Question 1

A fiber optic cable is constructed with two types of plastic, one with an index of refraction of 1.45 and the other with an index of refraction of 1.52. One plastic forms the centre, while the other surrounds the core.

Which plastic is the cladding and which is the core (the centre), and why?

The core has a higher refractive index, so that total internal reflection can occur. This way none of the light signal is lost by being transmitted to the ground.

What is the minimum angle that a light ray in the core can strike the cladding on the inside and not be transmitted into the other plastic?

We are looking for the minimum angle, so we have $\theta_2 = 90°$. Thus we know

$$n_1 \sin\theta_c = n_2 \sin 90° = n_2.$$

This implies that

$$\sin\theta_c = \frac{n_2}{n_1}.$$

We know that $n_1 > n_2$ from the last question so we have

$$\sin\theta_c = \frac{1.45}{1.52} = 0.954$$

This gives

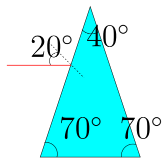
$$\theta_c = 72.54°$$

So rays with $\theta > 72.54°$ are totally internally reflected.

Question 2

We have a prism with refractive index 1.5, and an incident light ray as shown.

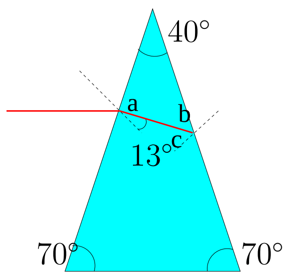
a) Use Snell's law to find the path of the ray of the final triangle



We already have the first normal drawn for us. We know that the light is going to bend toward the normal, as the glass has a higher refractive index than the surrounding air. Putting this into Snell's law, we have

$$\begin{aligned} n_{\text{air}} \sin\theta_{\text{air}} &= n_{\text{glass}} \sin\theta_{\text{glass}} \\ (1.0)\sin 20^\circ &= (1.5)\sin\theta_{\text{glass}} \\ \sin\theta_{\text{glass}} &= 0.228 \\ \theta_{\text{glass}} &= 13.2^\circ \end{aligned}$$

We now have the following picture



Here a, b and c all stand for the angles in the triangle. We need a little bit of geometry to be able to figure out what is going to happen here. But first, which angle are we looking for? Well, we want the angle between the normal and the incident ray, which in this case is angle c.

We know the angle between the normal and the surface of the triangle is 90°, by definition of the normal. This tells us

$$a + 13.2^\circ = 90^\circ \Rightarrow a = 76.8^\circ.$$

We also know that the sum of all the interior angles of a triangle is 180 degrees. This tells us

$$a + b + 40^\circ = 180^\circ \Rightarrow a + b = 140^\circ$$

Using the value of a that we already calculated, we derive

$$b = 63.2°$$

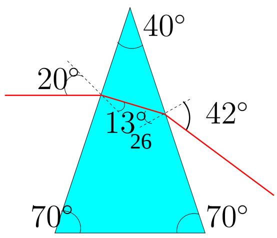
By the definition of normal, we can figure out c, as the angle $(b + c)$ is the angle between the normal and the triangle:

$$b + c = 90° \Rightarrow c = 26.8°$$

Now that we know what the angle between the glass and the normal is, we can just apply Snell's law again:

$$\begin{aligned} n_{\text{glass}} \sin c &= n_{\text{air}} \sin \theta_{\text{air}} \\ (1.5) \sin 26.8° &= (1.0) \sin \theta_{\text{air}} \\ \sin \theta_{\text{air}} &= 0.6763 \\ \theta_{\text{air}} &= 42.6° \end{aligned}$$

So the final picture looks like this:



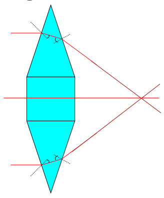
As we can see, the initial light is bend downward from the horizontal position.

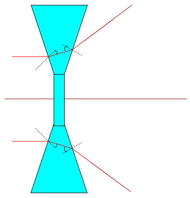
c) Inverting the prism

This would be the same picture (and the same angles) turned upside down, so the light would now be bent upward.

d) What happens to the two diagrams shown?

Just take the rays and apply each prism that we have already calculated to it. The middle bit we have not done, but the angle of incidence (and hence the angle of refraction) is zero degrees, meaning it goes right through.





As we see, the figure on the left focuses the light, while the one on the right defocuses it. This will be important when we look at lenses in the next DL. . .