L1: Course Intro & Logistics

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Today

- **Why** we analyze programs
- A first look at **security, vulnerabilities & exploits**
- The **state of the art** in finding bugs and writing exploits
- **What** the course covers
- **How** it runs: logistics, grading, the project

Software runs the world.

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Finance. Healthcare. Defence. Infrastructure. Communication.

Big Software, Big Risk

Linux Kernel: **36.9 million** lines of C, 4,037 contributors[1]

Chromium: **36.2 million** lines of C++, 2,109 contributors[2]

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70% of security issues are memory-safety bugs[3]

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Real-World Impact

Heartbleed (2014): OpenSSL buffer over-read. Leaked private keys worldwide.[1]

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One insecure line can compromise **millions** of systems.

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What Is Software Security?

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The goal: find and fix the flaws **before an attacker does**.

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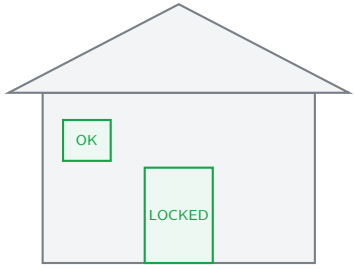
A Vulnerability Is a Flaw in Software



Your Software

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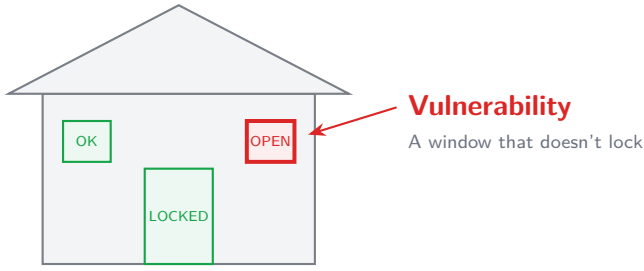

A **weakness** in software that *could* be exploited to cause harm.

Unintentional. But attackers hunt for exactly these.

Cataloging Vulnerabilities: CWE & CVE

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CWE is the taxonomy of *kinds* of bugs; CVE is the ledger of *actual* ones found in software/hardware.

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From Vulnerability to Exploit to Impact

Vulnerability

The flaw

The vulnerability is the **unlocked window**.

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The exploit is the **burglar climbing through**.

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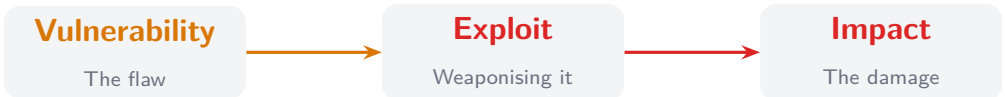

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The exploit is the **burglar climbing through**.

The impact is **everything they steal**.

The State of the Art: Finding Bugs

Scale. ∼40,000 new CVEs were published in 2025 — a record, and rising.[1]

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AI arrives. In 2024, Google's LLM agent "**Big Sleep**" found a real, previously-unknown vulnerability in SQLite — automatically.[3]

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Three Ways to Analyze Code

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- **Static analysis** — inspect code *without* running it
- **Dynamic analysis** — *run* the code and watch what happens
- **Hybrid** — combine the two

What This Course Is About

A course on **static, dynamic, and hybrid** program analysis — and using it to find bugs in software.

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Hands-on assignments on **LLVM**, **Static, Dynamic Analysis**, and modern fuzzers — the same tools used in industry and research.

Course Roadmap — 9 Topics

#	Topic	Lectures
1	**Foundations & Program Representation**	L1–L8
2	**Testing** (fuzzing, coverage-guided, concurrency)	L9–L12
3	**Dataflow Analysis**	L13–L20
4	**Pointer Analysis**	L21–L24
5	**Constraint-Based Analysis**	L25–L28
6	**Type Systems**	L29–L32
7	**Symbolic Execution**	L33–L36
8	**Automated Test Generation**	L37–L39
9	**LLM-Assisted Software Analysis**	L40–L42

Meets Mon / Tue / Wed · 23 Jul – 12 Nov 2026 · full schedule on the course page

A Glimpse of the Frontier: LLMs Finding Vulnerabilities

LLM **agents** can now read code, hypothesise flaws, and confirm them — finding **real, previously-unknown** bugs on their own.

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- **XBOW** — an autonomous AI hacker that topped the HackerOne US leaderboard (2025).[2]

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How the Course Runs

Grading

End-semester exam	**30%**
Mid-semester exam	**25%**
Quizzes ($2 \times 5\%$)	**10%**
Term project	**20%**
H/W assignments	**10%**
Attendance	**5%**
Total	**100%**

The Term Project

Pick a **widely-used** open-source target, build or adapt a tool from the course, and find bugs that get **accepted upstream**.

e.g. Linux, Chromium, FFmpeg, OpenSSL, SQLite, Postgres, CPython, LLVM...

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Proposal due right after the mid-sem (**20 Sep 2026**); get your target approved before you start.

Logistics & Policies

Classes. Mon / Tue / Wed in Room 5101, Core 5 (Mon 5:00, Tue 4:00, Wed 3:00 PM — 55 min each).

Thursday 2:00 PM slot reserved for quizzes & industry talks.

Prerequisites. Data structures; C/C++ or Java; basic OS & compilers.

Contact. Office hours by appointment (email instructor or TAs); Microsoft Teams for discussion.

Website. `https://bernardnongpoh.github.io/cs-5187/`

Policies. Discuss freely, write up individually, cite your sources. LLM use must be **disclosed**

Your Teaching Team

Instructor. Bernard Nongpoh bnongpoh@iitg.ac.in

Teaching Assistants.

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Yatharth Sonteke	y.sonteke@iitg.ac.in
Leisel Rangsuo Koireng	leisel.koireng@iitg.ac.in

Welcome to CS 5187.

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By the end of the semester, your tool will have found a bug in software that millions of people use.

Why analysis matters more than ever

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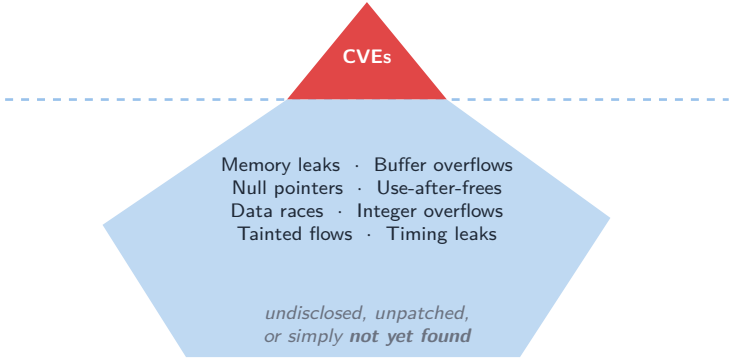

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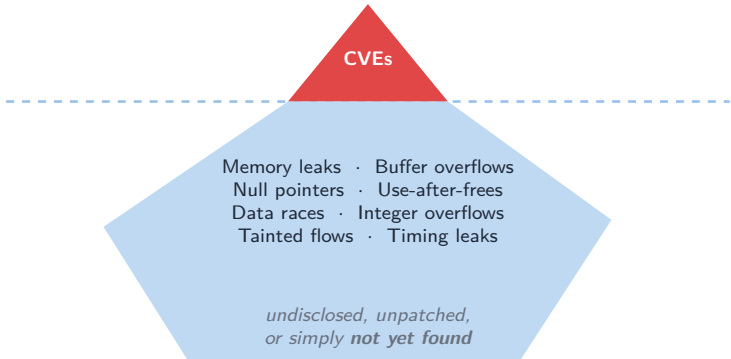

∼40,000 CVEs published in 2024[1] — and that is only what somebody **found**, **reported**, and **published**.

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The Shift: AI Agents Are Writing the Code Now

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- Roughly **41–42%** of code written in 2025 was AI-generated or AI-assisted.[2]
- Result: **more code than ever**, produced **faster than ever**, and understood by **nobody in particular**.

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Meme :)

Activity	Before AI
Writing code	2 hours
Debugging	6 hours

Meme :)

Activity	Before AI	After AI
Writing code	2 hours	5 minutes
Debugging	6 hours	24 hours

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"Almost right" is the **worst** failure mode — it passes review and fails in production.

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The generator got faster. The **verifier** did not get less necessary — it got **more**.

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Automatically analysing and assuring the behaviour of programs with respect to a property — *correctness*, *robustness*, *safety*, *liveness*.

Software Analysis

(this course)

Find the **existence** of bugs.

If **a path exists** where a bug may be triggered, report it.

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"*There exists a path...*" versus "*For all paths...*" — one quantifier apart.

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A program with no crashes that does the **wrong thing** is still broken. Correctness is always *relative to a specification*.

After Sui, COMP6131, UNSW