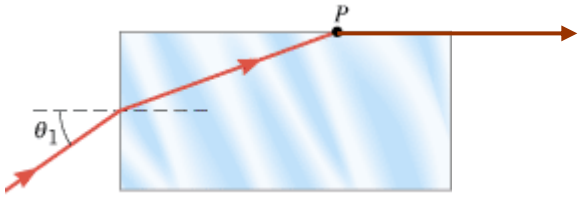
Q- The drawing shows a glass slab (n = 1.4) with a rectangular cross section. A ray of light strikes the slab at an incident angle of θ_1 = 45°, enters the slab, and travels to point *P*. This slab is surrounded by a fluid with a refractive index *n*. What is the maximum value of *n* such that total internal reflection occurs at point *P*?



Refractive index of the material of slab relative to liquid medium is given by 1.4/n, here n is the refractive index of the liquid.

According to Snell's law if r is the angle of refraction for angle of incidence 45^0

$1.4/n = \sin 45^0/\sin r$

Or $\sin r = n \sin 45^0/1.4$ ..... (1)

Angle of incidence at point P will be (90^0- r), which should be critical angle for the pair of materials (for which angle of refraction is taken as 90^0).

Applying Snell's law again

$\sin(90^0-r)/\sin 90^0 = n/1.4$ (light going from slab to liquid)

Or $\cos r = n/1.4$ .....(2)

Squaring and adding equations (1) and (2)

$1 = n^2(\sin 45^0/1.4)^2 + n^2/(1.4)^2$

Or $1 = \frac{n^2}{1.4^2}\ (0.5 + 1)$

gives n = 1.14

hence for total internal reflection at P, n < 1.14

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