e5e387
5f17120caa74885b2f2b94ffb5570032de0d84597038771fe3fba8e0427b
de37157e2e673e02475ad03306739bab754e50dbd2ed0ce73eda5f370fcb
0f7b7f4318f7675d
>>>
```

C. Create multiple transactions and display them.

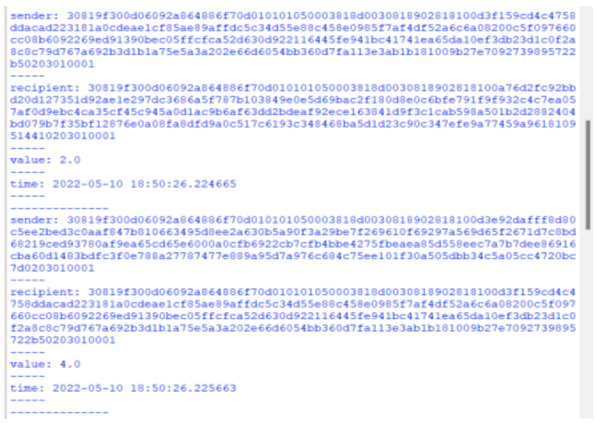
Code:

```
import hashlib
import random
import string
import json
import binascii
import numpy as np
import pandas as pd
import pylab as pl
import logging
import datetime
import collections
import Crypto
import Crypto.Random
from Crypto.Hash import SHA
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')
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 ):
 if self.sender == "Genesis":
 identity = "Genesis"
 else:
 identity = 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')
def display_transaction(transaction):
 #for transaction in transactions:
 dict = transaction.to_dict()
 print ("sender: " + dict['sender'])
 print ('-----')
 print ("recipient: " + dict['recipient'])
 print ('-----')
 print ("value: " + str(dict['value']))
 print ('-----')
 print ("time: " + str(dict['time']))
 print ('-----')
transactions = []
Dinesh = Client()
Ramesh = Client()
Seema = Client()
Vijay = Client()
t1 = Transaction(
 Dinesh,
 Ramesh.identity,
 15.0 )
t1.sign_transaction()
transactions.append(t1)
t2 = Transaction(
 Dinesh,
 Seema.identity,
 6.0 )
t2.sign_transaction()
transactions.append(t2)
t3 = Transaction(
 Ramesh,
 Vijay.identity,
 2.0 )
```

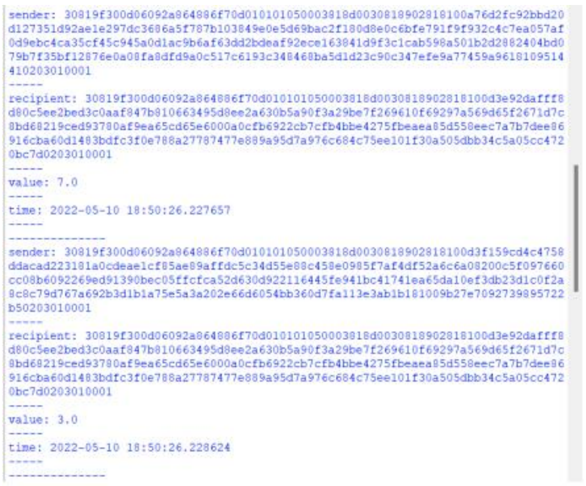
```
t3.sign_transaction()
transactions.append(t3)
t4 = Transaction(
 Seema,
 Ramesh.identity,
 4.0 )
t4.sign_transaction()
transactions.append(t4)
t5 = Transaction(
 Vijay,
 Seema.identity,
 7.0 )
t5.sign_transaction()
transactions.append(t5)
t6 = Transaction(
 Ramesh,
 Seema.identity,
3.0 )
t6.sign_transaction()
transactions.append(t6)
t7 = Transaction(
 Seema,
 Dinesh.identity,
 8.0 )
t7.sign_transaction()
transactions.append(t7)
t8 = Transaction(
 Seema,
 Ramesh.identity,
 1.0 )
t8.sign_transaction()
transactions.append(t8)
t9 = Transaction(
 Vijay,
 Dinesh.identity,
 5.0 )t9.sign_transaction()
transactions.append(t9)
t10 = Transaction(
 Vijay,
 Ramesh.identity,
 3.0 )
t10.sign_transaction()
transactions.append(t10)
for transaction in transactions:
 display_transaction (transaction)
 print ('--------------')
```



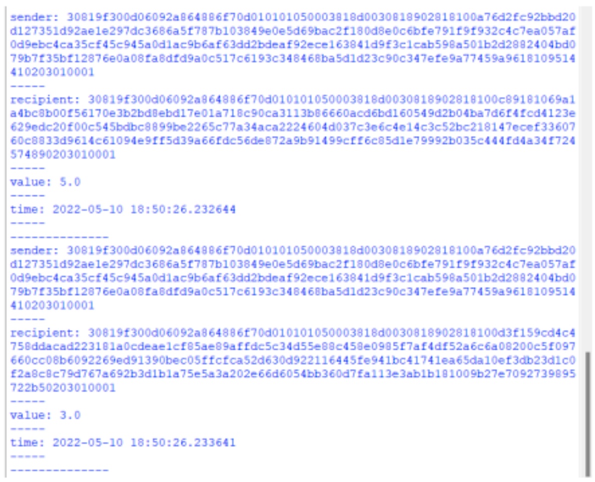
```
>>>
================ RESTART: D:/blockchain/multiple transactions.py ================
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100c89181069a1a4b
c8b00f56170e3b2bd8ebd17e01a718c90ca3113b86660acd6bd160549d2b04ba7d6f4fcd4123e629
edc20f00c545bdbc8899be2265c77a34aca2224604d037c3e6c4e14c3c52bc218147ecef3360760c
8833d9614c61094e9ff5d39a66fdc56de872a9b91499cff6c85d1e79992b035c444fd4a34f724574
890203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3f159cd4c4
758ddacad223181a0cdeae1cf85ae89affdc5c34d55e88c458e0985f7af4df52a6c6a08200c5f097
660cc08b6092269ed91390bec05ffcfca52d630d922116445fe941bc41741ea65da10ef3db23d1c0
f2a8c8c79d767a692b3d1b1a75e5a3a202e66d6054bb360d7fa113e3ab1b181009b27e7092739895
722b50203010001
-----
value: 15.0
-----
time: 2022-05-10 18:50:26.221666
-----
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100c89181069a1a4b
c8b00f56170e3b2bd8ebd17e01a718c90ca3113b86660acd6bd160549d2b04ba7d6f4fcd4123e629
edc20f00c545bdbc8899be2265c77a34aca2224604d037c3e6c4e14c3c52bc218147ecef3360760c
8833d9614c61094e9ff5d39a66fdc56de872a9b91499cff6c85d1e79992b035c444fd4a34f724574
890203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3e92dafff8
d80c5ee2bed3c0aaf847b810663495d8ee2a630b5a90f3a29be7f269610f69297a569d65f2671d7c
8bd68219ced93780af9ea65cd65e6000a0cfb6922cb7cfb4bbe4275fbeaea85d558eec7a7b7dee86
916cba60d1483bdfc3f0e788a27787477e889a95d7a976c684c75ee101f30a505dbb34c5a05cc472
0bc7d0203010001
-----
value: 6.0
-----
time: 2022-05-10 18:50:26.223666
-----
--------------
```



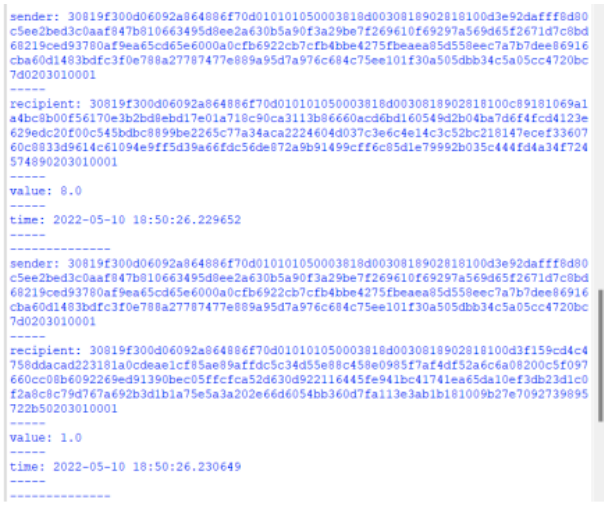
```
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100d3f159cd4c4758
ddacad223181a0cdeae1cf85ae89affdc5c34d55e88c458e0985f7af4df52a6c6a08200c5f097660
cc08b6092269ed91390bec05ffcfca52d630d922116445fe941bc41741ea65da10ef3db23d1c0f2a
8c8c79d767a692b3d1b1a75e5a3a202e66d6054bb360d7fa113e3ab1b181009b27e7092739895722
b50203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100a76d2fc92bb
d20d127351d92ae1e297dc3686a5f787b103849e0e5d69bac2f180d8e0c6bfe791f9f932c4c7ea05
7af0d9ebc4ca35cf45c945a0d1ac9b6af63dd2bdeaf92ece163841d9f3c1cab598a501b2d2882404
bd079b7f35bf12876e0a08fa8dfd9a0c517c6193c348468ba5d1d23c90c347efe9a77459a9618109
514410203010001
-----
value: 2.0
-----
time: 2022-05-10 18:50:26.224665
-----
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100d3e92dafff8d80
c5ee2bed3c0aaf847b810663495d8ee2a630b5a90f3a29be7f269610f69297a569d65f2671d7c8bd
68219ced93780af9ea65cd65e6000a0cfb6922cb7cfb4bbe4275fbeaea85d558eec7a7b7dee86916
cba60d1483bdfc3f0e788a27787477e889a95d7a976c684c75ee101f30a505dbb34c5a05cc4720bc
7d0203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3f159cd4c4
758ddacad223181a0cdeae1cf85ae89affdc5c34d55e88c458e0985f7af4df52a6c6a08200c5f097
660cc08b6092269ed91390bec05ffcfca52d630d922116445fe941bc41741ea65da10ef3db23d1c0
f2a8c8c79d767a692b3d1b1a75e5a3a202e66d6054bb360d7fa113e3ab1b181009b27e7092739895
722b50203010001
-----
value: 4.0
-----
time: 2022-05-10 18:50:26.225663
-----
--------------
```



```
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100a76d2fc92bbd20
d127351d92ae1e297dc3686a5f787b103849e0e5d69bac2f180d8e0c6bfe791f9f932c4c7ea057af
0d9ebc4ca35cf45c945a0d1ac9b6af63dd2bdeaf92ece163841d9f3c1cab598a501b2d2882404bd0
79b7f35bf12876e0a08fa8dfd9a0c517c6193c348468ba5d1d23c90c347efe9a77459a9618109514
410203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3e92dafff8
d80c5ee2bed3c0aaf847b810663495d8ee2a630b5a90f3a29be7f269610f69297a569d65f2671d7c
8bd68219ced93780af9ea65cd65e6000a0cfb6922cb7cfb4bbe4275fbeaea85d558eec7a7b7dee86
916cba60d1483bdfc3f0e788a27787477e889a95d7a976c684c75ee101f30a505dbb34c5a05cc472
0bc7d0203010001
-----
value: 7.0
-----
time: 2022-05-10 18:50:26.227657
-----
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100d3f159cd4c4758
ddacad223181a0cdeae1cf85ae89affdc5c34d55e88c458e0985f7af4df52a6c6a08200c5f097660
cc08b6092269ed91390bec05ffcfca52d630d922116445fe941bc41741ea65da10ef3db23d1c0f2a
8c8c79d767a692b3d1b1a75e5a3a202e66d6054bb360d7fa113e3ab1b181009b27e7092739895722
b50203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3e92dafff8
d80c5ee2bed3c0aaf847b810663495d8ee2a630b5a90f3a29be7f269610f69297a569d65f2671d7c
8bd68219ced93780af9ea65cd65e6000a0cfb6922cb7cfb4bbe4275fbeaea85d558eec7a7b7dee86
916cba60d1483bdfc3f0e788a27787477e889a95d7a976c684c75ee101f30a505dbb34c5a05cc472
0bc7d0203010001
-----
value: 3.0
-----
time: 2022-05-10 18:50:26.228624
-----
--------------
```



```
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100a76d2fc92bbd20
d127351d92ae1e297dc3686a5f787b103849e0e5d69bac2f180d8e0c6bfe791f9f932c4c7ea057af
0d9ebc4ca35cf45c945a0d1ac9b6af63dd2bdeaf92ece163841d9f3c1cab598a501b2d2882404bd0
79b7f35bf12876e0a08fa8dfd9a0c517c6193c348468ba5d1d23c90c347efe9a77459a9618109514
410203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100c89181069a1
a4bc8b00f56170e3b2bd8ebd17e01a718c90ca3113b86660acd6bd160549d2b04ba7d6f4fcd4123e
629edc20f00c545bdbc8899be2265c77a34aca2224604d037c3e6c4e14c3c52bc218147ecef33607
60c8833d9614c61094e9ff5d39a66fdc56de872a9b91499cff6c85d1e79992b035c444fd4a34f724
574890203010001
-----
value: 5.0
-----
time: 2022-05-10 18:50:26.232644
-----
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100a76d2fc92bbd20
d127351d92ae1e297dc3686a5f787b103849e0e5d69bac2f180d8e0c6bfe791f9f932c4c7ea057af
0d9ebc4ca35cf45c945a0d1ac9b6af63dd2bdeaf92ece163841d9f3c1cab598a501b2d2882404bd0
79b7f35bf12876e0a08fa8dfd9a0c517c6193c348468ba5d1d23c90c347efe9a77459a9618109514
410203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3f159cd4c4
758ddacad223181a0cdeae1cf85ae89affdc5c34d55e88c458e0985f7af4df52a6c6a08200c5f097
660cc08b6092269ed91390bec05ffcfca52d630d922116445fe941bc41741ea65da10ef3db23d1c0
f2a8c8c79d767a692b3d1b1a75e5a3a202e66d6054bb360d7fa113e3ab1b181009b27e7092739895
722b50203010001
-----
value: 3.0
-----
time: 2022-05-10 18:50:26.233641
-----
--------------
```



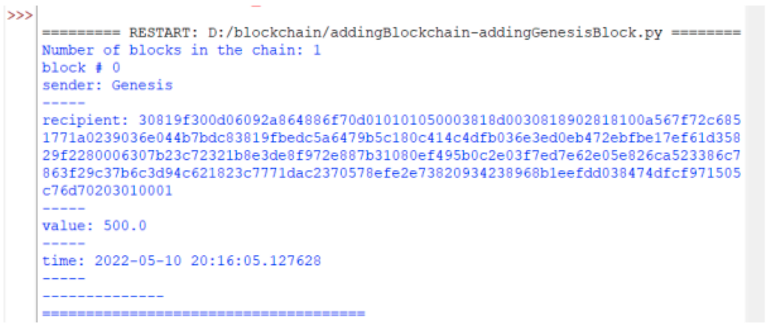
```
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100d3e92dafff8d80
c5ee2bed3c0aaf847b810663495d8ee2a630b5a90f3a29be7f269610f69297a569d65f2671d7c8bd
68219ced93780af9ea65cd65e6000a0cfb6922cb7cfb4bbe4275fbeaea85d558eec7a7b7dee86916
cba60d1483bdfc3f0e788a27787477e889a95d7a976c684c75ee101f30a505dbb34c5a05cc4720bc
7d0203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100c89181069a1
a4bc8b00f56170e3b2bd8ebd17e01a718c90ca3113b86660acd6bd160549d2b04ba7d6f4fcd4123e
629edc20f00c545bdbc8899be2265c77a34aca2224604d037c3e6c4e14c3c52bc218147ecef33607
60c8833d9614c61094e9ff5d39a66fdc56de872a9b91499cff6c85d1e79992b035c444fd4a34f724
574890203010001
-----
value: 8.0
-----
time: 2022-05-10 18:50:26.229652
-----
--------------
sender: 30819f300d06092a864886f70d010101050003818d0030818902818100d3e92dafff8d80
c5ee2bed3c0aaf847b810663495d8ee2a630b5a90f3a29be7f269610f69297a569d65f2671d7c8bd
68219ced93780af9ea65cd65e6000a0cfb6922cb7cfb4bbe4275fbeaea85d558eec7a7b7dee86916
cba60d1483bdfc3f0e788a27787477e889a95d7a976c684c75ee101f30a505dbb34c5a05cc4720bc
7d0203010001
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100d3f159cd4c4
758ddacad223181a0cdeae1cf85ae89affdc5c34d55e88c458e0985f7af4df52a6c6a08200c5f097
660cc08b6092269ed91390bec05ffcfca52d630d922116445fe941bc41741ea65da10ef3db23d1c0
f2a8c8c79d767a692b3d1b1a75e5a3a202e66d6054bb360d7fa113e3ab1b181009b27e7092739895
722b50203010001
-----
value: 1.0
-----
time: 2022-05-10 18:50:26.230649
-----
--------------
```

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

Code:

```
import hashlib
import random
import string
import json
import binascii
import numpy as np
import pandas as pd
import pylab as pl
import logging
import datetime
import collections
import Crypto
import Crypto.Random
from Crypto.Hash import SHA
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')
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 ):
 if self.sender == "Genesis":
 identity = "Genesis"
 else:
 identity = 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')
def display_transaction(transaction):
 #for transaction in transactions:
 dict = transaction.to_dict()
 print ("sender: " + dict['sender'])
 print ('-----')
 print ("recipient: " + dict['recipient'])
 print ('-----')
 print ("value: " + str(dict['value']))
 print ('-----')
print ("time: " + str(dict['time']))
 print ('-----')
class Block:
 def __init__(self):
 self.verified_transactions = []
 self.previous_block_hash = ""
 self.Nonce = ""
last_block_hash = ""
def dump_blockchain (self):
 print ("Number of blocks in the chain: " + str(len (self)))
 for x in range (len(TPCoins)):
 block_temp = TPCoins[x]
 print ("block # " + str(x))
 for transaction in block_temp.verified_transactions:
 display_transaction (transaction)
 print ('--------------')
 print ('=====================================')
Dinesh = Client()
t0 = Transaction (
 "Genesis",
 Dinesh.identity,
 500.0
)
```

```
block0 = Block()
block0.previous_block_hash = None
Nonce = None
block0.verified_transactions.append (t0)
digest = hash (block0)
last_block_hash = digest
TPCoins = []
TPCoins.append (block0)
dump_blockchain(TPCoins)
```

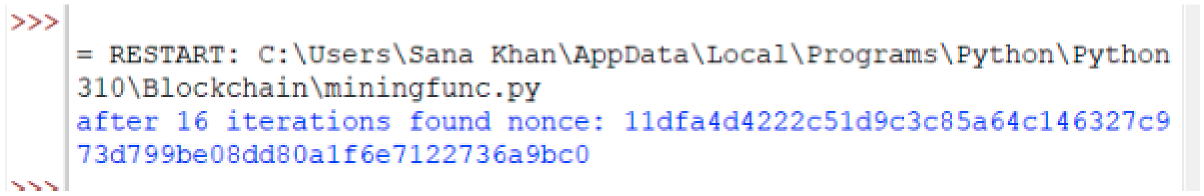


```
>>>
========= RESTART: D:/blockchain/addingBlockchain-addingGenesisBlock.py ========
Number of blocks in the chain: 1
block # 0
sender: Genesis
-----
recipient: 30819f300d06092a864886f70d010101050003818d0030818902818100a567f72c685
1771a0239036e044b7bdc83819fbedc5a6479b5c180c414c4dfb036e3ed0eb472ebfbe17ef61d358
29f2280006307b23c72321b8e3de8f972e887b31080ef495b0c2e03f7ed7e62e05e826ca523386c7
863f29c37b6c3d94c621823c7771dac2370578efe2e73820934238968b1eefdd038474dfcf971505
c76d70203010001
-----
value: 500.0
-----
time: 2022-05-10 20:16:05.127628
-----
--------------
=====================================
```

E. Create a mining function and test it

Code:

```
import hashlib
import random
import string
import json
import binascii
import numpy as np
import pandas as pd
import pylab as pl
import logging
import datetime
import collections
import Crypto
import Crypto.Random
from Crypto.Hash import SHA
from Crypto.PublicKey import RSA
from Crypto.Signature import PKCS1_v1_5
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 ("after " + str(i) + " iterations found nonce: "+ digest)
 return digest
mine ("test message", 2)
 for i in range(1000):
 digest = sha256(str(hash(message)) + str(i))
 if digest.startswith(prefix):
 print ("after " + str(i) + " iterations found nonce: "+ digest)
 return digest
mine ("test message", 2)
```



```
>>>
= RESTART: C:\Users\Sana Khan\AppData\Local\Programs\Python\Python
310\Blockchain\miningfunc.py
after 16 iterations found nonce: 11dfa4d4222c51d9c3c85a64c146327c9
73d799be08dd80a1f6e7122736a9bc0
>>>
```

Practical 02

A. Install and configure Go Ethereum and the Mist browser.

☆ Installing GETH (Go Ethereum)

Step 1: Go to website https://geth.ethereum.org/downloads/
Step 2: From stable releases Geth 1.5.8 (kind = installer)
Step 3: once downloaded run it then click next
Step 4: Select Geth and Development tools click next
Step 5: Select location to install click next
Step 6: Once Installation is finished Click Close and its done

☆ Installing Mist Browser

Step 1: https://github.com/ethereum/mist/releases
Step 2: Under Ethereum Wallet and Mist 0.8.9 - "The Wizard" download mist installer-0-8-9.exe
Step 3: For installation click, I agree → next → install

☆ Run Mist

Step 1: Open the Mist from the start menu
Step 2: It will start downloading Blockchain data once you open it
Step 3: Once it finishes downloading it is ready to use

☆ Run Geth

Step 1: Open CMD
Step 2: Type GETH and press enter
Step 3: After it finishes loading press ctrl+c to exit the process.
Step 4: Now it's ready to use

Practical 03

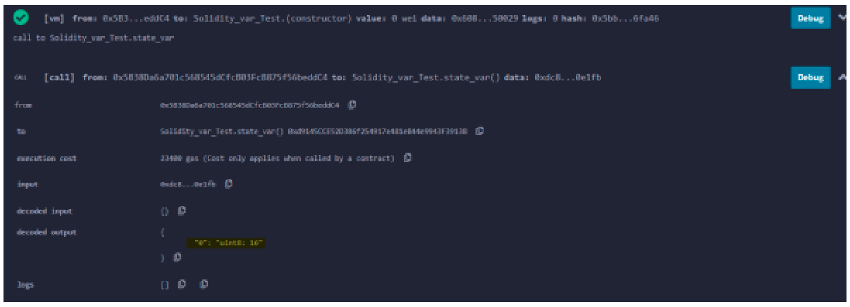
Implement and demonstrate the use of the following in Solidity

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

a. Variable

Code:

```
// Solidity program to demonstrate state variables
pragma solidity ^0.5.0;
// Creating a contract
contract Solidity_var_Test {
// Declaring a state variable
uint8 public state_var;
// Defining a constructor
constructor() public {
state_var = 16;
}
}
```



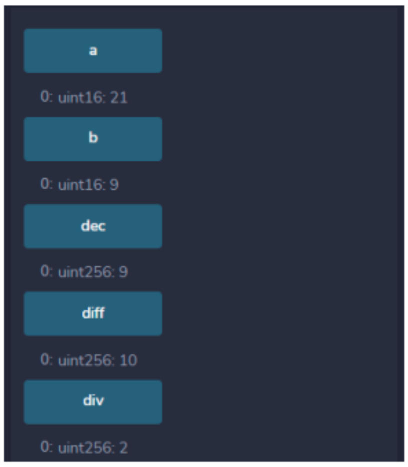
```
[vm] from: 0x5B3...eddC4 to: Solidity_var_Test.(constructor) value: 0 wei data: 0x608...50029 logs: 0 hash: 0x5bb...6fa46
call to Solidity_var_Test.state_var

[call] from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: Solidity_var_Test.state_var() data: 0xdc8...0e1fb
from              0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                Solidity_var_Test.state_var() [illegible]
execution cost    23400 gas (Cost only applies when called by a contract)
input             0xdc8...0e1fb
decoded input     {}
decoded output    {
                      "0": "uint8: 16"
                  }
logs              []
```

b. Operators

1. Arithmetic Operator

Code:

```
// Solidity contract to demonstrate
// Arithmetic Operator
pragma solidity ^0.5.0;
// Creating a contract
contract SolidityTest {
 // Initializing variables
 uint16 public a = 20;
 uint16 public b = 10;
 // Initializing a variable
 // with sum
 uint public sum = a + b;
 // Initializing a variable
 // with the difference
uint public diff = a - b;
// Initializing a variable
// with product
uint public mul = a * b;
// Initializing a variable
// with quotient
uint public div = a / b;
// Initializing a variable
// with modulus
uint public mod = a % b;
// Initializing a variable
// decrement value
uint public dec = --b;
// Initializing a variable
// with increment value
uint public inc = ++a;
}
```



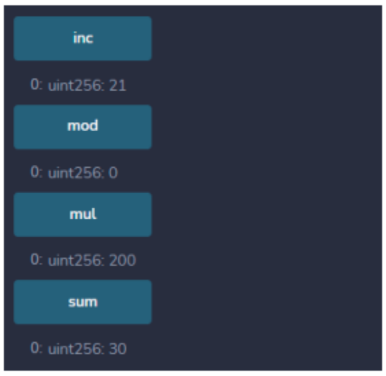
```
0: uint16: 21
```

```
0: uint16: 9
```

```
0: uint256: 9
```

```
0: uint256: 10
```

```
0: uint256: 2
```



```
0: uint256: 21
```

```
0: uint256: 0
```

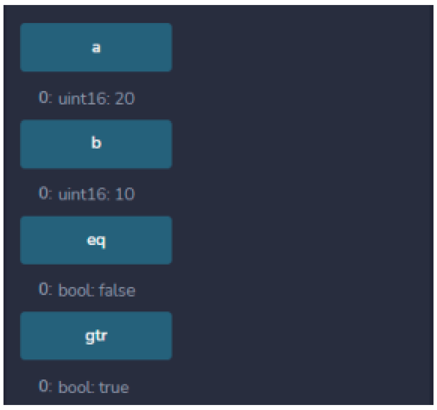
```
0: uint256: 200
```

```
0: uint256: 30
```

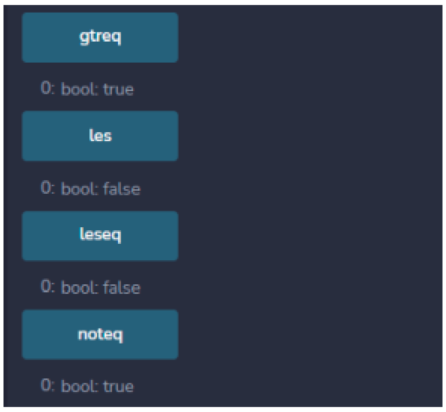
2. Relational Operator

Code:

```
// Solidity program to demonstrate
// Relational Operator
pragma solidity ^0.5.0;
// Creating a contract
contract SolidityTest {
// Declaring variables
uint16 public a = 20;
uint16 public b = 10;
// Initializing a variable
// with bool equal result
bool public eq = a == b;
// Initializing a variable
// with bool not equal result
bool public noteq = a != b;
// Initializing a variable
// with bool greater than result
bool public gtr = a > b;
// Initializing a variable
// with bool less than result
bool public les = a < b;
// Initializing a variable
// with bool greater than equal to result
bool public gtreq = a >= b;
// Initializing a variable
// bool less than equal to result
bool public leseq = a <= b;
}
```



```
a
0: uint16: 20
b
0: uint16: 10
eq
0: bool: false
gtr
0: bool: true
```

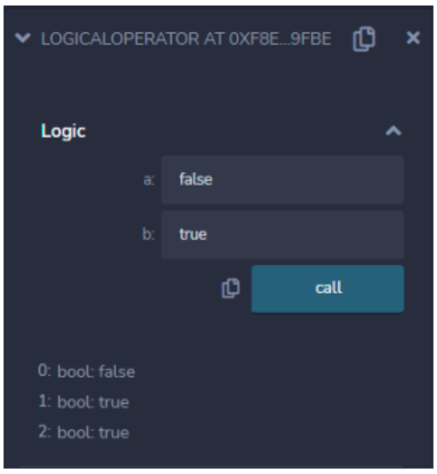


```
gtreq
0: bool: true
les
0: bool: false
leseq
0: bool: false
noteq
0: bool: true
```

3. Logical Operator

Code:

```
// Solidity program to demonstrate
// Logical Operators
pragma solidity ^0.5.0;
// Creating a contract
contract logicalOperator{
// Defining function to demonstrate
// Logical operator
function Logic(
bool a, bool b) public view returns(
bool, bool, bool){
// Logical AND operator
bool and = a&&b;
// Logical OR operator
bool or = a||b;
// Logical NOT operator
bool not = !a;
return (and, or, not);
}
}
```

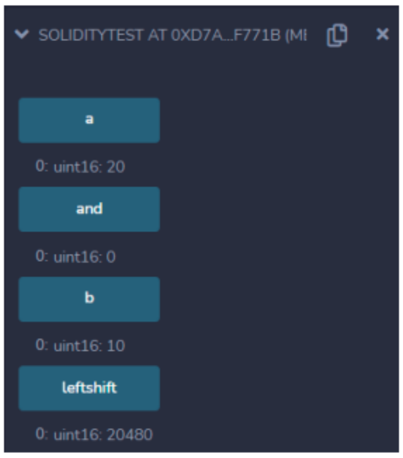


```
LOGICALOPERATOR AT 0XF8E...9FBE
Logic
a: false
b: true
call
0: bool: false
1: bool: true
2: bool: true
```

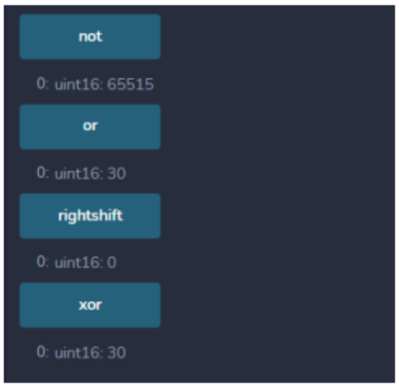
4. Bitwise Operator.

Code:

```
// Solidity program to demonstrate
// Bitwise Operator
pragma solidity ^0.5.0;
// Creating a contract
contract SolidityTest {
// Declaring variables
uint16 public a = 20;
uint16 public b = 10;
// Initializing a variable
// to '&' value
uint16 public and = a & b;
// Initializing a variable
// to '|' value
uint16 public or = a | b;
// Initializing a variable
// to '^' value
uint16 public xor = a ^ b;
// Initializing a variable
// to '<<' value
uint16 public leftshift = a << b;
// Initializing a variable
// to '>>' value
uint16 public rightshift = a >> b;
// Initializing a variable
// to '~' value
uint16 public not = ~a ;
}
```



```
a
0: uint16: 20
and
0: uint16: 0
b
0: uint16: 10
leftshift
0: uint16: 20480
```

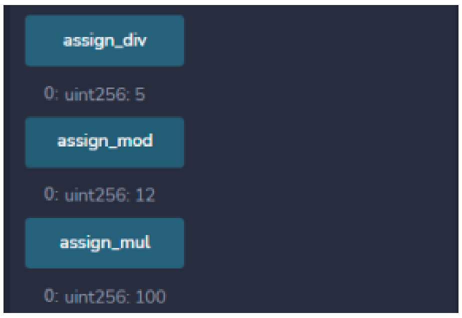


```
not
0: uint16: 65515
or
0: uint16: 30
rightshift
0: uint16: 0
xor
0: uint16: 30
```

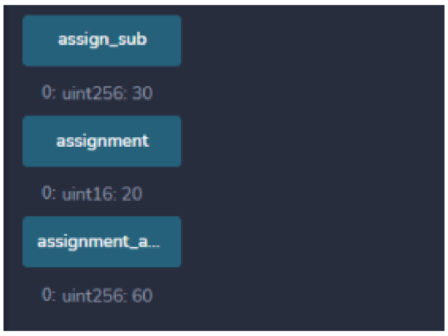
5. Assignment Operator.

Code:

```
// Solidity program to demonstrate
// Assignment Operator
pragma solidity ^0.5.0;
// Creating a contract
contract SolidityTest {
// Declaring variables
uint16 public assignment = 20;
uint public assignment_add = 50;
uint public assign_sub = 50;
uint public assign_mul = 10;
uint public assign_div = 50;
uint public assign_mod = 32;
// Defining function to
// demonstrate Assignment Operator
function getResult() public{
assignment_add += 10;
assign_sub -= 20;
assign_mul *= 10;
assign_div /= 10;
assign_mod %= 20;
return ;
}}
```



```
assign_div
0: uint256: 5
assign_mod
0: uint256: 12
assign_mul
0: uint256: 100
```

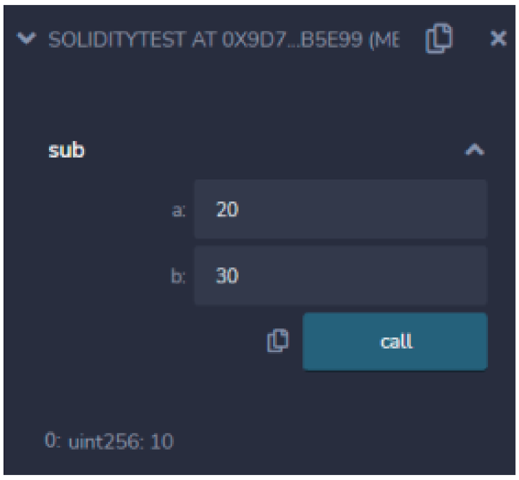


```
assign_sub
0: uint256: 30
assignment
0: uint16: 20
assignment_a...
0: uint256: 60
```

6. Conditional Operator.

Code:

```
// Solidity program to demonstrate
// Conditional Operator
pragma solidity ^0.5.0;
// Creating a contract
contract SolidityTest{
// Defining function to demonstrate
// conditional operator
function sub(
uint a, uint b) public view returns(
uint){
uint result = (a > b? a-b : b-a);
return result;
}
}
```



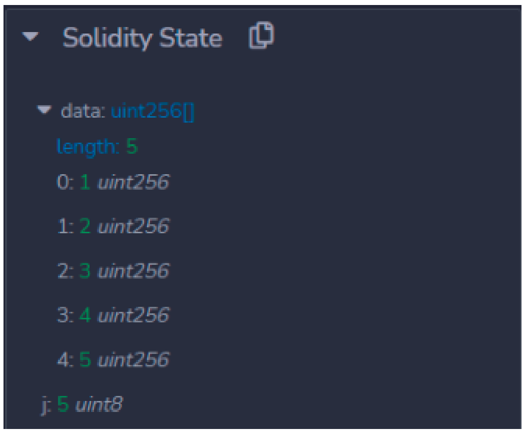
```
SOLIDITYTEST AT 0X9D7...B5E99 (ME
sub
a: 20
b: 30
call
0: uint256: 10
```

c. Loops

1. While Loop.

```
// Solidity program to
// demonstrate the use
// of 'While loop'
pragma solidity ^0.5.0;
```

```
// Creating a contract
contract Types {
// Declaring a dynamic array
uint[] data;
// Declaring state variable
uint8 j = 0;
// Defining a function to
// demonstrate While loop'
function loop(
) public returns(uint[] memory){
while(j < 5) {
j++;
data.push(j);
}
return data;
}
}
```

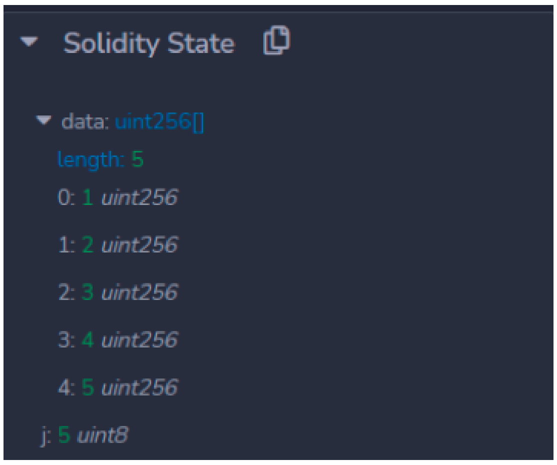


```
Solidity State
data: uint256[]
length: 5
0: 1 uint256
1: 2 uint256
2: 3 uint256
3: 4 uint256
4: 5 uint256
j: 5 uint8
```

2. Do-While Loop.

Code:

```
// Solidity program to
// demonstrate the use of
// 'Do-While loop'
pragma solidity ^0.5.0;
// Creating a contract
contract Types {
// Declaring a dynamic array
uint[] data;
// Declaring state variable
uint8 j = 0;
// Defining function to demonstrate
// 'Do-While loop'
function loop(
) public returns(uint[] memory){
do{
j++;
data.push(j);
}while(j < 5) ;
return data;
}
}
```

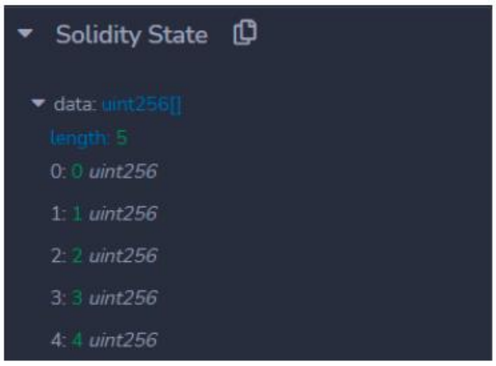


```
Solidity State

data: uint256[]
length: 5
0: 1 uint256
1: 2 uint256
2: 3 uint256
3: 4 uint256
4: 5 uint256
j: 5 uint8
```

3. For Loop.

Code:

```
// Solidity program to
// demonstrate the use
// of 'For loop'
pragma solidity ^0.5.0;
// Creating a contract
contract Types {
// Declaring a dynamic array
uint[] data;
// Defining a function
// to demonstrate 'For loop'
function loop(
) public returns(uint[] memory){
for(uint i=0; i<5; i++){
data.push(i);
}
return data;
}
}
```



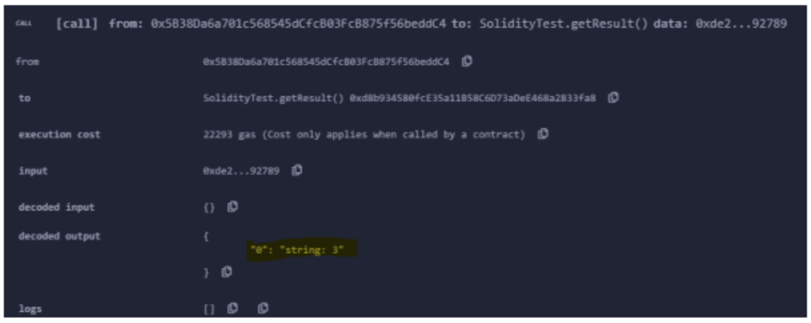
```
Solidity State
data: uint256[]
length: 5
0: 0 uint256
1: 1 uint256
2: 2 uint256
3: 3 uint256
4: 4 uint256
```

d. Decision Making

1. If Statement

Code:

```
pragma solidity ^0.5.0;
contract SolidityTest {
 uint storedData;
 constructor() public {
 storedData = 10;
 }
 function getResult() public view returns(string memory){
 uint a = 1;
 uint b = 2;
 uint result = a + b;
 return integerToString(result);
 }
 function integerToString(uint _i) internal pure
 returns (string memory) {
 if (_i == 0) { // if statement
 return "0";
 }
 uint j = _i;
 uint len;
 while (j != 0) {
 len++;
 j /= 10;
 }
 bytes memory bstr = new bytes(len);
 uint k = len - 1;
 while (_i != 0) {
 bstr[k--] = byte(uint8(48 + _i % 10));
 _i /= 10;
 }
 return string(bstr);//access local variable
 }
}
```

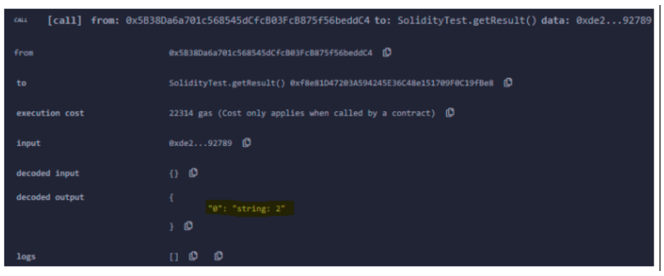


```
CALL    [call] from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: SolidityTest.getResult() data: 0xde2...92789
from                  0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                    SolidityTest.getResult() 0xd8b934580fcE35a11B58C6D73aDeE468a2833fa8
execution cost        22293 gas (Cost only applies when called by a contract)
input                 0xde2...92789
decoded input         {}
decoded output        {
                          "0": "string: 3"
                      }
logs                  []
```

2. If else statement

Code:

```
pragma solidity ^0.5.0;
contract SolidityTest {
 uint storedData;
 constructor() public{
 storedData = 10;
 }
 function getResult() public view returns(string memory){
 uint a = 1;
 uint b = 2;
 uint result;
 if( a > b) { // if else statement
 result = a;
 }
 else {
 result = b;
 }
 return integerToString(result);
 }
 function integerToString(uint _i) internal pure
returns (string memory) {
 if (_i == 0) {
 return "0";
 }
 uint j = _i;
 uint len;
 while (j != 0) {
 len++;
 j /= 10;
 }
 bytes memory bstr = new bytes(len);
 uint k = len - 1;
 while (_i != 0) {
 bstr[k--] = byte(uint8(48 + _i % 10));
 _i /= 10;
 }
 return string(bstr);//access local variable
 }
}
```



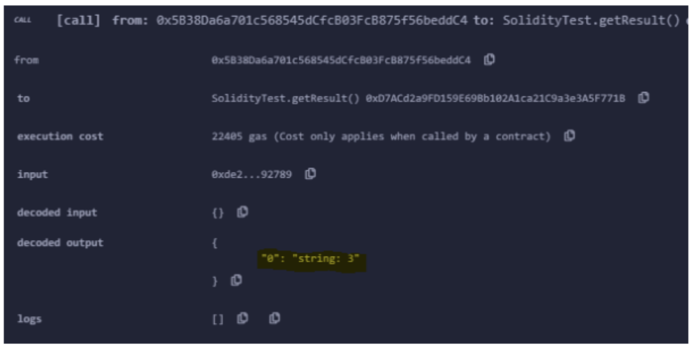
```
CALL   [call] from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: SolidityTest.getResult() data: 0xde2...92789

from               0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                 SolidityTest.getResult() 0xf8e81D47203A594245E36C48e151709F0C19fBe8
execution cost     22314 gas (Cost only applies when called by a contract)
input              0xde2...92789
decoded input      {}
decoded output     {
                       "0": "string: 2"
                   }
logs               []
```

3. If-else-If statement

Code:

```
pragma solidity ^0.5.0;
contract SolidityTest {
 uint storedData; // State variable
 constructor() public {
 storedData = 10;
 }
 function getResult() public view returns(string memory) {
 uint a = 1;
 uint b = 2;
 uint c = 3;
 uint result
 if( a > b && a > c) { // if else statement
 result = a;
 } else if( b > a && b > c ){
 result = b;
 } else {
 result = c;
 }
 return integerToString(result);
 }
 function integerToString(uint _i) internal pure
 returns (string memory) {
```

```
 if (_i == 0) {
 return "0";
 }
 uint j = _i;
 uint len;
 while (j != 0) {
len++;
 j /= 10;
 }
 bytes memory bstr = new bytes(len);
 uint k = len - 1;
 while (_i != 0) {
 bstr[k--] = byte(uint8(48 + _i % 10));
 _i /= 10;
 }
 return string(bstr);//access local variable
 }
}
```



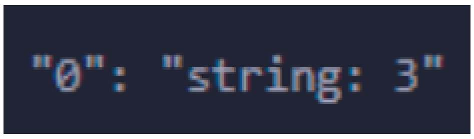
```
CALL  [call] from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: SolidityTest.getResult()

from               0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                 SolidityTest.getResult() 0xD7ACd2a9FD159E69Bb102A1ca21C9a3e3A5F771B
execution cost     22405 gas (Cost only applies when called by a contract)
input              0xde2...92789
decoded input      {}
decoded output     {
                       "0": "string: 3"
                   }
logs               []
```

e. Strings

Code:

```
pragma solidity ^0.5.0;
contract SolidityTest {
 constructor() public{
 }
 function getResult() public view returns(string memory){
 uint a = 1;
 uint b = 2;
 uint result = a + b;
 return integerToString(result);
 }
 function integerToString(uint _i) internal pure
 returns (string memory) {
```

```
 if (_i == 0) {
 return "0";
 }
 uint j = _i;
 uint len;
 while (j != 0) {
 len++;
 j /= 10;
 }
 bytes memory bstr = new bytes(len);
 uint k = len - 1;
 while (_i != 0) {
 bstr[k--] = byte(uint8(48 + _i % 10));
 _i /= 10;
 }
 return string(bstr);
 }
}
```

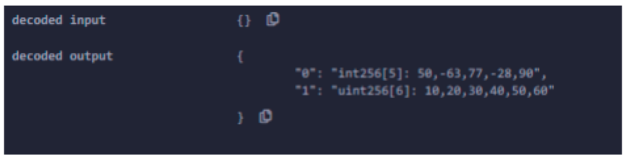


```
"0": "string: 3"
```

f. Arrays

Code:

```
// Solidity program to demonstrate
// creating a fixed-size array
pragma solidity ^0.5.0;
// Creating a contract
contract Types {
// Declaring state variables
// of type array
uint[6] data1;
// Defining function to add
// values to an array
function array_example() public returns (
int[5] memory, uint[6] memory){
int[5] memory data
= [int(50), -63, 77, -28, 90];
data1
= [uint(10), 20, 30, 40, 50, 60];
return (data, data1);
}
}
```



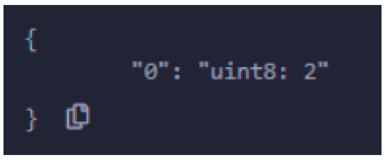
```
decoded input          {}

decoded output         {
                           "0": "int256[5]: 50,-63,77,-28,90",
                           "1": "uint256[6]: 10,20,30,40,50,60"
                       }
```

g. Enums

Code:

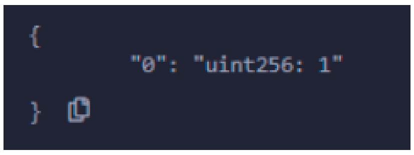
```
pragma solidity ^0.5.0;
contract test {
 enum FreshJuiceSize{ SMALL, MEDIUM, LARGE }
 FreshJuiceSize choice;
 FreshJuiceSize constant defaultChoice = FreshJuiceSize.MEDIUM;
 function setLarge() public {
 choice = FreshJuiceSize.LARGE;
 }
 function getChoice() public view returns (FreshJuiceSize) {
 return choice;
 }
 function getDefaultChoice() public pure returns (uint) {
 return uint(defaultChoice);
 }
}
```

On clicking getChoice



```
{
        "0": "uint8: 2"
}
```

On clicking getDefaultChocie

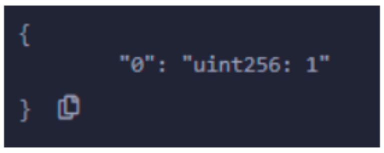


```
{
        "0": "uint256: 1"
}
```

h. Structs

Code:

```
pragma solidity ^0.5.0;
contract test {
 struct Book {
 string title;
 string author;
 uint book_id;
 }
 Book book;
 function setBook() public {
 book = Book('Learn Java', 'TP', 1);
 }
 function getBookId() public view returns (uint) {
 return book.book_id;
 }
}
```

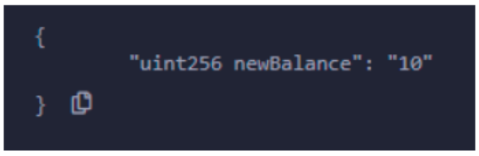


```
{
        "0": "uint256: 1"
}
```

i. Mapping

Code:

```
pragma solidity ^0.5.0;
contract LedgerBalance {
 mapping(address => uint) public balances;
 function updateBalance(uint newBalance) public {
 balances[msg.sender] = newBalance;
 }
}
contract Updater {
 function updateBalance() public returns (uint) {
 LedgerBalance ledgerBalance = new LedgerBalance();
 ledgerBalance.updateBalance(10);
 return ledgerBalance.balances(address(this));
 }
}
```



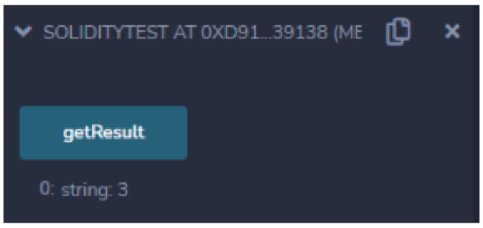
```
{
        "uint256 newBalance": "10"
}
```

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

a. Functions

Code:

```
pragma solidity ^0.5.0;
contract SolidityTest {
constructor() public{
}
function getResult() public view returns(string memory){
uint a = 1;
uint b = 2;
uint result = a + b;
return integerToString(result);
}
function integerToString(uint _i) internal pure
returns (string memory) {
if (_i == 0) {
return "0";
}
uint j = _i;
uint len;
while (j != 0) {
len++;
j /= 10;
}
bytes memory bstr = new bytes(len);
uint k = len - 1;
while (_i != 0) {
bstr[k--] = byte(uint8(48 + _i % 10));
_i /= 10;
}
return string(bstr);//access local variable
}
}
```

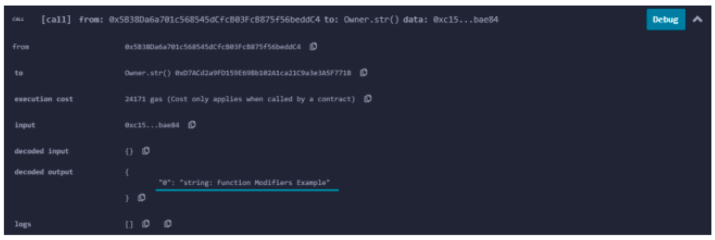


```
0: string: 3
```

b. Function Modifiers

Code:

```
pragma solidity ^0.5.0;
contract Owner {
address owner;
string public str = "Function Modifiers Example";
constructor() public {
owner = msg.sender;
}
modifier onlyOwner {
require(msg.sender == owner);
_;
}
modifier costs(uint price) {
if (msg.value >= price) {
_;
}
}
}
contract Register is Owner {
mapping (address => bool) registeredAddresses;
uint price;
constructor(uint initialPrice) public { price = initialPrice; }
function register() public payable costs(price) {
registeredAddresses[msg.sender] = true;
}
function changePrice(uint _price) public onlyOwner {
price = _price;
}
}
```



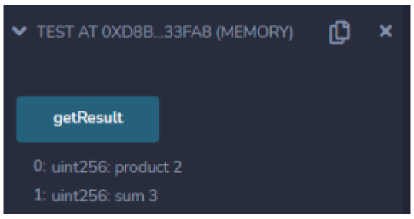
```
CALL [call] from: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4 to: Owner.str() data: 0xc15...bae84
from                0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                  Owner.str() 0xD7ACd2a9FD159E69Bb102A1ca21C9a3e3A5F771B
execution cost      24171 gas (Cost only applies when called by a contract)
input               0xc15...bae84
decoded input       {}
decoded output      {
                        "0": "string: Function Modifiers Example"
                    }
logs                []
```

c. View Funciton

Code:

```
pragma solidity ^0.5.0;
contract Test {
 function getResult() public view returns(uint product, uint sum){
```

```
uint a = 1; // local variable
uint b = 2;
product = a * b;
sum = a + b;
}
}
```

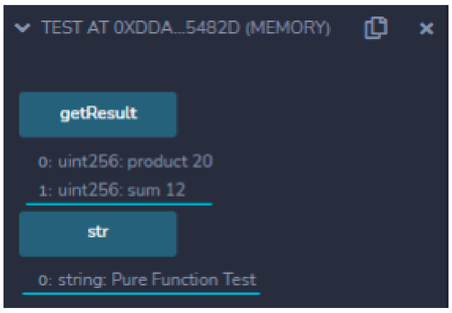


```
TEST AT 0XD8B...33FA8 (MEMORY)
getResult
0: uint256: product 2
1: uint256: sum 3
```

d. Pure Function

Code:

```
pragma solidity ^0.5.0;
contract Test {
function getResult() public pure returns(uint product, uint sum){
uint a = 10;
uint b = 2;
product = a * b;
sum = a + b;
}
string public str = "Pure Function Test";
}
```



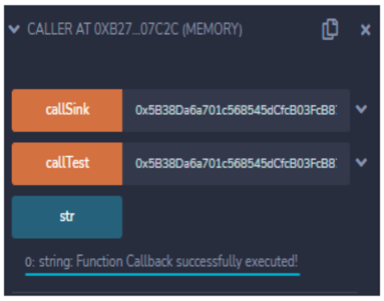
```
TEST AT 0XDDA...5482D (MEMORY)
getResult
0: uint256: product 20
1: uint256: sum 12
str
0: string: Pure Function Test
```

e. Fallback Function:

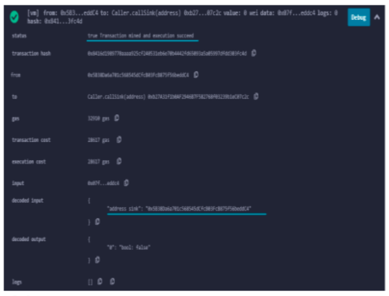
Code:

```
pragma solidity ^0.5.0;
contract Test {
uint public x ;
function() external { x = 1; }
}
contract Sink {
function() external payable { }
}
```

```
contract Caller {
function callTest(Test test) public returns (bool) {
(bool success,) =
address(test).call(abi.encodeWithSignature("nonExistingFunction()"));
require(success);
// test.x is now 1
address payable testPayable = address(uint160(address(test)));
// Sending ether to Test contract,
// the transfer will fail, i.e. this returns false here.
return (testPayable.send(2 ether));
}
function callSink(Sink sink) public returns (bool) {
address payable sinkPayable = address(sink);
return (sinkPayable.send(2 ether));
}
string public str = "Function Callback successfully executed!";
}
```

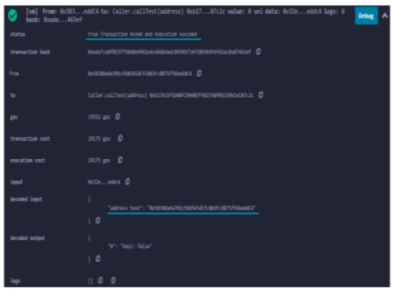


```
CALLER AT 0XB27...07C2C (MEMORY)
callSink   0x5B38Da6a701c568545dCfcB03FcB8
callTest   0x5B38Da6a701c568545dCfcB03FcB8
str
0: string: Function Callback successfully executed!
```



```
[vm] from: 0x5B3...eddC4 to: Caller.callSink(address) 0xb27...07c2c value: 0 wei data: 0x07f...eddc4 logs: 0
hash: 0x841...3fc4d
status              true Transaction mined and execution succeed
transaction hash    0x8416d198977Baaaa925cf240531eb6e70b44424d65093a5a05997d4dd383fc4d
from                0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                  Caller.callSink(address) 0xb27A31f1b0AF2946B7F582768f03239b1eC07c2c
gas                 32910 gas
transaction cost    28617 gas
execution cost      28617 gas
input               0x07f...eddc4
decoded input       {
                        "address sink": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4"
                    }
decoded output      {
                        "0": "bool: false"
                    }
logs                []
```

Call Sink



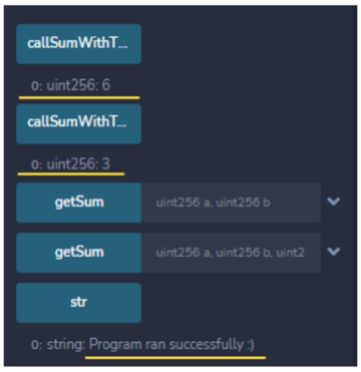
```
[vm] from: 0x5B3...eddC4 to: Caller.callTest(address) 0xb27...07c2c value: 0 wei data: 0x32e...eddc4 logs: 0
hash: 0xada...463ef
status              true Transaction mined and execution succeed
transaction hash    0xada7ca0f015f75468e9961e4c44d6dadc09501f34f28b9b959fd2ac8a87463ef
from                0x5B38Da6a701c568545dCfcB03FcB875f56beddC4
to                  Caller.callTest(address) 0xb27A31f1b0AF2946B7F582768f03239b1eC07c2c
gas                 33552 gas
transaction cost    29175 gas
execution cost      29175 gas
input               0x32e...eddc4
decoded input       {
                        "address test": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4"
                    }
decoded output      {
                        "0": "bool: false"
                    }
logs                []
```

Call Test

f. Function Overloading:

Code:

```
pragma solidity ^0.5.0;
contract Test {
string public str="Program ran successfully :)";
function getSum(uint a, uint b) public pure returns(uint){
return a + b;
}
function getSum(uint a, uint b, uint c) public pure returns(uint){
return a + b + c;
}
function callSumWithTwoArguments() public pure returns(uint){
return getSum(1,2);
}
function callSumWithThreeArguments() public pure returns(uint){
return getSum(1,2,3);
}
}
```

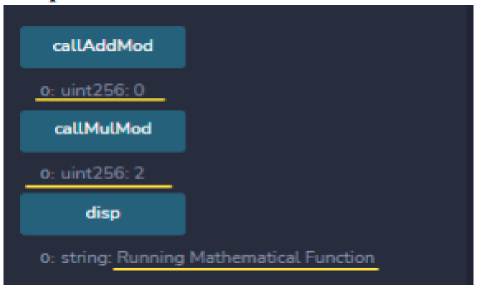


```
0: uint256: 6
0: uint256: 3
0: string: Program ran successfully :)
```

g. Mathematical Functions:

Code:

```
pragma solidity ^0.5.0;
contract Test {
string public disp="Running Mathematical Function";
function callAddMod() public pure returns(uint){
return addmod(4, 5, 3);
}
function callMulMod() public pure returns(uint){
return mulmod(4, 5, 3);
}
}
```

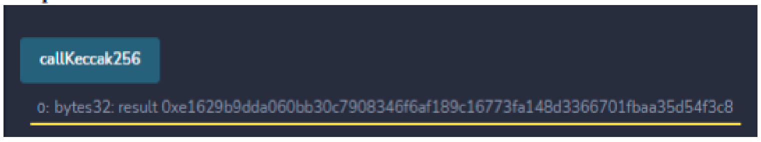


```
0: uint256: 0
0: uint256: 2
0: string: Running Mathematical Function
```

h. Cryptographic Functions:

Code:

```
pragma solidity ^0.5.0;
contract Test {
function callKeccak256() public pure returns(bytes32 result){
return keccak256("ABC");
}
}
```



```
0: bytes32: result 0xe1629b9dda060bb30c7908346f6af189c16773fa148d3366701fbaa35d54f3c8
```

Practical 04

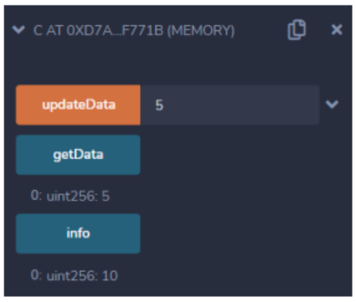
Implement and demonstrate the use of the following in Solidity:

A. Contracts, Inheritance, Constructors, Abstract Contracts, Interfaces.

a. Contracts:

Code:

```
pragma solidity ^0.5.0;
contract C {
 //private state variable
 uint private data;
 //public state variable
 uint public info;
 //constructor
 constructor() public {
 info = 10;
 }
 //private function
 function increment(uint a) private pure returns(uint) { return a + 1; }
 //public function
 function updateData(uint a) public { data = a; }
 function getData() public view returns(uint) { return data; }
 function compute(uint a, uint b) internal pure returns (uint) { return a + b; }
}
//External Contract
contract D {
 function readData() public returns(uint) {
 C c = new C();
 c.updateData(7);
 return c.getData();
 }
}
//Derived Contract
contract E is C {
 uint private result;
 C private c;
 constructor() public {
 c = new C();
 }
 function getComputedResult() public {
 result = compute(3, 5);
 }
 function getResult() public view returns(uint) { return result; }
function getData() public view returns(uint) { return c.info(); }
}
```

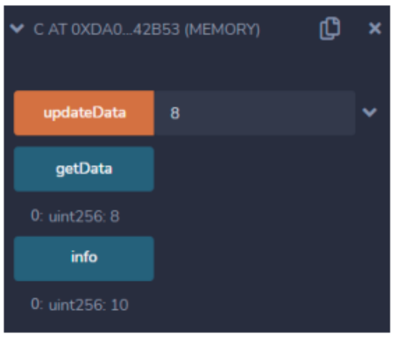


```
0: uint256: 5
0: uint256: 10
```

b. Inheritance

Code:

```
pragma solidity ^0.5.0;
contract C {
 //private state variable
 uint private data;
 //public state variable
 uint public info;
 //constructor
 constructor() public {
 info = 10;
 }
 //private function
 function increment(uint a) private pure returns(uint) { return a + 1; }
 //public function
 function updateData(uint a) public { data = a; }
 function getData() public view returns(uint) { return data; }
 function compute(uint a, uint b) internal pure returns (uint) { return a + b; }
}
//Derived Contract
contract E is C {
 uint private result;
 C private c;
 constructor() public {
 c = new C();
}
 function getComputedResult() public {
 result = compute(3, 5);
 }
 function getResult() public view returns(uint) { return result; }
 function getData() public view returns(uint) { return c.info(); }}
```

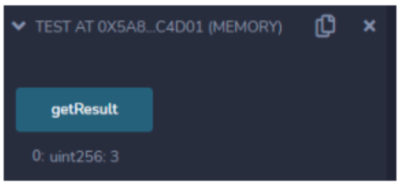


```
0: uint256: 8
0: uint256: 10
```

c. Interfaces

Code:

```
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;
 }
}
```



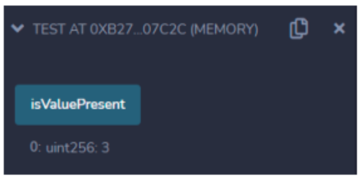
```
0: uint256: 3
```

B. Libraries, Assembly, Events, Error handling.

a. Libraries

Code:

```
pragma solidity ^0.5.0;
library Sum {
function sumUsingInlineAssembly(uint[] memory _data) public pure returns (uint
o_sum) {
for (uint i = 0; i < _data.length; ++i) {
assembly {
o_sum := add(o_sum, mload(add(add(_data, 0x20), mul(i, 0x20))))
}
}
}
}
contract Test {
uint[] data;
constructor() public {
data.push(1);
data.push(2);
data.push(3);
data.push(4);
data.push(5);
}
function sum() external view returns(uint){
return Sum.sumUsingInlineAssembly(data);
}
}
```

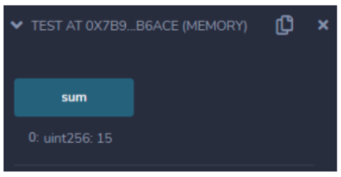


```
0: uint256: 3
```

b. Assembly

Code:

```
pragma solidity ^0.5.0;
library Sum {
 function sumUsingInlineAssembly(uint[] memory _data) public pure returns (uint
o_sum) {
 for (uint i = 0; i < _data.length; ++i) {
 assembly {
 o_sum := add(o_sum, mload(add(add(_data, 0x20), mul(i, 0x20))))
 } } } }
contract Test {
 uint[] data;
 constructor() public {
 data.push(1);
 data.push(2);
 data.push(3);
 data.push(4);
 data.push(5);
 }
 function sum() external view returns(uint){
 return Sum.sumUsingInlineAssembly(data);
 }
}
```

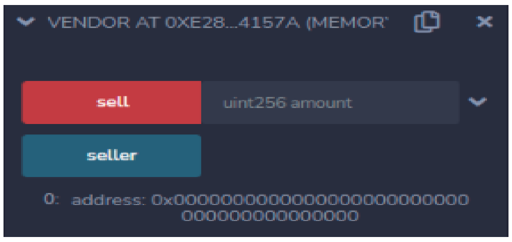


```
TEST AT 0X7B9...B6ACE (MEMORY)
sum
0: uint256: 15
```

c. Error Handling

Code:

```
pragma solidity ^0.5.0;
contract Vendor {
address public seller;
modifier onlySeller() {
require(
msg.sender == seller,
"Only seller can call this."
);
_;
}
function sell(uint amount) public payable onlySeller {
if (amount > msg.value / 2 ether)
revert("Not enough Ether provided.");
// Perform the sell operation.
} }
```



```
VENDOR AT 0XE28...4157A (MEMOR
sell    uint256 amount
seller
0: address: 0x0000000000000000000000000
000000000000000
```

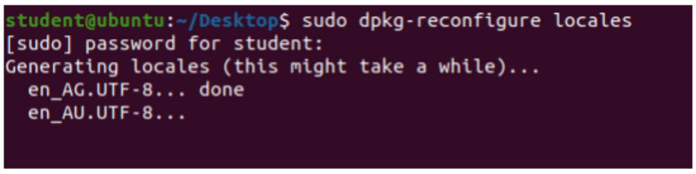
Practical 05

Install hyperledger fabric and composer. Deploy and execute the application.

Create VM

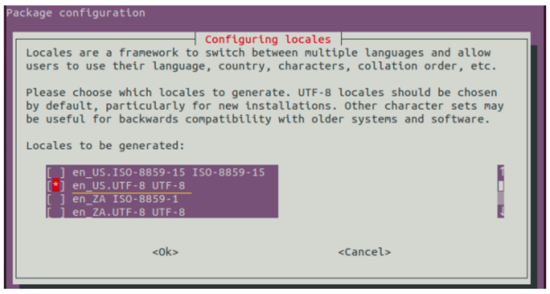
1. Download VMware Player.
2. Download Ubuntu ISO
3. Install vmware player
4. Create VM of Ubuntu using vmware player

$ sudo dpkg-reconfigure locales // choose en_US.UTF-8 if in doubt

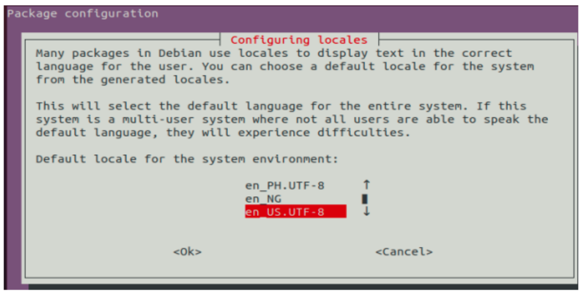


```
student@ubuntu:~/Desktop$ sudo dpkg-reconfigure locales
[sudo] password for student:
Generating locales (this might take a while)...
  en_AG.UTF-8... done
  en_AU.UTF-8...
```

$ sudo apt-get update

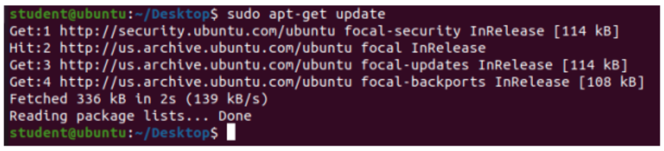


```
Package configuration

              ┤ Configuring locales ├
 Locales are a framework to switch between multiple languages and allow
 users to use their language, country, characters, collation order, etc.

 Please choose which locales to generate. UTF-8 locales should be chosen
 by default, particularly for new installations. Other character sets may
 be useful for backwards compatibility with older systems and software.

 Locales to be generated:

    [ ] en_US.ISO-8859-15 ISO-8859-15
    [*] en_US.UTF-8 UTF-8
    [ ] en_ZA ISO-8859-1
    [ ] en_ZA.UTF-8 UTF-8

              <Ok>                      <Cancel>
```



```
Package configuration

              ┤ Configuring locales ├
 Many packages in Debian use locales to display text in the correct
 language for the user. You can choose a default locale for the system
 from the generated locales.

 This will select the default language for the entire system. If this
 system is a multi-user system where not all users are able to speak the
 default language, they will experience difficulties.

 Default locale for the system environment:

                          en_PH.UTF-8       ↑
                          en_NG             ▮
                          en_US.UTF-8       ↓

              <Ok>                      <Cancel>
```

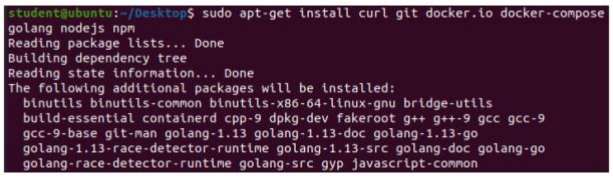
$ sudo apt-get upgrade



```
student@ubuntu:~/Desktop$ sudo apt-get update
Get:1 http://security.ubuntu.com/ubuntu focal-security InRelease [114 kB]
Hit:2 http://us.archive.ubuntu.com/ubuntu focal InRelease
Get:3 http://us.archive.ubuntu.com/ubuntu focal-updates InRelease [114 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal-backports InRelease [108 kB]
Fetched 336 kB in 2s (139 kB/s)
Reading package lists... Done
student@ubuntu:~/Desktop$ 
```

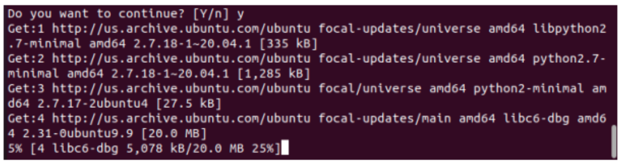
Install pre-requists

$ sudo apt-get install curl git docker.io docker-compose golang nodejs npm



```
student@ubuntu:~/Desktop$ sudo apt-get install curl git docker.io docker-compose
golang nodejs npm
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  binutils binutils-common binutils-x86-64-linux-gnu bridge-utils
  build-essential containerd cpp-9 dpkg-dev fakeroot g++ g++-9 gcc gcc-9
  gcc-9-base git-man golang-1.13 golang-1.13-doc golang-1.13-go
  golang-1.13-race-detector-runtime golang-1.13-src golang-doc golang-go
  golang-race-detector-runtime golang-src gyp javascript-common
```

Type Y for yes



```
Do you want to continue? [Y/n] y
Get:1 http://us.archive.ubuntu.com/ubuntu focal-updates/universe amd64 libpython2
.7-minimal amd64 2.7.18-1~20.04.1 [335 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu focal-updates/universe amd64 python2.7-
minimal amd64 2.7.18-1~20.04.1 [1,285 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 python2-minimal am
d64 2.7.17-2ubuntu4 [27.5 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu focal-updates/main amd64 libc6-dbg amd6
4 2.31-0ubuntu9.9 [20.0 MB]
5% [4 libc6-dbg 5,078 kB/20.0 MB 25%]
```

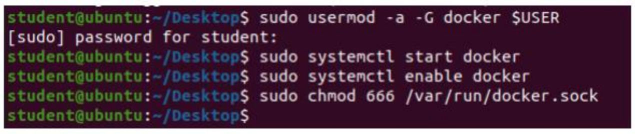
Install Docker

$ sudo usermod -a -G docker $USER

$ sudo systemctl start docker

$ sudo systemctl enable docker

$ sudo chmod 666 /var/run/docker.sock

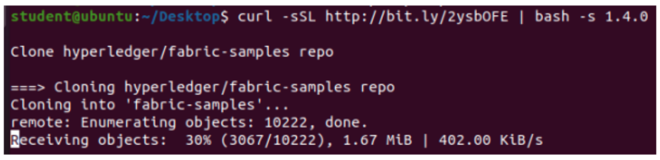


```
student@ubuntu:~/Desktop$ sudo usermod -a -G docker $USER
[sudo] password for student:
student@ubuntu:~/Desktop$ sudo systemctl start docker
student@ubuntu:~/Desktop$ sudo systemctl enable docker
student@ubuntu:~/Desktop$ sudo chmod 666 /var/run/docker.sock
student@ubuntu:~/Desktop$
```

Install Hyperledger Fabric

1. Check the latest version of fabric repository
2. Install Fabric

$ curl -sSL http://bit.ly/2ysbOFE | bash -s 1.4.0

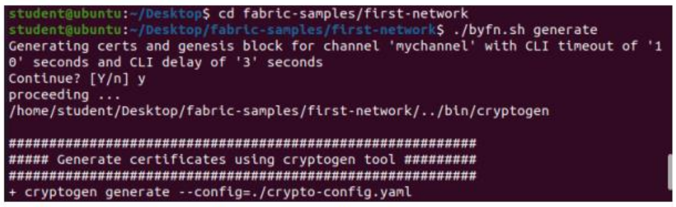


```
student@ubuntu:~/Desktop$ curl -sSL http://bit.ly/2ysbOFE | bash -s 1.4.0

Clone hyperledger/fabric-samples repo

===> Cloning hyperledger/fabric-samples repo
Cloning into 'fabric-samples'...
remote: Enumerating objects: 10222, done.
Receiving objects:  30% (3067/10222), 1.67 MiB | 402.00 KiB/s
```

3. Check if fabric is installed, you should see big "END" once done

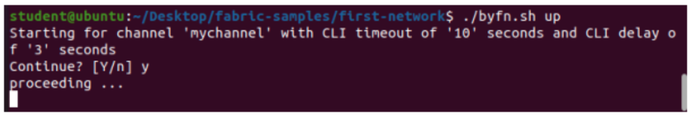
$ cd fabric-samples/first-network

$ ./byfn.sh generate



```
student@ubuntu:~/Desktop$ cd fabric-samples/first-network
student@ubuntu:~/Desktop/fabric-samples/first-network$ ./byfn.sh generate
Generating certs and genesis block for channel 'mychannel' with CLI timeout of '1
0' seconds and CLI delay of '3' seconds
Continue? [Y/n] y
proceeding ...
/home/student/Desktop/fabric-samples/first-network/../bin/cryptogen

##########################################################
##### Generate certificates using cryptogen tool #########
##########################################################
+ cryptogen generate --config=./crypto-config.yaml
```

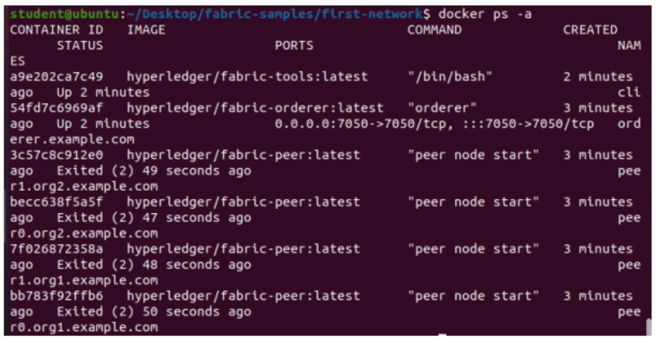
$ ./byfn.sh up



```
student@ubuntu:~/Desktop/fabric-samples/first-network$ ./byfn.sh up
Starting for channel 'mychannel' with CLI timeout of '10' seconds and CLI delay o
f '3' seconds
Continue? [Y/n] y
proceeding ...
```

4. Check if fabric docker is running smoothly

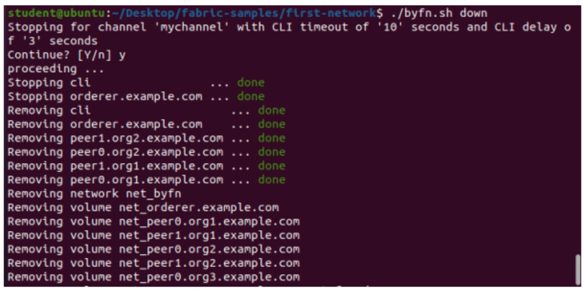
$ docker ps -a



```
student@ubuntu:~/Desktop/fabric-samples/first-network$ docker ps -a
CONTAINER ID   IMAGE                               COMMAND               CREATED
      STATUS                      PORTS                                       NAM
ES
a9e202ca7c49   hyperledger/fabric-tools:latest     "/bin/bash"           2 minutes
ago    Up 2 minutes                                                           cli
54fd7c6969af   hyperledger/fabric-orderer:latest   "orderer"             3 minutes
ago    Up 2 minutes               0.0.0.0:7050->7050/tcp, :::7050->7050/tcp   ord
erer.example.com
3c57c8c912e0   hyperledger/fabric-peer:latest      "peer node start"     3 minutes
ago    Exited (2) 49 seconds ago                                              pee
r1.org2.example.com
becc638f5a5f   hyperledger/fabric-peer:latest      "peer node start"     3 minutes
ago    Exited (2) 47 seconds ago                                              pee
r0.org2.example.com
7f026872358a   hyperledger/fabric-peer:latest      "peer node start"     3 minutes
ago    Exited (2) 48 seconds ago                                              pee
r1.org1.example.com
bb783f92ffb6   hyperledger/fabric-peer:latest      "peer node start"     3 minutes
ago    Exited (2) 50 seconds ago                                              pee
r0.org1.example.com
```

5. Stop the network

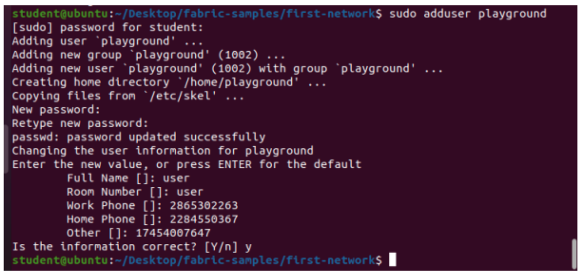
$ ./byfn.sh down



```
student@ubuntu:~/Desktop/fabric-samples/first-network$ ./byfn.sh down
Stopping for channel 'mychannel' with CLI timeout of '10' seconds and CLI delay o
f '3' seconds
Continue? [Y/n] y
proceeding ...
Stopping cli                  ... done
Stopping orderer.example.com ... done
Removing cli                    ... done
Removing orderer.example.com    ... done
Removing peer1.org2.example.com ... done
Removing peer0.org2.example.com ... done
Removing peer1.org1.example.com ... done
Removing peer0.org1.example.com ... done
Removing network net_byfn
Removing volume net_orderer.example.com
Removing volume net_peer0.org1.example.com
Removing volume net_peer1.org1.example.com
Removing volume net_peer0.org2.example.com
Removing volume net_peer1.org2.example.com
Removing volume net_peer0.org3.example.com
```

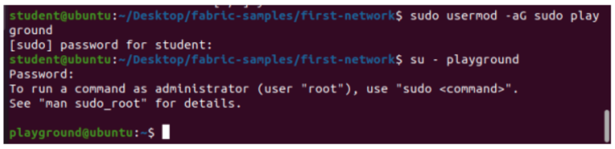
Install Composer

1. Create new user, when asked about the full name, use something different than the full name used of the main user, to avoid confusion next time you are logging on. $ sudo adduser playground



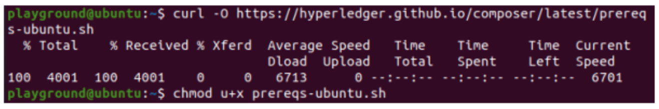
```
student@ubuntu:~/Desktop/fabric-samples/first-network$ sudo adduser playground
[sudo] password for student:
Adding user `playground' ...
Adding new group `playground' (1002) ...
Adding new user `playground' (1002) with group `playground' ...
Creating home directory `/home/playground' ...
Copying files from `/etc/skel' ...
New password:
Retype new password:
passwd: password updated successfully
Changing the user information for playground
Enter the new value, or press ENTER for the default
        Full Name []: user
        Room Number []: user
        Work Phone []: 2865302263
        Home Phone []: 2284550367
        Other []: 17454007647
Is the information correct? [Y/n] y
student@ubuntu:~/Desktop/fabric-samples/first-network$
```

2. Set permission for the new user $ sudo usermod -aG sudo playground
3. Login as the new user $ su – playground



```
student@ubuntu:~/Desktop/fabric-samples/first-network$ sudo usermod -aG sudo play
ground
[sudo] password for student:
student@ubuntu:~/Desktop/fabric-samples/first-network$ su - playground
Password:
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

playground@ubuntu:~$
```

4. Install the prerequisites by getting and running the script from github. It will ask for the password of "playground" account to proceed.
   $ curl-O https://hyperledger.github.io/composer/latest/prereqs-ubuntu.sh
   $ chmod u+x prereqs-ubuntu.sh



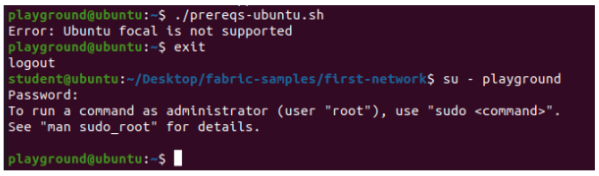
```
playground@ubuntu:~$ curl -O https://hyperledger.github.io/composer/latest/prereq
s-ubuntu.sh
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100  4001  100  4001    0     0   6713      0 --:--:-- --:--:-- --:--:--  6701
playground@ubuntu:~$ chmod u+x prereqs-ubuntu.sh
```

$ ./prereqs-ubuntu.sh

5. Logout and login with the new user to get things activated properly

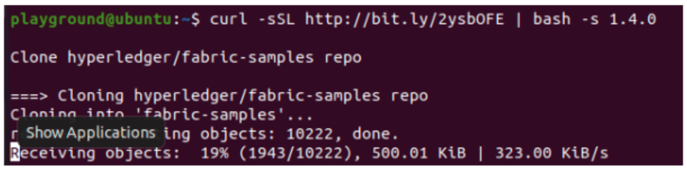
$ exit

$ su – playground



```
playground@ubuntu:~$ ./prereqs-ubuntu.sh
Error: Ubuntu focal is not supported
playground@ubuntu:~$ exit
logout
student@ubuntu:~/Desktop/fabric-samples/first-network$ su - playground
Password:
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

playground@ubuntu:~$
```

6. Install components needed for running Hyperledger Fabric
   $ curl -sSL http://bit.ly/2ysbOFE | bash -s 1.4.0



```
playground@ubuntu:~$ curl -sSL http://bit.ly/2ysbOFE | bash -s 1.4.0

Clone hyperledger/fabric-samples repo

===> Cloning hyperledger/fabric-samples repo
Cloning into 'fabric-samples'...
r Show Applications ing objects: 10222, done.
Receiving objects:  19% (1943/10222), 500.01 KiB | 323.00 KiB/s
```

7. Install components needed for running Hyperledger Composer
   $ npm install -g composer-cli composer-rest-server generator-hyperledger-composer yo composer-playground
8. Start Composer $ composer-playground
9. Open your browser and check it: http://localhost:8080

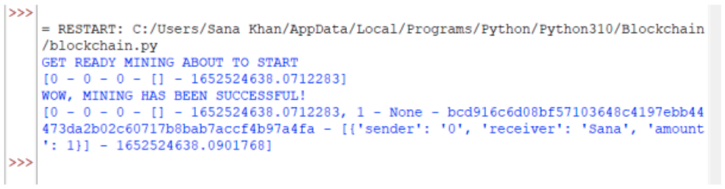
Practical 06

Create your own blockchain and demonstrate its use.

Code:

```
import hashlib
import time
class Block(object):
 def __init__(self, index, proof_number, previous_hash, data, timestamp=None):
 self.index = index
 self.proof_number = proof_number
 self.previous_hash = previous_hash
 self.data = data
 self.timestamp = timestamp or time.time()
 @property
 def compute_hash(self):
 string_block = "{}{}{}{}{}".format(self.index, self.proof_number, self.previous_hash,
self.data, self.timestamp)
 return hashlib.sha256(string_block.encode()).hexdigest()
 def __repr__(self):
 return "{} - {} - {} - {} - {}".format(self.index, self.proof_number, self.previous_hash,
self.data, self.timestamp)
class BlockChain(object):
 def __init__(self):
 self.chain = []
 self.current_data = []
self.nodes = set()
 self.build_genesis()
 def build_genesis(self):
 self.build_block(proof_number=0, previous_hash=0)
 def build_block(self, proof_number, previous_hash):
 block = Block(
 index=len(self.chain),
 proof_number=proof_number,
 previous_hash=previous_hash,
 data=self.current_data
 )
 self.current_data = []
 self.chain.append(block)
 return block
 @staticmethod
 def confirm_validity(block, previous_block):
```

```
 if previous_block.index + 1 != block.index:
 return False
 elif previous_block.compute_hash != block.previous_hash:
 return False
 elif block.timestamp <= previous_block.timestamp:
 return False
return True
 def get_data(self, sender, receiver, amount):
 self.current_data.append({
 'sender': sender,
 'receiver': receiver,
 'amount': amount
 })
 return True
 @staticmethod
 def proof_of_work(last_proof):
 pass
 @property
 def latest_block(self):
 return self.chain[-1]
 def chain_validity(self):
 pass
 def block_mining(self, details_miner):
 self.get_data(
 sender="0", #it implies that this node has created a new block
 receiver=details_miner,
 quantity=1, #creating a new block (or identifying the proof number) is awared with 1
 )
last_block = self.latest_block
 last_proof_number = last_block.proof_number
 proof_number = self.proof_of_work(last_proof_number)
 last_hash = last_block.compute_hash
 block = self.build_block(proof_number, last_hash)
 return vars(block)
 def create_node(self, address):
 self.nodes.add(address)
 return True
 @staticmethod
 def get_block_object(block_data):
 return Block(
 block_data['index'],
 block_data['proof_number'],
 block_data['previous_hash'],
 block_data['data'],
 timestamp=block_data['timestamp']
 )
blockchain = BlockChain()
print("GET READY MINING ABOUT TO START")
print(blockchain.chain)
last_block = blockchain.latest_block
last_proof_number = last_block.proof_number
proof_number = blockchain.proof_of_work(last_proof_number)
blockchain.get_data(
 sender="0", #this means that this node has constructed another block
 receiver="Sana",
 amount=1, #building a new block (or figuring out the proof number) is awarded with
1
)
last_hash = last_block.compute_hash
block = blockchain.build_block(proof_number, last_hash)
print("WOW, MINING HAS BEEN SUCCESSFUL!")
print(blockchain.chain)
```



```
>>>
= RESTART: C:/Users/Sana Khan/AppData/Local/Programs/Python/Python310/Blockchain
/blockchain.py
GET READY MINING ABOUT TO START
[0 - 0 - 0 - [] - 1652524638.0712283]
WOW, MINING HAS BEEN SUCCESSFUL!
[0 - 0 - 0 - [] - 1652524638.0712283, 1 - None - bcd916c6d08bf57103648c4197ebb44
473da2b02c60717b8bab7accf4b97a4fa - [{'sender': '0', 'receiver': 'Sana', 'amount
': 1}] - 1652524638.0901768]
>>>
```