第一题

0.1 运行结果

注意左边图片是生产者，右边图片时消费者

参数为（1，1）时结果—分别对应生产者，消费者

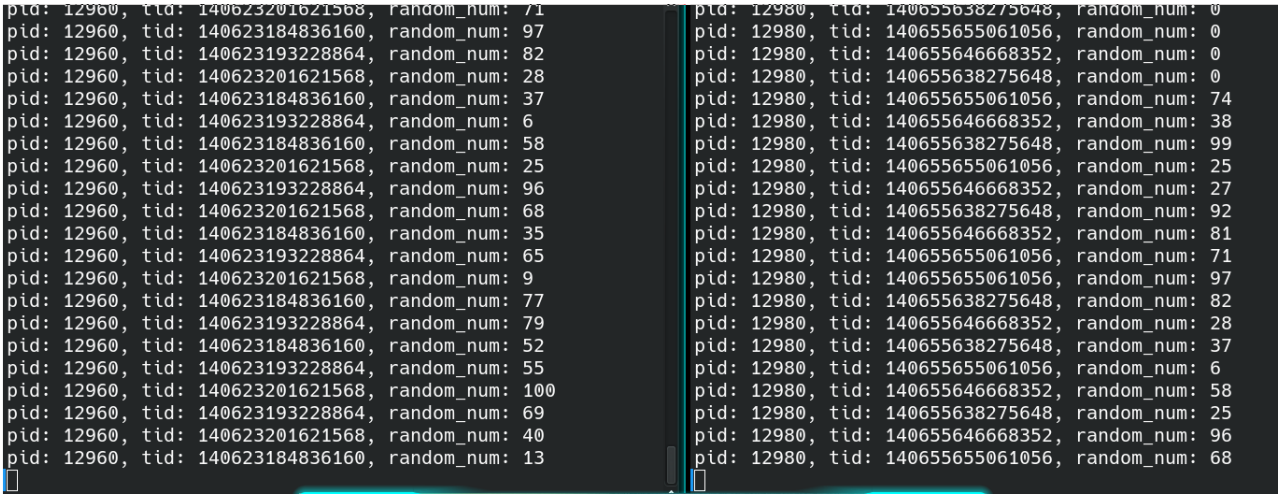
```
pid: 12655, tid: 140097100629568, random_num: 9
pid: 12655, tid: 140097109022272, random_num: 77
pid: 12655, tid: 140097117414976, random_num: 79
pid: 12655, tid: 140097100629568, random_num: 52
pid: 12655, tid: 140097109022272, random_num: 55
pid: 12655, tid: 140097117414976, random_num: 100
pid: 12655, tid: 140097109022272, random_num: 69
pid: 12655, tid: 140097117414976, random_num: 40
pid: 12655, tid: 140097100629568, random_num: 13
pid: 12655, tid: 140097117414976, random_num: 40
pid: 12655, tid: 140097109022272, random_num: 96
pid: 12655, tid: 140097100629568, random_num: 71
pid: 12655, tid: 140097117414976, random_num: 2
pid: 12655, tid: 140097109022272, random_num: 98
pid: 12655, tid: 140097100629568, random_num: 3
pid: 12655, tid: 140097109022272, random_num: 57
pid: 12655, tid: 140097117414976, random_num: 2
pid: 12655, tid: 140097100629568, random_num: 81
pid: 12655, tid: 140097100629568, random_num: 90
pid: 12655, tid: 140097109022272, random_num: 45
pid: 12655, tid: 140097117414976, random_num: 20
WarriorHanamy%
```

```
pid: 12687, tid: 140360040347200, random_num: 9
pid: 12687, tid: 140360031954496, random_num: 77
pid: 12687, tid: 140360023561792, random_num: 79
pid: 12687, tid: 140360031954496, random_num: 52
pid: 12687, tid: 140360040347200, random_num: 55
pid: 12687, tid: 140360023561792, random_num: 100
pid: 12687, tid: 140360023561792, random_num: 69
pid: 12687, tid: 140360031954496, random_num: 40
pid: 12687, tid: 140360040347200, random_num: 13
pid: 12687, tid: 140360040347200, random_num: 40
pid: 12687, tid: 140360023561792, random_num: 96
pid: 12687, tid: 140360031954496, random_num: 71
pid: 12687, tid: 140360023561792, random_num: 2
pid: 12687, tid: 140360031954496, random_num: 98
pid: 12687, tid: 140360040347200, random_num: 3
pid: 12687, tid: 140360023561792, random_num: 57
pid: 12687, tid: 140360031954496, random_num: 2
pid: 12687, tid: 140360040347200, random_num: 81
pid: 12687, tid: 140360023561792, random_num: 90
pid: 12687, tid: 140360040347200, random_num: 45
pid: 12687, tid: 140360031954496, random_num: 20
WarriorHanamy%
```

参数为（1，2）时结果，生产速度快于消费速度

```
pid: 12960, tid: 140623184836160, random_num: 68
pid: 12960, tid: 140623193228864, random_num: 30
pid: 12960, tid: 140623184836160, random_num: 24
pid: 12960, tid: 140623201621568, random_num: 68
pid: 12960, tid: 140623193228864, random_num: 36
pid: 12960, tid: 140623184836160, random_num: 59
pid: 12960, tid: 140623201621568, random_num: 70
pid: 12960, tid: 140623193228864, random_num: 68
pid: 12960, tid: 140623184836160, random_num: 43
pid: 12960, tid: 140623201621568, random_num: 30
pid: 12960, tid: 140623193228864, random_num: 74
pid: 12960, tid: 140623201621568, random_num: 38
pid: 12960, tid: 140623184836160, random_num: 99
pid: 12960, tid: 140623193228864, random_num: 25
pid: 12960, tid: 140623201621568, random_num: 27
pid: 12960, tid: 140623193228864, random_num: 92
pid: 12960, tid: 140623184836160, random_num: 81
pid: 12960, tid: 140623201621568, random_num: 71
pid: 12960, tid: 140623184836160, random_num: 97
pid: 12960, tid: 140623193228864, random_num: 82
pid: 12960, tid: 140623201621568, random_num: 28
```

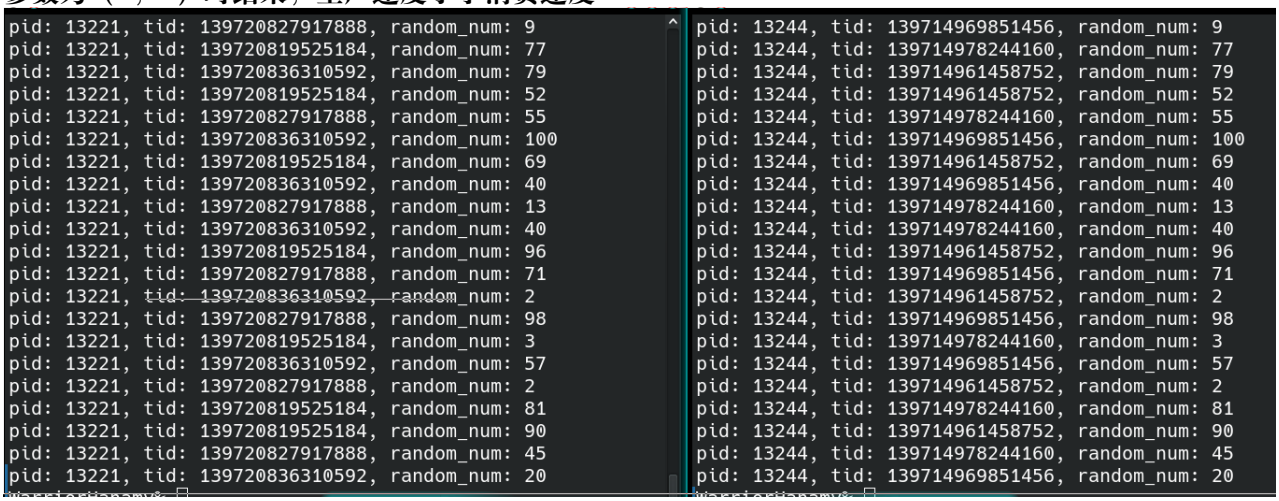
```
pid: 12980, tid: 140655655061056, random_num: 30
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
```



```
pid: 12960, tid: 140623201621568, random_num: 71
pid: 12960, tid: 140623184836160, random_num: 97
pid: 12960, tid: 140623193228864, random_num: 82
pid: 12960, tid: 140623201621568, random_num: 28
pid: 12960, tid: 140623184836160, random_num: 37
pid: 12960, tid: 140623193228864, random_num: 6
pid: 12960, tid: 140623184836160, random_num: 58
pid: 12960, tid: 140623201621568, random_num: 25
pid: 12960, tid: 140623193228864, random_num: 96
pid: 12960, tid: 140623201621568, random_num: 68
pid: 12960, tid: 140623184836160, random_num: 35
pid: 12960, tid: 140623193228864, random_num: 65
pid: 12960, tid: 140623201621568, random_num: 9
pid: 12960, tid: 140623184836160, random_num: 77
pid: 12960, tid: 140623193228864, random_num: 79
pid: 12960, tid: 140623184836160, random_num: 52
pid: 12960, tid: 140623193228864, random_num: 55
pid: 12960, tid: 140623201621568, random_num: 100
pid: 12960, tid: 140623193228864, random_num: 69
pid: 12960, tid: 140623201621568, random_num: 40
pid: 12960, tid: 140623184836160, random_num: 13
```

```
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 0
pid: 12980, tid: 140655646668352, random_num: 0
pid: 12980, tid: 140655638275648, random_num: 0
pid: 12980, tid: 140655655061056, random_num: 74
pid: 12980, tid: 140655646668352, random_num: 38
pid: 12980, tid: 140655638275648, random_num: 99
pid: 12980, tid: 140655655061056, random_num: 25
pid: 12980, tid: 140655646668352, random_num: 27
pid: 12980, tid: 140655638275648, random_num: 92
pid: 12980, tid: 140655646668352, random_num: 81
pid: 12980, tid: 140655655061056, random_num: 71
pid: 12980, tid: 140655655061056, random_num: 97
pid: 12980, tid: 140655638275648, random_num: 82
pid: 12980, tid: 140655646668352, random_num: 28
pid: 12980, tid: 140655638275648, random_num: 37
pid: 12980, tid: 140655655061056, random_num: 6
pid: 12980, tid: 140655646668352, random_num: 58
pid: 12980, tid: 140655638275648, random_num: 25
pid: 12980, tid: 140655646668352, random_num: 96
pid: 12980, tid: 140655655061056, random_num: 68
```

参数为（2，1）时结果，生产速度小于消费速度



```
pid: 13221, tid: 139720827917888, random_num: 9
pid: 13221, tid: 139720819525184, random_num: 77
pid: 13221, tid: 139720836310592, random_num: 79
pid: 13221, tid: 139720819525184, random_num: 52
pid: 13221, tid: 139720827917888, random_num: 55
pid: 13221, tid: 139720836310592, random_num: 100
pid: 13221, tid: 139720819525184, random_num: 69
pid: 13221, tid: 139720836310592, random_num: 40
pid: 13221, tid: 139720827917888, random_num: 13
pid: 13221, tid: 139720836310592, random_num: 40
pid: 13221, tid: 139720819525184, random_num: 96
pid: 13221, tid: 139720827917888, random_num: 71
pid: 13221, tid: 139720836310592, random_num: 2
pid: 13221, tid: 139720827917888, random_num: 98
pid: 13221, tid: 139720819525184, random_num: 3
pid: 13221, tid: 139720836310592, random_num: 57
pid: 13221, tid: 139720827917888, random_num: 2
pid: 13221, tid: 139720819525184, random_num: 81
pid: 13221, tid: 139720819525184, random_num: 90
pid: 13221, tid: 139720827917888, random_num: 45
pid: 13221, tid: 139720836310592, random_num: 20
```

```
pid: 13244, tid: 139714969851456, random_num: 9
pid: 13244, tid: 139714978244160, random_num: 77
pid: 13244, tid: 139714961458752, random_num: 79
pid: 13244, tid: 139714961458752, random_num: 52
pid: 13244, tid: 139714978244160, random_num: 55
pid: 13244, tid: 139714969851456, random_num: 100
pid: 13244, tid: 139714961458752, random_num: 69
pid: 13244, tid: 139714969851456, random_num: 40
pid: 13244, tid: 139714978244160, random_num: 13
pid: 13244, tid: 139714978244160, random_num: 40
pid: 13244, tid: 139714961458752, random_num: 96
pid: 13244, tid: 139714969851456, random_num: 71
pid: 13244, tid: 139714961458752, random_num: 2
pid: 13244, tid: 139714969851456, random_num: 98
pid: 13244, tid: 139714978244160, random_num: 3
pid: 13244, tid: 139714969851456, random_num: 57
pid: 13244, tid: 139714961458752, random_num: 2
pid: 13244, tid: 139714978244160, random_num: 81
pid: 13244, tid: 139714961458752, random_num: 90
pid: 13244, tid: 139714978244160, random_num: 45
pid: 13244, tid: 139714969851456, random_num: 20
```

0.2 生产者代码部分

```
#include <stdio.h>
#include <string.h>
#include <fcntl.h>
#include <sys/stat.h>
#include <semaphore.h>
#include <unistd.h>
#include <stdlib.h>
```

```c
#include <sys/mman.h>
#include <time.h>
#include <math.h>
#include <pthread.h>

/// BASIC STRUCTURE
#define NUM_THREADS 3
#define MAX_PRODUCT 20
typedef struct product_s
{
        pthread_mutex_t mutex;
        short init;
        int rear;
        int front;
        int data[20];
}product;


int negative_exponential_distribution(double lambda)
{
        double pV = 0.0;
    while(1)
    {
        pV = (double)rand()/(double)RAND_MAX;
        if (pV != 1)
        {
            break;
        }
    }
    pV = (-1.0/lambda)*log(1-pV);
    return (int)(pV * 1000000);
}
```

```
sem_t *sem_full;
sem_t *sem_empty;
product *p;
pthread_t tid[NUM_THREADS];

void *producer(void *param)
{
        int lambda = *(int*)param;
        int random_time = negative_exponential_distribution(lambda);
        usleep(random_time);




        int random_data = rand() % 100 + 1;

///CRTICAL REGION///
        sem_wait(sem_empty);
        pthread_mutex_lock(&(p->mutex));
    p->data[p->rear] = random_data;
    printf("pid: %d, tid: %lu, random_num: %d\n",
                        getpid(), (unsigned long)pthread_self(), p->data[p->re
        p->rear = (p->rear + 1) % MAX_PRODUCT;
        pthread_mutex_unlock(&(p->mutex));
    sem_post(sem_full);

}

int main(int argc, char** argv)
{

    sem_full = sem_open("/Full", O_CREAT, 0644, 0);
```

```
sem_empty = sem_open("/Empty", O_CREAT, 0644, 20);

///SHARED MEMORY CREATE
int fd = shm_open("/sh_product", O_CREAT | O_RDWR, 0644);


ftruncate(fd, sizeof(product));

//MAP FOR SHARED MOREMORY
p = mmap(0, sizeof(product), PROT_WRITE, MAP_SHARED, fd, 0);
p->init = 0;


if (p->init != 1) {
    memset(p, 0, sizeof(product));
    p->init = 1;
}

pthread_mutex_init(&(p->mutex), NULL);


pthread_attr_t attr;
pthread_attr_init(&attr);

int lambda = atoi(argv[1]);

for (int loop = 0; loop < 20; loop++)
    {
        int i;
            for(i = 0; i < NUM_THREADS; i++)
            pthread_create(&tid[i], &attr, producer, &lambda);

        for(i = 0; i < NUM_THREADS; i++)
```

```
                pthread_join(tid[i], NULL);
        }


    munmap(p, sizeof(product));
    //UNLINK SHARED MOREMORY
    shm_unlink("/sh_product");

    sem_close(sem_full);
    sem_close(sem_empty);

    return 0;
}
```

0.3 消费者代码部分

```
#include <stdio.h>
#include <string.h>
#include <fcntl.h>
#include <sys/stat.h>
#include <semaphore.h>
#include <unistd.h>
#include <stdlib.h>
#include <sys/mman.h>
#include <time.h>
#include <math.h>
#include <pthread.h>

//SAME TO prodocuer.c

///BASIC STRUCTURE
#define NUM_THREADS 3
#define MAX_PRODUCT 20
```

```
typedef struct product_s
{
        pthread_mutex_t mutex;
        short init;
        int rear;
        int front;
        int data[20];
}product;

int negative_exponential_distribution(double lambda){
        double pV = 0.0;
    while(1)
    {
        pV = (double)rand()/(double)RAND_MAX;
        if (pV != 1)
        {
            break;
        }
    }
    pV = (-1.0/lambda)*log(1-pV);
    return (int)(pV * 1000000);
}

sem_t *sem_full;
sem_t *sem_empty;
product *p;
pthread_t tid[NUM_THREADS];

void *consumer(void *param)
{
        int lambda = *(int*)param;
        int random_time = negative_exponential_distribution(lambda);
        usleep(random_time);
```

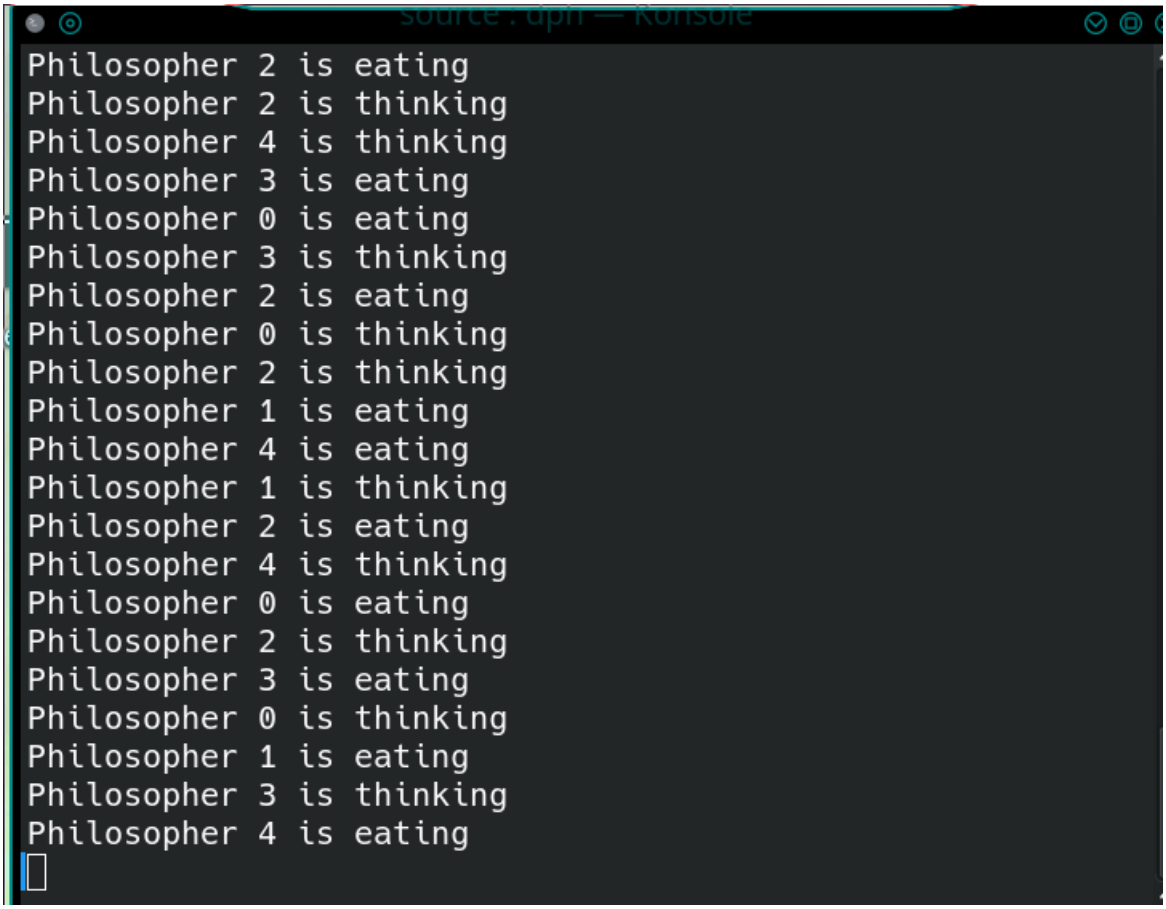
```
    sem_wait(sem_full);


    pthread_mutex_unlock(&(p->mutex));
    printf("pid: %d, tid: %lu, random_num: %d\n", getpid(), (unsigned long)p
    p->data[p->front] = 0;
    p->front = (p->front + 1) % MAX_PRODUCT;
        pthread_mutex_unlock(&(p->mutex));

    sem_post(sem_empty);


}

int main(int argc, char** argv)
{

        sem_full = sem_open("/Full", O_EXCL, 0644, 0);
    if (sem_full == SEM_FAILED) {
        fprintf(stderr, "sem_open error\n");
        exit(1);
    }


    sem_empty = sem_open("/Empty", O_EXCL, 0644, 20);
    if (sem_empty == SEM_FAILED) {
        fprintf(stderr, "sem_open error\n");
        exit(1);
    }
```

```
int fd = shm_open("/sh_product", O_CREAT | O_RDWR, 0666);
if (fd < 0) {
    fprintf(stderr, "shm_open error\n");
    exit(1);
}


p = mmap(NULL, sizeof(product), PROT_WRITE, MAP_SHARED, fd, 0);
if (p == MAP_FAILED) {
    fprintf(stderr, "mmap error\n");
    exit(1);
}

if (p->init != 1) {
    memset(p, 0, sizeof(product));
    p->init = 1;
}

pthread_attr_t attr;
pthread_attr_init(&attr);

int lambda = atoi(argv[1]);
int loop;
for (loop = 0; loop < 20; loop++)
    {
        int i;
            for(i = 0; i < NUM_THREADS; i++)
            pthread_create(&tid[i], &attr, consumer, &lambda);

        for(i = 0; i < NUM_THREADS; i++)
            pthread_join(tid[i], NULL);
    }
```

```
    munmap(p, sizeof(product));
    shm_unlink("/sh_product");

    sem_close(sem_full);
    sem_close(sem_empty);

    return 0;
}
```

第二题

0.4 运行结果



0.5 哲学家代码部分

```
#include <pthread.h>
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <time.h>
#include <pthread.h>


#define NUMBER 5
#define MAX_SLEEP_TIME  3
enum {THINKING, HUNGRY, EATING} state[NUMBER];

// THREADS FOR PHILOSOPHERS
int thread_id[NUMBER];


pthread_cond_t          cond_vars[NUMBER];
pthread_mutex_t         mutex_lock;

void *philosopher(void *param);
pthread_t tid[NUMBER];

void init()
{
        int i;

        for (i = 0; i < NUMBER; i++)
        {
                state[i] = THINKING;
                thread_id[i] = i;
                pthread_cond_init(&cond_vars[i],NULL);
        }
```

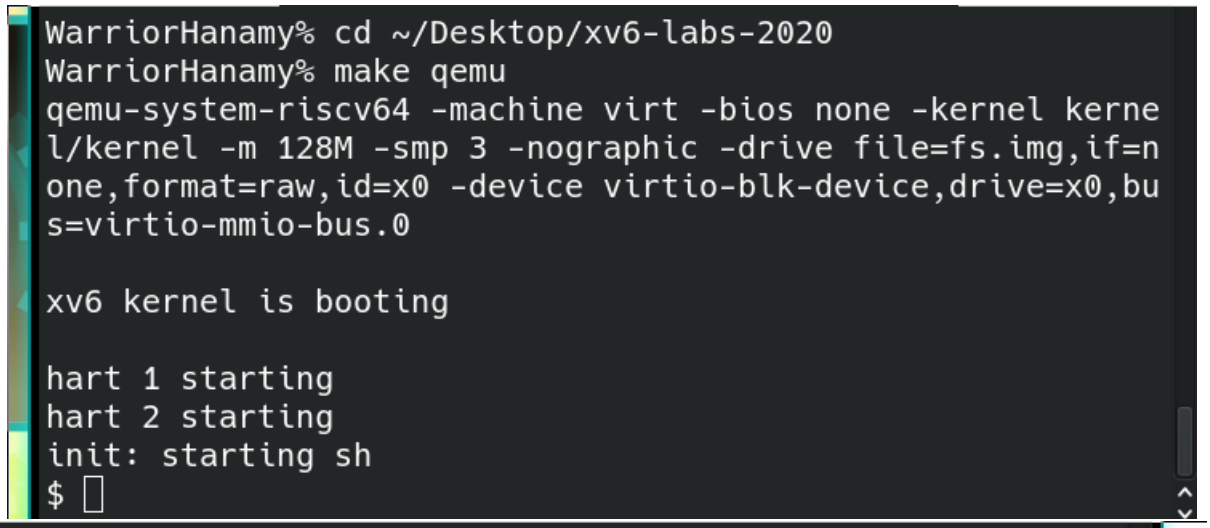
```
        pthread_mutex_init(&mutex_lock, NULL);


        for (i = 0; i < NUMBER; i++)
                pthread_create(&tid[i], 0, philosopher, (void *)&thread_id[i
}

void test(int i)
{
        if ( (state[(i + NUMBER - 1) % NUMBER] != EATING) && (state[i] == HU
        {
                state[i] = EATING;
                printf("Philosopher %d is eating\n", i);
                pthread_cond_signal(&cond_vars[i]);
        }
}

void pickup_forks(int number)
{
        pthread_mutex_lock(&mutex_lock);

        state[number] = HUNGRY;

        test(number);
        while (state[number] != EATING)
                pthread_cond_wait(&cond_vars[number], &mutex_lock);

        pthread_mutex_unlock(&mutex_lock);
}

void return_forks(int number)
{
```

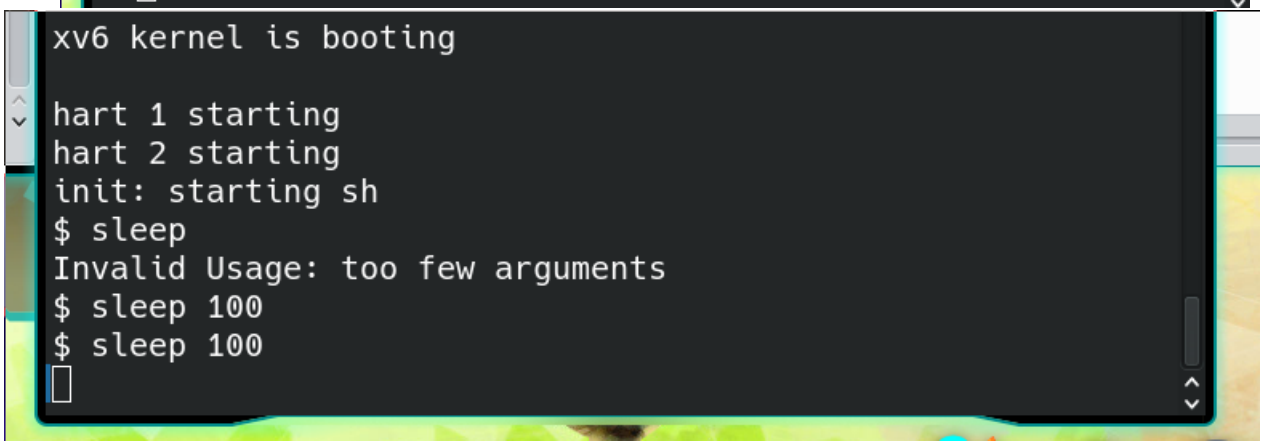
```
        pthread_mutex_lock(&mutex_lock);

        state[number] = THINKING;
        printf("Philosopher %d is thinking\n", number);


        test((number + NUMBER - 1) % NUMBER);
        test((number + 1) % NUMBER);

        pthread_mutex_unlock(&mutex_lock);
}

void *philosopher(void *param)
{
        int number = *(int *)param;
        int sleep_time = (rand() % 3) + 1;



        while(1)
        {
                sleep(sleep_time);
                pickup_forks(number);

                sleep(sleep_time);
                return_forks(number);
        }
}

int main()
{
        init();
```

```
        int i;
        for (i = 0; i < NUMBER; i++)
                pthread_join(tid[i],NULL);
        return 0;
}
```

第三题

0.6 sleep 运行结果





0.7 sleep 代码部分

```
#include "kernel/types.h"
#include "user.h"

int main(int argc, char *argv[]) {
        int sleep_sec;
        if (argc < 2){
                printf("Invalid Usage: too few arguments\n");
                exit(1);
        }

        sleep_sec = atoi(argv[1]);
        if (sleep_sec > 0){
                sleep(sleep_sec);
        } else {
                printf("Invalid interval %s\n", argv[1]);
        }
        exit(0);
}
```

0.8 第三题第二部分

ddl 到了，没写完