

## Lab 6.6.4 Password Cracking using Rainbow Tables

*From TestOut CompTIA Security+ Course*

In this lab I will be cracking a password hash file using Rainbow Tables.

### **The scenario for this lab is as follows:**

"A recent breach of a popular third-party service has exposed a password database. The security team is evaluating the risk of the exposed passwords for the company. The password hashes are saved in the root user's home directory, /root/captured\_hashes.txt. You want to attempt to hack these passwords using a rainbow table. The password requirements for your company are as follows:

- The password must be 12 or more characters in length.
- The password must include at least one uppercase and one lowercase letter.
- The password must have at least one of these special characters: !, ", #, \$, %, &, \_, ', \*, or @.
- All passwords are encrypted using a hash algorithm of either md5 or sha1.

In this lab, your task is to:

- Create md5 and sha1 rainbow tables using rtgen.
- Sort the rainbow tables using the rtsort command.
- Crack the hashes using the rcrack command. You can run rcrack on an individual hash or the hash file (/root/captured\_hashes.txt).
- Answer the questions.

**The type of charset that can be used to create a rainbow table is stored in the /usr/share/rainbowcrack/charset.txt file. This file can be viewed using the cat command. "**

Since we are working with Rainbow Tables we will need to generate some hashes. A Rainbow Table by definition is a table with varying hashes according to certain character sets.

Our constraints in this lab is that the passwords are:

- The password must be 12 or more characters in length.
- The password must include at least one uppercase and one lowercase letter.
- The password must have at least one of these special characters: !, ", #, \$, %, &, \_, ', \*, or @.
- All passwords are encrypted using a hash algorithm of either md5 or sha1.

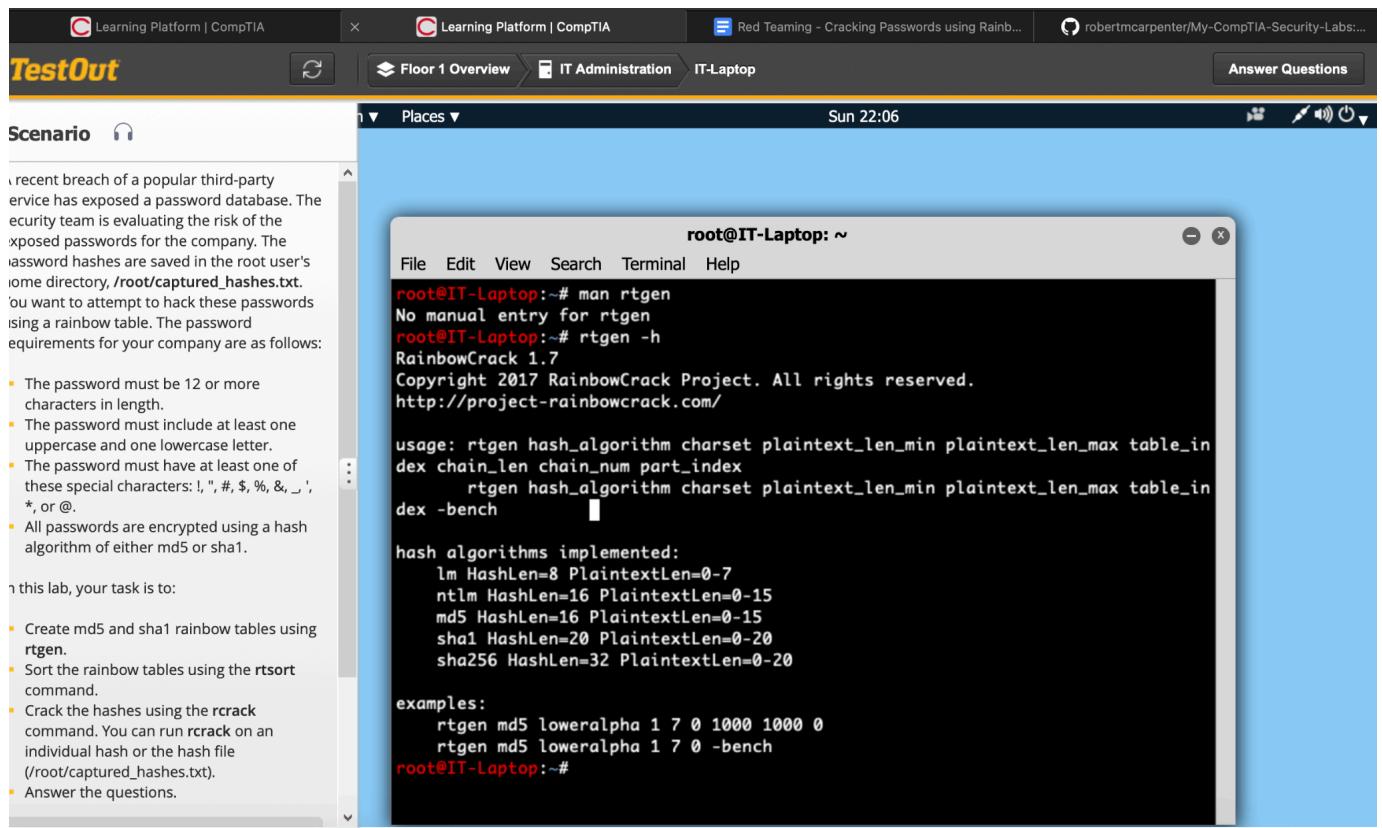
Based off these constraints I will create a Rainbow Table around them.

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The binary to do this on my Kali Linux box is **rtgen**. To see what this command can do I will issue the command: **rtgen -h**



A screenshot of a Kali Linux desktop environment. In the top bar, there are tabs for "TestOut", "Floor 1 Overview", "IT Administration", and "IT-Laptop". The "IT-Laptop" tab is active. The system tray shows icons for battery, signal, and volume. The main window is a terminal window titled "root@IT-Laptop: ~". The terminal displays the help output for the "rtgen" command:

```
root@IT-Laptop:~# man rtgen
No manual entry for rtgen
root@IT-Laptop:~# rtgen -h
RainbowCrack 1.7
Copyright 2017 RainbowCrack Project. All rights reserved.
http://project-rainbowcrack.com/

usage: rtgen hash_algorithm charset plaintext_len_min plaintext_len_max table_in
dex chain_len chain_num part_index
      rtgen hash_algorithm charset plaintext_len_min plaintext_len_max table_in
dex -bench

hash algorithms implemented:
  lm HashLen=8 PlaintextLen=0-7
  ntlm HashLen=16 PlaintextLen=0-15
  md5 HashLen=16 PlaintextLen=0-15
  sha1 HashLen=20 PlaintextLen=0-20
  sha256 HashLen=32 PlaintextLen=0-20

examples:
  rtgen md5 loweralpha 1 7 0 1000 1000 0
  rtgen md5 loweralpha 1 7 0 -bench
root@IT-Laptop:~#
```

To the left of the terminal window, there is a sidebar titled "Scenario" which contains a text block about a password breach and a list of constraints for the password. Below the scenario text is a list of tasks to complete.

**Scenario**

A recent breach of a popular third-party service has exposed a password database. The security team is evaluating the risk of the exposed passwords for the company. The password hashes are saved in the root user's home directory, /root/captured\_hashes.txt. You want to attempt to hack these passwords using a rainbow table. The password requirements for your company are as follows:

- The password must be 12 or more characters in length.
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- All passwords are encrypted using a hash algorithm of either md5 or sha1.

In this lab, your task is to:

- Create md5 and sha1 rainbow tables using rtgen.
- Sort the rainbow tables using the rtsort command.
- Crack the hashes using the rcrack command. You can run rcrack on an individual hash or the hash file (/root/captured\_hashes.txt).
- Answer the questions.

As we can see , the syntax for inputting the **rtgen** command is listed above:

**Rtgen [hash\_algorithm] [charset] [plaintext\_len\_min] [plaintext\_len\_max] [table\_index] [chain\_len] ...**

- The password must be 12 or more characters in length.
- The password must include at least one uppercase and one lowercase letter.
- The password must have at least one of these special characters: !, #, \$, %, &, \_, ', \*, or @.
- All passwords are encrypted using a hash algorithm of either md5 or sha1.

I repasted the constraints again for quick reference. Looking at them in order I can tell that:

- **[plaintext\_len\_min]** is **12**: Since minimum password length is 12
- **[charset]** is ascii-32-95: Because it's A-z , a-z, and special characters as well. The great thing about ASCII is that we can manually specify these special characters using this standard. (See Ascii Table below). The Lab also

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gives us a hint

gives us a hint that the available character sets are in  
**/usr/share/rainbowcrack/charset.txt**

The screenshot shows a terminal window titled "root@IT-Laptop: ~". The terminal displays the following command-line session:

```
rtgen md5 loweralpha 1 7 0 1000 1000 0
rtgen md5 loweralpha 1 7 0 -bench
root@IT-Laptop:~# cat /usr/share/rainbowcrack/charset.txt

numeric = [0123456789]
alpha = [ABCDEFGHIJKLMNOPQRSTUVWXYZ]
alpha-numeric = [ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789]
loweralpha = [abcdefghijklmnopqrstuvwxyz]
loweralpha-numeric = [abcdefghijklmnopqrstuvwxyz0123456789]
mixalpha_WXYZ = [abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ]
mixalpha-numeric_WXYZ = [abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789]
ascii-32-95 = [ !#$%&'()*+,.-./0123456789:;<=>?@ABCDEFGHIJKLMNO
PQRSTUVWXYZ[\]^_`abcdefghijklmnopqrstuvwxyz{|}~]
ascii-32-65-123-4 = [ !#$%&'()*+,.-./0123456789:;<=>?@ABCDEFGHIJKLMNO
PQRSTUVWXYZ[\]^_`{|}~]
alpha-numeric-symbol32-space = [ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789!@#$%^&*(()-_
+=~`[]{}\\;';\"<,>,?.?/]

root@IT-Laptop:~#
```

Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char
0	0	[NULL]	32	20	[SPACE]	64	40	@	96	60	'
1	1	[START OF HEADING]	33	21	!	65	41	A	97	61	a
2	2	[START OF TEXT]	34	22	"	66	42	B	98	62	b
3	3	[END OF TEXT]	35	23	#	67	43	C	99	63	c
4	4	[END OF TRANSMISSION]	36	24	\$	68	44	D	100	64	d
5	5	[ENQUIRY]	37	25	%	69	45	E	101	65	e
6	6	[ACKNOWLEDGE]	38	26	&	70	46	F	102	66	f
7	7	[BELL]	39	27	'	71	47	G	103	67	g
8	8	[BACKSPACE]	40	28	(	72	48	H	104	68	h
9	9	[HORIZONTAL TAB]	41	29	)	73	49	I	105	69	i
10	A	[LINE FEED]	42	2A	*	74	4A	J	106	6A	j
11	B	[VERTICAL TAB]	43	2B	+	75	4B	K	107	6B	k
12	C	[FORM FEED]	44	2C	,	76	4C	L	108	6C	l
13	D	[CARRIAGE RETURN]	45	2D	-	77	4D	M	109	6D	m
14	E	[SHIFT OUT]	46	2E	.	78	4E	N	110	6E	n
15	F	[SHIFT IN]	47	2F	/	79	4F	O	111	6F	o
16	10	[DATA LINK ESCAPE]	48	30	0	80	50	P	112	70	p
17	11	[DEVICE CONTROL 1]	49	31	1	81	51	Q	113	71	q
18	12	[DEVICE CONTROL 2]	50	32	2	82	52	R	114	72	r
19	13	[DEVICE CONTROL 3]	51	33	3	83	53	S	115	73	s
20	14	[DEVICE CONTROL 4]	52	34	4	84	54	T	116	74	t
21	15	[NEGATIVE ACKNOWLEDGE]	53	35	5	85	55	U	117	75	u
22	16	[SYNCHRONOUS IDLE]	54	36	6	86	56	V	118	76	v
23	17	[END OF TRANS. BLOCK]	55	37	7	87	57	W	119	77	w
24	18	[CANCEL]	56	38	8	88	58	X	120	78	x
25	19	[END OF MEDIUM]	57	39	9	89	59	Y	121	79	y
26	1A	[SUBSTITUTE]	58	3A	:	90	5A	Z	122	7A	z
27	1B	[ESCAPE]	59	3B	:	91	5B	[	123	7B	{
28	1C	[FILE SEPARATOR]	60	3C	<	92	5C	\	124	7C	
29	1D	[GROUP SEPARATOR]	61	3D	=	93	5D	]	125	7D	}
30	1E	[RECORD SEPARATOR]	62	3E	>	94	5E	^	126	7E	-
31	1F	[UNIT SEPARATOR]	63	3F	?	95	5F	-	127	7F	[DEL]

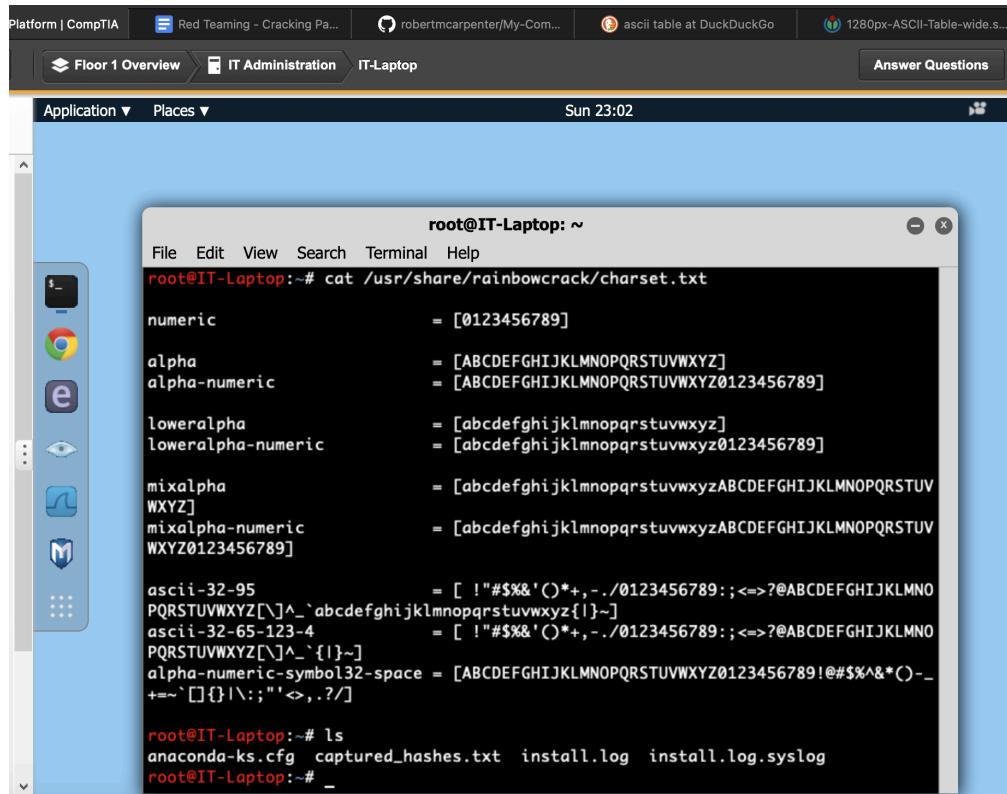
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- [algorithm] is SHA1 and md5 : Because we need to generate 2 Rainbow Tables, one sha1 and md5 per the lab's instructions.

To generate a sha1 rainbow table I will use:

```
rtgen sha1 ascii-32-95 1 20 0 1000 1000 0
```

Before, I will verify that I'm in the correct directory I want to be, which is the same directory as the captured hashes from the data breach.



```
root@IT-Laptop:~# cat /usr/share/rainbowcrack/charset.txt
numeric = [0123456789]
alpha = [ABCDEFGHIJKLMNOPQRSTUVWXYZ]
alpha-numeric = [ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789]
loweralpha = [abcdefghijklmnopqrstuvwxyz]
loweralpha-numeric = [abcdefghijklmnopqrstuvwxyz0123456789]
mixalpha = [abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ]
mixalpha-numeric = [abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789]
ascii-32-95 = [ !#$%&'()*+,-./@^_`{|}~-]
PQRSTUVWXYZ[\]^_`{}`~-] = [ !#$%&'()*+,-./@^_`{|}~-]
ascii-32-65-123-4 = [ !#$%&'()*+,-./@^_`{|}~-]
PQRSTUVWXYZ[\]^_`{}`~-] = [ !#$%&'()*+,-./@^_`{|}~-]
alpha-numeric-symbol32-space = [ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789!@#$%^&*()_-+=~`{|}~;"<,.?/]

root@IT-Laptop:~# ls
anaconda-ks.cfg captured_hashes.txt install.log install.log.syslog
root@IT-Laptop:~#
```

Indeed I am! I will generate the sha1 and md5 tables with these two commands:

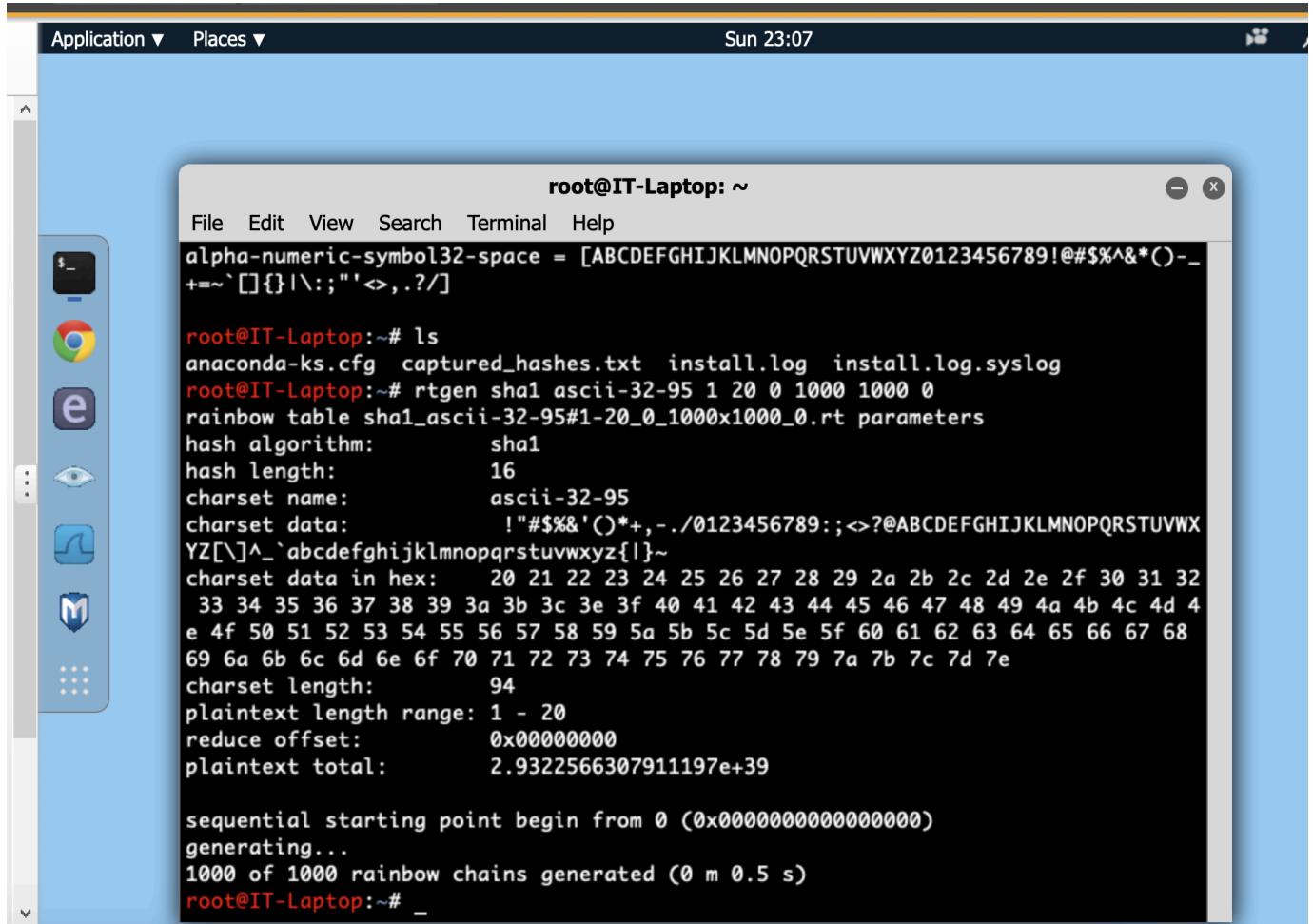
```
rtgen sha1 ascii-32-95 1 20 0 1000 1000 0
```

```
rtgen md5 ascii-32-95 1 20 0 1000 1000 0
```

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The screenshot shows a terminal window titled "root@IT-Laptop: ~". The terminal displays the following command and its output:

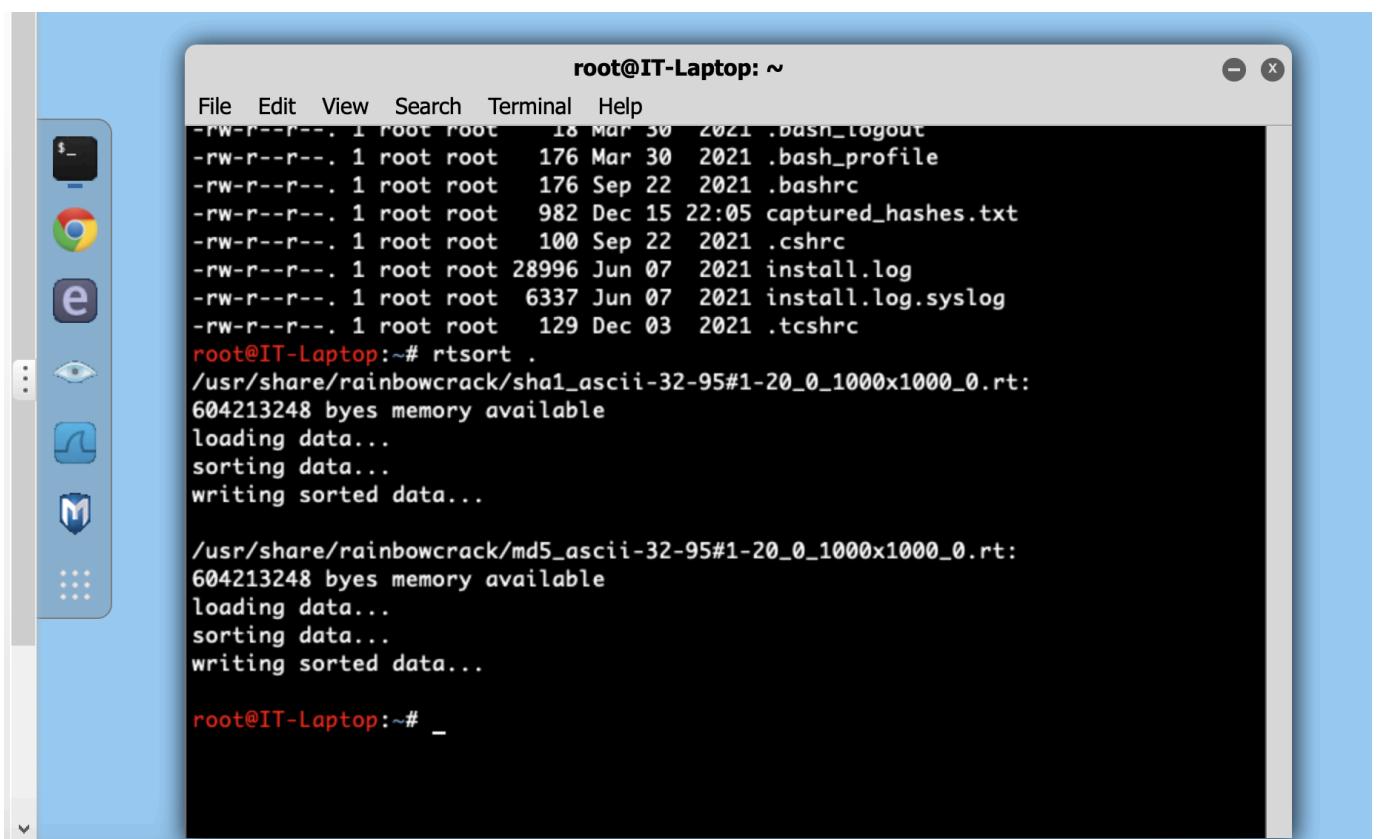
```
alpha-numeric-symbol32-space = [ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789!@#$%^&*()_-+=~`[]{}|\:;'"<>,.?/] 

root@IT-Laptop:~# ls
anaconda-ks.cfg  captured_hashes.txt  install.log  install.log.syslog
root@IT-Laptop:~# rtgen sha1 ascii-32-95 1 20 0 1000 1000 0
rainbow table sha1_ascii-32-95#1-20_0_1000x1000_0.rt parameters
hash algorithm:      sha1
hash length:        16
charset name:       ascii-32-95
charset data:        !"#$%&'()*+,.-./0123456789:;,<>?@ABCDEFGHIJKLMNPQRSTUVWXYZ[\]^_`abcdefghijklmnopqrstuvwxyz{!}~
charset data in hex:   20 21 22 23 24 25 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32
                      33 34 35 36 37 38 39 3a 3b 3c 3e 3f 40 41 42 43 44 45 46 47 48 49 4a 4b 4c 4d 4
                      e 4f 50 51 52 53 54 55 56 57 58 59 5a 5b 5c 5d 5e 5f 60 61 62 63 64 65 66 67 68
                      69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76 77 78 79 7a 7b 7c 7d 7e
charset length:      94
plaintext length range: 1 - 20
reduce offset:        0x00000000
plaintext total:      2.9322566307911197e+39

sequential starting point begin from 0 (0x0000000000000000)
generating...
1000 of 1000 rainbow chains generated (0 m 0.5 s)
root@IT-Laptop:~# _
```

Success! I've generated the sha1 table. Now let's generate the md5 table.

After generating both tables I need sort them. The default directory/path to rainbow tables is **/usr/share/rainbowcrack**. In order to sort the table I need to use the **rtsort** binary as part of the rainbowcrack package.



The screenshot shows a terminal window titled "root@IT-Laptop: ~". The terminal displays the following command and its execution:

```
root@IT-Laptop:~# rtsort .
/usr/share/rainbowcrack/sha1_ascii-32-95#1-20_0_1000x1000_0.rt:
604213248 bytes memory available
loading data...
sorting data...
writing sorted data...

/usr/share/rainbowcrack/md5_ascii-32-95#1-20_0_1000x1000_0.rt:
604213248 bytes memory available
loading data...
sorting data...
writing sorted data...

root@IT-Laptop:~# _
```

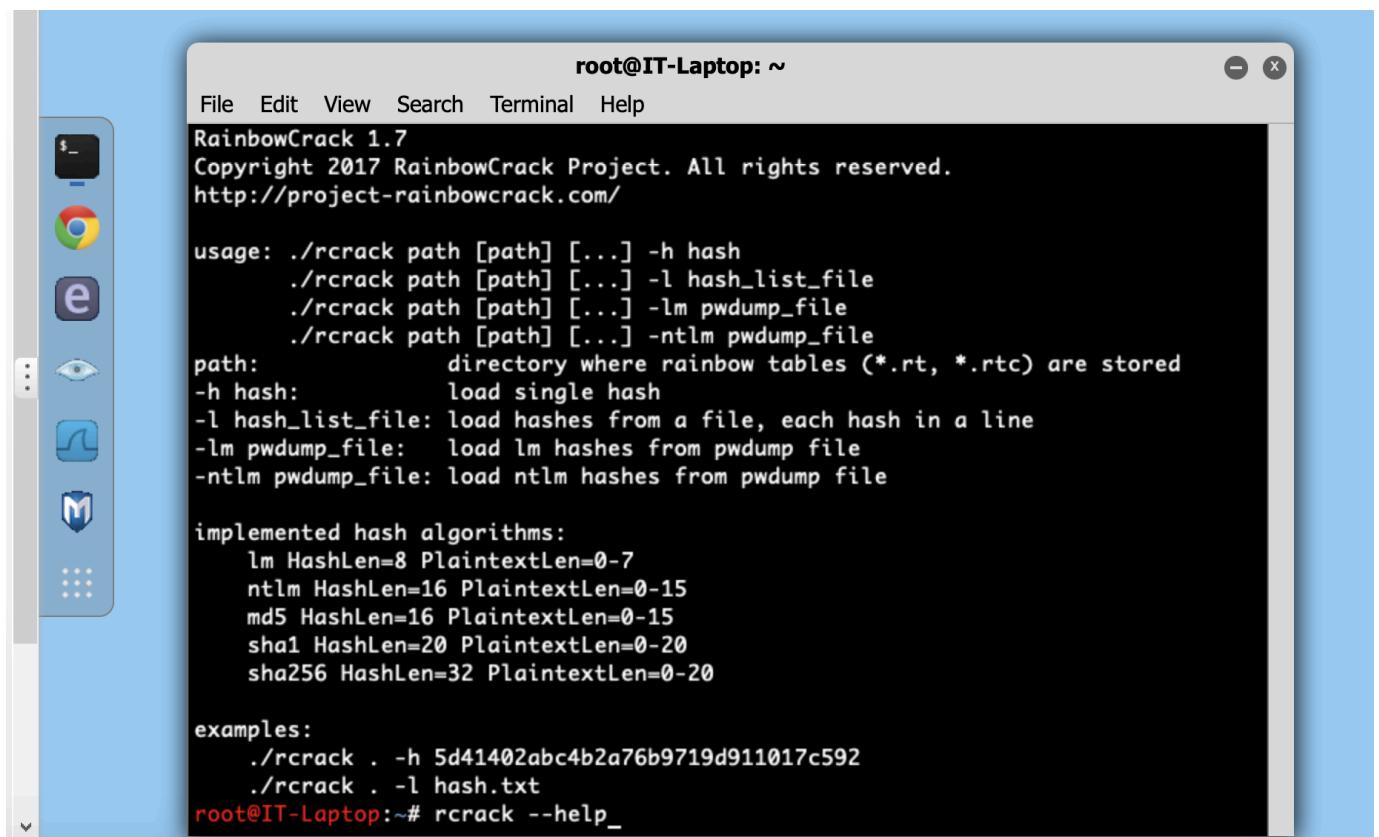
The terminal window is part of a desktop environment, as evidenced by the application dock on the left containing icons for a file manager, browser, terminal, eye, and other utilities.

Notice how **rtsort** has sorted both the md5 and sha1 tables. To execute the actual crack using the rainbow tables I need to use **the binary “rcrack -l [path/to/hashfile]”** To check the options and flags for the **rcrack** command I can use **rcrack –help**.

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The screenshot shows a terminal window titled "root@IT-Laptop: ~". The window contains the help documentation for the "rcrack" command. The text is as follows:

```
RainbowCrack 1.7
Copyright 2017 RainbowCrack Project. All rights reserved.
http://project-rainbowcrack.com/

usage: ./rcrack path [...] -h hash
       ./rcrack path [...] -l hash_list_file
       ./rcrack path [...] -lm pwdump_file
       ./rcrack path [...] -ntlm pwdump_file
path:          directory where rainbow tables (*.rt, *.rtc) are stored
-h hash:       load single hash
-l hash_list_file: load hashes from a file, each hash in a line
-lm pwdump_file:  load lm hashes from pwdump file
-ntlm pwdump_file: load ntlm hashes from pwdump file

implemented hash algorithms:
    lm HashLen=8 PlaintextLen=0-7
    ntlm HashLen=16 PlaintextLen=0-15
    md5 HashLen=16 PlaintextLen=0-15
    sha1 HashLen=20 PlaintextLen=0-20
    sha256 HashLen=32 PlaintextLen=0-20

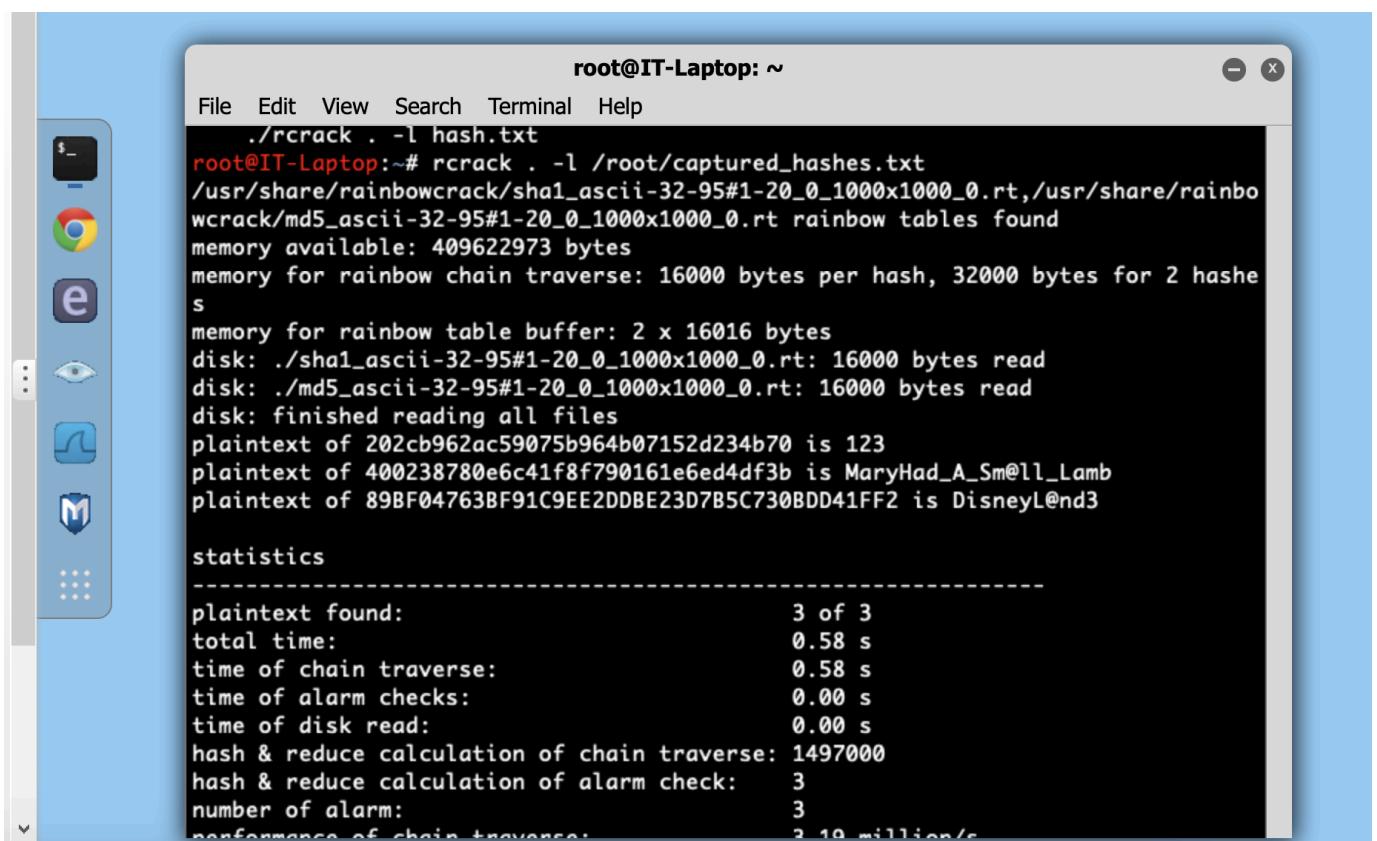
examples:
    ./rcrack . -h 5d41402abc4b2a76b9719d911017c592
    ./rcrack . -l hash.txt
root@IT-Laptop:~# rcrack --help_
```

I'll need to use **-l** which is a hash list file. I can feed in the **captured\_hashes.txt** to the command to use the Rainbow tables on them.

To crack the hashes I will issue:

```
rcrack . -l /root/captured_hashes.txt
```

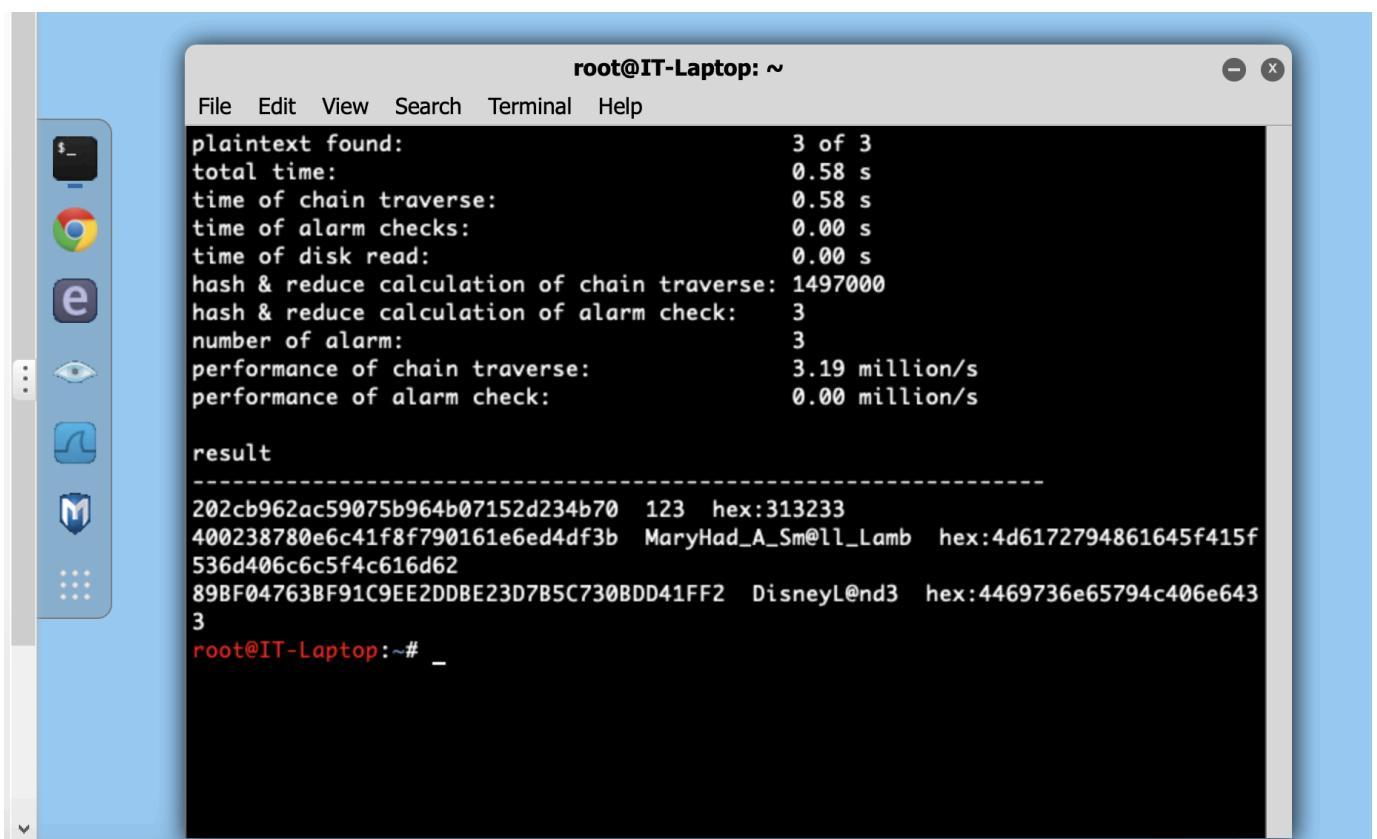
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```
root@IT-Laptop: ~
File Edit View Search Terminal Help
./rcrack . -l hash.txt
root@IT-Laptop:~# rcrack . -l /root/captured_hashes.txt
/usr/share/rainbowcrack/sha1_ascii-32-95#1-20_0_1000x1000_0.rt,/usr/share/rainbo
wcrack/md5_ascii-32-95#1-20_0_1000x1000_0.rt rainbow tables found
memory available: 409622973 bytes
memory for rainbow chain traverse: 16000 bytes per hash, 32000 bytes for 2 hashe
s
memory for rainbow table buffer: 2 x 16016 bytes
disk: ./sha1_ascii-32-95#1-20_0_1000x1000_0.rt: 16000 bytes read
disk: ./md5_ascii-32-95#1-20_0_1000x1000_0.rt: 16000 bytes read
disk: finished reading all files
plaintext of 202cb962ac59075b964b07152d234b70 is 123
plaintext of 400238780e6c41f8f790161e6ed4df3b is MaryHad_A_Sm@ll_Lamb
plaintext of 89BF04763BF91C9EE2DBE23D7B5C730BDD41FF2 is DisneyL@nd3

statistics
-----
plaintext found: 3 of 3
total time: 0.58 s
time of chain traverse: 0.58 s
time of alarm checks: 0.00 s
time of disk read: 0.00 s
hash & reduce calculation of chain traverse: 1497000
hash & reduce calculation of alarm check: 3
number of alarm: 3
performance of chain traverse: 3.19 million/s
```

Looks like we've found some matches! I'll screenshot the second half of this output because it's quite a lot.



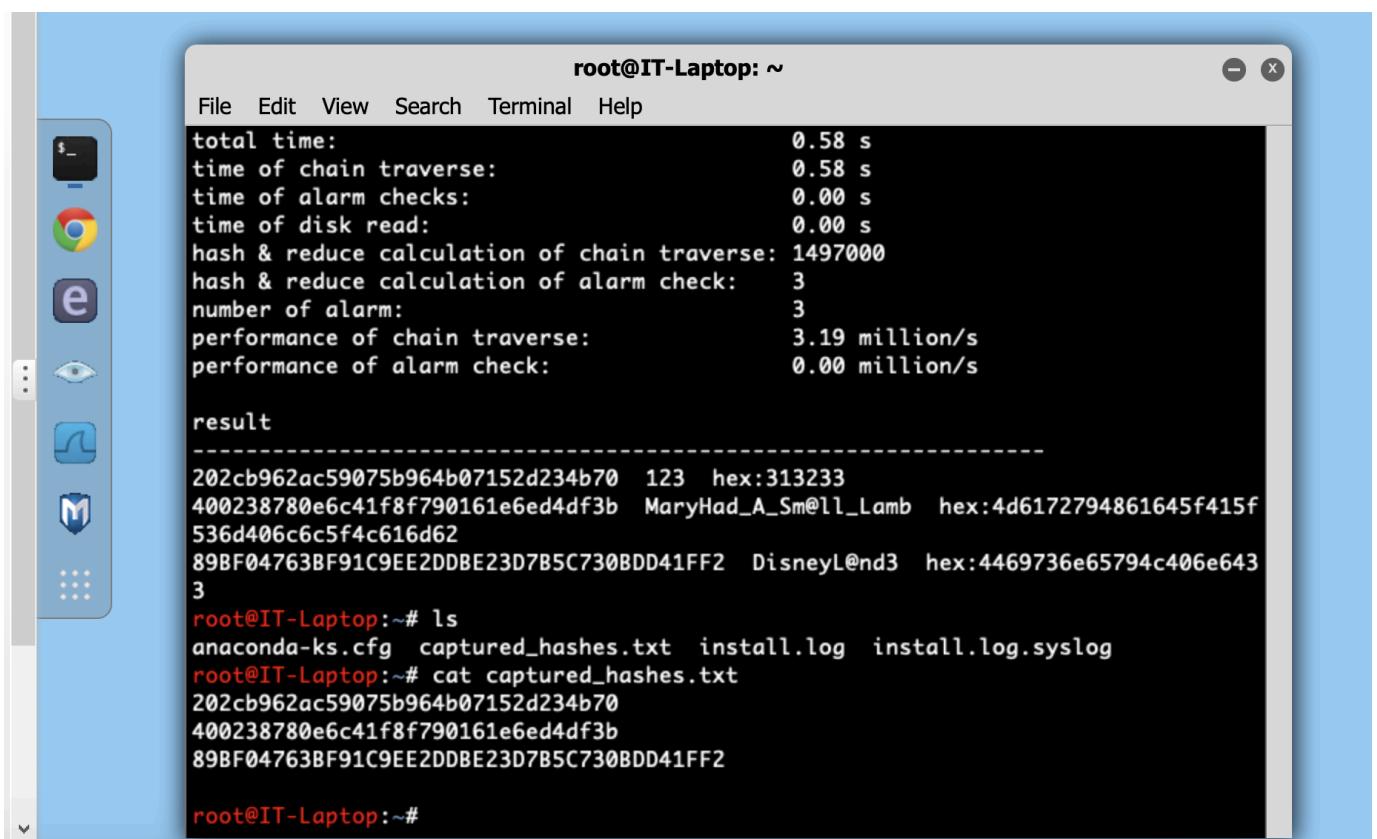
The screenshot shows a terminal window titled "root@IT-Laptop: ~". The window contains the following output:

```
root@IT-Laptop: ~
File Edit View Search Terminal Help
plaintext found: 3 of 3
total time: 0.58 s
time of chain traverse: 0.58 s
time of alarm checks: 0.00 s
time of disk read: 0.00 s
hash & reduce calculation of chain traverse: 1497000
hash & reduce calculation of alarm check: 3
number of alarm: 3
performance of chain traverse: 3.19 million/s
performance of alarm check: 0.00 million/s

result
-----
202cb962ac59075b964b07152d234b70 123 hex:313233
400238780e6c41f8f790161e6ed4df3b MaryHad_A_Sm@ll_Lamb hex:4d6172794861645f415f
536d406c6c5f4c616d62
89BF04763BF91C9EE2DDBE23D7B5C730BDD41FF2 DisneyL@nd3 hex:4469736e65794c406e643
3
root@IT-Laptop:~# _
```

**BINGO!!!!** We've successfully cracked the hashes. Let's verify that we've cracked all the hashes by printing out the `captured_hashes.txt`

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root@IT-Laptop: ~

```
total time: 0.58 s
time of chain traverse: 0.58 s
time of alarm checks: 0.00 s
time of disk read: 0.00 s
hash & reduce calculation of chain traverse: 1497000
hash & reduce calculation of alarm check: 3
number of alarm: 3
performance of chain traverse: 3.19 million/s
performance of alarm check: 0.00 million/s

result
-----
202cb962ac59075b964b07152d234b70 123 hex:313233
400238780e6c41f8f790161e6ed4df3b MaryHad_A_Sm@ll_Lamb hex:4d6172794861645f415f
536d406c6c5f4c616d62
89BF04763BF91C9EE2DBBE23D7B5C730BDD41FF2 DisneyL@nd3 hex:4469736e65794c406e643
3

root@IT-Laptop:~# ls
anaconda-ks.cfg captured_hashes.txt install.log install.log.syslog
root@IT-Laptop:~# cat captured_hashes.txt
202cb962ac59075b964b07152d234b70
400238780e6c41f8f790161e6ed4df3b
89BF04763BF91C9EE2DBBE23D7B5C730BDD41FF2

root@IT-Laptop:~#
```

We indeed cracked all of them. Let's answer the questions now:

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The screenshot shows a Linux desktop environment with a terminal window open. The terminal window has a title bar 'Floor 1 Overview' and 'IT Adminstr'. The main area of the terminal displays a password cracking session. It shows the following text:

```
File Edit View S
plaintext of 202
plaintext of 400
plaintext of 89B
statistics
-----
plaintext found:
total time:
time of chain tr
time of alarm ch
time of disk rea
hash & reduce co
hash & reduce co
number of alarm:
performance of c
performance of a
result
-----
202cb962ac59075b
400238780e6c41f8
536d406c6c5f4c61
89BF04763BF91C9E
3
root@IT-Laptop:~#
```

To the right of the terminal, there is a sidebar titled 'Lab Questions' with a refresh icon. It contains four questions:

1. What is the password for hash 202cb962ac59075b964b07152d234b70?  
Answer: 123
2. What is the password for hash 400238780e6c41f8f790161e6ed4df3b?  
Answer: MaryHad\_A\_Sm@ll\_Lamb
3. What is the password for hash 89BF04763BF91C9EE2DDBE23D7B5C730BDD41FF2?  
Answer: DisneyL@nd3
4. How many of the passwords found meet the company's password requirements?  
Options:
  - 0
  - 1
  - 2
  - 3

Only one of the passwords matches the company's password policy. This now concludes this lab.

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The screenshot shows a cybersecurity lab interface. A modal window is open, displaying a question and the user's answer. The question is: "2. What is the password for hash 100000700...?". The user's answer is "123". Below the question, there is a "Print" icon and a close "X" button. The main interface shows a "Lab Report" section with a progress bar indicating 7/7 (100%) completed. The report also includes a "Time Spent: 08:04" and a "Score: 7/7 (100%)". The "Required Actions & Questions" section lists several tasks, with the first one being "Q1: What is the password for hash 202cb962ac59075b964b07152d234b70?". The user's answer to this question is "123", which is marked as correct. A "Score Lab" button is visible in the bottom right corner of the modal.

123

2. What is the password for hash  
100000700...?

Print X

## Lab Report

Time Spent: 08:04

Score: 7/7 (100%)

TASK SUMMARY

Required Actions & Questions

- Create rainbow tables [Show Details](#)
- Sort the rainbow tables using rtsort
- Crack the hash using rcrack . -l or rcrack . -h
- Q1: What is the password for hash 202cb962ac59075b964b07152d234b70?  
Your answer: 123  
Correct answer: 123

Score Lab