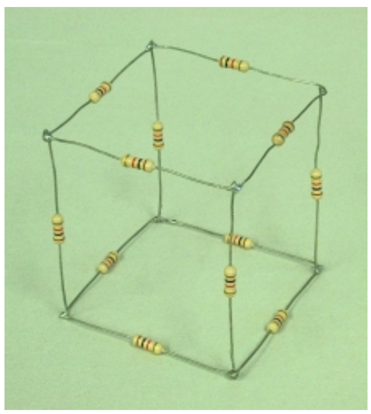
Physics HW 4 Solutions

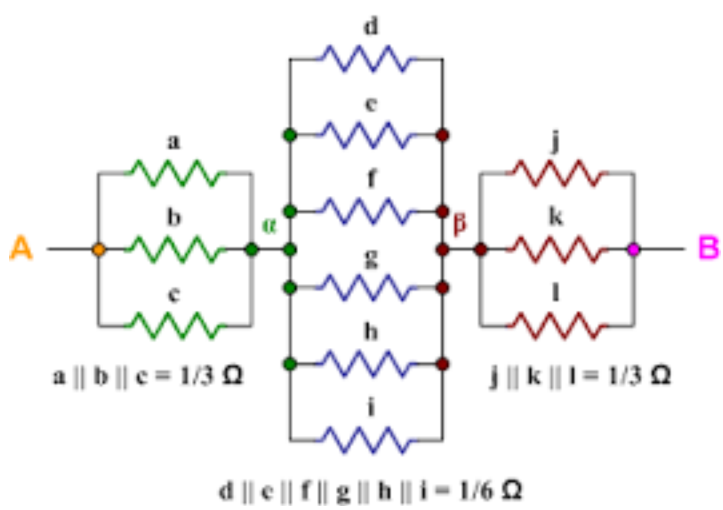
Problem 1:
Write a program to solve for the currents in a resistor cube. There are 12 resistors, one along each edge. A voltage source is connected across a body diagonal of the cube.

- *Find the equivalent resistance for the symmetric case when all the resistors have the same resistance, say 1 Ohm. You might remember this problem from freshman E&M.*
- *Plot the equivalent resistance as a function of one resistor (choose any one) when all 11 others are fixed at 1 Ohm*
- *How many different cases are there when one resistor is varied as in the previous part?*

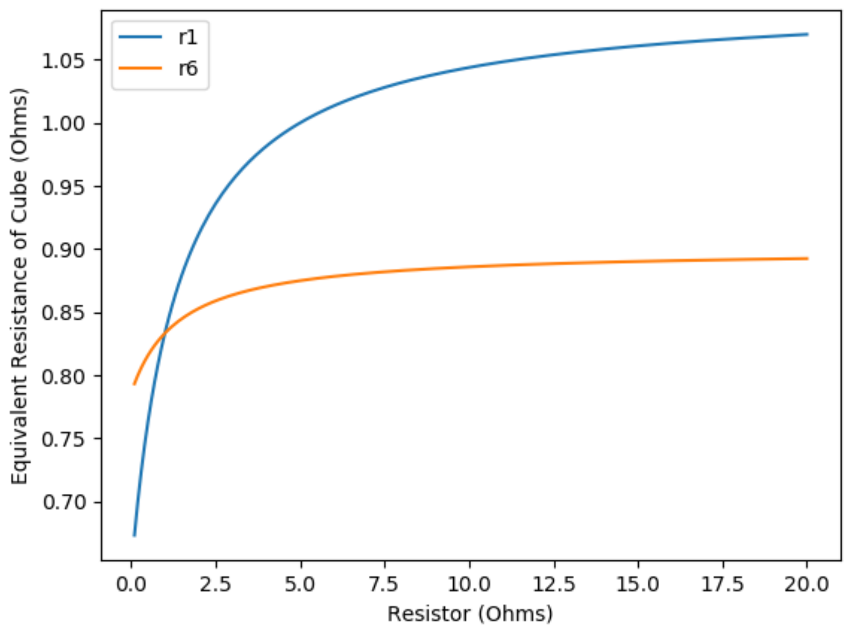
<u>Solution:</u> There are two cases, (a) when you vary a resistor on the edge touching the corner with the voltage applied (call it r1), and (b) when you vary a resistor on an edge that does not touch the corner (call it r6):



This is clear if you look at the equivalent resistor diagram:



So, we vary r1 and r6 in the code and plot:



Problem 2:

Carbon suboxide is five-atom linear molecule. Simulate a C3O2 molecule with a linear system of 5 masses and 4 ideal springs, similar to the linear triatomic molecule. There are two distinct mass values M and m , and two distinct force constants K and k. Search the web for information on the force constants. If you cannot locate data on C3O2 , make a reasonable estimate from data on Molecular Vibrations simpler molecules with similar bonds, for example CO2). Find the eigenfrequencies and normal modes for longitudinal oscillations.

Solution: To avoid huge or tiny numbers, we will work in units where the mass is in atomic mass units (AMU) and the strength is in N/cm. The values are then:
m(oxygen) = 16.
m(carbon) = 12.
k1 = 14.87
k2 = 14.15

In that case, the matrices are:

```
M =
 16.00   0.00   0.00   0.00   0.00
  0.00  12.00   0.00   0.00   0.00
  0.00   0.00  12.00   0.00   0.00
  0.00   0.00   0.00  12.00   0.00
  0.00   0.00   0.00   0.00  16.00

K =
 14.87 -14.87   0.00   0.00   0.00
-14.87  29.02 -14.15   0.00   0.00
  0.00 -14.15  28.30 -14.15   0.00
  0.00   0.00 -14.15  29.02 -14.87
  0.00   0.00   0.00 -14.87  14.87
```

Performing the eigenvalue solution we get:

```
Eigenvalues =
0.3677531941404121,
-8.05768684422316e-17,
1.4638859380195373,
2.9799551391929215,
4.2421557286471305

Eigenvectors =
 -0.16  -0.12   0.12   0.08   0.04
 -0.09  -0.12  -0.07  -0.18  -0.15
 -0.00  -0.12  -0.18  -0.00   0.19
  0.09  -0.12  -0.07   0.18  -0.15
  0.16  -0.12   0.12  -0.08   0.04
```

Problem 3:
Repeat Problem 1 for an octahedron.

Solution: There is only one case that matters here (the others cause no change in the equivalent resistance because they connect points at the same potential):