

Question 1: (0 points)
Bank of Questions

Binary Representation of jal and Branches (V05)

For the RISC-V code given in Figure ??, notice the `bne` and `jal` instructions at the addresses `0x0040 0010` and `0x0040 0020` respectively. What are the hexadecimal representations of these instructions? To solve this problem, you need to recall that registers `t3` and `zero` are mapped to register number 28 and 0, respectively. Also, you need to recall the formats and effects of branch and jump instructions. They are shown below.

Question 2: (10 points)
Branch Instruction

31	30	25 24	20 19	15 14	12 11	8	7	6	0
imm[12]	imm[10:5]	rs2	rs1	funct3	imm[4:1]	imm[11]	opcode		

```
bne rs, rt, imm <==> if(rs != rt)    PC <-- PC + {imm,1b'0}
                        else           PC <-- PC + 4
```

The opcode of `bne` instruction is `1100011` and the `funct3` is `001`.

Question 3: (10 points)
Jump and Link Instruction

31	30	21	20	19	12 11	7 6	0
imm[20]	imm[10:1]	imm[11]	imm[19:12]	rd	opcode		

```
jal rd, imm <==> rd <-- PC + 4
                  PC <-- PC + {imm,1b'0}
```

The opcode of `jal` instruction is `1101111`.

```
1  0x0040 0000    mysteryProc:  addi  t1, zero, 32
2  0x0040 0004                                sll  s0, s0, t1
3  0x0040 0008                                L1:  add  t2, a0, zero
4  0x0040 000C                                lbu  t3, 0(t2)
5  0x0040 0010                                bne  t3, zero, L2
6  0x0040 0014                                jal  zero, L3
7  0x0040 0018                                L2:  addi  a0, a0, 1
8  0x0040 001C                                addi  s0, s0, 1
9  0x0040 0020                                jal  zero, L1
10 0x0040 0024                                L3:  add  a0, zero, s0
11 0x0040 0028                                jalr  zero, ra, 0
```

Figure 1: Mystery code procedure