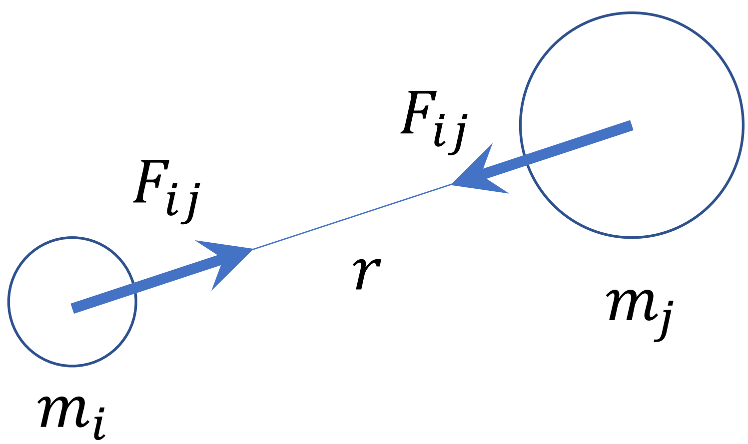
N-Body Problem Specifications

You are to develop code that will simulate the behavior of a system of n bodies interacting with one another through gravitation. Newton's law states that given two bodies with masses m_i and $m_j$respectively, the force exerted on each is inversely proportional to the square of their distance i.e. $F_{ij} = G\frac{m_i m_j}{r^2}$ as indicated in the figure below.



The gravitational constant $G = 6.67408 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$.
From kinematics, an object whose position at time t is $\vec{\boldsymbol{s}}$ and whose velocity is $\vec{\boldsymbol{v}}$ and acceleration is $\vec{\boldsymbol{\gamma}}$, after a short period of time Δt, will move to position $\vec{\boldsymbol{s}}_{\boldsymbol{\Delta t}} = \vec{\boldsymbol{s}} + \vec{\boldsymbol{v}}\Delta t + \frac{1}{2}\vec{\boldsymbol{\gamma}}(\Delta t)^2$ assuming that during the interval Δt the velocity and acceleration are constant. This is a reasonable approximation when Δt is small.
A body of mass m on which a force $\vec{\boldsymbol{F}}$ is applied, exhibits acceleration $\vec{\boldsymbol{\gamma}} = \frac{\vec{\boldsymbol{F}}}{m}$.
Your code should be able to read in the initial positions, masses and velocities of the bodies to be simulated, carry out the simulation over a length of time, and output the positions, masses and velocities of the bodies at the end of the simulation and at set intervals in-between. Optionally, the positions, masses and velocities of a limited number of bodies may be outputted on a more frequent basis to study their trajectories in detail.
The bodies are arranged in a Cartesian-coordinate space. The unites used in the calculations are in standard units i.e. the mass is expressed in kg, the position in m, the velocity in m/s, acceleration in m/s^2, and time in seconds s.
Since masses and distances are very large, you are advised to use double-precision floating point arithmetic (i.e. 64-bit) for your data and calculations.
The bodies are considered points in space, i.e. they have mass but their volume is zero.
To simplify the calculations, we consider that the bodies do not collide nor merge.
Finally, to avoid singularities, we assume that gravitation ceases to manifest itself when the objects are very close, less than 1000m. If there are no forces exerted on an object, the object continues to move due to its momentum, but it does not accelerate.

Since we considered point masses, we allow two objects to occupy the same point in space. This assumption, together with the no collision nor merging clause, further simplifies the code. For accuracy in your simulations, it is suggested that your time step (Δt) be less than 0.1 s.
Your code will be evaluated on how quickly and how accurately it simulates a particular set of objects.
It is expected that initially your code will be serial, but as we progress studying parallel techniques, you will be able to parallelize your code to gain performance and of course experience in developing a parallel application.
Simulation scenarios will be published on the course's website.
The initial scenario involves a set of 27 objects of a proto-planetary cloud. The central object at the origin of the coordinate system, has a mass that is several orders of magnitude larger than the rest, and represents a central star.
The initial positions, masses and velocities of a test scenario are presented below. Each record corresponds to a single object and it is comprised of the following entries:
$x\ y\ z\ mass\ v_x\ v_y\ v_z$ White space separates the entries themselves, and a new line separates the objects.

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NUMBER OF BODIES 27 INDEX OF CENTER BODY 14
-1.000000E+11 -1.000000E+11 -1.000000E+11 8.401877E+27 -0.000000E+00 2.830992E+03 -0.000000E+00
-1.000000E+11 -1.000000E+11 0.000000E+00 9.116473E+27 -0.000000E+00 -1.647772E+03 -0.000000E+00
-1.000000E+11 -1.000000E+11 1.000000E+11 2.777747E+27 0.000000E+00 -2.260294E+02 -0.000000E+00
-1.000000E+11 0.000000E+00 -1.000000E+11 3.647845E+27 0.000000E+00 4.522297E+03 -0.000000E+00
-1.000000E+11 0.000000E+00 0.000000E+00 6.357117E+27 0.000000E+00 -3.583974E+03 -0.000000E+00
-1.000000E+11 0.000000E+00 1.000000E+11 1.630057E+26 -0.000000E+00 -3.627684E+03 -0.000000E+00
-1.000000E+11 1.000000E+11 -1.000000E+11 1.566791E+27 -0.000000E+00 -3.702096E+03 -0.000000E+00
-1.000000E+11 1.000000E+11 0.000000E+00 9.989244E+27 -0.000000E+00 1.293242E+02 -0.000000E+00
-1.000000E+11 1.000000E+11 1.000000E+11 6.126398E+27 -0.000000E+00 1.375523E+03 -0.000000E+00
0.000000E+00 -1.000000E+11 -1.000000E+11 4.935830E+27 0.000000E+00 -2.074832E+03 -0.000000E+00
0.000000E+00 -1.000000E+11 0.000000E+00 5.267449E+27 0.000000E+00 -9.977138E+02 -0.000000E+00
0.000000E+00 -1.000000E+11 1.000000E+11 2.833147E+27 -0.000000E+00 3.077245E+03 -0.000000E+00
0.000000E+00 0.000000E+00 -1.000000E+11 6.975528E+26 0.000000E+00 2.599537E+02 -0.000000E+00
0.000000E+00 0.000000E+00 0.000000E+00 1.370000E+30 0.000000E+00 3.902326E+03 -0.000000E+00
0.000000E+00 0.000000E+00 1.000000E+11 6.417132E+26 -0.000000E+00 -4.229826E+02 -0.000000E+00
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0.000000E+00 1.000000E+11 1.000000E+11 5.125354E+27 0.000000E+00 3.160644E+02 -0.000000E+00
1.000000E+11 -1.000000E+11 -1.000000E+11 4.376376E+27 0.000000E+00 4.308098E+03 -0.000000E+00
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1.000000E+11 1.000000E+11 1.000000E+11 1.476600E+27 0.000000E+00 1.410806E+03 -0.000000E+00
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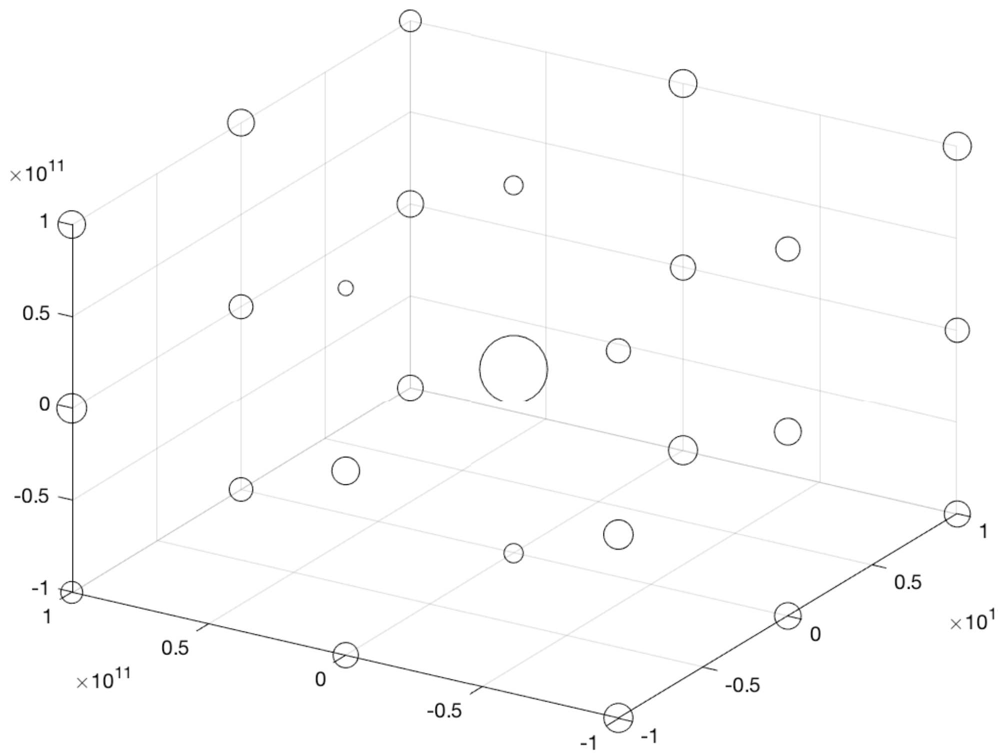
A depiction of the arrangement of these objects in space is presented below


×10^11
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0
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×10^11