National Taiwan Normal University
CSIE Computer Programming I

Instructor: Po-Wen Chi
Due Date: 2024.10.22 PM 11:59

Assignment 2

Policies:

- Zero tolerance for late submission.
- Please pack all your submissions in one zip file. **RAR is not allowed!!**
- For convenience, your executable programs must be named following the rule hwXXYY, where the red part is the homework number and the blue part is the problem number. For example, hw0102 is the executable program for homework #1 problem 2.
- I only accept **PDF** or **TEXT**. MS Word is not allowed.
- Do not forget your Makefile. For convenience, each assignment needs only one Makefile.
- Please provide a README file. The README file should have at least the following information:
  - Your student ID and your name.
  - How to build your code.
  - How to execute your built programs.
  - Anything that you want to notify our TAs.
- **DO NOT BE A COPYCAT!!** You will get ZERO if you are caught.

2.1 Golden Ratio (20 pts)

In mathematics, two quantities are in the golden ratio if their ratio is the same as the ratio of their sum to the larger of the two quantities. That is,

$$\frac{a+b}{a} = \frac{a}{b} = \phi,$$

where the Greek letter ϕ denotes the golden ratio. It is easily shown that

$$\phi = \frac{1+\sqrt{5}}{2} = 1.618033988749\ldots.$$

The golden ratio is an irrational number and therefore, it is impossible to store the value as a floating point in your computer. What we can do is to make an approximation. I will show you an approach called **Continued fraction** .

$$\phi = 1 + \cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\ddots}}}$$

The sequence will be $1, 2, 1.5, 1.666\ldots, \ldots$ where you can verify them as follows:

$$1, 1+\frac{1}{1}, 1+\frac{1}{1+\frac{1}{1}}, 1+\frac{1}{1+\frac{1}{1+\frac{1}{1}}}, \ldots.$$

In mathematics, this sequence will finally converge to a constant. Is this true in programming? Please develop a program to calculate the value of ϕ from 1 to n. For your simplicity, I promise that n is a 16-bits unsigned integer. You should also calculate the difference between the value and **1.61803398874989484820**.

```
$ ./hw0201
Please enter n (16-bits unsigned): 2
n = 1: 1.00000000000000000000 (0.61803398874989484820)
n = 2: 2.00000000000000000000 (-0.xxxx) // 我懶的算了
```

Note that you should use **double** instead of float. The precision should be 20. This problem is to remind you that **precision of the floating point is a big issue in C language**.

2.2 DNA Sequence (20 pts)

The canonical structure of DNA has four bases: thymine (T), adenine (A), cytosine (C), and guanine (G). DNA sequencing is the determination of the physical order of these bases in a molecule of DNA. Many researches show that DNA sequence segment can be used to determine diseases. For example, suppose there is disease which has a DNA sequence segment as TAACCCGGG, then the molecule of DNA **AGCTTAG**TAACCCGGG**CCAATG** will show that the patient may have the disease.

First, the encoding of four bases is as follows:

- thymine (T): 1

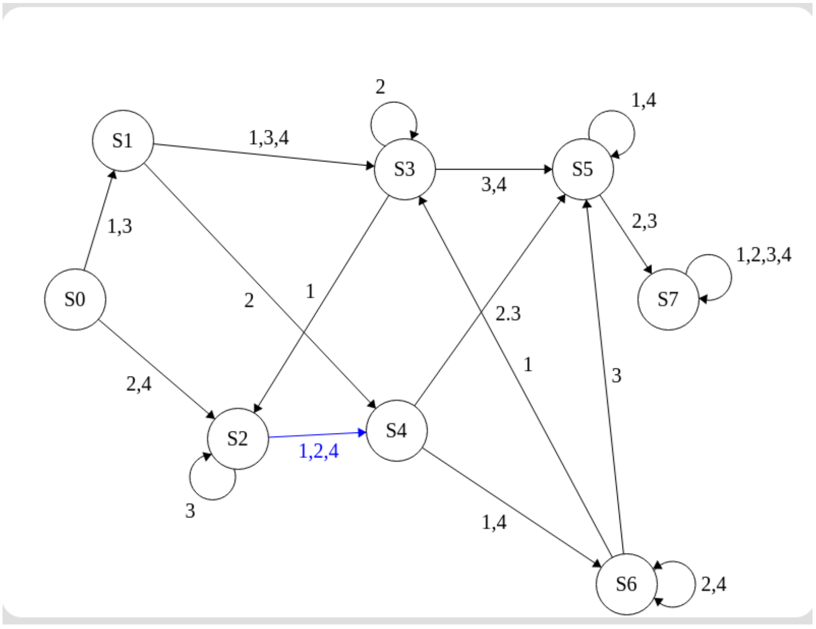


FIGURE 2.1: DNA sequence pattern.

- adenine (A): 2
- cytosine (C): 3
- guanine (G): 4

Undoubtedly, the DNA sequence segment may have more complex pattern. In this problem, I want to show you how to check if a given DNA sequence satisfies some complex pattern. Please see Fig. 2.1. The input starts from S_0 and transits to different states according to the inputs. After the last input, if the state is in S_7, it implies the given DNA sequence match this pattern. Here we use 0 to indicate the end of input.

The example is as follows.

```
$ ./hw0202
Please enter DNA base: 1
Please enter DNA base: 1
Please enter DNA base: 2
Please enter DNA base: 2
Please enter DNA base: 4
Please enter DNA base: 3
Please enter DNA base: 0
The state is in S7, the sequence satisfies the pattern.
$ ./hw0202
Please enter DNA base: 2
Please enter DNA base: 3
Please enter DNA base: 3
Please enter DNA base: 3
Please enter DNA base: 3
Please enter DNA base: 3
Please enter DNA base: 0
The state is in S2, the sequence does not satisfy the pattern.
```

Note that if there is an invalid input, **you should make the user re-input the base**.

PS. I am not familiar with DNA. So do not challenge me about DNA common sense.

2.3 Climate Change (20 pts)

Human-induced climate change includes both global warming driven by emissions of greenhouse gases and the resulting large-scale shifts in weather patterns. Though there have been previous periods of climatic change, since the mid-20th century humans have had an unprecedented impact on Earth's climate system and caused change on a global scale.

In this homework, I want you to implement a program to predict the temperature in the future. The user will input some past temperature data and you need to use **the linear model** to simulate the temperature change. That is, you need to use the following equation to predict the temperature.

$$T(t) = at + b,$$

where t is the year and $T(t)$ is the temperature of the year. Your job is to derive a and b from inputs based on the **least squares approach**. Do not worry, this is not a mathematics class, so you can learn how to get a and b from wikipedia.

The user input ends with -1.

```
$ ./hw0203
Please enter the year: 2000
Temperature: 29.5
Please enter the year: 2001
Temperature: 29.7
Please enter the year: 2002
Temperature: 29.6
Please enter the year: 2003
Temperature: 31.2
Please enter the year: 2004
Temperature: 30.5
Please enter the year: -1
Please enter the prediction year: 2022
Temperature: XXX
```

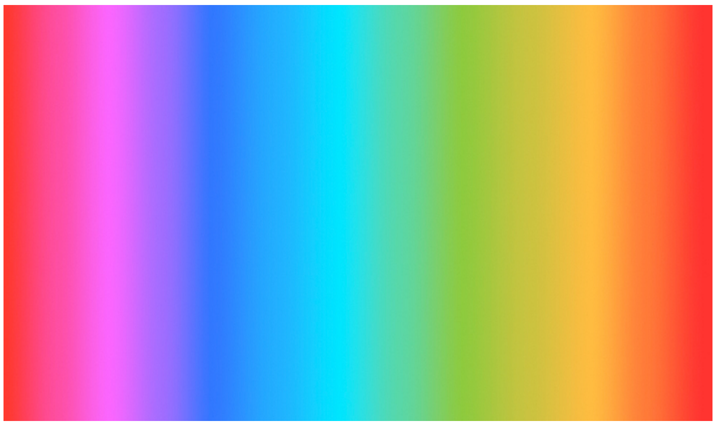
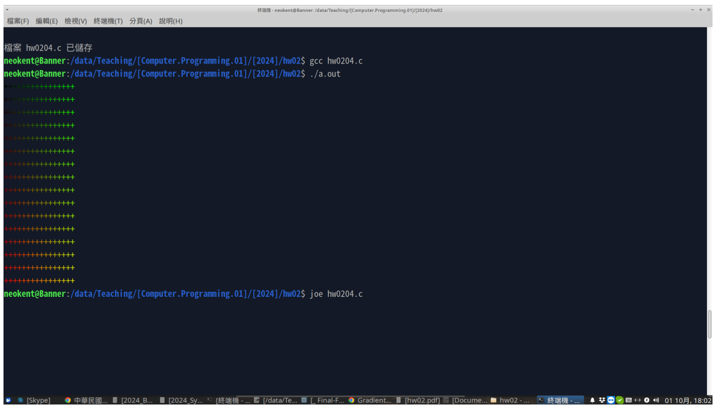


FIGURE 2.2: Colorful Gradient.



終端機 - neokent@Banner: /data/Teaching/[Computer.Programming.01]/[2024]/hw02
檔案(F) 編輯(E) 檢視(V) 終端機(T) 分頁(A) 說明(H)

```
檔案 hw0204.c 已儲存
neokent@Banner:/data/Teaching/[Computer.Programming.01]/[2024]/hw02$ gcc hw0204.c
neokent@Banner:/data/Teaching/[Computer.Programming.01]/[2024]/hw02$ ./a.out
++++++++++++++++
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neokent@Banner:/data/Teaching/[Computer.Programming.01]/[2024]/hw02$ joe hw0204.c
```

[Skype] 中華民國... [2024_B... [2024_Sy... [終端機 - ... [/data/Te... [_Final-F... Gradient... [hw02.pdf] [Docume... hw02 - ... 終端機 - ... 01 10月, 18:02

FIGURE 2.3: Colorful Gradient on Terminal.

2.4 Colorful Gradient (20 pts)

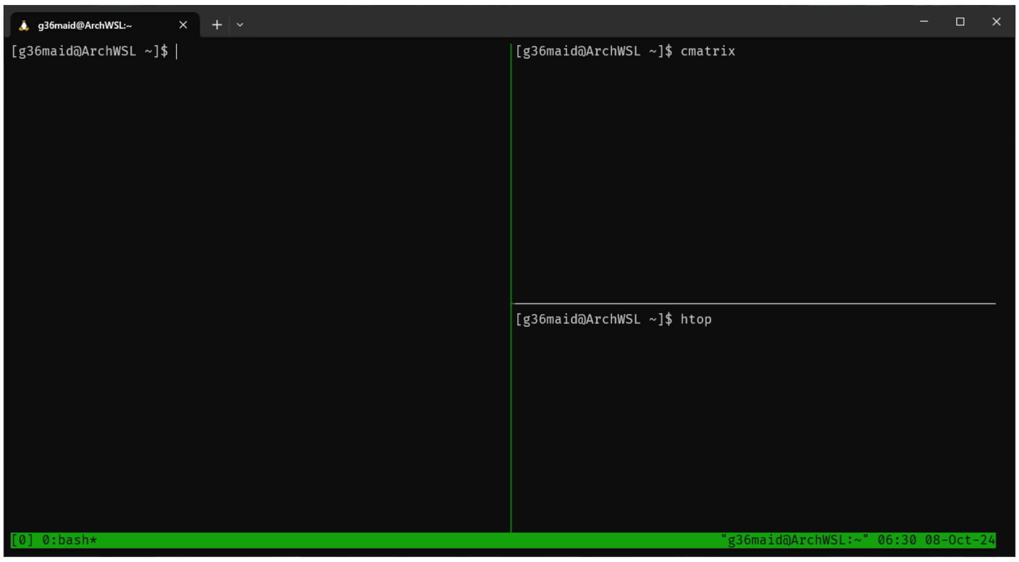
Do you know what gradient is? If no, that is fine. You can see Fig. 2.2.

This time, I want you to print a colorful gradient on your terminal like Fig. 2.3.

The input interface is defined as follows.

```
$ ./hw0204
Please enter the width (10-80):     16
Please enter the height (10-20):    16
Please enter the top left RGB:      255,255,255
Please enter the top right RGB:     255,0,0
Please enter the bottom left RGB:   255,255,0
Please enter the bottom right RGB: 0,0,0
```

Note that the RGB values must be between 0 to 255. For all invalid inputs, make the user to re-input again.



```
[g36maid@ArchWSL ~]$ |
```

```
[g36maid@ArchWSL ~]$ cmatrix
```

```
[g36maid@ArchWSL ~]$ htop
```

```
[0] 0:bash*                                        "g36maid@ArchWSL:~" 06:30 08-Oct-24
```

FIGURE 2.4: A tmux window tith 3 panes

2.5 Tmux is a Terminal Multiplexer (20 pts)

See HackMD version here.

In this problem, you CAN'T use any type of array..

Our TA G36 is a DevOps specialist. While configuring a new machine cluster using the terminal, he noticed that a single command line can only handle one operation at a time unless the task is sent to the background.

G36 is enthusiastic about tmux because it allows him to SSH into the machine, perform multiple tasks simultaneously, and avoid connection timeouts.

Tmux is an open-source terminal multiplexer for Unix-like operating systems. It allows multiple terminal sessions to be accessed simultaneously in a single window, which is useful for running more than one command-line program at a time.

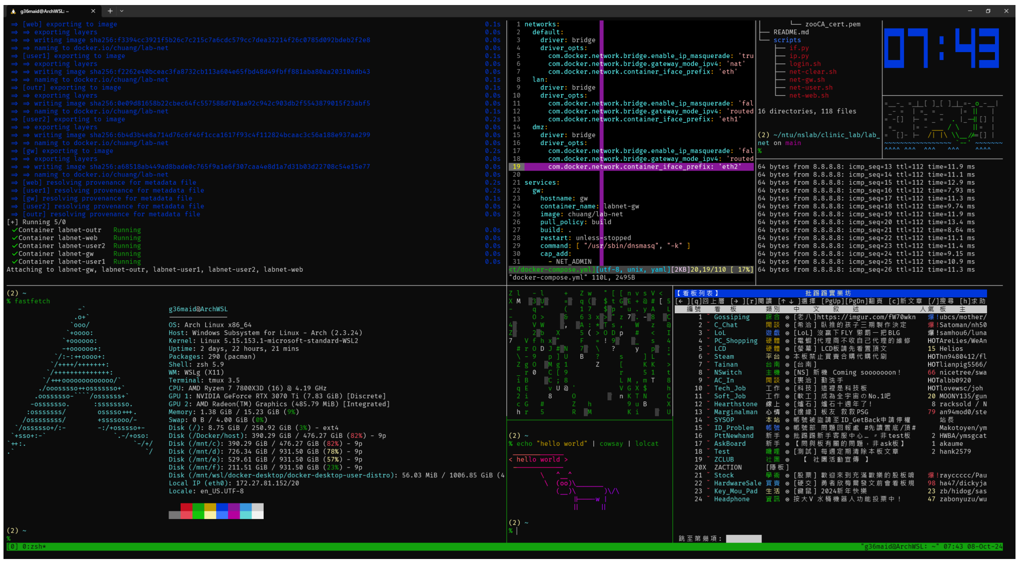
Each terminal inside tmux belongs to a pane, which is a rectangular area that displays the terminal' s contents. Multiple panes can appear within a single window, and each window is made up of one or more panes that cover its entire area.

Today, G36 wants to complete a task using tmux in a situation where multiple tasks need to be handled. Help him resize the panes into an equal layout and execute the final job on the machine:

Use**fastfetch** to print the Arch Linux logo, because he uses Arch BTW.

2.5.1 Example:

see figure 3,4 and 5



```
g36maid@ArchWSL: ~

 ⇒ [web] exporting to image                                                     0.1s
 ⇒ ⇒ exporting layers                                                           0.0s
 ⇒ ⇒ writing image sha256:f3394cc3921f5b26c7c215c7a6cdc579cc7dea32214f26c0785d092bdeb2f2e8   0.0s
 ⇒ ⇒ naming to docker.io/chuang/lab-net                                         0.0s
 ⇒ [user1] exporting to image                                                   0.1s
 ⇒ ⇒ exporting layers                                                           0.0s
 ⇒ ⇒ writing image sha256:f2262e40bceac3fa8732cb113a604e65fbd48d49fbff881aba80aa20310adb43   0.0s
 ⇒ ⇒ naming to docker.io/chuang/lab-net                                         0.1s
 ⇒ [outr] exporting to image                                                    0.1s
 ⇒ ⇒ exporting layers                                                           0.0s
 ⇒ ⇒ writing image sha256:0e09d81658b22cbec64fc557588d701aa92c942c903db2f5543879015f23abf5   0.0s
 ⇒ ⇒ naming to docker.io/chuang/lab-net                                         0.1s
 ⇒ [user2] exporting to image                                                   0.2s
 ⇒ ⇒ exporting layers                                                           0.0s
 ⇒ ⇒ writing image sha256:6b4d3b4e8a714d76c6f46f1cca1617f93c4f112824bcaac3c56a188e937aa299   0.0s
 ⇒ ⇒ naming to docker.io/chuang/lab-net                                         0.0s
 ⇒ [gw] exporting to image                                                      0.2s
 ⇒ ⇒ exporting layers                                                           0.0s
 ⇒ ⇒ writing image sha256:a68518ab449ad8bade0c765f9a1e6f307caa4e8d1a7d31b03d22708c54e15e77   0.0s
 ⇒ ⇒ naming to docker.io/chuang/lab-net                                         0.0s
 ⇒ [web] resolving provenance for metadata file                                 0.2s
 ⇒ [user1] resolving provenance for metadata file                               0.2s
 ⇒ [gw] resolving provenance for metadata file                                  0.1s
 ⇒ [user2] resolving provenance for metadata file                               0.0s
 ⇒ [outr] resolving provenance for metadata file                                0.0s
[+] Running 5/0
 ✓Container labnet-outr   Running                                               0.0s
 ✓Container labnet-web    Running                                               0.0s
 ✓Container labnet-user2  Running                                               0.0s
 ✓Container labnet-gw     Running                                               0.0s
 ✓Container labnet-user1  Running                                               0.0s
Attaching to labnet-gw, labnet-outr, labnet-user1, labnet-user2, labnet-web
```

```
networks:
  default:
    driver: bridge
    driver_opts:
      com.docker.network.bridge.enable_ip_masquerade: 'tru
      com.docker.network.bridge.gateway_mode_ipv4: 'nat'
      com.docker.network.container_iface_prefix: 'eth'
  lan:
    driver: bridge
    driver_opts:
      com.docker.network.bridge.enable_ip_masquerade: 'fal
      com.docker.network.bridge.gateway_mode_ipv4: 'routed
      com.docker.network.container_iface_prefix: 'eth1'
  dmz:
    driver: bridge
    driver_opts:
      com.docker.network.bridge.enable_ip_masquerade: 'fal
      com.docker.network.bridge.gateway_mode_ipv4: 'routed
      com.docker.network.container_iface_prefix: 'eth2'

services:
  gw:
    hostname: gw
    container_name: labnet-gw
    image: chuang/lab-net
    pull_policy: build
    build: .
    restart: unless-stopped
    command: [ "/usr/sbin/dnsmasq", "-k" ]
    cap_add:
      - NET_ADMIN
<t/docker-compose.yml][utf-8, unix, yaml][2KB]20,19/110 [ 17%]
"docker-compose.yml" 110L, 2495B
```

```
        └── zooCA_cert.pem
├── README.md
└── scripts
    ├── if.py
    ├── ip.py
    ├── login.sh
    ├── net-clear.sh
    ├── net-gw.sh
    ├── net-user.sh
    └── net-web.sh

16 directories, 118 files

(2) ~/ntu/nslab/clinic_lab/lab_
net on main
%
```

```
07:43
```

```
64 bytes from 8.8.8.8: icmp_seq=13 ttl=112 time=11.9 ms
64 bytes from 8.8.8.8: icmp_seq=14 ttl=112 time=11.1 ms
64 bytes from 8.8.8.8: icmp_seq=15 ttl=112 time=12.9 ms
64 bytes from 8.8.8.8: icmp_seq=16 ttl=112 time=7.93 ms
64 bytes from 8.8.8.8: icmp_seq=17 ttl=112 time=11.3 ms
64 bytes from 8.8.8.8: icmp_seq=18 ttl=112 time=9.74 ms
64 bytes from 8.8.8.8: icmp_seq=19 ttl=112 time=11.9 ms
64 bytes from 8.8.8.8: icmp_seq=20 ttl=112 time=13.4 ms
64 bytes from 8.8.8.8: icmp_seq=21 ttl=112 time=8.64 ms
64 bytes from 8.8.8.8: icmp_seq=22 ttl=112 time=11.1 ms
64 bytes from 8.8.8.8: icmp_seq=23 ttl=112 time=11.4 ms
64 bytes from 8.8.8.8: icmp_seq=24 ttl=112 time=9.15 ms
64 bytes from 8.8.8.8: icmp_seq=25 ttl=112 time=10.9 ms
64 bytes from 8.8.8.8: icmp_seq=26 ttl=112 time=11.3 ms
```

```
(2) ~
% fastfetch
                        g36maid@ArchWSL
                        ───────────────
                        OS: Arch Linux x86_64
                        Host: Windows Subsystem for Linux - Arch (2.3.24)
                        Kernel: Linux 5.15.153.1-microsoft-standard-WSL2
                        Uptime: 2 days, 22 hours, 21 mins
                        Packages: 290 (pacman)
                        Shell: zsh 5.9
                        WM: WSLg (X11)
                        Terminal: tmux 3.5
                        CPU: AMD Ryzen 7 7800X3D (16) @ 4.19 GHz
                        GPU 1: NVIDIA GeForce RTX 3070 Ti (7.83 GiB) [Discrete]
                        GPU 2: AMD Radeon(TM) Graphics (485.79 MiB) [Integrated]
                        Memory: 1.38 GiB / 15.23 GiB (9%)
                        Swap: 0 B / 4.00 GiB (0%)
                        Disk (/): 8.75 GiB / 250.92 GiB (3%) - ext4
                        Disk (/Docker/host): 390.29 GiB / 476.27 GiB (82%) - 9p
                        Disk (/mnt/c): 390.29 GiB / 476.27 GiB (82%) - 9p
                        Disk (/mnt/d): 726.34 GiB / 931.50 GiB (78%) - 9p
                        Disk (/mnt/e): 529.61 GiB / 931.50 GiB (57%) - 9p
                        Disk (/mnt/f): 211.51 GiB / 931.50 GiB (23%) - 9p
                        Disk (/mnt/wsl/docker-desktop/docker-desktop-user-distro): 56.03 MiB / 1006.85 GiB (4
                        Local IP (eth0): 172.27.81.152/20
                        Locale: en_US.UTF-8

(2) ~
%
[0] 0:zsh*
```

```
(2) ~
% echo "hello world" | cowsay | lolcat
 _____________
< hello world >
 -------------
        \   ^__^
         \  (oo)\_______
            (__)\       )\/\
                ||----w |
                ||     ||

(2) ~
% |
```

```
【看板列表】                         批踢踢實業坊
[←][q]回上層 [→][r]閱讀 [↑↓]選擇 [PgUp][PgDn]翻頁 [c]新文章 [/]搜尋 [h]求助
   編號   看  板       類別   中   文   敘   述              人氣 板   主
     1 ˇ Gossiping    綜合 ◎ [老八]https://imgur.com/fW70wkn  爆!ubcs/mother/
     2 ˇ C_Chat       閒談 ◎ [希洽] 臥推的孩子三期製作決定     爆!Satoman/nh50
     3 ˇ LoL          遊戲 ◎ [LoL] 沒贏下FLY 懲罰一把BLG       爆!samhou6/luna
     4 ˇ PC_Shopping  硬體 ◎ [電蝦]代理商不收自己代理的維修   HOTAreLies/WeAn
     5 ˇ LCD          硬體 ◎ [螢幕] LCD板請先看置頂文          15 Helios
     6 ˇ Steam        平台 ◎ 本板禁止買賣合購代購代刷          HOThn9480412/fl
     7 ˇ Tainan       台南 ◎ [台南]                            HOTlianpig5566/
     8 ˇ NSwitch      主機 ◎ [NS] 新機 Coming soooooooon!      66 nicetree/swa
     9 ˇ AC_In        閒談 ◎ [裏洽] 勤洗手                     HOTalbb0920
    10 ˇ Tech_Job     工作 ◎ [科技] 這裡是科技板               HOTlovewsc/joh
    11 ˇ Soft_Job     工作 ◎ [軟工] 成為全宇宙のNo.1吧         20 MOONY135/gun
    12 ˇ Hearthstone  線上 ◎ [爐石] 爐石十週年了!              8 racksold / N
    13 ˇ Marginalman  心情 ◎ [邊緣] 板友 救救PSG               79 an94mod0/ste
    14 ˇ SYSOP        本站 ◎ 帳號被盜請至ID_GetBack申請停權       站長
    15 ˇ ID_Problem   帳號 ◎ 帳號部 問題回報處 #先讀置底/頂#      Makotoyen/ym
    16   PttNewhand   新手 ◎ 批踢踢新手客服中心… 〃非test板     2 HWBA/ymsgcat
    17 ˇ AskBoard     新手 ◎ 【問與板有關的問題，非ask板】      1 akaume
    18 ˇ Test         嘰哩 ◎ [測試] 每週定期清除本板文章        2 hank2579
    19 ˇ ZCLUB        社團 ◎   【 社團活動宣傳 】
    20X  ZACTION      [隱板]
    21 ˇ Stock        學術 ◎ [股票] 歡迎來到充滿歡樂的股板唷   爆!rayccccc/Pau
    22 ˇ HardwareSale 買賣 ◎ [硬交] 勇者欣梅爾發文前會看板規  98 ha47/dickyja
    23 ˇ Key_Mou_Pad  生活 ◎ [鍵鼠] 2024新年快樂              23 zb/hidog/sas
    24 ˇ Headphone    資訊 ◎ 按大V 水桶機器人功能投票中!       47 zabonyuzu/wu

 跳至第幾項:
                                       "g36maid@ArchWSL: ~" 07:43 08-Oct-24
```

FIGURE 2.5: A tmux window with a complex pane layout

2.5.2 Explanation

Your task is to display a window with multiple panes, equally dividing the window into panes of the same size. Each pane should be separated by box-drawing characters from Unicode.

For each pane, print a single character **$** to represent the shell. At the bottom of the window, print **[0] 0:bash*** at the bottom left with black text on a green background.

You should divide the panes to fill the window, allowing only a one-character difference in height and width per pane.

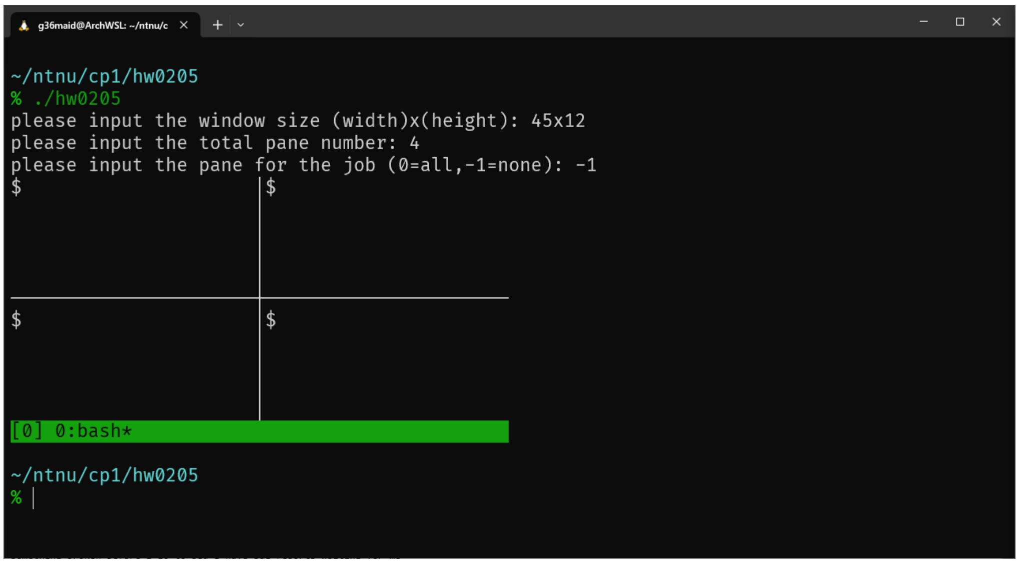
The number of panes should be arranged in a near-square layout, allowing only one pane to differ in height and width when handling extra panes.

You don't need to worry about commands that fill all the space in a line; this is not a test case.

2.5.3 Handling Extra Panes:

- If the number of extra panes is less than or equal to the number of panes in the width, display them at the bottom from left to right. These panes don' t need to be divided; the last one can be larger and take up extra space.(see testcase 2)

- If the number of extra panes is greater than the number of panes in the width, increase the number of panes per row by 1, then resize and display them at the bottom from left to right.(see testcase 3)



```
~/ntnu/cp1/hw0205
% ./hw0205
please input the window size (width)x(height): 45x12
please input the total pane number: 4
please input the pane for the job (0=all,-1=none): -1
$                                            |$
                                             |
                                             |
                                             |
                                             |
---------------------------------------------+---------------------------------------------
$                                            |$
                                             |
                                             |
                                             |
[0] 0:bash*

~/ntnu/cp1/hw0205
% |
```

FIGURE 2.6: testcase1

- Note that when increasing the number of panes per row or column, they should be resized to maintain a uniform appearance, allowing only a one-character difference.

2.5.4 Task: Print the Arch Linux Logo

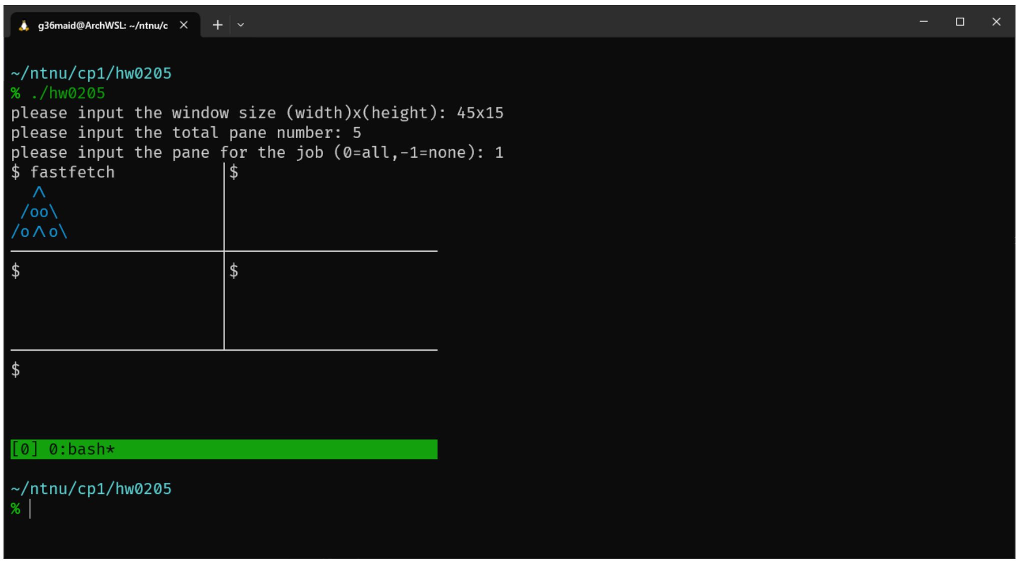
In the specified pane, print the Arch Linux logo using **fastfetch**. For simplicity, the logo is redesigned to contain only **/,o,\**, forming a triangle with a smaller empty triangle with 1/3 size inside.

You should automatically resize the logo' s height and width to fit within the pane after printing fastfetch. The bottleneck can determine the size.

The logo should be printed in Arch Linux's Curious Blue (Hex: #1793d1, RGB: 23, 147, 209).

```
$ fastfetch
        /\
       /oo\
      /oooo\
     /oooooo\
    /oooooooo\
   /oooooooooo\
  /ooooo/\ooooo\
 /ooooo/  \ooooo\
/ooooo/    \ooooo\
```

Examples: see example at here



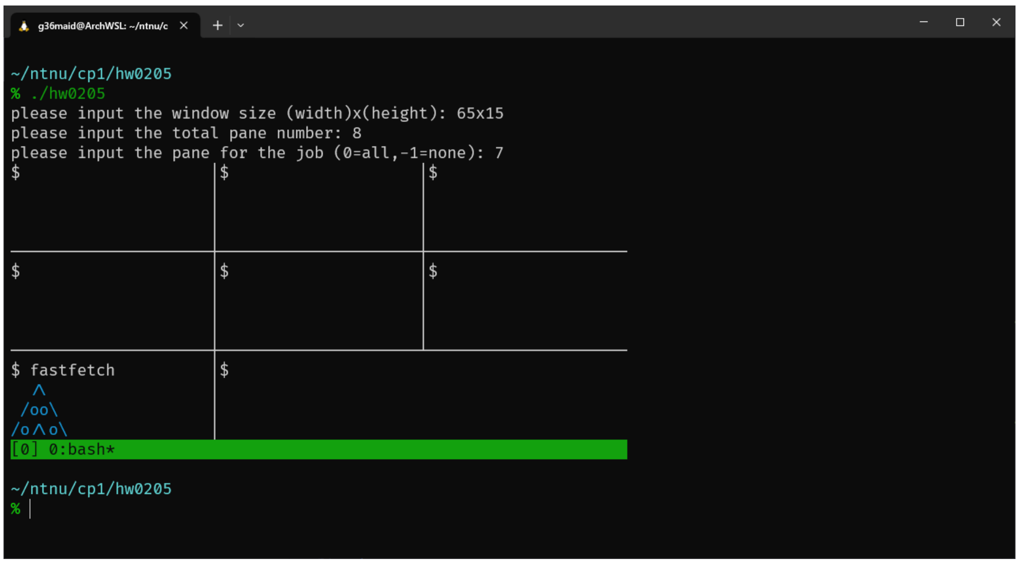
```
~/ntnu/cp1/hw0205
% ./hw0205
please input the window size (width)x(height): 45x15
please input the total pane number: 5
please input the pane for the job (0=all,-1=none): 1
$ fastfetch           |$
  /\
 /oo\
/o/\o\
----------------------+---------------------
$                     |$
                      |
                      |
----------------------+---------------------
$



[0] 0:bash*

~/ntnu/cp1/hw0205
%
```

FIGURE 2.7: testcase2



```
~/ntnu/cp1/hw0205
% ./hw0205
please input the window size (width)x(height): 65x15
please input the total pane number: 8
please input the pane for the job (0=all,-1=none): 7
$                    |$                    |$
                     |                     |
                     |                     |
---------------------+---------------------+--------------------
$                    |$                    |$
                     |                     |
                     |                     |
---------------------+---------------------+--------------------
$ fastfetch          |$
  /\                 |
 /oo\                |
/o/\o\               |
[0] 0:bash*

~/ntnu/cp1/hw0205
%
```

FIGURE 2.8: testcase3

2.5.5 Box-drawing characters

- (U+2500) Box Drawings Light Horizontal
- (U+2502) Box Drawings Light Vertical
- (U+250C) Box Drawings Light Down and Right
- (U+2510) Box Drawings Light Down and Left
- (U+2514) Box Drawings Light Up and Right
- (U+2518) Box Drawings Light Up and Left
- (U+251C) Box Drawings Light Vertical and Right
- (U+2524) Box Drawings Light Vertical and Left
- (U+252C) Box Drawings Light Down and Horizontal
- (U+2534) Box Drawings Light Up and Horizontal
- (U+253C) Box Drawings Light Vertical and Horizontal

2.5.6 reference

- Wikipedia:tmux (EN)
- tmux(1)-linux manual page
- Box-drawing characters (Unicode)
- fastfetch

2.6 Bonus: How Conversion Works? (5 pts)

In this class, I have told you that standard C allows conversion between different numeric types, like **int, unsigned int, float double**. Please describe how conversion works between the following pairs.

- **float ↔ int32_t**
- **int32_t ↔ uint32_t**
- **double ↔ float**

Please look up the specification instead of guess from observation. You should also provide examples to show your description.