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QUICK START GUIDE

Problem-Based Optimization with Optimization Toolbox™

Use a natural syntax for defining and solving optimization problems, least squares problems, and systems of nonlinear equations.

1. Define Problem

Following the *problem-based workflow*, first create an optimization problem with **`optimproblem`** to hold the objective, constraints, and associated variables. Create an **`eqnproblem`** when solving a system of nonlinear equations.

Examples:

```
assignmentProb = optimproblem
responseProb = optimproblem
initialStateProb = eqnproblem
```

2. Define Variables

Create optimization variables with **`optimvar`**. Set display name and optional dimensions, bounds, and type. Index with integers or character strings.

Examples:

```
x = optimvar("x");
y = optimvar("y");

employees = ["a","b","c"];
tasks = ["t1","t2","t3"];
assign = optimvar("assign",employees,tasks,"LowerBound",0,"UpperBound",1,"Type","integer")
```

3. Define Expressions to Use in Objective, Constraints, and Equations

Directly specify an **`OptimizationExpression`** with *supported operations.*

Examples:

```
response = -3*(y - x.^3 - x).^2 - (x - 4/3).^2;
totalCost = sum(sum(cost.*assign));
sumByEmployee = sum(assign,2);
sumByTask = sum(assign,1);
```

Use any MATLAB® function by converting it to an optimization expression with **`fcn2optimexpr`**.

Examples:

```
a = 4;
xyfcn = @(x,y,a)gamma(y)*a*x.^2;
xyexpr = fcn2optimexpr(xyfcn,x,y,a);
```

4. Define Objective

Set the *sense* of the optimization. Set the *objective function* with a scalar **`OptimizationExpression`**.

Examples:

```
responseProb.ObjectiveSense = "maximize";
responseProb.Objective = response;

assignmentProb.ObjectiveSense = "minimize";
assignmentProb.Objective = totalCost;
```

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5. Define Constraints and Equations

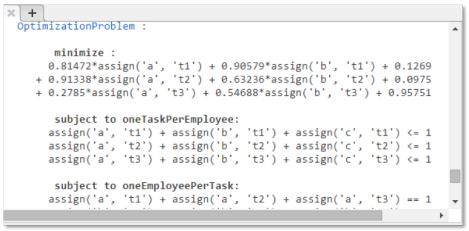
Combine **`OptimizationExpression`**s with a relational operator to specify an **`OptimizationConstraint`** or an **`OptimizationEquality`**. Assign to a problem.

Examples:

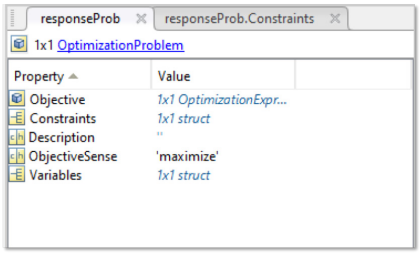
```
responseProb.Constraints.ellipse = x.^2/2 + y.^2/4 <= 1;
responseProb.Constraints.xyconstr = xyexpr >= 1;

assignmentProb.Constraints.oneTaskPerEmployee = sumByTask <= 1;
assignmentProb.Constraints.oneEmployeePerTask = sumByEmployee == 1;

initialStateProb.Equations.eq1 = x*cos(y) + y*sin(x) == 1/2;
initialStateProb.Equations.eq2 = exp(-exp(-(x + y))) == y*(1 + x^2);
```

6. Review

Display with **`show`** and **`showbounds`**. Write to a file with **`write`** and **`writebounds`**.



View with the Workspace browser.



7. Solve and Analyze

Solve the problem, providing an initial point for nonlinear problems. The **`solve`** function returns solution values, objectives values, the reason the problem stopped, and more.

Example:

```
x0.x = 0;
x0.y = 0;
[sol,fval,exitflag] = solve(responseProb,x0)
```

```
sol = struct with fields:
    x: 0.8883
    y: 1.5563
fval = -0.2013
exitflag =
    OptimalSolution
```

Solve with *optimization options*.

Example:

```
o = optimoptions(assignProb,"MaxTime",10);
sol = solve(assignmentProb,"Options",o)
```

Do More

- Use **`evaluate`** and **`infeasibility`** to analyze results
- *Interpret* and *improve* results
- Convert to solver-based form with **`prob2struct`**

Learn more: *mathworks.com/help/optim*

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