Introduction to Scientific Computing Example

Approximating the Area of a Circle

In this example, you will estimate the area of a circle by considering a square grid of elements that are slowly refined. This idea is similar in concept to the idea of numerical integration and will test your knowledge of for and while loops and conditionals. This problem also emphasises the idea of divide-and-conquer, where you will have to take this problem and split it down into a number of logical steps.

For these exercises, you may find it easier to code a different program for each of the problems (particularly the final problem).

1. Consider a square area with the side length $a = 10cm$. Create a square grid of $N \times N$ elements covering the area of interest - Figure 1. Organise a loop checking whether the centre of each element, (x_c, y_c), is inside or outside the circle with the radius $R < a/2$. Use the following criterion:

$$x_c^2 + y_c^2 \leq R^2 \tag{1}$$

   Calculate the total area of all the elements attributed to the circle and the error against the theoretical analytical solution.

   User inputs: N, a, R.

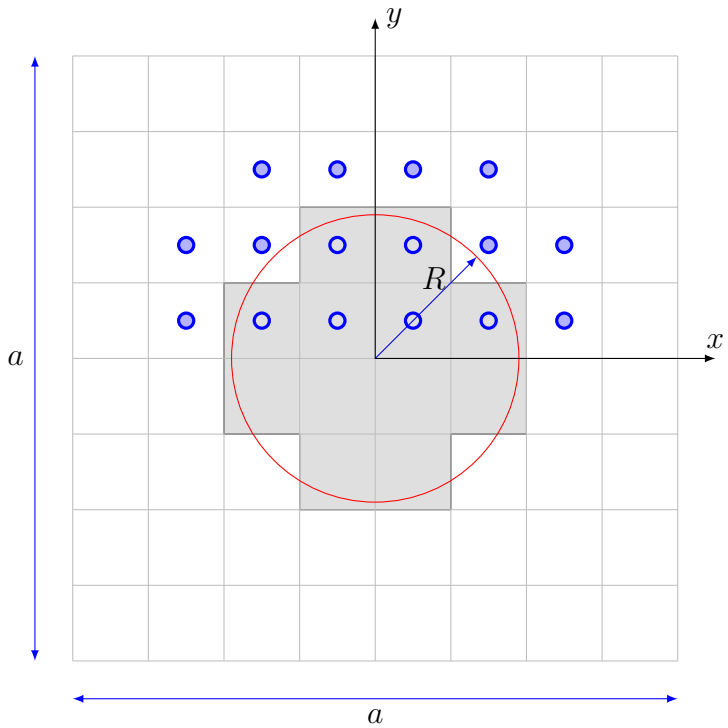
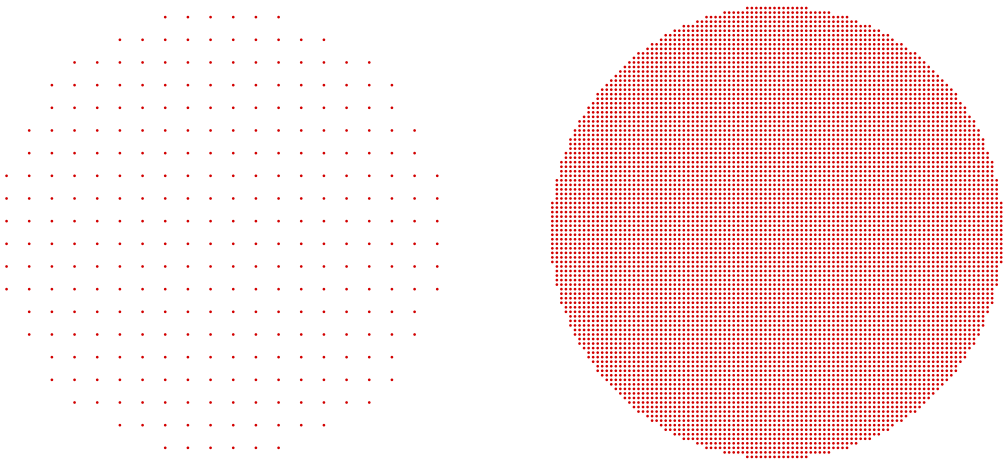


Figure 1: Problem schematic

2. Export the coordinates of the element centres to a Tecplot formatted file and plot these centres. Examples of the type of plots are shown below.



(a) Coarse (b) Fine

Figure 2: Element centres

3. In an iterative procedure identify the minimum number of elements required for the numerical estimation of the area to be within a user-specified percentage of the analytical solution (e.g. within 1%).