1. a) $n_{ice} = \frac{c_{vacuum}}{c_{ice}} = \frac{299'792\ \frac{km}{s}}{190'000\ \frac{km}{s}} = \underline{1.58}$

   b) $n_{plexiglass} = \frac{c_{vacuum}}{c_{plexiglass}} = \frac{299'792\ \frac{km}{s}}{201'000\ \frac{km}{s}} = \underline{1.49}$

2. a) $c_{salt} = \frac{c_{vacuum}}{n_{salt}} = \frac{299'792\ \frac{km}{s}}{1.54} = 194'670\ \frac{km}{s} = \underline{\underline{1.94 \cdot 10^5\ \frac{m}{s}}}$

   b) $c_{ethanol} = \frac{c_{vacuum}}{n_{ethanol}} = \frac{299'792\ \frac{km}{s}}{1.36} = 220'435\ \frac{km}{s} = \underline{\underline{2.20 \cdot 10^5\ \frac{m}{s}}}$

3. a) slower

   b) smaller

   c) less / larger

4. The angle between the light ray and the normal is smaller on the upper side. Thus, on the upper side, light travels slower and the material's index of refraction is higher. Glass is on the upper side.

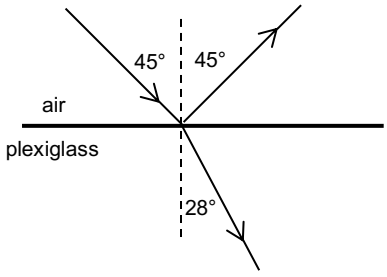
5. $n_{unknown} = \frac{\sin(\theta_{air})}{\sin(\theta_{unknown})} = \frac{\sin(45°)}{\sin(17°)} = 2.42$ <u>Diamond</u>

6. a) $\frac{\sin(\theta_{plexiglass})}{\sin(\theta_{air})} = \frac{c_{plexiglass}}{c_{air}} = \frac{n_{air}}{n_{plexiglass}} = \frac{1}{n_{plexiglass}}$

   $\sin(\Theta_{plexiglass}) = \frac{c_{plexiglass} \cdot \sin(\theta_{air})}{c_{air}}$

   $\Theta_{plexiglass} = \arcsin\left(\frac{c_{plexiglass} \cdot \sin(\theta_{air})}{c_{air}}\right)$

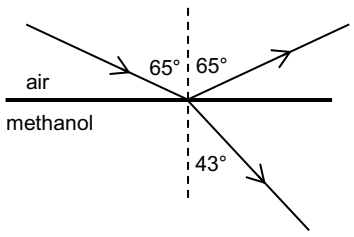
   $= \arcsin\left(\frac{2.01 \cdot 10^8\ \frac{m}{s} \cdot \sin(45°)}{2.997 \cdot 10^8\ \frac{m}{s}}\right) = \underline{28.3°}$



   b) $\frac{\sin(\theta_{methanol})}{\sin(\theta_{air})} = \frac{c_{methanol}}{c_{air}} = \frac{n_{air}}{n_{methanol}} = \frac{1}{n_{methanol}}$

   $\sin(\Theta_{methanol}) = \frac{\sin(\theta_{air})}{n_{methanol}}$

   $\Theta_{methanol} = \arcsin\left(\frac{\sin(\theta_{air})}{n_{methanol}}\right) = \arcsin\left(\frac{\sin(65°)}{1.33}\right) = \underline{43.0°}$



7. a) $\Theta_{critical} = \arcsin\left(\frac{n_{vacuum}}{n_{window\ glass}}\right) = \arcsin\left(\frac{1}{1.52}\right) = \underline{41.1\ °}$

b) $\Theta_{critical} = \arcsin\left(\frac{n_{ethanol}}{n_{diamond}}\right) = \arcsin\left(\frac{1.36}{2.42}\right) = \underline{34.2\ °}$

c) $\Theta_{critical} = \arcsin\left(\frac{c_{ice}}{c_{water}}\right) = \arcsin\left(\frac{190'000\ \frac{km}{s}}{225'000\ \frac{km}{s}}\right) = \underline{57.6\ °}$

8. a) yes, because the light ray is coming from the medium with the higher index of refraction

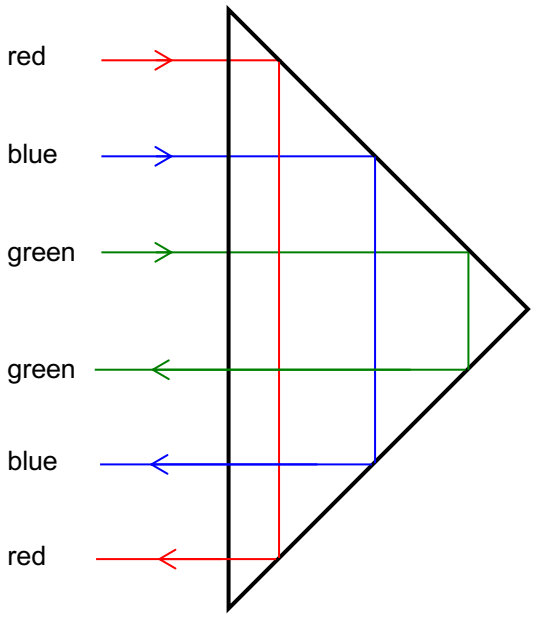
$\Theta_{critical} = \arcsin\left(\frac{n_{air}}{n_{diamond}}\right) = \arcsin\left(\frac{1}{2.42}\right) = \underline{24.4\ °}$

b) No, because light travels faster in air than in water.

c) Yes, because the light ray strikes the boundary from the glass side. The refractive index of glass is higher than the refractive index of ethanol.

$\Theta_{critical} = \arcsin\left(\frac{n_{ethanol}}{n_{window\ glass}}\right) = \arcsin\left(\frac{1.36}{1.52}\right) = \underline{63.5\ °}$

9.



The light rays are upside down. Red is now at the bottom and green is on the top.

10. Due to total internal reflection the light ray stays within the glass rod.