Q- Two polarizing sheets have their transmission axes crossed so that no light gets through. A third sheet is inserted between the first two such that its transmission axis makes an angle θ with that of the first sheet. Unpolarized light of intensity I_0 is incident on the first sheet. Find the intensity of the light transmitted through all three sheets for
(a) $\theta = 45^0$
(b) $\theta = 30^0$

When the two sheets are not allowing light the angle between their axes is 90^0. Hence when the axis of the third sheet is making angle Θ with the first the angle between the axes of second and third will be 90^0 - Θ

Now the intensity of the un polarized light incident on the first sheet is I_0 then half of the light is emerging from it as light polarized along its axis and hence the intensity becomes

$$I_1 = I_0/2.$$

When this linearly polarized light passes through the second sheet its intensity is given by Malus law as

$$I_2 = (I_0/2) \cos^2\Theta$$

Now this light is again passes through the third sheet whose axis is making an angle 90 – Θ hence using Malus law again the intensity of the transmitted beam is given by

$$I_3 = I_1 * \cos^2(90 - \Theta) = (I_0/2) \cos^2\Theta * \sin^2 \Theta$$

Thus

(a) $\theta = 45°$

through first sheet $I_1 = I_0/2$.

through first two sheets $I_2 = (I_0/2) \cos^2\Theta = I_0/4$.

through all three sheets $I_3 = (I_0/2) \cos^2\Theta * \sin^2 \Theta = I_0/8$.

(b) $\theta = 30°$

through first sheet $I_1 = I_0/2$.

through first two sheets $I_2 = (I_0/2) \cos^2 30^0 = 0.375\ I_0$.

through all three sheets $I_3 = (I_0/2) \cos^2 30^0 * \sin^2 30^0 = 0.094\ I_0$