

## Matlab for Engineers, 5th Edition

### Chapter 2 Homework Solutions

```
clear,clc, format shortg
```

You can either solve these problems in the command window, using MATLAB® as an electronic calculator, or you can create an M-file of the solutions. If you are solving these problems as a homework assignment or if you want to keep a record of your work, the best strategy is to use an M-file, divided into cells with the cell divider %%.

#### Problem 2.1

Predict the outcome of the following MATLAB® calculations. Check your results by entering the calculations into the command window.

```
1 + 3/4
```

```
ans =      1.75
```

```
5*6*4/2
```

```
ans =      60
```

```
5/2*6*4
```

```
ans =      60
```

```
5^2*3
```

```
ans =      75
```

```
5^(2*3)
```

```
ans =    15625
```

```
1 + 3 + 5/5 + 3 + 1
```

```
ans =      9
```

```
(1 + 3 + 5)/(5 + 3 + 1)
```

```
ans =      1
```

### Using Variables

#### Problem 2.2

Identify which name in each of the following pairs is a legitimate MATLAB® variable name. Test your answers by using `isvarname`—for example,

## **isvarname fred**

Remember, `isvarname` returns a 1 if the name is valid and a 0 if it is not. Although it is possible to reassign a function name as a variable name, doing so is not a good idea. Use `which` to check whether the preceding names are function names—for example,

## **which sin**

In what case would MATLAB® tell you that `sin` is a variable name, not a function name?

The legitimate Matlab names are: `fred` `book_1` `Second_Place` `No_1` `vel_5` `tan`

```
isvarname fred
```

```
ans = 1
```

```
isvarname book_1
```

```
ans = 1
```

```
isvarname Second_Place
```

```
ans = 1
```

```
isvarname No_1
```

```
ans = 1
```

```
isvarname vel_5
```

```
ans = 1
```

```
isvarname tan %although tan is a function name it can be used as a variable name
```

```
ans = 1
```

```
isvarname fred! %! is not an allowed character
```

```
ans = 0
```

```
isvarname book-1 % - is not an allowed character
```

```
ans = 0
```

```
isvarname 2ndplace %variable names must start with a letter
```

```
ans = 0
```

```
isvarname #1 %# is not an allowed character
```

```
ans = 0
```

```
isvarname vel.5 % . is not an allowed character
```

```
ans = 0
```

```
isvarname while %while is a reserved name
```

```
ans = 0
```

```
which tan % tan is a function name
```

```
built-in (C:\Program Files\MATLAB\R2016b\toolbox\matlab\elfun\@double\tan) % double method
```

```
which while %while is also a function name, but is reserved
```

```
built-in (C:\Program Files\MATLAB\R2016b\toolbox\matlab\lang\while)
```

```
%You can reassign a function name as a variable name  
%For example  
sin=3
```

```
sin = 3
```

```
%The which function now tells us sin is a variable  
which sin
```

```
sin is a variable.
```

```
% Use the clear function to return sin to its function definition  
clear sin  
which sin
```

```
built-in (C:\Program Files\MATLAB\R2016b\toolbox\matlab\elfun\@double\sin) % double method
```

## Scalar Operations and Order of Operations

### Problem 2.3

Create MATLAB® code to perform the following calculations. Check your code by entering it into MATLAB® and performing the calculations on your scientific calculator.

```
5^2
```

```
ans = 25
```

```
(5 + 3)/(5*6)
```

```
ans = 0.26667
```

```
sqrt(4+6^3) % or...
```

```
ans = 14.832
```

```
(4+6^3)^(1/2)
```

```
ans = 14.832
```

```
9*6/12 + 7*5^(3+2)
```

```
ans =      21880
```

```
1 + 5*3/6^2 + 2^(2-4) *1/5.5
```

```
ans =      1.4621
```

## Problem 2.4

(a) The area of a circle is  $\pi r^2$ . Define  $r$  as 5, then find the area of a circle, using MATLAB®.

```
r=5
```

```
r =      5
```

```
area=pi*r^2
```

```
area =      78.54
```

(b) The surface area of a sphere is  $4\pi r^2$ . Find the surface area of a sphere with a radius of 10 ft.

```
r=10
```

```
r =     10
```

```
surface_area=4*pi*r^2
```

```
surface_area =     1256.6
```

(c) The volume of a sphere is  $\frac{4}{3}\pi r^3$ . Find the volume of a sphere with a radius of 2 ft.

```
r=2
```

```
r =      2
```

```
volume=4/3*pi*r^3
```

```
volume =      33.51
```

## Problem 2.5

(a) The area of a square is the edge length squared ( $A = \text{edge}^2$ ). Define the edge length as 5, then find the area of a square, using MATLAB®.

```
edge=5
```

```
edge =      5
```

```
area=edge^2
```

```
area =      25
```

**(b)** The surface area of a cube is 6 times the edge length squared ( $SA = 6 \times \text{edge}^2$ ). Find the surface area of a cube with edge length 10.

```
edge=10
```

```
edge =      10
```

```
surface_area=6*edge^2
```

```
surface_area =      600
```

**(c)** The volume of a cube is the edge length cubed ( $V = \text{edge}^3$ ). Find the volume of a cube with edge length 12.

```
edge=12
```

```
edge =      12
```

```
volume=edge^3
```

```
volume =      1728
```

## Problem 2.6

Consider the barbell shown in Figure P2.6.

**(a)** Find the volume of the figure, if the radius of each sphere is 10 cm, the length of the bar connecting them is 15 cm, and the diameter of the bar is 1 cm. Assume that the bar is a simple cylinder.

```
r=10; %cm
length=15; %cm
d=1; % cm
% Find the volume of each sphere
volume_sphere=4/3*pi*r^3;
% Find the volume of the bar
volume_bar=pi*(d/2)^2*length;
% Combine the components to get the total volume
total_volume=2*volume_sphere +volume_bar
```

```
total_volume =      8389.4
```

## b)Surface Area

**(b)** Find the surface area of the figure.

Find the surface area of each sphere

```
sa_sphere=4*pi*r^2;
% Find the surface area of the bar
```

```
sa_bar=pi*d*length;
% Combine the components to get the total surface area
total_sa=2*sa_sphere + sa_bar
```

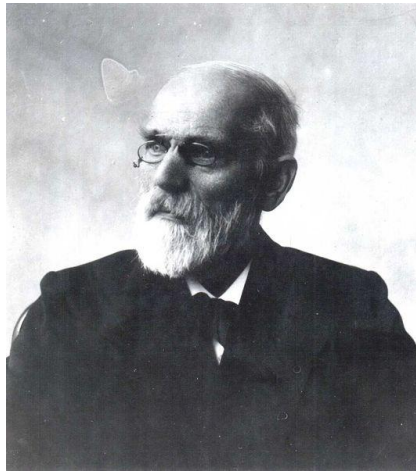
```
total_sa =          2560.4
```

## Problem 2.7

The ideal gas law was introduced in Example 2.1. It describes the relationship between pressure ( $P$ ), temperature ( $T$ ), volume ( $V$ ), and the number of moles of gas ( $n$ ).

$$PV = nRT$$

The additional symbol,  $R$ , represents the ideal gas constant. The ideal gas law is a good approximation of the behavior of gases when the pressure is low and the temperature is high. (What constitutes low pressure and high temperature varies with different gases.) In 1873, Johannes Diderik van der Waals, Figure P2.7 proposed a modified version of the ideal gas law that better models the behavior of real gases over a wider range of temperature and pressure.



$$\left( \left( P + \frac{n^2 a}{V^2} \right) (V - nb) \right) = nRT$$

In this equation the additional variables  $a$  and  $b$  represent values characteristic of individual gases.

Use both the ideal gas law and van der Waals' equation to calculate the temperature of water vapor (steam), given the following data.

```
P=220;
n=2;
V=1;
a=5.536;
b=0.03049;
R=0.08314472;
% Find the temperature using the ideal gas law
T_ideal=P*V/(n*R)
```

```
T_ideal =          1323
```

```
% Find the temperature using Van der Waal's equation
T_VW=(P+n^2*a/V^2)*(V-n*b)/(n*R)
```

T\_VW = 1367.4

## Problem 2.8

(a) The volume of a cylinder is  $\pi r^2 h$ . Define  $r$  as 3 and  $h$  as the matrix

**h = [1, 5, 12]**

Find the volume of the cylinders (see Figure P2.8a).

```
r=3;
h=[1,5,12];
volume = pi*r^2.*h
```

volume = 28.274 141.37 339.29

%We need to use the .\* operator because h is an array

(b) The area of a triangle is  $1/2$  the length of the base of the triangle, times the height of the triangle. Define the base as the matrix

**b = [2, 4, 6]**

and the height  $h$  as 12, and find the area of the triangles

```
b=[ 2, 4, 6];
h=12;
area=1/2*b.*h
```

area = 12 24 36

%Although you don't have to use the .\* operator for both  
%multiplications and the ./ for the division it won't hurt if you do  
area=1./2.\*b.\*h

area = 12 24 36

(c) The volume of any right prism is the area of the base of the prism, times the vertical dimension of the prism. The base of the prism can be any shape—for example, a circle, a rectangle, or a triangle. Find the volume of the prisms created from the triangles of part (b). Assume that the vertical dimension of these prisms is 6

```
h=6;
volume=h.*area
```

volume = 72 144 216

## Problem 2.9

The response of circuits containing resistors, inductors and capacitors depends upon the relative values of the resistors and the way they are connected. An important intermediate quantity used in describing

the response of such circuits is  $s$ . Depending on the values of  $R$ ,  $L$ , and  $C$ , the values of  $s$  will be either both real values, a pair of complex values, or a duplicated value.

The equation that identifies the response of a particular series circuit (Figure P2.9) is

$$s = \frac{-R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

**(a)** Determine the values of  $s$  for a resistance of  $800 \, \Omega$ .

$R=800 \, \Omega$

$R = 800$

$L=100\text{e-}3 \, \text{H}$

$L = 0.1$

$C=1\text{e-}6 \, \text{F}$

$C = 1\text{e-}06$

$s(1) = -R/(2*L) + \sqrt{(R/(2*L))^2 - 1/(L*C)}$

$s = -1550.5$

$s(2) = -R/(2*L) - \sqrt{(R/(2*L))^2 - 1/(L*C)}$

$s = -1550.5 \quad -6449.5$

**(b)** Create a vector of values for  $R$  ranging from  $100$  to  $1000 \, \Omega$  and evaluate  $s$ . Refine your values of  $R$  until you find the approximate size of resistor that yields a pure real value of  $s$ . Describe the effect on  $s$  as  $R$  increases in value.

*Hint:*

$1 \, \mu\text{F} = 1\text{e-}6\text{F}$

$1 \, \text{mH} = 1\text{e-}3\text{H}$

```
R=100:100:1000;
s_plus = -R./(2*L)+sqrt((R./(2*L)).^2 - 1/(L*C))
```

```
s_plus = -500 + 3122.5i -1000 + 3000i -1500 + 2783.9i -2000 + 2449.4i
```

```
s_minus = -R./(2*L)-sqrt((R./(2*L)).^2 - 1/(L*C))
```

```
s_minus = -500 - 3122.5i -1000 - 3000i -1500 - 2783.9i -2000 - 2449.4i
```

```
table_values = [R',s_plus',s_minus']
```

```
table_values =
    100 + 0i -500 - 3122.5i -500 + 3122.5i
    200 + 0i -1000 - 3000i -1000 + 3000i
    300 + 0i -1500 - 2783.9i -1500 + 2783.9i
```



|        |    |           |         |           |         |
|--------|----|-----------|---------|-----------|---------|
| 400 +  | 0i | -2000 -   | 2449.5i | -2000 +   | 2449.5i |
| 500 +  | 0i | -2500 -   | 1936.5i | -2500 +   | 1936.5i |
| 600 +  | 0i | -3000 -   | 1000i   | -3000 +   | 1000i   |
| 700 +  | 0i | -2000 +   | 0i      | -5000 +   | 0i      |
| 800 +  | 0i | -1550.5 + | 0i      | -6449.5 + | 0i      |
| 900 +  | 0i | -1298.4 + | 0i      | -7701.6 + | 0i      |
| 1000 + | 0i | -1127 +   | 0i      | -8873 +   | 0i      |

```
% Repeat for R between 600 and 700
```

```
R=600:10:700;
```

```
s_plus = -R./(2*L)+sqrt((R./(2*L)).^2 - 1/(L*C))
```

|          |         |       |         |         |         |        |       |
|----------|---------|-------|---------|---------|---------|--------|-------|
| s_plus = | -3000 + | 1000i | -3050 + | 835.16i | -3100 + | 624.5i | -3150 |
|----------|---------|-------|---------|---------|---------|--------|-------|

```
s_minus = -R./(2*L)-sqrt((R./(2*L)).^2 - 1/(L*C))
```

|           |         |       |         |         |         |        |       |
|-----------|---------|-------|---------|---------|---------|--------|-------|
| s_minus = | -3000 - | 1000i | -3050 - | 835.16i | -3100 - | 624.5i | -3150 |
|-----------|---------|-------|---------|---------|---------|--------|-------|

```
table_values = [R',s_plus',s_minus']
```

|                |    |           |         |           |         |  |
|----------------|----|-----------|---------|-----------|---------|--|
| table_values = |    |           |         |           |         |  |
| 600 +          | 0i | -3000 -   | 1000i   | -3000 +   | 1000i   |  |
| 610 +          | 0i | -3050 -   | 835.16i | -3050 +   | 835.16i |  |
| 620 +          | 0i | -3100 -   | 624.5i  | -3100 +   | 624.5i  |  |
| 630 +          | 0i | -3150 -   | 278.39i | -3150 +   | 278.39i |  |
| 640 +          | 0i | -2710.1 + | 0i      | -3689.9 + | 0i      |  |
| 650 +          | 0i | -2500 +   | 0i      | -4000 +   | 0i      |  |
| 660 +          | 0i | -2356.6 + | 0i      | -4243.4 + | 0i      |  |
| 670 +          | 0i | -2244.3 + | 0i      | -4455.7 + | 0i      |  |
| 680 +          | 0i | -2151 +   | 0i      | -4649 +   | 0i      |  |
| 690 +          | 0i | -2070.7 + | 0i      | -4829.3 + | 0i      |  |
| 700 +          | 0i | -2000 +   | 0i      | -5000 +   | 0i      |  |

## Problem 2.10

The equation that identifies the response parameter,  $s$ , of the parallel circuit shown in Figure P2.10 is

$$S = -\frac{1}{2RC} \pm \sqrt{\left(\frac{1}{2RC}\right)^2 - \frac{1}{LC}}$$

(a) Determine the values of  $s$  for a resistance of 200  $\Omega$ .

```
R=200;  
C=1e-6;  
L=0.64
```

```
L = 0.64
```

```
s_plus=-1/(2*R*C) + sqrt((1/(2*R*C))^2 - 1/(L*C))
```

```
s_plus = -334.94
```

```
s_minus=-1/(2*R*C) - sqrt((1/(2*R*C))^2 - 1/(L*C))
```

```
s_minus = -4665.1
```

**(b)** Create a vector of values for  $R$  ranging from 100 to 1000  $\Omega$  and evaluate  $s$ . Refine your values of  $R$  until you find the size of resistor that yields a pure real value of  $s$ . Describe the effect on  $s$  as  $R$  decreases.

```
R=100:100:1000;
s_plus=-1./(2*R*C) + sqrt((1./(2*R*C)).^2 - 1/(L*C));
s_minus=-1./(2*R*C) - sqrt((1./(2*R*C)).^2 - 1/(L*C));
table_values = [R',s_plus',s_minus']
```

```
table_values =
    100 +      0i   -158.77 +      0i   -9841.2 +      0i
    200 +      0i   -334.94 +      0i   -4665.1 +      0i
    300 +      0i   -564.27 +      0i   -2769.1 +      0i
    400 +      0i   -1250 +      0i   -1250 +      0i
    500 +      0i   -1000 -      750i   -1000 +      750i
    600 +      0i   -833.33 -      931.69i   -833.33 +      931.69i
    700 +      0i   -714.29 -      1025.8i   -714.29 +      1025.8i
    800 +      0i   -625 -      1082.5i   -625 +      1082.5i
    900 +      0i   -555.56 -      1119.8i   -555.56 +      1119.8i
   1000 +      0i   -500 -      1145.6i   -500 +      1145.6i
```

```
% Refine the R values
R=400:10:500;
s_plus=-1./(2*R*C) + sqrt((1./(2*R*C)).^2 - 1/(L*C));
s_minus=-1./(2*R*C) - sqrt((1./(2*R*C)).^2 - 1/(L*C));
table_values = [R',s_plus',s_minus']
```

```
table_values =
    400 +      0i   -1250 +      0i   -1250 +      0i
    410 +      0i   -1219.5 -      274.39i   -1219.5 +      274.39i
    420 +      0i   -1190.5 -      381.14i   -1190.5 +      381.14i
    430 +      0i   -1162.8 -      458.71i   -1162.8 +      458.71i
    440 +      0i   -1136.4 -      520.75i   -1136.4 +      520.75i
    450 +      0i   -1111.1 -      572.65i   -1111.1 +      572.65i
    460 +      0i   -1087 -      617.27i   -1087 +      617.27i
    470 +      0i   -1063.8 -      656.33i   -1063.8 +      656.33i
    480 +      0i   -1041.7 -      690.96i   -1041.7 +      690.96i
    490 +      0i   -1020.4 -      721.99i   -1020.4 +      721.99i
    500 +      0i   -1000 -      750i   -1000 +      750i
```

## Problem 2.11

Burning one gallon of gasoline in your car produces 19.4 pounds of CO<sub>2</sub>. Calculate the amount of CO<sub>2</sub> emitted during a year for the following vehicles, assuming they all travel 12,000 miles per year. The reported fuel-efficiency numbers were extracted from the U.S. Department of Energy website, [www.fueleconomy.gov](http://www.fueleconomy.gov), and reflect the combined city and highway estimates.

```
%Create a matrix of mpg values
mpg=[107, 35, 35, 46, 56, 32];
% Calculate the emissions
Mass_CO2=(12000./mpg*19.4)'
```

```
Mass_CO2 =
    2175.7
    6651.4
    6651.4
    5060.9
    4157.1
```

% Notice that I transposed the result so that it is easier to read

### Problem 2.12

(a) Create an evenly spaced vector of values from 1 to 20 in increments of 1.

```
a=1:20
```

```
a =      1      2      3      4      5      6      7      8      9     10     11     12     13     14     15     16
```

(b) Create a vector of values from zero to  $2\pi$  in increments of  $\pi/10$ .

```
b=0:pi/10:2*pi
```

```
b =      0      0.31416      0.62832      0.94248      1.2566      1.5708      1.885      2.19911
```

(c) Create a vector containing 15 values, evenly spaced between 4 and 20. (Hint: Use the linspace command. If you can't remember the syntax, type `help linspace`.)

```
c=linspace(4,20,15)
```

```
c =      4      5.1429      6.2857      7.4286      8.5714      9.7143     10.857
```

(d) Create a vector containing 10 values, spaced logarithmically between 10 and 1000. (Hint: Use the logspace command.)

```
d=logspace(1,3,4)
```

```
d =      10      46.416      215.44      1000
```

### Problem 2.13

(a) Create a table of conversions from feet to meters. Start the feet column at 0, increment it by 1, and end it at 10 feet. (Look up the conversion factor in a textbook or online.)

```
feet=0:1:10;
meters=feet./3.28;
[feet',meters']
```

```
ans =
      0      0
      1      0.30488
      2      0.60976
      3      0.91463
      4      1.2195
      5      1.5244
      6      1.8293
      7      2.1341
      8      2.439
      9      2.7439
     10      3.0488
```

**(b)** Create a table of conversions from radians to degrees. Start the radians column at 0 and increment by 0.1 $\pi$  radian, up to  $\pi$  radians. (Look up the conversion factor in a textbook or online.)

```
radians=0:0.1*pi:pi;
degrees=radians*180/pi;
[radians',degrees'] % Or we could also give this table a name
```

```
ans =
      0      0
0.31416    18
0.62832    36
0.94248    54
1.2566     72
1.5708     90
1.885     108
2.1991    126
2.5133    144
2.8274    162
3.1416    180
```

```
conversion_table=[radians',degrees']
```

```
conversion_table =
      0      0
0.31416    18
0.62832    36
0.94248    54
1.2566     72
1.5708     90
1.885     108
2.1991    126
2.5133    144
2.8274    162
3.1416    180
```

**(c)** Create a table of conversions from mi/h to ft/s. Start the mi/h column at 0 and end it at 100 mi/h. Print 15 values in your table. (Look up the conversion factor in a textbook or online.)

```
mph=linspace(0,100,15);
ft_per_sec=mph*5280/3600;
vel_conversion=[mph',ft_per_sec']
```

```
vel_conversion =
      0      0
7.1429   10.476
14.286   20.952
21.429   31.429
28.571   41.905
35.714   52.381
42.857   62.857
50       73.333
57.143   83.81
64.286   94.286
71.429  104.76
78.571  115.24
85.714  125.71
92.857  136.19
100     146.67
```

**(d)** The acidity of solutions is generally measured in terms of  $pH$ . The  $pH$  of a solution is defined as  $-\log_{10}$  of the concentration of hydronium ions. Create a table of conversions from concentration of hydronium ion to  $pH$ , spaced logarithmically from .001 to .1 mol/liter with 10 values. Assuming that you have named the concentration of hydronium ions  $H\_conc$ , the syntax for calculating the negative of the logarithm of the concentration (and thus the  $pH$ ) is

**$pH = -\log_{10}(H\_conc)$**

```
%d
H_conc=logspace(-3,-1,10);
pH=-log10(H_conc);
pH_table=[H_conc',pH']
```

```
pH_table =
    0.001          3
    0.0016681      2.7778
    0.0027826      2.5556
    0.0046416      2.3333
    0.0077426      2.1111
    0.012915        1.8889
    0.021544        1.6667
    0.035938        1.4444
    0.059948        1.2222
    0.1             1
```

## Problem 2.14

The general equation for the distance that a freely falling body has traveled (neglecting air friction) is

$$d = \frac{1}{2}gt^2$$

Assume that  $g = 9.8 \text{ m/s}^2$ . Generate a table of time versus distance traveled for values of time from 0 to 100 seconds. Choose a suitable increment for your time vector. (*Hint: Be careful to use the correct operators;  $t^2$  is an array operation!*)

```
g=9.8;
t=0:10:100;
d=1/2*g*t.^2;
table_values=[t',d']
```

```
table_values =
    0          0
   10        490
   20       1960
   30       4410
   40       7840
   50      12250
   60      17640
   70      24010
   80      31360
   90      39690
  100     49000
```

## Problem 2.15

In direct current applications, electrical power is calculated using Joule's law as

$$P = VI$$

where  $P$  is power in watts

$V$  is the potential difference, measured in volts

$I$  is the electrical current, measured in amperes

Joule's law can be combined with Ohm's law

$$V = IR$$

to give

$$P = I^2 R$$

where  $R$  is resistance measured in ohms.

The resistance of a conductor of uniform cross section (a wire or rod for example) is

$$R = \rho \frac{l}{A}$$

where

$\rho$  is the electrical resistivity measured in ohm-meters

$l$  is the length of the wire

$A$  is the cross-sectional area of the wire

This results in the equation for power

$$P = I^2 \rho \frac{l}{A}$$

Electrical resistivity is a material property that has been tabulated for many materials. For example

```
rho = [1.59e-8; 1.68e-8; 2.44e-8; 2.82e-8; 1.0e-7];
```

Calculate the power that is dissipated through a wire with the following dimensions for each of the materials listed.

diameter 0.001 m

length 2.00 m

Assume the wire carries a current of 120 amps.

```
d=0.001; %meters
area = pi*d^2/4;
length = 2; %meters

I=120; %amps
P=I.^2.*rho.*length./area
```

```
P =
    583.04
    616.04
```

894.73  
1034.1  
3666.9

### Problem 2.16

Repeat the previous problem for 10 wire lengths, from 1 m to 1 km. Use logarithmic spacing.

|                                     |        |        |        |        |            |           |            |     |  |
|-------------------------------------|--------|--------|--------|--------|------------|-----------|------------|-----|--|
| length=logspace(1,3,10)             |        |        |        |        |            |           |            |     |  |
| length =                            | 10     | 16.681 | 27.826 | 46.416 | 77.426     | 129.15    | 215.44     |     |  |
| P_silver=I.^2.*rho(1).*length./area |        |        |        |        |            |           |            |     |  |
| P_silver =                          | 2915.2 | 4862.9 | 8111.7 | 13531  | 22571      | 37651     | 62806      |     |  |
| P_copper=I.^2.*rho(2).*length./area |        |        |        |        |            |           |            |     |  |
| P_copper =                          | 3080.2 | 5138.1 | 8570.9 | 14297  | 23849      | 39783     | 66361      |     |  |
| P_gold = I.^2.*rho(3).*length./area |        |        |        |        |            |           |            |     |  |
| P_gold =                            | 4473.7 | 7462.5 | 12448  | 20765  | 34638      | 57779     | 96382      |     |  |
| P_al = I.^2.*rho(4).*length./area   |        |        |        |        |            |           |            |     |  |
| P_al =                              | 5170.4 | 8624.7 | 14387  | 23999  | 40032      | 66778     | 1.1139e+05 | 1.8 |  |
| P_Fe = I.^2.*rho(5).*length./area   |        |        |        |        |            |           |            |     |  |
| P_Fe =                              | 18335  | 30584  | 51017  | 85102  | 1.4196e+05 | 2.368e+05 | 3.9501e+05 | 6.5 |  |

### Problem 2.17

Newton's law of universal gravitation tells us that the force exerted by one particle on another is

$$F = G \frac{m_1 m_2}{r^2}$$

where the universal gravitational constant  $G$  is found experimentally to be

$$G = 6.673 \times 10^{-11} \text{ N m}^2/\text{kg}^2$$

The mass of each particle is  $m_1$  and  $m_2$ , respectively, and  $r$  is the distance between the two particles. Use Newton's law of universal gravitation to find the force exerted by the earth on the moon, assuming that

the mass of the earth is approximately  $6 \times 10^{24}$  kg,

the mass of the moon is approximately  $7.4 \times 10^{22}$  kg, and

the earth and the moon are an average of  $3.9 \times 10^8$  m apart.

```
G=6.673e-11;
m_earth=6e24;
m_moon=7.4e22;
r=3.9e8;
F=G*m_earth*m_moon/r^2
```

```
F = 1.9479e+20
```

### Problem 2.18

We know that the earth and the moon are not always the same distance apart. Based on the equation in the previous problem, find the force the moon exerts on the earth for 10 distances between  $3.8 \times 10^8$  m and  $4.0 \times 10^8$  m. Be careful when you do the division to use the correct operator.

```
r=linspace(3.8e8,4.0e8,10);
F=G*m_earth*m_moon./r.^2; %Notice the .^ and ./ operators
[r',F']
```

```
ans =
    3.8e+08    2.0518e+20
    3.8222e+08    2.028e+20
    3.8444e+08    2.0046e+20
    3.8667e+08    1.9817e+20
    3.8889e+08    1.9591e+20
    3.9111e+08    1.9369e+20
    3.9333e+08    1.9151e+20
    3.9556e+08    1.8936e+20
    3.9778e+08    1.8725e+20
    4e+08    1.8518e+20
```

### Problem 2.19

Recall from Problem 2.7 that the ideal gas law is:

$$PV = nRT$$

and that the Van der Waals modification of the ideal gas law is

$$\left( \left( P + \frac{n^2 a}{V^2} \right) (V - nb) \right) = nRT$$

Using the data from Problem 2.7, find the value of temperature ( $T$ ), for

(a) 10 values of pressure from 0 bar to 400 bar for volume of 1 L

```
%a
P=linspace(0,400,10);
n=2;
V=1;
a=5.536;
b=0.03049;
R=0.08314472;
% Find the temperature using the ideal gas law
T_ideal=P*V/(n*R)
```



|           |   |        |        |        |        |        |        |
|-----------|---|--------|--------|--------|--------|--------|--------|
| T_ideal = | 0 | 267.27 | 534.54 | 801.81 | 1069.1 | 1336.4 | 1603.6 |
|-----------|---|--------|--------|--------|--------|--------|--------|

```
% Find the temperature using Van der Waal's equation
T_VW=(P+n^2*a/V^2)*(V-n*b)/(n*R)
```

|        |        |        |        |        |        |        |        |
|--------|--------|--------|--------|--------|--------|--------|--------|
| T_VW = | 125.04 | 376.02 | 626.99 | 877.97 | 1128.9 | 1379.9 | 1630.9 |
|--------|--------|--------|--------|--------|--------|--------|--------|

```
% It would be easier to compare the calculated values if they are listed in
% a table
[T_ideal',T_VW']
```

```
ans =
      0      125.04
    267.27    376.02
    534.54    626.99
    801.81    877.97
   1069.1    1128.9
   1336.4    1379.9
   1603.6    1630.9
   1870.9    1881.9
   2138.2    2132.8
   2405.4    2383.8
```

**(b) 10 values of volume from 0.1 L to 10 L for a pressure of 220 bar**

```
V=linspace(0.1,10,10);
P=220;
% Find the temperature using the ideal gas law
T_ideal=P*V/(n*R)
```

|           |       |        |        |        |        |        |        |
|-----------|-------|--------|--------|--------|--------|--------|--------|
| T_ideal = | 132.3 | 1587.6 | 3042.9 | 4498.2 | 5953.5 | 7408.8 | 8864.1 |
|-----------|-------|--------|--------|--------|--------|--------|--------|

```
% Find the temperature using Van der Waal's equation
T_VW=(P+n^2*a./V.^2).*(V-n*b)/(n*R)
```

|        |        |        |        |      |      |        |        |
|--------|--------|--------|--------|------|------|--------|--------|
| T_VW = | 571.23 | 1612.2 | 3018.6 | 4456 | 5902 | 7351.6 | 8803.1 |
|--------|--------|--------|--------|------|------|--------|--------|

```
% It would be easier to compare the calculated values if they are listed in
% a table
[T_ideal',T_VW']
```

```
ans =
    132.3    571.23
   1587.6    1612.2
   3042.9    3018.6
   4498.2    4456
   5953.5    5902
   7408.8    7351.6
   8864.1    8803.1
   10319    10256
   11775    11709
   13230    13163
```

**c**

You might interpret this problem to mean that the 10 values of pressure  
and ten values of volume should be used in the same calculation

```
V=linspace(0.1,10,10);
P=linspace(0,400,10);
% Find the temperature using the ideal gas law
T_ideal=P.*V/(n*R)
```

```
T_ideal =          0          320.73          1229.4          2726.2          4810.9          7483.6          10744
```

```
% Find the temperature using Van der Waal's equation
T_VW=(P+n^2*a./V.^2).*(V-n*b)/(n*R)
```

```
T_VW =          519.61          409.76          1253.2          2715.7          4774.9          7425.6          10666
```

```
% It would be easier to compare the calculated values if they are listed in
% a table
[T_ideal',T_VW']
```

```
ans =
          0          519.61
        320.73          409.76
        1229.4          1253.2
        2726.2          2715.7
        4810.9          4774.9
        7483.6          7425.6
        10744          10666
        14593          14496
        19030          18914
        24054          23921
```

## Number Display

### Problem 2.20

Create a matrix `aequal` to  $[-1/3, 0, 1/3, 2/3]$ , and use each of the built-in format options to display the results:

`format short` (which is the default)

`format long`

`format bank`

`format short e`

`format long e`

`format short eng`

`format long eng`

`format short g`

`format long g`

`format +`

## format rat

```
a=[-1/3,0,1/3,2/3] %displays as format short automatically
```

```
a = -0.33333 0 0.33333 0.66667
```

```
format long  
a
```

```
a = -0.3333333333333333 0 0.3333333333333333 0.6666666666666667
```

```
format bank  
a
```

```
a = -0.33 0 0.33 0.67
```

```
format short e  
a
```

```
a = -3.3333e-01 0 3.3333e-01 6.6667e-01
```

```
format long e  
a
```

```
a = -3.333333333333333e-01 0 3.333333333333333e-01 6.666666666666666e-01
```

```
format short eng  
a
```

```
a = -333.3333e-003 0.0000e+000 333.3333e-003 666.6667e-003
```

```
format long eng  
a
```

```
a = -333.3333333333333e-003 0.000000000000000e+000 333.3333333333333e-003 666.6666666666667e-003
```

```
format short g  
a
```

```
a = -0.33333 0 0.33333 0.66667
```

```
format long g  
a
```

```
a = -0.3333333333333333 0 0.3333333333333333 0.6666666666666666
```

```
format +  
a
```

```
a = - ++
```

```
format rat  
a
```

```
a =      -1/3      0      1/3      2/3
```

```
format shortg %This is my favorite  
a
```

```
a =      -0.33333      0      0.33333      0.66667
```

## Saving Your Work in Files

### Problem 2.21

```
D=0:10:180;  
R=D*pi/180;  
D_to_R=[D',R']
```

```
D_to_R =  
      0      0  
    10    0.17453  
    20    0.34907  
    30    0.5236  
    40    0.69813  
    50    0.87266  
    60    1.0472  
    70    1.2217  
    80    1.3963  
    90    1.5708  
   100    1.7453  
   110    1.9199  
   120    2.0944  
   130    2.2689  
   140    2.4435  
   150    2.618  
   160    2.7925  
   170    2.9671  
   180    3.1416
```

```
save degrees.dat -ascii D_to_R  
%Check your current directory to confirm that the file  
%was saved  
clear  
load degrees.dat  
degrees
```

```
degrees =  
      0      0  
    10    0.17453  
    20    0.34907  
    30    0.5236  
    40    0.69813  
    50    0.87266  
    60    1.0472  
    70    1.2217  
    80    1.3963  
    90    1.5708  
   100    1.7453  
   110    1.9199  
   120    2.0944  
   130    2.2689  
   140    2.4435
```

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|     |        |
|-----|--------|
| 150 | 2.618  |
| 160 | 2.7925 |
| 170 | 2.9671 |
| 180 | 3.1416 |

---