Macaulay2 RTG Seminar

Meetings: MW at 4-5pm, LCB 115.

For the first few weeks, we hope to cover the following basic Macaualay2.

1. Running and installing Macaulay2.
2. Making files to load.
3. Lists, sequences, hash tables, and other data structures.
4. Functions, methods.
5. Loops, making lists, and conditional statements.
6. Packages.

I'll also frequently ask small groups of students to present more mathematical functions of Macaulay2 (15 or 20 minute presentations). In particular, here are some ideas for things to present.

1. Modules, complexes and more.
2. Hilbert functions, polynomials, series.
3. Ext and Tor functors.
4. Dimension and codimension.
5. Matrix operations.
6. Projective varieties, sheaves and cohomology.
7. Detecting singularities (singularLocus, and Jacobian ideals).
8. Higher direct images (BGG package).
9. Restriction of scalars (PushForward package).
10. Toric varieties (NormalToricVarieites and other packages).
11. Maps between projective varieties (Cremona, RationalMaps, and other packages).
12. D-modules (DModulesPackage).
13. Spectral sequences (SpectralSequences package).
14. Characteristic p commutative algebra (TestIdeals package).

Our next goal will be to find a group of other participants to make a project on (probably a Package, and paper to submit to the journal JSAG). Think about what your Macaulay2 project could be. Talk to your mentors. You can see what packages are already available here:

`https://www.macaulay2.com/`

Some ideas for packages are on the next page, some are mine and some are things that people emailed me:

Ideas for packages.

(a) Cyclic covers (including finite ones).

(b) Properties of divisors and line bundles (nef, big, ample, etc.).

(c) Ruled surfaces.

(d) De Rham complexes in characteristic p and Cartier isomorphisms (including for projective varieties).

(e) Invariant subrings / group quotients. Even for finite subgroups of GL_n acting on polynomial rings (see the InvariantRing package), or even quotients thereof.

(f) (Finite dimensional) Hopf algebras (finite affine group schemes).

(g) Witt vectors.

(h) Frobenius invariants (ie F-pure threshold) of non-principal ideals.

(i) Annihilating cohomology with finite maps.

(j) Finding geometric points in characteristic zero (see RandomPoints for characteristic $p > 0$).

(k) Creating a structure to handle products of rings (disjoint unions of schemes).

(l) Hodge ideals.

(m) Resolution of singularities.

(n) Abelian varieties. (Jacobians of curves)

One could also try to add functionality to the core of Macaulay2, or help other bits of software interface with it (for instance, add better support to vim/vscode/atom, a language server for M2?).