

MA/CS 109 Homework One

Please write up your answers neatly and hand in at the beginning of lecture on Thursday 11/9.

Problem 1

Give the decimal for the following binary numbers:

- a) 11011
- b) 1111
- c) 1001001

Problem 2

Give the binary numbers for the following decimal numbers:

- a) 23
- b) 128
- c) 72

Problem 3

Add the following two binary numbers (check your work by doing it in decimal as well and verifying the results check out).

- a) $101101 + 010111$
- b) $101010 + 111$
- c) $111111111 + 1$

Problem 4

What is the largest number that can be represented in 4 bits? How about in N bits, where N is an arbitrary number (come up with a general mathematical formula)?

We have studied in class the various units for computer storage. Answer the following questions about the correspondence between typical amounts of information produced by humans and computer memories.

You should use www.wolframalpha.com to do the calculations: it can evaluate very large numbers. For exponents use the notation "10^4" for "10⁴" and use asterisk "*" for multiplication. Round to the nearest integer for smallish numbers and use scientific notation for large numbers.

For example, here is how you would find how many copies of the U. S. Constitution (with Amendments) you can store on a CD (it has 50,534 characters total):

WolframAI

(737 * 2²⁰) / 50534

Input:

$$\frac{737 \times 2^{20}}{50534}$$

Exact result:

$$\frac{35\,127\,296}{2297}$$

Decimal approximation:

15292.684370918589464518937744884632128

So your answer would be 15,293.

Problem 5

There are about 3,566,480 characters in the Bible and 320,015 in the Koran.

A standard CD can hold about 737 MB (MB = 2²⁰ bytes) of data. In comparison, a single-layer DVD-ROM can hold 4.7 GB (GB = 2³⁰ bytes) of data.

a) How many copies of the Bible could you store on a typical CD, assuming one byte for each character?

b) How many copies of the Koran could you store on a typical CD, assuming two bytes for each character (since storing Arabic letters must be done in Unicode)?

Problem 6

Currently you can buy on Amazon a Seagate 8 TB (TB = 2⁴⁰) external disk drive for your Mac on for \$199.99.

(a) The Library of Congress stores about 3 x 10¹⁵ bytes of data. How much would it cost to store the whole of the Library of Congress on these disks? (Round to the nearest penny!)

(b) Human DNA holds about 725 MB of data, and there are about 7.6 billion people on Earth. How much would it cost to store all the data in human DNA on the planet on Seagate external disks?

Problem 7

If you are a sophomore, you will graduate BU (hopefully) in 2020, at which point it is predicted that there will be 44×10^{21} bytes of data stored on this planet.

(a) A sheet of book paper is about 0.1 millimeters (10^{-4} meters) thick. If all the data in the world in 2020 were printed on paper and stacked up, and assuming about 3000 characters each side (two sided) of a page, and two bytes per word (in Unicode, and forget about images and sounds, just pretend it is all text), and assuming the solar system (ending at Neptune) has a diameter of 9.09 billion kilometers, how many times larger would this stack of paper be than the diameter of the solar system?

b) The Seagate disk drive mentioned above has dimensions 4.65" x 1.61" x 7.8", so it is 1.61" wide. If you stored all the data in 2020 in such drives, and lined them up side to side (each taking up 1.61 inches), how many times around the circumference of the earth (24,901 miles, with 5280 feet per mile) would they go?

c) A gram of DNA can hold 215×10^{15} bytes of data. How many kilograms of DNA would it take to store all the information on the planet in 2020? Would you be able to lift it?

Problem 8

What would be the minimum bit depth (total number of bits) necessary to represent 512 colors? How about to represent 179 colors?

Problem 9

If you use 4 bits per color component and three components (red/green/blue), how many different colors can you represent?

Problem 10

If a typical audio CD uses a sample rate of 44.1 KHz (KHz = 1000 / second) and stores each sample in 16 bits, how many hours and minutes of audio can be stored on a typical audio CD? Give your answer in whole number of hours and then minutes (e.g. "1 hour and 34 minutes").