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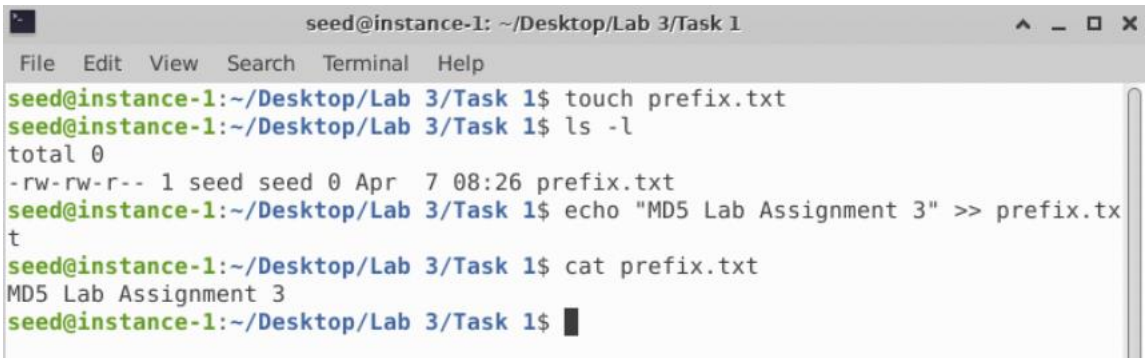
Lab 3 - MD5 Collision Attack Lab

CS 458 – Introduction to Information Security

2.1 Task 1: Generating Two Different Files with the Same MD5 Hash

1) Let's begin with creating a prefix file as shown below.



- touch: It is used to create empty files.
- Cat: It is used to concatenate and display the content of files.
- echo: It is used to display a line of text or to redirect text into a file.

2) Next, run the md5collgen command as follow:

- md5collgen is a tool used to generate MD5 hash collisions.
- MD5 is a cryptographic hash function that produces a 128-bit hash value.
- A hash collision occurs when two different inputs produce the same hash value.

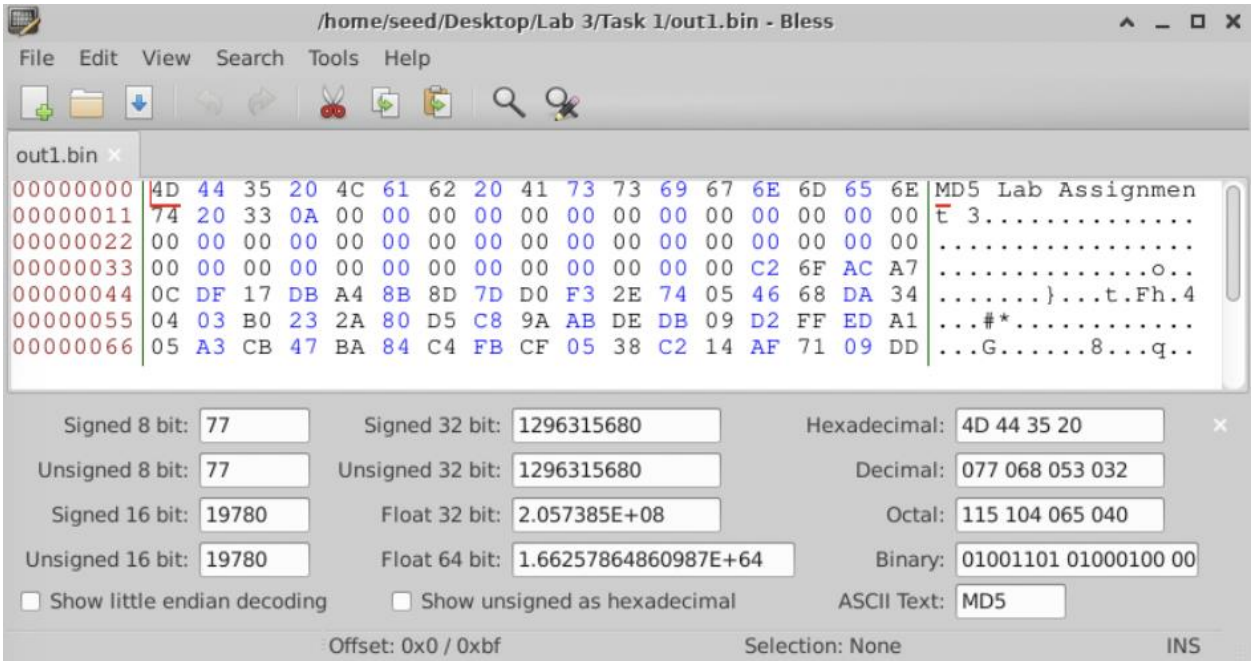
The above command generates two output files, out1.bin and out2.bin, for a given a prefix file prefix.txt.

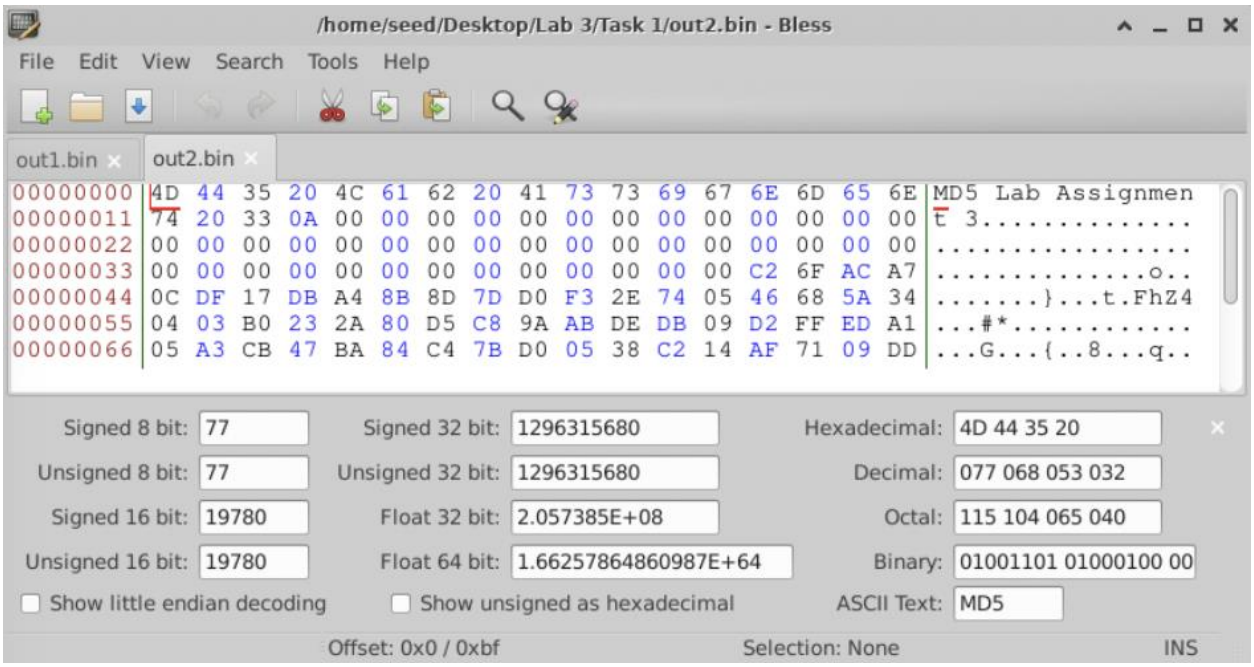
3) To check that the output files are distinct or not, we use the diff command.

```
seed@instance-1:~/Desktop/Lab 3/Task 1$ diff out1.bin out2.bin
Binary files out1.bin and out2.bin differ
```

4) Next, we use the bless editor to check the binary files for out1, out2.

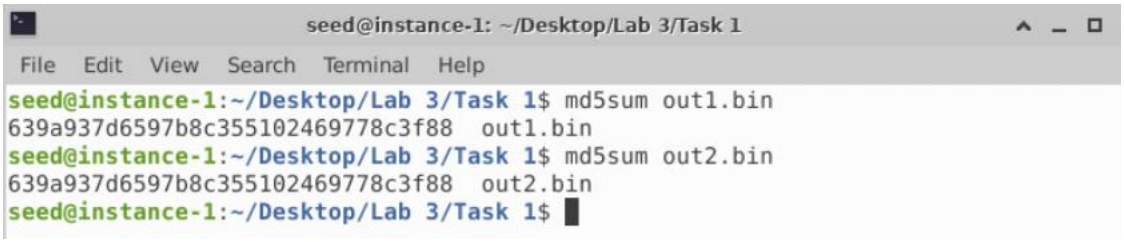
- Bless is a hex editor designed for reading and manipulating binary files. It allows you to view and change the hexadecimal and ASCII representations of files.





- We can see that the values for both output files out1 and out2 are the same.

5) Next, we use the md5sum command to check the MD5 hash of each output file.
   - md5sum calculates and verifies MD5 checksums for files.
   - It takes a file as input, computes its MD5 hash, and outputs a 32-character hexadecimal number representing the hash value.



We can observe that the MD5 hash values for both the output files out1, out2 are same.

Question 1: If the length of your prefix file is not multiple of 64, what is going to happen?

- Files are padded with 0's.
- Message is padded with bits to produce the length of the message ≈ modulo of 512.
- This padding includes a single '1' bit followed by '0' bits to fill the space, and then the length of the original message in bits is appended to the end
- if the length of the prefix file is not a multiple of 64 bytes, padding is added to the file to meet requirement.

Create new prefix text file:

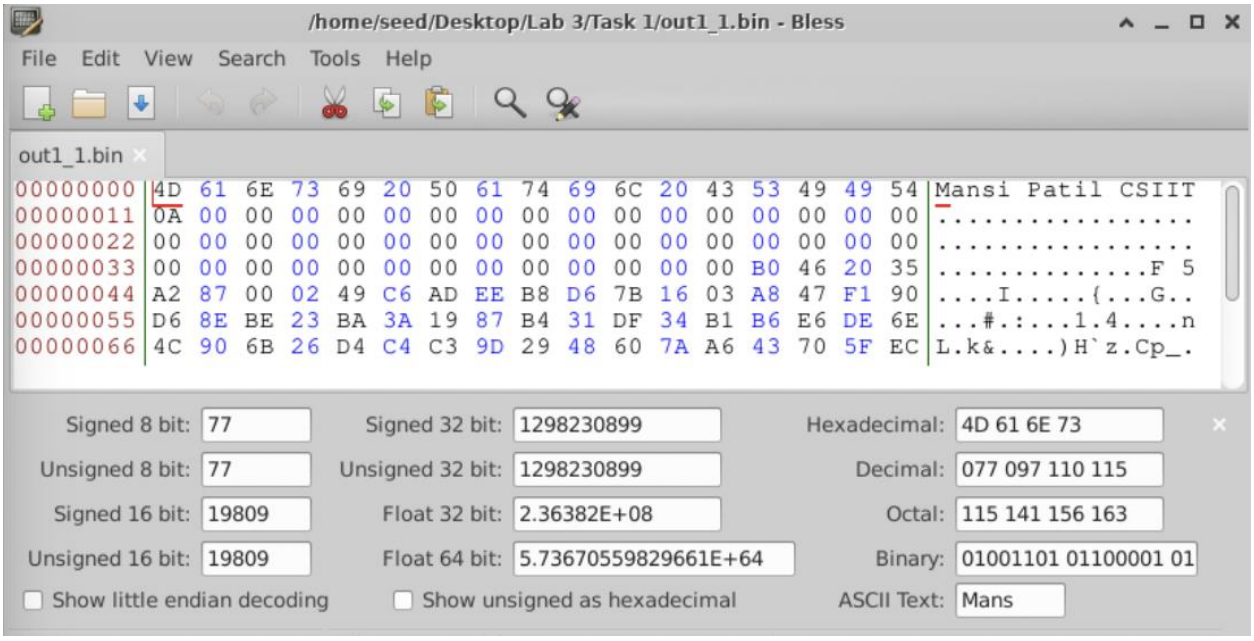
```
seed@instance-1:~/Desktop/Lab 3/Task 1$ echo "Mansi Patil CSIIT" >> prefix_1.txt
seed@instance-1:~/Desktop/Lab 3/Task 1$ echo "$(python -c 'print("A"*63)')" >> p
refix_64.txt
Command 'python' not found, did you mean:
  command 'python3' from deb python3
  command 'python' from deb python-is-python3
seed@instance-1:~/Desktop/Lab 3/Task 1$ echo "$(python3 -c 'print("A"*63)')" >>
prefix_64.txt
seed@instance-1:~/Desktop/Lab 3/Task 1$ ls -l
total 24
-rw-rw-r-- 1 seed seed 192 Apr  7 08:32 out1.bin
-rw-rw-r-- 1 seed seed 192 Apr  7 08:32 out2.bin
-rw-rw-r-- 1 seed seed   2 Apr  7 16:27 prefix
-rw-rw-r-- 1 seed seed  21 Apr  7 08:27 prefix.txt
-rw-rw-r-- 1 seed seed  18 Apr  7 16:31 prefix_1.txt
-rw-rw-r-- 1 seed seed  65 Apr  7 16:32 prefix_64.txt
seed@instance-1:~/Desktop/Lab 3/Task 1$ ls -l *.txt
-rw-rw-r-- 1 seed seed 21 Apr  7 08:27 prefix.txt
-rw-rw-r-- 1 seed seed 18 Apr  7 16:31 prefix_1.txt
-rw-rw-r-- 1 seed seed 65 Apr  7 16:32 prefix_64.txt
seed@instance-1:~/Desktop/Lab 3/Task 1$
```

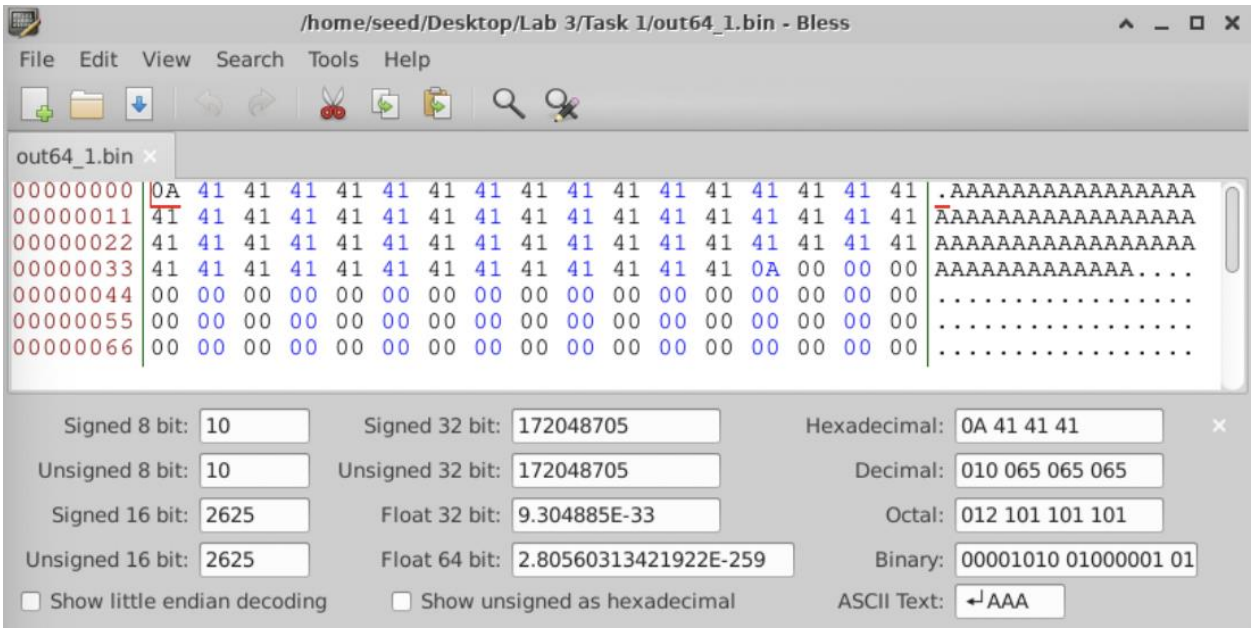
Output filenames: Out1_1.bin and out1_64.bin

```
seed@instance-1:~/Desktop/Lab 3/Task 1$ md5collgen -p prefix_1.txt -o out1_1.bin
 out1_2.bin
MD5 collision generator v1.5
by Marc Stevens (http://www.win.tue.nl/hashclash/)

Using output filenames: 'out1_1.bin' and 'out1_2.bin'
Using prefixfile: 'prefix_1.txt'
Using initial value: ae155900cc63a0eb7d97f42f4f1d7b8f

Generating first block: ..............
Generating second block: S00..
Running time: 11.4852 s
seed@instance-1:~/Desktop/Lab 3/Task 1$
```

```
seed@instance-1:~/Desktop/Lab 3/Task 1$ md5collgen -p prefix_64.txt -o out64_1.b
in out64_2.bin
MD5 collision generator v1.5
by Marc Stevens (http://www.win.tue.nl/hashclash/)

Using output filenames: 'out64_1.bin' and 'out64_2.bin'
Using prefixfile: 'prefix_64.txt'
Using initial value: d46b988132ccf1a01611c6fb99de1691

Generating first block: ............
Generating second block: S11.....................................................
...................
Running time: 17.3553 s
seed@instance-1:~/Desktop/Lab 3/Task 1$
```

Bless: out1_1.bin & out64_1.bin





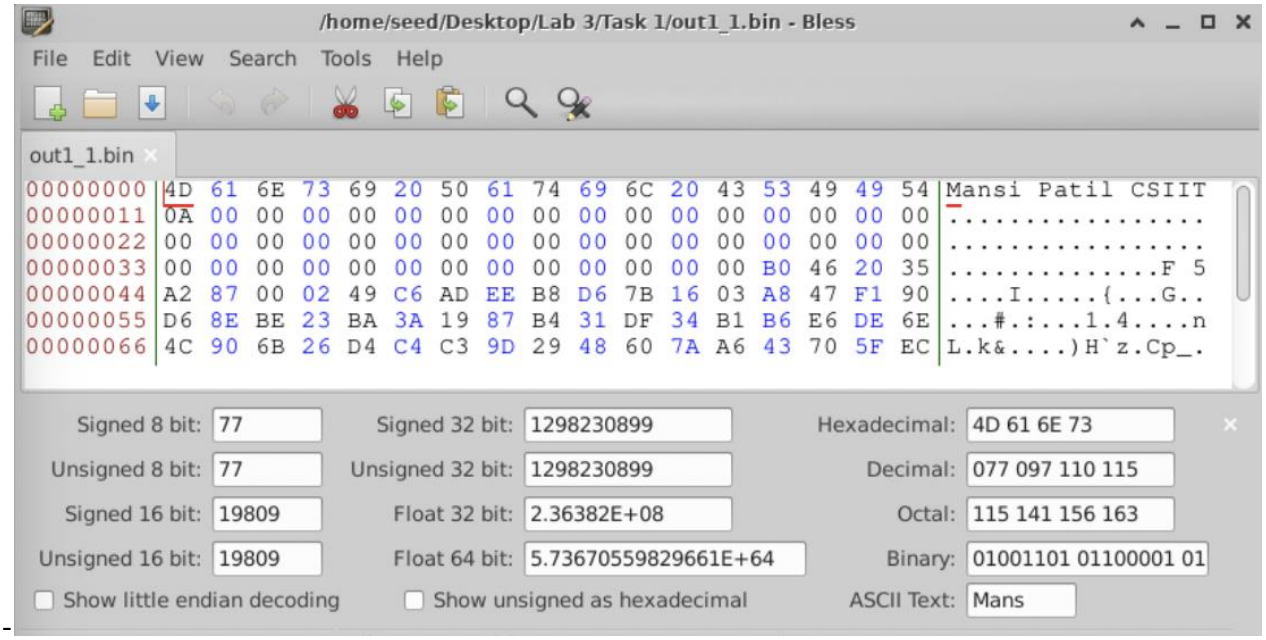
Question 2: Create a prefix file with exactly 64 bytes, and run the collision tool again, and see what happens.

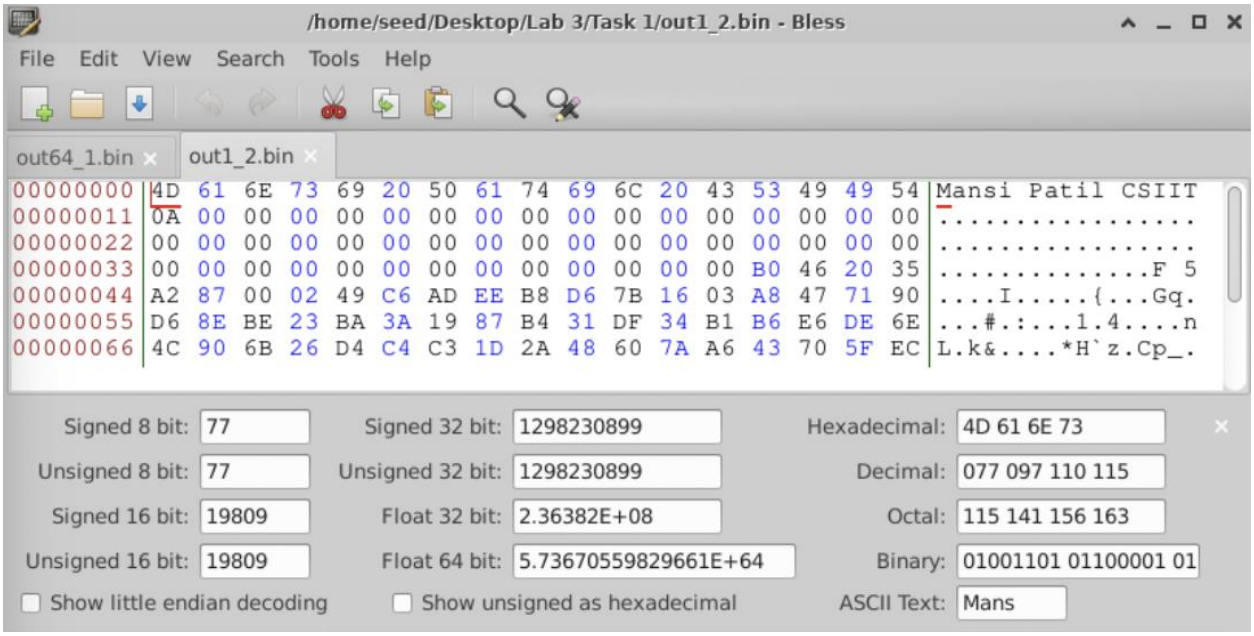
- The 64-byte prefix eliminates the need for padding with zero bytes.
-The prefix file is followed by some randomly generated data for collision.

Question 3: Are the data (128 bytes) generated by md5collgen completely different for the two output files? Please identify all the bytes that are different.

- We can observe that there are minor difference between out1_1.bin and out1_2.bin files.

-






```
seed@instance-1:~/Desktop/Lab 3/Task 1$ md5sum out1_1.bin
25c3885f2c2002384f1b0c0a02462c73  out1_1.bin
seed@instance-1:~/Desktop/Lab 3/Task 1$ md5sum out64_1.bin
68760d3b96d19e064ada4be27422f7fa  out64_1.bin
seed@instance-1:~/Desktop/Lab 3/Task 1$
```

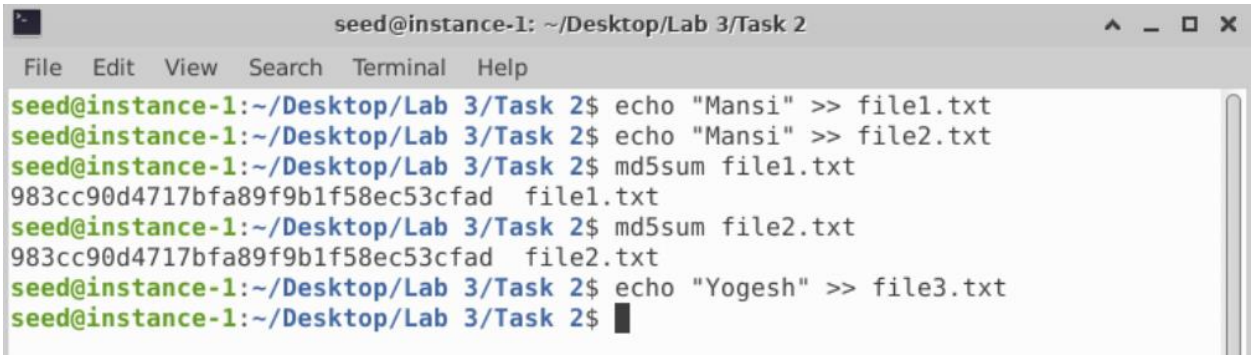
- They look relatively similar but there exist some byte difference between them.

```
seed@instance-1:~/Desktop/Lab 3/Task 1$ xxd out1_1.bin > 1.txt
seed@instance-1:~/Desktop/Lab 3/Task 1$ xxd out1_2.bin > 2.txt
seed@instance-1:~/Desktop/Lab 3/Task 1$ diff 1.txt 2.txt
6,8c6,8
< 00000050: 03a8 47f1 90d6 8ebe 23ba 3a19 87b4 31df  ..G.....#.:...1.
< 00000060: 34b1 b6e6 de6e 4c90 6b26 d4c4 c39d 2948  4....nL.k&....)H
< 00000070: 607a a643 705f ecca de80 8ea8 68a7 a424  `z.Cp_......h..$
---
> 00000050: 03a8 4771 90d6 8ebe 23ba 3a19 87b4 31df  ..Gq....#.:...1.
> 00000060: 34b1 b6e6 de6e 4c90 6b26 d4c4 c31d 2a48  4....nL.k&....*H
> 00000070: 607a a643 705f ecca de80 8e28 68a7 a424  `z.Cp_.....(h..$
10,12c10,12
< 00000090: ba67 c4eb 12b9 6015 d5bb 14c1 d061 799e  .g....`......ay.
< 000000a0: 7b33 16be 6265 8361 a174 b50f 51ee 57c6  {3..be.a.t..Q.W.
< 000000b0: bdb9 fe07 26c3 e6bc f7df e57d a8d8 3822  ....&......}..8"
---
> 00000090: ba67 c46b 12b9 6015 d5bb 14c1 d061 799e  .g.k..`......ay.
> 000000a0: 7b33 16be 6265 8361 a174 b50f 516e 57c6  {3..be.a.t..QnW.
> 000000b0: bdb9 fe07 26c3 e6bc f7df e5fd a8d8 3822  ....&.........8"
```

2.2 Task 2: Understanding MD5's Property

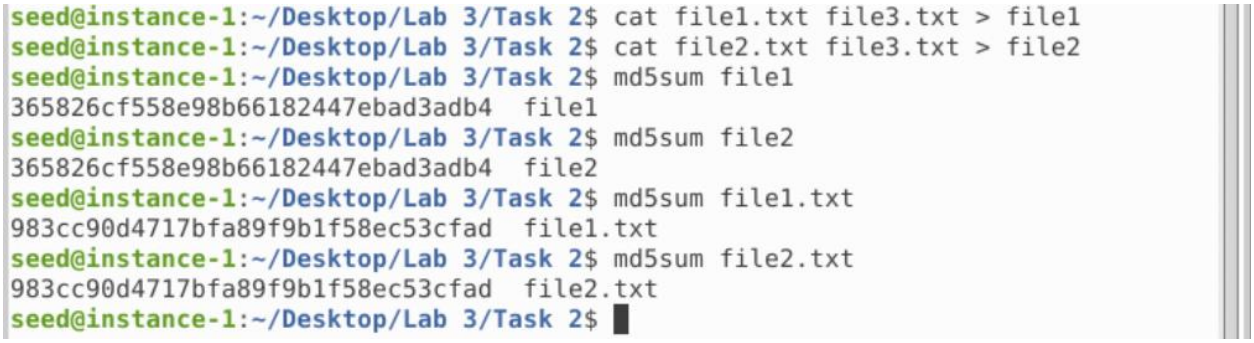
Create a file: file1.txt and file2.txt

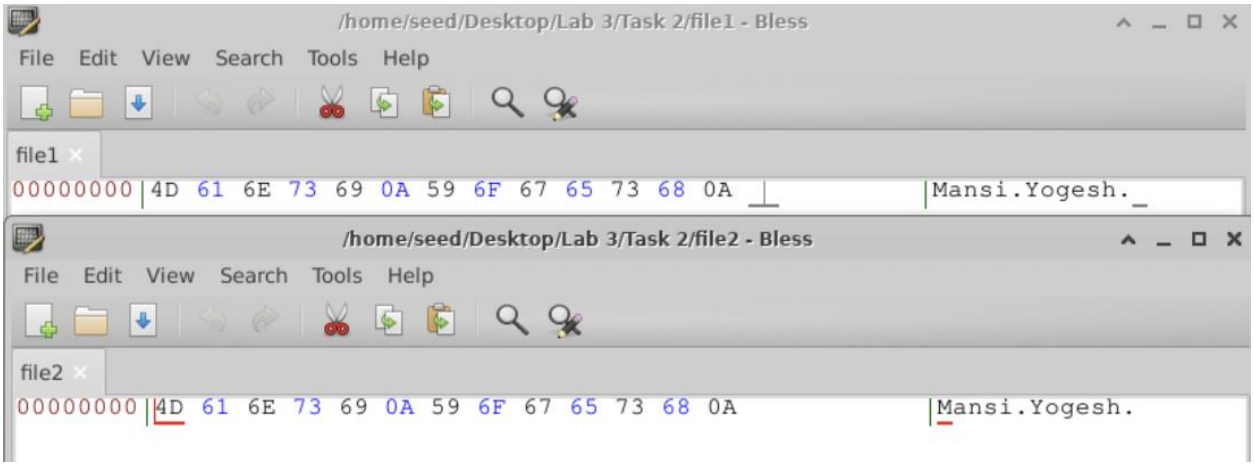
we observe they have the same checksums for MD5 algorithm.



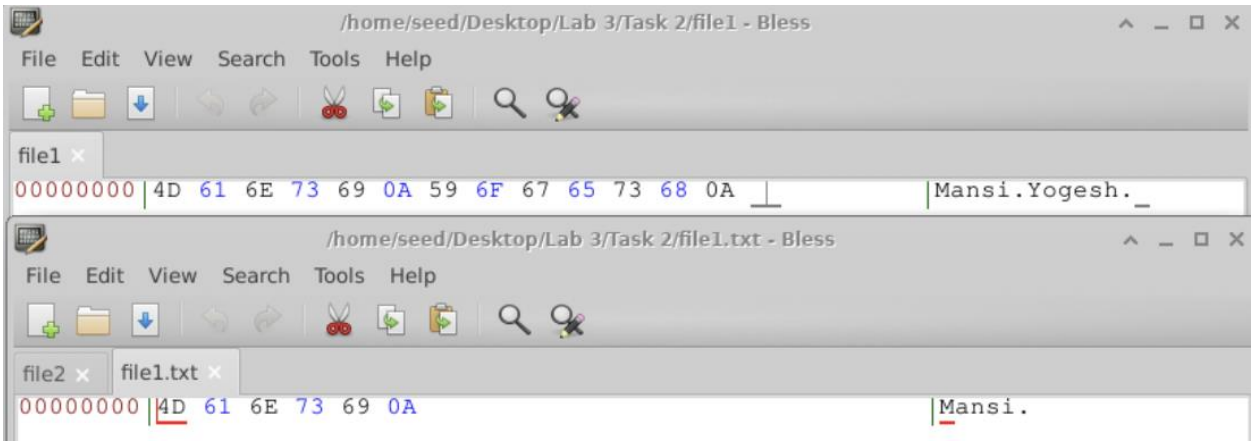
Concatenation and MD5sum:

Here, Cat command is used for concatenate the files.





- From the above screenshots, we can conclude that file1 and file2 have the same checksums.



The checksums are different for file1.txt & file1, due to the concatenation.

2.3 Task 3: Generating Two Executable Files with the Same MD5 Hash

1) First generate the file.

code.c
~/Desktop/Lab 3/Task 3

```
#include <stdio.h>
unsigned char xyz[200] = {
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
        0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,
};
int main()
{
int i;
for (i=0; i<200; i++){
printf("%x", xyz[i]);
}
printf("\n");
}
```

2) Run the file

seed@instance-1: ~/Desktop/Lab 3/Task 3

```
seed@instance-1:~/Desktop/Lab 3/Task 3$ gedit code.c
seed@instance-1:~/Desktop/Lab 3/Task 3$ gcc code.c -o code.out
seed@instance-1:~/Desktop/Lab 3/Task 3$
```

- The gcc command is used to compile C code into an executable file.
- The -o option is used to specify the output file name for the executable.

We observe that array offset present at 4160 bytes farther from the start of binary file.

4160 / 64 = 65

So, we consider the first 4224 bytes of the file & save it as prefix.

generate a hash value like prefix that was generated from execution file.

```
seed@instance-1:~/Desktop/Lab 3/Task 3$ head -c 4224 code.out > prefix
seed@instance-1:~/Desktop/Lab 3/Task 3$ md5collgen -p prefix -o code.c_a.bin
MD5 collision generator v1.5
by Marc Stevens (http://www.win.tue.nl/hashclash/)

Error: exactly two output filenames should be specified.
seed@instance-1:~/Desktop/Lab 3/Task 3$ md5collgen -p prefix -o code.c_a.bin cod
e.c_b.bin
MD5 collision generator v1.5
by Marc Stevens (http://www.win.tue.nl/hashclash/)

Using output filenames: 'code.c_a.bin' and 'code.c_b.bin'
Using prefixfile: 'prefix'
Using initial value: 070f1cc7b9c5698310bb6c6f53bea269

Generating first block: ..........................................................
..........................
Generating second block: W.............
Running time: 171.665 s
seed@instance-1:~/Desktop/Lab 3/Task 3$ ls *.bin
code.c_a.bin  code.c_b.bin
```

Now, generate suffix:

As prefix is a multiple of 64, we take 4224 bytes of executable file i.e., multiple of 64 bytes.

4224 / 128 = 4352

Generate Suffix –

```
seed@instance-1:~/Desktop/Lab 3/Task 3$ tail -c +4352 code.out > suffix
seed@instance-1:~/Desktop/Lab 3/Task 3$
```

Concatenate p & q files i.e., suffix and prefix –

```
seed@instance-1:~/Desktop/Lab 3/Task 3$ tail -c 128 code.c_a.bin > p
seed@instance-1:~/Desktop/Lab 3/Task 3$ tail -c 128 code.c_b.bin > q
seed@instance-1:~/Desktop/Lab 3/Task 3$ cat prefix p suffix > task3_1
seed@instance-1:~/Desktop/Lab 3/Task 3$ cat prefix q suffix > task3_2
seed@instance-1:~/Desktop/Lab 3/Task 3$
```

Check the hash values for task3_1 and task3_2 -

```
seed@instance-1:~/Desktop/Lab 3/Task 3$ md5sum task3_1
56de303029aec2e0968130593da5457a  task3_1
seed@instance-1:~/Desktop/Lab 3/Task 3$ md5sum task3_2
56de303029aec2e0968130593da5457a  task3_2
seed@instance-1:~/Desktop/Lab 3/Task 3$
```

- **We can observe that the hash values have similar results.**
- **We can note that there are some differences of output even when the hash value is same.**

2.4 Task 4: Making the Two Programs Behave Differently

Code file –

*code.c
~/Desktop/Lab 3/Task 4

```c
#include <stdio.h>
unsigned char a[200] = {

0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x
};

unsigned char b[200] = {

0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x41,0x
};
int main()
{
int i;
for (i=0; i<200; i++){
if(a[i] != b[i])
{
break;
}
}
if(i==200)
{
printf("%s", "run benign code");
}
else
{
printf("%s", "WARNING: run malicious code");
}
printf("\n");
}
```

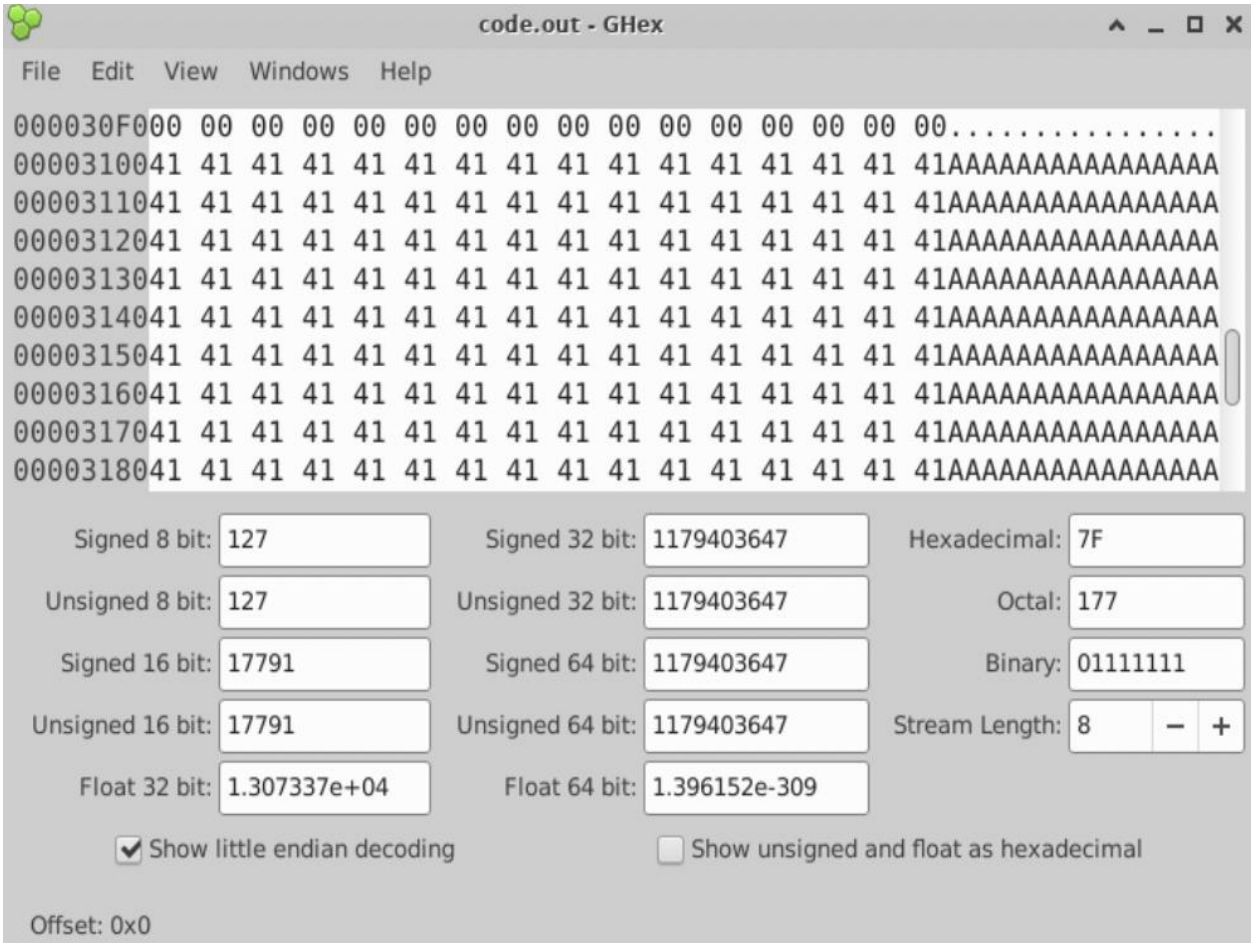
- #include <stdio.h>: Includes the standard input-output library for functions like printf.
- unsigned char a[200] = { ... };: Declares an array a of unsigned characters with a size of 200 elements and initializes it with hexadecimal values.
- unsigned char b[200] = { ... };: Declares another array b of unsigned characters with the same size and initializes it with the same hexadecimal values as array a.
- int main(): Entry point of the program, where execution begins.
- int i;: Declares an integer variable i without initializing it.
- for(i=0; i<200; i++): Starts a loop that iterates from 0 to 199 (<200 means less than 200) and increments i by 1 each time.
- if(a[i] != b[i]): Checks if the elements at index i in arrays a and b are not equal.
- break;: Breaks out of the loop immediately if a difference is found between corresponding elements of arrays a and b.
- if(i == 200): Checks if the loop completed all 200 iterations without breaking early.

This program essentially compares the elements of arrays a and b byte by byte. If all elements match, it prints "run benign code"; otherwise, it prints "WARNING: run malicious code"

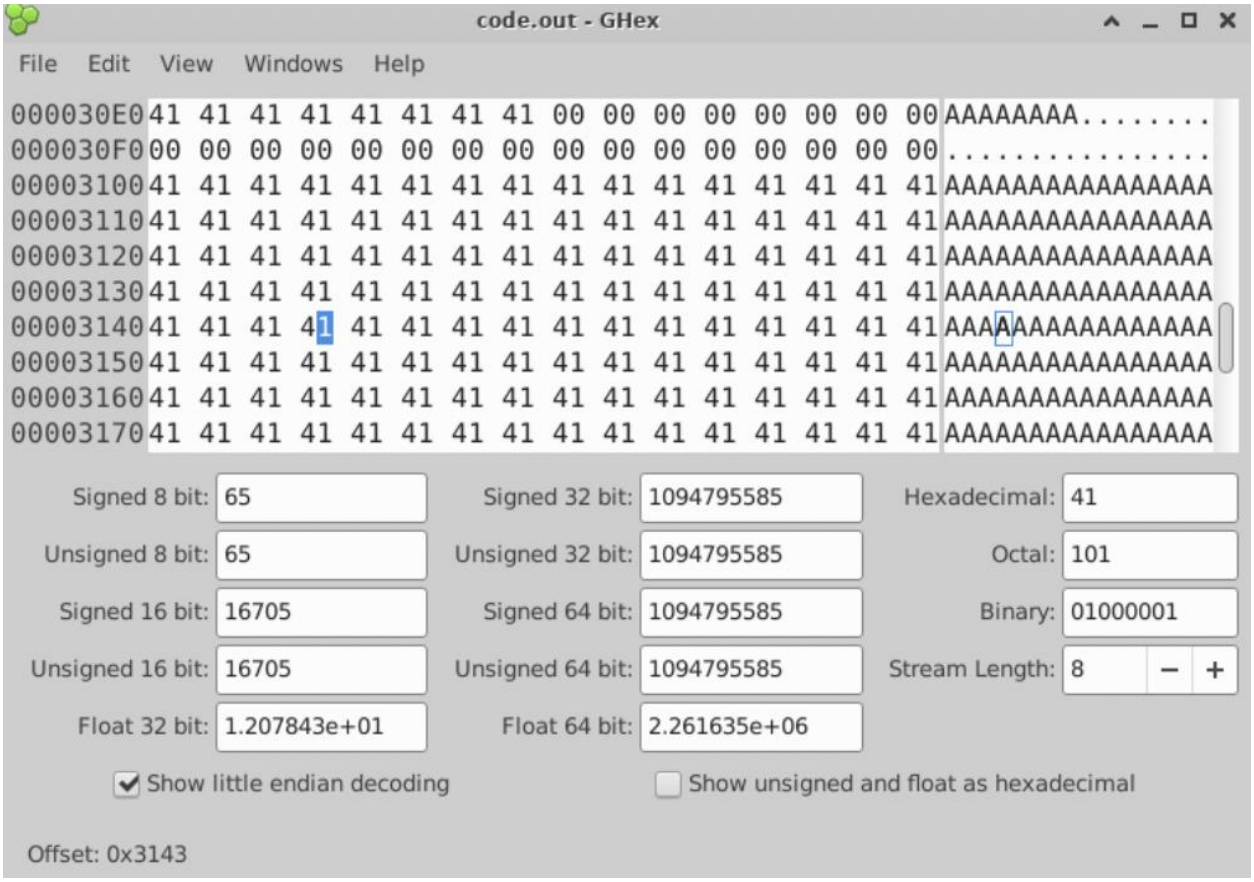
Compilation –

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ gcc code.c -o code.o
seed@instance-1:~/Desktop/Lab 3/Task 4$ ./code.o
run benign code
```

Now we observe the beginning of first array –



Next, we observe beginning of second array –



The first array is present at 4160. Next, we create a prefix called prefix_task4 and proceed to use the collision tool which in-turn generated 2 output files output1_task4.bin and output2_task4.bin.

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ head -c 4160 code.o > prefix_task4
seed@instance-1:~/Desktop/Lab 3/Task 4$ md5collgen -p prefix_task4 -o out1_task4
.bin out2_task4.bin
MD5 collision generator v1.5
by Marc Stevens (http://www.win.tue.nl/hashclash/)

Using output filenames: 'out1_task4.bin' and 'out2_task4.bin'
Using prefixfile: 'prefix_task4'
Using initial value: accf25041503e3f9d0dced6b4b914c76

Generating first block: ..................
Generating second block: S01.....................
Running time: 22.0528 s
```

Next, we create p and q as follow:

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ tail -c 128 out1_task4.bin > p
seed@instance-1:~/Desktop/Lab 3/Task 4$ tail -c 128 out2_task4.bin > q
```

Next we create a suffix from program.o and use it create 2 different suffix (temp_suffix1, temp_suffix2)5c

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ tail -c +4289 code.o > suffix
seed@instance-1:~/Desktop/Lab 3/Task 4$ head -c 97 suffix > temp_suffix1
seed@instance-1:~/Desktop/Lab 3/Task 4$ tail -c +255 suffix > temp_suffix2
```

- tail -c +4289 code.o > suffix: This command extracts the contents of code.o starting from byte 4289 to the end of the file and saves it into a new file called suffix.
- head -c 97 suffix > temp_suffix1: This command takes the first 97 bytes from the suffix file and saves them into a new file called temp_suffix1.
- tail -c +255 suffix > temp_suffix2: This command skips the first 254 bytes of the suffix file and extracts the rest, starting from byte 255, and saves it into a new file called temp_suffix2.

Next, we concatenate prefix_task4, p, temp_suffix1, temp_suffix2 as follow to generate 2 executable files (Task4_1 and Task4_2)

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ cat prefix_task4 p temp_suffix1 p temp_s
uffix2 > task4_1
seed@instance-1:~/Desktop/Lab 3/Task 4$ cat prefix_task4 q temp_suffix1 q temp_s
uffix2 > task4_2
```

Next, we run each executable as follows:

- The command chmod +x task4_1 is used to add executable permissions to a file named task4_1.
- This command allows the file to be executed as a program or script.

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ chmod +x task4_1
seed@instance-1:~/Desktop/Lab 3/Task 4$ ./task4_1
run benign code
```

- The command chmod +x task4_2 is used to add executable permissions to a file named task4_2.
- This command allows the file to be executed as a program or script.

```
seed@instance-1:~/Desktop/Lab 3/Task 4$ chmod +x task4_2
seed@instance-1:~/Desktop/Lab 3/Task 4$ ./task4_2
WARNING: run malicious code
```

We can see that task4_1 will always run benign instructions (benign code refers to code that is harmless and does not have malicious intent or behavior) while task4_2 will always execute malicious instructions.

Therefore, we can conclude that a successful launch of MD5 Collision Attack is done.