PHYSICS I
REFRACTION AND LENSES
Supplemental Worksheet: Refraction of light and Critical Angle

Medium	Index of Refraction	Medium	Index of Refraction
vacuum	**1.00**	**Crown Glass**	**1.52**
Air	**1.00**	**Quartz**	**1.54**
Water	**1.33**	**Flint glass**	**1.61**
Ethanol	**1.36**	**diamond**	**2.42**

Assume all substances are in air unless otherwise stated.

1. A ray of light has an angle of incidence of 30^o on a block of quartz and an angle of refraction of 20^o. What is the index of refraction for this block of quartz?

2. A ray of light travels from air into a liquid. The ray is incident upon the liquid at an angle of 30^o. The angle of refraction is 22^o. What is the index of refraction of the liquid?

3. A ray of light is incident at an angle of 60^o upon the surface of a piece of crown glass which has an index of refraction of 1.52. What is the angle of refraction?

4. A ray of light passes from water into crown glass at an angle of 23.2^o. Find the angle of refraction.

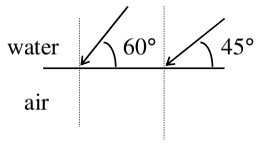
5. Light goes from flint glass into ethanol. The angle of refraction in the ethanol is 25^o. What is the angle of incidence in the glass?

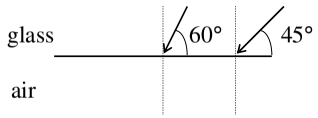
6. A beam of light strikes the flat, glass side of a water filled aquarium at an angle of 40^o to the normal. For glass, n=1.5, at what angle does the beam enter the glass? Enter the water?

7. What is the speed of light in a diamond? Water? Crown glass? Flint glass?

8. What is the critical angle for water? Diamond? Crown glass? Flint glass?

9. a) Complete the diagrams below showing the path of the refracted and/or the reflected ray. The critical angle for water is 49 degrees. b) Repeat the drawings for a glass - air boundary when the critical angle is 42 degrees.





10. The critical angle for an air to certain type of glass boundary is 39 degrees. (a) What is the index of refraction for that type of glass? (b) What is the speed of light in that type of glass?

11. Plates X and Y in the figure below have parallel surfaces and are surrounded by air. The values for the indices of refraction are shown in the figure as well as a ray of monochromatic light which is incident upon plate X from air.
    A) Calculate the angle of refraction for plate X
    B) Determine the angle of incidence and the angle of refraction for the X-Y boundary
    C) Calculate the angle of refraction of the Y-air boundary.