

## QUICK START GUIDE

# Solver-Based Optimization in MATLAB®

1. Group the optimization variables into a single vector  $\mathbf{x}$ . Write the objective and constraints in terms of  $\mathbf{x}$ .

Objective Type	Mathematical Form	Example
Linear	$f^T x$	$\mathbf{f} = [-1 \ 0 \ -5];$
Quadratic	$x^T H x + f^T x$	$\mathbf{H} = [5 \ 1 \ 0; \ 1 \ 3 \ 0; \ 0 \ 0 \ 0];$
Least Squares	$\ Cx - d\ _2$ $\sum F_i(x)^2$	$\mathbf{C} = [7 \ 8 \ 10; \ 1 \ 3 \ 4; \ 2 \ 5 \ 7];$ $\mathbf{d} = [2; \ 1; \ 1.5];$  function $\mathbf{F} = \text{myF}(\mathbf{x})$ $\mathbf{F}(1) = \mathbf{f1}(\mathbf{x});$ $\mathbf{F}(2) = \mathbf{f2}(\mathbf{x});$ end
General	$f(x)$	function $\text{objval} = \text{fobj}(\mathbf{x})$ $\text{objval} = 3*(\mathbf{x}(1) - \mathbf{x}(2))^4;$ end

Constraint Type	Mathematical Form	Example
Bound	$l \leq x \leq u$	$\mathbf{lb} = \text{zeros}(n,1);$ $\mathbf{ub} = 5*\text{ones}(n,1);$
Linear	$Ax \leq b$ $A_{eq} x = b_{eq}$	$\mathbf{A} = [1 \ 0 \ 1;$ $\quad \quad 0 \ -2 \ 1];$ $\mathbf{b} = [4; \ 2];$ $\mathbf{Aeq} = [1 \ 0 \ 2];$ $\mathbf{beq} = 1;$
General	$c(x) \leq 0$ $c_{eq}(x) = 0$	function $[\mathbf{c}, \mathbf{ceq}] = \text{nlcons}(\mathbf{x})$ $\mathbf{c}(1) = \mathbf{x}(1).^2 + \mathbf{x}(2).^2 - 1;$ $\mathbf{c}(2) = \mathbf{x}(1)*\mathbf{x}(3) - 5;$ $\mathbf{ceq} = [];$ end
Integer	$x_j \in \mathbb{Z}^n$	$\text{intcon} = [1 \ 2]$

2. Choose a solver matching the types of objective and constraints.

Solvers in Optimization Toolbox™ use derivatives, are usually faster, and scale to large problems. Solvers in Global Optimization Toolbox (*italic*) and MATLAB (\*) do not use derivatives and search for global minima.

Constraint Type	Objective Type					
	Linear	Quadratic	Least Squares	General Smooth	General Nonsmooth	Multiobjective
None		<code>quadprog</code>	<code>lsqcurvefit</code> <code>lsqnonlin</code> <code>mldivide</code>	<code>fminsearch*</code> <code>fminunc</code>	<code>fminsearch*</code> <code>patternsearch</code> <i><code>ga</code></i> <i><code>particleswarm</code></i> <i><code>simulannealbnd</code></i>	<code>fgoalattain</code> <code>fminimax</code> <i><code>paretosearch</code></i> <i><code>gamultiobj</code></i>
Bound	<code>linprog</code>	<code>quadprog</code>	<code>lsqcurvefit</code> <code>lsqnonlin</code> <code>lsqnonneg</code> <code>lsqlin</code>	<code>fmincon</code>	<i><code>surrogateopt</code></i> <i><code>patternsearch</code></i> <i><code>ga</code></i> <code>fminbnd*</code> <i><code>particleswarm</code></i> <i><code>simulannealbnd</code></i>	<code>fgoalattain</code> <code>fminimax</code> <i><code>paretosearch</code></i> <i><code>gamultiobj</code></i>
Linear	<code>linprog</code>	<code>quadprog</code>	<code>lsqlin</code>	<code>fmincon</code>	<code>patternsearch</code> <i><code>ga</code></i>	<code>fgoalattain</code> <code>fminimax</code> <i><code>paretosearch</code></i> <i><code>gamultiobj</code></i>
General Smooth	<code>fmincon</code>	<code>fmincon</code>	<code>fmincon</code>	<code>fmincon</code>	<code>patternsearch</code> <i><code>ga</code></i> <i><code>surrogateopt</code></i>	<code>fgoalattain</code> <code>fminimax</code> <i><code>paretosearch</code></i> <i><code>gamultiobj</code></i>
General Nonsmooth	<code>patternsearch</code> <i><code>ga</code></i> <i><code>surrogateopt</code></i>	<code>patternsearch</code> <i><code>ga</code></i> <i><code>surrogateopt</code></i>	<code>patternsearch</code> <i><code>ga</code></i> <i><code>surrogateopt</code></i>	<code>patternsearch</code> <i><code>ga</code></i> <i><code>surrogateopt</code></i>	<code>patternsearch</code> <i><code>ga</code></i> <i><code>surrogateopt</code></i>	<i><code>paretosearch</code></i> <i><code>gamultiobj</code></i>
Integer	<code>intlinprog</code>				<i><code>ga</code></i> <i><code>surrogateopt</code></i>	

### 3. Define initial point if required and options if desired. Call solver and obtain solution.

#### Initial Point

Examples:

```
x0 = lb + 0.5*(ub-lb)
x0 = zeros(n,1)
```

#### Options

Use `optimoptions` to set stopping criteria, plot functions, initial population, and more.

Example:

```
opts = optimoptions('fmincon','Display','iter')
```

#### Solve

Examples:

```
[x,fval] = fmincon(@fobj,x0,A,b,Aeq,beq,lb,ub,@nlcons,opts)
[x,fval,eflag] = ga(@fobj,nvars)
x = lsqlin(C,d,A,b,[],[],lb)
```

#### Do More

- » [Interpret](#) and [improve](#) results
- » [Pass extra parameters to functions](#)
- » Solver comparison [table](#) and [example](#)
- » [Solve systems of nonlinear equations](#)
- » [Search for global minima on smooth problems](#)

#### Learn more:

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