SENG 11232 · Engineering Foundation
STUDENT PRE-LECTURE NOTES · LECTURE 04

Number Systems, Data Representation & Binary Arithmetic

Module 2 — Systems & Digital Foundations

HOW TO USE Read these notes BEFORE the lecture. Highlight terms you don't recognise. Bring your questions to class. Use the blank spaces for your own notes.

Learning Objectives

By the end of this lecture, you should be able to:

- 1. Convert numbers between binary, octal, decimal and hexadecimal
- 2. Represent signed integers using two's complement and perform binary arithmetic
- 3. Explain IEEE 754 floating-point representation and software engineering implications
- 4. Describe UTF-8 and Unicode character encoding

Number Systems

Positional Systems

- Binary (base 2): digits 0,1 — powers of 2
- Octal (base 8): digits 0-7 — 1 octal digit = 3 binary bits
- Hexadecimal (base 16): digits 0-9,A-F — 1 hex digit = 4 binary bits

Conversion Tips

- Decimal → Binary: divide by 2 repeatedly; remainders (LSB first) form the binary number
- Binary → Hex: group bits in 4s from right; convert each group to hex digit

KEY 0.1 + 0.2 ≠ 0.3 in floating-point. This is not a bug — it is a consequence of how binary represents fractions.

Your notes:

Two's Complement & IEEE 754

Two's Complement

- Step 1: write magnitude in binary
- Step 2: flip all bits (1s complement)
- Step 3: add 1 — result is the 2s complement (negative representation)
- 8-bit range: -128 to +127. 32-bit: -2,147,483,648 to +2,147,483,647

NOTE Integer overflow: adding +2,147,483,647 + 1 in 32-bit gives -2,147,483,648. This caused the Ariane 5 launch failure.

IEEE 754 Floating Point

- 32-bit: 1 sign + 8 exponent + 23 mantissa bits
- Special values: ±∞, NaN (Not a Number), denormalised numbers near zero
- Never compare floats with ==. Use |a - b| < epsilon instead.
- For financial values: use integer arithmetic (store cents) or Decimal type

Your notes:

Key Terms for This Lecture

Term	Your Definition (fill in during/after lecture)
Bit	
Byte	
Binary	
Hexadecimal	
Two's Complement	
Overflow	
IEEE 754	
Floating Point	
UTF-8	
Unicode	
Code Point	

Self-Check Questions

Answer these after the lecture to test your understanding:

- Q1. Convert 173 decimal to binary and hexadecimal.

Answer: _____

- Q2. What is -47 in 8-bit two's complement? Show your working.

Answer: _____

- Q3. Why does 0.1 + 0.2 not equal 0.3 exactly in most programming languages?

Answer: _____

- Q4. What encoding would you choose to store a user's name in a multilingual application and why?

Answer: _____