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Few README points:

- For Q5 , run the following before running `./q5` :

```
chmod +x ./q5
```

- For Q2 , when overflow cases occur , the answer returned is with MOD `LONG_LONG_MAX`

Q3

OS:

- **OS Name:** Ubuntu 20.04.3 LTS(64 bit) (**Release Date:** August 2021)
- **Desktop Environment:** GNOME 3.36.8
- **Shell:** bash 5.0.17
- **Kernel:** Linux Kernel (**Version:** 5.13.0-44-generic)

Kernel Modules:

Note: There are about 160 kernel modules , here are some of the most important once:

1. **snd_soc_skl** : Intel Skylake ASoC HDA driver
2. **snd_soc_hdac_hda** : ASoC Extensions for legacy HDA Drivers
3. **snd_hda_ext_core** : HDA extended core
4. **snd_soc_sst_dsp** : Intel SST Core
5. **snd_soc_acpi_intel_match** : Intel Common ACPI MatQ1'21ch module
6. **iwlvm** : The new Intel(R) wireless AGN driver for Linux
7. **mac80211** : IEEE 802.11 subsystem
8. **i915** : Intel Graphics

File Systems:

- **'boot'** Partition uses FAT (32 bit) Format
- **'/'** and **'/home'** uses Ext4 (Version 1.0)

Processor:

- **Manufacturer:** Intel Corporation
- **Model:** Core i5
- **Generation:** 8th-generation (Kaby Lake)
- **Processor Number:** i5-8250U
- **Base Frequency:** 1.6 GHz (**Max Turbo Frequency:** 3.4 GHz)
- **Cache:** 6 MB Intel® Smart Cache
- **Lithograpy/Fabrication:** 14nm Fabrication
- **Cores:** 4 Core (**Threads:** 8 Threads)
- **Graphics:** Intel UHD Graphics 620 (integrated)

Memory:

- Total of 4 RAM slots (2 - empty , 2 - Used) (**Maximum Capacity:** 8 GB x 4 = 32 GB)
- Configuration of each RAM slot:

```
Form Factor: SODIMM
Data Width: 64 bits
Size: 4096 MB (supports upto 8192 MB)
Configured Memory Speed: 2400 MT/s
Configured Voltage: 1.2 V
```

PCI Devices:

- **Host bridge:** Intel Corporation Xeon E3-1200 v6/7th Gen Core Processor Host Bridge/DRAM Registers (rev 08)
- **Signal processing controller:** Intel Corporation Xeon E3-1200 v5/E3-1500 v5/6th Gen Core Processor Thermal Subsystem (rev 08) x 3
- **USB controller:** Intel Corporation Sunrise Point-LP USB 3.0 xHCI Controller (rev 21)
- **Communication controller:** Intel Corporation Sunrise Point-LP CSME HECI #1 (rev 21)

- **SATA controller:** Intel Corporation Sunrise Point-LP SATA Controller [AHCI mode] (rev 21)
- **PCI bridge:** Intel Corporation Sunrise Point-LP PCI Express Root Port #1 (rev f1) x 2
- **SD Host controller:** Intel Corporation Sunrise Point-LP Secure Digital IO Controller (rev 21)
- **ISA bridge:** Intel Corporation Sunrise Point LPC Controller/eSPI Controller (rev 21)
- **Memory controller:** Intel Corporation Sunrise Point-LP PMC (rev 21)
- **Audio device:** Intel Corporation Sunrise Point-LP HD Audio (rev 21)
- **SMBus:** Intel Corporation Sunrise Point-LP SMBus (rev 21)
- **Network controller:** Intel Corporation Wireless 8265 / 8275 (rev 78)

USB Devices:

- Linux Foundation 3.0 Root Hub (USB 3.0 x 1)
- Linux Foundation 2.0 Root Hub (USB 2.0 x 2)
- Chicony Electronics Co., Ltd USB2.0 VGA UVC WebCam (Webcam)

Battery:

- **Technology:** Lithium-ion
- **Vendor:** ASUSTeK
- **energy-full-design:** 33.156 Wh

Sensors:

- **Cooling Fan RPM Sensor:** asus-isa-0000
- **CPU Core Temperature Sensors:** coretemp-isa-0000 x 4
- **HDD temperature:** acpitz-acpi-0
- **Battery Voltage:** BAT0-acpi-0

Storage:

- **Capacity:** 1TB
- **Technology:** Hard disk drive (HDD)
- **Partitioning Scheme:** GUID Partition Table

DMI:

- Product:
 - **Name:** Vivobook 15_ASUS Laptop X540UAR
 - **Vendor:** ASUSTek COMPUTER INC.
- BIOS:
 - **Vendor:** American Megatrends inc. (AMI)
 - **Version:** X540UAR.306
- Board:
 - **Vendor:** ASUSTek COMPUTER INC.
- Chassis:
 - **Vendor:** ASUSTek COMPUTER INC.

Benchmarking Scores:

- **CPU Blowfish:** 1.33
- **CPU cryptohash:** 782.84
- **CPU Zlib:** 0.59
- **FPU FFT:** 0.88
- **FPU Raytracing:** 1.41
- **GPU Drawing:** 5471.91

Q4) before calling

0x15	
0xC	← %esp

<+0> push ebp

↳ pushing ebp to function stack

<+1> mov ebp, esp

making esp point to ebp

0x15	← ebp+0xC
0xC	← ebp+0x8
ret	← ebp+0x4
old ebp	← ebp

<+3> sub esp, 0x10 # esp = esp - 0x10

0x15	← ebp+0xC
0xC	← ebp+0x8
ret	← ebp+0x4
old ebp	← ebp
	← ebp-0x4, esp+0xC
	← ebp-0x8, esp+0x8
	← ebp-0xC, esp+0x4
	← esp, ebp+0x10

<+6> mov eax, DWORD PTR [ebp+0xC]
eax = 0x15

<+9> mov DWORD PTR [ebp-0x4], eax
*(ebp-0x4) = eax = 0x15

<+12> mov eax, DWORD PTR [ebp+0x8]
eax = *(ebp+0x8) = 0xC

<+15> mov DWORD PTR [ebp-0x8], eax
*(ebp-0x8) = eax = 0xC

0x15	← ebp+0xC
0xC	← ebp+0x8
ret	← ebp+0x4
old ebp	← ebp
0x15	← ebp-0x4, esp+0xC
0xC	← ebp-0x8, esp+0x8
	← ebp-0xC, esp+0x4
	← ebp-0x10, esp

<+18> jmp 0x50C <assemblycode +31>

jump to instruction at
address 0x50C i.e
assemblycode +31

<+20> add DWORD PTR [ebp-0x4], 0x1
*(ebp-0x4) += 1

<+24> add DWORD PTR [ebp-0x8], 0xaf
*(ebp-0x8) += 175

<+31> cmp DWORD PTR [ebp-0x8], 0xa3d3

<+38> jle 0x501 <assemblycode +20>

if *(ebp-0x8) <= 41939
go to instruction
on address
assemblycode +20

The above 5 lines are similar to:

while (*(ebp-0x8) <= 41939) {

*(ebp-0x4) += 1;

*(ebp-0x8) += 175;

}

The loop will execute

$$\text{floor}\left(\frac{0xa3d3 - 0xc}{0xaf}\right) + 1$$

times.

$$= 240 \text{ times} = 0xF0$$

$$\therefore *(ebp - 0x8) \text{ will become } 0xc + (0xF0 \cdot 0xaf) = 0xA41C$$

and $*(ebp - 0x4)$ will become

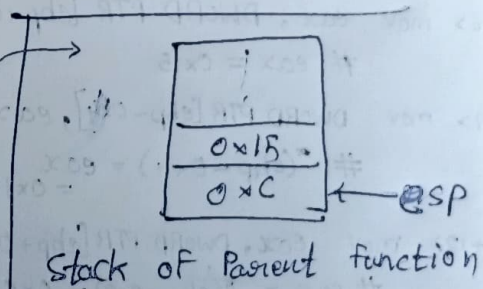
$$0x15 + (0xF0 \cdot 0x1) = 0x105$$

Stack before entering loop:

0x15	← ebp + 0xc
0xc	← ebp + 0x8
ret	← ebp + 0x4
old ebp	← ebp
0x15	← ebp - 0x4, esp + 0xc
0xc	← ebp - 0x8, esp + 0x8
	← ebp - 0xc, esp + 0x4
	← ebp - 0x10, esp

Stack after exiting loop.

0x15	
0xc	
ret	
old ebp	← ebp
0x105	← ebp - 0x4
0xA41C	



<+40> mov eax, DWORD PTR [ebp-0x4]

eax = $*(ebp - 0x4) = 0x105$

<+43> leave

make esp and ebp

as they were before

executing <+1>

<+44> ret # Return.

5 (a)

- the given executable "q5.out" shows up in the directory and also on running the command "ls" in terminal.
- But on trying to execute it by running "./q5.out" bash throws the error "No such file or directory"
- The problem here is the given executable is a DYN (shared object file), but the interpreter was not correct one.

(b)

- the type of the ELF file
DYN (shared object file)
- Machine - Advanced Micro Devices (x86-64)
- Data : 2's complement, Little endian