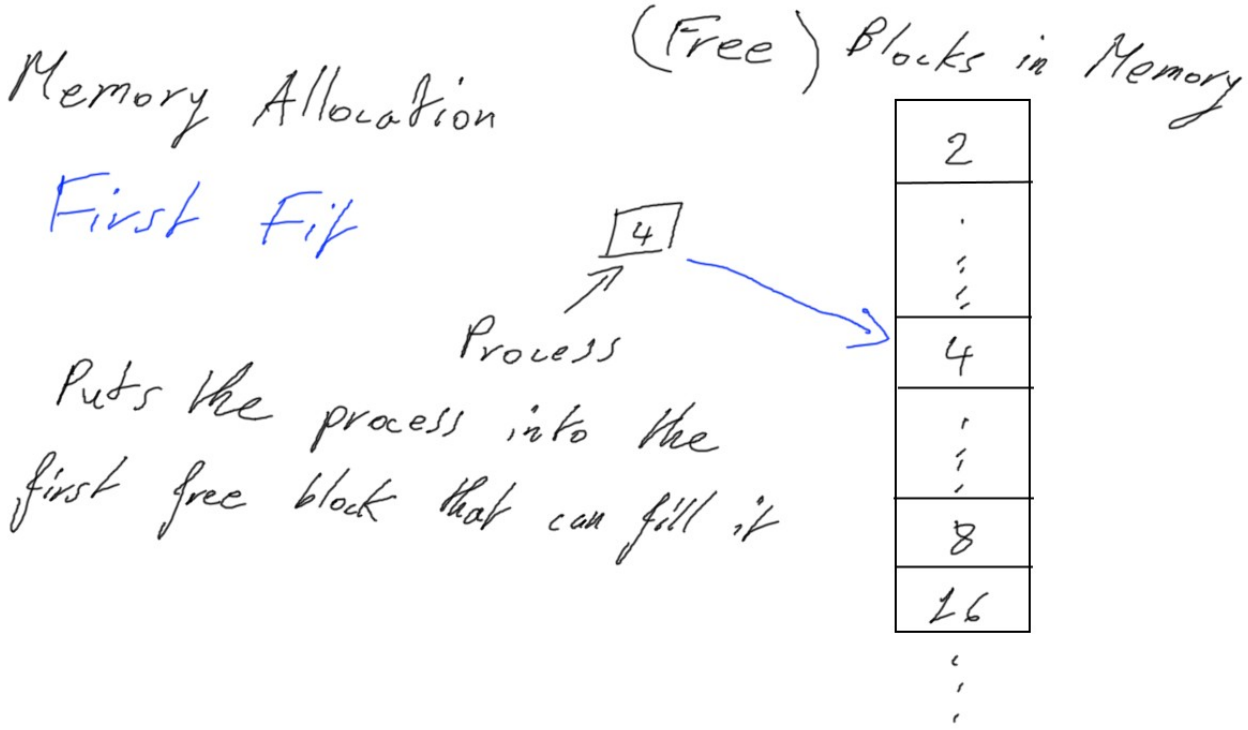
Lab 2 – Alexander Stradnic – 119377263

Task 1

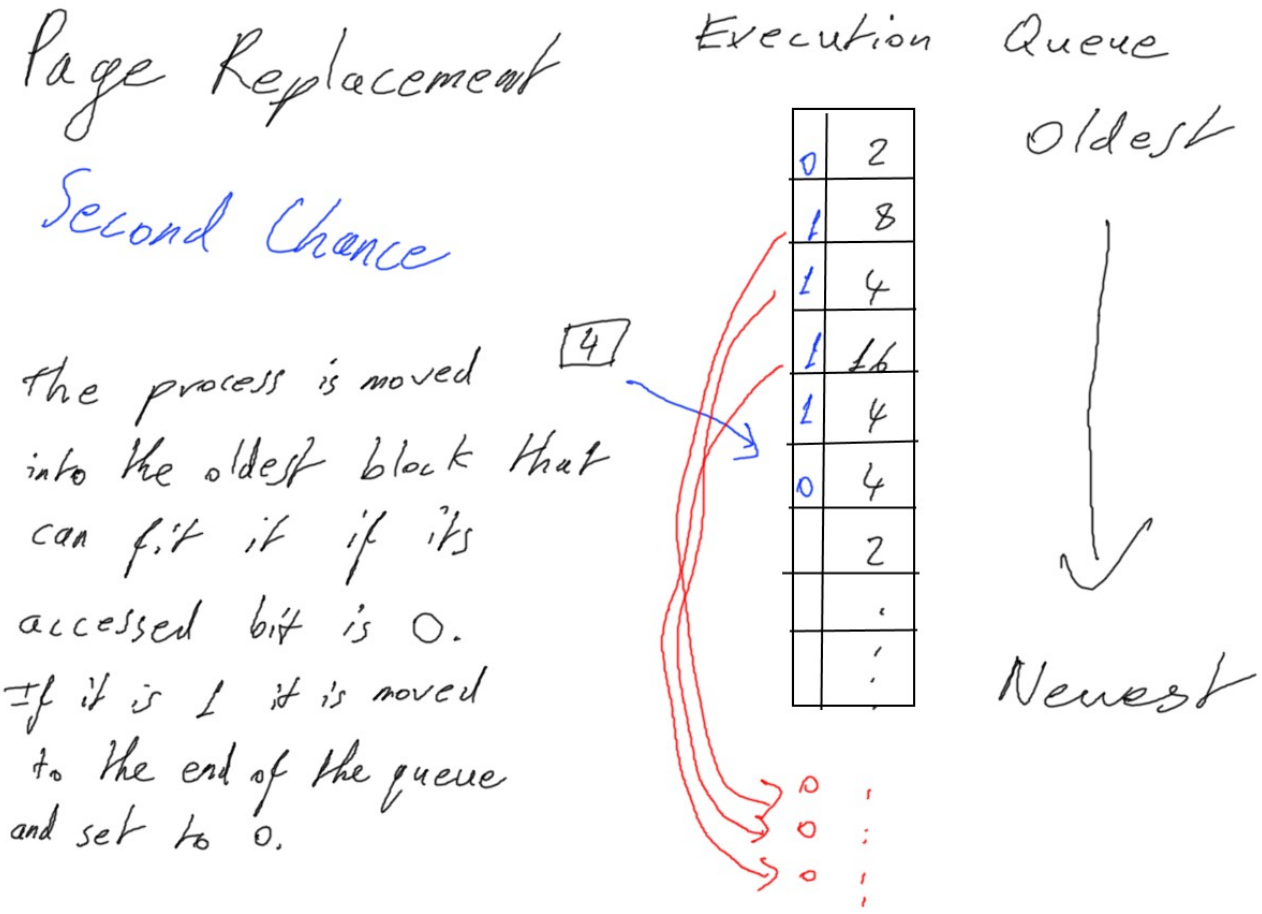
Main memory size : 4MB
Page size : 4KB

No. of blocks	No. of Pages	Size (KB)
32	2	256
16	4	256
16	8	512
16	16	1024
16	32	2048

Memory Allocation : First Fit – this will use the first block that can fit the process requesting space



Page Replacement Algorithm : Second Chance – this will replace the oldest block if it hasn't been accessed recently



Space : Linked List
Memory requests : Queue

Task 2

requests := [List of Processes to be moved to main memory]

class Block:
    #properties
    pages := No of pages

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        next := Next block in Space
        prev := Previous block in Space
        process := The process itself
        accessed := 1 if the process was accessed recently, else 0, used in the
Second Chance PRA

class Space:
        exec_list := A queue in which processes are sorted by their time of
execution; the oldest being the first process
        first := Block(pages=2) # A DLL made up of blocks from 2 pages to
32 pages
        function add(process):
                block = this.first
                while True:
                        if not block.process and process.pages <= block.pages:
                                block.process = process
                                this.exec_list.append(block)
                                break
                        if not block.next:
                                this.page_replace(process)

        function page_replace(process):
                for block in this.exec_list:
                        if block.pages >= process and block.accessed == 0:
                                block.process = process
                                this.exec_list.append(this.exec_list.pop(block))
                                return True
                return False


function process_requests():
        while True:
                process = requests[0]
                requests = requests[1::]
                success = space.page_replace(process)
                if not success:
                        requests.append(process)
```

Task 3

```
import random
import time

# Dictionary of symbols representing empty and full blocks
full = {2:"▪", 4:"■", 8:"▲", 16:"◆", 32:"●"}
empty = {2:"▫", 4:"□", 8:"△", 16:"◇", 32:"○"}

class Process:
    '''
    The Process Class - has a PID and takes up an amount of pages
    '''
    pid = 0
    pages = 0

    def generate_pid(self, space, N=1000000):
        pid = random.randint(0, N-1)
        for process in space.requests:
            if process.pid == pid:
                return self.generate_pid(N)
        return pid

    def __init__(self, space, pages=-1):
        if pages == -1:
            pages = random.randint(0, 5)
            if pages == 0:
                pages = 1
        self.pages = 2**pages
        self.pid = self.generate_pid(space)

    def __str__(self):
        string = "PID: " + str(self.pid) + ", pages: " + str(self.pages)
        return string


class Block:
    '''
```

```
    The Block Class - Has an amount of pages, contains or doesn't contain a process,
    has an accessed bit in line with Second Chance Page Replacement,
    and has pointers to the next and previous blocks in memory
    '''
    pages = 0
    prev = None
    next = None
    process = None
    accessed = 0

    def __init__(self, pages, prev=None, next=None):
        self.pages = pages
        self.prev = prev
        self.next = next

    def __str__(self):
        string = "Block: {a: " + str(self.accessed) + ", (" + (str(self.process) if self.process != None else "None") + "), prev pages: " + (str(self.prev.pages) if self.prev != None else "None") + ", next pages: " + (str(self.next.pages) if self.next != None else "None") + ", pages: " + str(self.pages) + "}"
        return string

class Space:
    '''
    This represents the main memory of a machine and has a pointer to the first block,
    a queue of incoming requests for memory,
    and a list holding the order in which processes were allocated memory for page replacement
    '''
    exec_list = [] # a queue maintaining the execution order of processes
    first = None
    current = None
    requests = [] # a queue holding all incoming processes

    def __init__(self):
        self.gen_blocks(32, 16, 16, 16, 16)
```

```
    print(str(self.first))

def __str__(self):
    '''
    Prints a visualisation of the memory in blocks
    '''
    string = "----------------------------------------\n"
    self.current = self.first
    string += str(self.current.pages) + "p\t"
    count = 0
    while self.current != None:
        count += 1
        if self.current.process:
            string += full[self.current.pages] + " "
        else:
            string += empty[self.current.pages] + " "
        if self.current.next != None:
            if self.current.next.pages != self.current.pages:
                string += "\n" + str(self.current.next.pages) + "p\t"
            elif count % 16 == 0:
                string += "\n\t"
        self.current = self.current.next

    # string += "\n----------------------------------------"
    string += "\n"
    return string

def gen_blocks(self, num2, num4, num8, num16, num32):
    '''
    Generates the memory blocks
    '''
    self.first = Block(2)
    self.current = self.first
    self.gen_group(num2-1, 2)
    self.gen_group(num4, 4)
    self.gen_group(num8, 8)
    self.gen_group(num16, 16)
    self.gen_group(num32, 32)
```

```
    def gen_group(self, num, size):
        '''
        More specific method that handles generating each group of blocks (grouped by size)
        '''
        for i in range(num):
            block = Block(size, self.current)
            self.current.next = block
            self.current = block

    def add(self, process):
        '''
        This method adds a process to a memory block using First Fit principles, otherwise calls page_replace
        '''
        block = self.first
        while True:
            if block.process == None and process.pages <= block.pages:
                block.process = process
                self.exec_list.append(block)
                return True
            elif block.next == None:
                return self.page_replace(process)
            block = block.next

    def page_replace(self, process):
        '''
        Handles page replacement using the Second Chance PRA
        '''
        for i, block in enumerate(self.exec_list):
            if block.pages >= process.pages:
                if block.accessed == 0: # if the block has not been accessed recently, then replace the process and add to the end of the exec_list
                    print("Replacing process in", str(block), " with", process)
                    block.process = process
                    self.exec_list.append(self.exec_list.pop(i))
                    # print([str(block) for block in self.exec_list])
                    return True
```

```
            else: # else set the accessed bit to 0, and move to the end of the exec_list
                block.accessed = 0
                self.exec_list.append(self.exec_list.pop(i))
        return False

    def gen_requests(self, n=20):
        '''
        Generates memory requests
        '''
        print("Generating", n, "processes requesting space...")
        for i in range(n):
            self.requests.append(Process(self))
        print("Handling requests: ", [str(process) for process in self.requests])

    def process_request(self):
        '''
        Handles process requests to memory, if it was not able to be added, then it is moved to the back of the requests queue
        '''
        if len(self.requests) == 0:
            return True
        process = self.requests[0]
        print("Handling process", str(process))
        if len(self.requests) > 1:
            self.requests = self.requests[1::]
        else:
            self.requests = []
        success = self.add(process)
        time.sleep(0.0333333333333333)
        if not success:
            self.requests.append(process)
        print(str(self))
        self.frag()

    def frag(self):
        '''
        Prints out the amount of blocks and pages affected by internal and external fragmentation
```

```
        '''
        self.current = self.first
        external_frag = 0
        external_blocks = 0
        internal_frag = 0
        internal_blocks = 0
        while self.current != None:
            if self.current.process == None:
                external_frag += self.current.pages
                external_blocks += 1
            else:
                if self.current.process.pages < self.current.pages:
                    internal_frag += self.current.pages - self.current.process.pages
                    internal_blocks += 1
            self.current = self.current.next
        print("Internal fragmentation:", internal_frag, "pages,",
internal_blocks, "blocks affected\nExternal fragmentation:", external_frag,
"pages,", external_blocks, "empty block(s)")

    def set_used(self):
        '''
        A method which randomly selects blocks to set their accessed bit to 0
or 1, simulating recent access of those memory blocks
        '''
        amount = random.randint(0, len(self.exec_list) // 4)
        while amount > 0:
            block = self.exec_list[random.randint(0, len(self.exec_list)-1)]
            if block.accessed == 1:
                block.accessed = 0
            else:
                block.accessed = 1
            amount -= 1

space = Space()
print(str(space))
space.gen_requests(100)

while True:
    no_reqs = space.process_request()
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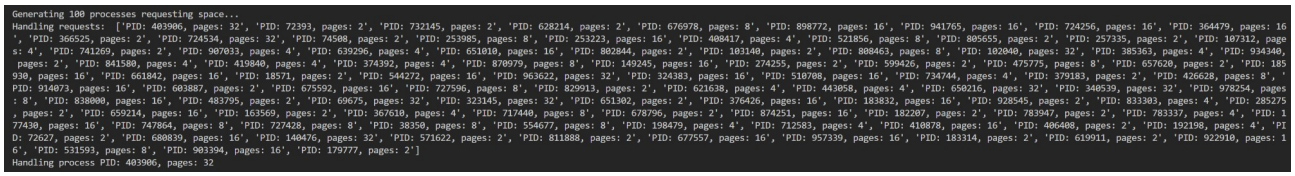
    if no_reqs:
        print("No more requests left...")
        break
    space.set_used()
```

Task 4

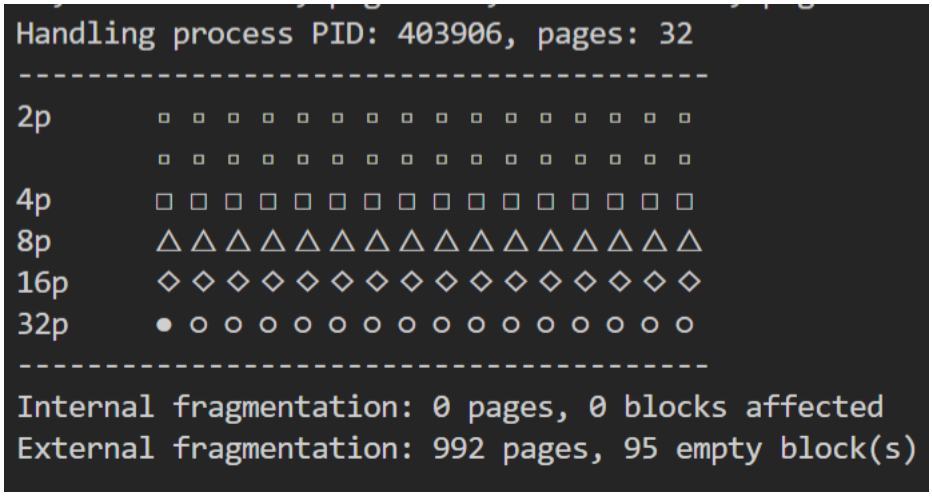
The program starts by creating a Space, simulating the main memory consisting of blocks. It runs an infinite loop during which processes are added (and replaced when needed) from memory. The execution of processes is not simulated, only their allocation and replacement.

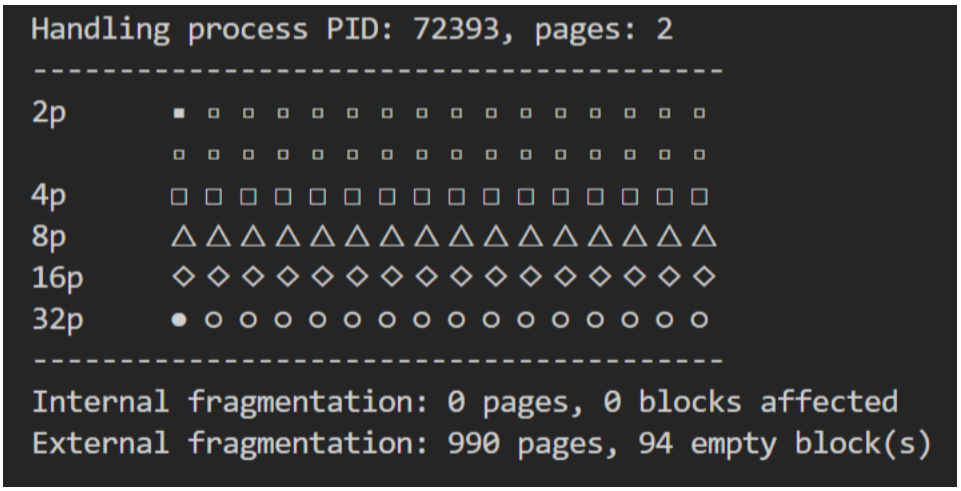
First the blocks are created, with space.first pointing to the first block

Then the processes are generated and added to a queue of memory requests

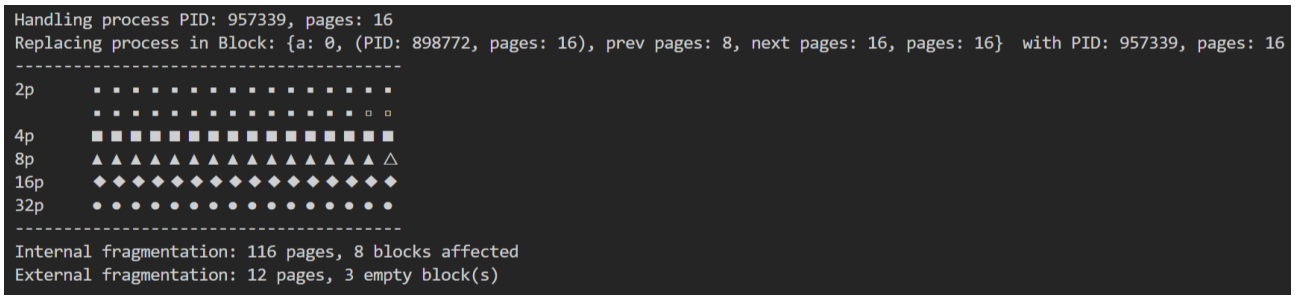


Each process is then handled in the infinite loop – initially as all blocks are empty they are all added with no replacement. The internal and external fragmentation of Space is reported after each iteration





As the memory is filled, a process has to be replaced. This is done using the Second Chance PRA, and in my implementation random blocks' accessed bit is changed to simulate usage



This continues until the requests queue is empty