MATLAB for Engineers, 6th 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 a program using a script (M-file) or a live script (MLX-file). 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 a program file, divided into sections with section dividers.

```
clear, clc
```

Getting Started

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`

The function `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 = logical
   1
```

```
isvarname book_1
```

```
ans = logical
   1
```

```
isvarname Second_Place
```

```
ans = logical
   1
```

```
isvarname No_1
```

```
ans = logical
   1
```

```
isvarname vel_5
```

```
ans = logical
   1
```

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

```
ans = logical
   1
```

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

```
ans = logical
   0
```

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

```
ans = logical
   0
```

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

```
ans = logical
   0
```

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

```
ans = logical
   0
```

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

```
ans = logical
   0
```

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

```
ans = logical
   0
```

```

which tan  % tan is a function name
```

```
built-in (C:\Program Files\MATLAB\R2022a\toolbox\matlab\elfun\@double\tan)  % double method
```

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

```
built-in (C:\Program Files\MATLAB\R2022a\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\R2022a\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 =        21884
```

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

```
ans =       1.4621
```

Problem 2.4

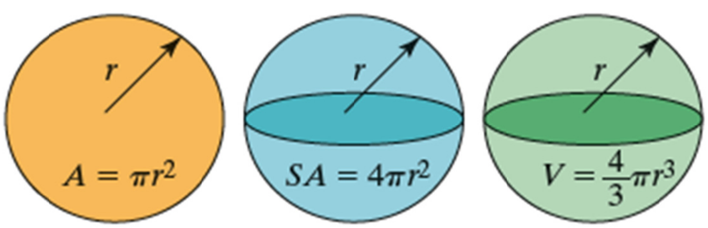


Figure 2.4
(a) Area of a circle, (b) Surface area of a sphere,
(c) Volume of a sphere with radius r.

(a) The area of a circle is πr^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

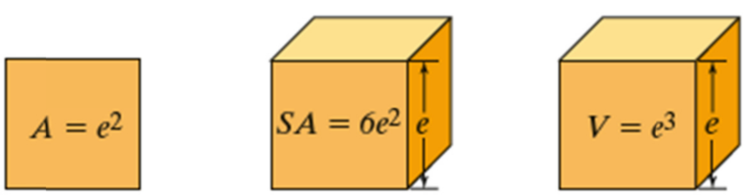


Figure P2.5
(a) Area of a square, (b) Surface area of a cube, (c) Volume of a cube with edge length e.

(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

$(\text{SA} = 6 \times \text{edge}^2)$. 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

Figure P2.6
The geometry of a barbell can be modeled as two spheres and a cylindrical rod.

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
```

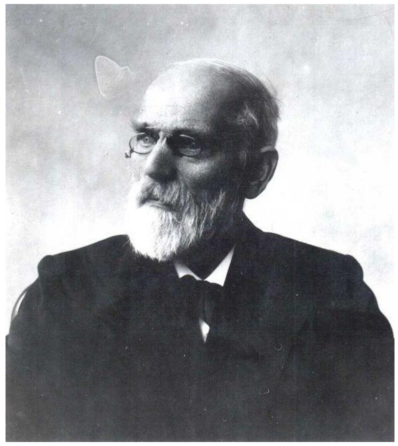
```
total_sa =        2560.4
```

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, (see 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.



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

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;  % Pressure in bars
n=2; % Moles
V=1; % Volume in liters
a=5.536; % constant in L^2 bar/mol^2
b=0.03049; % constant in L/mol
R=0.08314472; % ideal gas constant L bar/(K mole)
```

Find the temperature using the ideal gas law

```
T_ideal=P*V/(n*R)  % kelvins
```

```
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

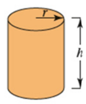


Figure P2.8(a)

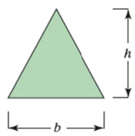


Figure P2.8(b)

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

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 = 1×3
        28.274        141.37        339.29
```

Note that 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 array

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 = 1×3
    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 and is good practice.

```
area=1./2.*b.*h
```

```
area = 1×3
    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

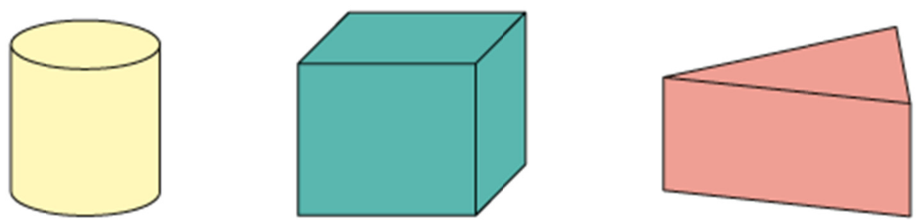


Figure P2.8(c)

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

```
volume = 1×3
    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.

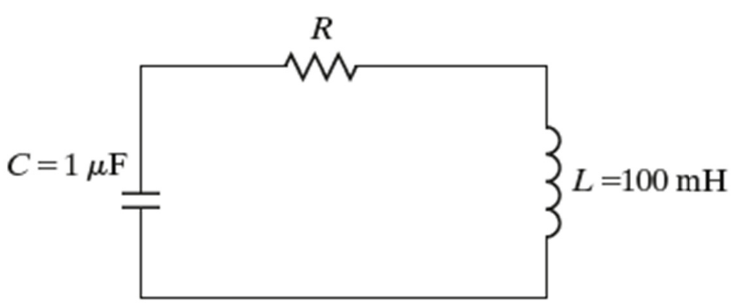


Figure P2.9
Series circuit.

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 Ω.

```
R=800 %ohms
```

```
R =    800
```

```
L=100e-3 %H
```

```
L =          0.1
```

```
C=1e-6 %F
```

```
C =        1e-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 = 1×2
       -1550.5       -6449.5
```

(b) Create a vector of values for *R* ranging from 100 to 1000 Ω 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 μF = 1e-6 F

1 mH = 1e-3 H

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

```
s_plus = 1×10 complex
          -500 +      3122.5i         -1000 +        3000i ⋯
```

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

```
s_minus = 1×10 complex
          -500 -      3122.5i         -1000 -        3000i ⋯
```

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

```
table_values = 10×3 complex
            100 +          0i          -500 -      3122.5i ⋯
            200 +          0i         -1000 -        3000i
            300 +          0i         -1500 -      2783.9i
            400 +          0i         -2000 -      2449.5i
            500 +          0i         -2500 -      1936.5i
```

```
         600 +         0i       -3000 -      1000i
         700 +         0i       -2000 +         0i
         800 +         0i     -1550.5 +         0i
         900 +         0i     -1298.4 +         0i
        1000 +         0i       -1127 +         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 = 1×11 complex
        -3000 +      1000i       -3050 +    835.16i ⋯
```

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

```
s_minus = 1×11 complex
        -3000 -      1000i       -3050 -    835.16i ⋯
```

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

```
table_values = 11×3 complex
         600 +         0i       -3000 -      1000i ⋯
         610 +         0i       -3050 -    835.16i
         620 +         0i       -3100 -     624.5i
         630 +         0i       -3150 -    278.39i
         640 +         0i     -2710.1 +         0i
         650 +         0i       -2500 +         0i
         660 +         0i     -2356.6 +         0i
         670 +         0i     -2244.3 +         0i
         680 +         0i       -2151 +         0i
         690 +         0i     -2070.7 +         0i
    ⋮
```

Problem 2.10

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

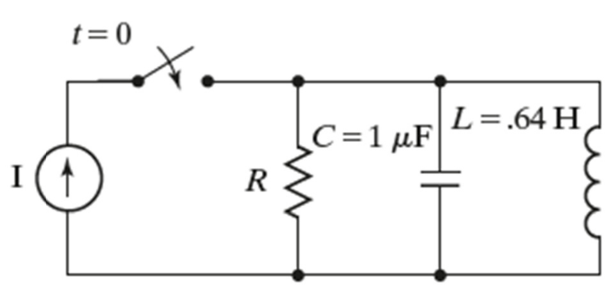


Figure P2.10
Parallel circuit.

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 Ω.

```
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 Ω 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));
results = [R',s_plus',s_minus']
```

```
results = 10×3 complex
         100 +          0i      -158.77 +          0i ⋯
         200 +          0i      -334.94 +          0i
         300 +          0i      -564.27 +          0i
         400 +          0i        -1250 +          0i
         500 +          0i        -1000 -        750i
         600 +          0i      -833.33 -     931.69i
         700 +          0i      -714.29 -     1025.8i
         800 +          0i         -625 -     1082.5i
         900 +          0i      -555.56 -     1119.8i
        1000 +          0i         -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));
results = [R',s_plus',s_minus']
```

```
results = 11×3 complex
         400 +          0i        -1250 +          0i ⋯
         410 +          0i      -1219.5 -     274.39i
```

```
      420 +           0i       -1190.5 -      381.14i
      430 +           0i       -1162.8 -      458.71i
      440 +           0i       -1136.4 -      520.75i
      450 +           0i       -1111.1 -      572.65i
      460 +           0i         -1087 -      617.27i
      470 +           0i       -1063.8 -      656.33i
      480 +           0i       -1041.7 -      690.96i
      490 +           0i       -1020.4 -      721.99i
   ⋮
```

Problem 2.11

Burning one gallon of gasoline in your car produces 19.4 pounds of CO2. Calculate the amount of CO2 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, and reflect the combined city and highway estimates.

Create an array of mpg values

```
mpg=[142, 36, 52, 35, 41,113];
```

Calculate the emissions

```
Mass_CO2=(12000./mpg*19.4)'
```

```
Mass_CO2 = 6×1
        1639.4
        6466.7
        4476.9
        6651.4
          5678
        2060.2
```

Notice that the result was transposed 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 = 1×20
     1     2     3     4     5     6     7     8     9    10    11    12
13 ⋯
```

(b) Create a vector of values from zero to 2π in increments of $\frac{\pi}{10}$.

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

```
b = 1×21
```

```
           0      0.31416      0.62832      0.94248       1.2566
1.5708 ⋯
```

(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 = 1×15
           4       5.1429       6.2857       7.4286       8.5714
9.7143 ⋯
```

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

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

```
d = 1×4
          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 = 11×2
           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
      ⋮
```

(b) Create a table of conversions from radians to degrees. Start the radians column at 0 and increment by 0.1π radians, up to π 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 array a name
```

```
ans = 11×2
           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
      ⋮
```

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

```
conversion_table = 11×2
              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
      ⋮
```

(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 = 15×2
              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
      ⋮
```

(d) The acidity of solutions is generally measured in terms of *p*H. The *p*H of a solution is defined as –log10 of the concentration of hydronium ions. Create a table of conversions from concentration of hydronium ion to *p*H, 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 *p*H) is

`pH = –log10(H_conc)`

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

```
pH_table = 10×2
        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 $\frac{m}{s^2}$. 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;
results=[t',d']
```

```
table_values = 11×2
           0            0
          10          490
          20         1960
          30         4410
          40         7840
          50        12250
          60        17640
          70        24010
          80        31360
          90        39690
    ⋮
```

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

$$P = I^2R$$

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

ρ 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

Material	Resistivity, ohm-meters (measured at 20°C)
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Gold	2.44×10^{-8}
Aluminum	2.82×10^{-8}
Iron	1.0×10^{-7}

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

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; % meters^2
length = 2; % meters

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

```
P = 5×1
        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.

Realizing that 1km is 1000 meters, define a length array

```
length=logspace(1,3,10) % meters
```

```
length = 1×10
           10       16.681       27.826       46.416       77.426
129.15 ⋯
```

```
P_silver=I.^2.*rho(1).*length./area
```

```
P_silver = 1×10
        2915.2       4862.9       8111.7        13531        22571
37651 ⋯
```

```
P_copper=I.^2.*rho(2).*length./area
```

```
P_copper = 1×10
        3080.2       5138.1       8570.9        14297        23849
39783 ⋯
```

```
P_gold = I.^2.*rho(3).*length./area
```

```
P_gold = 1×10
        4473.7       7462.5        12448        20765        34638
57779 ⋯
```

```
P_al = I.^2.*rho(4).*length./area
```

```
P_al = 1×10
```

```
        5170.4         8624.7          14387          23999          40032
  66778 ⋯
```

```
P_Fe = I.^2.*rho(5).*length./area
```

```
P_Fe = 1×10
         18335          30584          51017          85102    1.4196e+05
  2.368e+05 ⋯
```

In chapter 4 we'll learn how to do these calculations in a single step using the `meshgrid` function.

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 = *6.67*3 × 10^{-11} N m2/kg2

The mass of each particle is *m*1and *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 × 10^{24} kg,

the mass of the moon is approximately 7.4 × 10^{22} kg, and

the earth and the moon are an average of 3.9 × 10^{8}m apart.

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

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

Note that the operators *, / and ^ were used because all of the values are scalars. Dot operators could also have been used and would give the same result.

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 × 10^{8} m and 4.0 × 10^{8} m. Be careful when you do the division to use the correct operator.

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

```
ans = 10×2
      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

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

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); % pressure
n=2; % moles
V=1; % volume
a=5.536; % constant
b=0.03049; % constant
R=0.08314472; % ideal gas constant
```

Find the temperature using the ideal gas law

```
T_ideal=P*V/(n*R)
```

```
T_ideal = 1×10
            0       267.27       534.54       801.81       1069.1
1336.4 ⋯
```

Find the temperature using Van der Waal's equation

```
T_VW=(P+n^2*a/V^2)*(V-n*b)/(n*R)
```

```
T_VW = 1×10
        125.04        376.02        626.99        877.97        1128.9
1379.9 ⋯
```

It would be easier to compare the calculated values if they are listed in a table

```
[T_ideal',T_VW']
```

```
ans = 10×2
             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 = 1×10
         132.3        1587.6        3042.9        4498.2        5953.5
7408.8 ⋯
```

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

```
T_VW = 1×10
        571.23        1612.2        3018.6          4456          5902
7351.6 ⋯
```

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

```
ans = 10×2
         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 probem 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 = 1×10
             0        320.73        1229.4        2726.2        4810.9
7483.6 ⋯
```

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

```
T_VW = 1×10
        519.61        409.76        1253.2        2715.7        4774.9
7425.6 ⋯
```

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

```
ans = 10×2
             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 array **a** equal 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 (shortg)

format long g (longg)

format +

format rat

```
a=[-1/3,0,1/3,2/3]  % displays as format shortg automatically since shortg was specified at the beginning of this file
```

```
a = 1×4
     -0.33333             0       0.33333       0.66667
```

```
format long
a
```

```
a = 1×4
  -0.333333333333333                   0   0.333333333333333 ⋯
```

```
format bank
a
```

```
a = 1×4
         -0.33               0           0.33           0.67
```

```
format short e
a
```

```
a = 1×4
  -3.3333e-01            0   3.3333e-01   6.6667e-01
```

```
format long e
a
```

```
a = 1×4
    -3.333333333333333e-01                          0
3.333333333333333e-01 ⋯
```

```
format short eng
a
```

```
a = 1×4
  -333.3333e-003     0.0000e+000    333.3333e-003    666.6667e-003
```

```
format long eng
a
```

```
a = 1×4
   -333.333333333333e-003     0.00000000000000e+000     333.333333333333e-003
...
```

```
format short
a
```

```
a = 1×4
   -0.3333         0    0.3333    0.6667
```

```
format long g
a
```

```
a = 1×4
        -0.333333333333333                         0
0.333333333333333 ⋯
```

```
format +
a
```

```
a = 1×4
-  ++
```

```
format rat
a
```

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

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

```
a = 1×4
     -0.33333            0      0.33333      0.66667
```

Saving Your Work in Files

Problem 2.21

Create an array called D_to_R composed of two columns, one representing degrees, and the other representing the corresponding value in radians. Any value set will do for this exercise.

• Save the array to a file called degrees.dat.

• Once the file is saved, clear your workspace then load the data from the file back into MATLAB.

```
D=0:10:180;
```

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

```
D_to_R = 19×2
            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
```

```
save degrees.dat -ascii D_to_R
```

Check your current directory to confirm that the file was saved

```
clear
load degrees.dat
degrees
```

```
degrees = 19×2
            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
```