Physics Integration Lesson 21 – Optimal Universe?

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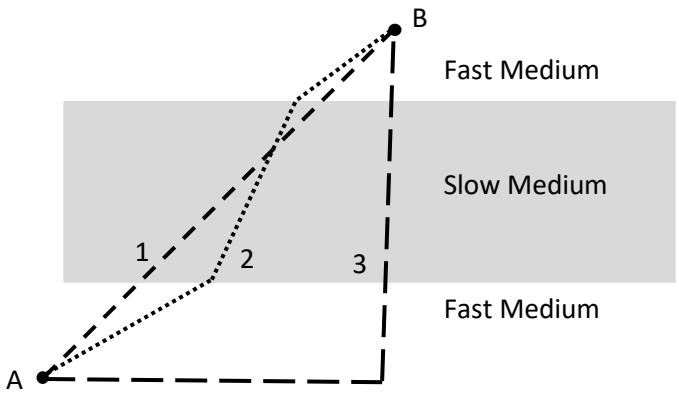
Whenever I cover the topic of refraction, I am reminded of a conversation with Dr. Hammett about "Do Dogs Know Calculus?" If a ball is thrown in still water at a beach, will a dog run/swim directly towards the ball or will it take a different path to reduce the swimming time. A mathematician and dog owner tested this out and recorded his findings in the document http://www.math.pitt.edu/~bard/bardware/classes/0220/dkc.pdf. The dog takes a path that minimizes the time to the ball, not the path to minimize swimming. This would imply that dogs know calculus because they are able to minimize a function.

In optics, there is a similar minimization going on. As illustrated in the following diagram, light originates at point A and reaches a destination at point B. The shaded region between those two points is a medium at which the speed of light is slower, such as glass. The question is, "What path does it take?" Path #1 is a line of sight motion that minimizes distance, path #2 is a combination of diagonal motions through the air and glass that minimizes travel time and path #3 is a path that minimizes the distance within the glass. It ends up that Path #2 is the one chosen by nature. Does this mean that light knows calculus?



This observation is called Fermat's Principle (1662): the path taken by a ray of light between any two points is the one that can be traveled in the least amount of time. In mechanics there is a corresponding principle developed by Lagrange (1760) by applying calculus of variations to T – V, the difference between kinetic energy and potential energy. This is called the Principle of Least Action. When these principles were discovered, they were considered evidences that the natural world is optimally designed. Mathematical principles, such as these, led Eugene Wigner to write the article, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences." Why is it that the universe can be modelled so effectively by mathematical principles?

As a creationist, we marvel at these connections between mathematics and nature. However, if the existence of a creator is denied, alternate explanations must be made. With respect to the dog, its optimal behavior may be explained as the result of learning, where the dog receives a reward quicker if it gets to its favorite ball faster. This could be tested by observing a dog first learning to retrieve a ball from water rather than by observing a dog conditioned by multiple years of experience. With regard to Fermat's principle and Lagrange's equations, one may state that it is the result of how we define concepts such as energy, velocity and force. In the case of Wigner's article, maybe mathematics is so rich and varied that eventually mankind would find something that worked.

1. Machine learning algorithms take large bodies of data and extract useful information. Their performance is improved if you program in a reward system that reinforces an acceptable outcome. This is not much different than the dog learning the best way to retrieve a ball in

water. Is this analogy between a computer program and a dog sufficient to explain away the need for a Creator? Are there any problems with this analogy? Explain.

2. The secular response to Wigner's article implies that evolution made mankind such a good problem solver that he could see patterns in nature that are unrelated to the need for survival. This implies that mathematics is just a human invention rather than "thinking God's thoughts after him" (Johannes Kepler). How would you respond to those who hold to this secular response that optimization in nature does not imply a creator? What questions would you ask them?