Refraction Problems

Remember   "n" for air is always 1.0 $c = 3.0 \times 10^8$ m/s

1) Use the given information to solve for the unknowns in the chart below.

Material	Index of refraction (n)	Speed of light in the given medium (v)
Ruby	1.54	1.95×10^8 m/s
Sapphire	1.78	1.69×10^8 m/s
Diamond	2.42	1.24×10^8 m/s
Water (liquid)	1.33	2.26×10^8 m/s
Water (ice)	1.30	2.31×10^8 m/s

$$n = \frac{c}{v}$$

$$v = \frac{c}{n}$$

2) Why is the index of refraction different for water as a liquid as compared to solid state?

Water in liquid state is more dense than ice. We know this since ice floats on water.

3) Complete the chart below. Make you calculations on another page.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Medium 1	Medium 2	Index of refraction (n_1)	Index of refraction (n_2)	Angle of incidence (θ_1)	Angle of refraction (θ_2)
Air	Diamond	1.00	2.42	30°	11.9°
Air	Zircon	1.00	1.90	30°	15.3°
Diamond	Air	2.42	1.00	4.1°	10°
Water	Diamond	1.33	2.42	18°	10°

$$\frac{(1.00)(\sin 30°)}{n_2} = \sin\theta_2$$

$$\frac{n_2 \sin 10°}{n_1} = \sin\theta_1$$

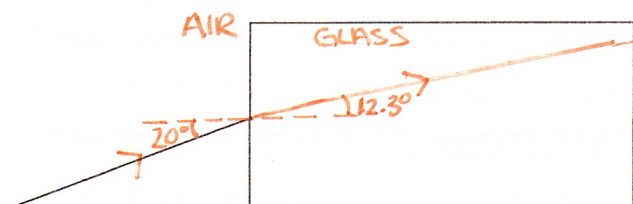4) If the angle of incidence (from crown glass, n=1.52) is 30°, find the angle of refraction in diamond.

$$\frac{(1.52)\sin 30°}{2.42} = \sin\theta_2 \qquad \theta_2 = 18.3°$$

5) a) Draw a **ray diagram** to show the path of ray of light as it passes from air into a block of glass (n=1.61). Be sure to sketch the **normal** and show your **measured angles** and **calculations** using Snell's Law.

$$\frac{(1.00)\sin 20°}{1.61} = \sin\theta_2$$

$$\sin\theta_2 = 0.212$$

$$\theta_2 = 12.3°$$

AIR   GLASS

20°   12.3°

b) What would happen to the angle of refraction if the block was made of ice (n=1.30)?

(larger)   smaller   same

c) How will the light bend when it passes back into the air?

Toward normal   OR   (away from normal)

6) Complete the chart below

Medium 1	Medium 2	Index of refraction (n_1)	Index of refraction (n_2)	Critical Angle (θ_2)
Diamond	Air	2.42	1.00	24.4°
Water	Air	1.33	1.00	48.8°
Glass	Water	1.52	1.33	61. °

7) In the diagram below, light is crossing a boundary from air to water (n = 1.33).
Draw the **normal line**, indicate the **direction** of the rays & **label** each medium as air or water.

Boundary _____ AIR / WATER
58°
40°
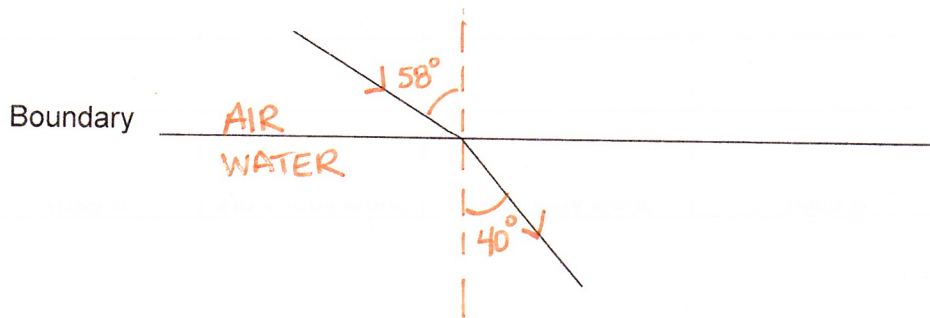
8) A diagram below shows a ray travelling from air into an object composed of 3 different media.
Complete the diagram by continuing the **ray** until it leaves the object.
Remember to draw a new normal at the boundary between each medium

$$\frac{(1.00)(\sin 35°)}{1.35} = \sin \theta_2$$

$$\theta_2 = 25.1°$$

n=1.35

3.4°

n=1.70

28°

$$\frac{(1.70)(\sin 28°)}{1.00} = \sin \theta_2$$

$$\theta_2 = 52.9°$$

48° 43.8°

25.1°

n=1.45 4°

35°

$$\frac{(1.35)(\sin 48°)}{1.45} = \sin \theta_2$$

$$\theta_2 = 43.8°$$

$$\frac{(1.45)(\sin 4°)}{1.70} = \sin \theta_2$$

$$\theta_2 = 3.4°$$