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Is Snooker Really That Difficult? by I. Morris

In the past, it was considered that a misspent youth was a prerequisite for playing good snooker but what can a scientist learn from a more analytical approach? 1

Snooker is rather a simple game and is concerned, mainly, with collisions between two spherical objects. All you have to do is hit one ball (the white or cue ball) in the right direction so that it hits another ball (the object ball) towards the hole (the pocket). With this in mind, one of the first things that a scientist with a good knowledge of dynamics can do is work out the angle at which the white ball leaves after the collision with the object ball. Consider, for example, the following set up: 2

Before collision

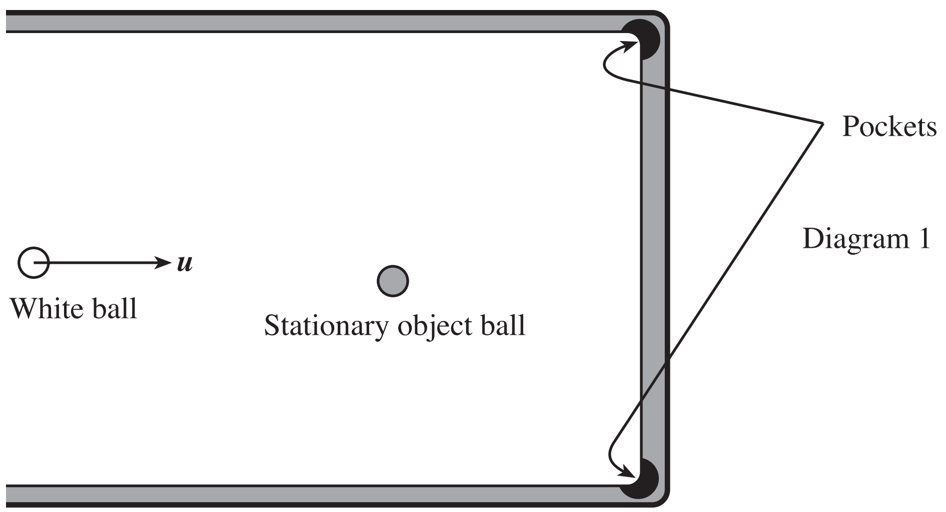

Diagram 1

After collision

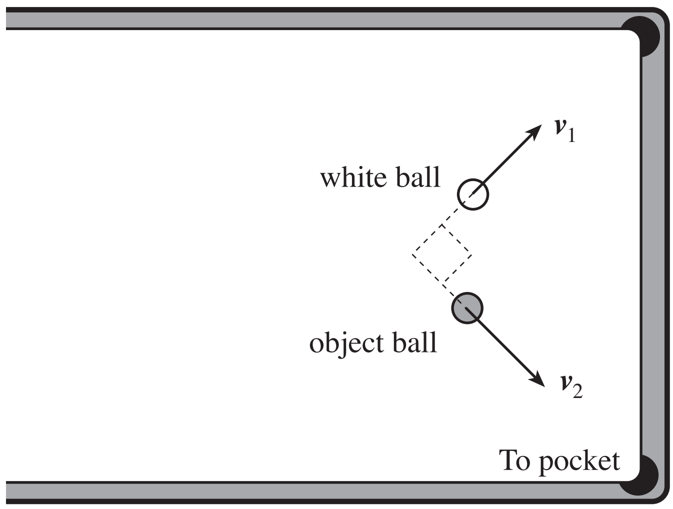

Diagram 2

If the snooker balls have mass m then conservation of momentum means that 3

$$m\boldsymbol{u} = m\boldsymbol{v}_1 + m\boldsymbol{v}_2 \qquad or \qquad \boldsymbol{u} = \boldsymbol{v}_1 + \boldsymbol{v}_2 \qquad \text{equation 1}$$

since the masses are equal and will cancel.

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In a similar manner, an elastic collision means that we will have 4

$$u^2 = v_1^2 + v_2^2 \qquad \text{equation 2}$$

The conservation of momentum equation ($\boldsymbol{u} = \boldsymbol{v}_1 + \boldsymbol{v}_2$) is a **vector** equation. It means that if we add $\boldsymbol{v}_1 + \boldsymbol{v}_2$ as **vectors** the resultant will be $\boldsymbol{u}$. It also means that we can draw a triangle with the ***vectors*** $\boldsymbol{u}$, $\boldsymbol{v}_1$, $\boldsymbol{v}_2$ as its sides. In combination with Equation 2 however, we gain information which is far more interesting. Note that equation 2 is in the form of Pythagoras's theorem and therefore tells us that the angle between $\boldsymbol{v}_1$ and $\boldsymbol{v}_2$ is 90°. 5

This is one of the most valuable pieces of information that physics provides the snooker player. No longer is the motion of the white ball a big mystery after potting the object ball, we now, at least, know in which direction the white ball is going to start to move after the collision - it will go at right angles to the direction the object ball leaves. 6

There are slight modifications that must be considered because collisions are not elastic on real snooker tables but this 90° theory is not a bad approximation for anyone starting to play snooker. 7

Unfortunately, physics does not always simplify the game of snooker. Another example of a snooker equation derived by mechanics tells us how difficult a pot is before we even attempt it. The equation is:

$$y = \frac{D_1 D_2}{d\cos\phi}\theta \qquad \text{equation 3}$$

where the variables are the following and may be clarified in diagram 3 and diagram 4.

- y = the final error in position of the object ball when it gets to the pocket
- D_1 = the distance between the object ball and the white ball
- D_2 = the distance between the object ball and the pocket
- ϕ = the angle between the direction of the white ball and the object ball
- θ = the angular error **(in radians)** of the direction of the white ball
- d = the diameter of a snooker ball (0.0525m)

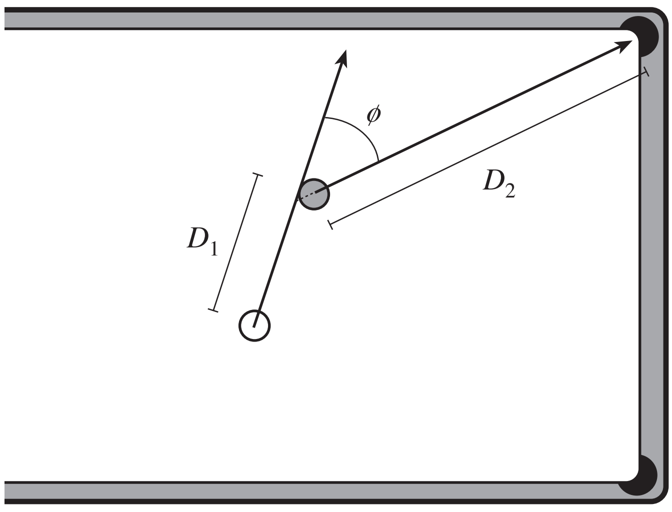

Diagram 3 (simplified snooker pot)

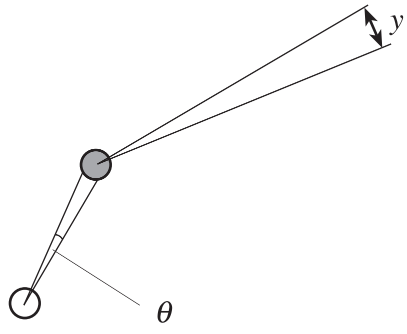

Diagram 4

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Equation 3 is not a particularly complicated equation, after all, there are more complicated equations in the 'A' level physics syllabus. Neither is equation 3 particularly exciting to look at. Nevertheless, equation 3 starts to give an insight into the true difficulty of the game of snooker when combined with another equation from a completely different and apparently unconnected realm of physics - astronomy. 8

Some Telescope Theory

$$\theta = 1{\cdot}22\frac{\lambda}{W} \qquad \text{equation 4}$$

where λ = the wavelength of the light
W = the width of the aperture of the telescope (see diagram 5)
θ = the smallest angle in radians where two objects (e.g. stars) can be seen as separate (images that do not overlap)

This equation is even less complicated than equation 3 and is rather useful for determining the resolving power of a telescope. 9

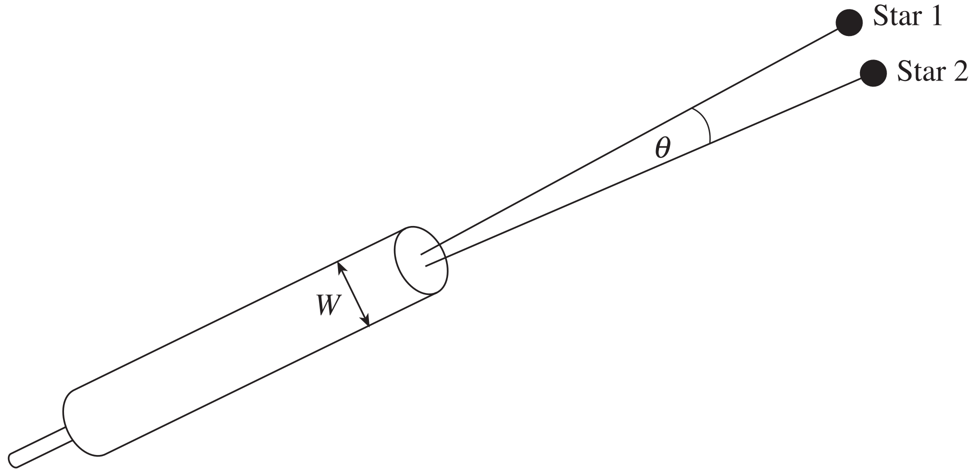

Diagram 5

Essentially, equation 4 is a limit to the power of a telescope due to light being diffracted as it enters the telescope. The reason for this is that, as light enters the aperture, it will 'spread out' due to diffraction, thus blurring the image. 10

Does equation 4 have anything to do with snooker? 11
Obviously, no one uses a telescope while they are playing snooker. However, they do use their eyes and the aperture of the eye will diffract light, just like the telescope. The width of the aperture of the eye (under playing conditions) is around 2 mm. When equation 4 is applied to the eye it gives the smallest resolvable angle as 0.3 milliradians (around 0.02°). Not bad, you might think, because this is better than a good laser sighting system which would only have accuracy of about 1 milliradians but where does this leave us for playing snooker? Is it possible, theoretically, for us to pot every shot on the table all the time ?

The answer to this question lies in combining equation 3 and equation 4. Why? Because, surely, it can't be possible to hit the white ball straighter than you can see? Surely, the absolute limit of accuracy with which a great player can hit the white ball (θ in equation 3) cannot be smaller (or more accurate) than the smallest angle the player can 'see' out of the player's own eye (θ in equation 4). 12

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Let's examine a reasonably easy pot for a professional player (see below).

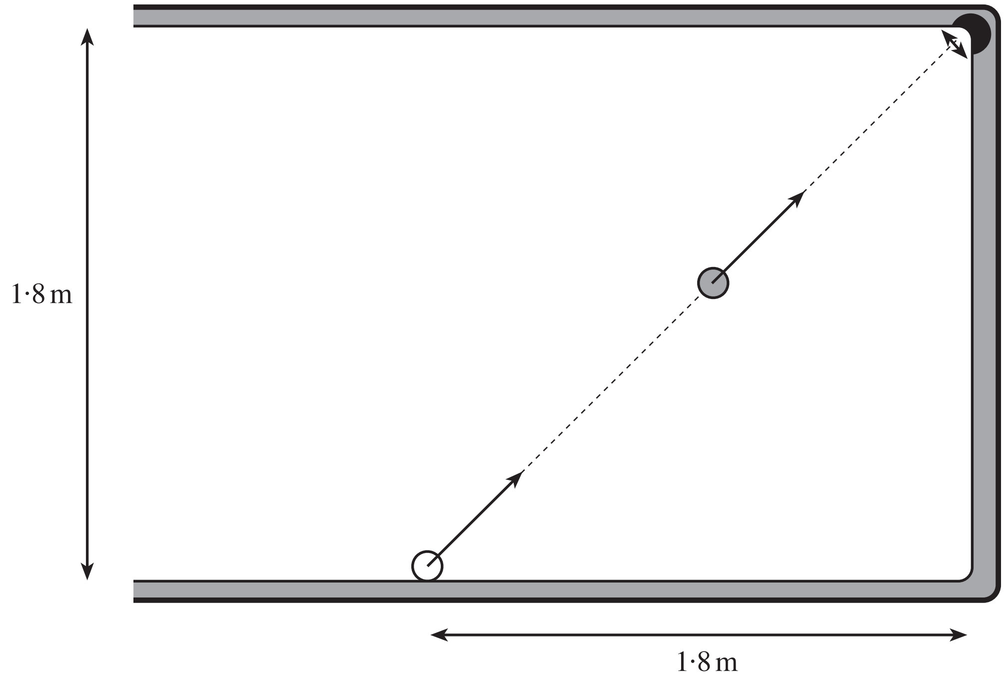

Diagram 6

Now, if you remember, y is the final error in position of the object ball when it gets to the pocket. For a professional snooker table, if $y > 0{\cdot}02$ m the pot will be missed. When this and the other relevant data is put in equation 3, we find that the above pot requires an accuracy of around 0·6 milliradians in the direction of the cue ball (θ). This is not very far from the ultimate limit of accuracy attainable because of the smallness of the human eye! 13

To the original question posed by the title of this article, I believe that we may answer confidently - YES! Nonetheless, theories discussed herein raise further questions that may or may not be answered some other time, for instance - do professional snooker players defy the laws of physics by potting more difficult pots regularly? 14