

**Possible marks:** 100

**Instructions:**

1. This is an individual exam. You can use code given to you by course staff this semester or code which you wrote yourself this semester.
2. Download the answer text file from blackboard.
3. Answer Questions 1–6 in that file (using plain ascii text).
4. Question 7 will require you to write one or more C files. The names required for these files are given in the question.
5. Submit your answers via blackboard.
  - Attach all of your answer files to the same submission (Don't submit once for each file).
  - Do not change the names of the files.
  - You may submit multiple times (within the timelimit) but each submission should be complete.
6. If you wish to record assumptions you relied upon, you may do so at the end of the answer file.
  - Do not use this part as an alternative answer box.

Question 1) Write shell commands to do the following:

[10 marks (1 each)]

A) Make an executable program from `start.c` which links the maths library.

B) Output the last 3 lines of `bill`

C) Output all lines from `bill` which contain “mud” but not “mudcake”.

D) Output the 4-th column of `bill` (columns are separated by spaces).

E) Output all lines from `bill` which contain “cake” in reverse (lexacographic) order.

F) Remove `pots.c` from the svn repository.

G) Compile `pond.c` and append errors to `logs.err`

H) Make an executable program called `box` from `dims.c` and `space.c`.

I) List all filenames in the current directory which have at least four characters in them and which end in `.cc`

J) Record changes made to `dims.c` and `space.c` into the svn repository.

Question 2) Write C to declare `foo` as ...:

[6 marks (1 each)]

A) An array of five `true` / `false` values.

B) An array of ten strings.

C) A pointer to a function which returns a small integer and takes a character.

D) A pointer to an integer which is modified by multiple threads.

E) A string which should not be modified by this code.

F) A high precision floating point number.

## Question 3)

[6 marks (2 each)]

Suppose a system uses 32bit virtual addresses, 36bit physical addresses and a two level page table. Pages are 4KiB (4096 Bytes) each. Page table entries are 4 Bytes each. (All addresses are expressed in base 10).

A) A process uses virtual address ranges:

- 3MiB starting at 57344
- 1MiB starting at 29356032

How much memory would be required to store the page table.

B) Part of a page table for a process is given below:

Page	Frame
18	-
19	18
20	16
21	17
22	21

Which physical address do the following virtual addresses map to?  
(If they would SEGFAULT say so.)

77829

77823

C) A single threaded process accesses the following virtual addresses in order. It segfaults on the last one.

94447

73633

92457

82916

Assuming that the process uses consistent virtual pages each time it runs, which of the following addresses would cause a segfault if accessed? (In your answer file, write each address followed by “Yes” or “No” as appropriate).

Segfaults?

91109 Yes / No

86015 Yes / No

82098 Yes / No

94386 Yes / No

## Question 4)

[11 marks]

Consider the following directory listing:

```
$ ls -ali
total 2164
1067385 drwxr-xr-x 3 andy      football  4096 Jul 17 11:08 .
1065112 drwxr-xr-x 1 andy      football  4096 Jul 17 10:43 ..
1061551 -rwxr-xr-x 1 librarian football  8192 Jul 19 10:23 apt
1067391 lrwxrwxrwx 1 librarian football    4 Jul 17 10:59 backup -> data
1066833 ddrxr-xr-x 2 librarian football  4096 Jul 17 10:59 data
1067386 -rwxr-xr-x 1 andy      football 2190232 Jul 17 11:00 generate
1068104 lrwxrwxrwx 1 andy      football    4 Jul 17 11:09 install -> apt
1067407 -rw-r--r-- 2 andy      football   179 Jul 17 11:05 log2
1067392 -rw-r--r-- 1 andy      football   179 Jul 18 11:05 logs
1067407 -rw-r--r-- 2 librarian football   179 Jul 17 11:05 logx
1067408 lrwxrwxrwx 1 andy      football    4 Jul 17 11:08 logz -> logs
```

A) There are some inconsistencies in the listing. What are they?

[4 marks]

B) What command was used to create **backup**.

[2 marks]

C) What command would prevent members of the **football** group (other than **andy**) from running **install** but not affect anyone else?

[2 marks]

D) A system has the following ordinary users and groups (and no others):

[3 marks]

User	Groups
mustrum	university football
librarian	university football
andy	football
havelock	palace

Consider the following directory listing:

```
-r--r-x--- 1 mustrum  palace      138856 Jul 17 10:46 f1
--w-r-xrwx 1 librarian university 2190232 Jul 17 11:49 f2
---xr--r-x 1 mustrum  football    24000 Jul 17 09:14 f3
```

Which **users** are allowed to:

1. Read from p1?

2. Write to p2?

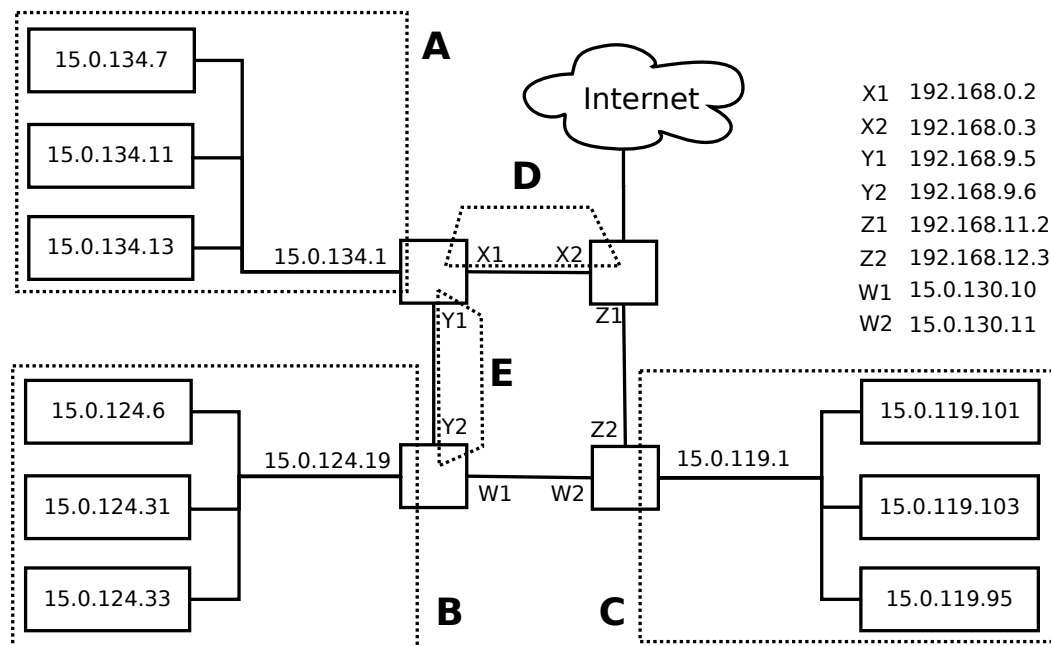
3. Run p3?



## Question 5)

[15 marks]

Consider the following network (assume that all networks are as small as possible):



X1 192.168.0.2  
 X2 192.168.0.3  
 Y1 192.168.9.5  
 Y2 192.168.9.6  
 Z1 192.168.11.2  
 Z2 192.168.12.3  
 W1 15.0.130.10  
 W2 15.0.130.11

A) Fill in the details for each of the subnets in the diagram.  
 (Assume each network is as small as possible.)

[6 marks]

Network	Netmask	Broadcast	CIDR
A			
B			
C			

B) Fill in the detail for the whole network shown above (as it should appear to the rest of the internet).

Netmask	Broadcast	CIDR

C) How many unused addresses are in each of the following networks?

[2 marks]

A	
C	
E	

D) An organisation owns the 8.19.29.0/21 block and they wish to break it into networks each containing 128 machines. What is the maximum number of such networks they could have? [2 marks]

E) Which layer of the network stack are each of the following terms primarily associated with? [3 marks]

putty	
ethernet	
MAC	
IPv6	
UDP	
TCP	

Question 6) Consider a “unix” filesystem where:

[8 marks, 2 each]

- blocks are 8KiB
- block pointers are 8 Bytes.
- inodes have:
  - 7 direct pointers
  - 3 single indirect pointers
  - 3 double indirect pointers.

A) What is the smallest file size which requires use of the second single indirect pointer?

B) What is the maximum file size on this filesystem?

C) If the inode had one of the double indirects replaced with a “triple indirect”, what would be the new maximum file size on this filesystem?

D) Assuming the inode is cached in RAM, how many blocks would need to be accessed to read the 40963rd byte in the file?

## Question 7)

[44 marks]

In this question you will be required to write one or more c programs described below. There will be constraints on what the files are to be called and which functions you are not allowed to use.

You can develop the programs on your own machines if you wish. However, they must compile and run on moss for marking purposes. You must attach each file to your blackboard exam submission.

Write one file:

- `2310merge.c` : `gcc 2310merge.c -std=gnu99 -pedantic -pthread -o 2310hub`

This file can only `#include` system headers. It must not include other `.c` files.

`2310merge num`

will listen on `num` ephemeral ports and print their port numbers (newline separated). Each port will accept a connection and read (and store) lines of text from it. You must use a separate thread to handle each connection. Each line will consist of an integer ("the line number") followed by a semi-colon and some text. You may assume:

- all lines are less than 80 chars long.
- all lines are correctly formatted.
- "line numbers" are unique.

When all connections have read all their lines you are to process them as follows: Look at the line numbers of the first line of each connection. Find the smallest one, print the whole line (number included) to standard out. Remove that line from the records. Repeat until all lines have been printed. Exit with status zero.

Eg: If `2310merge 2` prints:

```
54112
55442
```

Via the connection on port 54112 it reads:

```
1;hello
10;greetings
```

and via the connection on port 55442 it reads:

```
2;hi
3;yo
```

it should output the following to `stdout`:

```
1;hello
2;hi
3;yo
10;greetings
```

**Notes**

1. use 127.0.0.1 to guarantee IPv4
2. Test using netcat
3. Remember the fflush monkey.

**END OF EXAMINATION**

You may detach this sheet.  
**Do not record answers on this sheet.**

Example addresses:

broadcast 130.102.17.255  
 netmask 255.255.255.0  
 CIDR 130.102.17.0/24

%c	character
%d	integer
%u	unsigned integer
%lf	double (scanf)
%f	double (printf)
%p	void pointer
%ld	long integer

```
grep [-v] [ $ ^ . * ]
ls [-ladi]
ps [-ef]
sort [-r -k]
uniq [-c]
cat
head [-]
tail [-]
cut [-f -d]
wc [-l]
diff
svn
chmod
ln [-s]
rm [-rf]
mkdir
rmdir
cp [-r]
mv
vim/nano
less
```

Layers
link
application
onion
physical
network
gooey caramel
transport

KiB	=	2 <sup>10</sup> Bytes
MiB	=	2 <sup>20</sup> Bytes
GiB	=	2 <sup>30</sup> Bytes

[ ]	array access
.	member selection
- >	follow and select
+ + --	
sizeof	
~	bitwise not
!	logical not
+ -	unary forms
&	address of
*	follow
( )	cast
* / %	
+ -	binary forms
> < <= >=	
== !=	
&	bitwise AND
^	bitwise XOR
	bitwise OR
&&	logical AND
	logical OR
? :	ternary operator
= += -= ...	
,	comma operator

