# **DEPARTMENT OF PHYSICS & ASTRONOMY**

3459 EXAM-2

10:00 - 13:00 : December 4<sup>th</sup> 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

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

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.

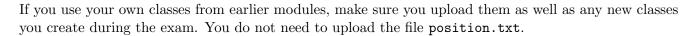
#### Part 3: 10/50 marks

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



## Spherical polar coordinates

The following results may be useful:

• For a direction defined in spherical polar coordinates  $(\theta, \phi)$  you can find the corresponding Cartesian unit direction vector (x, y, z) using the following equations:

$$x = \sin \theta \cos \phi$$
$$y = \sin \theta \sin \phi$$
$$z = \cos \theta$$

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

# END OF PAPER