

Introduction to GAP

Part I

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Arizona Summer Program 2008

Knowing the ropes

- Start/Stop
- Read-Eval-Print (Oops: View)-Loop
- Assignments, Variables
- Reading Files, Logging output
- Line editing
- Online help

Basic Objects

- Integers, Rationals ($5/3$), Cyclotomics ($\mathbb{E}(n) = e^{\frac{2\pi i}{n}}$); Booleans `true`, `false` and `fail`
- Lists (and sets), Ranges: `1[n]`, `Length`, `IsBound`, `[1..10]`, `[1, 3..7]`, `IsSortedList`, `Set`
- (Row) Vectors and Matrices are lists, respectively lists of lists
- Assigning a list assigns a pointer to the list: `ShallowCopy`
- Lists can be **immutable** to permit properties be stored.

```
l := [1, 2, 3];
```

```
m := [1, [4, 5, 6]];
```

```
l[1] := 9; # changes m from sorted to unsorted
```

- Finite fields: Elements are represented as powers of a primitive element $\mathbb{Z}(p^k)$. Conversion by multiplying an integer with $\mathbb{Z}(p^k)^0$ and `Int(elm)`. Compact matrix representations.
- Permutations in cycle form
- Words in abstract generators

List functions

The following extremely useful functions take as argument a list `l` and a one-argument function `f`, such functions often given by the shorthand `->` notation:

`List(l, f)` new list with `f` applied to all entries of `l`

`List([1..10], i->i^2);`

`Filtered(l, f)` list of elements of `l` for which `f` returns true.

Similar `First, Number`

`Filtered([1..100], IsPrimeInt);`

`ForAny(l, f)` are there elements of `l` for which `f` returns true?

Similar `ForAll`

More complicated constructions yield small programs:

`Filtered(Tuples([1..5], 4),`

`i->1 in i`

`and Number(i, j->j=2)=2`

`and Length(Set(i))=3);`

Caveat: direct loop programming can give better complexity.

Basic programming

- `function` assigned to function name. All non-local variables are assumed global. `return` the result.

```
f:=function(x,y)
  local z;
  z:=x+y;
  return z;
end;
```

- Control constructs

```
if condition then ...fi;
while condition do ...od;
repeat ...until condition;
for var in list do ...od;
```

- Variables are passed *by reference*
- Recommended to write code in external editor, then Read into GAP.

Debugging

Unless you are able to write perfect code first time:

- `Print(..., "\n");`
- `Assert(level, condition);` and `SetAssertionLevel(level);`
- You enter the `brk>` loop (apart from errors) when pressing CTRL-C or by an explicit `Error("your text");` command in the code.
- You can inspect local variables in the `brk>` loop
- In the `brk>` loop you can find the position in the execution stack by `Where();`, you can move up by `DownEnv(nr);`.
- If you issue the command `GASMAN("message");` GAP will print information about memory use.
- `time;` returns the time of the last command, `Runtime();` the time since GAP started (in milliseconds).