16.001 - Materials & Structures
Problem Set #6

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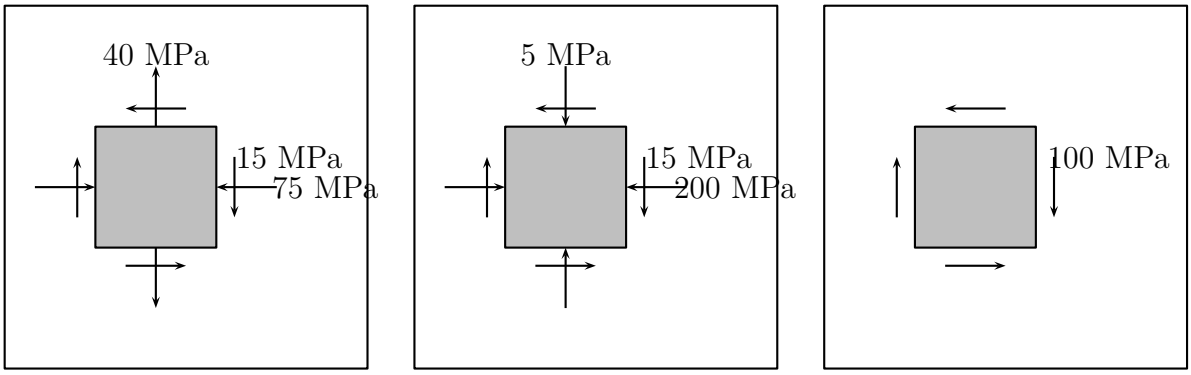
○ **Problems M-6.1** [5 points]

Metals and ceramics have a wide range of coefficient of thermal expansion (α) values and melting points (T_m); however, they all exhibit a similar amount of thermal expansion before they melt. Demonstrate this effect by generating a property diagram of density ρ vs. αT_m for bulk metals and ceramics and paste the property diagram below. You will need to use the "Advanced" y-axis function in the chart operation to compute a product of multiple material properties. What linear displacement would you expect to observe if you were to heat a 1 m long bar of some random metal or ceramic to its melting point?

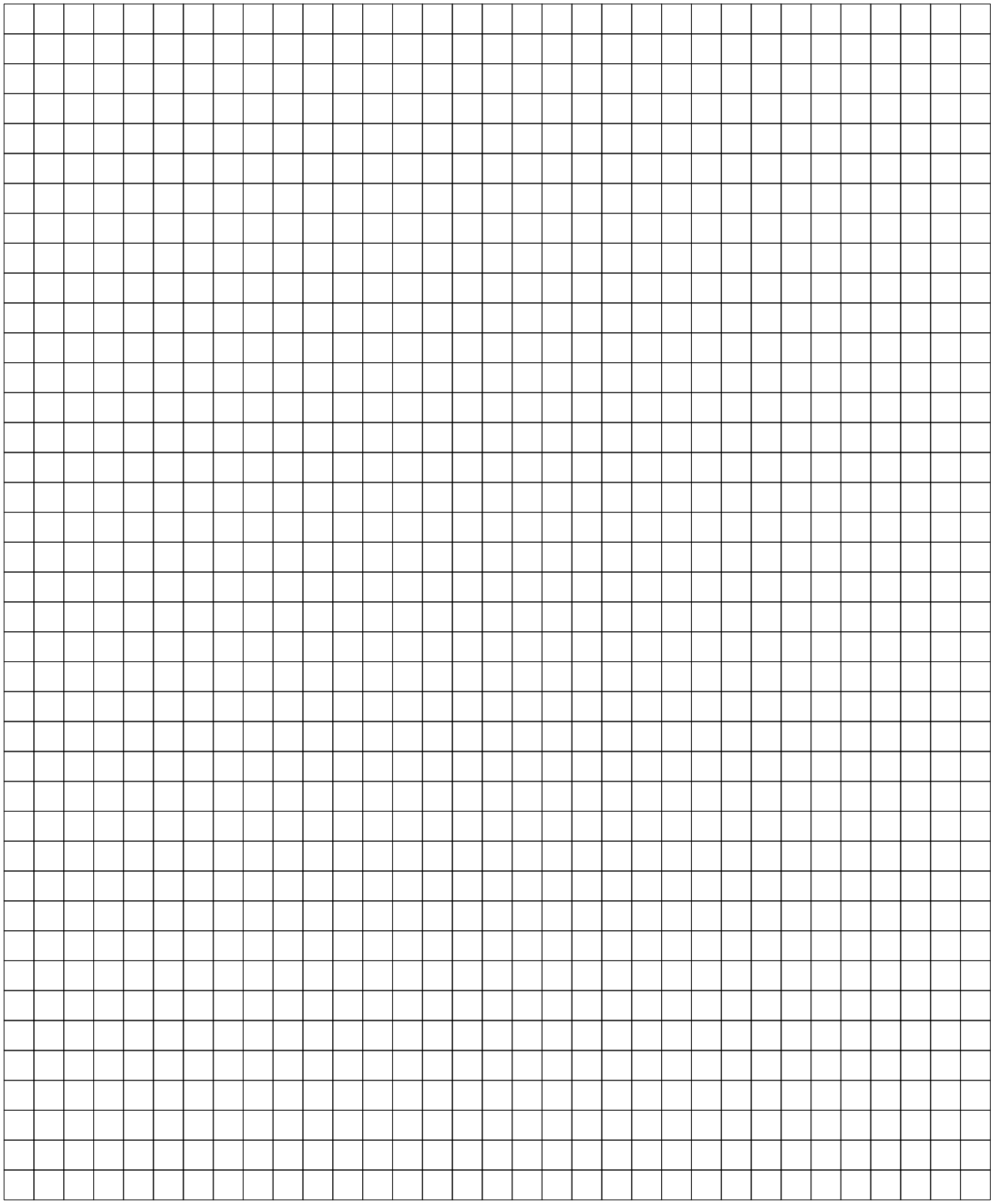
○ **Problems M-6.2** [6 points]

The state of stress on the surface of an airplane fuselage at three different locations are represented on the elements shown below in Figure **??**. For each location: a) Find the principal stresses and the orientation of the element at which they are achieved. b) Find the maximum shear stress and orientation. At this orientation also find the normal stresses.

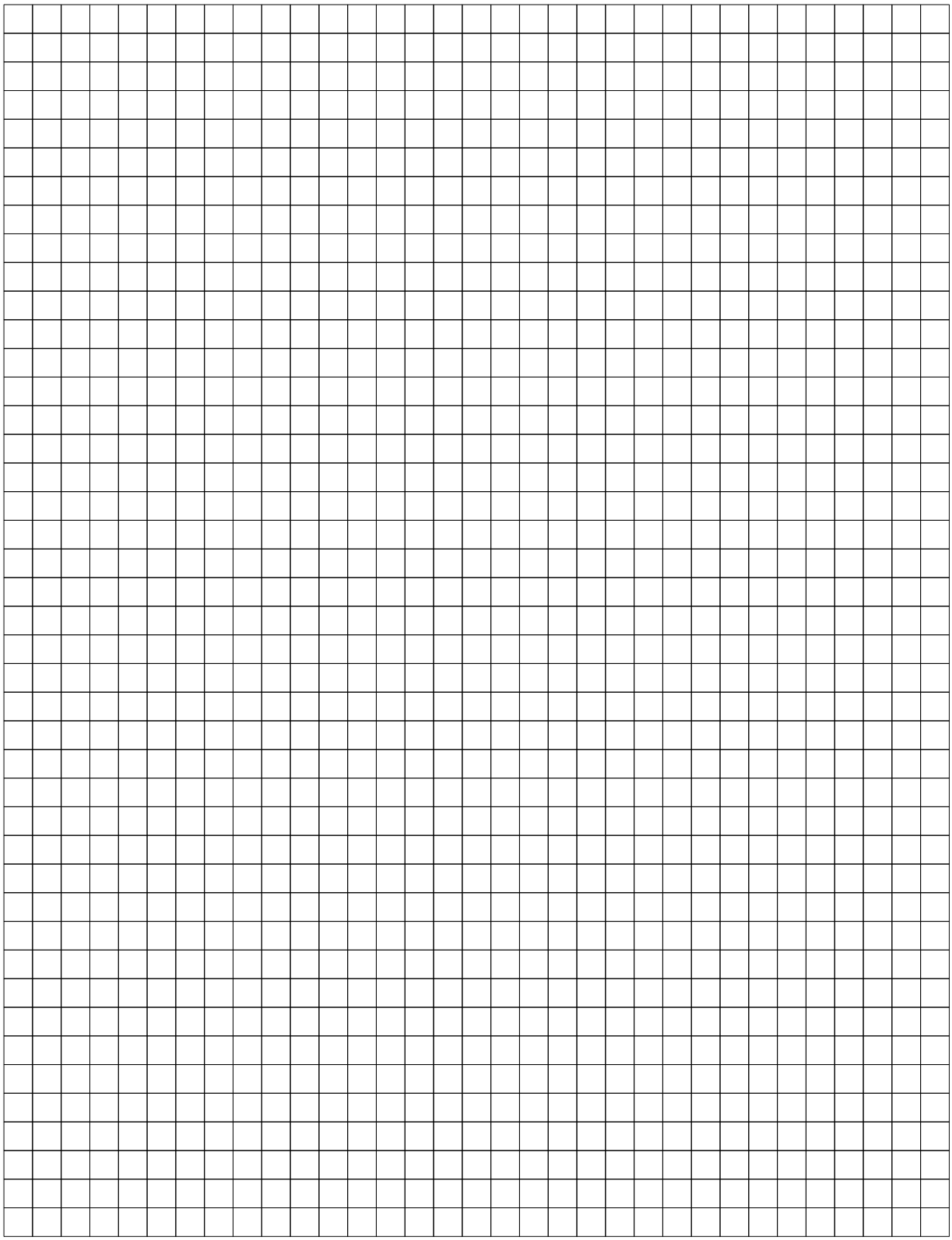


(a) Case 1 (b) Case 2 (c) Case 3

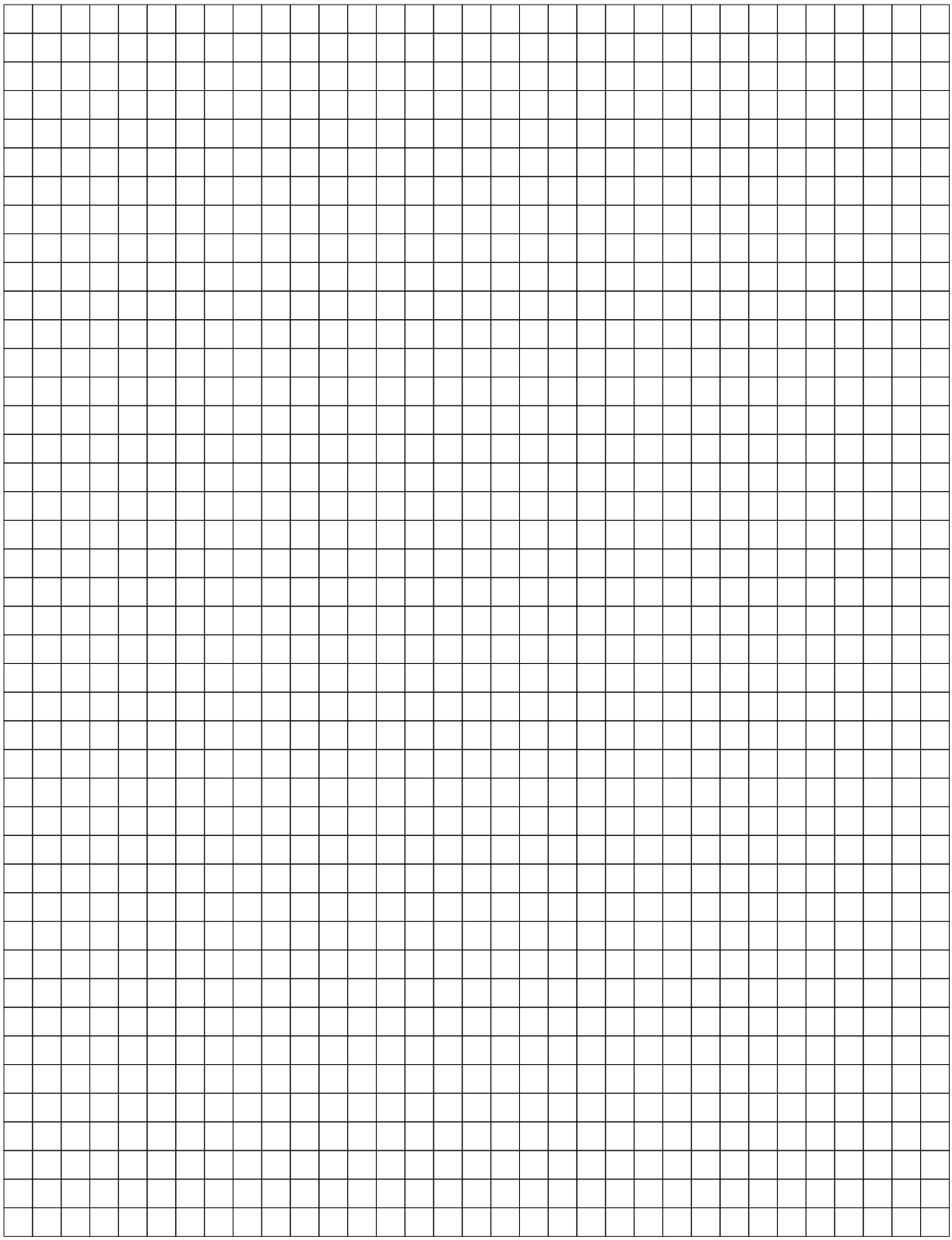
2.1 (2 points) Case 1



2.2 (2 points) Case 2



2.3 (2 points) Case 3



○ **Problems M-6.3** [6 points]

A point on a thin plate is subjected to the two successive states of stress shown in Figure 2. Determine the resultant state of stress represented on the element oriented as shown on the right.

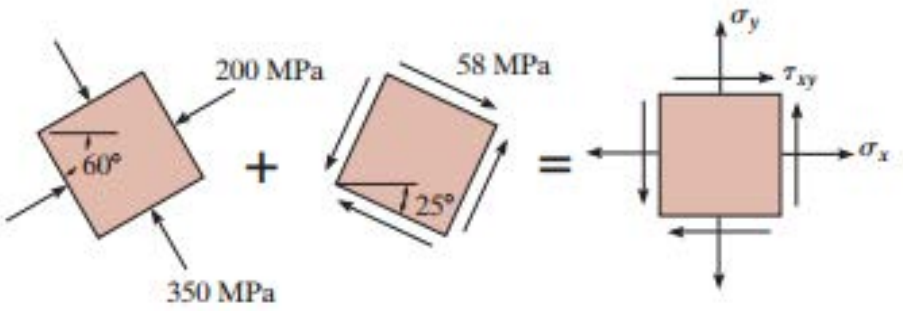


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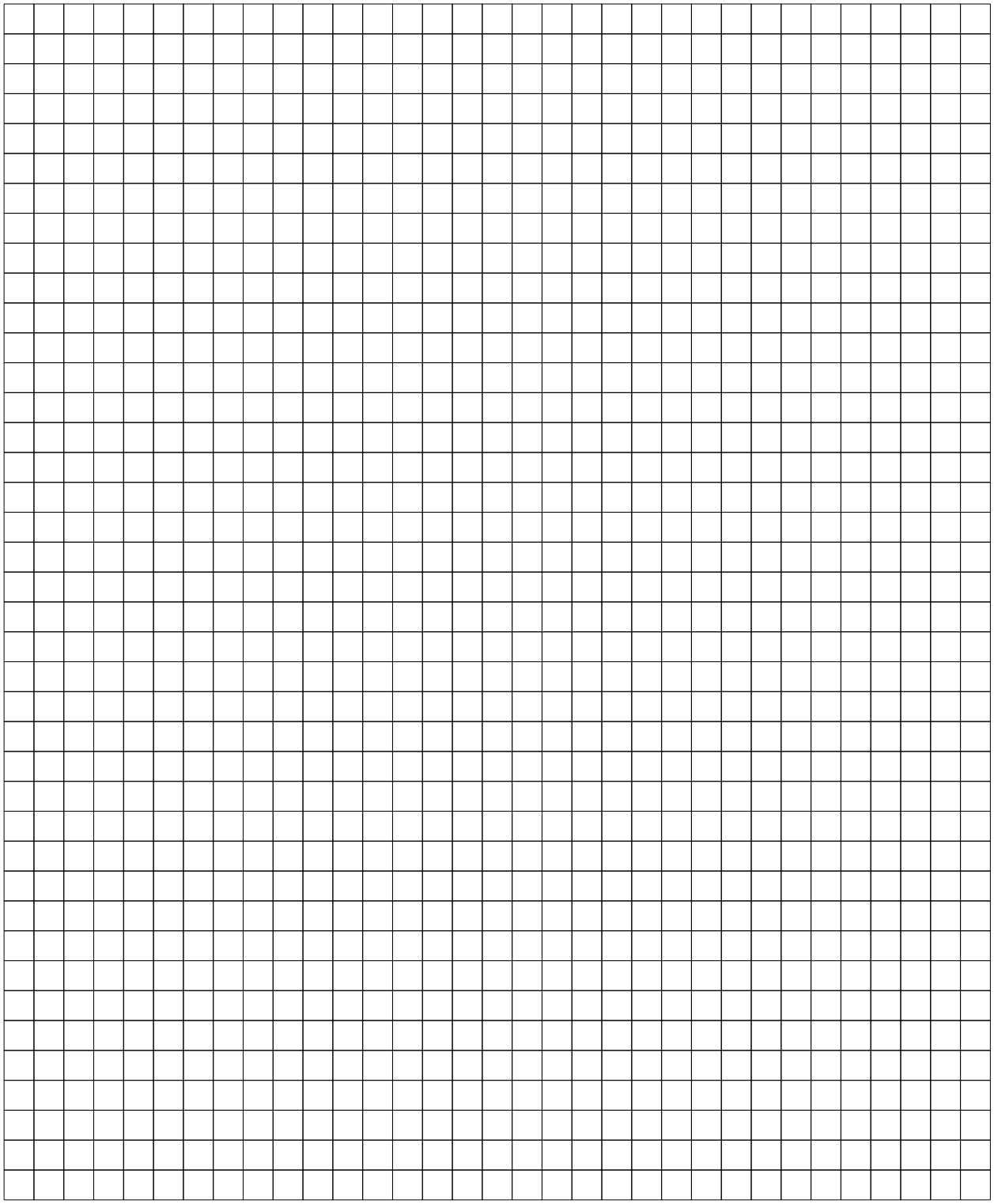
Figure 2: Addition of stress states



○ **Problems M-6.4** [5 points]

The cylindrical pressure vessel has an inner radius of 1.25 m and a wall thickness of 20 mm. It is made from steel plates that are welded along the 45° seam. Determine the normal and shear stress component along this seam if the vessel is subjected to an internal pressure of 45 MPa.

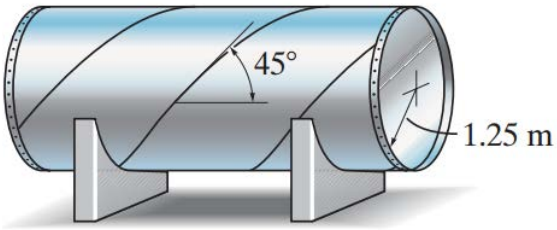


Figure 3: Pressure Vessel

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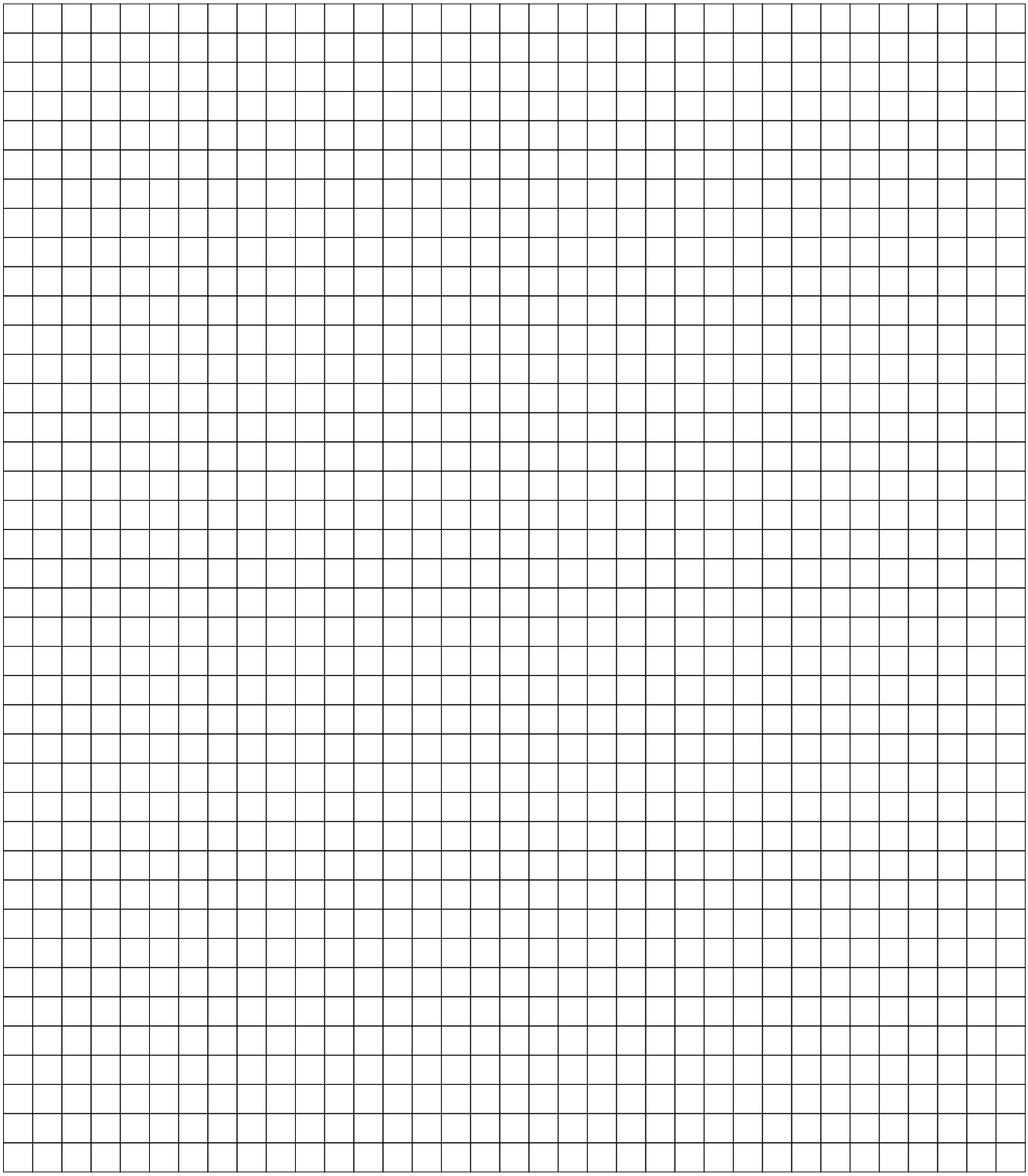
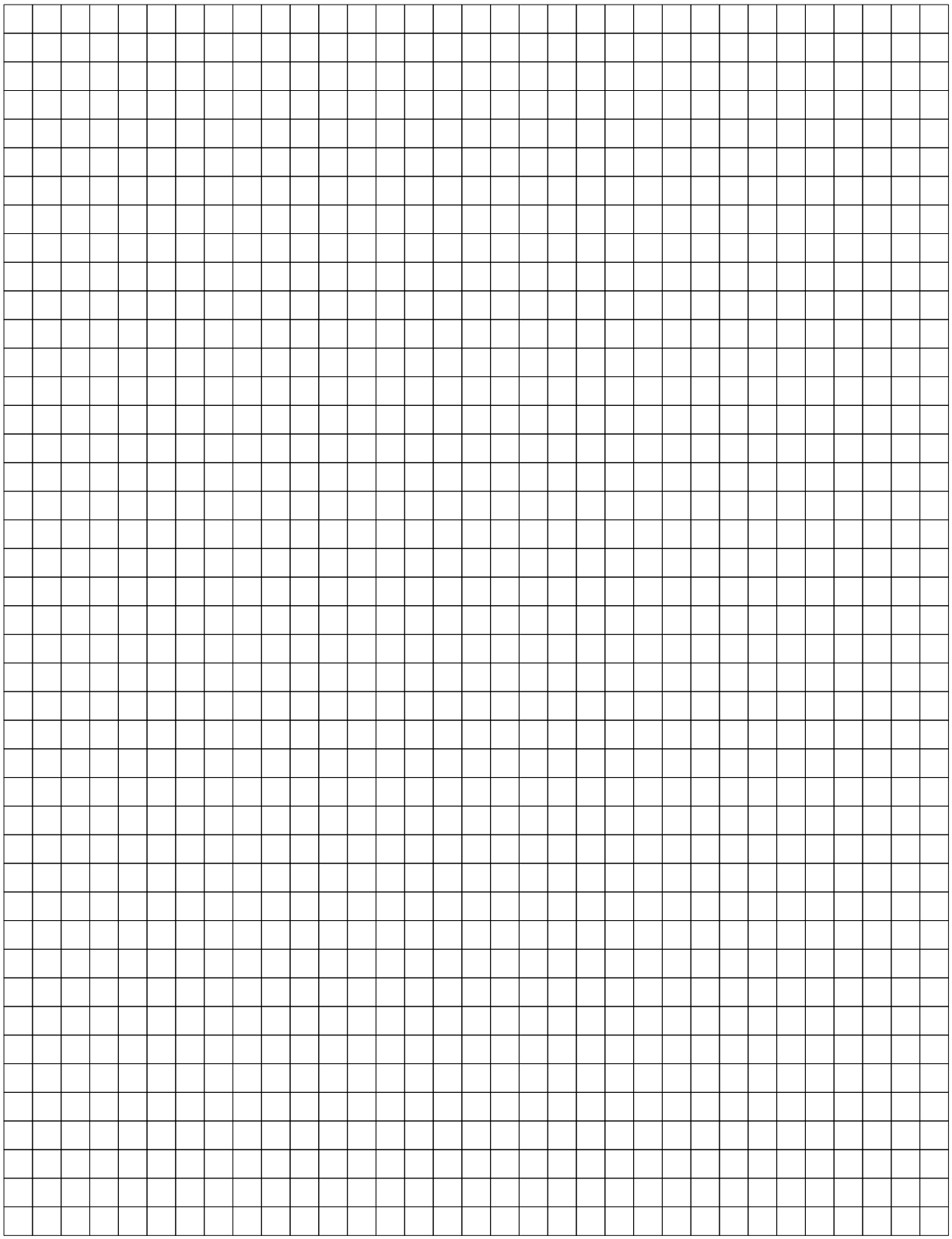


○ **Problems M-6.5** [6 points]

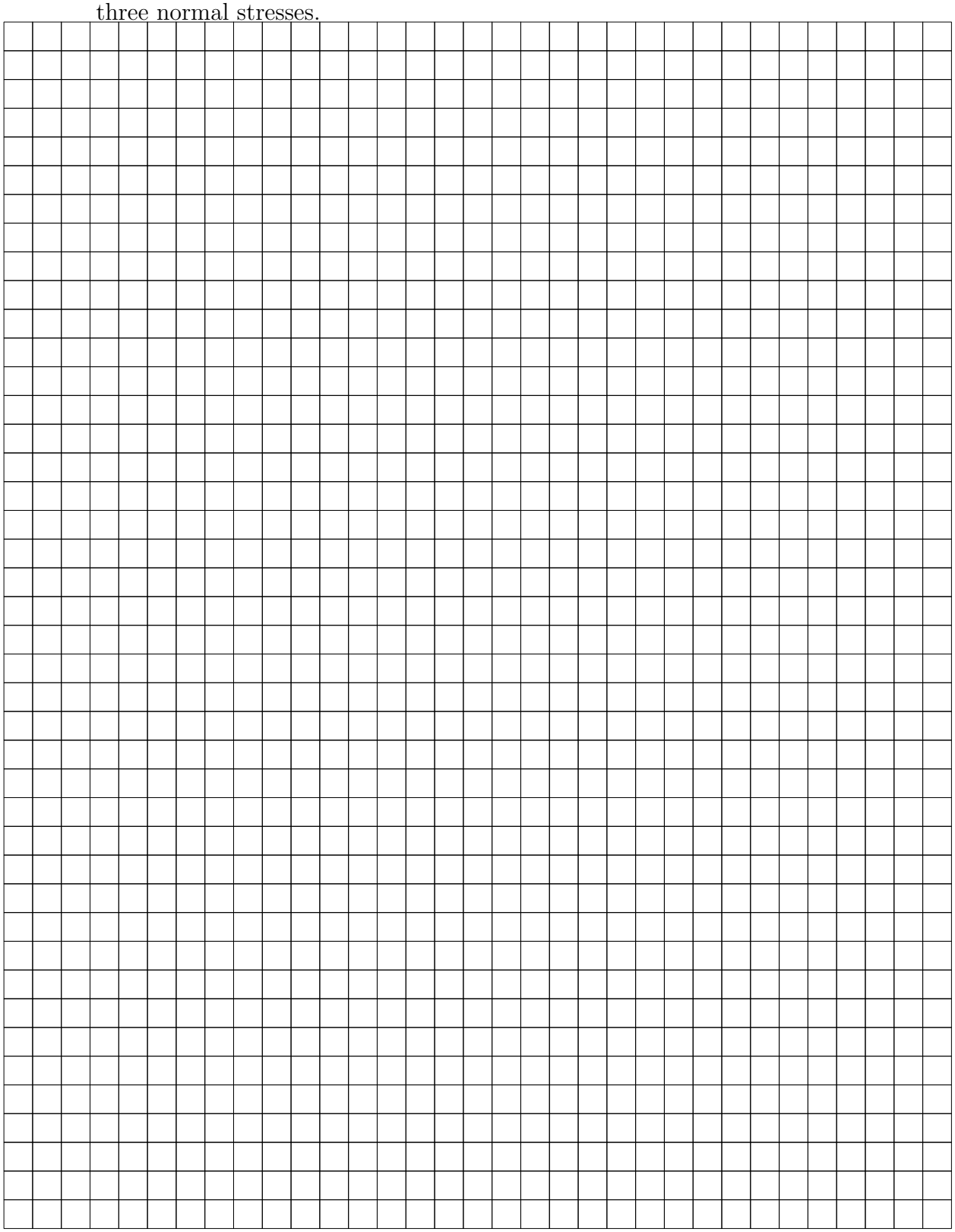
Three normal stress components $\sigma_{11} = 10, \sigma'_{11} = 5, \sigma''_{11} = -5$ (all in MPa) are given in three different directions $\mathbf{e}_1, \mathbf{e}'_1, \mathbf{e}''_1$ which are all at 60° apart from each other, i.e. $\widehat{\mathbf{e}_1\mathbf{e}'_1} = 60°$, $\widehat{\mathbf{e}'_1\mathbf{e}''_1} = 60°$.

5.1 (3 points) Determine all the stress components in the $\mathbf{e}_1, \mathbf{e}_2$ planes.

5.2 (1 point) Determine the principal stresses and directions



5.3 (2 points) Draw Mohr's circle for the state of stress corresponding to the given three normal stresses.



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