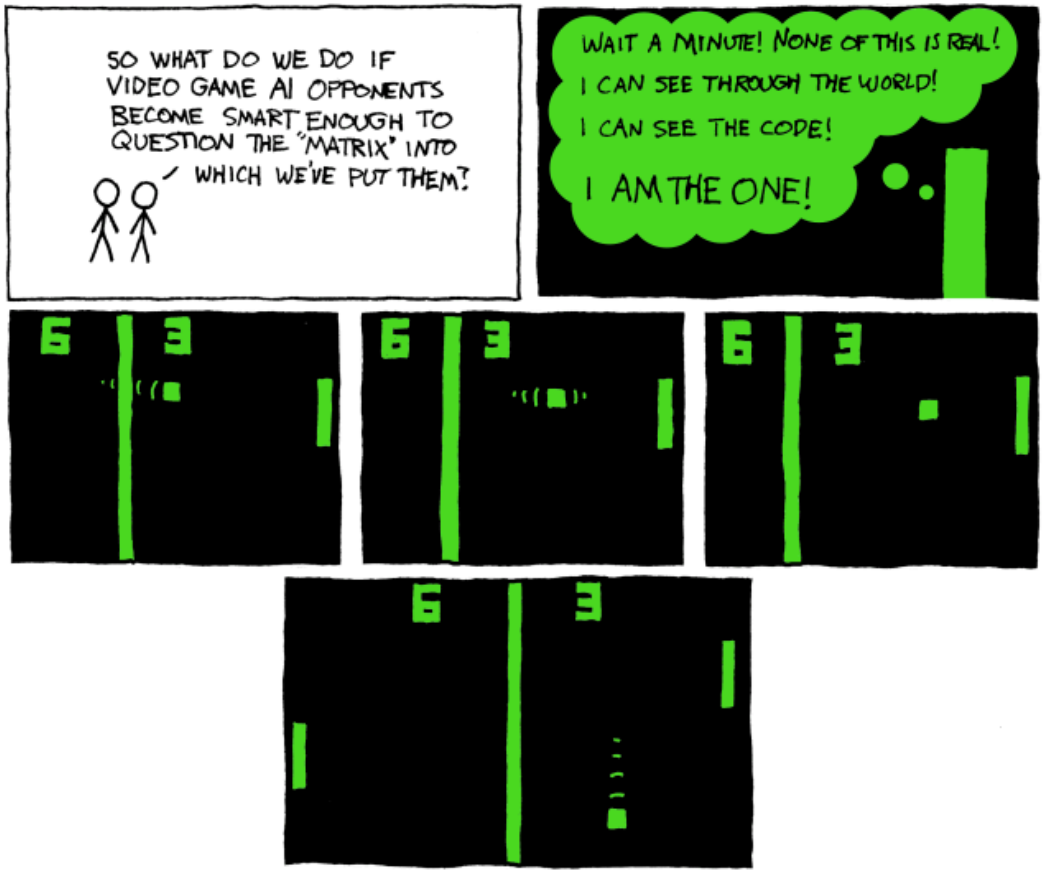
Mechanics of Materials
CIVL 3322 / MECH 3322
Shear Strain



THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

- Axial strain is the ratio of the deformation of a body along the loading axis to the original un-deformed length of the body
- The units of axial strain are length per length and are usually given without dimensions

THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

- Shear strain is defined as angular change at some point in a shape

THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

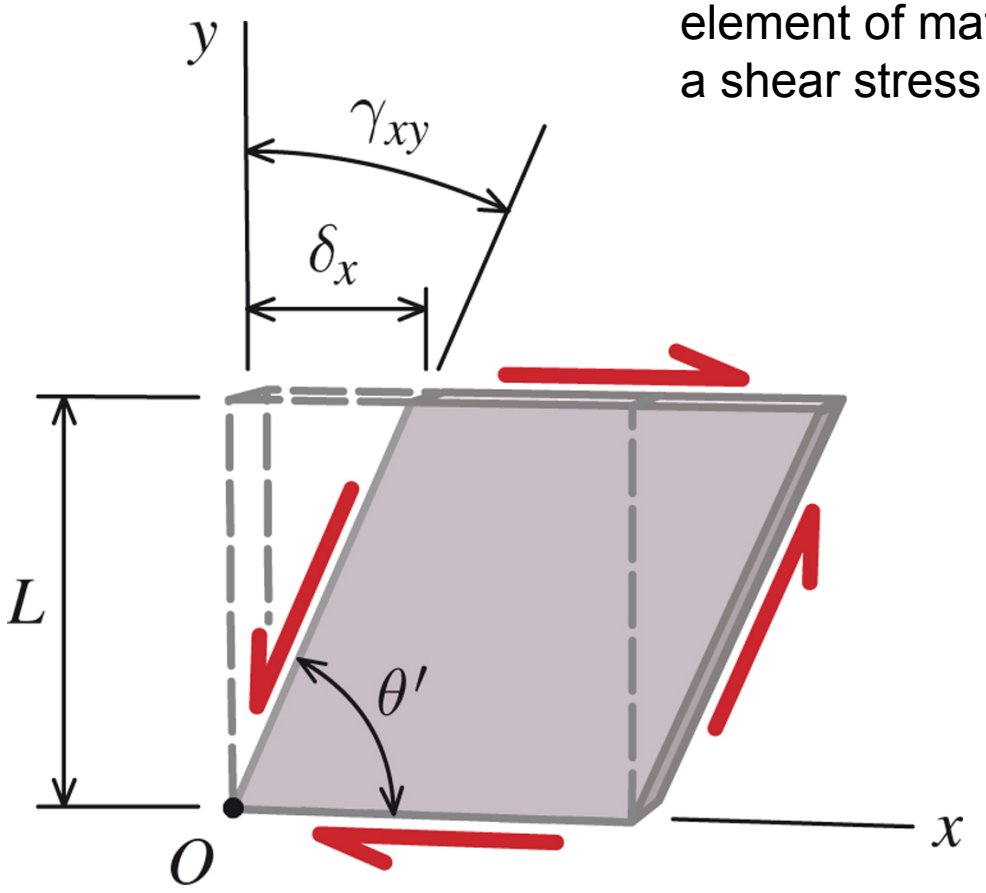
Shear Strain

- If we look at a material undergoing a shear stress, we have to go back to statics to start
- We need to remember about couples

THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

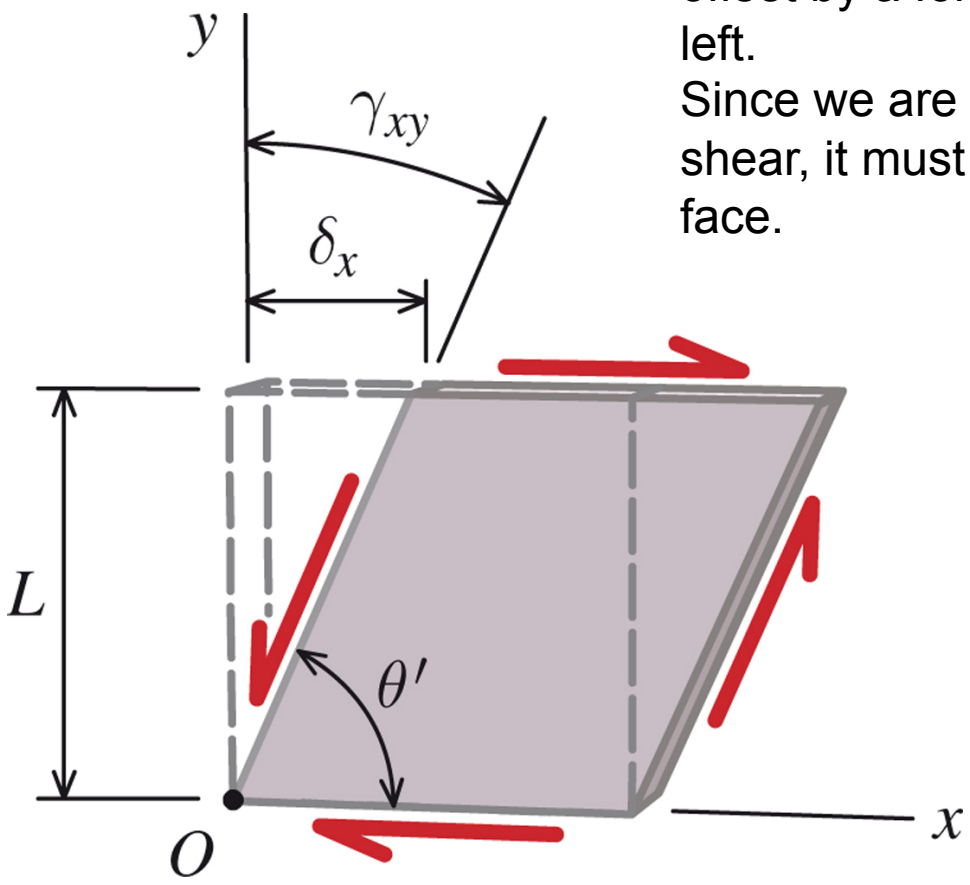
We can start by looking at an element of material undergoing a shear stress (the red arrows)



THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

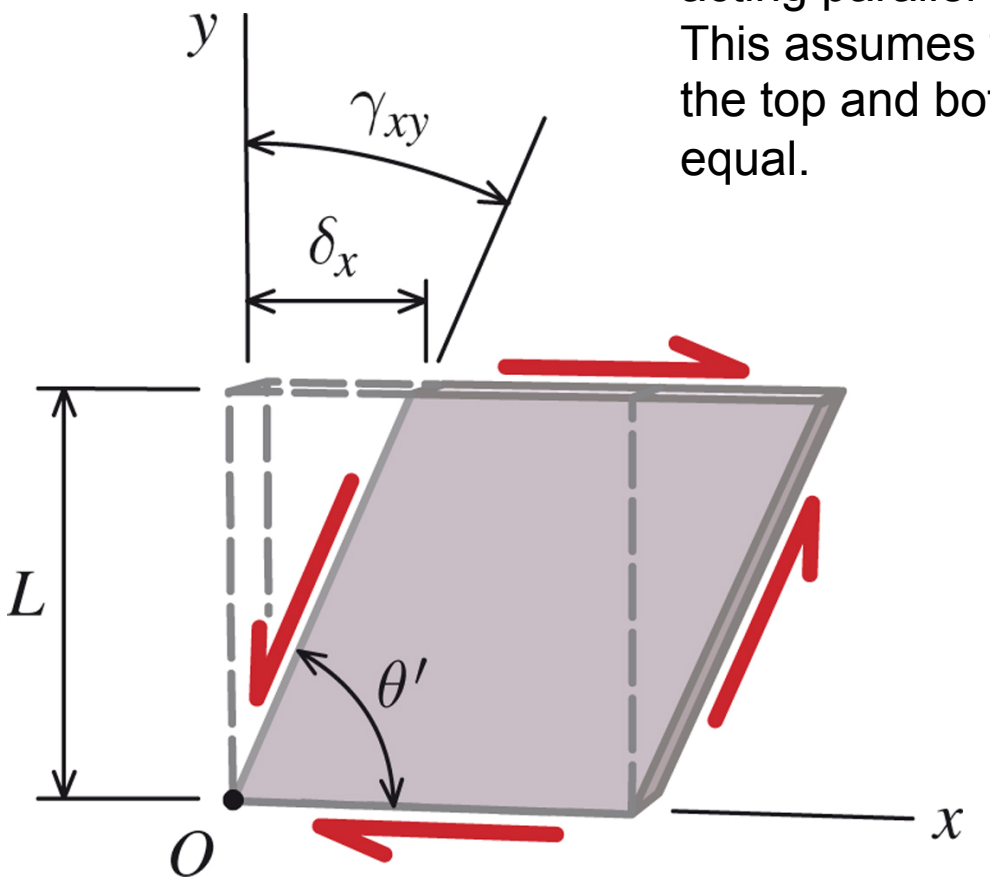
For the block to be in equilibrium, the top force directed to the right must be offset by a force directed to the left.
Since we are talking about shear, it must act parallel to a face.



THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

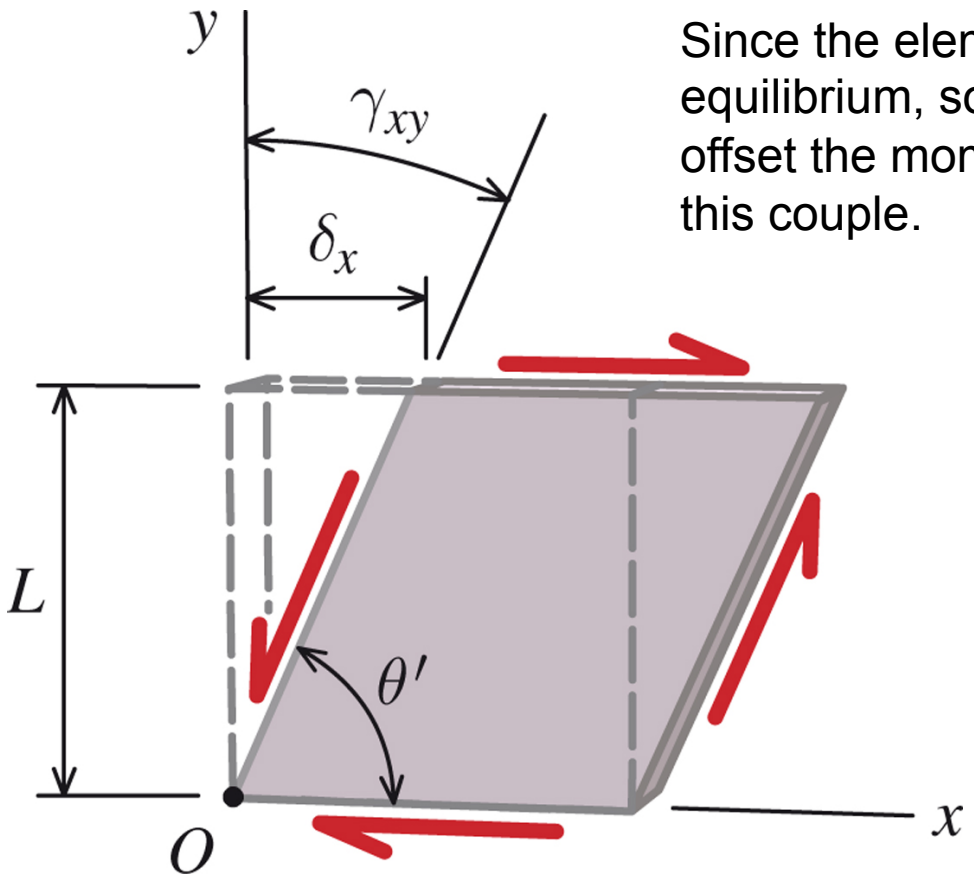
Shear Strain

So the bottom face has a force directed parallel to it that it equal and opposite to the force that is acting parallel to the top face. This assumes that the area of the top and bottom face are equal.



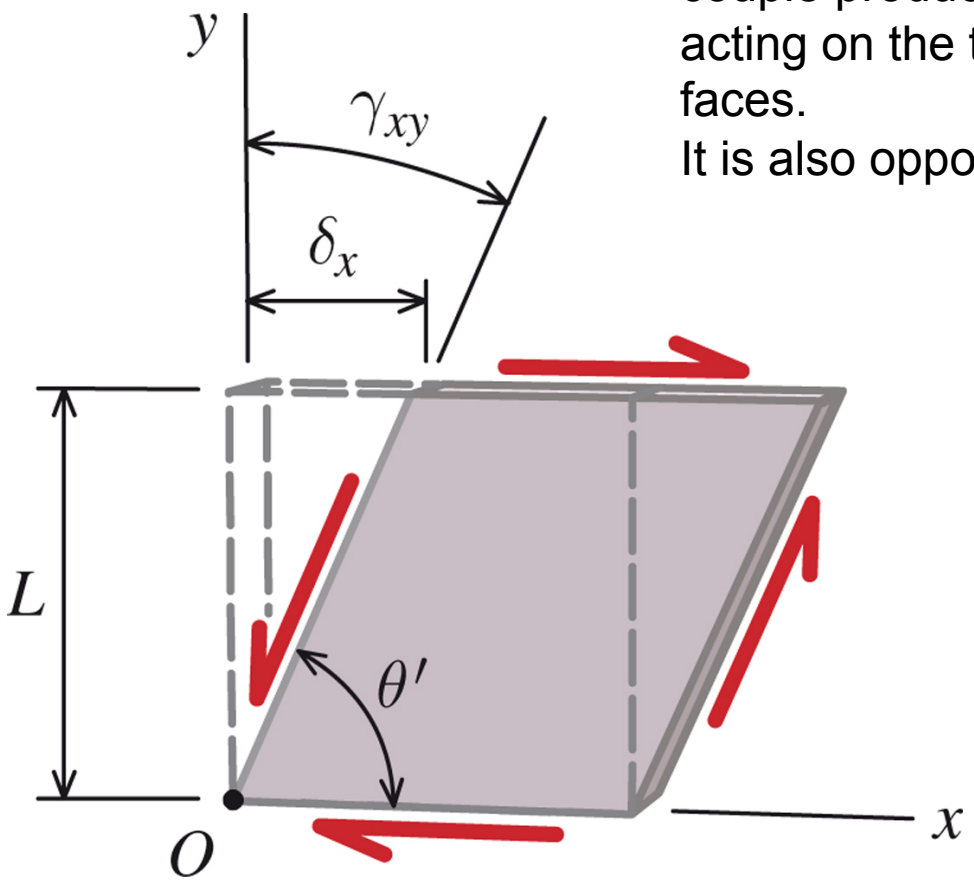
Shear Strain

These two forces equal in magnitude but opposite in direction generate a couple on the element.
Since the element is in equilibrium, something must offset the moment produced by this couple.



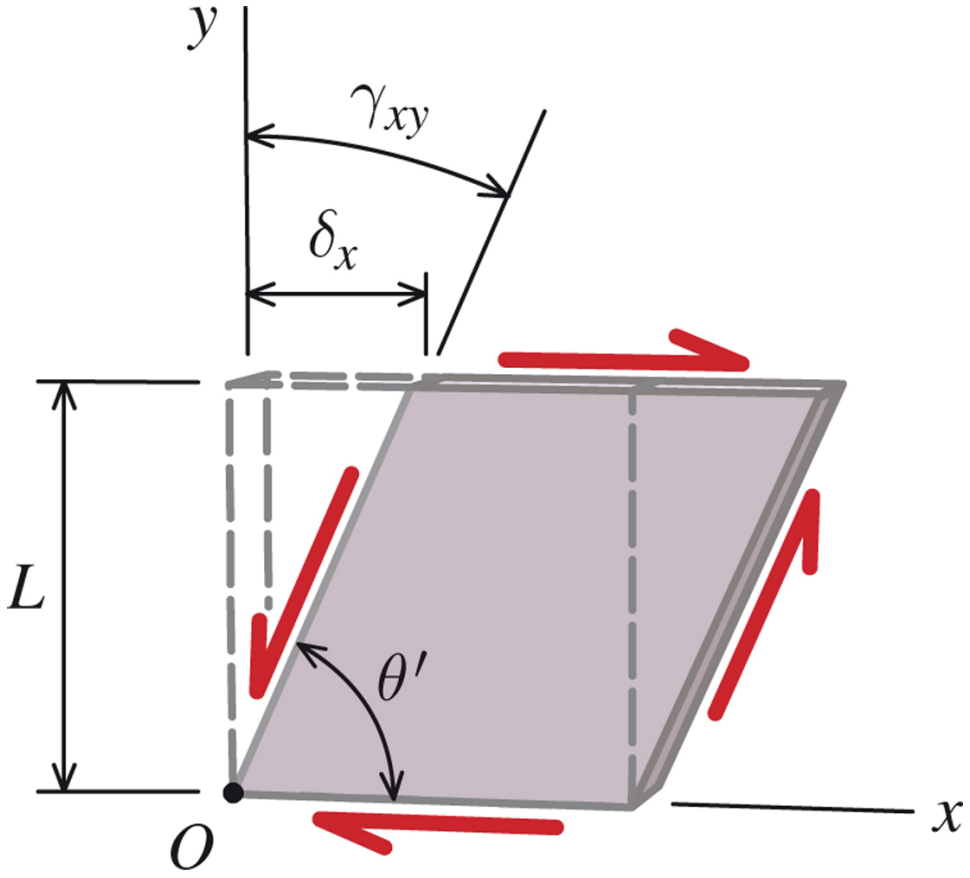
Shear Strain

The two forces acting on the left and right faces produce a couple that is equal in magnitude to the couple produced by the forces acting on the top and bottom faces.
It is also opposite in direction.



Shear Strain

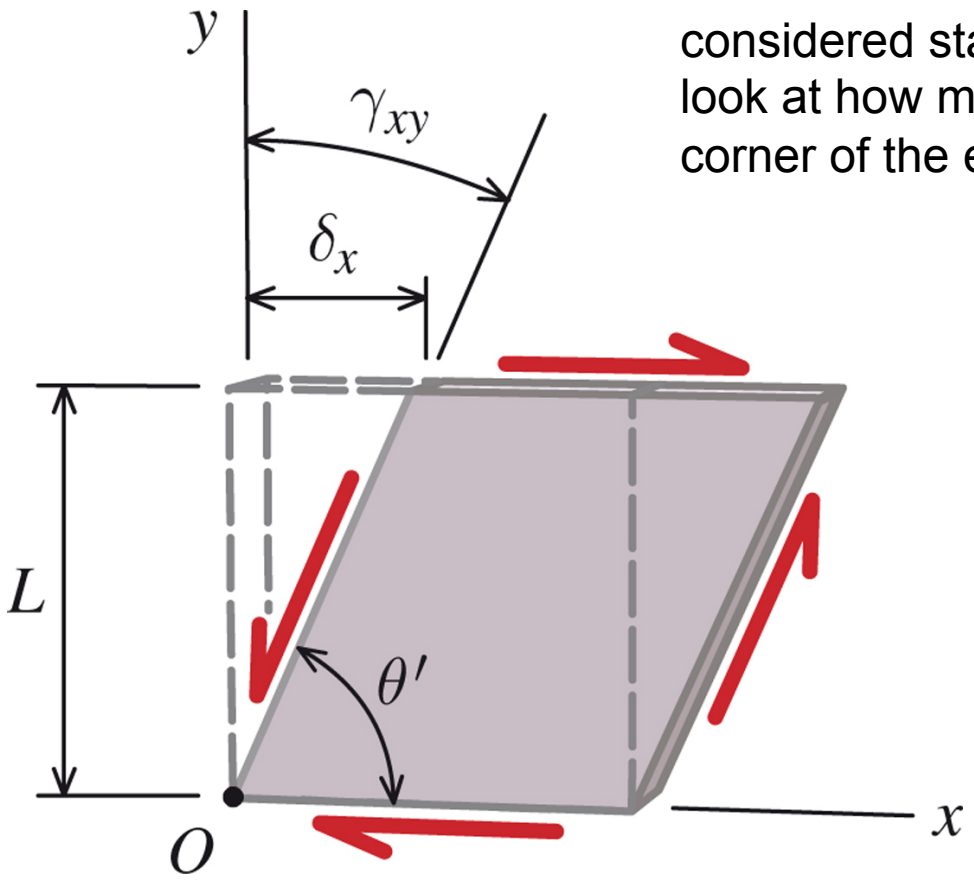
This will always be the case when an element in under shear.



THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

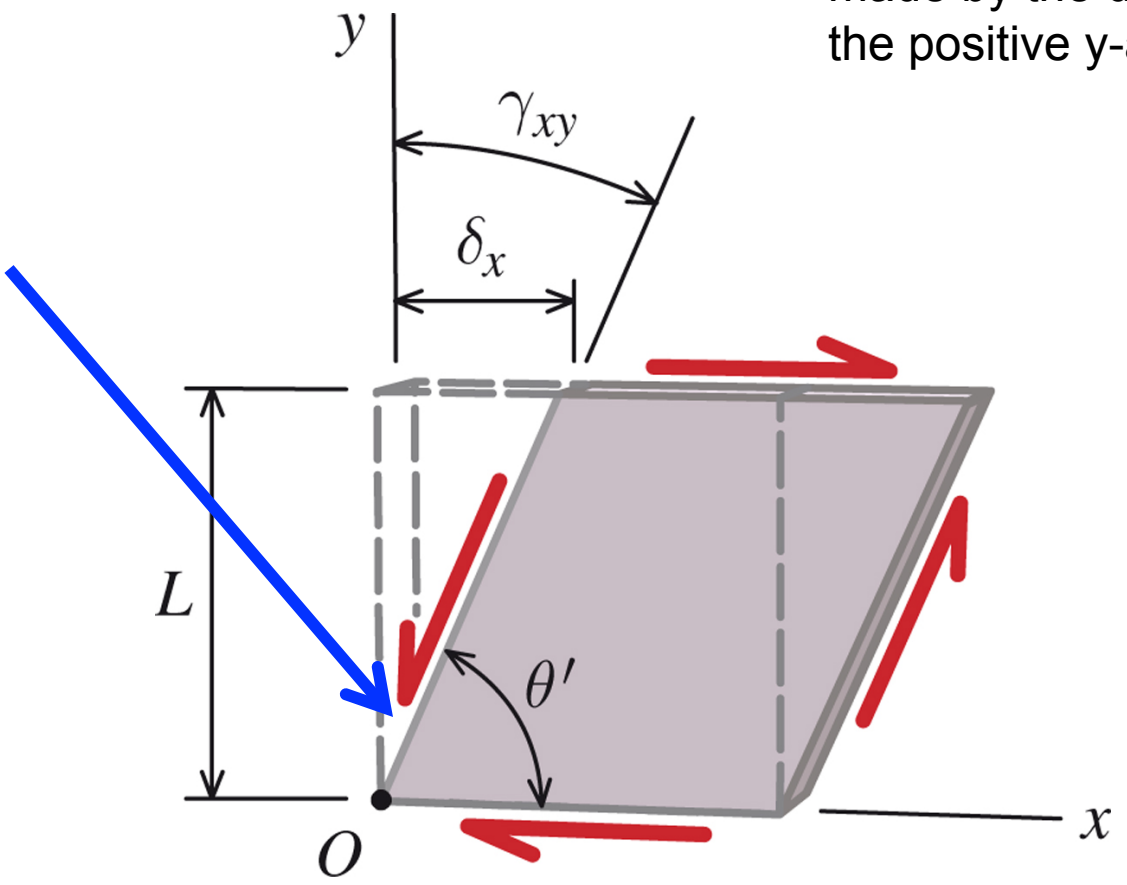
The shear acting on the four faces of the element cause a deformation of the element. If the lower left corner is considered stationary, we can look at how much the upper left corner of the element moves.



THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

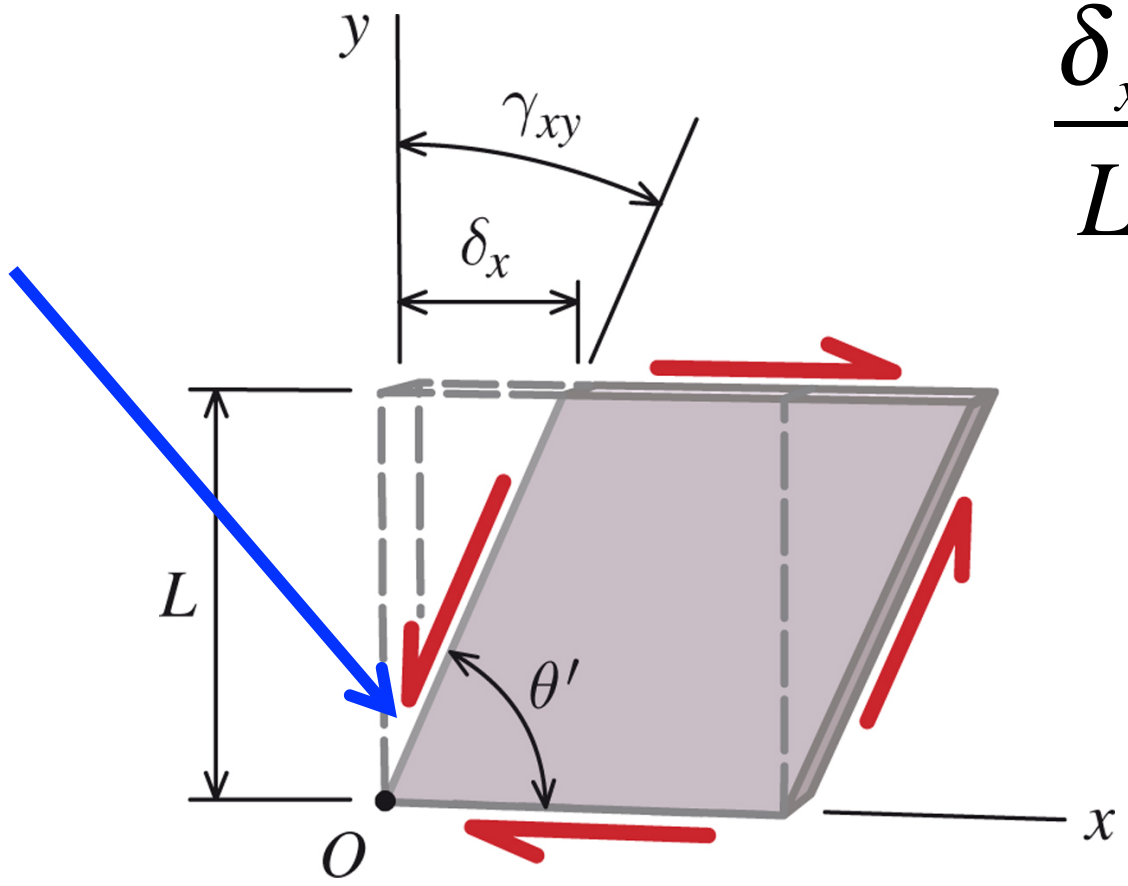
The upper left corner has moved a distance δ in the positive x-direction. If we look at the angle made by the deformation and the positive y-axis.



Shear Strain

This is not the angle θ'.
The sine of this angle is

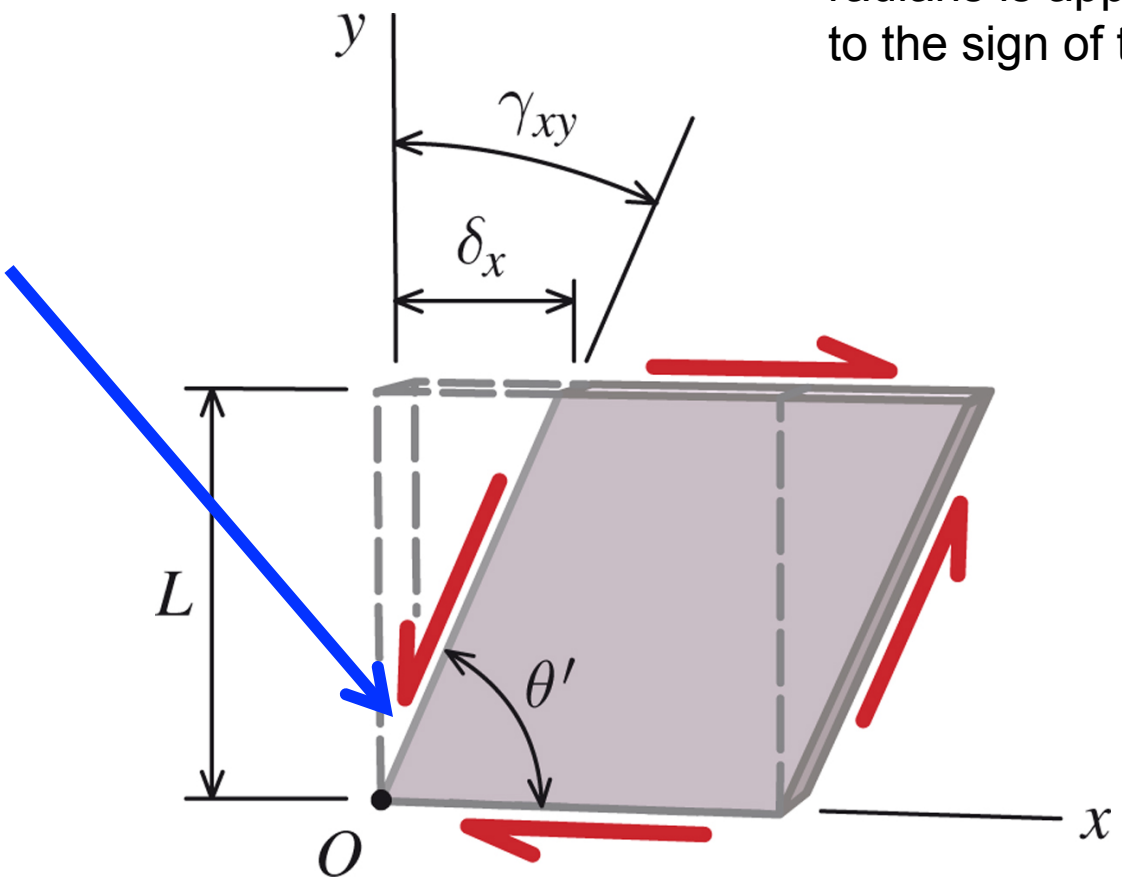
$$\frac{\delta_x}{L}$$



Shear Strain

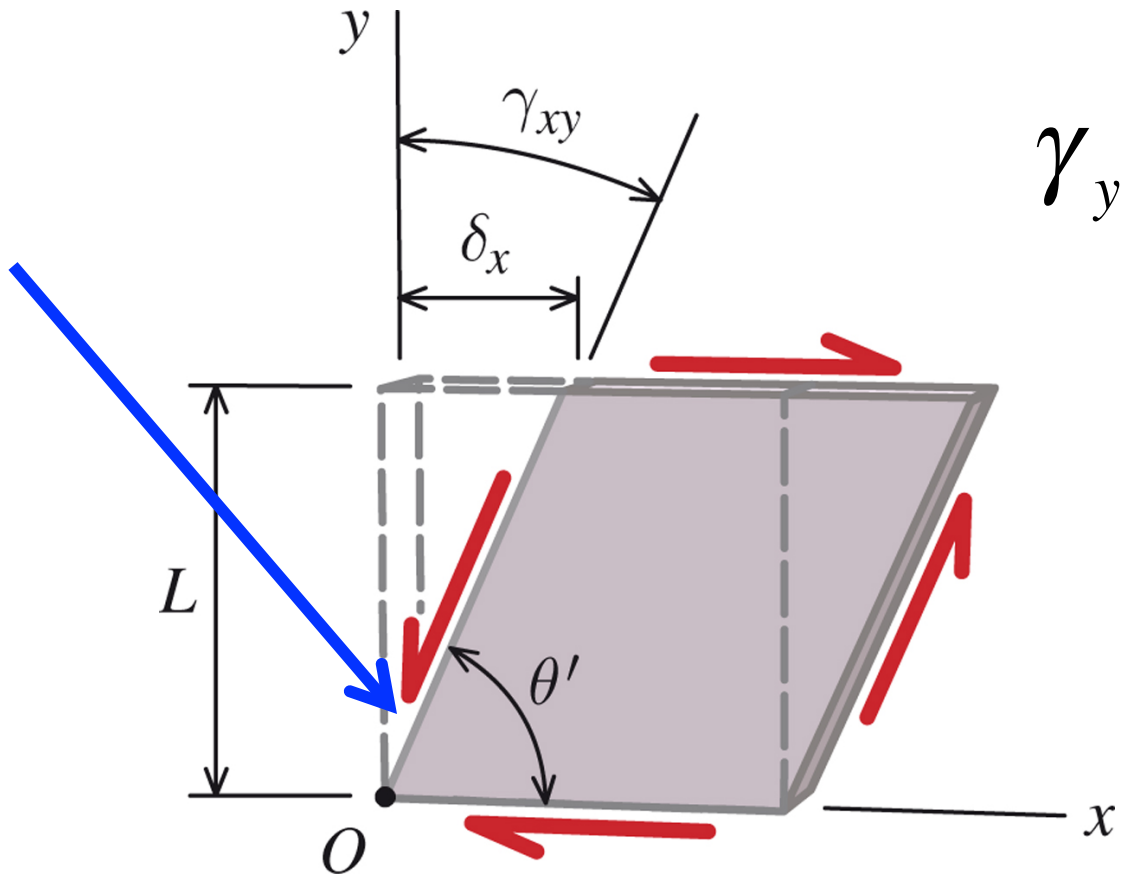
If δ_x is very small with respect to L, which is generally the case, then the value of the angle in radians is approximately equal to the sign of the angle.

$$\frac{\delta_x}{L}$$



Shear Strain

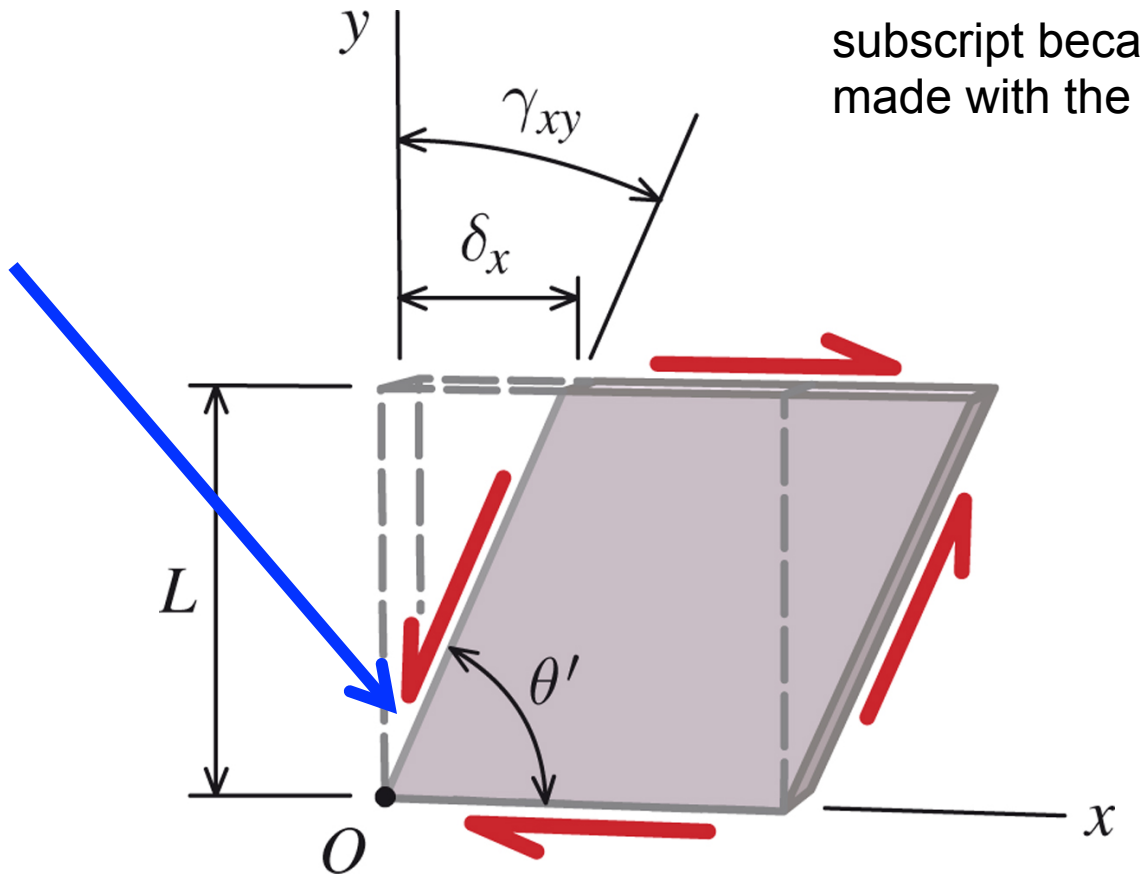
γ is the symbol for the shear, so we have



$$\gamma_y = \frac{\delta_x}{L}$$

Shear Strain

It is labeled with an xy subscript because we are looking at the shear strain in the xy plane
I have labeled it with a y subscript because it is the angle made with the y-axis.

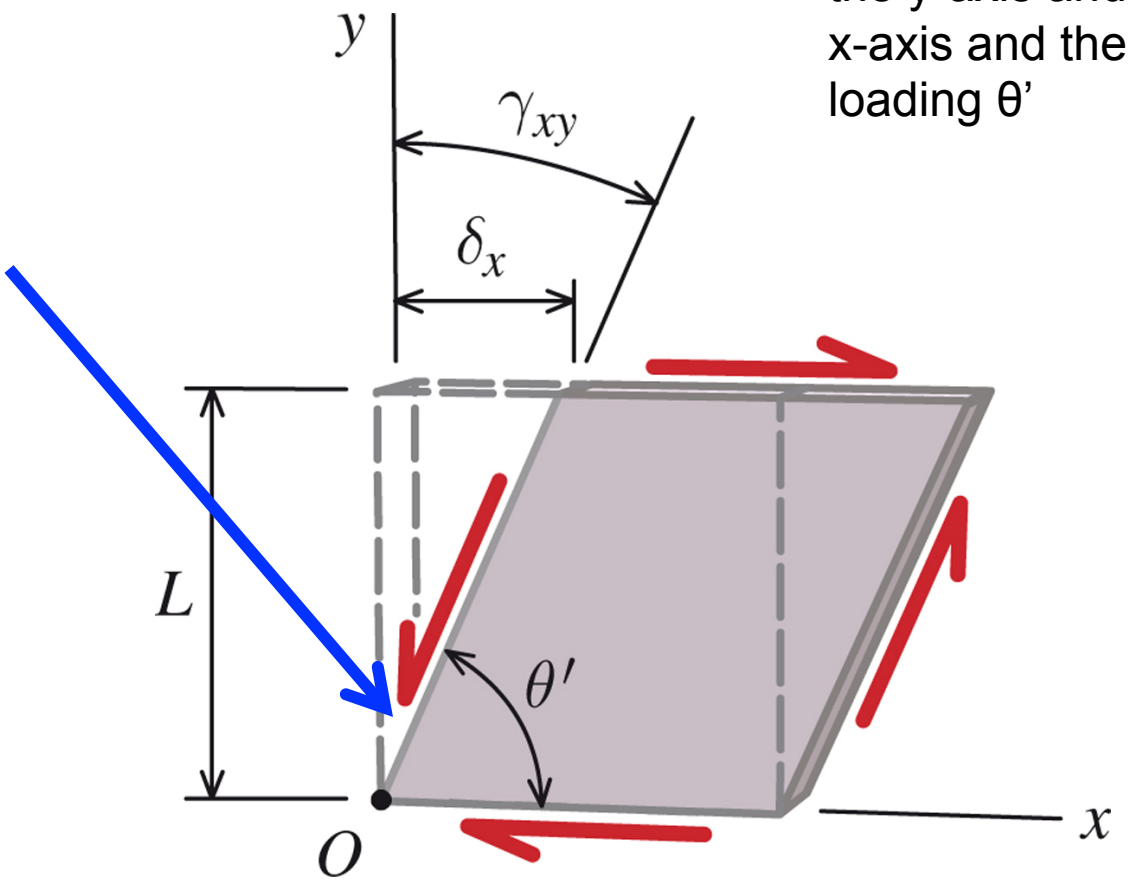


$$\gamma_y = \frac{\delta_x}{L}$$

THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Shear Strain

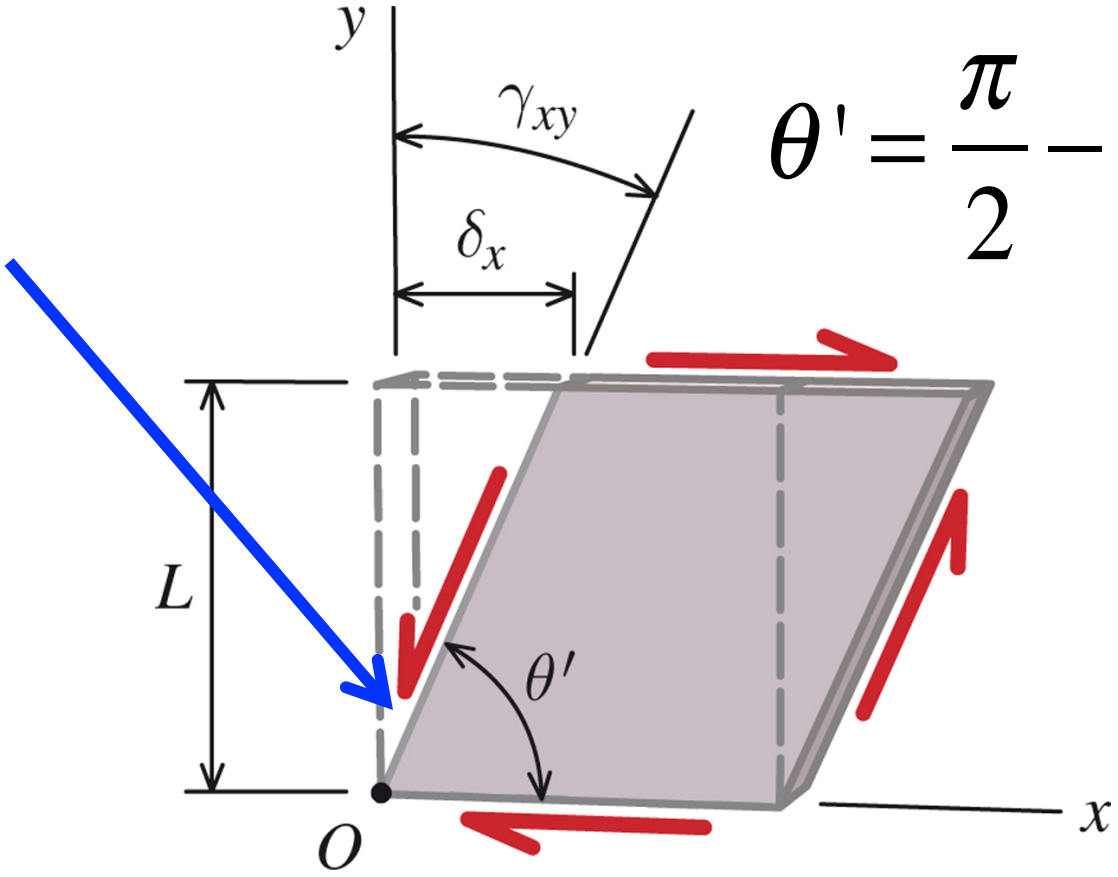
The shear is actually the difference between the original angle between the side along the y-axis and the side along the x-axis and the angle after loading θ'



$$\gamma_y = \frac{\delta_x}{L}$$

Shear Strain

The angle θ' is determined by using

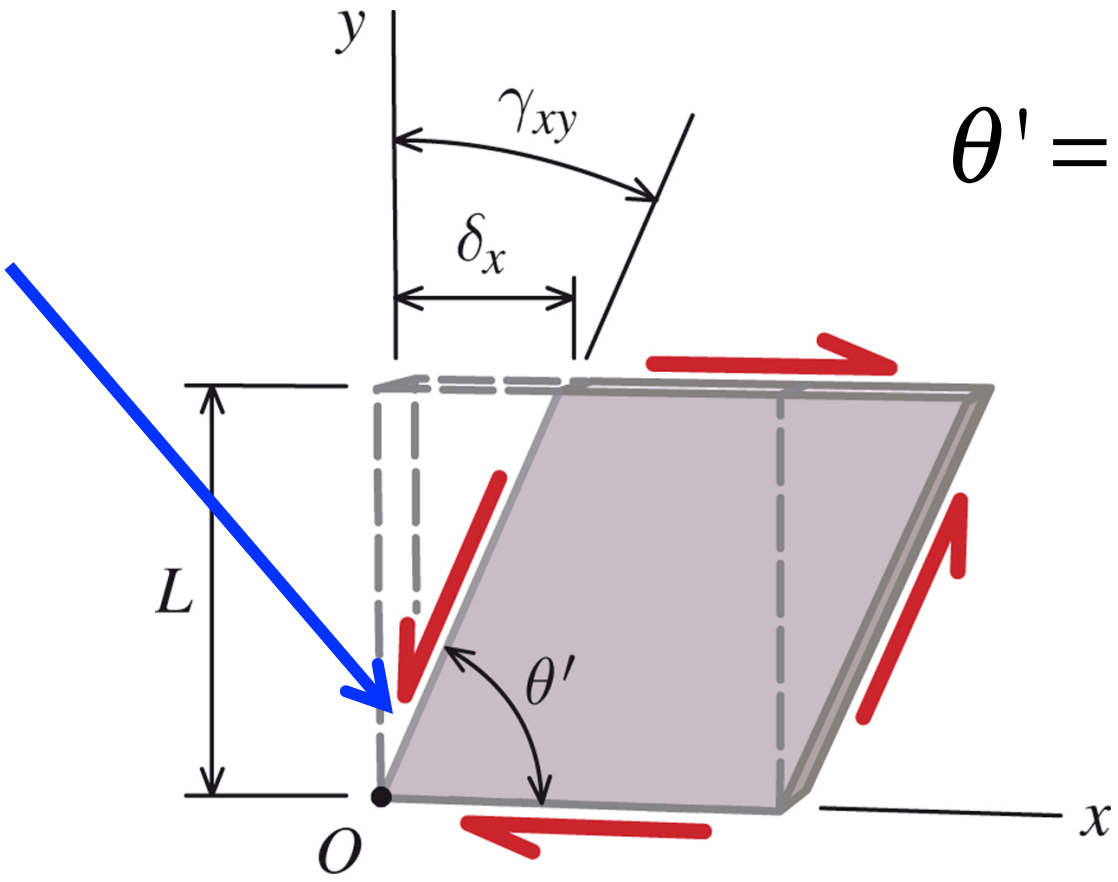


$$\theta' = \frac{\pi}{2} - \gamma_y = \frac{\pi}{2} - \frac{\delta_x}{L}$$

Shear Strain

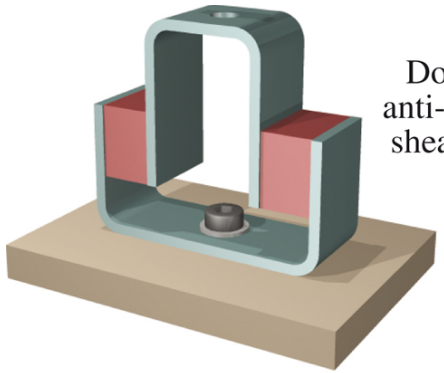
If there is also a deformation above or below the x-axis, it must also be included to solve for θ'

$$\theta' = \frac{\pi}{2} - \gamma_{xy}$$

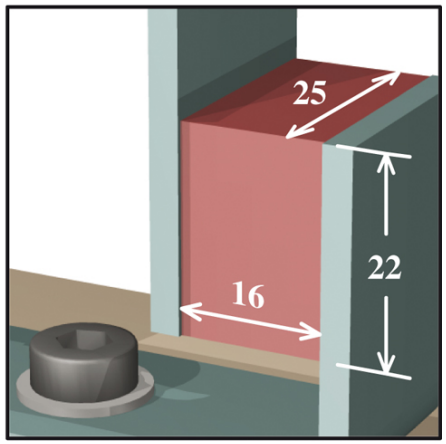


THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

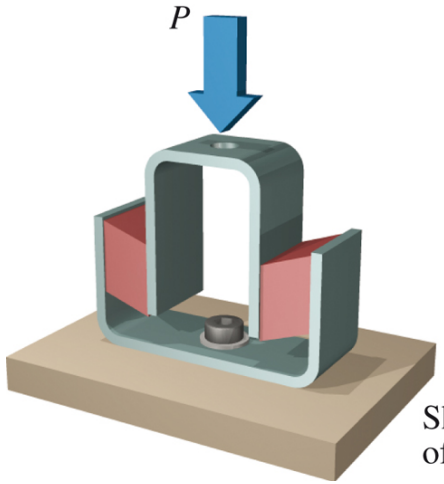
Problem 2.9



Double U anti-vibration shear mount

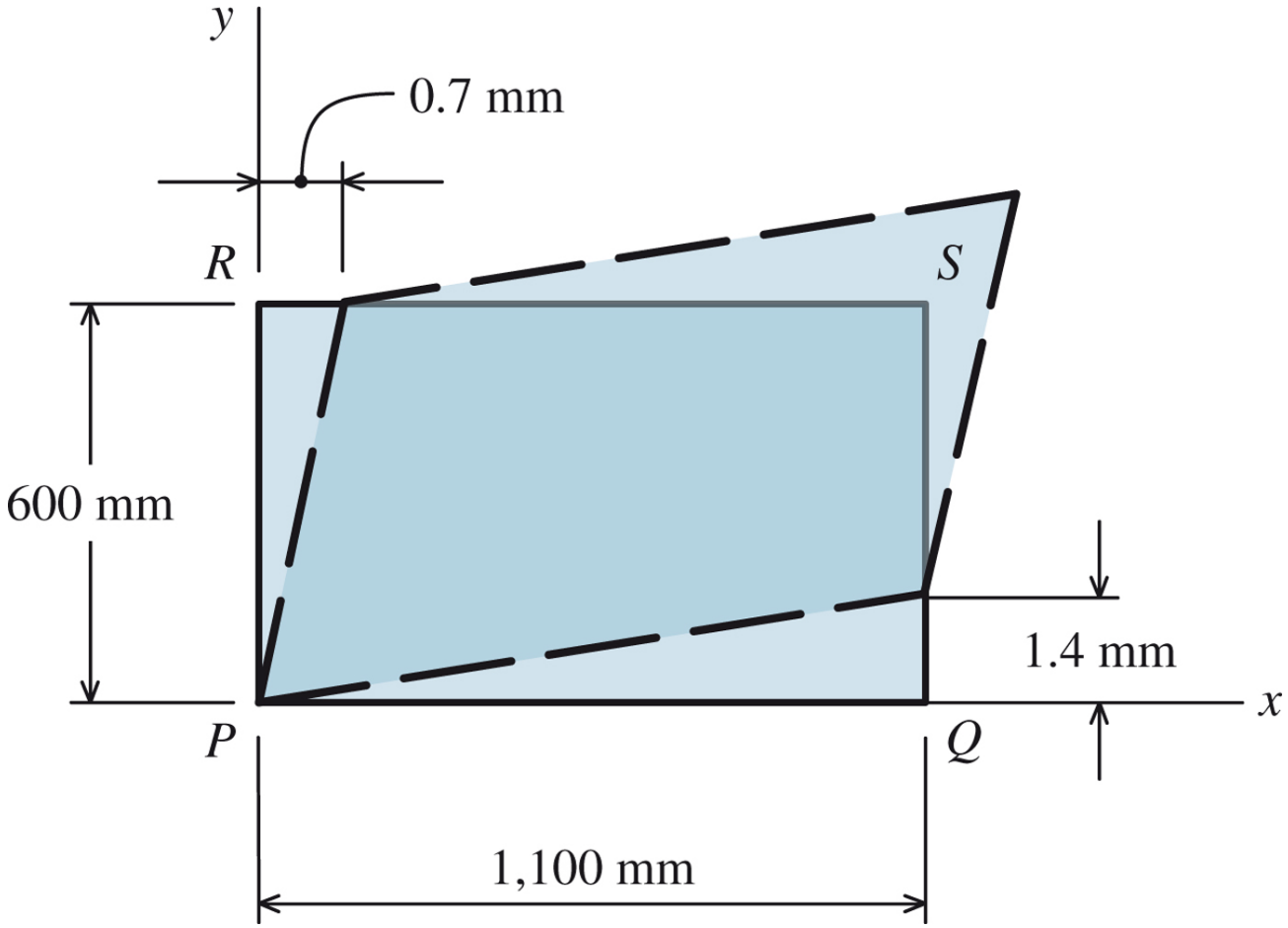


Rubber block dimensions



Shear deformation of blocks

Problem P2.12



P02_012

THE UNIVERSITY OF MEMPHIS
Department of Civil Engineering

Homework

- P 2.11
- P 2.13
- P 2.14