Solve a first-order scalar ODE

```matlab
syms x(t)
eqn1 = t*diff(x(t),t) == x(t) + 3*t^2*cos(2*t)
eqn1 = 
   t \frac{\partial}{\partial t} x(t) = x(t) + 3t^2\cos(2t)
%sol1 = dsolve(eqn1)
ic1 = x(pi) == -4
ic1 = x(\pi) = -4
sol1 = simplify(dsolve(eqn1,ic1))
sol1 = 
   \frac{3t\sin(2t)}{2} - \frac{4t}{\pi}
```

Solve a second-order ODE

```matlab
syms y(t)
Dy(t) = diff(y(t),t); D2y(t) = diff(y(t),t,2);
eqn2 = D2y(t) + 4*Dy(t) + 13*y(t) == 18*exp(-2*t) + 136*cos(5*t)
eqn2 = 
   \frac{\partial^2}{\partial t^2} y(t) + 4 \frac{\partial}{\partial t} y(t) + 13y(t) = 136\cos(5t) + 18e^{-2t}
sol2 = simplify(dsolve(eqn2))
sol2 = 
   2e^{-2t} - 3\cos(5t) + 5\sin(5t) + C_{11}\cos(3t)e^{-2t} + C_{12}\sin(3t)e^{-2t}
%ic2 = [y(0) == 4, Dy(0) == -1];
%sol2(t) = simplify(dsolve(eqn2,ic2))
%fplot(sol2(t))
```

Solve a system of ODEs

```matlab
syms x(t) y(t)
eqn3 = [diff(x(t),t) == y(t) + exp(-t), diff(y(t),t) == -2*x(t) - 3*y(t) + 4]
eqn3 = 
   \left( \frac{\partial}{\partial t} x(t) = e^{-t} + y(t) \quad \frac{\partial}{\partial t} y(t) = 4 - 3y(t) - 2x(t) \right)
[sol3x,sol3y] = dsolve(eqn3);
```
\[ x_3 = \text{simplify}(\text{sol3x}) \]

\[ x_3 = 2t e^{-t} - e^{-t} - C_{13} e^{-t} \frac{C_{14} e^{-2t}}{2} + 2 \]

\[ y_3 = \text{simplify}(\text{sol3y}) \]

\[ y_3 = e^{-2t} \left( C_{14} + 2e^t + C_{13} e^t - 2te^t \right) \]

\[
\%ic3 = [x(0) == 2, y(0) == -5] \\
\%[sol3x, sol3y] = \text{dsolve}(\text{eqn3}, \text{ic3}); \\
\%x3(t) = \text{simplify}(\text{sol3x}) \\
\%y3(t) = \text{simplify}(\text{sol3y}) \\
\%fplot(x3(t), 'b-') \\
\%hold on \\
\%fplot(y3(t), 'ro') \\
\%hold off \\
\%xlim([0 5])
\]

**Do partial fractions**

\[
\text{syms } s \\
f = (3s-1)/(s^2+6s+8)
\]

\[ f = \frac{3s-1}{s^2+6s+8} \]

\[ \text{fp} = \text{partfrac}(f) \]

\[ fp = \frac{13}{2(s+4)} - \frac{7}{2(s+2)} \]

**Solve ODEs with Heaviside and Dirac delta functions**

\[
\text{syms } y(t) \\
\text{sympref('HeavisideAtOrigin',1);} \\
\text{Dy(t)} = \text{diff}(y(t), t); \text{D2y(t)} = \text{diff}(y(t), t, 2); \\
\text{eqn4} = \text{D2y(t)} + 7\text{Dy(t)} + 10y(t) == 3\text{heaviside(t-1)} - 5\text{dirac(t-2)}
\]

\[ \text{eqn4} = \frac{\partial^2 y(t)}{\partial t^2} + 7 \frac{\partial y(t)}{\partial t} + 10 y(t) = 3 \text{heaviside}(t - 1) - 5 \delta(t - 2) \]

\[
\%sol4 = \text{simplify}(\text{dsolve}(\text{eqn4}, '\text{IgnoreAnalyticConstraints}', \text{false})) \\
\text{ic4} = [y(0) == 0, Dy(0) == 0]; \\
\text{sol4(t)} = \text{simplify}(\text{dsolve}(\text{eqn4}, \text{ic4}, '\text{IgnoreAnalyticConstraints}', \text{false}))
\]
\[ \text{sol4}(t) = \]
\[ e^{-5t} \left( \frac{5 \text{heaviside}(t - 2) e^{10}}{3} - \frac{\sigma_1 (e^{5t} - e^5)}{5} \right) - e^{-2t} \left( \frac{5 \text{heaviside}(t - 2) e^4}{3} - \frac{\sigma_1 (e^{2t} - e^2)}{2} \right) \]

where

\[ \sigma_1 = \frac{\text{sign}(t - 1)}{2} + \frac{1}{2} \]

\text{fplot(sol4(t),[0 6])}