1. Define the following using your own words.

   a) (3 pts) Describe the difference between a high-level language and a low-level language.

   Low level language is very close to machine language, but it is very hard for humans to understand. On the other hand, high-level language is closer to a language that can be understood by humans.

   b) (3 pts) What does a compiler do?

   A compiler translates a program from english-like instructions to a language that can be understood by computers.

   c) (3 pts) What is an operating system?

   An operating system is the main program running in a computer, and it is in charge of handling its resources.

   d) (3 pts) List 3 examples of operating systems, 3 examples of high-level programming languages and 3 examples of output hardware.

   Operating Systems: Windows, iOS, Ubuntu, MacOS, Mint, Red Hat Linux, Solaris
   High-level programming languages: Java, C++, Python, C, Fortran, C#
   Output Hardware: Monitor, Printer, Speakers, Projectors
e) (3 pts) Why is it convenient to have a hard drive if we already have RAM (or main) memory?

Hard drives can store more information, and they are non-volatile.

2. Complete the following:
(10 pts) If a program in RAM is using 1.1 Gb (base 2 definition), then it is using (write the exact number, even if, for example, fractional bits doesn't really make sense):

____________________1126.4__________________________ MB,
____________________1153433.6________________________ KB,
____________________118116006.4____________________ Bytes, and
____________________9448928051.2____________________ Bits.

(5 pts) If a song has a size of 4.2 MB in Hard Drive (base 10 definition), then its size is
____________________0.0042________________________ GB and
____________________4200000____________________ Bytes

3. ASCII Conversions
(15 pts) The following sentence cannot be neither true nor false, because in any case it leads to a paradox. The sentence, however, is encoded in (decimal) ASCII. Using an ASCII table either from the book or the internet, decode the sentence:

084 104 105 115 032 115 116 097 116 101 109 101 110 116 032 105 115 032 102 097 108 115 101 033

This statement is false!

The famous mathematician Kurt Gödel used a modified version of this paradox to propose the Incompleteness Theorem. Encode “Kurt Goedel” (without the quotations) in decimal ascii. Notice we cannot encode “ö” with ascii.

075 117 114 116 032 071 111 101 100 101 108

a) (3 pts) 145 in base 10 = ________10010001________________________ in base 2
b) (3 pts) 238 in base 10 = ____________22211________________________ in base 3
c) (3 pts) 101101 in base 2 = __________45__________________________ in base 10
d) (3 pts) 10110 in base 3 = __________93__________________________ in base 10
e) (3 pts) 1521 in base 10 = __________5F1__________________________ in base 16

2 5. (15 pts) Convert the following number to binary

314 in base 10 = ________100111010________________________ in base 2. If we tried storing this number in 1 byte, we would have an overflow, and the computer would only store the 8 right-most characters. Take the 8 right-most characters and convert it back to decimal.

In what way does this number relate to the original? By how much is it greater or lesser than the original? Why? (Hint: Think about how we convert numbers from binary to decimal, and what happens if we remove the left-most digits)

The new number is 58, which is 256 less than the original. Just like the decimal system, base 2 is a positional system, being the left-most digits more significant. Each position represents a power of 2. By removing the left-most 1, we are actually reducing the value of the number in $2^8$

6. Algorithm Tracing
Consider the following algorithm:

```java
n = 14;
a = 7;
b = 0;
while a < n do
{
    b = b + a;
a = a + 1;
}
```
Output is: b

a) (15 pts) Trace out each step as begun below for you: (Use as many rows as you need)
Initially: n = 14, a = 7, b = 0,
After 1 Step: n = 14, a = 8, b = 7
After 2 Steps: n = 14, a = 9, b = 15
After 3 Steps: n = 14, a = 10, b = 24
After 4 Steps: n = 14, a = 11, b = 34
After 5 Steps: n = 14, a = 12, b = 45
After 6 Steps: n = 14, a = 13, b = 57
After 7 Steps: n = 14, a = 14, b = 70

Output: 70

3 b) (10 pts) What does this algorithm accomplish? Explain the relationship between a, and n WITHOUT simply explaining the algorithm in the first part. You may want to try the algorithm for different values of n to see if the algorithm accomplishes what you think it does.

It is adding the values from a to (n-1). In this case, the algorithm accomplishes 7 + 8 + 9 + 10 + 11 + 12 + 13

Extra credit (+5)
Suppose you have 12 cubes, all of which look exactly the same. However, you know that one of them weighs differently (you don't know if it is heavier or lighter). You have at your disposition a weighing scale with which you can compare the weights of the cubes, but you can only use it three times. Describe the procedure you would follow to find the cube that weighs differently. Remember that an algorithm should have unambiguous instructions. You can try your algorithm with a few examples and see if at each step you know what to do next, and the algorithm manages to find out the cube that weighs differently.
1) Number the cubes 1-12
2) Take (1,2,3,4) and weigh against (5,6,7,8)
3) If balanced,
   Weigh (9,10,11) vs (1,2,3)
   if balanced => 12 weighs differently.
   Otherwise,
   Let MorL = “More” if (9,10,11) weighs more, or MorL=”Less” if (9,10,11) weighs less.
   Weigh 9 vs 10
   If balanced => 11 weighs differently.
   If 9 weighs MorL => 9 weighs MorL
   If 10 weighs MorL => 10 weighs MorL
   Otherwise,
   Let (H1,H2,H3,H4) be the 4 cubes that weigh more, and (L1,L2,L3,L4) the 4 cubes that weigh less
   Weigh (H1,H2,H3,L1,L2) vs (H4, 9,10,11,12) (We know 9,10,11,12 are OK)
   If balanced (it has to be either L3 or L4)
   Weigh L3 vs H1 (we know H1 is OK)
   if balanced => L4 is lighter.
   Otherwise => L3 is lighter.
   If (H1,H2,H3,L1,L2) weighs more. (The different has to be H1,H2, or H3)
   Weigh H1 vs H2
   If balanced => H3 is heavier.
   if H1 weighs more => H1 is heavier.
   If H2 weighs more => H2 is heavier.
   If (H4,9,10,11,12) weighs more (Then either L1 or L2 are lighter, or H4 is heavier)
   Weigh L1 vs L2
   If balanced => H4 is heavier.
   If L1 is heavier => L2 is lighter. If L2 is heavier => L1 is lighter.