The Monte Carlo method is a technique that can be used to approximate the distribution of random outcomes. This is done by recording the outcomes of running the same simulation multiple times. In this way, the method resembles repeated playing the same gambling game at a casino.

The Monte Carlo method is very useful, especially to approximate solutions to problems that are analytically difficult. In this assignment, we will use the Monte Carlo method in a simple scenario, to numerically estimate the area of a shape.

Consider a circle with radius 1, centered on $(0, 0)$.
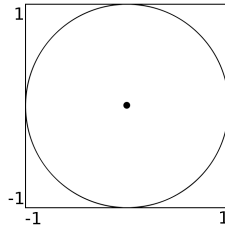
By generating N random points uniformly on the the circumscribing square and counting how many points n that fall within the circle, we can estimate the area of the circle by multiplying the area of the square by the fraction of points inside the circle

$$A_{\text{circle}} \approx A_{\text{square}} \cdot \frac{n}{N}, \tag{5.5}$$

where in this case $A_{\text{square}} = 4$. To test if a point (x, y) is inside the circle, we can simply check if it magnitude of the vector from the center of the circle to (x, y) is less than one.

■ Problem definition

Write a function that estimates the area of a circle by Monte Carlo simulation. As input the function must receive two vectors containing the coordinates of the randomly drawn points. The function must return the estimated value of the area as output.

To test your function, you can use the function implemented in exercise 5C to generate a vector for the random x-values and a vector for the random y-values.

■ Solution template

```
function A = circleAreaMC(xvals, yvals)
```

Input	
xvals	The x-coordinates of points (vector of decimal numbers)
yvals	The y-coordinates of points (vector of decimal numbers)

Output	
A	Estimated value for the area of the circle (scalar decimal number)

■ Example

If we have randomly have drawn the following $N = 5$ points

$$(-0.1, 0.3) \, , \, (0.7, -0.1) \, , \, (0.8, 0.9) \, , \, (0.5, 0.6) \, , \, (-0.4, -0.3) \tag{5.6}$$

four of the points lies within the circle, and the area would be estimated as $A \approx 4 \cdot \frac{4}{5} = 3.2$.

■ Test

You can test your solution by running the following test script and checking that the output is as expected.

Test script	Expected output
```circleAreaMC([-0.1, 0.7, 0.8, 0.5, -0.4], [0.3, -0.1, 0.9, 0.6, -0.3])```	```ans = 3.2000```

■ Hand in on CodeJudge

The assignment must be handed in on CodeJudge.

■ Discussion and futher analysis

- Try calling your function for different number of points (like 10, 1 000, and 1 000 000).

- Try calling your function multiple times with the same number of points.

- Try running the following code to plot an image of a circle along with your points.

```
p = 0:0.01:2*pi;
plot(sin(p), cos(p));
axis equal; hold on;
plot(xvals, yvals, 'o');
```