Lab 4: Kernel Module — Integer Stack with IOCTL & Userspace Interface

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Course: Advanced Linux
Lab: 4 — Kernel Modules
Topic: Character Device Driver with Stack Implementation and Userspace Interface

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✅ TASK, Part 1 – Kernel Module `int_stack.ko`

🔧 Objective Summary

In this part, I implemented a Linux kernel module `int_stack.ko` that functions as a character device driver representing a stack of integers. This device allows users to push and pop integers from the stack and supports configuring the maximum stack size using `ioctl`. The stack is dynamically allocated and protected using kernel synchronization primitives (`mutex`) to allow multithreaded access.

Key functionality includes:

- **Dynamic allocation** of stack memory
- **Mutex-based synchronization** for concurrent access (readers-writers safe)
- **Character device registration** with `open()`, `release()`, `read()`, `write()`, and `ioctl()` implementations
- **Proper error handling**:
  - Empty stack → returns `NULL`
  - Full stack → returns `-ERANGE`
  - Invalid ioctl size → returns `-EINVAL`
- **Full cleanup** on unload: memory deallocation, device node removal

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🔨 Building the Kernel Module

A `Makefile` is used to compile the kernel module:

```
obj-m += int_stack.o

KDIR := /lib/modules/$(shell uname -r)/build
PWD := $(shell pwd)

all:
 make -C $(KDIR) M=$(PWD) modules

clean:
 make -C $(KDIR) M=$(PWD) clean
```

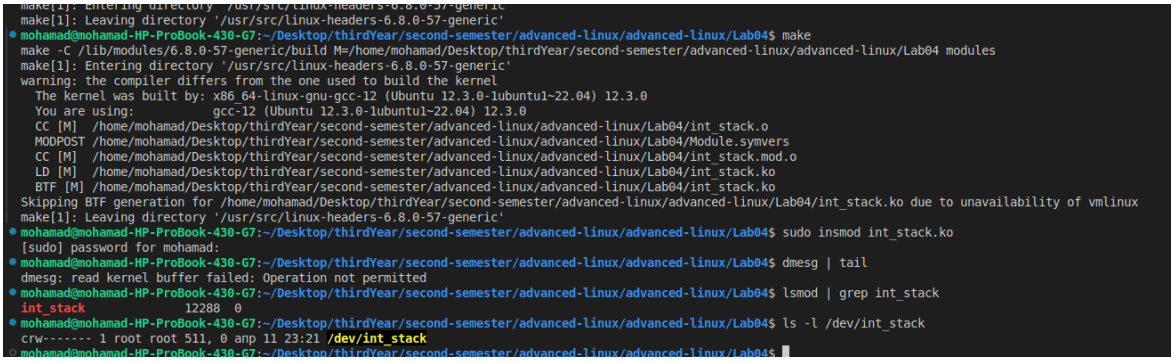
To build:

```
make
```

To load and verify the module:

```
sudo insmod int_stack.ko
dmesg | tail            # Check logs
lsmod | grep int_stack # Ensure module is loaded
ls -l /dev/int_stack   # Device node should exist
sudo chmod 666 /dev/int_stack
```

📸 Screenshots

Action	Screenshot
Module insertion	
Device node created	

✅ TASK, Part 2 – Userspace CLI `kernel_stack`

🗒️ Objective Summary

The second part of the lab required implementing a userspace program `kernel_stack` that interacts with the kernel module using file operations and `ioctl`. The utility supports the following CLI interface:

```
kernel_stack set-size <n>
kernel_stack push <n>
kernel_stack pop
kernel_stack unwind
```

Expected behavior:

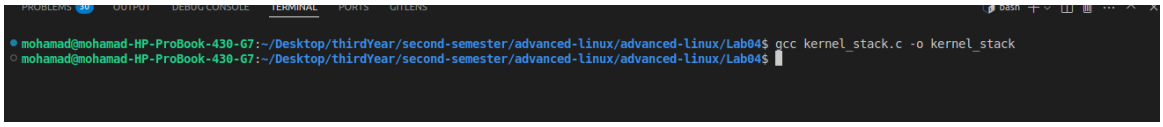
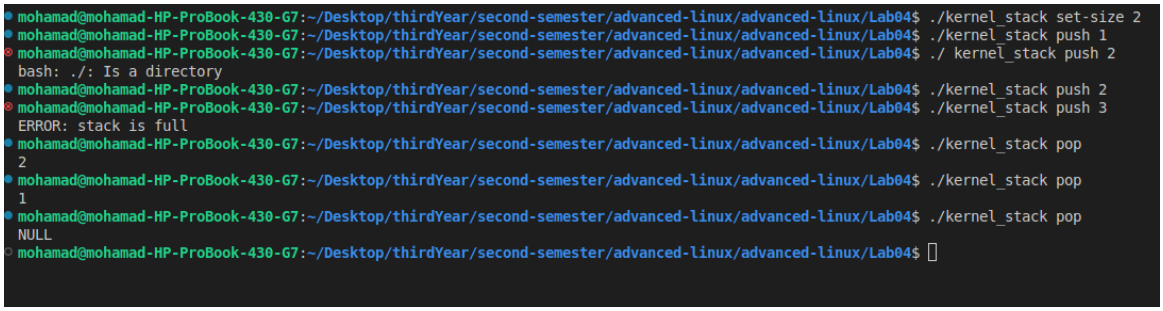
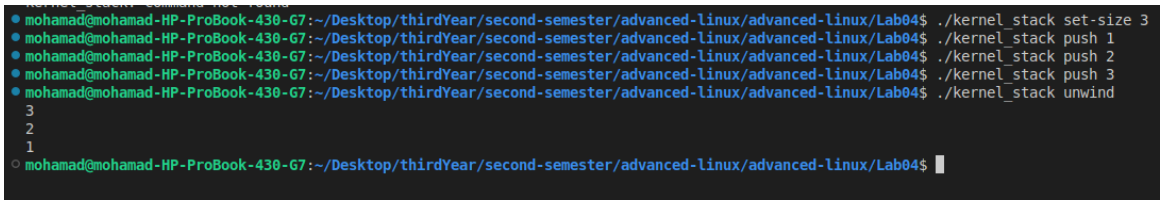
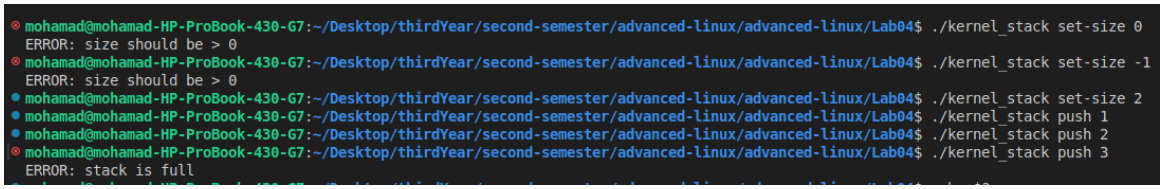
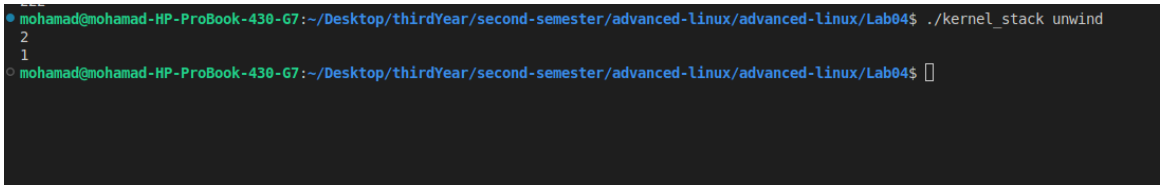
- Set valid stack sizes with `set-size`
- Reject size `0` or negative with an error
- Reject pushing to a full stack with `-ERANGE`
- Return `NULL` on popping from an empty stack
- Print full stack on `unwind`

🔧 Compilation and Usage

To compile:

```
gcc kernel_stack.c -o kernel_stack
```

Example output from tests:

Example	Screenshot
Build and command test	
Push to full stack	
Unwind full stack	
Pop from empty stack	
Invalid set-size tests	

Github code