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# P5_1 Squashing Slitheen

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**Abstract**

To disguise themselves on Earth, Raxacoricofallapatorians hid in suits of human skin using a compression field worn around their necks. Over time, developments in their technology allowed them to fit into average sized humans, as opposed to obese humans used previously. We calculated the pressure exerted on the inside of the skin as 138,000 Pa for an average human and 103,000 Pa for an obese human, both significantly beneath the ultimate tensile strength of human skin. We calculated the force from the compression fields to be 501,000 N and 374,000 N for average and obese humans respectively.

## Introduction

In the BBC television show Doctor Who, a family of calcium-based bipeds native to the Planet Raxacoricofallapatorius known as Slitheen disguise themselves as human beings by wearing the skins of their human victims. As these aliens are significantly larger than the average human, they are only able to do this by using a device to compress themselves into the skins of obese humans. In the spin-off programme The Sarah Jane Adventures, the creatures reappear with more advanced technology, meaning they can now pose as humans of an average weight. In this paper we calculate the pressure applied to the interior of the skin and what effect this would have, in addition to the force produced by their compression device in the cases for both an obese human and an average human.

## Theory and Results

In order to calculate the pressure of the aliens' bodies on the human skin, approximations of height, mass and volume were used. The volumes were calculated using the approximation of $1\text{kg} = 0.01\text{m}^3$. For an average human the height, mass and volume that we used were 1.7m, 70kg and $0.07\text{m}^3$ respectively. For an obese human the height, mass and volume that we used were 1.7m, 100kg and $0.1\text{m}^3$ respectively. The height of a Slitheen is 2.4m [1] and we estimated the mass to be 200kg. The volume was calculated as $0.28\text{m}^3$ by assuming the height scale factor applied to all three volume dimensions. We also assumed the bulk modulus of its flesh to be the same as for humans. The Bulk modulus of human flesh was found in literature as $0.1\times10^6$ N/m$^2$ [2]. The pressure can be calculated with Eq. (1) [3]:

$$B = -V\frac{dP}{dV}, \tag{1}$$

where $dP/dV$ is the rate of change of pressure on the skin with respect to volume, $B$ is the Bulk modulus of human flesh and $V$ is the volume. By integrating Eq. (1) we found a logarithmic relationship between the ratio of the volume of the Slitheen ($V_S$) and human ($V_H$) and the pressure exerted on the skin ($P$) as shown in Eq. (2):

$$P = B \ln \frac{V_S}{V_H}, \tag{2}$$

We found that for an obese human, the pressure applied to the skin is 103,000 Pa, and for an average human is 138,000 Pa . Both of these pressures are well below the ultimate tensile strength of skin, found in literature to be 27.2 ±9.3 MPa [4], and therefore the skin would easily withstand these pressures.

For the second part of our investigation, we calculated the force required by the compression field to fit the Slitheen inside the skin suits, using Eq. (3) [3] below

$$F = PA, \tag{3}$$

where $F$ is the force, $P$ is the pressure, and $A$ is the surface area of the human skin suit. We calculated the approximate surface area of a Slitheen using the Du Bois [5] formula, Eq. (4), where the height, $H$, in centimetres, and mass, $W$, are values we used above, and found it to be 3.63m$^2$.

$$A = 0.007184 \times W^{0.425} H^{0.725} \tag{4}$$

Using the pressures and surface areas calculated above we found that the force required to compress the Slitheen into an obese human is 374,000 N. For an average human the force required is 501,000 N. The force required when using an average human body is approximately 1.34 times larger than that required for an obese human body, therefore the development of the Slitheen technology between their appearance on Doctor Who and The Sarah Jane Adventures is clearly demonstrated.

## Discussion

We modelled the Slitheen as being completely composed of human flesh. This therefore neglects the effect of bones and other tissues inside the body of the alien. This model also is unlikely to be accurate as the species is calcium-based life, rather than carbon-based, and therefore the bulk modulus is likely to be different. However, we considered this to be an acceptable model, as we currently have no evidence of calcium-based life existing. We also modelled the bulk modulus as constant to simplify the calculations, however if we did not, it would likely increase greatly with the increased pressure. This would result in an increased pressure and force requirement. The equation used partially takes this into account, however further study could be done on this model to find out the full effects of the increasing bulk modulus.

This race of aliens are also very well known for having excessive flatulence due to the compression process, but we did not consider the additional pressures from the gas build-up in the skin suit. However, our results showed that the pressures calculated lie well below the maximum pressure that skin can endure and therefore these additional pressures would have a negligible effect.

## Conclusion

We conclude that human skin of both an obese and average individual would not be destroyed by the pressure of a Slitheen body being compressed inside. We also demonstrate that the compression technology of this species was able to advance to a point where the force exerted by their generated fields was approximately 1.34 times greater in their appearance in The Sarah Jane Adventures than in their first appearance in Doctor Who.

## References

[1] https://en.wikipedia.org/wiki/Slitheen [Accessed 4 October 2017]

[2] S. Mukherjee, et. al., *(*Modelling of Body Parts Consisting of Bones as well as Soft Tissue) IRCOBI, (Sept, 2003).

[3] https://en.wikipedia.org/wiki/Bulk_modulus [Accessed 26 October 2017]

[4] A. J. Gallagher, et. al., *(*Dynamic Tensile Properties of Human Skin) IRCOBI, (2012).

[5] http://www.calculator.net/body-surface-area-calculator.html [Accessed 4 October 2017]