Problem 1

32 bit → virtual adress

8 KB ⟹ page size

a) each table 4 entry

$8 kM = 2^{10} \cdot 2^3 = 2^{13}$ bytes

page offset

$32 - 13 = 19 \rightarrow 2^{19}$ virtual

virtual page number

number of pages

total page = $2^{19} \cdot 4$ bytes ⟹ 2^{21} bytes

2 MB

b) 28 bit physical adresses page

$$2^{28} \text{ bit} = 2^8 \text{ MB}$$
$$= 256 \text{ MB}$$

c) page offset = 13

$23 - 13 = 15$ pages

2^{15} = total pages

Problem 2

1, 2, 3, 4, 2, 1, 5, 2, 1, 2, 3

a)

— Fifo
page faults => 8

		3	3	3	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	3
1	1	1	4	4	4	5	5	5	2	2
*	*	*	*	#	*	*	#	#	*	*

— LRU
page faults = 7

		3	3	3	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2
1	1	1	4	4	4	5	5	5	5	3
*	*	*	*	#	*	*	#	#	#	*

we can
replace 4 on
all cells

— optimal
page faults => 6

		3	4	4	4	5	5	5	5	5
	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	3
*	*	*	*	#	#	*	#	#	#	*

b)

— FIFO #page faults ⇒ 11

			4	4	4	4	2	2	2	2
		3	3	3	3	5	5	5	5	3
	2	2	2	2	1	1	1	1	2	2
1	1	1	1	2	2	2	2	1	1	1
*	*	*	*	*	*	*	*	*	*	*

— LRU #page faults ⇒ 6

			4	4	4	4	4	4	4	3
		3	3	3	3	5	5	5	5	5
	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1
*	*	*	*	H	H	*	H	H	H	*

— Optimal #page faults ⇒ 5

			4	4	4	5	5	5	5	5
		3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1
*	*	*	*	H	H	*	H	H	H	H

Problem 3

	0	1	2	3	4	5	7	6	8	9	10		Δ=7
P1	2	5	7	4	4	1	2	3	7	3	3		
P2	1	1	1	3	3	4	4	3	5	6	7		
P3	4	9	3	2	9	8	7	7	7	1	2		

○ at time 8

○ at time 7

a)

$$W_{P1} = \{1, 2, 3, 4, 7\} \quad size = 5$$

$$W_{P2} = \{3, 4, 5, 6\} \quad size = 4$$

$$W_{P3} = \{1, 2, 7, 8, 8\} \quad size = 5$$

b) yes. because demand size for working set
is 14 (5+5+4) and it is bigger than total number
frames which is 10.

c) $$W_{P1} = \{1, 2, 3, 4, 5, 7\} \quad size = 6$$

$$W_{P2} = \{1, 3, 4\} \quad size = 3$$

$$W_{P3} = \{2, 3, 7, 8, 5\} \quad size = 5$$

$$D = 6+3+5 \Rightarrow 14$$

avoide suffering from trashing # frames should
be 14.

Problem 4

the inode number of ile1is e-determined by code.
when the file is edited file2 is also edited. the contents will be the same.
the soft link between file1 and file2 is file3 is created.
when file1 is removed file2 is not removed

```
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls -li file1.txt
3147937 -rw-r--r-- 1 gulbarin gulbarin 33 May  5  2021 file1.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ln file1.txt file2.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls -li file2.txt
3147937 -rw-r--r-- 2 gulbarin gulbarin 33 May  5  2021 file2.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ vim file2.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ vim file1.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ cat file2.txt
This is the first example file. 12.09
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ cat file1.txt
This is the first example file. 12.09
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ rm file1.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls
Book.pdf  file2.txt  file3.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ cat file3.txt
This is the file for soft links.
```

```
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ strace rm file2.txt
execve("/usr/bin/rm", ["rm", "file2.txt"], 0x7ffc4a93f298 /* 54 vars */) = 0
brk(NULL)                               = 0x562ac2363000
arch_prctl(0x3001 /* ARCH_??? */, 0x7fff629ff330) = -1 EINVAL (Invalid argument)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f64fbfdf000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=58427, ...}, AT_EMPTY_PATH) = 0
mmap(NULL, 58427, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f64fbfd0000
close(3)                                = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\1\0\0\0P\237\2\0\0\0\0\0\0"..., 832) = 832
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0\0@\0\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
pread64(3, "\4\0\0\0 \0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0"..., 48, 848) = 48
pread64(3, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0i8\235HZ\227\223\333\350s\360\352,\223\340."..., 68, 896) = 68
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=2216304, ...}, AT_EMPTY_PATH) = 0
pread64(3, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0\0@\0\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 784, 64) = 784
mmap(NULL, 2260560, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f64fbda8000
mmap(0x7f64fbdd0000, 1658880, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x28000) = 0x7f64fbdd0000
mmap(0x7f64fbf65000, 360448, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1bd000) = 0x7f64fbf65000
mmap(0x7f64fbfbd000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x214000) = 0x7f64fbfbd000
mmap(0x7f64fbfc3000, 52816, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f64fbfc3000
close(3)                                = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f64fbda5000
arch_prctl(ARCH_SET_FS, 0x7f64fbda5740) = 0
set_tid_address(0x7f64fbda5a10)         = 5074
set_robust_list(0x7f64fbda5a20, 24)     = 0
rseq(0x7f64fbda60e0, 0x20, 0, 0x53053053) = 0
mprotect(0x7f64fbfbd000, 16384, PROT_READ) = 0
mprotect(0x562ac1a68000, 4096, PROT_READ) = 0
mprotect(0x7f64fbfc019000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, {rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY}) = 0
munmap(0x7f64fbfd0000, 58427)           = 0
getrandom("\xcc\x8b\x7e\xe1\x5c\x56\x54\xce", 8, GRND_NONBLOCK) = 8
brk(NULL)                               = 0x562ac2363000
brk(0x562ac2384000)                     = 0x562ac2384000
openat(AT_FDCWD, "/usr/lib/locale/locale-archive", O_RDONLY|O_CLOEXEC) = 3
newfstatat(3, "", {st_mode=S_IFREG|0644, st_size=17388592, ...}, AT_EMPTY_PATH) = 0
mmap(NULL, 17388592, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f64fad0f000
close(3)                                = 0
ioctl(0, TCGETS, {B38400 opost isig icanon echo ...}) = 0
newfstatat(AT_FDCWD, "file2.txt", {st_mode=S_IFREG|0644, st_size=39, ...}, AT_SYMLINK_NOFOLLOW) = 0
geteuid()                               = 1000
newfstatat(AT_FDCWD, "file2.txt", {st_mode=S_IFREG|0644, st_size=39, ...}, AT_SYMLINK_NOFOLLOW) = 0
faccessat2(AT_FDCWD, "file2.txt", W_OK, AT_EACCESS) = 0
unlinkat(AT_FDCWD, "file2.txt", 0)      = 0
lseek(0, 0, SEEK_CUR)                   = -1 ESPIPE (Illegal seek)
close(0)                                = 0
close(1)                                = 0
close(2)                                = 0
exit_group(0)                           = ?
+++ exited with 0 +++
```

the soft link between file3 and file4 is created.
the inode numbers are unique.
when file4 is edited file3 is also edited automatically.
when ı delete the file3 the file4 is not editable or visible.

```
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ln -s file3.txt file4.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls -li file*.txt
3147936 -rw-r--r-- 1 gulbarin gulbarin 34 May  5  2021 file3.txt
3147608 lrwxrwxrwx 1 gulbarin gulbarin  9 Oca 19 04:16 file4.txt -> file3.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ vim file4.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ cat file4.txt
This is the file for soft links. 12.09
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ cat file3.txt
This is the file for soft links. 12.09
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ rm file3.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls
Book.pdf  file4.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ vim file4.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls
Book.pdf  file3.txt  file4.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ rm file3.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$ ls
Book.pdf  file4.txt
gulbarin@gulbarin-IdeaPad-L340-17IRH-Gaming:~/Desktop/Problem4$
```