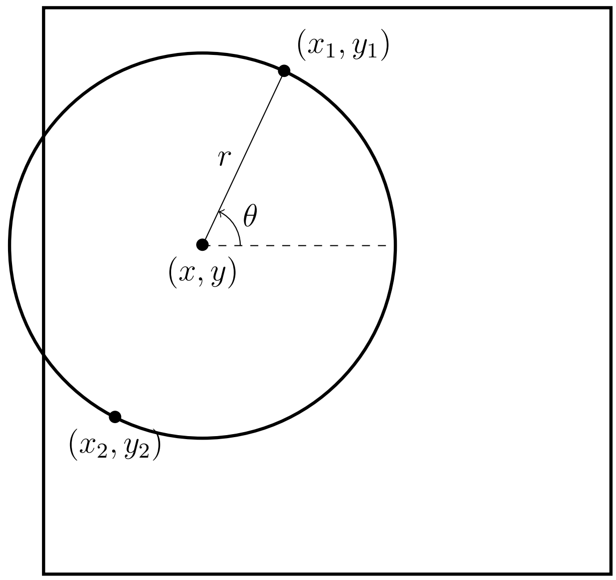
Here is the link to the problem : Some Off Square

Formulation: Use (x_1,y_1) and (x_2,y_2) to represent the randomly sampled points. (x,y) is the midpoint i.e. the center of the circle. And let r and θ mean the radius of circle and angle of elevation of the line joining the points.



Let us calculate the probability using (x,y,r,θ) .
The transformation of variables from (x_1,y_1,x_2,y_2) to (x,y,r,θ) can be as:

$$x_1 = x + rcos\theta \text{ , } y_1 = y + rsin\theta$$
$$x_2 = x \text{ - } rcos\theta \text{ , } y_2 = y \text{ - } rsin\theta$$

The joint cumulative distributive function of (x_1,y_1) and (x_2,y_2) is 1 as they are uniform random variables.
Let us calculate the jacobian $J(x, y, r, \theta)$ to use change of variables:

$$J(x,y,r,\theta) = \begin{vmatrix} \frac{\partial x_1}{\partial x} & \frac{\partial x_1}{\partial y} & \frac{\partial x_1}{\partial r} & \frac{\partial x_1}{\partial \theta} \\ \frac{\partial y_1}{\partial x} & \frac{\partial y_1}{\partial y} & \frac{\partial y_1}{\partial r} & \frac{\partial y_1}{\partial \theta} \\ \frac{\partial x_2}{\partial x} & \frac{\partial x_2}{\partial y} & \frac{\partial x_2}{\partial r} & \frac{\partial x_2}{\partial \theta} \\ \frac{\partial y_2}{\partial x} & \frac{\partial y_2}{\partial y} & \frac{\partial y_2}{\partial r} & \frac{\partial y_2}{\partial \theta} \end{vmatrix} = \begin{vmatrix} 1 & 0 & cos\theta & -rsin\theta \\ 0 & 1 & sin\theta & rcos\theta \\ 1 & 0 & -cos\theta & rsin\theta \\ 1 & 0 & -sin\theta & -rcos\theta \end{vmatrix} = 4r$$

In general, $2r$ cos$\theta \leq 1$ and $2r$ sin$\theta \leq 1$ as the two sampled points lay in the square.
For the center's coordinates, r cos$\theta \leq x \leq 1$ - r cosθ and similarly, r sin$\theta \leq y \leq 1$ - r sinθ due to the same reason.

If the circle fits inside the square, r has to be less than 1/2.
At the same time, x and y both must lie between 1 - r and r respectively.

The limits in the integral below follow from these inequalities.

Let us denote the probability of the circle being enclosed by the square as follows:

$$Prob. = \frac{\int_0^{\pi/2}\int_0^{1/2}\int_r^{1-r}\int_r^{1-r}|J(x,y,r,\theta)|.1dxdydrd\theta}{\int_0^{\pi/2}\int_0^{min(1/2cos\theta,1/2sin\theta)}\int_{rsin\theta}^{1-rsin\theta}\int_{rcos\theta}^{1-rcos\theta}|J(x,y,r,\theta)|.1dxdydrd\theta}$$

$$= \frac{\int_0^{\pi/4}\int_0^{1/2}\int_r^{1-r}\int_r^{1-r}4rdxdydrd\theta}{\int_0^{\pi/4}\int_0^{1/2cos\theta}\int_{rsin\theta}^{1-rsin\theta}\int_{rcos\theta}^{1-rcos\theta}4rdxdydrd\theta + \int_{\pi/4}^{\pi/2}\int_0^{1/2sin\theta)}\int_{rsin\theta}^{1-rsin\theta}\int_{rcos\theta}^{1-rcos\theta}4rdxdydrd\theta}$$

$$= \frac{\int_0^{\pi/4}\int_0^{1/2}4r(1-2r)^2drd\theta}{\int_0^{\pi/4}\int_0^{1/2cos\theta}4r(1-2rcos\theta)(1-2rsin\theta)drd\theta + \int_{pi/4}^{\pi/2}\int_0^{1/2sin\theta}4r(1-2rcos\theta)(1-2rsin\theta)drd\theta}$$

$$= \pi/6$$

The probability that a circle has a part off the square is 1 - $\pi/6$