1. Suppose that we have the following expressions using post-fix notations. What is the result for each of them?

1) 2 5 5 + – 1 * 2 /

Result:

2) x x 6 – 2 * x - /

If x = 8, result:

3) x 6 x – 2 * x - /

If x = 8, result:

2. Write the post-fix notations for following expressions. If x=5, show the stack state at the calculation progress and the key sequence that should be entered. At last, write a program for a HP 15C calculator for calculating the expression. In the program, the input is the value of x.

1) (x*4-2)*x/(x+5)

Post-fix notation:

\[
\begin{array}{cccc}
5 & \text{enter} & 4 & \text{*} \\
5 & 4 & 20 & \\
5 & \text{ } & \text{ } & \\
\end{array}
\]
Program for HP 15C calculator:

g P/R

f LBL A

;Add your code here

g RTN

g R/S

5

GSB A

2) $x^3+3x^2+3x+1$

Post-fix notation:

<table>
<thead>
<tr>
<th>enter</th>
<th>5</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>216</th>
</tr>
</thead>
<tbody>
<tr>
<td>215</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Program for HP 15C calculator:

g P/R

f LBL B

;Add your code here

3. You can find a program for HP 15C written in the table. It is for calculating the following expression. Please fill in the addresses, machine codes and comments for each instruction in the program.

\[ Y = \frac{x-5}{3} + 4(x+5) \]

<table>
<thead>
<tr>
<th>Address</th>
<th>Machine Code</th>
<th>Keystroke</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>000-001</td>
<td>44 0</td>
<td>sto 0</td>
<td>store in register 0</td>
</tr>
<tr>
<td>002</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>003</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>004</td>
<td>/</td>
<td>rcl 0</td>
<td></td>
</tr>
<tr>
<td>005</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>006</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>010</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>012</td>
<td>20</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>013</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>014-015</td>
<td>43 32</td>
<td>g rtn</td>
<td></td>
</tr>
</tbody>
</table>
4. Convert the following program written in accumulator architecture to stack architecture. You can only use push, add and pop.

load [100]
add [200]
store [300]

Hint: [100] means the content of memory cell located at address100.

5. Method cmp() in class homework_1 is used to compare two integer number. It is written in Java as bellow:

```java
public class homework_1{
    public int cmp(int a, int b){
        if(a>b) return 1;
        else if(a<b) return -1;
        else return 0;
    }
}
```

After using javap to dissemble the generated .class file, you can find an equivalent assembly program for method cmp() as bellow:

```
0:  iload_1
1:  iload_2
2:  if_icmple    7
5:  iconst_1
6:  ireturn
7:  iload_1
8:  iload_2
9:  if_icmpge   14
12:  iconst_m1
13:  ireturn
14:  iconst_0
15:  ireturn
```
Also, you can use xxd command to check a hex representation of .class file. Part of it is shown here:

00000c0: 052a b700 01b1 0000 0001 0007 0000 0006 .*.............
00000e0: 0000 003a 0002 0003 0000 0010 1b1c a400 ..........
00000f0: 0504 ac1b 1ca2 0005 02ac 03ac 0000 0002 ..........

The corresponding bytecode has been highlighted for that piece of assembly code. Filling the hex representation of bytecode for corresponding instructions in the following table. For example, for iload_1 in line 0, the hex representation of bytecode is 1b. And for ireturn in line 15, the hex representation of bytecode is ac. For if_icmple 7 in line 2, the hex representation of bytecode is a4 00 05.

| 1b       | 0: iload_1  
|          | 1: iload_2  
|          | 2: if_icmple 7  
|          | 5: iconst_1  
|          | 6: ireturn  
|          | 7: iload_1  
|          | 8: iload_2  
|          | 9: if_icmpge 14  
|          | 12: iconst_m1  
|          | 13: ireturn  
|          | 14: iconst_0  
|          | 15: ireturn  
| a4 00 05 |  

Hint: Opcodes for operators in each instruction can be found in https://docs.oracle.com/javase/specs/jvms/se8/html/jvms-7.html

Then answering the following questions.

What does iconst_1 mean? Can we use bipush to replace it? And how to replace it?

What does iload_1 mean? And which variable it relates to compared with java code?(Hint: variable a or b) Can we use iload_0 instead? And why if we cannot?

Why for if_icmple 7 in line 2, the hex representation of bytecode is a4 00 05, but not a4 00 07?
Submission:

• Upload an electronic copy (MS word or pdf) of your answer sheet to the folder named “Homework1” of the Dropbox in the desire2learn system.

• Please add the Home Work number and your name at the top of your file sheet.

• Name your file in the format of HW1_FirstnameLastname (e.g. HW1_FirstnameLastname.docx, HW1_FirstnameLastname.pdf)