Penalty!

The origin of this project is the need to estimate expected detector count rates. Assume a radioactive source emitting radiation of some kind (particles or gamma rays) isotropically, i.e. with no preferred direction. Assume further a detector with given dimensions placed in some distance from the source. We would be interested in knowing what fraction of the emitted radiation would impinge on the detector surface.

This problem can be transferred into the world of macroscopic objects. As an example, we chose a football pitch:

What is the probability that you score a goal when you shoot a football from the penalty spot, but in completely random directions (including e.g. straight up)?

Write a code that performs a Monte Carlo simulation of a (high) number of penalties and determine the fraction of kicks where the ball ends up in the goal. Make reasonable assumptions (shooting e.g. straight down is not a good idea). Find relevant information and give references!

For a start, you may assume that the ball has a diameter of zero (point mass) and that if will move on a straight line after the kick. (This would correspond to the emission from the radioactive source mentioned above.)

Obviously we assume that there is no goalkeeper.

Describe in your report your strategy to evaluate if your result is reasonable.

Additional work might include (some of) the following aspects:
- The ball has a finite diameter and so have the goalposts. A collision between the ball and the post can result in that the ball bounces into the goal or back in the pitch.
- There is gravity.
- There is a drag force.
- How large would the influence of a goalkeeper be, if he or she moves randomly to any position in front of the goal?
- What is the probability for scoring an own goal?

If you use any literature, don't forget to give references. If you include figures you did not create yourself, make sure that you have the permission to do so.

The grading will be based on the quality of the code (minimum requirement is that it produces a reasonable result) and the report (minimum requirement is a discussion of the methods used to get the results and the sanity checks).