```
muplot = exp(p(1)*Tplot.^2 + p(2)*Tplot + p(3));
semilogy(TK,mu,'o',Tplot,muplot)
```

When the program executes (saved as Chap8SamPro7), the coefficients that are determined by the `polyfit` function are displayed in the Command Window (shown below) as three elements of the vector `p`.

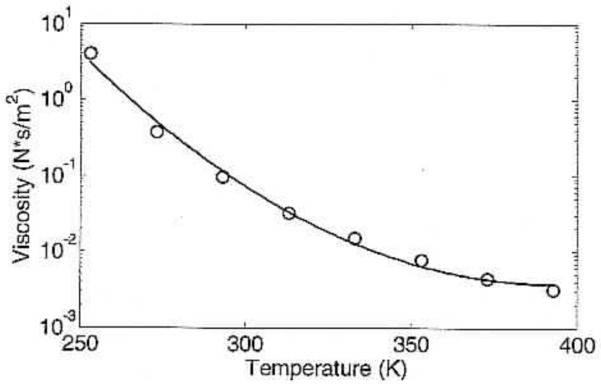
```
>> Chap8SamPro7
p =
    0.0003   -0.2685   47.1673
```

With these coefficients the viscosity of the oil as a function of temperature is:

$$\mu = e^{(0.0003T^2 - 0.2685T + 47.1673)} = e^{47.1673}e^{(-0.2685)T}e^{0.0003T^2}$$

The plot that is generated shows that the equation correlates well to the data points (axes labels were added with the Plot Editor).

hm... interesting



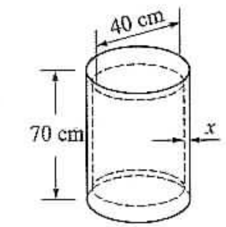
8.6 Problems

1. Plot the polynomial $y = 0.02x^4 - 0.75x^3 + 12.5x - 2$ in the domain $-6 \le x \le 6$. First create a vector for x, next use the `polyval` function to calculate y, and then use the `plot` function.

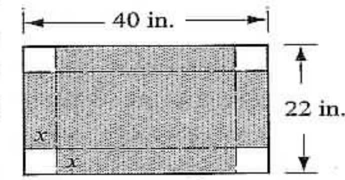
2. Divide the polynomial $12x^6 + 21x^5 - 11x^4 - 14x^3 + 18x^2 + 28x - 4$ by the polynomial $4x^2 + 7x - 1$.

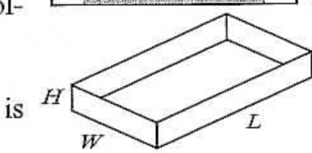
3. Divide the polynomial $4x^4 + 6x^3 - 2x^2 - 5x + 3$ by the polynomial $x^2 + 4x + 2$.

4. A cylindrical stainless-steel fuel tank has an outside diameter of 40 cm and a length of 70 cm. The side of the cylinder and the bottom and top ends have a thickness of x. Determine x if the mass of the tank is 18 kg. The density of stainless steel is 7920 kg/m^3.

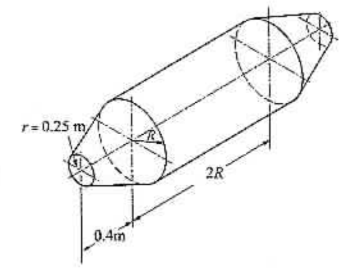


5. A rectangular piece of cardboard, 40 inches long by 22 inches wide, is used for making a rectangular box (open top) by cutting out squares of x by x from the corners and folding up the sides.
   a) Create a polynomial expression for the volume V in terms of x.
   b) Make a plot of V versus x.
   c) Determine x if the volume of the box is 1000 in^3.
   d) Determine the value of x that corresponds to the box with the largest possible volume, and determine that volume.





6. A gas tank has the geometry shown in the figure (two frustum end caps that are attached to a circular cylinder). The radius of the cylinder is R and its length is $2R$. Each frustum has a base with radius R, and a top with radius 0.25 m, and a height of 0.4m. Determine R if the volume of the tank is 1.7 m^3.



7. Write a user-defined function that adds or subtracts two polynomials of any order. Name the function `p=polyadd(p1,p2,operation)`. The first two input arguments `p1` and `p2` are the vectors of the coefficients of the two polynomials. (If the two polynomials are not of the same order the function adds the necessary zero elements to the shorter vector.) The third input argument `operation` is a string that can be either `'add'` or `'sub'`, for adding or subtracting the polynomials, respectively, and the output argument is the resulting polynomial.

   Use the function to add and subtract the following polynomials:

   $f_1(x) = x^5 - 7x^4 + 11x^3 - 4x^2 - 5x - 2$ and $f_2(x) = 9x^2 - 10x + 6$.

8. Write a user-defined function that calculates the maximum (or minimum) of a quadratic equation of the form:

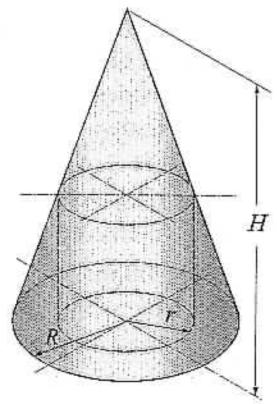
$$f(x) = ax^2 + bx + c$$

Name the function `[x,y,w] = maxormin(a,b,c)`. The input arguments are the coefficients `a`, `b`, and `c`. The output arguments are `x` the coordinate of the maximum (or minimum), `y` the maximum (or minimum) value, and `w` which is equal to 1 if `y` is a maximum, and equal to 2 if `y` is a minimum.

Use the function to determine the maximum or minimum of the following functions:

a) $f(x) = 3x^2 - 7x + 14$ *b)* $f(x) = -5x^2 - 11x + 15$

9. A cylinder of radius r and height h is constructed inside a cone with base radius $R = 10$ in. and height of $H = 30$ in., as shown in the figure.
   a) Create a polynomial expression for the volume V of the cylinder in terms of r.
   b) Make a plot of V versus r.
   c) Determine r if the volume of the cylinder is 800 in^3.
   d) Determine the value of r that corresponds to the cylinder with the largest possible volume, and determine that volume.



10. The van der Waals equation gives a relationship between the pressure p (in atm.), volume V (in L), and temperature T (in K) for a real gas:

$$p = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$

where n is the number of moles, $R = 0.08206$ (L atm)/(mole K) is the gas constant, and a (in L^2 atm/mole^2), and b (in L/mole) are material constants. The equation can be easily used for calculating p (given T and V), or T (given p and V). The equation is not as readily solved for V when p and T are given, since it is nonlinear in V. One useful way to solve for V is by rewriting the equation as a third-order polynomial:

$$V^3 - \left(nb + \frac{nRT}{p}\right)V^2 + \frac{n^2 a}{p}V - \frac{n^3 ab}{p} = 0$$

and calculating the root of the polynomial.

Write a user-defined function that calculates V for given p, T, n, a, and b. For function name and arguments use `V=waals(p,T,n,a,b)`. The function calculates V by using MATLAB's built-in function `roots`. Note that the solution of the polynomial can have non-real (complex) roots. The output argument `V` in `waals` should be the physically realistic solution (positive and real). (MATLAB's built-in function `imag(x)` can be used for determining which root is real.)

Use the user-defined function to calculate V for $p = 30$ atm, $T = 300$K, $n = 1.5$, $a = 1.345$L^{2}atm/mole^2, $b = 0.0322$ L/mole.

11. The following points are given:

x	−6	−3.5	−2.5	−1	0	1.5	2.2	4	5.2	6	8
y	0.3	0.4	1.1	3.6	3.9	4.5	4.2	3.5	4.0	5.3	6.1

a) Fit the data with a first-order polynomial. Make a plot of the points and the polynomial.
b) Fit the data with a second-order polynomial. Make a plot of the points and the polynomial.
c) Fit the data with a fourth-order polynomial. Make a plot of the points and the polynomial.
d) Fit the data with a tenth-order polynomial. Make a plot of the points and the polynomial.

12. The population of India from the year 1940 to the year 2000 is given in the following table:

Year	1910	1930	1940	1950	1960	1970	1980	1990	2000
Population (millions)	249	277	316	350	431	539	689	833	1014

a) Determine the exponential function that best fits the data. Use the function to estimate the population in 1975.
b) Curve fit the data with a quadratic equation (second-order polynomial). Use the function to estimate the population in 1975.
c) Fit the data with linear and spline interpolations. Estimate the population in 1975 with linear and spline interpolations.

In each part make a plot of the data points (circle markers) and the curve fitting or the interpolation curves. Note that part *c* has two interpolation curves. The actual population in India in 1955 was 600.8 million.

13. The standard air density, D (average of measurements made) at different heights, h, from sea level up to a height of 33 km is given below.

h (km)	0	3	6	9	12	15
D (kg/m^3)	1.2	0.91	0.66	0.47	0.31	0.19
h (km)	18	21	24	27	30	33
D (kg/m^3)	0.12	0.075	0.046	0.029	0.018	0.011

a) Make the following four plots of the data points (density as a function of height): (1) both axes with linear scale, (2) h with log axis, D with linear axis, (3) h with linear axis D with log axis, (4) both with log axes. According to the plots choose a function (linear, power, exponential, or logarithmic) that can best fit the data points and determine the coefficients of the function.

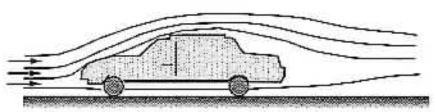
b) Plot the function and the points using linear axes.

14. Write a user-defined function that fits data points to an exponential function of the form: $y = be^{mx}$. Name the function `[b,m] = expofit(x,y)`, where the input arguments `x` and `y` are vectors with the coordinates of the data points, and the output arguments `b` and `m` are the constants of the fitted exponential equation. Use `expofit` to fit the data below. Make a plot that shows the data points and the function.

x	0.6	2.1	3.1	5.1	6.2	7.6
y	0.9	9.1	24.7	58.2	105	222

15. The aerodynamic drag force F_D that is applied to a car is given by:

$$F_D = \frac{1}{2}\rho C_D A v^2$$



where $\rho = 1.2$ kg/m^3 is the air density, C_D is the drag coefficient, A is the projected front area of the car, and v is the speed of the car (in units of m/s) relative to the wind. The product $C_D A$ characterizes the air resistance of a car. (At speeds above 70 km/h the aerodynamic drag force is typically more than half of the total resistance to motion.) Data obtained in a wind tunnel test is displayed in the table. Use the data to determine the product $C_D A$ for the tested car by using curve fitting. Make a plot of the data points and the curve fitted equation.

v (km/h)	20	40	60	80	100	120	140	160
F_D (N)	10	50	109	180	300	420	565	771

16. The relationship between two variables P and t is known to be:

$$P = \frac{5}{m\sqrt{t} + b}$$

The following data points are known:

t	1	2	3	4	5	6	7
P	8.9	3.4	2.1	2.0	1.6	1.3	1.2

Determine the constants m and b by curve fitting the equation to the data points. Make a plot of P versus t. In the plot show the data points with markers and the curve-fitted equation with a solid line. (The curve fitting can be done by writing the reciprocal of the equation, and using a first-order polynomial.)

17. The yield strength, σ_y, of many metals depends on the size of the grains. For these metals the relationship between the yield stress and the average grain diameter d can be modeled by the Hall-Petch equation:

$$\sigma_y = \sigma_0 + kd^{\left(\frac{-1}{2}\right)}$$

The following are results from measurements of average grain diameter and yield stress.

d (mm)	0.005	0.009	0.016	0.025	0.040	0.062	0.085	0.110
σ_y (MPa)	205	150	135	97	89	80	70	67

a) Using curve fitting, determine the constants σ_0 and k in the Hall-Petch equation for this material. Using the constants determine with the equation the yield stress of material with grain size of 0.05 mm. Make a plot that shows the data points with circle markers and the Hall-Petch equation with a solid line.

b) Use linear interpolation to determine the yield stress of material with grain size of 0.05 mm. Make a plot that shows the data points with circle markers and linear interpolation with a solid line.

c) Use cubic interpolation to determine the yield stress of material with grain size of 0.05 mm. Make a plot that shows the data points with circle markers and cubic interpolation with a solid line.

18. The ideal gas equation relates the volume, pressure, temperature, and the quantity of a gas by:

$$V = \frac{nRT}{P}$$

where V is the volume in liters, P is the pressure in atm, T is the temperature in degrees K, n is the number of moles, and R is the gas constant.

An experiment is conducted for determining the value of the gas constant R. In the experiment 0.05 mol of gas is compressed to different volumes by applying pressure to the gas. At each volume the pressure and temperature of the gas is recorded. Using the data given below, determine R by plotting V versus T/P, and fitting the data points with a linear equation.

V (L)	0.75	0.65	0.55	0.45	0.35
T (°C)	25	37	45	56	65
P (atm)	1.63	1.96	2.37	3.00	3.96

19. Viscosity is a property of gases and fluids that characterizes their resistance to flow. For most materials viscosity is highly sensitive to temperature. For gases, the variation of viscosity with temperature is frequently modeled by an equation which has the form:

$$\mu = \frac{CT^{3/2}}{T+S}$$

where μ is the viscosity, T the absolute temperature, and C and S are empirical constants. Below is a table that gives the viscosity of air at different temperatures (data from B.R. Munson, D.F. Young, and T.H. Okiishi, "Fundamental of Fluid Mechanics," 4th Edition, John Wiley and Sons, 2002).

T (°C)	−20	0	40	100	200	300	400	500	1000
μ (N s/m²) ($\times 10^{-5}$)	1.63	1.71	1.87	2.17	2.53	2.98	3.32	3.64	5.04

Determine the constants C and S by curve fitting the equation to the data points. Make a plot of viscosity versus temperature (in °C). In the plot show the data points with markers and the curve-fitted equation with a solid line.

The curve fitting can be done by rewriting the equation in the form:

$$\frac{T^{3/2}}{\mu} = \frac{1}{C}T + \frac{S}{C}$$

and using a first-order polynomial.

Chapter 9

Three-Dimensional Plots

Three-dimensional (3-D) plots can be a useful way to present data that consists of more than two variables. MATLAB provides various options for displaying three-dimensional data. They include line and wire, surface, mesh plots, and many others. The plots can also be formatted to have a specific appearance and special effects. Many of the three-dimensional plotting features are described in this chapter. Additional information can be found in the Help Window under **Plotting and Data Visualization.**

In many ways this chapter is a continuation of Chapter 5 where two-dimensional plots were introduced. The 3-D plots are presented in a separate chapter since not all MATLAB users use them. In addition, it was felt that for new users of MATLAB it is better to practice 2-D plotting first and learn the material in Chapters 6–8 before attempting 3-D plotting. It is assumed in the rest of this chapter that the reader is familiar with 2-D plotting.

9.1 LINE PLOTS

A three-dimensional line plot is a line that is obtained by connecting points in a three-dimensional space. A basic 3-D plot is created with the `plot3` command, which is very similar to the `plot` command, and has the form: OK

```
plot3(x,y,z,'line specifiers','PropertyName',property value)
```

x, y, and z are vectors of the coordinates of the points.

(Optional) Specifiers that define the type and color of the line and markers.

(Optional) Properties with values that can be used to specify the line width, and marker's size and edge and fill colors.