# Homework 6 (sim11_solving equations)

## 1) Kepler problem

a) The equation cannot be solved analytically for E. Calculate E numerically for M=24 and e=0.1

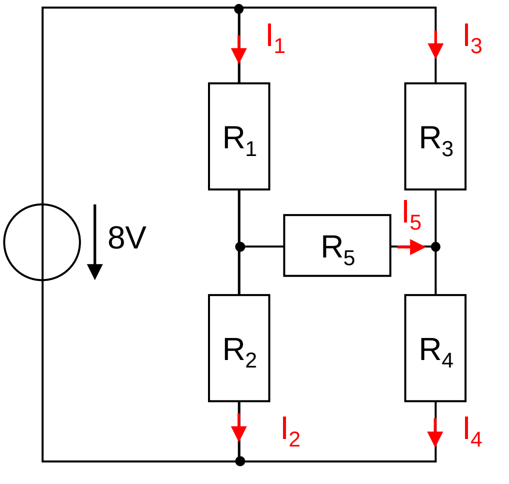
$$M = E - e \sin E$$

b) Compare the result with the following approximation formula

$$E = M + 2\sum_{m=1}^{\infty} \frac{1}{m} J_m(me)\sin(mM)$$

Where Jm(x) is the Bessel function of the first kind of order m. Use besselj(m,x) in Matlab to calculate E. How many summands m are necessary to get the result of a) to 4 decimal places?

## 2) electric network




a) Set up three mesh and two node equations and solve the system of equations for the currents $I_1$ - $I_5$ .

b) Replace the resistor $R_5$ by a diode with the characteristic curve

$I(U) = I_s \cdot (\exp(U/U_t) - 1)$

and calculate the currents $I_1$ - $I_5$.

$I_s$=1pA, $U_t$=25mV

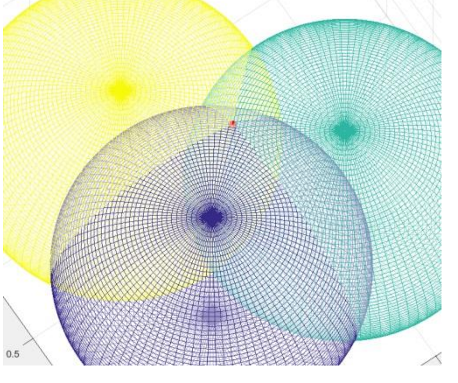
$R_1=1\Omega$, $R_2=2\Omega$, $R_3=3\Omega$, $R_4=4\Omega$, $R_5=5\Omega$

solution

a) $I_1$ - $I_5$ = 2.7355 2.6323 1.0839 1.1871 0.1032

b) $I_1$ - $I_5$ = 2.7063 2.6468 1.1089 1.1684 0.0595

## 3) point of intersection



Find the intersection points of three spheres with radius r=1 and the three center points

(0,0,0), (1,0,0), (0,1,0)

Check your result graphically using *sphere*() and *mesh(…,'FaceAlpha',0.5)* .

# Optional

## 4) Terminal velocity

A simple force balance on a spherical particle reaching terminal velocity in a fluid is given by

$$v_t = \sqrt{\frac{4g(\rho_p - \rho_f)D}{3C_D \cdot \rho_f}}$$

Where $v_t$ is the terminal velocity in m/s, g is the acceleration of gravity given by g=9,80665 m/s$^2$ ,$\rho_p$ is the particle density in kg/m$^3$, $\rho_f$ is the fluid density in kg/m$^3$, D is the diameter of the spherical particle in m and $C_D$ is a dimensionless drag coefficient. The drag coefficient on a spherical particle at terminal velocity varies with the Reynolds number Re as follows

$$C_D = \frac{24}{\mathrm{Re}} \qquad \text{for} \qquad \mathrm{Re} < 0,1$$

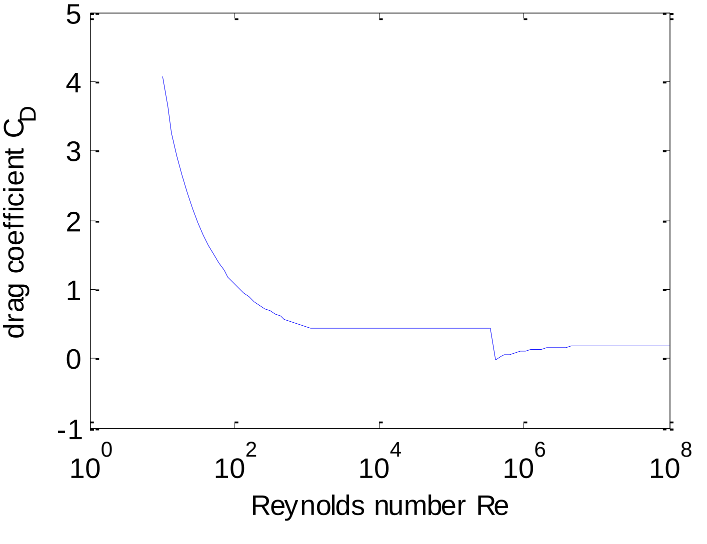
$$C_D = \frac{24}{\mathrm{Re}}(1 + 0,14\mathrm{Re}^{0,7}) \qquad \text{for} \quad 0,1 < \mathrm{Re} < 1000$$

$$C_D = 0,44 \qquad \text{for } 1000 < \mathrm{Re} < 350000$$

$$C_D = 0,19 - \frac{8 \cdot 10^4}{\mathrm{Re}} \qquad \text{for} \qquad \mathrm{Re} > 350000$$

where Re = $D \cdot v_t \cdot \rho_f / \mu$ and $\mu$ is the viscosity in Pa·s

a) Write a a matlab function cdrag(Re) and plot it with respect to Reynolds number Re.




b) Calculate the terminal velocity for particles of coal with density $\rho$=1800 kg/m$^3$ and diameter $D_p$=0.208mm falling in water at T=298.15K where $\rho$=994.6 kg/m$^3$ and viscosity $\mu$=8.931·10$^{-4}$ Pa·s

solution: v = 15.8 mm/s