Homework Ten.

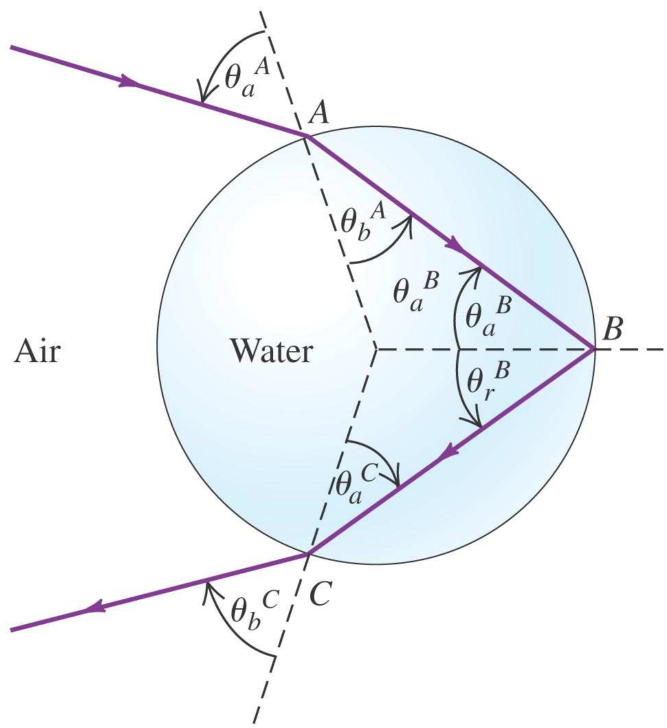
1) An astronaut loses contact with the hull of a space station and finds himself floating 16m from the station with zero velocity relative to it. Fortunately, he is carrying a 200W flashlight. Turning on the torch he uses it as a "light rocket". If he weighs 150kg, how long will it take to get back to the ship? Is there another way he could use the flashlight to accomplish the same job of returning to the ship?

2) An inside corner of a cube is lined with mirrors to make a corner reflector. A ray of light is reflected successively from each of the three mutually perpendicular mirrors. Show that its final direction is always eactly opposite to its initial direction.

3) The radius of curvature of the convex surface of a planoconvex lens is 95.2cm. The lens is placed convex side down on a perfectly flat glass plate that is illuminated from above with red light having a wavelength of 580 nm. Find the diameter of the second bright ring in the interference pattern.

4) What is the thinnest soap film (excluding the case of zero thickness) that appears black when illuminated with light with a wavelength of 480nm? The index of refraction of the film is 1.33 and there is air on both sides of the film.

Bonus, 25%) A rainbow is produced by the reflection of sunlight by spherical drops of water in the air. The following figure shows a ray that refracts into a drop at point A, is reflected from the back surface of the drop at point B, and refracts back into air at point C.



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i) Show that $\theta_a^B = \theta_b^A$, $\theta_a^C = \theta_b^A$ and $\theta_b^C = \theta_a^A$.

i) Show that the angle in radians between the ray before it enters the drop at A and after it exits at C (the total angular deflection of the ray) is $\Delta = 2\theta_a^A - 4\theta_b^A + \pi$.

iii) Use Snell's law to write Δ in terms of θ_a^A and n, the refractive index of the water in the drop.

iv) A rainbow will form when the angular deflection Δ is *stationary* in the incident angle θ_a^A - in other words, when $d\Delta/d\theta_a^A = 0$. If this condition is satisfied then all of the rays with incident angles close to θ_a^A will be sent back in the same direction, producing a bright zone in the sky. Let θ_1 be the value of θ_a^A for which this occurs. Show that $\cos^2\theta_1 = \frac{1}{3}(n^2 - 1)$. [Hint: You may find the derivative formula $d(\arcsin(u))/dx = (1 - u^2)^{-1/2}(du/dx)$ helpful.]