# Program 3: `aliens.asm`

Fall 2020

***Due November 12, 2020 @ 11:45pm***

This programming assignment must be completed individually. Do not share your code with or receive code from any other student. The only people who may see your code are the instructor and the ECE 109 TAs.

Evidence of copying or other unauthorized collaboration will be investigated as a potential academic integrity violation. **The minimum penalty for cheating on a programming assignment is a grade of -100 on the assignment.** If you are tempted to copy because you're running late, or don't know what you're doing, you will be better off missing the assignment and taking a zero. Providing your code to someone is cheating, just as much as copying someone else's work.

**DO NOT copy code from the Internet**, or use programs found online or in textbooks as a "starting point" for your code. Your job is to design and write this program from scratch, on your own. Evidence of using external code from any source will be investigated as a potential academic integrity violation.



For this assignment, you will create a program which acts as a simplified version of the old Space Invaders game. The program user will be able to direct their ship left and right and fire a laser beam at alien invaders.

The learning objectives for this assignment are:

- Use load and store instructions to manipulate the content of memory.
- Use I/O routines to allow a user to interact with the program.
- Subroutines

## Program Specification

The program must start at address x3000.

The program will manipulate the location of a rectangular box on the screen, which we will call the Pack Ship. The Pack Ship has a color and a location and is 12x24 pixels in size. The screen pixels inside the Pack Ship's current location will take on the Pack Ship's color. When the Ship moves, the pixels at the previous location return to the background color black. We must erase the old Ship, move to the new coordinates, and draw the new Ship. There are color keys to change the color of the Pack Ship. The Pack Ship should only be allowed to move left and right. Each keystroke on the appropriate key moves this ship 4 pixels on the display.

To fire a laser blast the user presses the space bar. A green laser bar 3x12 pixels in size is launched vertically from the center of the Pack Ship. It moves upward and disappears when it hits the top of the screen. The Alien Ships are 14x14 pixels in size. When a laser blast touches any pixel of these alien ships they are destroyed, and change to red-filled boxes as shown.

The PennSim graphics display (the "screen") is 128 by 124 pixels. We use an (x, y) coordinate system to describe a location on the screen. Location (0, 0) is the top left corner. The x coordinate increases as

we move to the right, and the y coordinate increases as we move down. In other words, (1, 0) is one pixel to the right of (0, 0), and location (0, 1) is one pixel below (0, 0). Location (127, 123) is the bottom right corner of the screen.

The program begins by drawing a screen as shown:

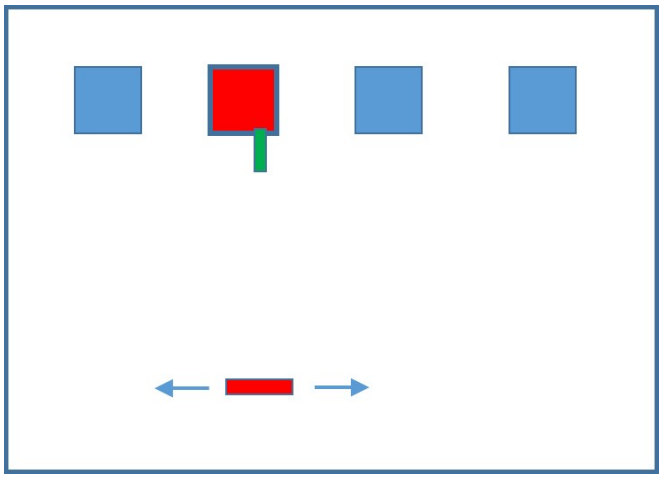


The coordinates for the "**aliens**" and the Pack Ship are given here in a table. This location is the **top-left** corner of the item.



| X | Y | Memory Decimal | Memory Hex |
|---|---|---|---|
| 10 | 3 | 394 | C18A |
| 40 | 3 | 424 | C1A8 |
| 70 | 3 | 454 | C1C6 |
| 100 | 3 | 484 | C1E4 |
| 51 | 103 | 13235 | F3B3 |

When the program begins, the Pack Ship location must be set to the center of the screen, as shown. The Pack Ship moves ONLY in the left and right directions and is not allowed to run off the end of the



screen. The figure below shows the screen when a laser blast hits an alien ship. When all 4 alien ships are hit, the program prints a message "GAME OVER !" on the console and halts.

When the program is working with the boxes, then modify it to read in icon images from higher memory, loaded separately. An alternative bitmap for the Alien Ships is located at address x5000 by loading the object alien.obj. An alternative bitmap for the Pack Ship is located at address x5200 by loading the file pack.obj. These bitmaps are oriented in row order, meaning the successive memory addresses move left to right across the top row and then move down to the next line of pixels.

The program is to read these bitmaps and use them on the display instead of the original blocks for the Alien and Pack Ships. The effect of a "hit" Alien Ship should remain the same, it should change the icon to a red box.



You are required to use **at least five (5) subroutines** in your program. You may use more, as many as you like. The choice of subroutines is up to you, but there are several obvious candidates: paint/erase a square, draw the course, check for crash, draw the start/finish line, etc.



Subroutines are used to modularize your code. Separate it into manageable pieces. As you write a subroutine, you should also write some code to test that routine on its own. Once you know that a subroutine works, then you can move on to implement and test some other parts of the program. (When there's a bug, you can be fairly confident that the problem is with the new code, since you've already tested and debugged the earlier subroutines.)



You must define the interface for each subroutine. What does the caller pass in? What does the caller get back? This interface must be documented in your code via comments. Each subroutine must have a **comment header** that describes what the subroutine does and how to use it. Lack of documentation will cause you to lose points.





The user interacts with the program using one-character commands. The commands are typed on the keyboard, but are not printed to the console display. Nothing will be printed to the console during the execution of this program. The program will wait for a keystroke, perform the corresponding command, and repeat. If the keystroke does not correspond to a legal command, it will have no effect.

There are four commands for changing the location of the Box. We use the WASD scheme of navigation, used by various computer games:

| Command Character | Action |
|---|---|
| a | *Move left 4 pixels*<br>Location changes from (x, y) to (x-1, y).<br>If the Box is at the left border of the screen, the command has no effect. |
| d | *Move right 4 pixels*<br>Location changes from (x, y) to (x+1, y).<br>If the Box is at the right border of the screen, the command has no effect. |
| Space | *Fire a Laser Blast* |
| q | *Quit the Program* |

There are five commands for changing the Pack Ship color:

| Command Character | Action |
|---|---|
| r | Change color to *Red*. |
| g | Change color to *Green*. |
| b | Change color to *Blue*. |
| y | Change color to *Yellow*. |
| b | Change color to *White*. |



Note: When you change the color of the Pack Ship, the color of the current location must change, before the next command is processed.



**NOTE**: You **MUST** use/load **p3os.obj** for this code to run properly!



## Details

The PennSim graphics display is memory mapped, meaning that each pixel maps to a corresponding memory location. The content of that memory location controls the color of the pixel.



### *Pixel Addresses*



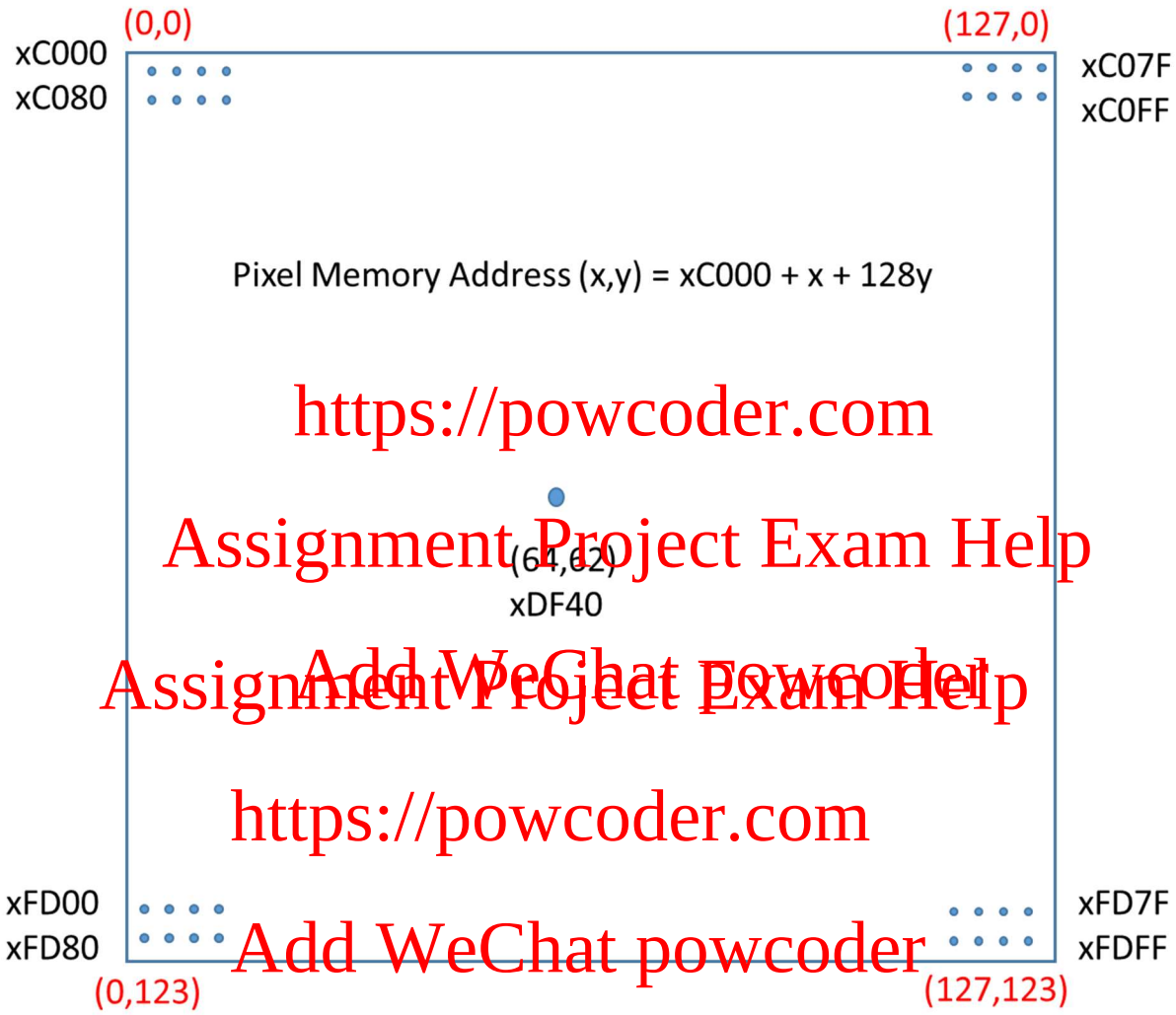
Addresses xC000 through xFDFF are assigned to the graphics display. The low address corresponds to the top left corner (0, 0). Moving one pixel to the right adds one to the address, and it "wraps around" to the next row when it gets to the right edge. Since the display is 128 pixels wide, this means that moving down one pixel is equivalent to adding 128 to the address.



The address of point ($x$, $y$) can be calculated as: xC000 + $x$ + 128$y$.

For this assignment, you will not need to calculate arbitrary pixel addresses, except to figure out where the initial location (64, 62) is. You will be moving left (-8), right (+8), up ((8*-128)) or down ((8*+128)) from the current address.

You will, however, need to recognize when the Pack Ship is at an edge of the display, so that you don't go beyond the edge.






***Pixel Color***

As mentioned above, the value of the pixel address determines the color of the pixel. The 16 bits contain 5 bits for each RGB component of color: bits [14:10] for red, [9:5] for green, and [4:0] for blue. Bit 15 is ignored. The higher value of a component, the more of that color is present. The table below gives the color values (in hex) needed for this program.

| Color | Value |
|---|---|
| Red | x7C00 |
| Green | x03E0 |
| Blue | x001F |

| | |
|---|---|
| Yellow | x7FED |
| White | x7FFF |
| Black | x0000 |

### *Miscellaneous*

For more explanation about the PennSim display, see the PennSim Reference Manual.

The ASCII code for the Return key is x0A (#10). This is listed as linefeed (LF) in the ASCII table.

## Hints and Suggestions

- As always, **design before you code!** Draw a flowchart to organize and document your thinking before you start writing the program.
- **Work incrementally!** For example, implement one command at a time. Make sure the program works before moving on to the next command. This way you always have working code.
- It's not a bad idea to submit each working version of your program to Wolfware. Then, if your machine crashes (it happens!), you haven't lost everything. Each time you submit, it overwrites the previous submission; so you can submit as many times as you like. But don't expect that we can recover some previous version of your code if you accidentally clobber it. (You should have some sort of backup system for your schoolwork, right?)
- *Test your program with a wide variety of inputs.* Make sure that you have tested the "corner cases," such as reaching the border of the display.
- Use the PennSim simulator and assembler. There are other simulators and assemblers out there, but there are some differences. Your program will be graded using PennSim, and no other tools will be used or considered.



## Administrative Info

Any corrections or clarifications to this program spec will be posted on the **Discussion Forum**. It is important that you read these postings, so that your program will match the updated specification. (I recommend strongly that you subscribe to the forum, so that you will not miss any updates or corrections.)

*What to turn in:*

- Assembly Language Source file – it must be named **aliens.asm**. Submit via **Moodle** to the Program 3 assignment.
- DO NOT submit .obj or .sym files. Do not submit a .txt file, a .doc file, or anything like that. It must be a simple text file with the proper .asm extension. If we are unable to open or interpret your file, you will get a zero for the assignment (even if it has the right name!).

*Grading criteria:*

There is NO flowchart submission for this assignment. However, you will know by now to use this to plan your program.

5 points: Correct type of file, submitted with the **proper name**. (No partial credit!! These are essentially FREE POINTS! Don't screw it up.)

10 points: **Program is complete** and **assembles with no warnings and no errors** using the PennSim assembler. To be "complete," there must be code that makes a reasonable attempt to meet the program specs. Programs that do not assemble will not be graded any further. (For warnings, points will be deducted, but the program will be tested for correctness.)

10 points: **Proper coding style, comments, and header**. Use indentation to easily distinguish labels from opcodes. Leave whitespace between sections of code. Include *useful* comments and *meaningful* labels to make your code more readable. Your file **must** include a header (comments) that includes your name and a description of the program, Section Number, and Submission Date. Don't cut-and-paste the description from the program spec – that's plagiarism. Describe the program in your own words. This category is somewhat subjective, but the goal is that your program should be easy to read and to understand.



75 points: The program **handles all function correctly**:

(10 points) Draws the initial screen with the Alien and Pack ships as shown above.

(20 points) Left/Right movements, check that Alien Ship does not cross edges



(10 points) Change colors in the Pack Ship box

(15 points) Launch a Laser Blast and have it move upward as specified.

(10 points) Properly identifies a hit of an Alien Ship. Change the Alien Ship Box as specified.





(10 points) Read the Bitmaps for the Alien and Pack Ships from high memory and replace the original boxes with the bitmap.



**NOTE**: You **MUST** use/load **p3os.obj** for this code to run properly!