

# CS-458: Computer & Network Forensics

Winter 2021

Midterm Exam

Total Points: 100

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## Instructions (Read them!):

1. The final is a take-home exam.
2. The final exam will be due on **2/20/2021 @ 11:00 PM.**
3. The exam has a total of 8 questions. Total of 13 pages
4. Read each question carefully. Complete **all** problems.
5. The answers can be typed or handwritten. Your responses should be legible. They won't be graded if I can't read them.
6. Upload your answers to the blackboard dropbox in a single PDF file.
7. Show your work and **state your assumptions** clearly, if any; partial credit may be awarded. Assumptions must be valid.
8. **If you do not understand the question, please clarify the question with the instructor.**
9. If any student is caught cheating, he/she will be awarded zero, and action will be taken according to Kettering University Code of Student Conduct

Section	Points
NTFS Forensics	30
LINUX Forensics	35
FAT32 Forensics	30
FREE Points :-)	5
Total	100

## NTFS Forensics

1. Refer to the Master boot record of a Hard Drive. Given that the sector size is 0x200 bytes.

[8 points]

Offset	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	ASCII
00000000	33 C0 8E D0 BC 00 7C 8E	C0 8E D8 BE 00 7C BF 00	3..... ..... ..
00000010	06 B9 00 02 FC F3 A4 50	68 1C 06 CB FB B9 04 00	.....Ph.....
00000020	BD BE 07 80 7E 00 00 7C	0B 0F 85 0E 01 83 C5 10	....~.. .....
00000030	E2 F1 CD 18 88 56 00 55	C6 46 11 05 C6 46 10 00	.....V.U.F...F..
. . . . . BOOT CODE . . . . .			
00000180	20 6C 6F 61 64 69 6E 67	20 6F 70 65 72 61 74 69	loading operati
00000190	6E 67 20 73 79 73 74 65	6D 00 4D 69 73 73 69 6E	ng system.Missin
000001A0	67 20 6F 70 65 72 61 74	69 6E 67 20 73 79 73 74	g operating syst
000001B0	65 6D 00 00 00 63 7B 9A	1A 46 36 F9 00 00 80 20	em...c{..F6....
000001C0	21 00 07 DD 1E 3F 00 08	10 00 00 A0 0F 00 00 DD	!....?.....
000001D0	1F 3F 83 FE FF FF 00 A8	0D 10 00 50 B0 03 00 00	.?.....P....
000001E0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 80 EE	!....?.....
000001D0	6F 7F AB FE FF FF 0F 99	9F 00 00 50 B0 03 55 AA	.....U.

Based on the record shown above fill in the following table.

Partition Type	Physical Location		Active Yes/No
	in dec	in hex	
NTFS, HPFS, exFat			Yes
Linux			No
Unused			No
Mac OSX boot			Yes

Rough work available in the next page

Rough work if needed

Sector size = 0x00BE = 190 bytes  
Sectors per cluster = 0x7C = 124 sectors  
Cluster size = 0xBE \* 0x7C = 0x5C08

LC of \$MFT: 0x5500568818CDF1E2

2. Refer to the NTFS boot record.

[7 points]

Offset	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	ASCII
00000000	EB 52 90 4E 54 46 53 20	20 20 20 00 02 20 00 00	.R.NTFS .. ..
00000010	00 00 00 00 00 F8 00 00	3F 00 FF 00 80 00 00 00	.....?.....
00000020	00 00 00 00 80 00 80 00	FF E7 0F 00 00 00 00 00	.....
00000030	6A 2A 00 00 00 00 00 00	01 00 00 00 00 00 00 00	j*.....
00000040	F6 00 00 00 F4 00 00 00	5F 55 F4 8C 65 F4 8C 82	....._U..e...
00000050	00 00 00 00 FA 33 C0 8E	D0 BC 00 7C FB 68 C0 07	.....3..... .h..
00000060	1F 1E 68 66 00 CB 88 16	0E 00 66 81 3E 03 00 4E	..hf.....f.>..N
00000070	54 46 53 75 15 B4 41 BB	AA 55 CD 13 72 0C 81 FB	TFSu..A..U..r...
00000080	55 AA 75 06 F7 C1 01 00	75 03 E9 DD 00 1E 83 EC	U.u.....u.....
. . . . . BOOT CODE . . . . .			
000001F0	00 00 00 00 00 00 8A 01	A7 01 BF 01 00 00 55 AA	.....U.

Based on the record shown above answer the following questions

Bytes per sector =  $0x200 = 512$  bytes

a) Number of sectors per cluster in decimal.

Sectors per cluster =  $0x02 = 2$  sectors.

b) Size of each cluster in bytes (in dec)

Cluster size =  $0x02 * 0x200 = 0x400 = 1024$  bytes

c) Physical location of \$MFT record (in hex).

LCN of \$MFT =  $0x2A6A$

Location of \$MFT =  $0x2A6A * 0x400 = 0xA9A800$

3. The following is the data attribute (**0x80**) of one of the user file record of the NTFS file system shown above. **[15 points]**

Offset	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	ASCII
0A9B3110									80	00	00	00	48	00	00	00	....H...
0A9B3120	01	00	00	00	00	00	01	00	00	00	00	00	00	00	00	00	.....
0A9B3130	8F	0D	00	00	00	00	00	00	40	00	00	00	00	00	00	00	.....@.....
0A9B3140	00	00	64	03	00	00	00	00	00	D6	E3	89	2A	00	00	00	.....
0A9B3150	00	D6	E3	89	2A	00	00	00	32	90	0D	AC	0B	FF	32	00	.....".....
0A9B3160	DD	AD	EF	BE	00	00	00	00	FF	FF	FF	FF	FF	00	00	00	.....

a) Determine if the file is a resident or a non-resident

Non-resident, the size on disk is greater than the file size.

b) Provide the physical location of the data and the size of the data. The data is divided into chunks, identify the LCN portion and VCN portion and also provide the size of each chunk and provide the command to extract each portion. Show all the steps.

i) LCN

LCN: 32 | 90 | 0D | AC | 0B | FF

Cluster runs: 0xAC0D90

First Cluster Location: 0xFF0B

Decimal: 65,291

Byte offset: 267,431,936

Cluster location = 0xFF0B000

ii) VCN

Assuming 0x00 means that we take the bytes available, in this case they are: DD AD EF BE

This assumption could be wrong. I couldn't find any notes on this case as we use the first byte to determine the run length and offset.

VCN: 00 | DD | AD | EF | BE

Cluster Runs: 0xADDD

First cluster location: 0xBEEF

Decimal: 48,879

VCN offset = 48,879 + 65,291 = 114,170

Byte offset: 467,640,320

Cluster Location = 0x1BDFA000

empty space in the next page

## LINUX Forensics

4. Given below is the long listing of a directory named “**foobar**”. Refer to the output below and answer the questions: **[15 Points]**

```
student@autobot:~/foobar$ ls -ila
```

```
total 16
```

```
296539 drwxrwxr-x  2 student student 4096 Feb 11 16:40 .
311299 drwxr-xr-x 27 student student 4096 Feb 11 16:35 ..
296538 -rw-rw-r--  2 student student  21 Feb 11 16:02 foo
296538 -rw-rw-r--  2 student student  21 Feb 11 16:02 link1
296541 lrwxrwxrwx  2 student student   5 Feb 11 16:03 link2 -> link1
296541 lrwxrwxrwx  2 student student   5 Feb 11 16:03 link3 -> link1
296542 lrwxrwxrwx  1 student student   5 Feb 11 16:35 link4 -> link3
296543 lrwxrwxrwx  1 student student   3 Feb 11 16:39 link5 -> foo
296566 lrwxrwxrwx  1 student student   5 Feb 11 16:40 link6 -> link5
296566 lrwxrwxrwx  2 student student   5 Feb 11 16:40 link7 -> link5
```

- a) Identify all the hardlinks. Your answer should be of the form ('a' is a hardlink to file 'b' (or) link 'c'; where a, b and c are the names of links/files)

link1 is a hardlink to foo

link3 is a hardlink to link1

link6 is a hardlink to link5

link7 is a hardlink to link5

- b) Identify all the symbolic links. Your answer should be of the form ('a' is a symbolic link to file 'b' (or) link 'c'; where a, b and c are the names of links/files)

link2 is a softlink to link1

link4 is a softlink to link3

link5 is a softlink to foo

Softlinks are determined by having unique inode values.

- c) What happens when the file **“foo”** is renamed to **“bar”**.

Nothing should change. The only direct link to "foo" is the softlink link5. Though link6 and link7 are hardlinks to link5, the inode to link5 will not be impacted.

- d) What happens when **“link1”** is deleted

If link1 is deleted, the link2, link3, and link4 will also lose their connection to "foo".

5. Given below is the command to check the number of inodes used and the number of inodes available. Assume there is a file called “temp.txt” present. Refer to the output below and answer the questions: [5 Points]

```
student@autobot:~$ df -i /dev/sdb1
```

Filesystem	Inodes	IUsed	IFree	IUse%	Mounted on
udev	10000	9900	100	99%	/dev

- a) How many new hard links can be created to the file “temp.txt”

The limit to hardlinks is determined by the OS since they do not require a unique inode value

- b) How many new symbolic links can be created to the file “temp.txt”

Assuming IFree is the amount of free inodes, there would be 100 possible symbolic links to temp.txt

- c) How many new copies of “temp.txt” can be created.

Based on the same logic that a new file has a unique inode, there would be 100 possible copies of temp.txt

6. The following is an output of an ext4 directory entry named “dir”. Based on the contents of the directory, fill in the table. Include the “.” and “..” in the table. [15 Points]

	00	01	02	03	04	05	06	07	08	09	0A	0B	<--- organization
00000000	0C	00	00	00	0C	00	01	02	2E	00	00	00	.....
0000000C	02	00	00	00	0C	00	02	02	2E	2E	00	00	.....
00000018	0E	00	00	00	10	00	08	01	74	65	73	74	.....test
00000024	66	69	6C	65	0F	00	00	00	0C	00	04	02	file.....
00000030	74	65	6D	70	10	00	00	00	10	00	05	07	temp.....
0000003C	6C	69	6E	6B	31	00	00	00	0E	00	00	00	link1.....
00000048	10	00	05	01	6C	69	6E	6B	32	00	00	00	....link2...
00000054	11	00	00	00	10	00	05	07	6C	69	6E	6B	.....link
00000060	33	00	00	00	12	00	00	00	9C	03	05	07	3.....
0000006C	6C	69	6E	6B	34	00	00	00	00	00	00	00	link4.....
00000078	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000084	00	00	00	00	00	00	00	00	00	00	00	00	.....



**Note: If a file is a link identify to which file is it linking to**

offset	Inode_number		Rec length	File type	Linked to	File Name
(in hex)	(in hex)	(in dec)	(in dec)	Sym/hard /file/dir		
0xA	0x2e	14	512	unknown		.

## FAT Forensics

7. Refer to the following FAT32 boot record and answer the following questions **[7 Points]**

Offset	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	ASCII
-----			
00010000	EB 58 90 4D 53 44 4F 53	35 2E 30 00 02 01 6E 10	.X.MSDOS5.0.....
00010010	02 00 00 00 00 F8 00 00	3F 00 10 00 80 00 00 00	.....?.....
00010020	00 E8 07 00 E5 03 00 00	00 00 00 00 02 00 00 00	.....
00010030	01 00 06 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
00010040	80 00 29 85 B3 EA 1C 4E	4F 20 4E 41 4D 45 20 20	..)....NO NAME
00010050	20 20 46 41 54 33 32 20	20 20	FAT32

- a) Number of sectors per cluster in decimal.
- b) Size of each cluster in bytes (in dec)
- c) Identify the physical location of the Root directory. Show the steps
- d) Identify the physical location of the first FAT table.

8. Following is the **Root directory entry** information of a FAT32 file system.

Offset	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	ASCII
00400000	46 41 54 33 32 20 20 20	20 20 20 08 00 00 00 00	FAT32 .....
00400010	00 00 00 00 00 00 38 98	4D 52 00 00 00 00 00 00	.....8.MR.....
00400080	E5 4E 4F 4E 59 20 20 20	4A 50 47 20 18 8E 3A 98	.NONY JPG ...:
00400090	4D 52 4D 52 00 00 86 4E	3D 4E 06 00 69 28 00 00	MRMR...N=N..i(..
004000A0	41 74 00 65 00 73 00 74	00 2E 00 0F 00 E5 74 00	At.e.s.t.....t.
004000B0	78 00 74 00 2E 00 74 00	78 00 00 00 74 00 00 00	x.t...t.x...t...
004000C0	54 45 53 54 54 58 7E 31	54 58 54 20 00 8E 3A 98	TESTTX~1TXT ...:
004000D0	4D 52 4D 52 00 00 4B 8E	41 4E 1B 00 1F 00 00 00	MRMR..K.AN.....
004000E0	24 52 45 43 59 43 4C 45	42 49 4E 16 00 AF 3A 98	\$RECYCLEBIN....:
004000F0	4D 52 4D 52 00 00 3B 98	4D 52 1C 00 00 00 00 00	MRMR...;.MR.....
00400100	42 78 00 74 00 2E 00 74	00 78 00 0F 00 32 74 00	Bx.t...t.x...2t.
00400110	00 00 FF FF FF FF FF FF	FF FF 00 00 FF FF FF FF	.....
00400120	01 6C 00 61 00 72 00 67	00 65 00 0F 00 32 5F 00	.l.a.r.g.e...2_.
00400130	5F 00 66 00 69 00 6C 00	65 00 00 00 2E 00 74 00	_.f.i.l.e.....t.
00400140	4C 41 52 47 45 5F 7E 31	54 58 54 20 00 02 EE A1	LARGE_~1TXT ....
00400150	4D 52 4D 52 00 00 E4 A1	4D 52 1E 00 00 C0 17 00	MRMR....MR.....
00400160	E5 74 00 78 00 74 00 2E	00 74 00 0F 00 96 78 00	.t.x.t...t....x.
00400170	74 00 00 00 FF FF FF FF	FF FF 00 00 FF FF FF FF	t.....
00400180	E5 73 00 65 00 63 00 72	00 65 00 0F 00 96 74 00	.s.e.c.r.e....t.
00400190	5F 00 5F 00 66 00 69 00	6C 00 00 00 65 00 2E 00	_._.f.i.l...e...
004001A0	E5 45 43 52 45 54 7E 31	54 58 54 20 00 21 F8 A1	.ECRET~1TXT .!..
004001B0	4D 52 4D 52 00 00 E4 A1	4D 52 FE 0B 00 C0 17 00	MRMR....MR.....
004001C0	42 74 00 78 00 74 00 2E	00 74 00 0F 00 39 78 00	Bt.x.t...t...9x.
004001D0	74 00 00 00 FF FF FF FF	FF FF 00 00 FF FF FF FF	t.....
004001E0	01 61 00 6E 00 6F 00 74	00 68 00 0F 00 39 65 00	.a.n.o.t.h...9e.
004001F0	72 00 5F 00 66 00 69 00	6C 00 00 00 65 00 2E 00	r_.f.i.l...e...

## FAT TABLE 1

Offset		00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F		ASCII
-----																			
0001BC00		F8	FF	FF	0F	FF	FF	FF	FF	DE	17	00	00	FF	FF	FF	0F		.....
0001BC10		FF	FF	FF	0F	FF	FF	FF	0F	07	00	00	00	0A	00	00	00		.....
0001BC20		11	00	00	00	FF	FF	FF	0F	0F	00	00	00	0C	00	00	00		.....
0001BC30		0E	00	00	00	13	00	00	00	0D	00	00	00	10	00	00	00		.....
0001BC40		08	00	00	00	0B	00	00	00	FF	FF	FF	0F	FF	FF	FF	0F		.....

- a) The root directory is split into 2 cluster locations. The first cluster is at physical sector **0x400000**. With the help of the FAT table, identify the second physical location in hex. Given that the logical cluster location of root directory is 2.

**[5 points]**

b) Identify the 2 deleted files and fill in the table

**[8 points]**

File Name	Type (txt/jpg/png)	Physical location (in hex)	Size of the file (in dec)

c) With the help of the FAT table, provide all the logical and physical cluster locations of the file whose starting cluster number (logical) is 6. Show all the steps. **[10 points]**

**Note: This is a tricky question. If you get it correct, you get 5 additional points as bonus!**