Stacks and Procedures: 1

12 points possible (ungraded)

Harry Hapless is a friend struggling to finish his Lab; knowing that you completed it successfully, he asks your help understanding the operation of the quicksort procedure, which he translated from the Python code given in the lab handout:

```
def quicksort(array, left, right):
   if left < right:</pre>
      pivotIndex = partition(array,left,right)
      quicksort(array,left,pivotIndex-1)
      quicksort(array,pivotIndex+1,right)
```

You recall from your lab that each of the three arguments and the local variable are 32bit binary integers. You explain to Harry that quicksort returns no value, but is called for its effect on the contents of a region of memory dictated by its argument values. Harry asks some questions about the possible effect of the call quicksort(0×1000, 0×10, 0×100):

0

9

0

2F0

94C

F94

1

2

3

4

8

0

2F0

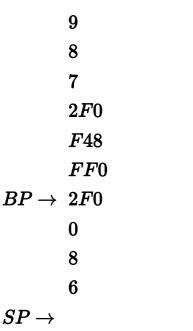
F24

FCC

2F0

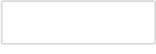
0

9



1. Given the above call to quicksort, what is the region of memory locations (outside of the stack) that might be changed?

Lowest memory address possibly effected: 0x



Highest memory address possibly effected: 0x

Harry's translation of quicksort to Beta assembly language appears above on the right.

2. What register did Harry choose to hold the value of the variable **pivotIndex**?

Register holding pivotIndex value: R



After loading and assembling this code in BSim, Harry has questions about its translation to binary.

3. Give the hex value of the 32-bit machine instruction with the tag aa in the program to the right.

Hex translation of instruction at aa: 0x

```
quicksort:
      PUSH(LP)
      PUSH(BP)
      MOVE(SP, BP)
      PUSH(R1)
      PUSH(R2)
      PUSH(R3)
      PUSH(R4)
      LD(BP, -12, R1)
      LD(BP, -16, R2)
      LD(BP, -20, R3)
aa:
      CMPLT(R2, R3, R0)
      BF(R0, qx)
      PUSH(R3)
      PUSH(R2)
      PUSH(R1)
      BR(partition, LP)
      DEALLOCATE(3)
      MOVE(R0, R4)
XX:
      SUBC(R4, 1, R0)
      PUSH(R0)
      PUSH(R2)
      PUSH(R1)
      BR(quicksort, LP)
      DEALLOCATE(3)
      PUSH(R3)
      ADDC(R4, 1, R0)
      PUSH(R0)
      PUSH(R1)
      BR(quicksort, LP)
bb:
      DEALLOCATE(3)
      P0P(R4)
qx:
      P0P(R3)
      P0P(R2)
      P0P(R1)
      MOVE(BP, SP)
cc:
      POP(BP)
      POP(LP)
      JMP(LP)
```

		~ ~ ~	
6/17.	/24	8:20	AM

	Harry tests his code, which seems to work fine. He questions whether it could be shortened by simply eliminating certain instructions.
4.	Would Harry's quicksort continue to work properly if the instruction at bb were
	eliminated? If the instruction at cc were eliminated? Indicate which, if any, of
	these instructions could be deleted. OK to delete instruction at bb?
	Yes
	○ No
	OK to delete instruction at cc?
	Yes
	○ No
	Harry runs his code on one of the Lab test cases, which executes a call to quicksort(Y, 0, X) via a BR(quicksort, LP) at address 0×948 . Harry halts its execution just as the instruction following the xx tag is about to be executed. The contents of a region of memory containing the topmost locations on the stack is shown to the right.
5.	What are the arguments to the current quicksort call? Use the stack trace shown above to answer this question.
	Arguments: array = 0x
	left = 0x
	right = 0x
	right – OA

6. What is the value **X** in the original call **quicksort(Y, 0, X)**?

Value of X in original call: 0x

7. Wha	at were the conte de?	nts of R4 when t	he original ca	ll to quicksort	(Y, 0, X) was
Cor	ntents of R4 at or	iginal call: 0x			
	at is the address of value of bb: Ox	of the instruction	tagged bb: i	n the program?	?
Submit					

Stacks and Procedures: 2

11 points possible (ungraded)

The following C program implements a function (ffo) of two arguments, returning an integer result. The assembly code for the procedure is shown on the right, along with a partial stack trace showing the execution of **ffo(0xDECAF,0)**. The execution has been halted just as the Beta is about to execute the instruction labeled **rtn**, i.e., the value of the Beta's program counter is the address of the first instruction in POP(R1). In the C code below, note that "v>>1" is a logical right shift of the value v by 1 bit.

```
// bit position of left-most 1
int ffo(unsigned v, int b) {
  if (v == 0) ???;
  else return ffo(v>>1,b+1);
}
```

1. Examining the assembly language for ffo, what is the appropriate C code for ??? in the C representation for ffo?

C cod	le fo	r ??	??:
-------	-------	------	-----

return b		0x000F	ffo:	PUSH(LP)
		0x001B	110.	PUSH(BP)
return 0		0x0208		MOVE(SP, BP)
		0x012C		PUSH(R1)
return ffo(v>>1,b)		0x001B		LD(BP,-16,R0)
		0x0010	xxx:	LD(BP,-12,R1) BEQ(R1,rtn)
		0x000D		
		0x0208		ADDC(R0,1,R0) PUSH(R0)
		0x0140		SHRC(R1,1,R1)
		0x000D		PUSH(R1) BR(ffo,LP)
		0x000D $0x0011$		DEALLOCATE(2)
		0x0001	rtn:	P0P(R1)
		0x0000 $0x0208$	1 (11.	MOVE(BP,SP)
		$0x0208 \\ 0x0154$		POP(BP) POP(LP)
	DD .	$0x0104 \\ 0x0006$		JMP(LP)
•	$D\Gamma \rightarrow$			
		0x0012		
2 M/s at value will be not one of free		0x0003	:f ~ (0.100)0	
2. What value will be returned from Value returned from procedure	•		10(3,100)?	
3. What are the values of the arguinabout to return? Please express				
value cannot be determined.	tilo van	acc in rick of	Wiite 57 ii	
Value of argument v or "CAN'T	TELL": (Ox		
Value of argument b or "CAN'T	TELL": (Ох		
4. Determine the specified values	at the ti	me executior	was halte	d. Please express
each value in hex or write "CAN"		' if the value o	cannot be	determined.
Value in R1 or "CAN'T TELL": 0x	•			

Value in BP or "CAN'T TELL": 0x

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	Value in LP or "CAN'T TELL": 0x	
	Value in SP or "CAN'T TELL": 0x	
	Value in PC or "CAN'T TELL": 0x	
5.	What is the address of the BR instruction for the original call to ffo(0xDECAF,0). Please express the value in hex or "CAN'T TELL". Address of the original BR, or "CAN'T TELL": 0x)?
6.	A 6.004 student modifies ffo by removing the DEALLOCATE(2) macro in the assembly compilation of the ffo procedure, reasoning that the MOVE(BP,SP) w perform the necessary adjustment of stack pointer. She runs a couple of tests and verifies that the modified ffo procedure still returns the same answer as	

6 before. Does the modified ffo obey our procedure call and return conventions? Does modified ffo obey call/return conventions?

Select an option ➤

Submit

Stacks and Procedures: 3

13/13 points (ungraded)

It was mentioned in lecture that recursion became a popular programming construct following the adoption of the stack as a storage allocation mechanism, ca. 1960. But the Greek mathematician Euclid, always ahead of his time, used recursion in 300 BC to compute the greatest common divisor of two integers. His elegant algorithm, translated to C from the ancient greek, is shown below:

```
int gcd(int a, int b) {
   if (a == b) return a;
  if (a > b) return gcd(a-b, b);
  else return gcd(a, b-a);
}
```

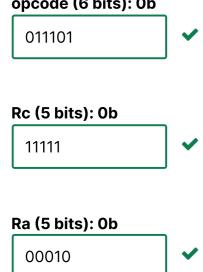
The procedure **gcd(a, b)** takes two positive integers **a** and **b** as arguments, and returns the greatest positive integer that is a factor of both **a** and **b**.

Note that the base case for this recursion is when the two arguments are equal (== in C tests for equality), and that there are two recursive calls in the body of the procedure definition.

Although Euclid's algorithm has been known for millennia, a recent archeological dig has uncovered a new document which appears to be a translation of the above C code to Beta assembly language, written in Euclid's own hand. The Beta code is known to work properly, and is shown below.

```
PUSH(LP)
gcd:
        PUSH(BP)
        MOVE(SP, BP)
        PUSH(R1)
        PUSH(R2)
        LD(BP, -12, R0)
        LD(BP, -16, R1)
        CMPEQ(R0, R1, R2)
        BT(R2, L1)
        CMPLE(R0, R1, R2)
        BT(R2, L2)
XXX:
        PUSH(R1)
        SUB(R0, R1, R2)
        PUSH(R2)
        BR(gcd, LP)
        DEALLOCATE(2)
        BR(L1)
L2:
        SUB(R1, R0, R2)
        PUSH(R2)
        PUSH(R0)
        BR(gcd, LP)
        DEALLOCATE(2)
L1:
        P0P(R2)
        P0P(R1)
        MOVE(BP, SP)
ууу:
        POP(BP)
        POP(LP)
        JMP(LP)
```

1. Give the 32-bit binary translation of the **BT(R2,L2)** instruction at the label **xxx opcode (6 bits): 0b**

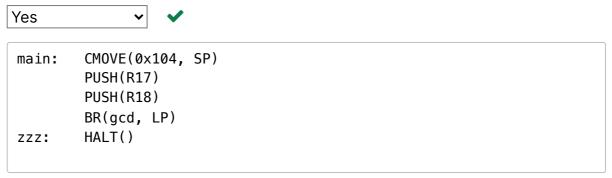


literal (16 bits): 0b

00000000000100

2. One historian studying the code, a Greek major from Harvard, questions whether the **MOVE(BP, SP)** instruction at **yyy** is really necessary. If this instruction were deleted from the assembly language source and re-translated to binary, would the shorter Beta program still work properly?

Still works?



At a press conference, the archeologists who discovered the Beta code give a demonstration of it in operation. They use the test program shown above to initialize SP to hex **0×104**, and call gcd with two positive integer arguments from **R17** and **R18**. Unfortunately, the values in these registers have not been specified.

Address in Hex Data in Hex

100: 104 104: 18 108: 10C:D8110: D4114: EFBA118: 11C: \boldsymbol{F} 120: 9 124: 78 128: 114 12C:18 **130**: \boldsymbol{F} 134: 6 138:

13C:78 **140**: 12C144: \boldsymbol{F} 148: 6 14C:6 150: 3 154: 58 158: 144

 $SP \rightarrow 15C: 6$

They start their program on a computer designed to approximate the computers of Euclid's day (think of Moore's law extrapolated back to 300 BC!), and let it run for a while. Before the call to gcd returns, they stop the computation just as the instruction at **yyy** is about to be executed, and examine the state of the processor.

They find that **SP** (the stack pointer) contains **0×15C**, and the contents of the region of memory containing the stack as shown (in **HEX**) to the right.

You note that the instruction at **yyy**, about to be executed, is preparing for a return to a call from gcd(a,b).

3. What are the values of **a** and **b** passed in the call to gcd which is about to return? Answer in HEX.





4. What are the values of **a** and **b** passed in the *original* call to gcd, from registers **R17** and **R18**? Answer in HEX.







5. What is the address corresponding to the tag **zzz**: of the **HALT()** following the original call to **gcd**?

Address of zzz: (HEX): 0x

D8 🗸

6. What is the address corresponding to the tag L1: in the assembly b for gcd?

Address of L1: (HEX): 0x
7C

7. What value will be returned (in R0) as the result of the original call to **gcd**?

Value returned to original caller: (HEX): 0x



8. What was the value of R2 at the time of the original call to gcd?

Original value in R2: (HEX): 0x

ВА



Submit

Stacks and Procedures: 4

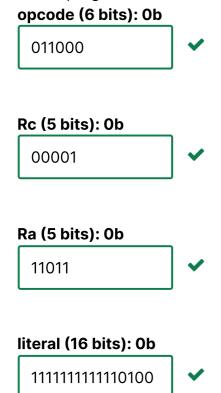
15/15 points (ungraded)

You are given the following listing of a C program and its translation to Beta assembly code:

```
int f(int x, int y)
  int a = x - 1; b = x + y;
  if (x == 0) return y;
  return f(a, ???)
```

```
f:
      PUSH(LP)
      PUSH(BP)
      MOVE(SP, BP)
mm:
      PUSH(R1)
      PUSH(R2)
      LD(BP, -16, R0)
      LD(BP, -12, R1)
уу:
      BEQ(R1, xx)
      SUBC(R1, 1, R2)
      ADD(R0, R1, R1)
      PUSH(R1)
      PUSH(R2)
      BR(f, LP)
      DEALLOCATE(2)
ZZ:
      LD(BP, -16, R1)
      ADD(R1, R0, R0)
      PUSH(R0)
      PUSH(R2)
ww:
      BR(f, LP)
      DEALLOCATE(2)
      P0P(R2)
XX:
      P0P(R1)
      POP(BP)
      POP(LP)
      JMP(LP)
```

1. Fill in the binary value of the **LD** instruction stored at the location tagged **yy** in the above program.



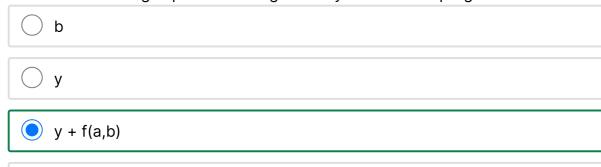
2. Suppose the MOVE instruction at the location tagged **mm** were eliminated from the above program. Would it continue to run correctly?

Still works fine?

Yes		
Can't Tell		
No		



3. What is the missing expression designated by ??? in the C program above.





f(a,b)

The procedure f is called from location 0xFC and its execution is interrupted during a recursive call to f, just prior to the execution of the instruction tagged xx. The contents of a region of memory, including the stack, are shown to the left.

NB: All addresses and data values are shown in hex. The BP register contains 0×494, and SP contains 0×49C.

Address in Hex Contents in Hex

448	${f 2}$
44 <i>C</i>	4
450	7
454	3
458	2
45C	100
460	D4
464	3
404	J
468	4

4. What are the arguments to the *most recent* active call to **f**?

Most recent arguments (HEX): x = 0x



y = 0xВ

5. What value is stored at location **0×478**, shown as **???** in the listing to the left?

Contents 0×478 (HEX): 0x

464

6. What are the arguments to the original call to f?

Original arguments (HEX): x = 0x

2

y = Ox

3

7. What value is in the **LP** register?

Contents of LP (HEX): 0x

70

8. What value was in R1 at the time of the original call?

Contents of R1 (HEX): 0x

3

9. What value is in **RO**?

Value currently in RO (HEX): 0x



10. What is the hex address of the instruction tagged ww

```
Address of ww (HEX): 0x?
 64
```

Submit

Stacks and Procedures: 5

16/17 points (ungraded)

The **wfps** procedure determines whether a string of left and right parentheses is well balanced, much as your Turing machine of Lab 4 did. Below is the code for the wfps ("well-formed paren string") procedure in C, as well as its translation to Beta assembly code.

```
int STR[100];
                         // string of parens
int wfps(int i,
                         // current index in STR
 int n)
                         // LPARENs to balance
{ int c = STR[i];
                         // next character
 int new_n;
                         // next value of n
 if (c == 0)
                        // if end of string,
   return (n == 0);
                        // return 1 iff n == 0
 else if (c == 1)
                        // on LEFT PAREN,
   new_n = n+1;
                        //
                               increment n
   else {
                         // else must be RPAREN
     xxxxx; }
                         // MYSTERY CODE!
 return wfps(i+1, new_n); // and recurse.
}
```

```
STR:
      . = .+4*100
wfps: PUSH(LP)
      PUSH(BP)
      MOVE(SP, BP)
      ALLOCATE(1)
      PUSH(R1)
      LD(BP, -12, R0)
      MULC(R0, 4, R0)
      LD(R0, STR, R1)
      ST(R1, 0, BP)
      BNE(R1, more)
      LD(BP, -16, R0)
      CMPEQC(R0, 0, R0)
      P0P(R1)
rtn:
      MOVE(BP, SP)
      POP(BP)
      POP(LP)
      JMP(LP)
more: CMPEQC(R1, 1, R0)
      BF(R0, rpar)
      LD(BP, -16, R0)
      ADDC(R0, 1, R0)
      BR(par)
rpar: LD(BP, -16, R0)
      BEQ(R0, rtn)
      ADDC(R0, -1, R0)
      PUSH(R0)
par:
      LD(BP, -12, R0)
      ADDC(R0, 1, R0)
      PUSH(R0)
      BR(wfps, LP)
      DEALLOCATE(2)
      BR(rtn)
```

wfps expects to find a string of parentheses in the integer array stored at **STR**. The string is encoded as a series of **32-bit integers** having values of

- 1 to indicate a left paren,
- 2 to indicate a right paren, or
- 0 to indicate the end of the string.

These integers are stored in consecutive 32-bit locations starting at the address **STR**.

wfps is called with two arguments:

1. The first, **i**, is the index of the start of the part of **STR** that this call of **wfps** should examine. Note that indexes start at 0 in C. For example, if **i** is 0, then **wfps** should examine the entire string in **STR** (starting at the first character, or **STR[0]**). If **i** is

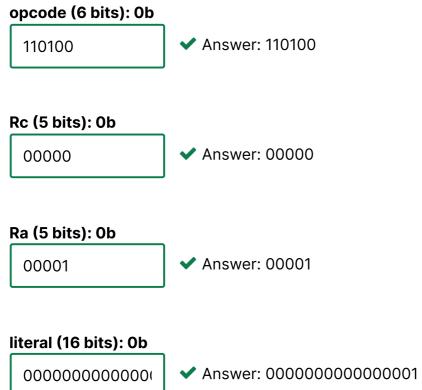
- 4, then wfps should ignore the first four characters and start examining STR starting at the fifth character (the character at **STR[4]**).
- 2. The second argument, **n**, is zero in the original call; however, it may be nonzero in recursive calls.

wfps returns 1 if the part of STR being examined represents a string of balanced parentheses if **n** additional left parentheses are prepended to its left, and returns 0 otherwise.

Note that the compiler may use some simple optimizations to simplify the assemblylanguage version of the code, while preserving equivalent behavior.

The C code is incomplete; the missing expression is shown as **xxxx**.

1. Fill in the binary value of the instruction stored at the location tagged more in the above assembly-language program.



Explanation

The instruction tagged **more** is **CMPEQC(R1, 1, R0)**.

The opcode for the **CMPEQC** instruction is 110100.

Register Rc is R0, or 00000 when encoded using 5 bits.

Register Ra is R1, or 00001.

The literal is 1 using 16 bits of binary.

2. Is the variable c from the C program stored as a local variable in the stack frame?

		Yes		
		No		
	✓ If so, g	give its (signed) offset from BP; else select "NA".		
		BP-16		
		BP-12		
		BP-8		
		BP+0		
		BP+4		
		BP + 8		
		NA		
	~			
3.	This s location Is the	tack frame for wfps looks like this: hows that to access the variable C, we want to access the on that BP points to without adding any offset. variable new_n from the C program stored as a local variable stack frame? Yes	BP o	$n \ i \ LP \ BP \ c$
		No		R1
	✓ If so, g	give its (signed) offset from BP; else select "NA".		
		BP-16		
		BP-12		

○ <i>BP</i> − 8		
$\bigcirc BP + 0$		
$\bigcirc BP+4$		
$\bigcirc BP + 8$		
○ NA		
✓		

Explanation

new_n is not stored as a local variable in the stack frame. It is passed as the next value of n in the recursive calls to wfps.

4. What is the missing C source code represented by xxxxx in the given C program?



Explanation

The **rpar:** portion of code implements the final **else** statement. It first loads n into R0 and returns 0 if n == 0. Otherwise it subtracts 1 from n and pushes that onto the stack as the new value of variable n for the next recursive call. So new_n = n - 1.

The procedure **wfps** is called from an external procedure and its execution is interrupted during a recursive call to wfps, just prior to the execution of the instruction labeled rtn. The contents of a region of memory are shown below. At this point, **SP** contains $0\times1D8$, and **BP** contains $0\times1D0$.

NOTE: All addresses and data values are shown in hexadecimal.

Address in Hex Contents in Hex

188:	7
18C:	4A8
190:	0
194:	0
198:	458
19C:	D4
1A0:	1
1A4:	D8
1A8:	1
1AC:	1
1B0:	3B8
1B4:	1A0
1B8:	2
1BC:	1
1C0:	0
1C4:	2
1C8:	3B8
1CC:	1B8
BP→1D0:	2
1D4:	2
SP→1D8:	0

5. What are the arguments to the *most recent* active call to **wfps**?

Most recent arguments (HEX): i = 0x





Explanation

The remaining questions are easier to answer if we label the stack with the stack frame elements that each location represents.

Address in Hex Contents in Hex

188:	7	
18C:	4 <i>A</i> 8	
190:	0	n

		0.
194:	0	i
198:	458	LP
19C:	D4	ВР
1A0:	1	С
1A4:	D8	R1
1A8:	1	n
1AC:	1	i
1B0:	3B8	LP
1B4:	1A0	ВР
1B8:	2	С
1BC:	1	R1
1C0:	0	n
1C4:	2	i
1C8:	3B8	LP
1CC:	1B8	ВР
BP→1D0:	2	С
1D4:	2	R1
SP→1D8:	0	

The arguments for the most recent call to wfps are at address 1C0 and 1C4, i = 2 and n = 0.

6. What are the arguments to the *original* call to **wfps**?

Original arguments (HEX): i = 0x



Explanation

There are three stack frame instances shown on the stack. The two that have LP = 0×3B8 are from the recursive call to wfps, whereas the top one where LP = 0×458 is from the original call to wfps. This means that the arguments for the original call are the ones at addresses 0×190 and 0×194 , or i = 0 and n = 0.

7. What value is in **RO** at this point?

Contents of RO (HEX): 0x



Explanation

In the most recent active call to **wfps**, the arguments are i = 2 and n = 0. From the current stack frame we also see that the current c = 2 and its stored at address 0×1D0. Since c!= 0, we enter the else if portion of the code which is at label **more**. There R0 is assigned to the result of checking if c == 1. Since it doesn't R0 is set to 0, and the code branches to label rpar to check for a right parenthesis. There n is loaded into R0, so again R0 = 0 and we then branch to label **rtn**. So R0 = 0 when execution is stopped.

8. How many parens (left and right) are in the string stored at STR (starting at index 0)? Give a number, or "CAN'T TELL" if the number can't be determined from the given information.

Length of string, o	or "CAN'T TELL":	
<u> </u>		
<u> </u>		
<u>3</u>		
Can't Tell		

Explanation

There is no way to tell the actual number of parentheses in the string because we don't have the entire history of execution of the wfps routine.

9. What is the hex address of the instruction tagged par?

Address of par (HEX): 0x

✓ Answer: 39C 39C

Explanation

The LP value stored in the recursive calls to **wfps** points to the DEALLOCATE(2) instruction. This value is 0×3B8. Below is a table showing the addresses of the instructions beginning at label par and ending at the DEALLOCATE(2) instruction. Recall that PUSH instructions are actually a macro consisting of two instructions so they take up 8 bytes instead of 4.

39C3A43A83AC3B43B8

HEX address instruction

PUSH(R0)

LD(BP, -12, R0)

ADDC(R0, 1, R0)

PUSH(R0)

BR(wfps, LP)

DEALLOCATE(2)

So the address of par is 0×39C.

10. What is the hex address of the BR instruction that called wfps originally? Address of original call (HEX): 0x

```
0×454
```

X Answer: 454

Explanation

Since the original LP = 0×458 and that points at the instruction immediately following the original branch instruction, that means that the original BR instruction is at 0×454.

Submit

1 Answers are displayed within the problem

Stacks and Procedures: 6

13 points possible (ungraded)

You've taken a summer internship with BetaSoft, the worlds largest supplier of Beta software. They ask you to help with their library procedure sqr(j), which computes the square of a non-negative integer argument j. Because so many Betas don't have a multiply instruction, they have chosen to compute sqr(j) by adding up the first j odd integers, using the C code below and its translation to Beta assembly language to the left.

```
int sqr(j) {
   int s = 0;
   int k = j;
   while (k != 0) {
      s = s + nthodd(k);
      k = k - 1;
   return s;
}
int nthodd(n) {
   if (n == 0) return 0;
   return ???;
}
```

You notice that the **sqr** procedure takes an integer argument j, and declares two local integer variables s and k (initialized to zero and j, respectively).

The body of **sqr** is a loop that is executed repeatedly, decrementing the value of k at each iteration, until k reaches zero. Each time through the loop, the local variable s incremented by the value of the kth odd integer, a value that is computed by an auxiliary procedure **nthodd**.

 What is the missing expression shown as ??? in the C code defining nthodd above?
 What is the missing expression denoted ??? in above C code:

```
PUSH (LP)
sqr:
        PUSH (BP)
        MOVE (SP, BP)
        ALLOCATE(2)
        PUSH (R1)
        ST(R31, 0, BP)
        LD (BP, -12, R0)
        ST(R0, 4, BP)
loop:
        LD(BP, 4, R0)
        BEQ(R0, done)
        PUSH(R0)
        SUBC(R0, 1, R0)
        ST(R0, 4, BP)
        BR(nthodd, LP)
        DEALLOCATE(1)
        LD(BP, 0, R1)
        ADD(R0, R1, R1)
        ST(R1, 0, BP)
        BR(loop)
done:
        LD(BP, 0, R0)
        P0P(R1)
        DEALLOCATE(2)
        MOVE(BP, SP)
        POP(BP)
        POP(LP)
        JMP(LP)
nthodd: PUSH (LP)
        PUSH (BP)
        MOVE (SP, BP)
        LD (BP, -12, R0)
        BEQ(R0, zero)
        ADD(R0, R0, R0)
        SUBC(R0, 1, R0)
        MOVE(BP, SP)
zero:
        POP(BP)
        POP(LP)
        JMP(LP)
```

2. What variable in the C code, if any, is loaded into R0 by the LD instruction tagged **loop**? Answer "none" if no such value is loaded by this instruction.

Value loaded by instruction at loop:, or "none":

Using a small test program to run the above assembly code, you begin computing sqr(X) for some positive integer X, and stop the machine during its execution.

You notice, from the value in the PC, that the instruction tagged zero is about to

be executed. Examining memory, you find the following values in a portion of the area reserved for the Beta's stack.

F0: F45 F4: ECF8: D4FC: 15 100:

DECAF108:

1

2 10C

104:

4C110

100 114

*BP*118: 0 \rightarrow

NB: All values are in HEX! Give your answers in hex, or write "CAN'T TELL" if you can't tell.

You notice that BP contains the value **0×118**.

3. What argument (in hex) was passed to the current call to nthodd? Answer "CAN'T TELL" if you can't tell.

HEX Arg to nthodd, or "CAN'T TELL": 0x

4. What is the value X that was passed to the original call to sqr(X)? Answer "CAN'T TELL" if you can't tell.

HEX Arg X to sqr, or "CAN'T TELL": 0x

5. What is the hex value in SP? Answer "CAN'T TELL" if you can't tell.

HEX Value in SP, or "CAN'T TELL": 0x

6. What is the current value of the variable k in the C code for sqr? Answer "CAN'T TELL" if you can't tell.

HEX Value of k in sqr, or "CAN'T TELL": 0x

7. The test program invoked sqr(X) using the instruction BR(sqr,LP). What is the address of that instruction? Answer "CAN'T TELL" if you can't tell.

HEX Address of BR instruction that called sqr, or "CAN'T TELL": 0x

 olog Hall Coulde Hall
What value was in R1 at the time of the call to sqr(X) ? Answer "CAN'T TELL" if you can't tell.
HEX Value in R1 at call to sqr, or "CAN'T TELL": 0x
Your boss at BetaSoft Tes Ismoore suspects that some of the instructions in t

Beta code could be eliminated, saving both space and execution time. He hands you an annotated listing of the code (shown below), identical to the original assembly code but with some added tags.

```
sqr:
        PUSH (LP)
        PUSH (BP)
        MOVE (SP, BP)
        ALLOCATE(2)
        PUSH (R1)
        ST(R31, 0, BP)
        LD (BP, -12, R0)
        ST(R0, 4, BP)
        LD(BP, 4, R0)
loop:
        BEQ(R0, done)
        PUSH(R0)
        SUBC(R0, 1, R0)
        ST(R0, 4, BP)
        BR(nthodd, LP)
        DEALLOCATE(1)
        LD(BP, 0, R1)
        ADD(R0, R1, R1)
        ST(R1, 0, BP)
        BR(loop)
done:
        LD(BP, 0, R0)
        P0P(R1)
q1:
        DEALLOCATE(2)
        MOVE(BP, SP)
        POP(BP)
        POP(LP)
        JMP(LP)
nthodd: PUSH (LP)
q5:
        PUSH (BP)
q2:
        MOVE (SP, BP)
        LD (BP, -12, R0)
        BEQ(R0, zero)
        ADD(R0, R0, R0)
        SUBC(R0, 1, R0)
zero:
        MOVE(BP, SP)
        POP(BP)
        POP(LP)
        JMP(LP)
```

Les proposes several optimizations, each involving just the deletion of one or more instructions from the annotated code. He asks, in each case, whether the resulting code would still work properly. For each of the following proposed deletions, select "OK" if the code would still work after the proposed deletion, or "NO" if not. For each question, **assume that the proposed deletion is the ONLY change** (i.e., you needn't consider combinations of proposed changes).

9. Delete the instruction tagged q1.

Proposed deletion OK or NO?

BEQ(R0, zero) ADD(R0, R0, R0) SUBC(R0, 1, R0) JMP(LP) zero:

He's quite sure this code will work, but doesn't know the appropriate value for NNN.

13. What is the proper value for the constant **NNN** in the shortened version of nthodd?

Αı	ppro	priate	value	for NNN	(in	decimal):
----	------	--------	-------	---------	-----	-----------

Submit

Stacks and Procedures: 7

15 points possible (ungraded)

You are given the following listing of a C program and its translation to Beta assembly code:

```
// Mystery function:
int f(int x, int y) {
  int a = (x+y) >> 1;
  if (a == 0) return y;
  else return ???;
}
```

(Recall that a >> b means a shifted b bits to the right, propagating – ie, preserving -- sign)

1. Fill in the binary value of the BR instruction stored at the location tagged **yy** in the above program.

```
opcode (6 bits): 0b
```

```
Rc (5 bits): 0b
```

```
Ra (5 bits): 0b
```

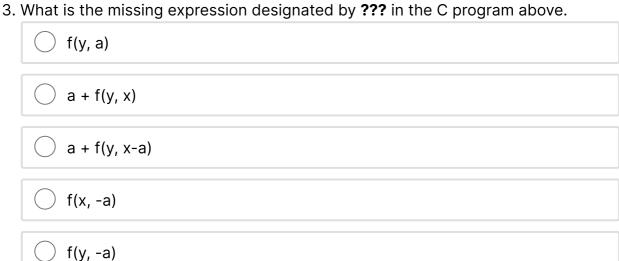
```
literal (16 bits): 0b
```

```
f:
     PUSH(LP)
     PUSH(BP)
     MOVE(SP, BP)
     PUSH(R1)
     PUSH(R2)
     LD(BP, -12, R1)
     LD(BP, -16, R0)
     ADD(R0, R1, R2)
     SRAC(R2, 1, R2)
     BEQ(R2, bye)
XX:
     SUB(R1, R2, R1)
     PUSH(R1)
     PUSH(R0)
     BR(f, LP)
уу:
     DEALLOCATE(2)
     ADD(R2, R0, R0)
bye: POP(R2)
     P0P(R1)
zz: MOVE(BP, SP)
     POP(BP)
     POP(LP)
     JMP(LP)
```

2.	. Suppose the MOVE instruction at the location tagged zz were eliminated	from	the
	above program. Would it continue to run correctly?		

Still works fine?

YES			
O NO			



The procedure **f** is called from an external procedure and its execution is interrupted during a recursive call to f, just prior to the execution of the instruction tagged bye. The contents of a region of memory are shown below.

NB: All addresses and data values are shown in hex. The BP register contains 0×250, SP contains 0×258, and R0 contains 0×5.

CC204:

4 208:

7 20C:

210: 6

7 214:

E8218:

D421C:

BAD220:

BABE224

228 1

IVI		6.004.2x Courseware Ledx
	22C	6
	230	54
	234	
	238	1
	23C	6
	240	3
	244	1
	248	54
	24C	238
	<i>BP</i> 250: →	3
	254	3
	<i>SP</i> 258: →	-1
4.		the arguments to the <i>most recent</i> active call to f ? ent arguments (HEX): x = 0x
	y = 0x	
	What are	missing value in the stack trace. the arguments to the <i>original</i> call to f ? arguments (HEX): x = 0x
	y = 0x	
7.	What valu	ue is in the LP register?

Contents of LP (HEX): 0x

Contents of R1 (HEX): 0x

8. What value was in **R1** at the time of the original call?

9	. What v	alue will	be returned	l in R0	as the	value (of the	original	call?	[HINT:	You	can
	figure t	this out v	without gett	ing the	e C coc	le right	!].					

1	Value returned to	origina	l caller (HI	EX): O>

10. What is the hex address of the instruction tagged **yy**?

Address	of yy	(HEX)	: 0x

Submit

Stacks and Procedures: 8

15 points possible (ungraded)

You are given the following listing of a C program and its translation to Beta assembly code:

```
int f(int x, int y) {
  int a = (x+y) >> 2;
  if (a == 0) return x;
 else return y + f(a, x+a);
}
```

(Recall that a >> b means a shifted b bits to the right, propagating – ie, preserving -- sign)

1. Fill in the binary value of the BEQ instruction stored at the location tagged laby in the above program.

```
opcode (6 bits): 0b
```

```
Rc (5 bits): 0b
```

```
Ra (5 bits): 0b
```

```
f:
       PUSH(LP)
       PUSH(BP)
       MOVE(SP, BP)
       PUSH(R1)
       LD(BP, -12, R0)
       LD(BP, -16, R1)
       ADD(R0, R1, R1)
       SRAC(R1, 2, R1)
       BEQ(R1, labx)
laby:
       ADD(R0, R1, R0)
       PUSH(R0)
       PUSH(R1)
       BR(f, LP)
       DEALLOCATE(2)
       LD(BP, -16, R1)
labz:
       ADD(R1, R0, R0)
labx:
       P0P(R1)
       MOVE(BP, SP)
       POP(BP)
       POP(LP)
       JMP(LP)
```

literal	(16 b	its):	0b

2. Is a location reserved for the argument **x** in **f**'s stack frame? Give its (signed) offset from **BP**, or **NONE** if there is no such location.

Offset of x (in decimal), or "NONE":

3. Is a location reserved for the variable **a** in **f**'s stack frame? Give its (signed) offset from **BP**, or **NONE** if there is no such location.

Offset of variable a, or "NONE":



The procedure **f** is called from an external procedure and its execution is interrupted during a recursive call to \mathbf{f} , just prior to the execution of the instruction tagged labz. The contents of a region of memory are shown below.

NB: All addresses and data values are shown in hex. The SP contains 0×1C8.

- 184: 4
- 188:
- 3 18C:
- 5 190:
- D0194:
- D4198:
- D819C:
- 7 1A0:
- 1A4 2
- 1A8 4C
- 19C1AC
- 2 1B0
- 1B4 4
- 2 1B8
- 4C1BC

	1C0	1B0
	1C4	2
	SP1C8 $ ightarrow$	3
4.		e the arguments to the <i>most recent</i> active call to f ?
	MOSCIEC	
	y = 0x	
	y – OX	
5.	What are	e the arguments to the <i>original</i> call to f ?
		arguments (HEX): x = 0x
	y = Ox	
6.		ue is in the BP register?
	Content	s of BP (HEX): Ox
7	What val	ue is in R1 prior to the execution of the LD at labz ?
,.		s of R1 (HEX): 0x
8.		ue will be loaded into R1 by the instruction at labz if program execution
	continue Content	s? s of R1 (HEX): 0x
9.	What is t	the hex address of the instruction tagged labz ?
		of labz (HEX): 0x
10.		the hex address of the BR instruction that called f originally?
	Address	of original call (HEX): 0x
Sub	mit	

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	KS AND PROCEDURES 6: Why Mem[0×100] == 15? Sing to Question D in this problem, the value X that was passed to the original call to sqr	<u>3</u>
	KS AND PROCEDURES: 8.G. nat value is in R1 prior to the execution of the LD at labz?" A: "The value in R1 prior to exe	6 ec
•	s and Procedures: 1-A. Highest memory address possibly effected g to sound pedantic, shouldn't I say the highest memory address effected is 0×1403, ins	4 :te
-	This tutorial has many problems Itorial has exceptionally high number of problems as compared to other topics. Any parti	7
-	FF] Cannot grade problem 7 ecking the problem 7, it gave me "We're sorry, there was an error with processing your re	3
_	em with Stacks and Procedures: 6 stack trace, I expected to see a value of R0 right after the value of R1 since we have a "F	2
	in Stacks and Procedures 4? St me, or does the stack of question set 4 have a small error? There is a small section at	3 <u>0</u>
	s and Procedures 4: result of recursive call e explanation, the result of a recursive call to f is returned in R0. How does it get there?	3
	2: Question D (value of R1 at halt time) answer it's stated that the value of R1 at the time the program is halted is 0×03, given pr	4
	er optimisation of program in Stack and procedure: 2 program given in stack and procedure: 2 under rtn label, if we remove the instruction MO	<u>2</u> <u>)V</u>
	FF] Stack discipline in beta assembly language case of recursion, how will the program know that stack discipline has been achieved? Is	2 S
	ial problem: stacks and procedures 1 - typo? splanation for part E says: "This means that the BP is pointing immediately following a ful	2 <u>II</u>
	F] Typo on "CAN'T TELL" stating problems, e.g. Problem 2, question C > Please express the values in hex or write	<u>"</u>