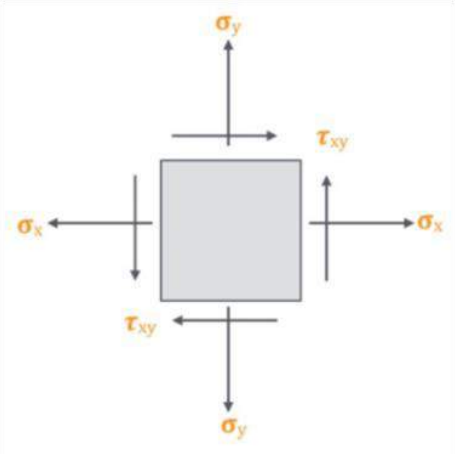
Mohr’s Circle

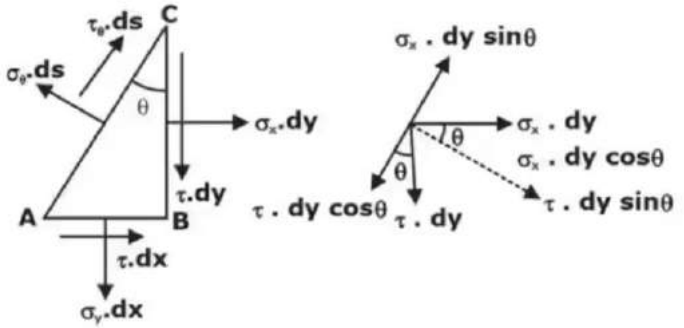
A combination of Shear stress and Normal stress act at different planes in a stressed body. Normal stress is represented by shear stress is represented by τ. Mohr's circle is essential for the GATE exam. Various concepts related to this are helpful in scoring high on the exam. Check out the diagram shown below:



According to Moment equilibrium in a stressed body $\tau_{xy}=\tau_{yx}$

Mohr’s Circle Equation

And according to Force equilibrium, stresses on opposite planes are equal and opposite in direction. Hence, Shear stress will be equal on two mutually perpendicular planes.



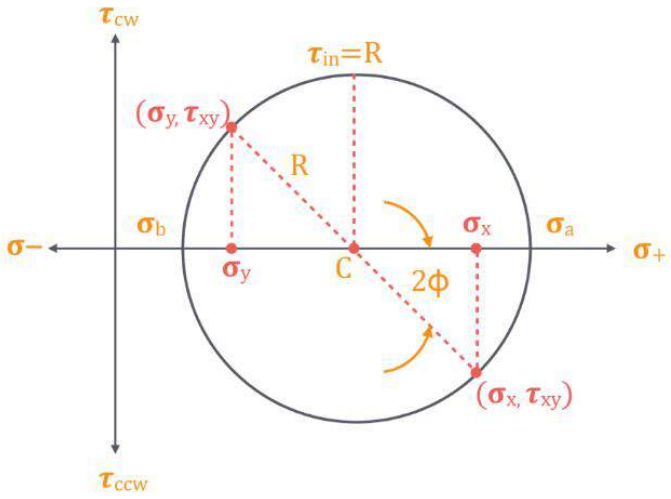
$$\text{Normal Stress at any angle } \Theta\ (\sigma_\theta) = \frac{(\sigma_x+\sigma_y)}{2} + \frac{(\sigma_x-\sigma_y)}{2} cos2\theta + \tau\, sin2\theta$$

$$\text{Shear Stress at any angle } \Theta\ (\tau_\theta) = -\frac{(\sigma_x-\sigma_y)}{2} sin\ 2\theta + \tau\, cos\ 2\theta$$

Mohr’s Circle Diagram

Variations of Normal stress and Shear stress value concerning angle Θ represent a form of a circle, which is known as Mohr’s Circle. Mohr’s circle is the circle in which each point represents a plane in a stressed body in which the x-coordinate of the

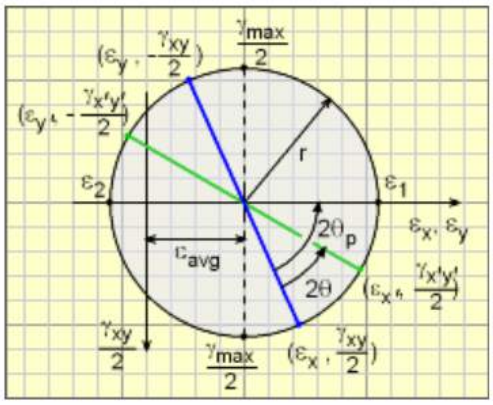
point represents the Normal stress, and the y-coordinate represents the Shear stress acting on the plane. Mohr's Circle diagram can be used for creating various questions in the GATE question paper, and the use of this has been seen over the years.



Mohr's Circle Diagram For Plane Strain System

Mohr's Circle can also be used for finding the Normal strain and Shear strain for a plane strain system. For finding strain with the help of Mohr's Circle, it can be used similar to that of Mohr's Circle for stress. In the case of Mohr's Circle, the strain maximum ordinate on the shear strain axis is $\gamma_{max}/2$, while the maximum ordinate of Mohr's Circle for stress is τ_{max}.

Mohr's Circle diagram for the strain is given below.



Mohr's Circle of Stress

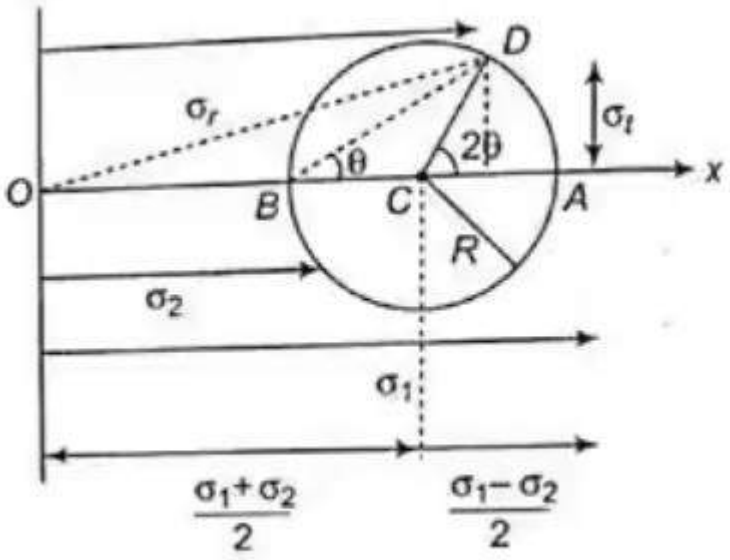
To find out Normal stress and Shear stress on a plane with the help of Mohr's Circle method few terms are used. These terms are as follows.

Principal Stress: Principal stress is the maximum or minimum normal stress acting on the plane at which shear stress is zero. Maximum normal stress is known as the major principal stress, and minimum normal stress is known as the minor principal stress, which is represented as σ_1 and σ_2, respectively.

Maximum Shear Stress: Maximum shear stress is the maximum shear stress acting on the plane in the overall 2-D stressed body. It is represented by τ_{max} and is equal to Mohr's Circle's radius. On the plane of maximum shear stress, normal stress is not zero.

Representation of Stress in Mohr's Circle For Plane Stress and Strain

Mohr's circle is the representation of stress in the 2-D plane. The relationship between plane stress and strain is shown here. Mohr's circle represents normal stress and shear stress on any plane of a stressed body. In Mohr's Circle, Normal Stress is represented on the x-axis, and Shear Stress is represented on the y-axis.



Mohr's circle for plane stress and strain

Some Important Facts about Mohr's Circle

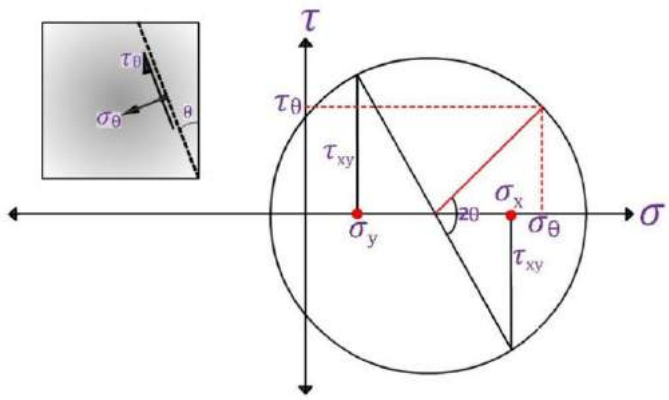
Mohr's Circle is a very important tool for finding the stress or strain on any plane for a stressed body. Mohr's Circle is a graphical method for finding stress. Candidates can check the GATE previous question papers and understand the trend of the questions asked from Mohr's circle in the exam. Mohr's circle helps to visualize the normal stress and shear stress acting on the plane and helps to determine principal stress and maximum shear stresses along with their planes.

Major and Minor principal stress $(\sigma_1, \sigma_2) = \frac{(\sigma_x+\sigma_y)}{2} \pm \sqrt{\left(\frac{(\sigma_x-\sigma_y)}{2}\right)^2 + (\tau_{xy})^2}$

Radius of Mohr's Circle = $\sqrt{\left(\frac{(\sigma_x-\sigma_y)}{2}\right)^2 + (\tau_{xy})^2} = \frac{\sigma_1-\sigma_2}{2}$

- Maximum Shear stress (τ_{max})=(σ_1-σ_2)/2
- Coordinate of Mohr's Circle is denoted by σ_x, τ_{xy}
- Center of Mohr's Circle (C)=((σ_1+σ_2)/2, 0)
- σ_x+σ_y=σ_1+σ_2
- The angle between the maximum shear and principal stress planes is 45^0.
- Normal stress on the maximum shear stress plane is (σ_1+σ_2)/2.

These points related to Mohr's Circle can be explained with the help of a diagram as follows.



Mohr's Circle For 3D Stress Body

Mohr's Circle is a graphical method for finding stress on any plane of the stressed body. Mohr's Circle can also be used for the 3D representation of stress. In the case of the three-dimensional stress system, there are three principal stresses which are represented as σ_1, σ_2 and σ_3, respectively. And maximum shear stress is the maximum of τ_{max1}, τ_{max2} and τ_{max3}.