Computer Labs: Lab 1
Video Adapter in Text Mode
2º MIEIC

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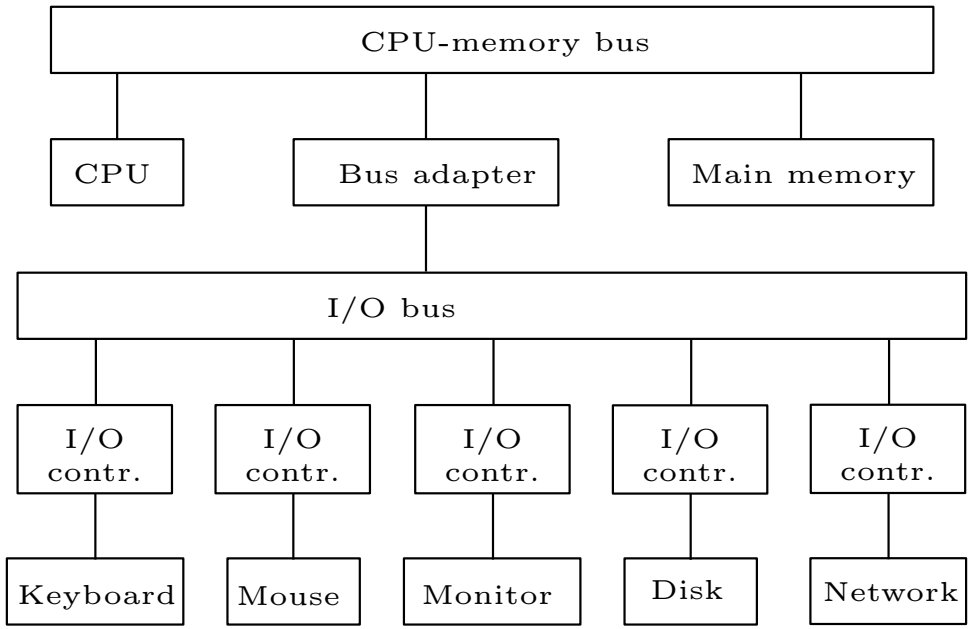
I/O Devices

- In LCOM, we will work with the PC I/O devices.
- I/O devices provide the interface between the CPU and the outside world.



I/O Controllers

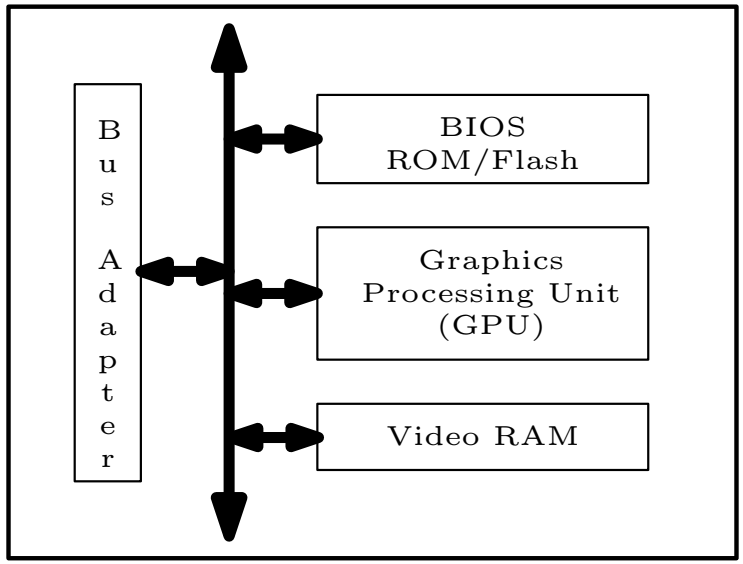
- Each I/O device is controlled by an electronic component, usually called **controller** or **adapter**.
- I/O controllers typically include three kinds of registers:

  Control: used to request I/O operations

  Status: used to get the state of the device or pending I/O operations

  Data: used to transfer data to/from the I/O devices
- Programming at the register level may require a detailed knowledge of the device's operation

Graphics Adapter/Video Card



GPU Earlier known as the Graphics Controller:

- Controls the display hardware (CRT vs. LCD)
- Performs 2D and 3D rendering algorithms, offloading the CPU and accelerating graphics applications

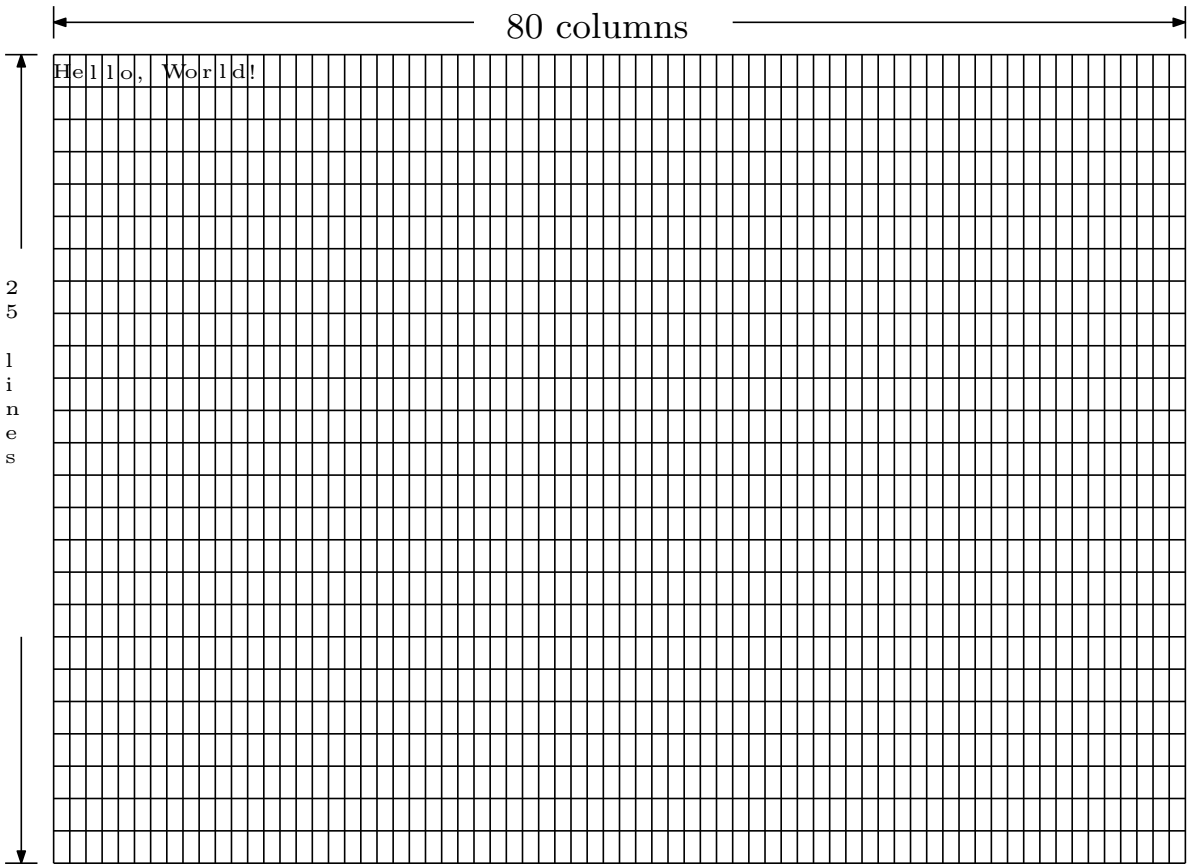
BIOS ROM/Flash ROM/Flash Memory with firmware. Includes code that performs some standardized basic video I/O operations, such as the Video BIOS Extension (VBE) – cf. Lab. 4

Video RAM Stores the data that is rendered on the screen.

- It is acessible also by the CPU (at least part of it)

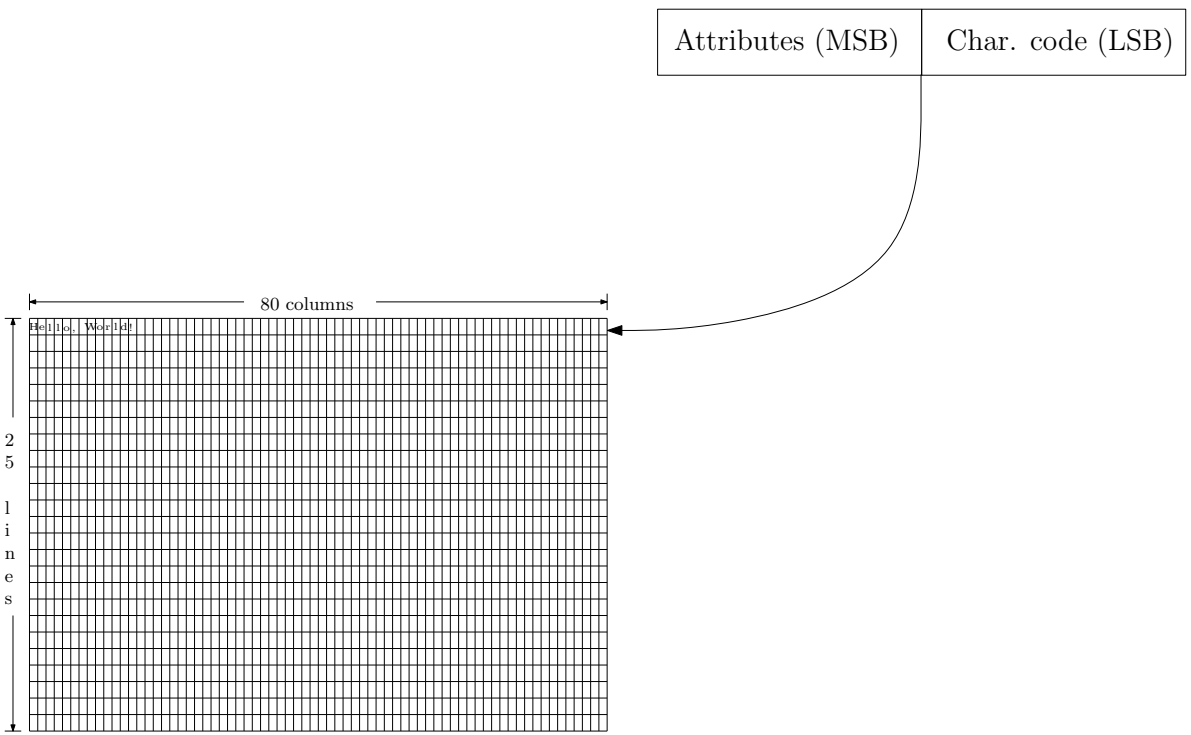
PC's Graphics Adapter Text Modes (1)

- Used to render mostly text
- Abstracts the screen as a matrix of characters (row x cols)
  - E.g. **25x80**, 25x40, 50x80, 25x132
  - Black and white vs color (16 colors)



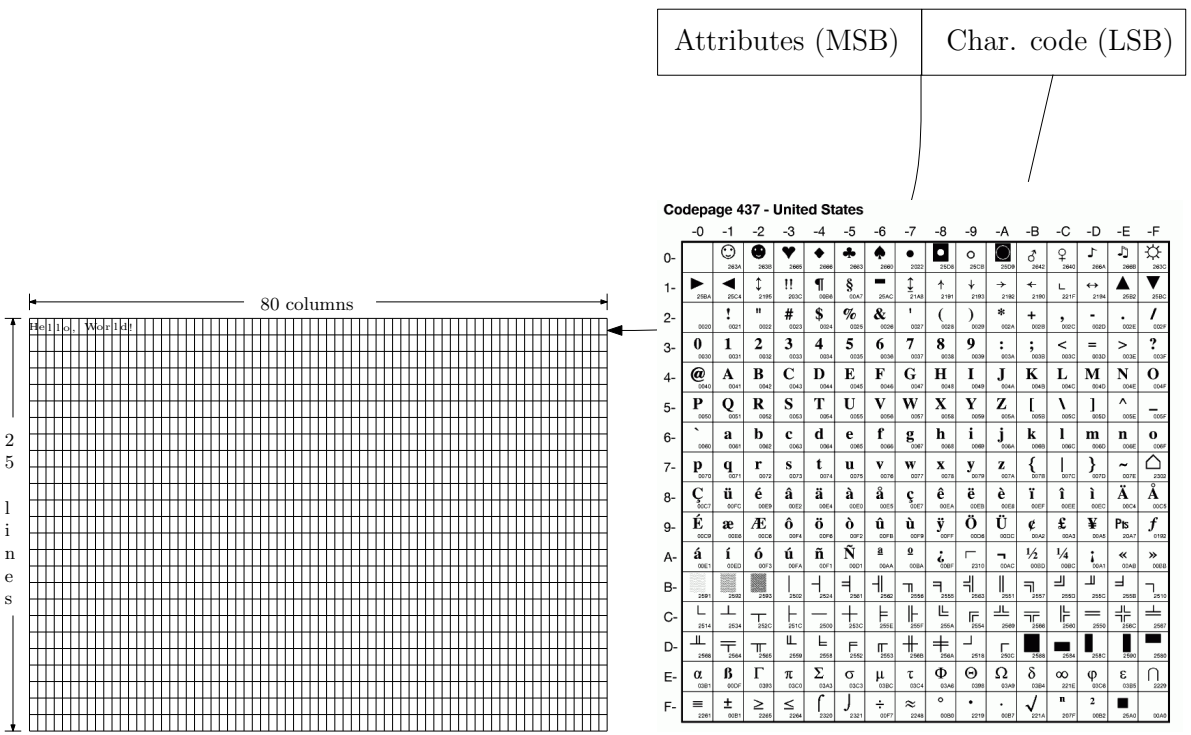
PC's Graphics Adapter Text Modes (2)

- Each character is represented by two bytes:



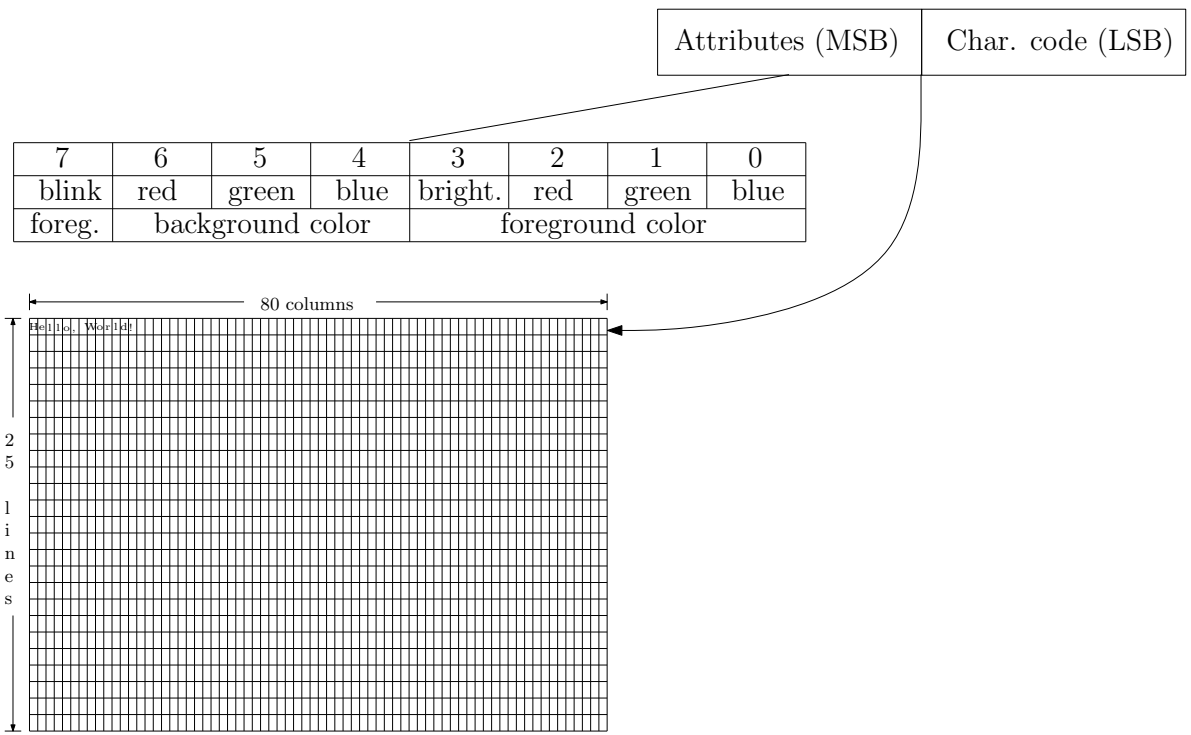
PC's Graphics Adapter Text Modes (2)

- Each character is represented by two bytes:
  - The character denoted by the code depends on the character encoding (code page), which can be changed



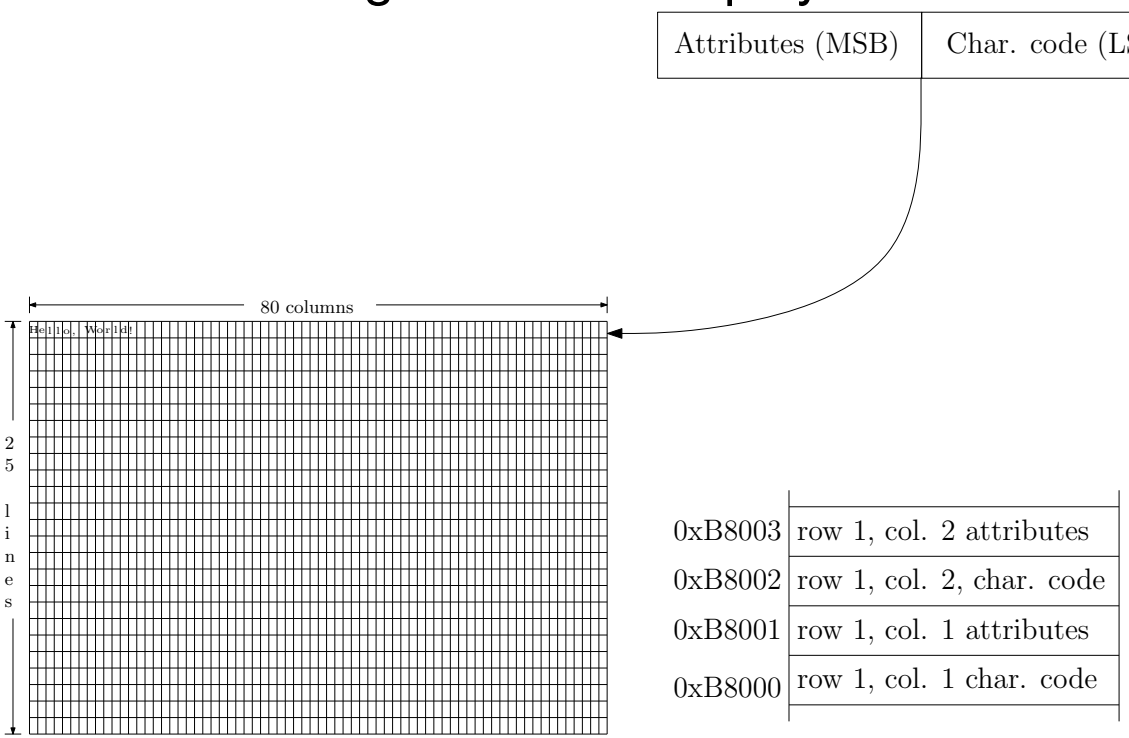
PC's Graphics Adapter Text Modes (2)

- Each character is represented by two bytes:
  - The character denoted by the code depends on the character encoding (code page ▸), which can be changed
  - The attributes specify mostly the colors



PC's Graphics Adapter Text Modes (2)

- Video RAM contains a representation of the screen in a matrix of 25x80 16-bit words
  - In the PC, this matrix is at **physical address** 0xB8000
  - By changing the contents of this matrix an application changes what is displayed on the screen



Lab 1

- Write a set of functions:

```
void vt_fill(char ch, char attr);
void vt_blank(void);
int vt_print_char(char ch, char attr, int r, int c);
int vt_print_string(char *str, char attr, int r, int c);
int vt_print_int(int n, char attr, int r, int c);
int vt_draw_frame(int width, int height,
                  char attr, int r, int c);
```

  to output some characters on the screen in text mode, by writing to video RAM (VRAM)
- No need to configure the video controller/GPU:
  - You'll use the Minix 3 default configuration.
- Need "only" to write to the appropriate positions of VRAM

Virtual and Physical Address Spaces

Issue 1 Most computer architectures support a **virtual address space** that is decoupled from the **physical address space**

- Processes can access (physical) memory using a **logical** address that is independent of the physical address (determined by the address bus decoding circuitry)
- Most modern operating systems, including Minix, take advantage of this feature to simplify memory management.

Issue 2 In modern operating systems, **user-level processes** cannot access **directly** HW resources, including VRAM

- Minix 3 handles this by allowing to grant **privileged** user-level processes the permissions they require to perform their tasks

Nomenclature note A **program** is a sequence of instructions that can be executed by a processor. A **process** is a program in execution.

Mapping Physical Memory to Virtual Address Space

- Each process has its own virtual address space, whose size is usually determined by the processor architecture (32-bit for IA-32)
- The operating system maps regions of the physical memory in the computer to the virtual address spaces of the different processes
  - The details of how this is done are studied in the Operating Systems course.

Lab 1: `char *vt_init(vt_info_t *vi_p)`

- The implementation of this function is complete
  - You should not change it.
- Mainly, maps VRAM on the address space of a process
  - Returns the address of the first byte of the process' address space region onto which VRAM was mapped
  - Subsequent accesses to that region of the process' address space access VRAM
    - Usually, to change the characters displayed on the screen and/or their attributes.

Issue how can one access a region of a process address space in C?

Lab 1: Preparation

- Read the material provided
  - Lab 1 handout;
  - Supporting notes;
  - Class notes.
- Write the functions:

  `vt_fill()` which should fill the entire screen with the same character and attribute;

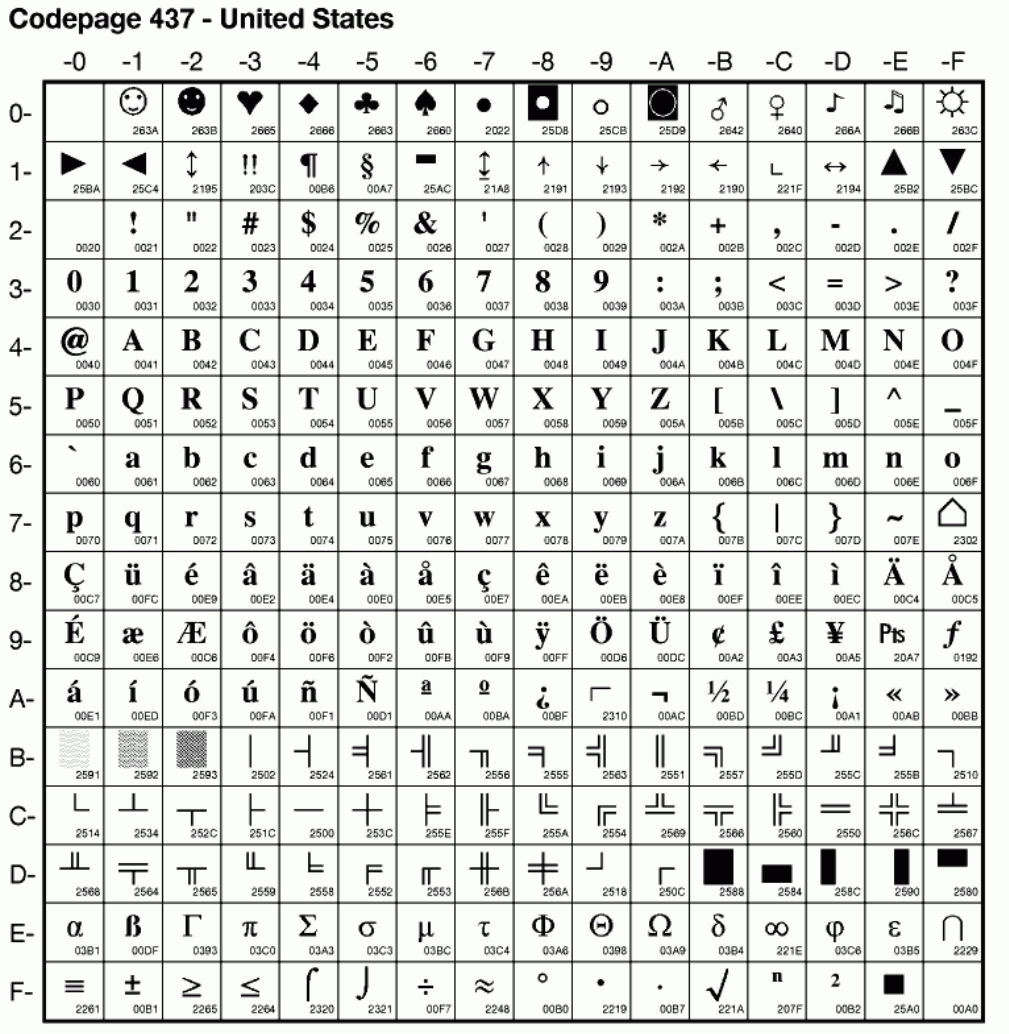
  `vt_blank()` which should blank the screen

Lab 1: Key Programming Issue

Given a virtual address, what is the C code that allows a process to access the physical memory mapped to that virtual address?

Character Encodings (Code Pages)

- The first 128 characters are the same for all western-language code pages.



Codepage 437 - United States

	-0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-A	-B	-C	-D	-E	-F
0-		☺ 263A	☻ 263B	♥ 2665	♦ 2666	♣ 2663	♠ 2660	• 2022	◘ 25D8	○ 25CB	◙ 25D9	♂ 2642	♀ 2640	♪ 266A	♫ 266B	☼ 263C
1-	► 25BA	◄ 25C4	↕ 2195	‼ 203C	¶ 00B6	§ 00A7	▬ 25AC	↨ 21A8	↑ 2191	↓ 2193	→ 2192	← 2190	∟ 221F	↔ 2194	▲ 25B2	▼ 25BC
2-	0020	! 0021	" 0022	# 0023	$ 0024	% 0025	& 0026	' 0027	(0028	) 0029	* 002A	+ 002B	, 002C	- 002D	. 002E	/ 002F
3-	0 0030	1 0031	2 0032	3 0033	4 0034	5 0035	6 0036	7 0037	8 0038	9 0039	: 003A	; 003B	< 003C	= 003D	> 003E	? 003F
4-	@ 0040	A 0041	B 0042	C 0043	D 0044	E 0045	F 0046	G 0047	H 0048	I 0049	J 004A	K 004B	L 004C	M 004D	N 004E	O 004F
5-	P 0050	Q 0051	R 0052	S 0053	T 0054	U 0055	V 0056	W 0057	X 0058	Y 0059	Z 005A	[005B	\ 005C	] 005D	^ 005E	_ 005F
6-	` 0060	a 0061	b 0062	c 0063	d 0064	e 0065	f 0066	g 0067	h 0068	i 0069	j 006A	k 006B	l 006C	m 006D	n 006E	o 006F
7-	p 0070	q 0071	r 0072	s 0073	t 0074	u 0075	v 0076	w 0077	x 0078	y 0079	z 007A	{ 007B	| 007C	} 007D	~ 007E	⌂ 2302
8-	Ç 00C7	ü 00FC	é 00E9	â 00E2	ä 00E4	à 00E0	å 00E5	ç 00E7	ê 00EA	ë 00EB	è 00E8	ï 00EF	î 00EE	ì 00EC	Ä 00C4	Å 00C5
9-	É 00C9	æ 00E6	Æ 00C6	ô 00F4	ö 00F6	ò 00F2	û 00FB	ù 00F9	ÿ 00FF	Ö 00D6	Ü 00DC	¢ 00A2	£ 00A3	¥ 00A5	Pts 20A7	ƒ 0192
A-	á 00E1	í 00ED	ó 00F3	ú 00FA	ñ 00F1	Ñ 00D1	ª 00AA	º 00BA	¿ 00BF	⌐ 2310	¬ 00AC	½ 00BD	¼ 00BC	¡ 00A1	« 00AB	» 00BB
B-	▒ 2591	▒ 2592	▓ 2593	| 2502	┤ 2524	╡ 2561	╢ 2562	╖ 2556	╕ 2555	╣ 2563	‖ 2551	╗ 2557	╝ 255D	╜ 255C	╛ 255B	┐ 2510
C-	└ 2514	┴ 2534	┬ 252C	├ 251C	─ 2500	┼ 253C	╞ 255E	╟ 255F	╚ 255A	╔ 2554	╩ 2569	╦ 2566	╠ 2560	═ 2550	╬ 256C	╧ 2567
D-	╨ 2568	╤ 2564	╥ 2565	╙ 2559	╘ 2558	╒ 2552	╓ 2553	╫ 256B	╪ 256A	┘ 2518	┌ 250C	▉ 2588	▄ 2584	▌ 258C	▐ 2590	▀ 2580
E-	α 03B1	ß 00DF	Γ 0393	π 03C0	Σ 03A3	σ 03C3	µ 03BC	τ 03C4	Φ 03A6	Θ 0398	Ω 03A9	δ 03B4	∞ 221E	φ 03C6	ε 03B5	∩ 2229
F-	≡ 2261	± 00B1	≥ 2265	≤ 2264	⌠ 2320	⌡ 2321	÷ 00F7	≈ 2248	° 00B0	• 2219	· 00B7	√ 221A	ⁿ 207F	² 00B2	■ 25A0	00A0