

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

Constraint Type	Mathematical Form	Example
Bound	$l \leq x \leq u$	$lb = \text{zeros}(n,1);$ $ub = 5*\text{ones}(n,1);$
Linear	$Ax \leq b$ $A_{eq} x = b_{eq}$	$A = [1 \ 0 \ 1;$ $\quad 0 \ -2 \ 1];$ $b = [4; \ 2];$ $A_{eq} = [1 \ 0 \ 2];$ $b_{eq} = 1;$
General	$c(x) \leq 0$ $c_{eq}(x) = 0$	function[c,ceq] = nlcons(x) c(1) = x(1).^2 + x(2).^2 - 1; c(2) = x(1)*x(3) - 5; ceq = []; end
Integer	$x_j \in Z^n$	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		quadprog	lsqcurvefit lsqnonlin mldivide	fminsearch* fminunc	fminsearch* patternsearch ga particleswarm simulannealbnd	fgoalattain fminimax paretosearch gamultiobj
Bound	linprog	quadprog	lsqcurvefit lsqnonlin lsqnonneg lsqlin	fmincon	surrogateopt patternsearch ga fminbnd* particleswarm simulannealbnd	fgoalattain fminimax paretosearch gamultiobj
Linear	linprog	quadprog	lsqlin	fmincon	patternsearch ga	fgoalattain fminimax paretosearch gamultiobj
General Smooth	fmincon	fmincon	fmincon	fmincon	patternsearch ga	fgoalattain fminimax paretosearch gamultiobj
General Nonsmooth	patternsearch ga	patternsearch ga	patternsearch ga	patternsearch ga	patternsearch ga	paretosearch gamultiobj
Integer	intlinprog				ga surrogateopt	

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](#)

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