

НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ УКРАЇНИ
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ»
ФАКУЛЬТЕТ ІНФОРМАТИКИ І ОБЧИСЛЮВАЛЬНОЇ ТЕХНІКИ
КАФЕДРА ОБЧИСЛЮВАЛЬНОЇ ТЕХНІКИ

Лабораторна робота №5
з дисципліни «Архітектура комп'ютерів 2»

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Перевірів:
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Київ 2021 р.

Лістинг програми:

hello.c

```
#include <linux/init.h>
#include <linux/module.h>
#include <linux/moduleparam.h>
#include <linux/printk.h>

MODULE_AUTHOR("Kocherga Andry IV-93");
MODULE_DESCRIPTION("AK Lab5");
MODULE_LICENSE("Dual BSD/GPL");

static int amount = 1;
module_param(amount, uint, S_IRUGO);
MODULE_PARM_DESC(times, "Amount of outputting Hello worlds");

static int __init hello_init(void)
{
    uint i = 0;

    if(amount == 0)
    {
        printk(KERN_WARNING "Entered parameter equals 0");
    }
    else if(amount >= 5 && amount <= 10)
    {
        printk(KERN_WARNING "Entered parameter is between 5 and 10");
    }
    else if(amount > 10)
    {
        printk(KERN_ERR "Entered parameter is bigger than 10");
        return -EINVAL;
    }

    for(i=0; i<amount; i++)
    {
        printk(KERN_EMERG "Hello, world!\n");
    }

    printk(KERN_INFO "Amount: %d\n", amount);

    return 0;
}

static void __exit hello_exit(void)
{
}

module_init(hello_init);
module_exit(hello_exit);
```

Makefile

```
ifneq ($(KERNELRELEASE),)
# kbuild part of makefile
obj-m := hello.o
else
# normal makefile
KDIR ?= /lib/modules/$(uname -r)/build

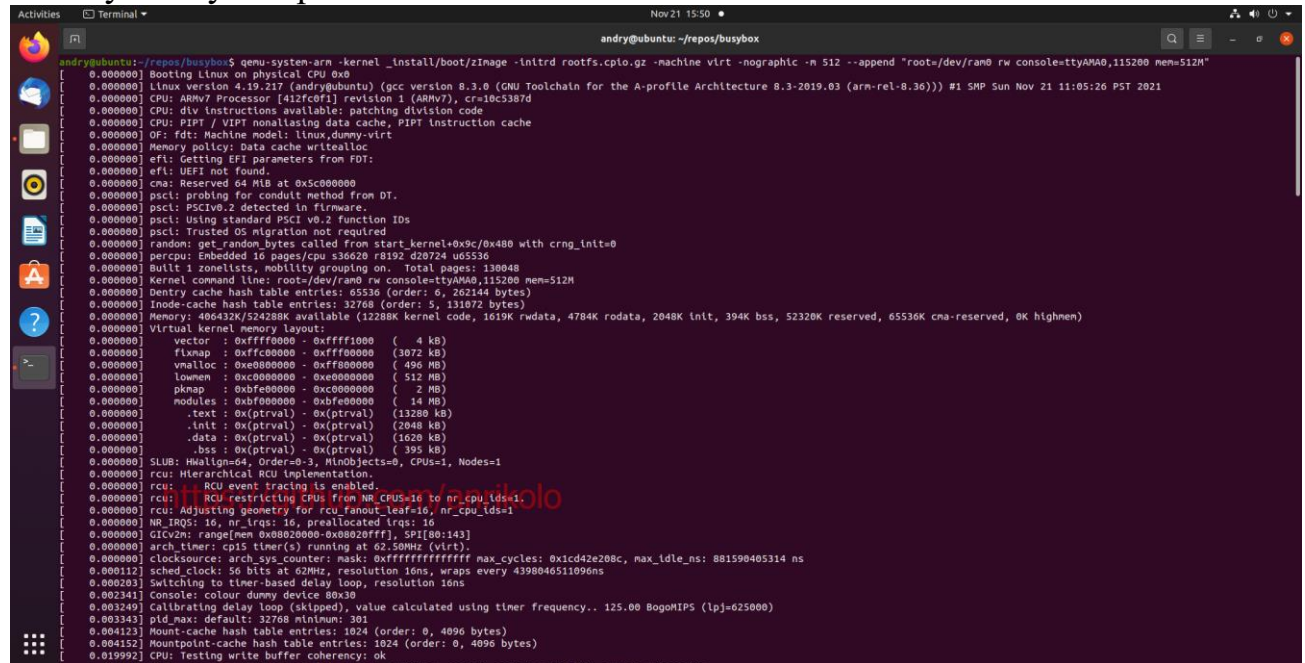
default:
$(MAKE) -C $(KDIR) M=$$PWD

clean:
$(MAKE) -C $(KDIR) M=$$PWD clean

endif
```

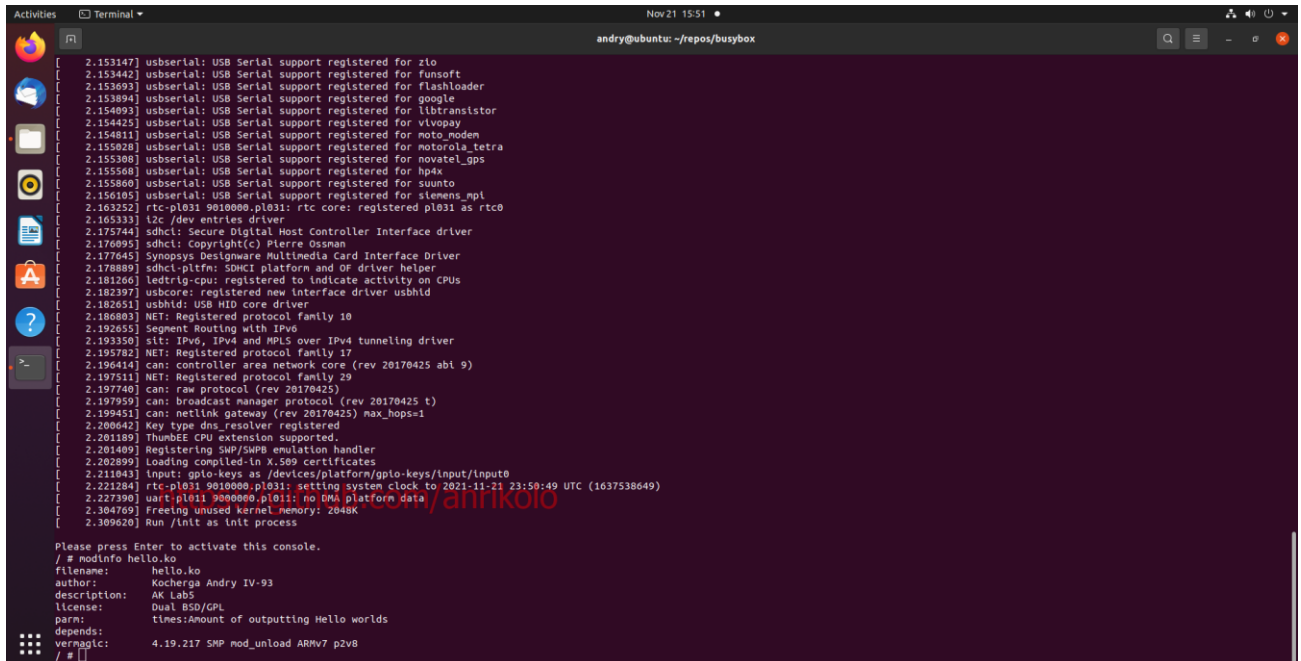
Скріншоти виконання:

1. Запуск емулятора:



```
andry@ubuntu: ~/repos/busybox
[ 0.000000] Booting Linux on physical CPU 0x0
[ 0.000000] Linux version 4.19.217 (andry@ubuntu) (gcc version 8.3.0 (GNU Toolchain for the A-profile Architecture 8.3-2019.03 (arm-rel-8.36))) #1 SMP Sun Nov 21 11:05:26 PST 2021
[ 0.000000] CPU: ARMv7 Processor [412fc0f1] revision 1 (ARMv7), cr=10c5387d
[ 0.000000] CPU: div instructions available: patching division code
[ 0.000000] CPU: PIPT / VIPT nonaliasing data cache, PIPT instruction cache
[ 0.000000] OF: fdt: Machine model: linux,dummy-virt
[ 0.000000] Memory policy: Data cache writealloc
[ 0.000000] efi: getting EFI parameters from FDT:
[ 0.000000] efi: UEFI not found.
[ 0.000000] cma: Reserved 64 MiB at 0x5c000000
[ 0.000000] psct: probing for conduit method from DT.
[ 0.000000] psct: PSCTv0.2 detected in firmware.
[ 0.000000] psct: Using standard PSCT v0.2 function IDs
[ 0.000000] psct: Trusted OS migration not required
[ 0.000000] random: get_random_bytes called from start_kernel@0x480 with crng_init=0
[ 0.000000] percpu: Embedded 16 pages/cpu @36620 r8192 d20724 u65536
[ 0.000000] Built 1 zonelists, mobility grouping on. Total pages: 138048
[ 0.000000] Kernel command line: root=/dev/ram0 rw console=ttyAMA0,115200 mem=512M
[ 0.000000] Dentry cache hash table entries: 65536 (order: 0, 262144 bytes)
[ 0.000000] Inode-cache hash table entries: 32768 (order: 5, 131072 bytes)
[ 0.000000] Memory: 406432K/524288K available (12288K kernel code, 1619K rwdata, 4784K rodata, 2048K init, 394K bss, 52320K reserved, 65536K cma-reserved, 0K highmem)
[ 0.000000] Virtual kernel memory layout:
[ 0.000000] vector : 0xffff0000 - 0xffff1000 ( 4 kB)
[ 0.000000] fixmap : 0xffff0000 - 0xffff0000 (3872 kB)
[ 0.000000] vmalloc : 0xe0000000 - 0xffff0000 ( 496 MB)
[ 0.000000] lowmem : 0xc0000000 - 0xe0000000 ( 512 MB)
[ 0.000000] pkmap : 0xbfe00000 - 0xc0000000 ( 2 MB)
[ 0.000000] modules : 0xbfe00000 - 0xbfe00000 ( 14 MB)
[ 0.000000] .text : 0x(ptrval) - 0x(ptrval) (13280 kB)
[ 0.000000] .init : 0x(ptrval) - 0x(ptrval) (2048 kB)
[ 0.000000] .data : 0x(ptrval) - 0x(ptrval) (1620 kB)
[ 0.000000] .bss : 0x(ptrval) - 0x(ptrval) ( 395 kB)
[ 0.000000] SLUB: HWalign=64, Order=0-3, MinObjects=0, CPUs=1, Nodes=1
[ 0.000000] rcu: Hierarchical RCU implementation.
[ 0.000000] rcu: RCU event tracing is enabled.
[ 0.000000] rcu: RCU restricting CPUs from NR_CPUS=16 to nr_cpu_ids=1
[ 0.000000] rcu: Adjusting geometry for rcu_fanout_leaf=16, nr_cpu_ids=1
[ 0.000000] NR_IRQS: 16, nr_irqs: 16, preallocated irqs: 16
[ 0.000000] GICv2n: range[mem 0x08020000-0x08020fff], SPI[80:143]
[ 0.000000] arch_timer: cp15 timer(s) running at 62.50MHz (virt).
[ 0.000000] clocksource: arch_sys_counter: mask: 0xfffffffffff max_cycles: 0x1cd42e20bc, max_idle_ns: 881590405314 ns
[ 0.001122] sched clock: 56 bits at 62MHz, resolution 16ns, wraps every 4398046511096ns
[ 0.002033] Switching to timer-based delay loop, resolution 16ns
[ 0.002341] Console: colour dummy device 80x30
[ 0.003240] calibrating delay loop (skipped), value calculated using timer frequency.. 125.00 BogoMIPS (lpj=625000)
[ 0.003343] pid_max: default: 32768 minimum: 301
[ 0.004123] Mount-cache hash table entries: 1024 (order: 0, 4096 bytes)
[ 0.004123] Mountpoint-cache hash table entries: 1024 (order: 0, 4096 bytes)
[ 0.019092] CPU: testing write buffer coherency: ok
[ 0.022722] CPU: testing write buffer coherency: ok
```

2. Запуск modinfo, параметр за замовчуванням:

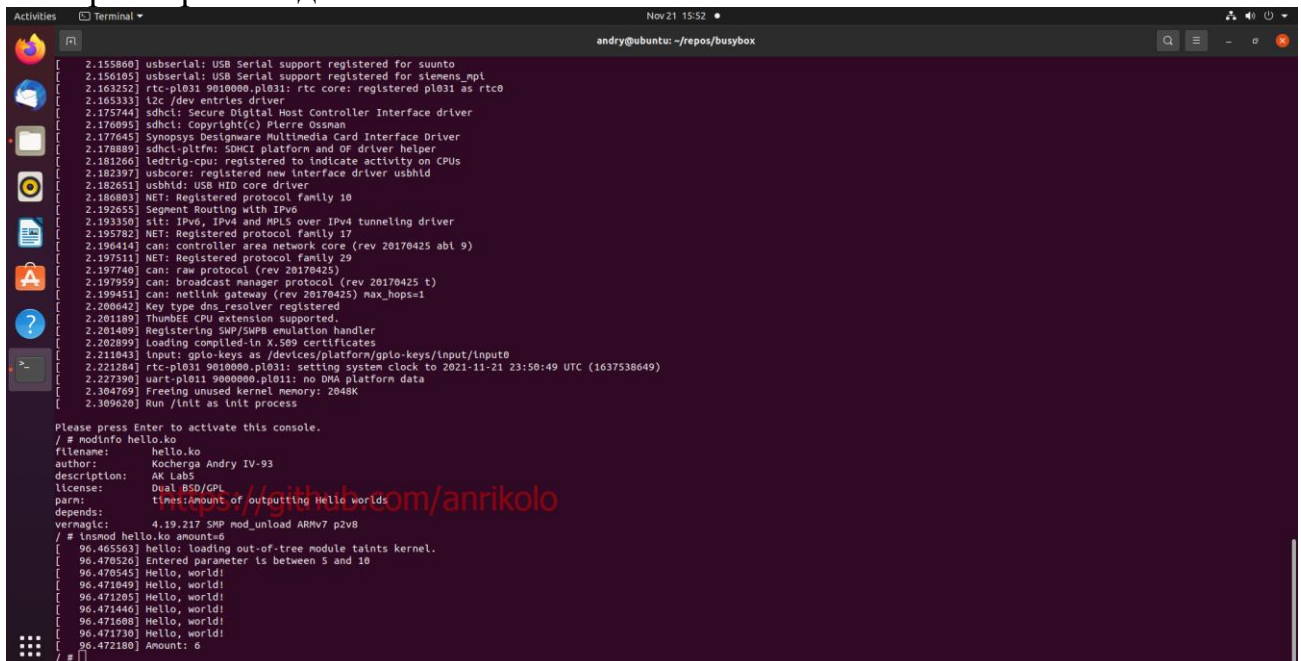


```
Activities Terminal Nov 21 15:51 andry@ubuntu: ~/repos/busybox

[ 2.153147] usbserial: USB Serial support registered for zio
[ 2.153442] usbserial: USB Serial support registered for funsoft
[ 2.153693] usbserial: USB Serial support registered for flashloader
[ 2.153894] usbserial: USB Serial support registered for google
[ 2.154093] usbserial: USB Serial support registered for libtransistor
[ 2.154425] usbserial: USB Serial support registered for vivopay
[ 2.154811] usbserial: USB Serial support registered for moto_modem
[ 2.155028] usbserial: USB Serial support registered for motorola_tetra
[ 2.155308] usbserial: USB Serial support registered for novatel_gps
[ 2.155508] usbserial: USB Serial support registered for hp4x
[ 2.155860] usbserial: USB Serial support registered for suunto
[ 2.156105] usbserial: USB Serial support registered for siemens_mpl
[ 2.163252] rtc-pl031 9010000.pl031: rtc core: registered pl031 as rtc0
[ 2.165333] tz /dev entries driver
[ 2.175744] sdhci: Secure Digital Host Controller Interface driver
[ 2.176095] sdhci: Copyright(c) Pierre Ossman
[ 2.177645] Synopsys Designware Multimedia Card Interface Driver
[ 2.178889] sdhci-pltfm: SDHCI platform and OF driver helper
[ 2.181266] ledtrig-cpu: registered to indicate activity on CPUs
[ 2.182397] usbcore: registered new interface driver usbhid
[ 2.182651] usbhid: USB HID core driver
[ 2.186803] NET: Registered protocol family 10
[ 2.192655] Segment Routing with IPv6
[ 2.193350] sit: IPv6, IPv4 and MPLS over IPv4 tunneling driver
[ 2.195782] NET: Registered protocol family 17
[ 2.196414] can: controller area network core (rev 20170425) abt 9)
[ 2.197511] NET: Registered protocol family 29
[ 2.197740] can: raw protocol (rev 20170425)
[ 2.197959] can: broadcast manager protocol (rev 20170425 t)
[ 2.199451] can: netlink gateway (rev 20170425) max_hops=1
[ 2.200642] Key type dns_resolver registered
[ 2.201189] ThumbEE CPU extension supported.
[ 2.201409] Registering SMP/SMPB emulation handler
[ 2.202899] Loading compiled-in X.509 certificates
[ 2.211043] Input: gpio-keys as /devices/platform/gpio-keys/input/input0
[ 2.221284] rtc-pl031 9010000.pl031: setting system clock to 2021-11-21 23:50:49 UTC (1637538649)
[ 2.227390] uart-pl011 9000000.pl011: no DMA platform data
[ 2.304769] Freeing unused kernel memory: 2048K
[ 2.309620] Run /init as init process

Please press Enter to activate this console.
/ # modinfo hello.ko
filename:      hello.ko
author:       Kocherga Andry IV-93
description:   AK Labs
license:      Dual BSD/GPL
parm:         times:Amount of outputting Hello worlds
depends:
vermagic:     4.19.217 SMP mod_unload ARMv7 p2v8
/ #
```

3. Параметр знаходиться між 5 і 10:



```
Activities Terminal Nov 21 15:52 andry@ubuntu: ~/repos/busybox

[ 2.155860] usbserial: USB Serial support registered for suunto
[ 2.156105] usbserial: USB Serial support registered for siemens_mpl
[ 2.163252] rtc-pl031 9010000.pl031: rtc core: registered pl031 as rtc0
[ 2.165333] tz /dev entries driver
[ 2.175744] sdhci: Secure Digital Host Controller Interface driver
[ 2.176095] sdhci: Copyright(c) Pierre Ossman
[ 2.177645] Synopsys Designware Multimedia card Interface Driver
[ 2.178889] sdhci-pltfm: SDHCI platform and OF driver helper
[ 2.181266] ledtrig-cpu: registered to indicate activity on CPUs
[ 2.182397] usbcore: registered new interface driver usbhid
[ 2.182651] usbhid: USB HID core driver
[ 2.186803] NET: Registered protocol family 10
[ 2.192655] Segment Routing with IPv6
[ 2.193350] sit: IPv6, IPv4 and MPLS over IPv4 tunneling driver
[ 2.195782] NET: Registered protocol family 17
[ 2.196414] can: controller area network core (rev 20170425) abt 9)
[ 2.197511] NET: Registered protocol family 29
[ 2.197740] can: raw protocol (rev 20170425)
[ 2.197959] can: broadcast manager protocol (rev 20170425 t)
[ 2.199451] can: netlink gateway (rev 20170425) max_hops=1
[ 2.200642] Key type dns_resolver registered
[ 2.201189] ThumbEE CPU extension supported.
[ 2.201409] Registering SMP/SMPB emulation handler
[ 2.202899] Loading compiled-in X.509 certificates
[ 2.211043] Input: gpio-keys as /devices/platform/gpio-keys/input/input0
[ 2.221284] rtc-pl031 9010000.pl031: setting system clock to 2021-11-21 23:50:49 UTC (1637538649)
[ 2.227390] uart-pl011 9000000.pl011: no DMA platform data
[ 2.304769] Freeing unused kernel memory: 2048K
[ 2.309620] Run /init as init process

Please press Enter to activate this console.
/ # modinfo hello.ko
filename:      hello.ko
author:       Kocherga Andry IV-93
description:   AK Labs
license:      Dual BSD/GPL
parm:         times:Amount of outputting Hello worlds
depends:
vermagic:     4.19.217 SMP mod_unload ARMv7 p2v8
/ # ./insmod hello.ko amount=6
[ 96.465563] hello: loading out-of-tree module taints kernel.
[ 96.470526] Entered parameter is between 5 and 10
[ 96.470545] Hello, world!
[ 96.471049] Hello, world!
[ 96.471205] Hello, world!
[ 96.471446] Hello, world!
[ 96.471688] Hello, world!
[ 96.471730] Hello, world!
[ 96.472180] Amount: 6
/ #
```

4. Параметр більше 10:

```
Activities Terminal Nov 21 15:53 andry@ubuntu: ~/repos/busybox

[ 2.165333] l2c /dev entries driver
[ 2.175744] sdhci: Secure Digital Host Controller Interface driver
[ 2.176095] sdhci: Copyright(c) Pierre Ossman
[ 2.177645] synopsys Designware Multimedia card Interface Driver
[ 2.178809] sdhci-pltfm: SDHCI platform and OF driver helper
[ 2.181266] ledtrig-cpu: registered to indicate activity on CPUs
[ 2.182397] usbcore: registered new interface driver usbhid
[ 2.182651] usbhid: USB HID core driver
[ 2.186803] NET: Registered protocol family 10
[ 2.192655] Segment Routing with IPv6
[ 2.193350] sit: IPv6, IPv4 and MPLS over IPv4 tunneling driver
[ 2.195782] NET: Registered protocol family 17
[ 2.196414] can: controller area network core (rev 20170425 abl 9)
[ 2.197511] NET: Registered protocol family 29
[ 2.197740] can: raw protocol (rev 20170425)
[ 2.197959] can: broadcast manager protocol (rev 20170425 t)
[ 2.199451] can: netlink gateway (rev 20170425) max_hops=1
[ 2.200642] Key type dns_resolver registered
[ 2.201189] ThumbEE CPU extension supported.
[ 2.201409] Registering SMP/SMPB emulation handler
[ 2.202899] Loading compiled-in X.509 certificates
[ 2.211043] input: gpio-keys as /devices/platform/gpio-keys/input/input0
[ 2.221284] rtc-pl031 9010000.pl031: setting system clock to 2021-11-21 23:50:49 UTC (1637538649)
[ 2.227390] uart-pl011 9000000.pl011: no DMA platform data
[ 2.304769] Freeing unused kernel memory: 2048K
[ 2.309620] Run /init as init process

Please press Enter to activate this console.
/ # modinfo hello.ko
filename:      hello.ko
author:        Kocherga Andry IV-93
description:    AK Labs
license:        Dual BSD/GPL
parm:          times:Amount of outputting Hello worlds
depends:
vermagic:      4.19.217 SMP mod_unload ARMv7 p2v8
/ # insmod hello.ko amount=6
[ 96.465563] hello: loading out-of-tree module taints kernel.
[ 96.470526] Entered parameter is between 5 and 10
[ 96.470545] Hello, world!
[ 96.471049] Hello, world!
[ 96.471205] Hello, world!
[ 96.471446] Hello, world!
[ 96.471608] Hello, world!
[ 96.471730] Hello, world!
[ 96.472180] Amount: 6
/ # rmmod hello.ko
/ # insmod hello.ko amount=20
insmod: can't insert 'hello.ko': Invalid parameter
/ #
```

5. Значення встановленого параметру після виконання insmod(параметр 6):

```
Activities Terminal Nov 21 15:54 andry@ubuntu: ~/repos/busybox

[ 2.197959] can: broadcast manager protocol (rev 20170425 t)
[ 2.199451] can: netlink gateway (rev 20170425) max_hops=1
[ 2.200642] Key type dns_resolver registered
[ 2.201189] ThumbEE CPU extension supported.
[ 2.201409] Registering SMP/SMPB emulation handler
[ 2.202899] Loading compiled-in X.509 certificates
[ 2.211043] input: gpio-keys as /devices/platform/gpio-keys/input/input0
[ 2.221284] rtc-pl031 9010000.pl031: setting system clock to 2021-11-21 23:50:49 UTC (1637538649)
[ 2.227390] uart-pl011 9000000.pl011: no DMA platform data
[ 2.304769] Freeing unused kernel memory: 2048K
[ 2.309620] Run /init as init process

Please press Enter to activate this console.
/ # modinfo hello.ko
filename:      hello.ko
author:        Kocherga Andry IV-93
description:    AK Labs
license:        Dual BSD/GPL
parm:          times:Amount of outputting Hello worlds
depends:
vermagic:      4.19.217 SMP mod_unload ARMv7 p2v8
/ # insmod hello.ko amount=6
[ 96.465563] hello: loading out-of-tree module taints kernel.
[ 96.470526] Entered parameter is between 5 and 10
[ 96.470545] Hello, world!
[ 96.471049] Hello, world!
[ 96.471205] Hello, world!
[ 96.471446] Hello, world!
[ 96.471608] Hello, world!
[ 96.471730] Hello, world!
[ 96.472180] Amount: 6
/ # rmmod hello.ko
/ # insmod hello.ko amount=20
insmod: can't insert 'hello.ko': Invalid parameter
/ # rmmod hello.ko
rmmod: remove 'hello': No such file or directory
/ # insmod hello.ko amount=6
[ 132.821936] Entered parameter is bigger than 10
[ 194.959420] Entered parameter is between 5 and 10
[ 194.960691] Hello, world!
[ 194.961950] Hello, world!
[ 194.962320] Hello, world!
[ 194.962658] Hello, world!
[ 194.963075] Hello, world!
[ 194.963433] Hello, world!
[ 194.963818] Amount: 6
/ #
/ # cat sys/module/hello/parameters/amount
6
/ #
```