1. For the following, use no more than 3 sentences in your answer.
a) Succinctly explain Turing’s thesis.
Disregarding speed and memory, any computer can compute the same thing. This means that a small and slow computer can compute the same as a large and fast computer given enough time. Turing machines are essentially universal computation devices in this case.
b) What are the components of a Turing machine?
A Turing machine has a strip of numbers like an array. It has something that reads the number, changes it, deletes it, or leaves it and moves on to the next index.

2. Explain some advantages digital computers have over analog computers.
Digital computers can represent anything in a simple 0 or 1 case. In this case, they are discrete than continuous so you can organize information. Also they are more accurate because the data in a digital computer are numbers.

3. How would one write 9_{10} in unary (base one)?
You would write 9 1’s. So it would be 111111111.

4. Write out the following numbers in terms of powers of 2. Omit the powers of 2 that are not present. For example, 43_{10} would be written as : $(1 \times 2^5) + (1 \times 2^3) + (1 \times 2^1) + (1 \times 2^0)$
a) 32
1×2^5
b) 15
$(1 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$
c) 65
$(1 \times 2^6) + (1 \times 2^1)$
d) 10
$(1 \times 2^3) + (1 \times 2^1)$

5. Convert 11101_2 to decimal. Assume it is unsigned.
$(1 \times 2^4) + (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$
16 + 8 + 4 + 1
29

6. Solve for x in $2^x = 00100000_2$
$2^x = 32$
$2^x = 2^5$
$x = 5$

7. Convert 01011001_2 to decimal. Assume unsigned again.
$(0 \times 2^7) + (1 \times 2^6) + (0 \times 2^5) + (1 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$
64 + 16 + 8 + 1
= 89

8. a) Given a 4-bit string of binary digits, how many unique binary strings are there?
The general rule for calculating the number of possibilities in binary digits is in the form 2^n. Thus, the answer would be $2^4 = 16$.
b) What's the largest unsigned integer we can represent with this many bits?
1111 because this gives a value to each and every bit possible. This value is 15.
c) How many unique binary strings for an n-bit string?
The general rule for calculating the number of possibilities in binary digits is in the form 2^n.
d) And the largest unsigned integer with n bits?
2^n

9. Add 20 and 35 in binary (give the answer in binary). Assume 8-bit unsigned integers. Show your work.

```
        00100011 = 35
+       00010100 = 20
---------------------
        00110111 = 55
```

10. Subtract 20 from 87 in binary. Again, 8-bit unsigned.

```
        01010111 = 87
    -   00010100 = 20
---------------------
        01000011 = 67
```

11. Take the one's complement of 01110101_2. Give the result in binary and in decimal.
One's complement: 10001010_2
$(1 \times 2^7) + (0 \times 2^6) + (0 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (0 \times 2^0)$
128 + 8 + 2
= 138

12. a) We have a 7-bit signed, two's complement integer. What are the maximum (most positive) and minimum (most negative) values we can represent with it?
Binary: the maximum value is 0111111 and the minimum value is 1000000.
Decimal: -64 to 63
b) For an n-bit signed, 2's complement int, what are the most positive and negative numbers we can represent?
The most positive is $2^{n-1} - 1$ and the most negative numbers is -2^{n-1}.

13. Fill in the rows in the following table. The first row is an example for your reference. Put an X when the number cannot be represented. Assume 6 bits.

Number	Signed Magnitude	One's Comp.	Two's Comp.	Unsigned

-10	101010	110101	110110	X
-6	100110	111001	111010	X
7	000111	000111	000111	000111
-1	100001	111110	111111	X
10	000110	000110	000110	000110
-32	X	X	100000	X
31	011111	011111	011111	011111

14. Subtract 10_{10} from 7_{10} (7 − 10) in binary using 6-bit, signed, 2's complement integers.
Hint: x − y = x + (−y).
001010 = 10
2's comp.

```
        110101
    +        1
--------------------------------
        110110 = -10

        000111 = 7
    +   110110 = -10
--------------------------------
        111101 = -3
```