Battlestar Buzzy

Battlestar Buzzy has just finished defending GaTech from the evil space bulldogs. It was a fierce battle and only **seven** yellow jackets are still operational and need to dock as soon as possible. The yellow jackets are all damaged, flying blind, and having propulsion issues. Your mission is to develop a distributed **MPI** program that will be able to guide the yellow jackets safely back to Buzzy so that they can dock.

The following rules must be followed:

1) Create a PBS script file to allocate 4 nodes with 2 processors per node. Call the output file **out.dat**.

2) The main process (rank=0) reads in the following from an input file (all values are in MKS units).
   a. The name of the input file is **in.dat** and is in the same folder as the executable.
   b. The first line contains the length of time in seconds that the yellow jackets have to dock before Buzzy must jump to ludicrous speed.
   c. The second line contains the maximum thrust (F_{max}) in Newtons that each thruster can provide.
   d. The third line contains the x y z location, initial speed and the initial normalized direction vector of Battlestar Buzzy. The speed and direction of Buzzy will remain constant while the yellow jackets are docking.
   e. The next seven lines contain the same information for each of the yellow jackets.

3) The kinematics of each yellow jacket must be controlled by a different process, other than the main process. The main process calculates the new location for Buzzy every second and is used to gather and broadcast the location of Buzzy and the seven yellow jackets. Each yellow jacket is assume to have a mass of 10,000 kg.
   a. The yellow jackets have three thrusters. One for each direction (xyz), that can be used to change its direction by applying a one second burst of constant thrust from $–F_{max}$ to $+F_{max}$. The thrust force (F) can be changed every one second as needed. The thrusters are independent of each other and can be fired at the same time if needed with different thrust force values.

b. There is an issue with the propulsion system and the thrusters are randomly misfiring. Each time you use a thruster, the value you use needs to be multiplied by a random number between 0.8 to 1.2 to simulate the misfiring.

c. Use Newton's 2nd Law to determine the acceleration of the yellow jacket in each direction.

$$F_{x,y,z} = m * a_{x,y,z}$$

d. Use the equations of motion for constant acceleration in each direction (xyz) to determine the location and velocity of the yellow jacket every second.

$$x = x_o + v_{xo}t + \frac{1}{2}a_x t^2$$
$$v_x = v_{xo} + a_x * t$$

4) Each second the yellow jackets must report their current status, xyz location and their next F_x, F_y, F_z values to Buzzy in the main process.

5) Each second Buzzy in the main process broadcasts the status and location of itself and all seven yellow jackets, so that the yellow jackets are aware of the status and location of everyone. Battlestar Buzzy should always have a status of 1.

6) The yellow jackets must stay at least **250m** away from other "**active**" yellow jackets. If they come closer than 250m, it is considered a collision and both yellow jackets are considered destroyed. In this case, the processes for the two yellow jackets change their status to destroyed and their position stays constant at the point of destruction. Destroyed or docked yellow jackets are not a consideration for collision avoidance.

7) A yellow jacket will automatically dock with Buzzy once its distance is less than **50m** and the following two conditions are meet:

a. It must be flying in the same direction ($cos\theta > 0.8$) as Buzzy. You can calculate this value using the dot product between the velocity vector for Buzzy and the velocity vector of the yellow jacket.

$$cos\theta = \frac{\vec{v}_{Buzzy} \cdot \vec{v}_{Yello\ Jacket}}{|\vec{v}_{Buzzy}||\vec{v}_{Yello\ Jacket}|}$$

b. $\left|\vec{v}_{Yello\ Jacket}\right| < 1.1 \cdot |\vec{v}_{Buzzy}|$

8) If a yellow jacket comes within 50m of Buzzy and it does not meet conditions 7a and 7b then it is consider to have crashed into Buzzy and has been destroyed. In this case, the process for the yellow jacket changes its status to **destroyed** and the position stays constant at the point of destruction. If a yellow jacket has successfully docked then its status is updated to **docked** and its location is the same as the last broadcast Battlestar Buzzy location.

9) The program ends when one of the following occurs:
   a. The allowed time to dock has expired,
   b. All yellow jackets have either been destroyed or successfully docked with Buzzy.

10) While the program is running, the main process (rank=0) should output the status and location of each yellow jacket every second to the console. The output must be in the comma delimited format shown below:

    rankID, status, x, y, z, F_x, F_y, F_z

    RankID and status should be output as integers and x, y, z, F_x, F_y, F_z should be output using scientific notation with **6 decimal points** of precision. For example:

    1, 1, 2.345643e4, 8.765456e2, 5.879478e4, 1.001231e2, 2.456793e1, 4.003234e2

A yellow jacket can have one of three status values: **Active = 1, Docked = 2, Destroyed = 0**.