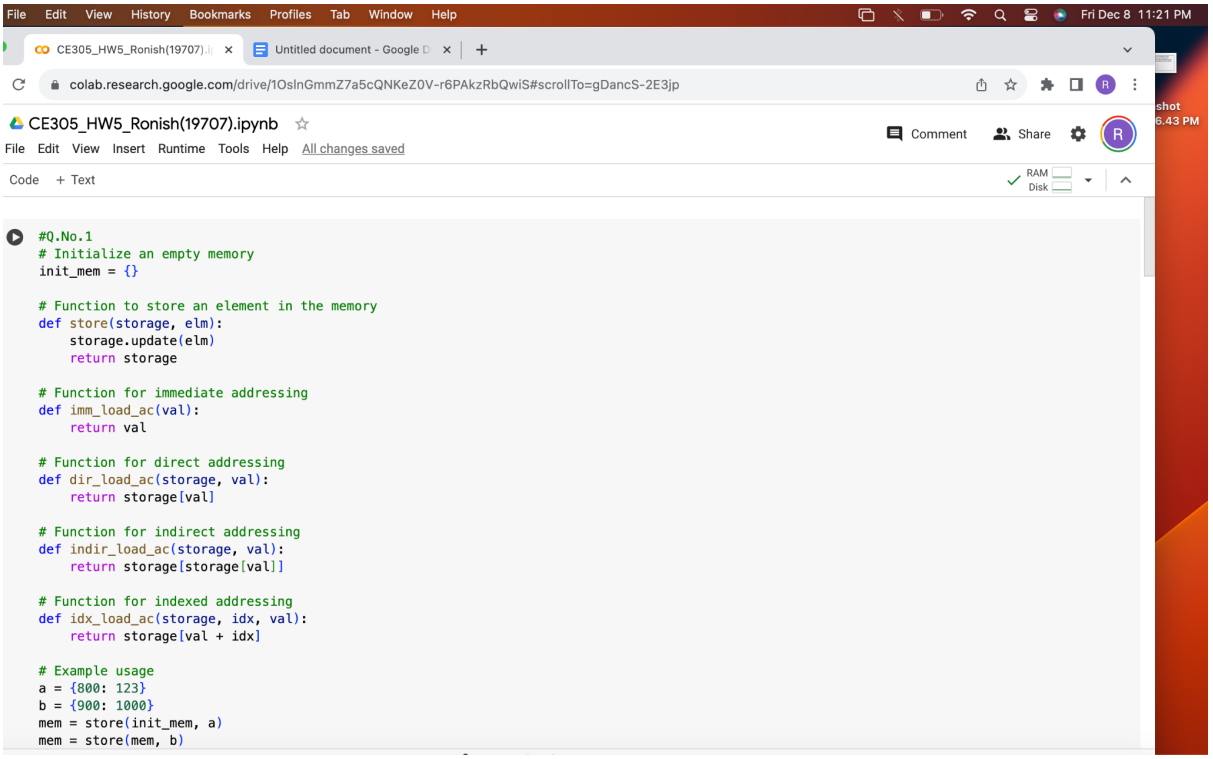
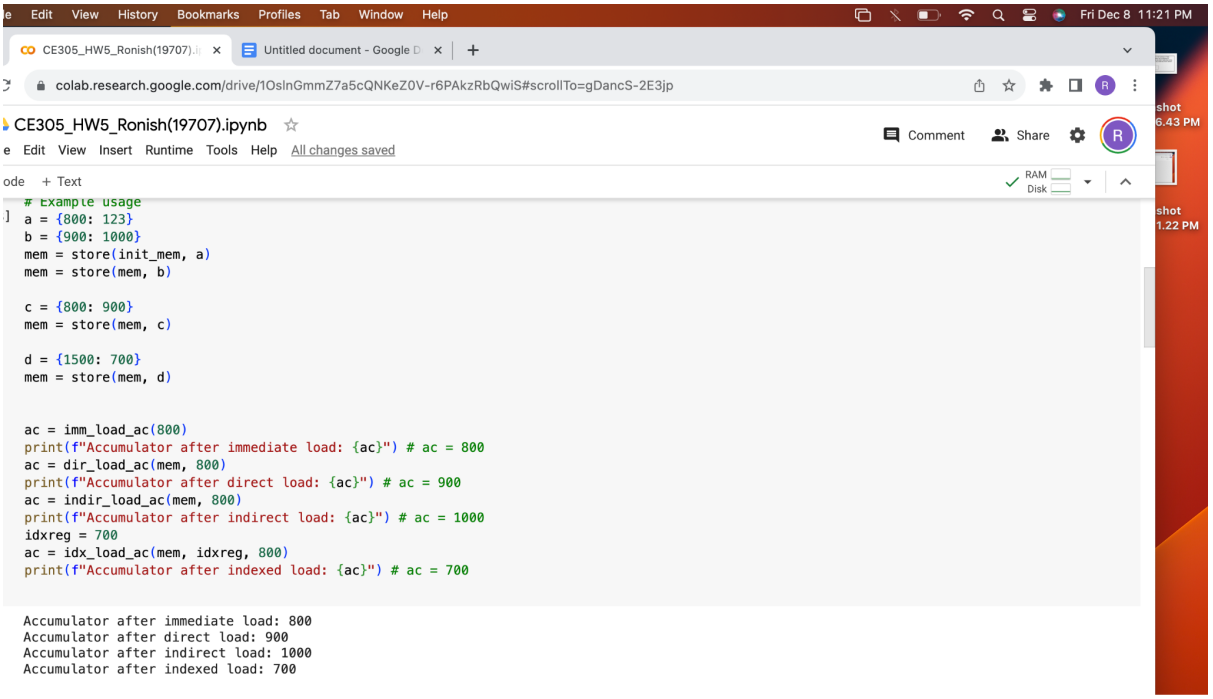
Q.no.1)In MARIE architecture ISA, there are several different types of addressing modes, such as immediate addressing, direct addressing, indirect addressing and indexed addressing. Please complete the following functions in Python to simulate how the different addressing modes work.



```python
#Q.No.1
# Initialize an empty memory
init_mem = {}

# Function to store an element in the memory
def store(storage, elm):
    storage.update(elm)
    return storage

# Function for immediate addressing
def imm_load_ac(val):
    return val

# Function for direct addressing
def dir_load_ac(storage, val):
    return storage[val]

# Function for indirect addressing
def indir_load_ac(storage, val):
    return storage[storage[val]]

# Function for indexed addressing
def idx_load_ac(storage, idx, val):
    return storage[val + idx]

# Example usage
a = {800: 123}
b = {900: 1000}
mem = store(init_mem, a)
mem = store(mem, b)
```

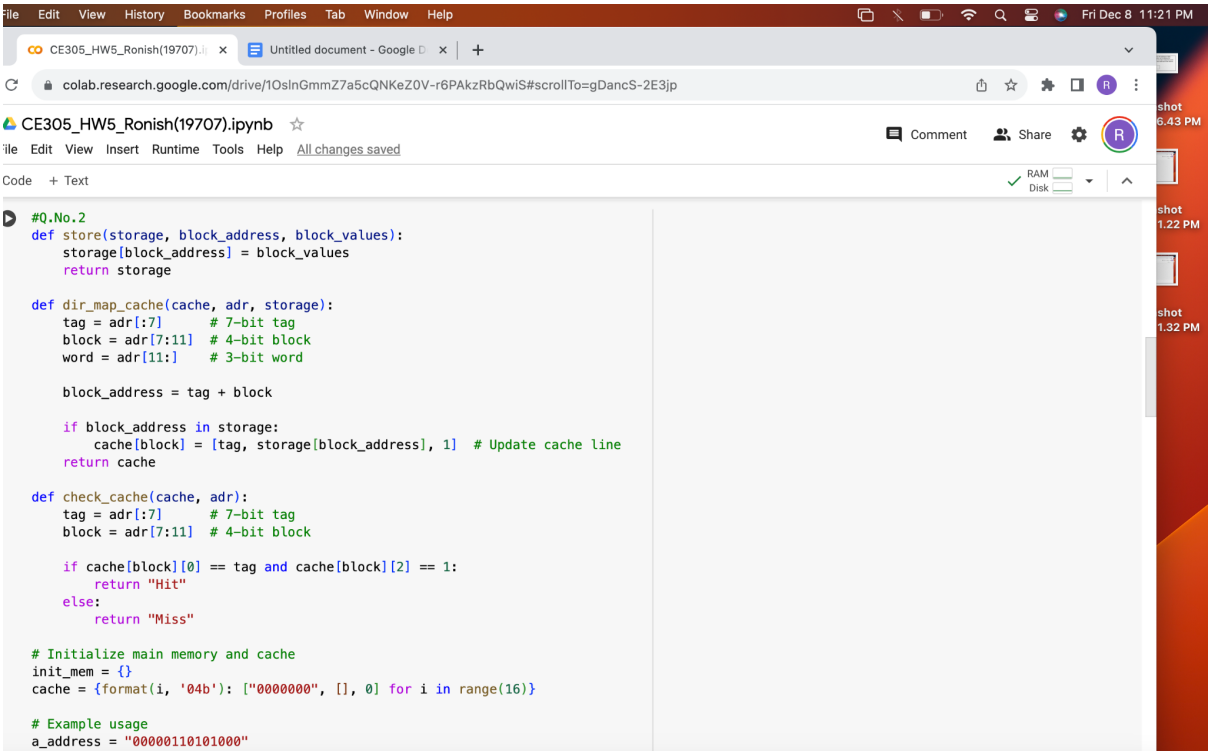


```python
# Example usage
a = {800: 123}
b = {900: 1000}
mem = store(init_mem, a)
mem = store(mem, b)

c = {800: 900}
mem = store(mem, c)

d = {1500: 700}
mem = store(mem, d)


ac = imm_load_ac(800)
print(f"Accumulator after immediate load: {ac}") # ac = 800
ac = dir_load_ac(mem, 800)
print(f"Accumulator after direct load: {ac}") # ac = 900
ac = indir_load_ac(mem, 800)
print(f"Accumulator after indirect load: {ac}") # ac = 1000
idxreg = 700
ac = idx_load_ac(mem, idxreg, 800)
print(f"Accumulator after indexed load: {ac}") # ac = 700
```

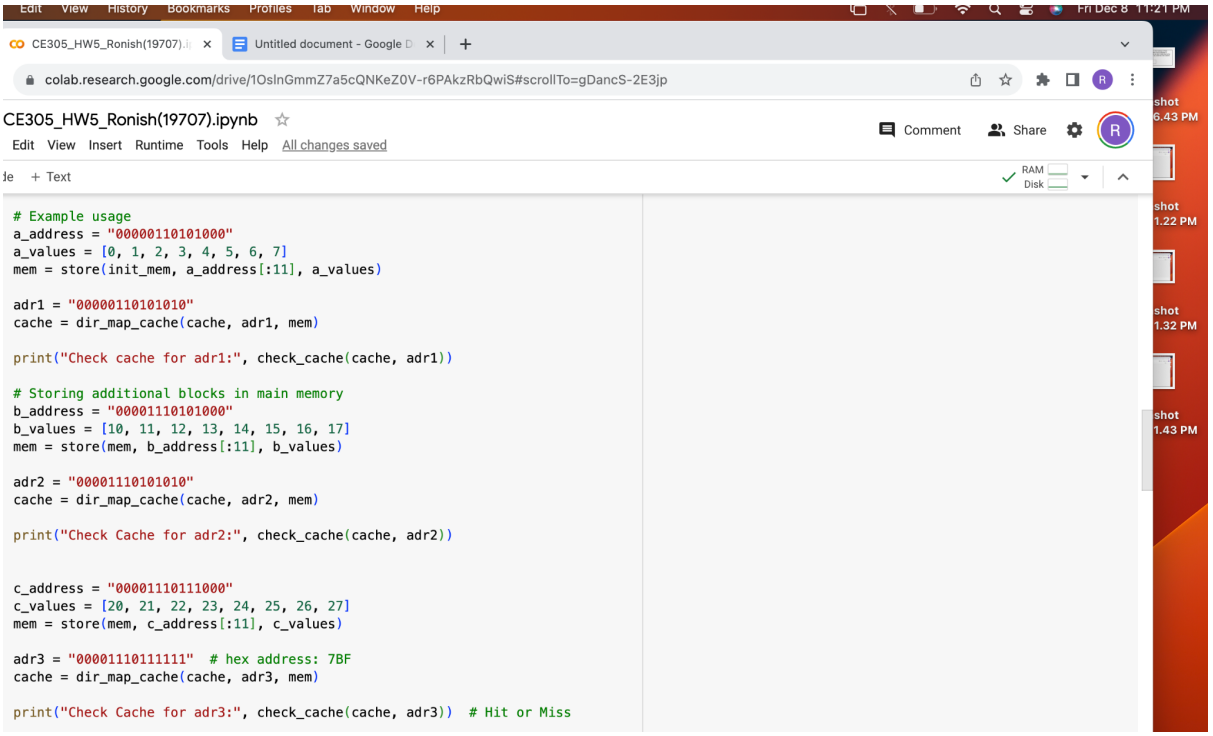
```
Accumulator after immediate load: 800
Accumulator after direct load: 900
Accumulator after indirect load: 1000
Accumulator after indexed load: 700
```

Q.No.2) If the main memory consists of 214 words, 211 blocks will be created in it, each block holds 8 words, and cache has 16 = 24 blocks, any memory address can be separate

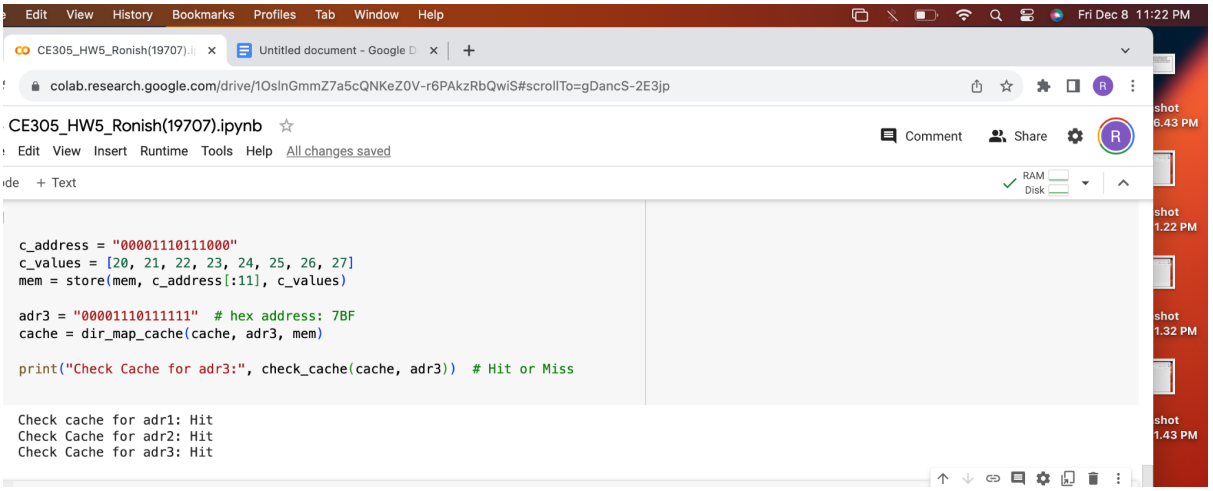
as following segments for Tag, Block and Word. In direct mapped cache, the whole block can be directly mapped to the cache line based on the values of 4-bit in Block segment. Please complete the following functions in Python program.



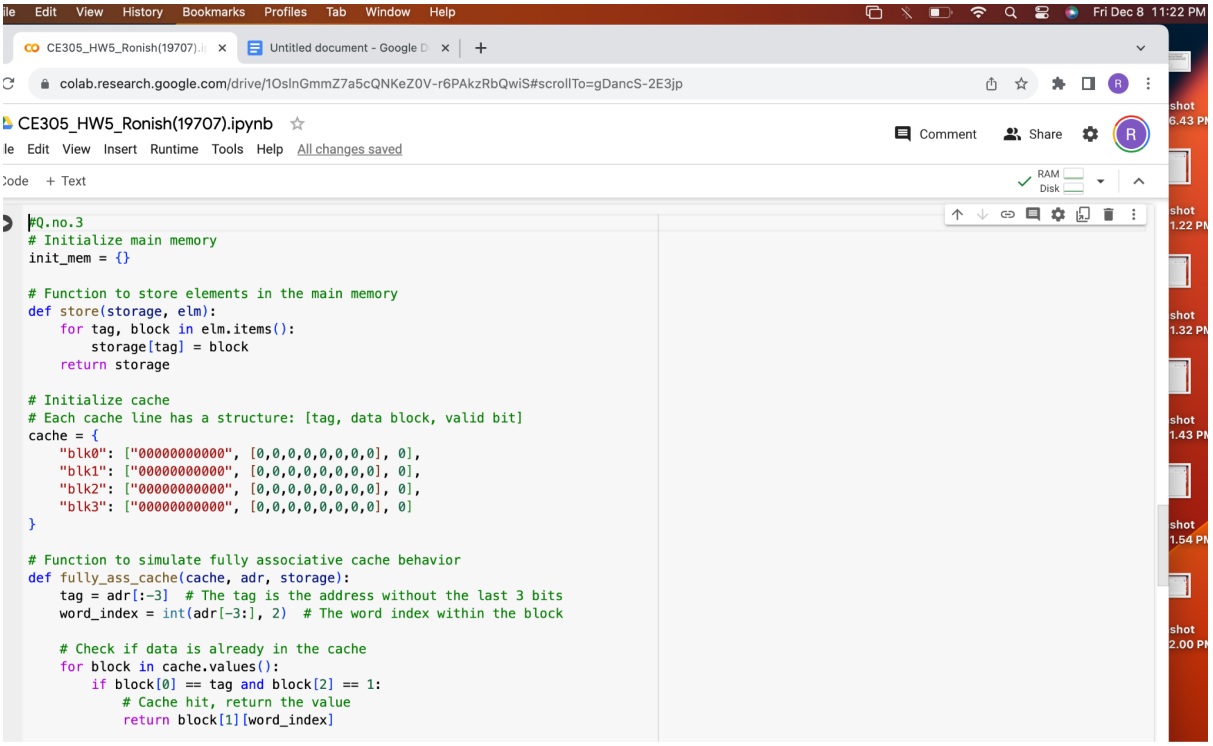
```python
#Q.No.2
def store(storage, block_address, block_values):
    storage[block_address] = block_values
    return storage

def dir_map_cache(cache, adr, storage):
    tag = adr[:7]      # 7-bit tag
    block = adr[7:11]  # 4-bit block
    word = adr[11:]    # 3-bit word

    block_address = tag + block

    if block_address in storage:
        cache[block] = [tag, storage[block_address], 1]  # Update cache line
    return cache

def check_cache(cache, adr):
    tag = adr[:7]      # 7-bit tag
    block = adr[7:11]  # 4-bit block

    if cache[block][0] == tag and cache[block][2] == 1:
        return "Hit"
    else:
        return "Miss"

# Initialize main memory and cache
init_mem = {}
cache = {format(i, '04b'): ["0000000", [], 0] for i in range(16)}

# Example usage
a_address = "00000110101000"
```

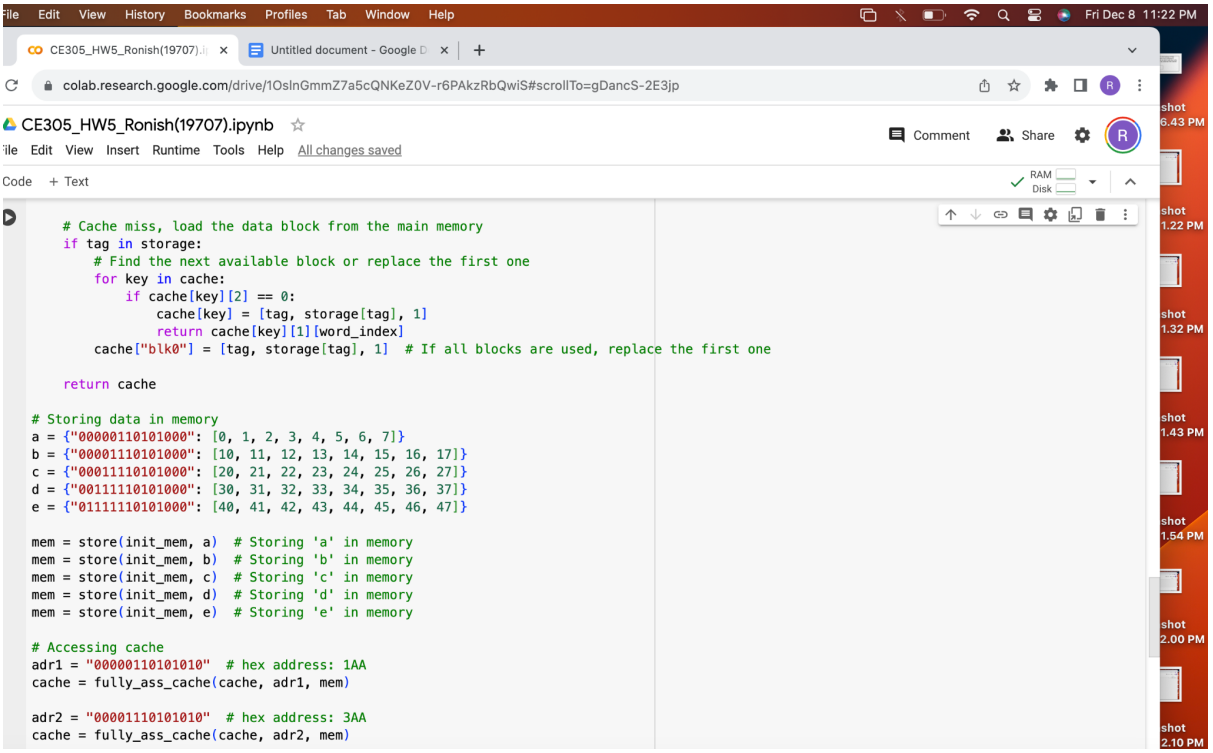


```python
# Example usage
a_address = "00000110101000"
a_values = [0, 1, 2, 3, 4, 5, 6, 7]
mem = store(init_mem, a_address[:11], a_values)

adr1 = "00000110101010"
cache = dir_map_cache(cache, adr1, mem)

print("Check cache for adr1:", check_cache(cache, adr1))

# Storing additional blocks in main memory
b_address = "00001110101000"
b_values = [10, 11, 12, 13, 14, 15, 16, 17]
mem = store(mem, b_address[:11], b_values)

adr2 = "00001110101010"
cache = dir_map_cache(cache, adr2, mem)

print("Check Cache for adr2:", check_cache(cache, adr2))


c_address = "00001110111000"
c_values = [20, 21, 22, 23, 24, 25, 26, 27]
mem = store(mem, c_address[:11], c_values)

adr3 = "00001110111111"  # hex address: 7BF
cache = dir_map_cache(cache, adr3, mem)

print("Check Cache for adr3:", check_cache(cache, adr3))  # Hit or Miss
```

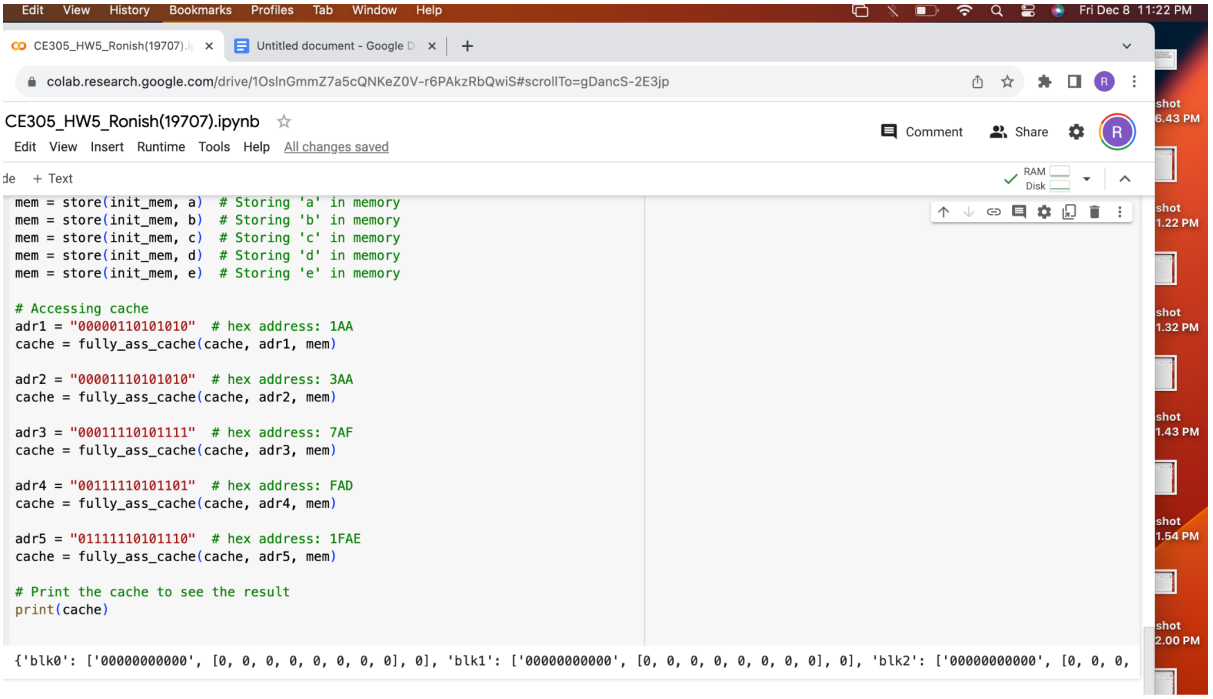


Q.no.3) To avoid thrashing issue in direct mapped cache as above, the technique of fully associative cache will be taken. The 14-bit memory address can be separated as follows for Tag and word segments. Assuming that there are only 4 cache lines in the cache, the block in the main memory can be mapped to any cache line if the valid bit is 1 showing it is available.





```
    # Cache miss, load the data block from the main memory
    if tag in storage:
        # Find the next available block or replace the first one
        for key in cache:
            if cache[key][2] == 0:
                cache[key] = [tag, storage[tag], 1]
                return cache[key][1][word_index]
        cache["blk0"] = [tag, storage[tag], 1]  # If all blocks are used, replace the first one

    return cache

# Storing data in memory
a = {"00000110101000": [0, 1, 2, 3, 4, 5, 6, 7]}
b = {"00001110101000": [10, 11, 12, 13, 14, 15, 16, 17]}
c = {"00011110101000": [20, 21, 22, 23, 24, 25, 26, 27]}
d = {"00111110101000": [30, 31, 32, 33, 34, 35, 36, 37]}
e = {"01111110101000": [40, 41, 42, 43, 44, 45, 46, 47]}

mem = store(init_mem, a)  # Storing 'a' in memory
mem = store(init_mem, b)  # Storing 'b' in memory
mem = store(init_mem, c)  # Storing 'c' in memory
mem = store(init_mem, d)  # Storing 'd' in memory
mem = store(init_mem, e)  # Storing 'e' in memory

# Accessing cache
adr1 = "00000110101010"  # hex address: 1AA
cache = fully_ass_cache(cache, adr1, mem)

adr2 = "00001110101010"  # hex address: 3AA
cache = fully_ass_cache(cache, adr2, mem)
```



```
mem = store(init_mem, a)  # Storing 'a' in memory
mem = store(init_mem, b)  # Storing 'b' in memory
mem = store(init_mem, c)  # Storing 'c' in memory
mem = store(init_mem, d)  # Storing 'd' in memory
mem = store(init_mem, e)  # Storing 'e' in memory

# Accessing cache
adr1 = "00000110101010"  # hex address: 1AA
cache = fully_ass_cache(cache, adr1, mem)

adr2 = "00001110101010"  # hex address: 3AA
cache = fully_ass_cache(cache, adr2, mem)

adr3 = "00011110101111"  # hex address: 7AF
cache = fully_ass_cache(cache, adr3, mem)

adr4 = "00111110101101"  # hex address: FAD
cache = fully_ass_cache(cache, adr4, mem)

adr5 = "01111110101110"  # hex address: 1FAE
cache = fully_ass_cache(cache, adr5, mem)

# Print the cache to see the result
print(cache)
```

```
{'blk0': ['00000000000', [0, 0, 0, 0, 0, 0, 0, 0], 0], 'blk1': ['00000000000', [0, 0, 0, 0, 0, 0, 0, 0], 0], 'blk2': ['00000000000', [0, 0, 0,
```