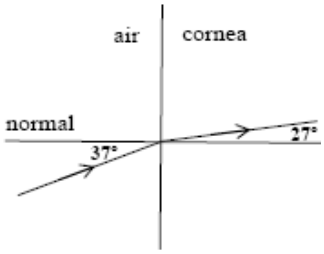
State Examination Commission – Physics Higher Level, 2008

Question 9

What is meant by refraction of light?
State Snell's law of refraction. (12)
An eye contains a lens system and a retina, which is 2.0 cm from the lens system.
The lens system consists of the cornea, which acts as a fixed lens of power 38 m^{-1}, and a variable internal lens just behind the cornea. The maximum power of the eye is 64 m^{-1}.
Calculate:
(i) how near an object can be placed in front of the eye and still be in focus;
(ii) the maximum power of the internal lens. (15)
Light is refracted as it enters the cornea from air as shown in the diagram.
Calculate the refractive index of the cornea. (6)
Draw a diagram to show the path of a ray of light as it passes from water of refractive index 1.33 into the cornea. (6)



A swimmer cannot see properly when she opens her eyes underwater.
When underwater:

(i) why does the cornea **not** act as a lens?
(ii) what is the maximum power of the eye?
(iii) why do objects appear blurred?
(iv) explain how wearing goggles allows objects to be seen clearly. (17)

What is meant by refraction of light? State Snell's law of refraction. (12)

Basic terms

An eye contains a lens system and a retina, which is 2.0 cm from the lens system. The lens system consists of the cornea, which acts as a fixed lens of power 38 m^{-1}, and a variable internal lens just behind the cornea. The maximum power of the eye is 64 m^{-1}. Calculate:
(i) how near an object can be placed in front of the eye and still be in focus;

Maximum refractive power of lens system $P = 64\ m^{-1}$
=> minimum focal length of lens system $f = 1/64 = 0.0156$ m (1.56 cm)
Now, when the lens system has adjusted to this focal length, the distance u, (the near point), the object is away from the eye, when the image is formed 2 cm behind the eye, is got from

$1/f = 1/u + 1/v$
$1/u = 1/f - 1/v$
$= 64 - 1/0.02$
$= 64 - 50 = 14$
$\Rightarrow u = 0.071$ m $= 7.1$ cm

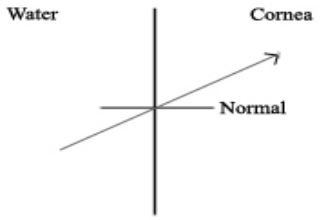
(ii) the maximum power of the internal lens. (15)

Since, $P = P_1 + P_2$
$64 = 38 + P_2$
$P_2 = 26\ m^{-1}$

Light is refracted as it enters the cornea from air as shown in the diagram.
Calculate the refractive index of the cornea. (6)

$n = \sin i / \sin r = \sin 37^0 / \sin 27^0 = 1.33$

Draw a diagram to show the path of a ray of light as it passes from water of refractive index 1.33 into the cornea. (6)



No refraction will take place as both media have equal indices of refraction

A swimmer cannot see properly when she opens her eyes underwater. When underwater:
(i) why does the cornea **not** act as a lens?

Because light entering the cornea is not refracted (see above)

(ii) what is the maximum power of the eye?

26 m^{-1} (power of the internal lens alone – cornea doesn't contribute)

(iii) why do objects appear blurred?

This maximum power gives a minimum focal length, f = 0.0385 m = 3.85 cm. A converging lens system cannot form a real image inside f, and as the image must be formed on the retina, 2 cm away from the lens, it would not be possible to have a clear image formed there.

(iv) explain how wearing goggles allows objects to be seen clearly. (17)

wearing goggles allows the light once again to be refracted at the air/cornea boundary, therby increasing the power of the lens combination.