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A4_7 Tipler in my back pocket

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Abstract

This paper determines the speed needed for an observer to travel at for them to believe that the book *Physics for Scientists and Engineers* by Tipler and Mosca could fit into an average sized back pocket, due to special relativitic effects. This value was then compared to the speed needed for the Elizabeth Tower to fit in one's back pocket. The speeds determined were $0.619 \pm 1 \times 10^{-3}$ c and $0.998886 \pm 2 \times 10^{-6}$ c for Tipler and the Elizabeth Tower respectively.

Introduction

Physics for Scientists and Engineers Volume 6 by Tipler and Mosca (from here onward referred to as Tipler) is a core reading book as part of undergraduate study at the University of Leicester [1]. It is a common thought of students to wish to take their books/notes into exams, as to make the memorisation of content easier. In this paper, we seek to determine the speed that one would need to travel in order for Tipler to appear able to fit into one's back pocket. We then compare this to fitting the Elizabeth Tower, of which Big Ben resides in, in one's back pocket. We chose the Elizabeth Tower as a comparison as it is a famous and recognisable building in the UK [2].

Theory

One way for an object to appear smaller is for length contraction to occur. In Einstein's 1905 paper, he stated that when approaching the speed of light, an object would appear to contract [3]. The formula for this shown in equation (1).

$$x' = x\sqrt{1 - \left(\frac{v}{c}\right)^2} \tag{1}$$

Where x' is the length observed in the frame moving relative to the object, x is the length in a stationary frame to the object, v is the speed of the moving observer and c is the speed of light. As we wish to know the speed at which an observer must be travelling in order to belive an object could fit into one's back pocket, we must rearrange equation (1) for $\frac{v}{c}$ (for the fractional speed of light), as is shown in equation (2). We state that the observer would *believe* this to be the case, as if Tipler were moving with the observer, no length contraction would occur.

$$\frac{v}{c} = \sqrt{1 - \frac{x'}{x}} \tag{2}$$

We must know the size on an average sized back pocket, to determine the value of x. This was done by measuring the width and height of different pockets, on various styles of trousers. Note, the same experimenter conducted all the readings, bending down to remove any parallax

effects. The readings were done from the inner hem line, as this would be the only *usable* pocket space. From table (1), the mean pocket height was found to be 16.6 ± 0.05 cm and the mean pocket width was found to be 13.7 ± 0.05 cm. We have made the assumption that all pockets are rectangular, as some pockets are tapered and have a shallow "V" shape towards the lower end, as can be seen in figure (1).

Person Number	Pocket Height (cm) ±1 mm	Pocket Width (cm) ±1 mm
1	17.2	15.0
2	14.3	12.0
3	16.2	13.7
4	16.9	12.6
5	18.6	15.1

Table 1: Pocket sizes

Figure 1: Triangular jean pocket [4]. The red length shows the height, and the white length shows the width of the pocket.

Using the mean values gathered from table (1) we can calculate the diagonal length of a pocket to be 21.5 cm ± 0.05 cm. We use this value as both the width and height of Tipler need to be reduced to fit in a pocket. It should be noted, as we are using the diagonal length of Tipler, the observer must travel along the diagonal axis of Tipler. The book has a height and width of 27.3 cm and 21.8 cm respectively [5]. It therefore has a diagonal length of 34.9 cm.

Results

From the given data in the Theory section and equation (2), we determine that an observer would need to go at 0.619 ± 1×10^{-3} c in order for Tipler to fit into their back pocket. We can then compare this to the Elizabeth Tower, which has a height of 96 m and a width of 12 m [6]. Using the same mathematical approach, an observer would need to travel 0.998886 ± 2 $\times10^{-6}$ c for the Tower to fit in their back pocket. This is a significant increase in speed compared to fitting Tipler into one's back pocket.

Conclusion

We determined that one requires to travel at a speed of 0.619 ± 1×10^{-3} c and 0.998886 ± 2 $\times10^{-6}$ c for Tipler and the Elizabeth Tower to fit into one's back pocket, respectively. These speeds would not be possible with today's given technology, and therefore students can just be advised to learn the content, rather than trying to smuggle Tipler in their back pocket for exams.

References

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