DEPARTMENT OF PHYSICS & ASTRONOMY
3459 EXAM-2
10:00 - 13:00 : December 4th 2008

Please read the exam guidelines, rules, instructions and marking criteria at
`http://moodle.ucl.ac.uk/mod/wiki/view.php?id=13963&page=Final+exam`
(linked from the *Exams and Coursework* page).

This exam is worth 50% of your final mark for the course. The duration of the exam is 3 hours. Students should upload the Java source code files for their solution using Moodle under the section headed "Exam 2".

Part 1: 20/50 marks

Write a program using appropriate classes and methods to do the following:

- Simulate a particle that makes a small random movement (in three dimensions) in each time-step. The distance moved each time should be constant, and the direction should be chosen at random.
- Generate 100 such particles, starting each at the origin, and track each for 1000 time steps.
- Write the final position of each particle to a file called `position.txt` (in the R: drive) with each line containing in order the x, y and z coordinates of the particle, separated by spaces.

You may choose suitable values for any parameters required. You may find the results quoted below (under *Spherical Polar Coordinates*) useful.

Part 2: 20/50 marks

A similar program has been run on a number of different types of particles, with the results being available at
`http://www.hep.ucl.ac.uk/undergrad/3459/exam-data/type-position.txt`
Each line contains the type of particle (a string) followed by the x, y and z coordinates (in mm) of the particle's position after 100 seconds.

Calculate the *diffusion coefficient* D for each type of particle, defined as

$$D = R_{\mathrm{RMS}}/t$$

where t is the elapsed time and R_{RMS} is the RMS (root-mean-square) displacement of the particles from the origin.

Determine which type of particle has the largest diffusion coefficient, and print the result to the screen.

Part 3: 10/50 marks

Modify your code so that it uses suitable interfaces that could:

- simulate different types of particles that move in a different way, e.g. moving a random distance in each time step or following some non-random equation of motion;
- use a different definition of the diffusion coefficient, e.g. using the mean displacement instead of the RMS.

Note that you do *not* need to provide specific implementations of alternative particle types or definitions.

Uploading your work

If you use your own classes from earlier modules, make sure you upload them as well as any new classes you create during the exam. You do not need to upload the file `position.txt`.

Spherical polar coordinates

The following results may be useful:

- For a direction defined in spherical polar coordinates (θ, ϕ) you can find the corresponding Cartesian unit direction vector (x, y, z) using the following equations:

$$\begin{aligned} x &= \sin\theta\cos\phi \\ y &= \sin\theta\sin\phi \\ z &= \cos\theta \end{aligned}$$

- To pick a random direction that is uniformly distributed in solid angle, the azimuthal angle ϕ should be uniformly distributed between $-\pi$ and $+\pi$, and $\cos\theta$ should be uniformly distributed between -1 and $+1$.

END OF PAPER