

# Combinatorial Optimization at Work

## polymake examples

### Defining an object:

```
polytope > $p = porta2poly("cutcube.ieq");

polytope > $q = new Polytope<Rational>(INEQUALITIES=><<".");
polytope (2)> 0 1 0
polytope (3)> 0 0 1
polytope (4)> 1 -1 -1
polytope (5)> 2 -1 -2
polytope (6)> .

polytope > $qq = new Polytope<Rational>(POINTS=><<".");
polytope (2)> 1 0 0
polytope (3)> 1 2 0
polytope (4)> 1 1 1
polytope (5)> 1 0 1
polytope (6)> .

polytope > $so = load("somepoly.poly");
```

### Computing the convex hull:

```
polytope > print $p->INEQUALITIES;
1 -1 0 0
0 1 0 0
1 0 -1 0
0 0 1 0
1 0 0 -1
0 0 0 1
5/2 -1 -1 -1

polytope > print $q->VERTICES;
1 0 1
1 1 0
1 0 0

polytope > print "these were the defining inequalities: \n", rows_labeled($q->INEQUALITIES),
polytope (2)> "that's the actual facets: \n", rows_labeled($q->FACETS);
these were the defining inequalities:
0:0 1 0
1:0 0 1
2:1 -1 -1
3:2 -1 -2
that's the actual facets:
0:0 1 0
1:0 0 1
2:1 -1 -1
```

## Obtaining properties:

```
polytope > print $q->DIM;
2

polytope > print $q->VERTICES_IN_FACETS;
{0 2}
{1 2}
{0 1}

polytope > print $so->SIMPLE;
1

polytope > print $so->SIMPLICIAL;
0

polytope > print $so->F_VECTOR;
60 90 32

polytope > $small = new Polytope<Rational>(POINTS=>(<<"."));
polytope (2)> 1 1 0 0
polytope (3)> 1 0 1 0
polytope (4)> 1 0 0 1
polytope (5)> .

polytope > print $small->DIM;
2

polytope > print $small->AMBIENT_DIM;
3

polytope > print $small->AFFINE_HULL;
-1 1 1 1
```

## Visualisation:

```
polytope > $p->VISUAL;

polytope > $so->VISUAL(VertexStyle=>"hidden",EdgeStyle=>"hidden",
polytope (2)> FacetColor=>[("white")x20,("black")x12],FacetTransparency=>0.2);

polytope > cube(4)->VISUAL;

polytope > cube(5)->VISUAL_GRAPH;

polytope > $p->VISUAL_FACE_LATTICE;
```

## Lattice points

```
polytope > $pp=load("bigcutcube.poly");

polytope > print $pp->LATTICE_POINTS;
1 1 3 0
1 2 2 0
1 3 1 0
1 0 3 1
1 1 2 1
1 2 1 1
1 3 0 1
1 0 2 2
1 1 1 2
1 2 0 2
1 0 1 3
1 1 0 3
1 0 3 0
1 1 2 0
1 2 1 0
1 3 0 0
1 0 2 1
1 1 1 1
1 2 0 1
1 0 1 2
1 1 0 2
1 0 0 3
1 0 2 0
1 1 1 0
1 2 0 0
1 0 1 1
1 1 0 1
1 0 0 2
1 0 1 0
1 1 0 0
1 0 0 1
1 0 0 0

polytope > $pp->VISUAL->LATTICE_COLORED;

polytope > print $pp->INTERIOR_LATTICE_POINTS;
1 1 2 1
1 2 1 1
1 1 1 2
1 1 1 1
```

## Polarity:

```
polytope > cube(3)->VISUAL;

polytope > polarize(cube(3))->VISUAL;

polytope > print isomorphic(polarize(cube(3)),cross(3));
```

## Transformations:

```
polytope > print $p->CENTERED;
0

polytope > $p_center=center($p);

polytope > $perm = permutahedron(3);

polytope > print "\$perm has dimension ", $perm->DIM,
polytope (2)> " but lives in ", $perm->AMBIENT_DIM, "-dimensional space";
$perm has dimension 3 but lives in 4-dimensional space

polytope > projection_full($perm)->VISUAL;
```

## Linear Programming:

```
polytope > $opt = new Polytope<Rational>(VERTICES=>$p->VERTICES,
polytope (2)> LP=>new LinearProgram<Rational>(LINEAR_OBJECTIVE=>[0,1,1,0]));

polytope > print $opt->LP->MAXIMAL_VERTEX;
1 1 1 0

polytope > print $opt->LP->MAXIMAL_FACE;
{0 7}
```

## Unbounded polyhedra:

```
polytope > $unb = new Polytope<Rational>(INEQUALITIES=>(("<<".)));
polytope (2)> 0 1 0 0
polytope (3)> 1 -1 0 0
polytope (4)> 0 0 1 0
polytope (5)> 1 0 -1 0
polytope (6)> 0 0 0 1
polytope (7)> .

polytope > print $unb->BOUNDED;
0

polytope > print $unb->VERTICES;
1 1 0 0
1 0 0 0
1 0 1 0
1 1 1 0
0 0 0 1

polytope > script("visual_unbounded", $unb);
```

## Constructions:

simplex pyramid bipyramid prism rand\_sphere

## Scripting:

```
polytope > sub myfunc($) {  
polytope (2)> $n = shift;  
polytope (3)> $avg = 0;  
polytope (4)> for ( $i = 0; $i < $n; ++$i) {  
polytope (5)> $p = rand_sphere(5,10);  
polytope (6)> print "i: $i\t# vert: ", $p->N_VERTICES, "\# facets: ", $p->N_FACETS, "\n";  
polytope (7)> $avg += $p->N_FACETS;  
polytope (8)> }  
polytope (9)> $avg /= $n;  
polytope (10)> print "average: $avg\n";  
polytope (11)> }
```

```
polytope > myfunc(20);  
i: 0      # vert: 10      # facets: 38  
i: 1      # vert: 10      # facets: 36  
i: 2      # vert: 10      # facets: 38  
i: 3      # vert: 10      # facets: 40  
i: 4      # vert: 10      # facets: 40  
i: 5      # vert: 10      # facets: 36  
i: 6      # vert: 10      # facets: 32  
i: 7      # vert: 10      # facets: 38  
i: 8      # vert: 10      # facets: 38  
i: 9      # vert: 10      # facets: 38  
i: 10     # vert: 10      # facets: 40  
i: 11     # vert: 10      # facets: 32  
i: 12     # vert: 10      # facets: 40  
i: 13     # vert: 10      # facets: 38  
i: 14     # vert: 10      # facets: 38  
i: 15     # vert: 10      # facets: 32  
i: 16     # vert: 10      # facets: 36  
i: 17     # vert: 10      # facets: 38  
i: 18     # vert: 10      # facets: 38  
i: 19     # vert: 10      # facets: 42  
average: 37.4
```

```
polytope > script("myscript");
```

## File Output:

```
polytope > save ($q,"small.poly");
```

## Help:

```
polytope > help;
```

## Exiting:

```
polytope > exit;
```