# Intro to practical computation for semigroups

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# libsemigroups - C++ library for semigroups

libsemigroups is a C++17 library containing implementations of:

- the Froidure-Pin Algorithm for finite semigroups/monoids
- the Todd-Coxeter algorithm for finitely presented semigroups/monoids, and congruences
- the Knuth-Bendix algorithm for string rewriting systems
- algorithms for finitely presented semigroups/monoids satisfying a small overlap condition (partially based on work of Mark Kambites)
- The low-index congruence algorithm
- Stephen's procedure for finitely presented (inverse) semigroups/monoids
- Schreier-Sims for permutation groups
- Konieczny's algorithm for finite semigroups/monoids
- Radoszewski-Rytter's algorithm for equality testing in free bands
- includes HPCombi by Florent Hivert (SIMD/AVX accelerated transformations, permutations, etc)

# libsemigroups

## History

The first commit was 2016-11-29 17:32:07.

libsemigroups arose from the desire:

- to have the performance, in GAP, of:

  J.-E. Pin, Semigroupe, C programme, available at https://www.irif.fr/ jep/Logiciels/Semigroupe/semigroupe.html

  It was impossible:

  - to get close to the performance of Semigroupe in GAP.
  - interface with Semigroupe directly.

  So we started again from scratch.
- to implement parallel algorithms
- to make things more widely accessible outside GAP.

# libsemigroups

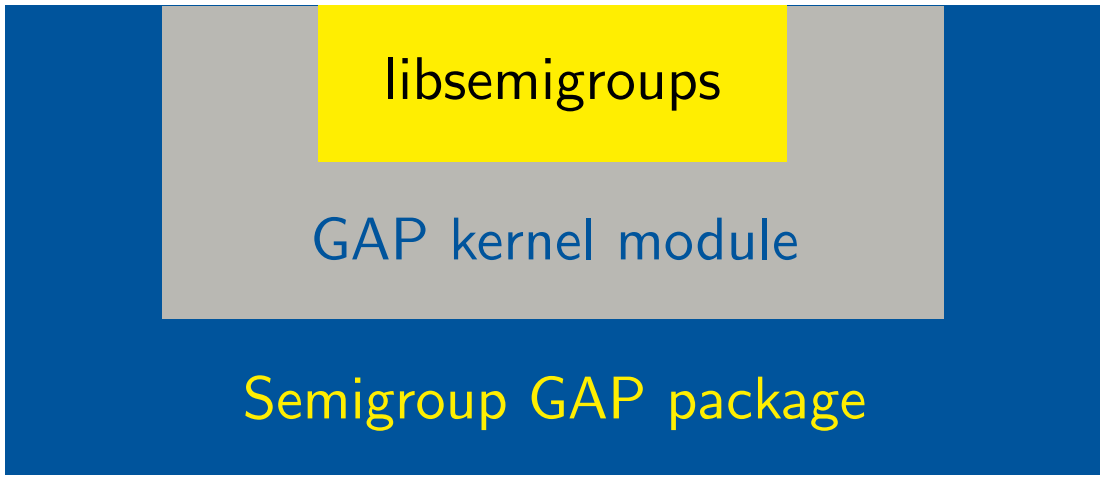
## Today

- Today: ∼237,680 lines of code, ∼1,638 total commits
- 350k+ downloads!
- Authors:
  - Reinis Cirpons
  - Joe Edwards
  - James Mitchell
- Today: 22 additional contributors.
- Packaged by conda, and almost every linux distro.

# The Semigroups package for GAP

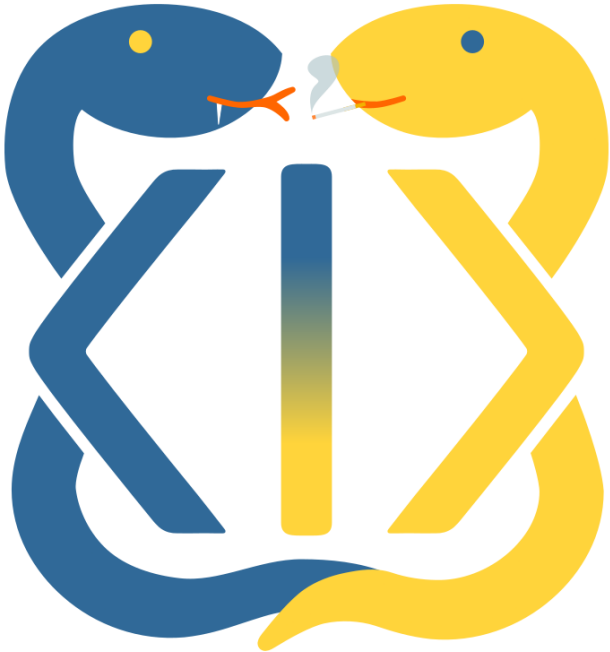
Semigroups has 39 contributors from UK, France, Germany, Portugal, USA, Japan, and Australia.

`https://semigroups.github.io/Semigroups`




Semigroups is higher level, not exposing the particular algorithms used to perform a calculation.

# Python and Julia



the functionality of libsemigroups in python

Semigroups.jl

the functionality of libsemigroups in Julia

Both of these are low-level providing direct access to libsemigroups objects and functions, but without higher-level constructions on top.

# Case studies



M. Anagnostopoulou-Merkouri, Z. Mesyan, JDM, *Properties of Congruence Lattices of Graph Inverse Semigroups*, 2024 https://doi.org/10.1142/S0218196724500139


R. Cirpons, JDM, J. East, *Transformation representations of diagram monoids*, 2026 https://doi.org/10.1093/imrn/rnag041


J. East, JDM, N. Ruskuc, M. Torpey, *Congruence lattices of finite diagram monoids*, 2018 https://doi.org/10.1016/j.aim.2018.05.016