Programming Language: MatLab

1st Semester 2015

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W15, 23rd Dec

Content

- Format and requirements for the final report
- Topic for final report
- A review of Euler method
- Runge–Kutta method
- Comparison of Euler method and Runge-Kutta method

Format and requirements for the final report

What should be included in your final project?

- Title, Name & student ID, Group number, Date (1^{st} page)
- Abstract (2^{nd} page)
- Background
- Method/Algorithm
- Result(s)
- Conclusion

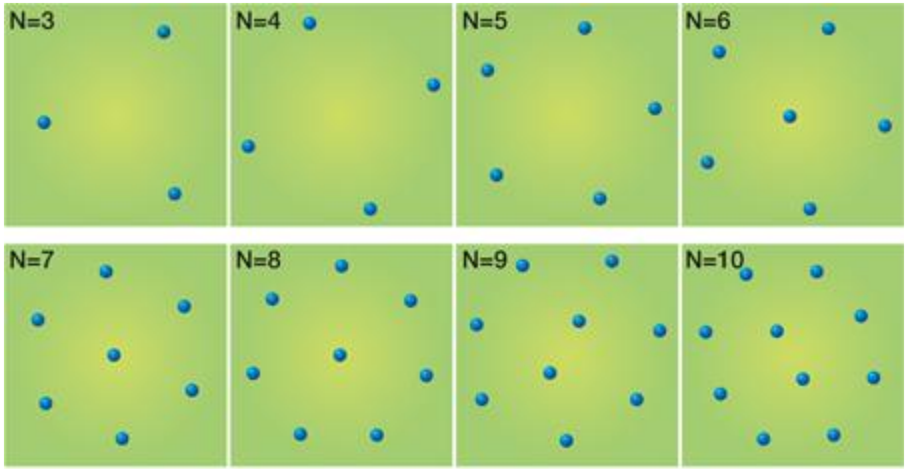
Format and requirements for the final report

Requirements:

- Select a topic you are interested, or you can prepare a topic you want
- Please submit your file before 23:59, 10th Jan
- Practice your presentation in advance
- Do not exceed 6 min (over 7 min you will have a penalty in your score)
- Each member is required to present at least 2 min
- Each group share one file

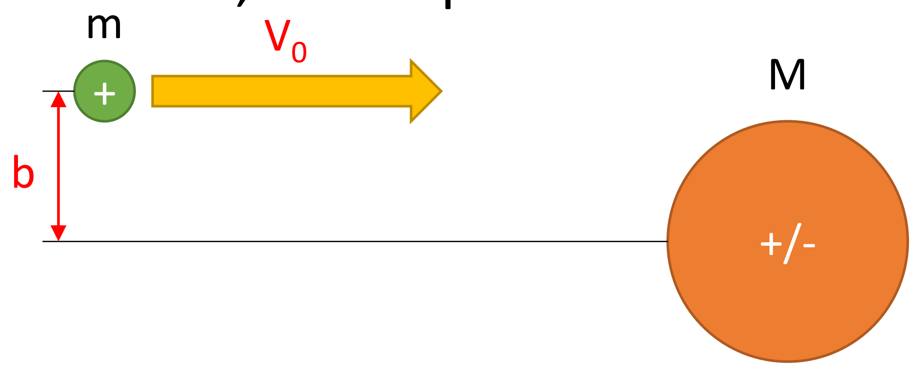
Topic 1

- Consider N (2~40) charged particles are confined in a 2D parabolic potential
- The 2D potential is given as: $U(X,Y) = k(X^2+Y^2)$
- Capture the picture of their equilibrium positions
- Hints: Wigner crystal



Topic 2

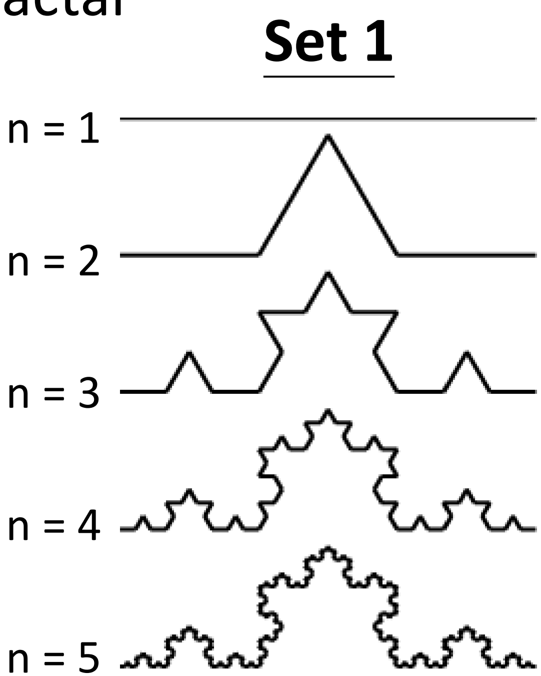
- Consider there are two charged particle with mass “m” and “M”, respectively.
- m has a initial speed V0 move along X direction (as the figure below), and M >> m, the displacement of M is negligible

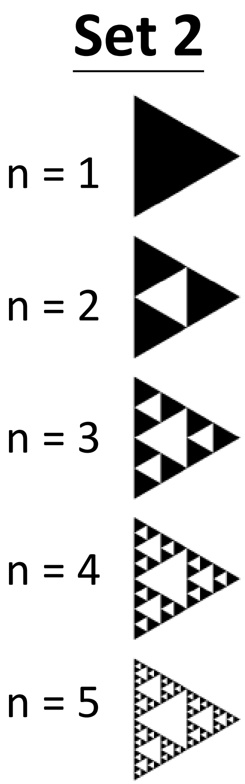


- There is another factor b (impact parameter), which describe the initial y position
- Try to find out the characteristics of different b and V_0 for M with positive and negative charge.
- Hint: Scattering

Topic 3

- Consider a ultra fine geometric sets (fractal) as below:
- Plotting the sets to for n = 1~10
- Try to calculate the length of set 1 vs n, and area of set 2 vs n
- Hint: Fractal



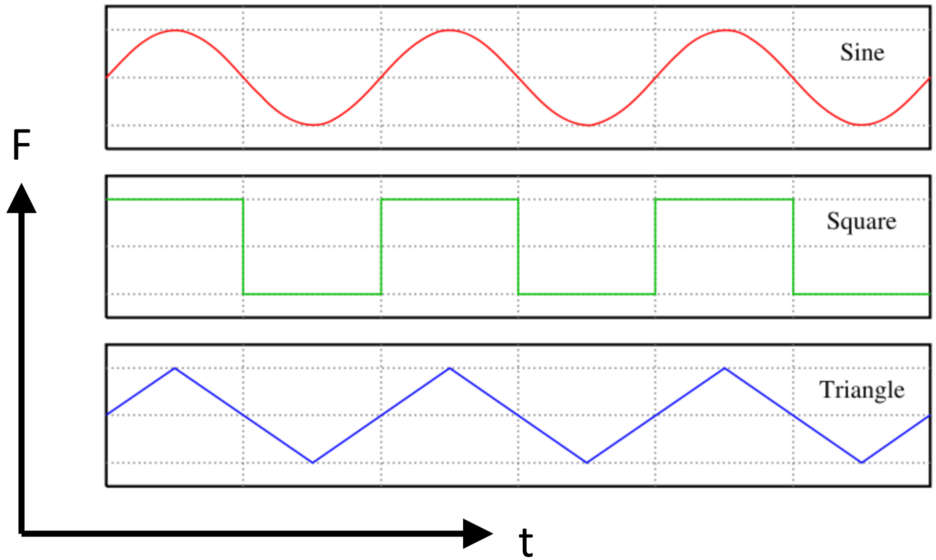


Topic 4

- Try to simulate the motion of **Solar System** (8 Planets) by using gravitation force
- Find out the data (Mass, speed, phase, and position)
- Plotting their trajectories and prepare a movie

Topic 5

- Forced oscillator
- Try to simulate the motion of a damped (under damp) oscillator with external forces with different frequency and wave forms
  i) sine
  ii) square
  iii) triangular



Topic 6

- If you throw 15 dices, the possible point are ranged from 15 to 90
- Try to compute the relative probability (number of configuration) of each point
  $P_{15}:P_{16}:P_{17}: \dots :P_{90,}$
- Plotting the histogram
- Hint : $P_{15}:P_{16} = 1:6$

Topic 7 and X

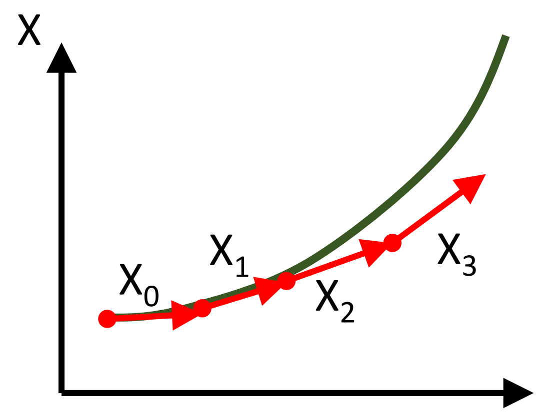
- Using your creativity to prepare a GUI App/game

- Open for any interesting topic you want

A review of Euler method

For a equation of motion:

$$\dot{X} = f(X;t)$$



Euler method

$$X_{n+1} = X_n + f(X;t)\Delta t$$

Algorithm:

$$X_1 = X_0 + f(X_0;t)\Delta t$$

$$X_2 = X_1 + f(X_1;t)\Delta t$$

$$X_3 = X_2 + f(X_2;t)\Delta t$$

$$\vdots$$

Runge–Kutta method

For a equation of motion:

$$\dot{X} = f(X;t)$$

Runge-Kutta method (RK4):

$$X_{n+1} = X_n + \frac{\Delta t}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

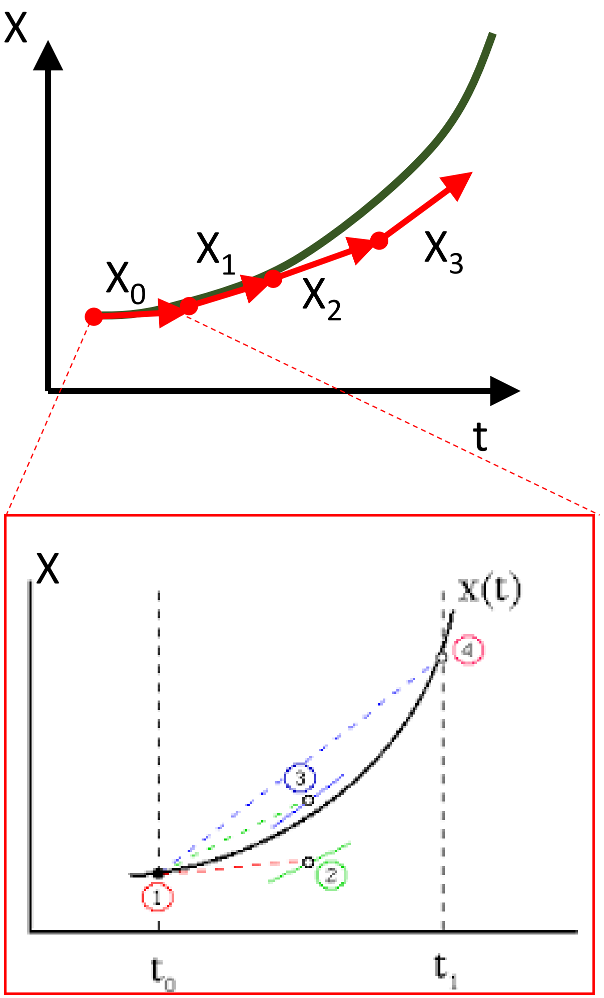
where

$$k_1 = f(X_n;t)$$

$$k_2 = f(X_n + \frac{\Delta t}{2}k_1;t + \frac{\Delta t}{2})$$

$$k_3 = f(X_n + \frac{\Delta t}{2}k_2;t + \frac{\Delta t}{2})$$

$$k_4 = f(X_n + k_3\Delta t;t + \Delta t)$$



Comparison

Example: Simple Harmonic Oscillator $\begin{cases} \dot{X} = V \\ \dot{V} = -(k/m)X = -cX \end{cases}$

Euler method:

$X(i+1) = X(i) + V(i)*\Delta t$

$V(i+1) = V(i) - c*X(i) *\Delta t$

Runge-Kutta method (RK4):

$K_{x1} = V(i)$

$K_{v1} = -c*X(i)$

$K_{x2} = X(i) + K_{x1} *\Delta t/2$

$K_{v2} = V(i) + K_{v1} *\Delta t/2$

$K_{x3} = X(i) + K_{x2} *\Delta t/2$

$K_{v3} = V(i) + K_{v2} *\Delta t/2$

$K_{x4} = X(i) + K_{x3} *\Delta t$

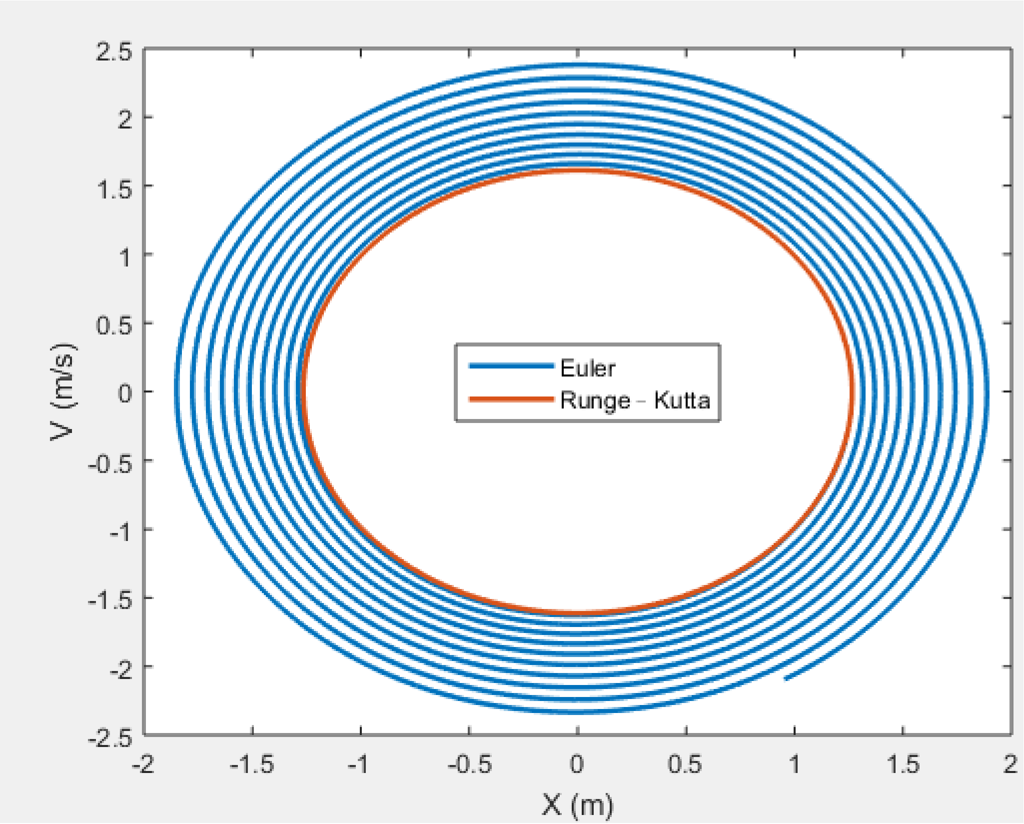
$K_{v4} = V(i) + K_{v3} *\Delta t$

$X(i+1) = X(i) + (K_{x1} +2 K_{x2} + 2K_{x3} + K_{x4})*\Delta t/6$

$V(i+1) = V(i) + (K_{v1} +2 K_{v2} + 2K_{v3} + K_{v4})*\Delta t/6$

Comparison

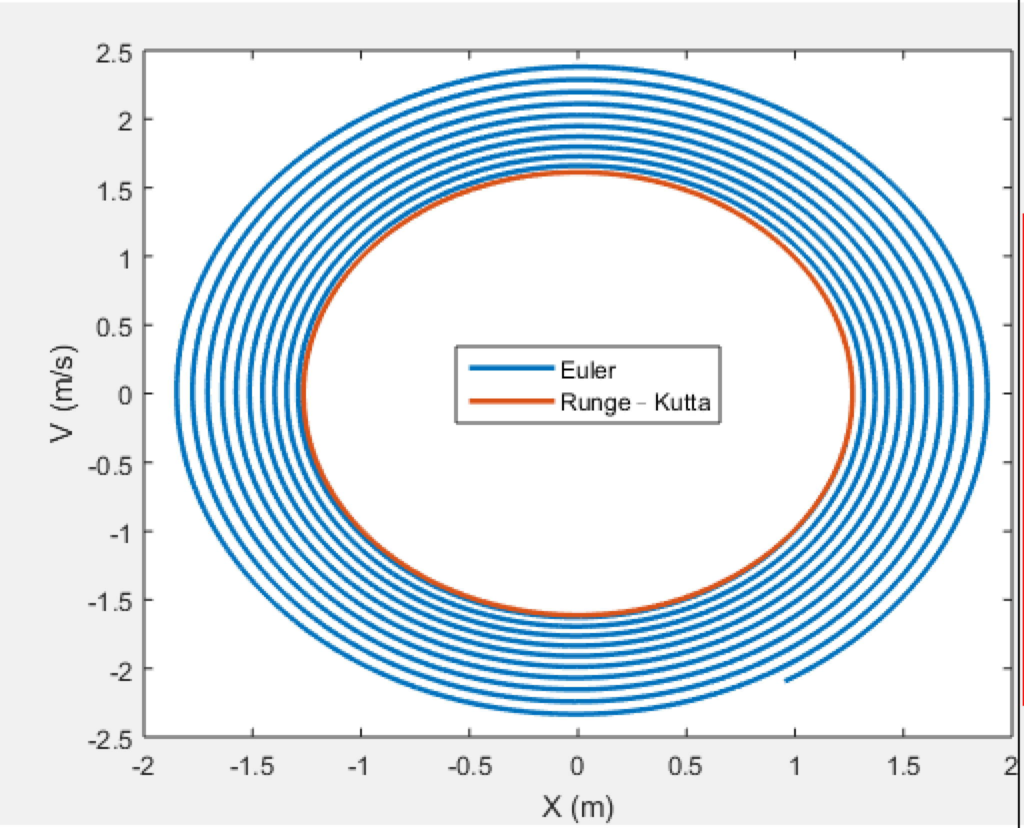
Example: Simple Harmonic Oscillator
$$\begin{cases} \dot{X} = V \\ \dot{V} = -(k/m)X = -cX \end{cases}$$




```
M = 2.0;
K = 3.25;
Dur = 50.0;
dt = 0.01;
dt_RK = dt*4;  % 4X time step for RK4

N_step = ceil(Dur/dt);
N_step_RK = ceil(Dur/dt_RK);

X_E = zeros(N_step,1);
V_E = zeros(N_step,1);
X_RK = zeros(N_step_RK,1);
V_RK = zeros(N_step_RK,1);
KX = zeros(4,1);
KV = zeros(4,1);

X_E(1) = 1.25;
V_E(1) = -0.25;
X_RK(1) = 1.25;
V_RK(1) = -0.25;
```

Comparison

Example: Simple Harmonic Oscillator $\begin{cases} \dot{X} = V \\ \dot{V} = -(k/m)X = -cX \end{cases}$




```
for i = 2:N_step          % Euler method
    V_E(i)  = V_E(i-1) - dt*K*X_E(i-1)/M;
    X_E(i)  = X_E(i-1) + dt*V_E(i-1);
    t(i)  = (i-1)*dt;
end

for i = 2:N_step_RK                    % RK4
      KX(1)  = V_RK(i-1);
      KV(1)  = -K/M*X_RK(i-1);
    for j = 2:3
      KX(j)  = V_RK(i-1)  + KV(j-1)*dt_RK/2;
      KV(j)  = -K/M*(X_RK(i-1)+KX(j-1)*dt_RK/2)
    end
      KX(4)  = V_RK(i-1)  + KV(3)*dt_RK;
      KV(4)  = -K/M*(X_RK(i-1)+KX(3)*dt_RK);

    X_RK(i)  = X_RK(i-1)  +
dt_RK*(KX(1)+2*KX(2)+2*KX(3)+KX(4))/6;

    V_RK(i)  = V_RK(i-1)  +
dt_RK*(KV(1)+2*KV(2)+2*KV(3)+KV(4))/6;
end
```