Assignment 8
Operating Systems

Submitted to:

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Assignment 8

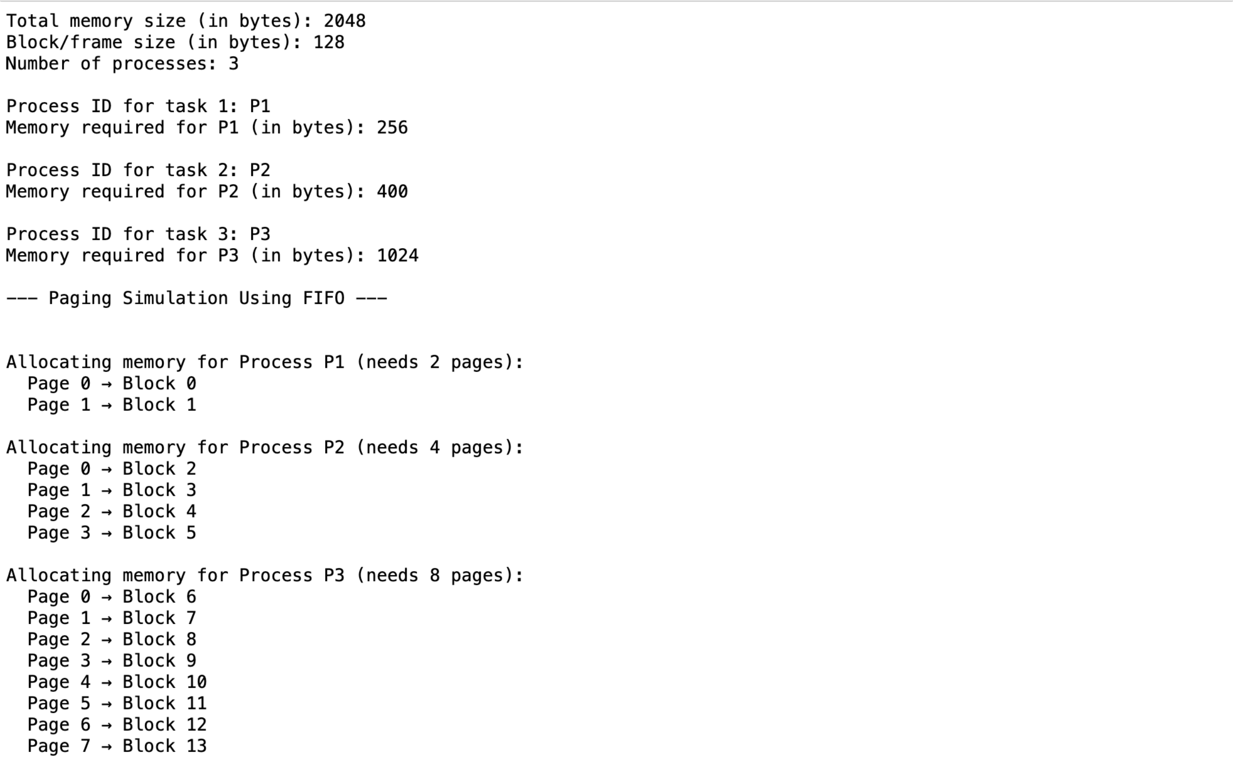
Problem1: Write a Python program to simulate memory management using paging. The program should:

1. Accept the total size of physical memory and the size of each frame.
2. Accept multiple processes with their individual memory requirements.
3. Divide each process into pages, allocate available memory frames, and construct a page table for each process.
4. If memory is full, simulate a simple page replacement strategy (e.g., FIFO or LRU).
5. Display the final page table and frame allocation status for all processes.

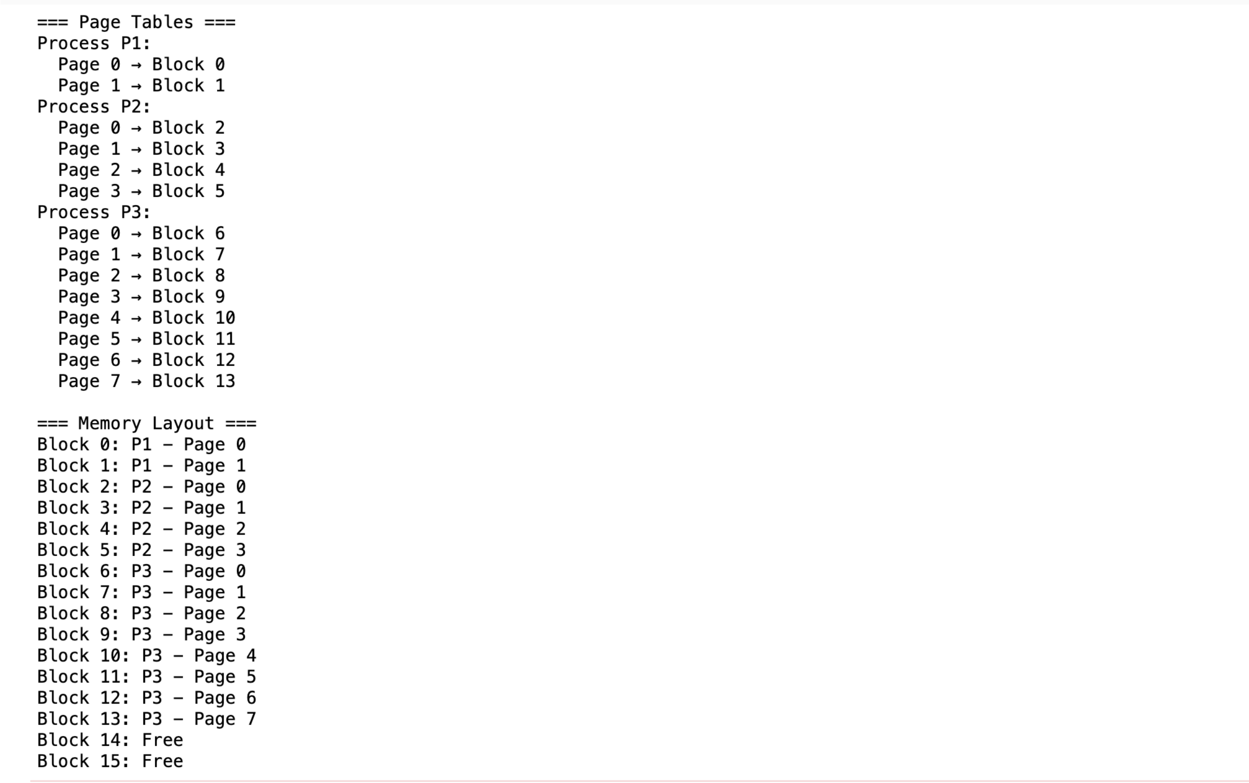
Answer:

```
import matplotlib.pyplot as plt
from collections import deque
import matplotlib.patches as mpatches

class MemoryBlock:
    def __init__(self, block_id):
        self.id = block_id
        self.content = None  # Stores (process_name, page_index)

class Task:
    def __init__(self, name, memory_needed, unit_size):
        self.name = name
        self.memory_needed = memory_needed
        self.unit_size = unit_size
        self.total_pages = (memory_needed + unit_size - 1) // unit_size
        self.mapping = {}  # page_index -> block_id

def assign_memory(process_list, memory_capacity, block_size):
    max_blocks = memory_capacity // block_size
    blocks = [MemoryBlock(i) for i in range(max_blocks)]
    queue = deque()
    print("\n--- Paging Simulation Using FIFO ---\n")

    for task in process_list:
        print(f"\nAllocating memory for Process {task.name} (needs {task.total_pages} pages):")
        for pg in range(task.total_pages):
            available_block = next((b for b in blocks if b.content is None), None)

            if available_block:
                available_block.content = (task.name, pg)
                task.mapping[pg] = available_block.id
                queue.append(available_block)
                print(f"  Page {pg} → Block {available_block.id}")
            else:
                replaced = queue.popleft()
                prev_task, prev_pg = replaced.content
                print(f"  Memory full. Replacing {prev_task}'s Page {prev_pg} from Block
{replaced.id}")
                for t in process_list:
                    if t.name == prev_task:
                        t.mapping.pop(prev_pg)
                        break
                replaced.content = (task.name, pg)
                task.mapping[pg] = replaced.id
                queue.append(replaced)
                print(f"  Page {pg} → Block {replaced.id}")

    return blocks

def show_summary(process_list, blocks):
    print("\n=== Page Tables ===")
    for task in process_list:
        print(f"Process {task.name}:")
        for pg, blk in task.mapping.items():
            print(f"  Page {pg} → Block {blk}")

    print("\n=== Memory Layout ===")
    for blk in blocks:
        if blk.content:
            pname, pg = blk.content
            print(f"Block {blk.id}: {pname} - Page {pg}")
        else:
            print(f"Block {blk.id}: Free")

def plot_allocation(process_list, blocks):
    palette = plt.cm.get_cmap('tab10', len(process_list))
    task_colors = {task.name: palette(i) for i, task in enumerate(process_list)}

    tags = []
    colors = []
    for blk in blocks:
        if blk.content:
            pname, pg = blk.content
            tags.append(f"{pname}:P{pg}")
            colors.append(task_colors[pname])
        else:
            tags.append("Free")
            colors.append((0.9, 0.9, 0.9))  # light grey

    plt.figure(figsize=(12, 2))
    visual_blocks = plt.bar(range(len(blocks)), [1]*len(blocks), color=colors)
    plt.xticks(range(len(blocks)), [f"B{i}" for i in range(len(blocks))])
    plt.yticks([])
    for bar, label in zip(visual_blocks, tags):
        plt.text(bar.get_x() + bar.get_width()/2, 0.5, label, ha='center', va='center')
    plt.title("Memory Block Usage")
    legend_entries = [mpatches.Patch(color=clr, label=name) for name, clr in task_colors.items()]
    plt.legend(handles=legend_entries, bbox_to_anchor=(1.05, 1), loc='upper left')
    plt.tight_layout()
    plt.show()

    for task in process_list:
        fig, ax = plt.subplots()
        pages = list(task.mapping.keys())
        assigned_blocks = [task.mapping[p] for p in pages]
        ax.axis('tight')
        ax.axis('off')
        table_entries = [[p, b] for p, b in zip(pages, assigned_blocks)]
        table = ax.table(cellText=table_entries, colLabels=["Page", "Block"], loc='center')
        table.auto_set_font_size(False)
        table.set_fontsize(10)
        ax.set_title(f"Page Table - {task.name}", pad=10)
        plt.show()

# Execution starts here
if __name__ == "__main__":
    memory_limit = int(input("Total memory size (in bytes): "))
    block_unit = int(input("Block/frame size (in bytes): "))

    task_count = int(input("Number of processes: "))
    all_tasks = []

    for i in range(task_count):
        identifier = input(f"\nProcess ID for task {i + 1}: ")
        required_mem = int(input(f"Memory required for {identifier} (in bytes): "))
        all_tasks.append(Task(identifier, required_mem, block_unit))

    final_blocks = assign_memory(all_tasks, memory_limit, block_unit)
    show_summary(all_tasks, final_blocks)
    plot_allocation(all_tasks, final_blocks)
```

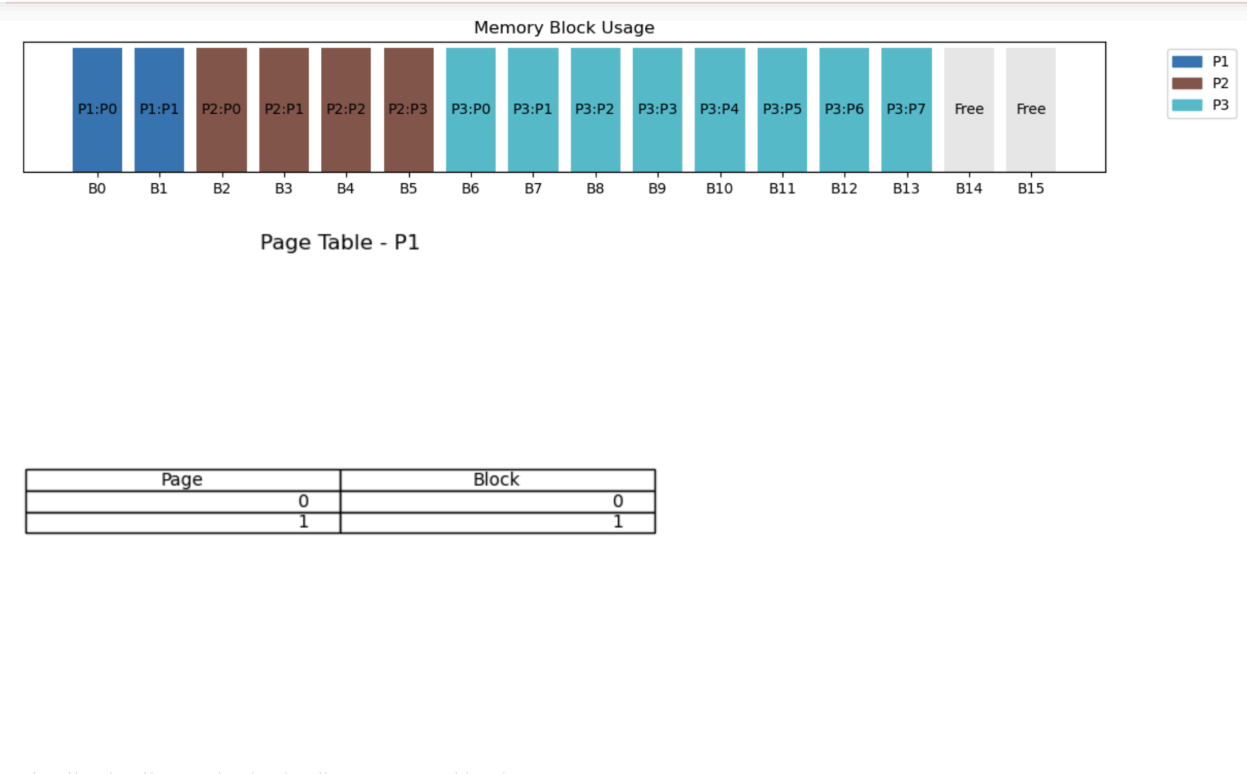
Output:



```
Total memory size (in bytes): 2048
Block/frame size (in bytes): 128
Number of processes: 3

Process ID for task 1: P1
Memory required for P1 (in bytes): 256

Process ID for task 2: P2
Memory required for P2 (in bytes): 400

Process ID for task 3: P3
Memory required for P3 (in bytes): 1024

--- Paging Simulation Using FIFO ---


Allocating memory for Process P1 (needs 2 pages):
  Page 0 → Block 0
  Page 1 → Block 1

Allocating memory for Process P2 (needs 4 pages):
  Page 0 → Block 2
  Page 1 → Block 3
  Page 2 → Block 4
  Page 3 → Block 5

Allocating memory for Process P3 (needs 8 pages):
  Page 0 → Block 6
  Page 1 → Block 7
  Page 2 → Block 8
  Page 3 → Block 9
  Page 4 → Block 10
  Page 5 → Block 11
  Page 6 → Block 12
  Page 7 → Block 13
```

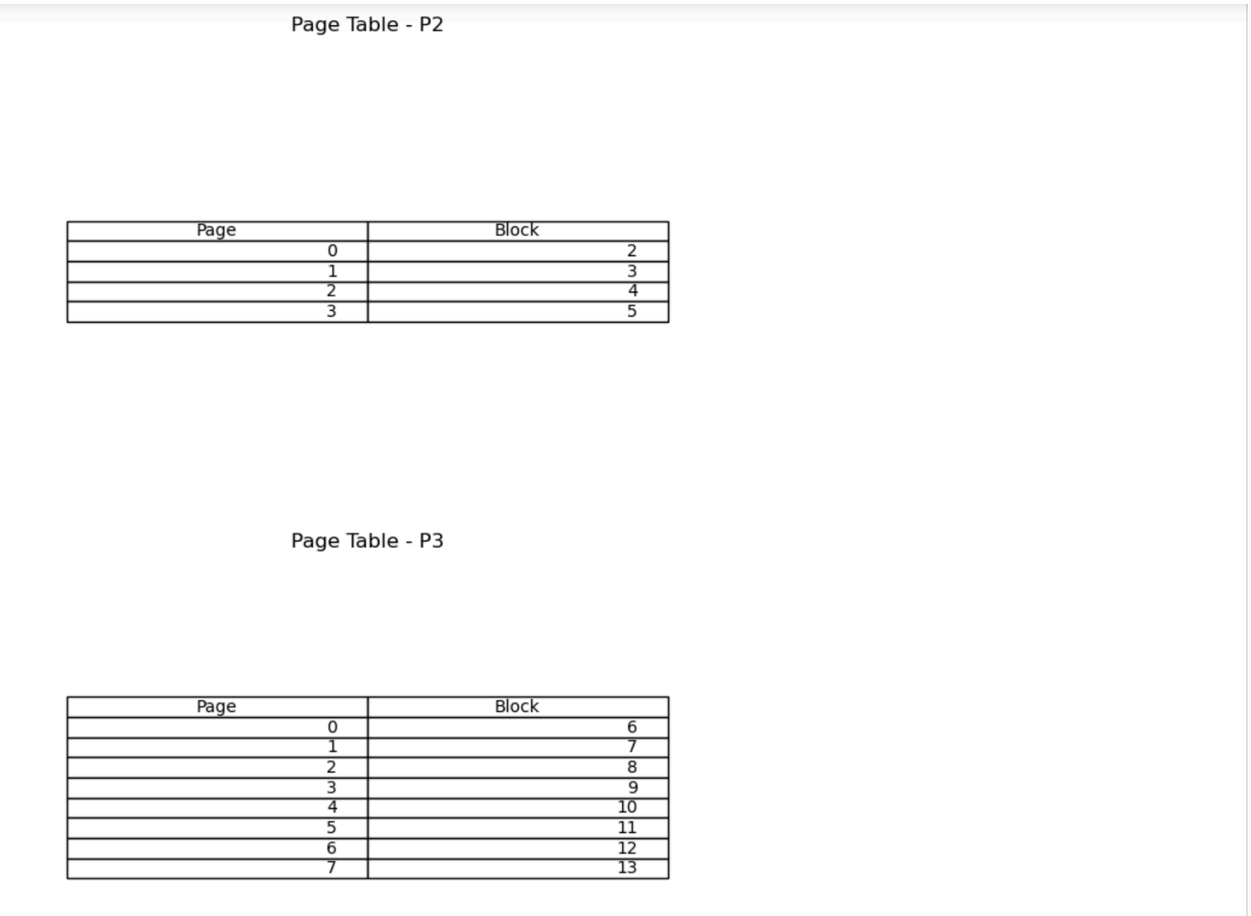


```
=== Page Tables ===
Process P1:
  Page 0 → Block 0
  Page 1 → Block 1
Process P2:
  Page 0 → Block 2
  Page 1 → Block 3
  Page 2 → Block 4
  Page 3 → Block 5
Process P3:
  Page 0 → Block 6
  Page 1 → Block 7
  Page 2 → Block 8
  Page 3 → Block 9
  Page 4 → Block 10
  Page 5 → Block 11
  Page 6 → Block 12
  Page 7 → Block 13

=== Memory Layout ===
Block 0: P1 - Page 0
Block 1: P1 - Page 1
Block 2: P2 - Page 0
Block 3: P2 - Page 1
Block 4: P2 - Page 2
Block 5: P2 - Page 3
Block 6: P3 - Page 0
Block 7: P3 - Page 1
Block 8: P3 - Page 2
Block 9: P3 - Page 3
Block 10: P3 - Page 4
Block 11: P3 - Page 5
Block 12: P3 - Page 6
Block 13: P3 - Page 7
Block 14: Free
Block 15: Free
```



Page Table - P1

Page	Block
0	0
1	1



Page Table - P2

Page	Block
0	2
1	3
2	4
3	5

Page Table - P3

Page	Block
0	6
1	7
2	8
3	9
4	10
5	11
6	12
7	13