Eddie Price **Quiz 10 Solutions** **Spring 2017**

High score: 10; Non-0 Low score: 2; Average score: 7.78 (including 0's)

Problem 1 (10 Points). In a laboratory, a device measures the number of photons that pass through a tube, closed at both ends. A beam of light containing 60 trillion photons is fired from one end of the tube, passing the measuring device. Whenever the beam of light hits one of the ends of the tube, approximately 80% of the photons remaining in the beam bounce back, pass by the measuring device, and head for the other end of the tube, while the other 20% of the remaining photons are absorbed into the ends of the tube and do not pass the measuring device again. In the long run, how many photons will be recorded as having passed by the measuring device?

Solution. Initially, 60 trillion photons pass the measuring device. The beam hits the end and 80% of the photons in the beam ((60 trillion) $\cdot$ 0.8 photons) bounce back and pass the measuring device. Then that beam hits the end, and 80% of that beam ((60 trillion)$\cdot 0.8 \cdot 0.8 =$ (60 trillion) $\cdot\, 0.8^2$ photons) bounce back and pass the measuring device. Then that beam hits the end, and 80% of that beam ((60 trillion) $\cdot\, 0.8^2 \cdot 0.8 =$ (60 trillion) $\cdot\, 0.8^3$ photons) bounce back and pass the measuring device. etc. Therefore, we have the series

$$(60 \text{ trillion}) + (60 \text{ trillion}) \cdot 0.8 + (60 \text{ trillion}) \cdot 0.8^2 + (60 \text{ trillion}) \cdot 0.8^3 + \dots$$

From the above series, we can see that the series is geometric with $a = 60$ trillion and $r = 0.8$. Since $-1 < 0.8 < 1$, the series converges and its sum is

$$\frac{a}{1-r} = \frac{60 \text{ trillion}}{1 - 0.8} = \boxed{300 \text{ trillion photons}}$$

Common Mistakes

Many people did not include the photons measured from the original beam of light which passed by the measuring device.

Many people forgot to label their result as "trillions" instead saying that 300 photons passed by.