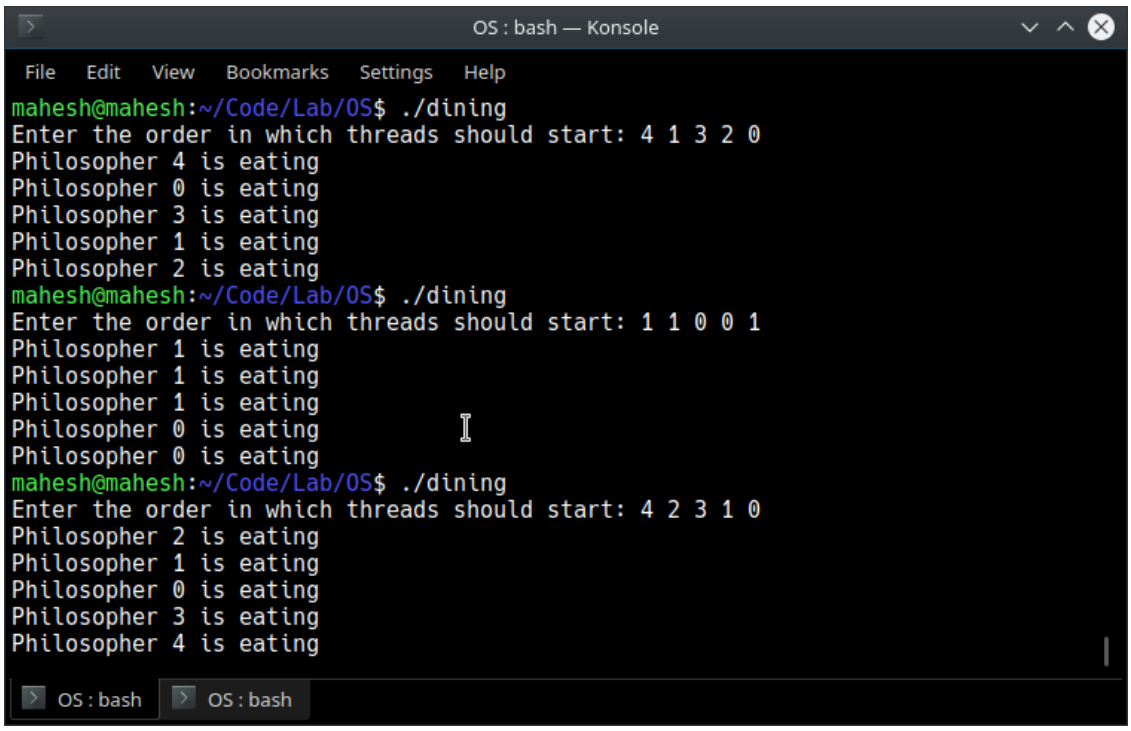
Program 5: Process/Thread Synchronization:

1. Dining Philosopher Problem

```
#include<stdio.h>
#include<semaphore.h>
#include<stdlib.h>
#include<sys/types.h>
#include<pthread.h>

#define NUM_PHIL 5

sem_t chopstick[NUM_PHIL];

void *eat_phil(void *arg) {
      long int index = (long int) arg;
      if (index % 2 == 0) {
            sem_wait(&chopstick[(index+1) % NUM_PHIL]);
            sem_wait(&chopstick[index]);
      } else {
            sem_wait(&chopstick[index]);
            sem_wait(&chopstick[(index+1) % NUM_PHIL]);
      }
      printf("Philosopher %d is eating\n", index);
      sem_post(&chopstick[index]);
      sem_post(&chopstick[(index+1) % NUM_PHIL]);
      return NULL;
}

int main() {
      long int i;
      pthread_t threads[NUM_PHIL];
      printf("Enter the order in which threads should start: ");

      for (i = 0l; i < NUM_PHIL; i++) {
            sem_init(&chopstick[i],0,1);
      }

      for (i = 0l; i < NUM_PHIL; i++) {
            long int n;
            scanf("%ld", &n);
            if (n < 0 || n >= NUM_PHIL) {
                  printf("Number %d not in range!!\n", n);
                  return 1;
            }
            pthread_create(&threads[i], NULL, eat_phil, (void *)n);
      }

      for (i = 0l; i < NUM_PHIL; i++) {
            pthread_join(threads[i], NULL);
      }

      return 0;
}
```

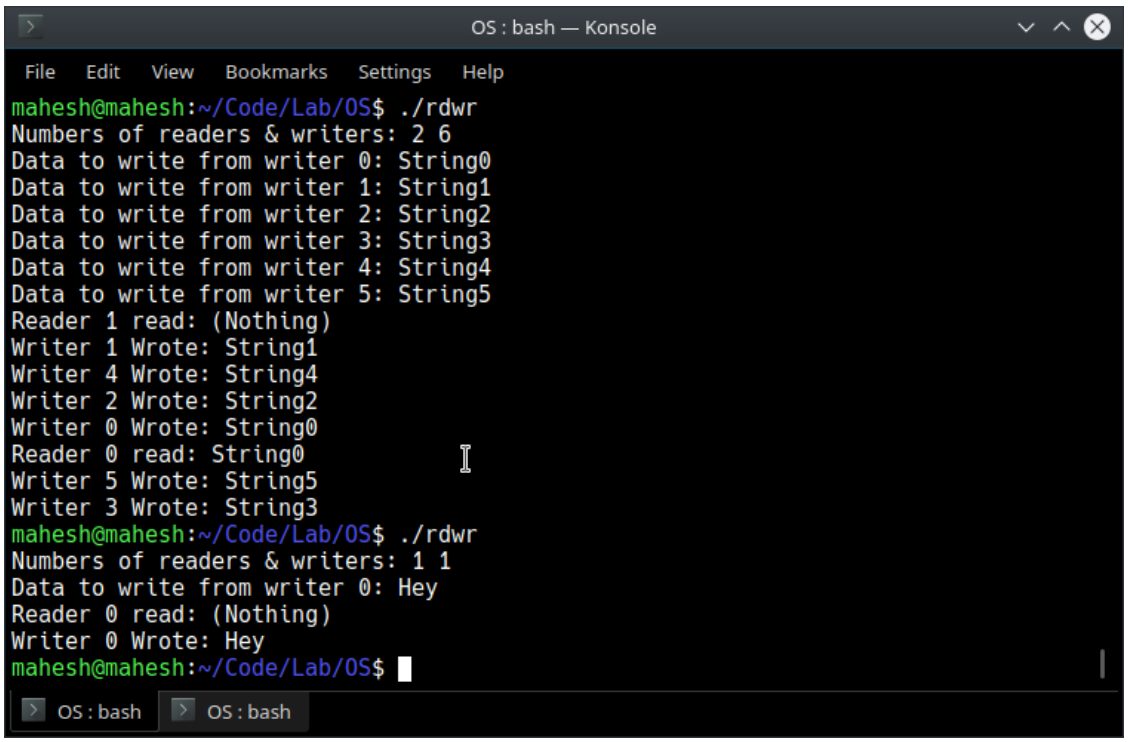
Output:



2. Reader-writer problem:

```
#include<stdio.h>
#include<pthread.h>
#include<sys/types.h>
#include<semaphore.h>
#include<string.h>

char data[40];

sem_t mutex, rw_mutex;
int read_count = 0;

char messages[10][40];

void *writer(void *arg) {
      long int wn = (long int)arg;
      char *s = messages[wn];
      size_t sz = strlen(s);
      sem_wait(&rw_mutex);
      memcpy(data,s,sz + 1); // writing
      printf("Writer %ld Wrote: %s\n", wn, data);
      sem_post(&rw_mutex);
      return NULL;
}

void *reader(void *arg) {
      long int rn = (long int) arg;
      sem_wait(&mutex);
      read_count ++;
      if (read_count == 1) {
            sem_wait(&rw_mutex);
      }
      sem_post(&mutex);
      // Reading
      printf("Reader %ld read: %s\n", rn, data);
      sem_wait(&mutex);
      read_count--;
      if (read_count == 0) sem_post(&rw_mutex);
```

```
	sem_post(&mutex);
	return NULL;
}

int main() {
	int nr, nw, i, j;
	pthread_t readers[10], writers[10];
	sem_init(&mutex,0,1);
	sem_init(&rw_mutex,0,1);

	memcpy(data, "(Nothing)", 10);
	printf("Numbers of readers & writers: ");
	scanf("%d %d", &nr, &nw);
	if (nr > 10 || nr <= 0 || nw > 10 || nw <= 0) {
		printf("Enter valid numbers!!\n");
		return 1;
	}
	for (i = 0; i < nw; i++) {
		printf("Data to write from writer %d: ", i);
		scanf(" %38[^\n]", messages[i]);
	}

	for (i = 0; i < nr; i++) {
		pthread_create(&readers[i], NULL, reader, (void *)i);
	}

	for (i = 0; i < nw; i++) {
		pthread_create(&writers[i], NULL, writer, (void *)i);
	}

	for (i = 0; i < nr; i++) {
		pthread_join(readers[i], NULL);
	}
	for (i = 0; i < nw; i++) {
		pthread_join(writers[i], NULL);
	}
}
```



3. Producer-Consumer problem:

```
#include<stdio.h>
#include<stdlib.h>
#include<pthread.h>
#include<semaphore.h>
#include<sys/types.h>
#include<assert.h>

#define MAX 5

sem_t empty, full, mutex;

int pt, ct;

typedef struct queue {
      int items[MAX];
      int size, begin;
} Queue;

Queue *q;

int dequeue(Queue *q) {
      int r;
      if (q->size == 0) return -1;

      r = q->items[q->begin];
      q->size--;
      q->begin++;
      if(q->begin == MAX) q->begin = 0;
      return r;
}

int enqueue(Queue *q, int i) {
      if (q->size == MAX) {
            // Queue Full
            return -1;
      }
      q->items[(q->begin+q->size) % MAX] = i;
      q->size++;
      return 0;
}

void *prod(void *arg) {
      int pn = (int) arg;
      int i;
      for(i = 0; i < ct; i++) {
            sem_wait(&empty);
            sem_wait(&mutex);
            printf("Prod %d produced %d\n", pn, pn*10+i);
            enqueue(q, pn*10+i);
            sem_post(&mutex);
            sem_post(&full);
      }
      return NULL;
}

void *cons(void *arg) {
      int cn = (int) arg;
      int i, n;
      for (i = 0; i < pt; i++) {
            sem_wait(&full);
            sem_wait(&mutex);
```

```
            printf(" Cons %d consumed %d\n", cn, dequeue(q));
            sem_post(&mutex);
            sem_post(&empty);
      }
      return NULL;
}

int main() {
      Queue qm;
      int i;
      pthread_t prods[10], conss[10];
      qm.size = 0;
      q = &qm;
      sem_init(&full,0,0);
      sem_init(&mutex,0,1);
      sem_init(&empty,0,MAX);
      printf("Number of producers & consumers: ");
      scanf("%d %d", &pt, &ct);
      assert(pt <= 10 && ct <= 10);

      for(i = 0; i < pt; i++) {
            pthread_create(&prods[i], NULL, prod, (void *)i);
      }

      for(i = 0; i < ct; i++) {
            pthread_create(&conss[i], NULL, cons, (void *)i);
      }

      for(i = 0; i < pt; i++) {
            pthread_join(prods[i], NULL);
            pthread_join(conss[i], NULL);
      }

      return 0;
}
```