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P4_8 Macau Tower G forces

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Abstract
The world's highest Bungee jump is recorded at Macau Tower in China. This paper investigates the g forces that would be experienced by a bungee jumper at the Macau Tower. The value calculated is 1.7g. The value obtained is compared with other accelerations to calculate the risk to the jumper. It was determined the acceleration experienced would not cause any permanent physiological effects to the jumper.

Introduction

Bungee jumping is an extreme sport where the participant jumps from a great height while attached to a bungee cord. There are many attempts made to set the record for the longest jump. The highest commercial jump has been set at the Macau Tower in China [1].

The human body is used to Earth's gravity. The forces felt as a body accelerates or decelerates can be measured in multiples of Earth's gravity g. The g force is a descriptive measure of acceleration.

This paper examines the g forces experienced by a jumper off the Macau Tower and calculates if there are any dangers to the jumper from acceleration experienced.

Analysis

The Macau tower platform is 233m from the ground and the bungee cord is 50m long. The cord is attached to the jumper's ankles, the jumper will free fall 50m before the cable stretches. The jumper will rebound 30m above the ground [1].

Assuming the jumper has a mass of 70kg, the cord has negligible mass, the cord obeys Hooke's law and neglecting air resistance, the g force experienced by the jumper at the bottom of the jump can be calculated.

The work energy theorem was applied in two cases: where the cord stretches and at the end of the free fall region.

Where the cord stretches the relation,

$$\frac{1}{2}kl_s^{\,2} = mgl_s + \frac{1}{2}mv_s^{\,2}, \qquad (1)$$

can be found, where k is the spring constant for the cord, l_s is displacement of the cord from rest, m is the mass of the jumper, g is the gravitational acceleration and v_s is the velocity of the body at the stretched length. Applying the relation at the end of the free fall scenario and rearranging for k gives,

$$k = \frac{2mg(l_c+l_s)}{l_s^{\,2}}, \qquad (2)$$

where l_c is the length of the cord.

Applying Newton's second law to the lowest point gives (where the bungee is fully stretched and v_s=0):

$$-mg + kl_s = ma_y. \qquad (3)$$

Rearranging for a_y:

$$a_y = g\left(1 + 2\frac{l_c}{l_s}\right), \qquad (4)$$

where a_y is the acceleration in the vertical direction towards the tower platform.

Substituting the values of l_c, 50m, and l_s, 153m, into equation (4) a value of 1.7g is obtained.

Issues

In the situation analysed the g force acts in the vertical direction. The duration of the force is an important factor; a human body can tolerate large amounts of force in a small time interval. The effects vary depending on where the g force acts on the body. At 2-3 G a human accelerated in a head ward position will experience lower arterial pressure in the eyes. They then lose peripheral vision creating a tunnel vision effect, slowly cone vision disappears until vision loss and then total blackout [2]. Figure 1 shows the human tolerance to g acceleration. The value calculated will not have any major impact on the health of the jumper as it is below the threshold stated. With the freefall lasting approximately 5 seconds [1] the whole jump can be estimated to last around 20 seconds which is a relatively low time for the force to act.

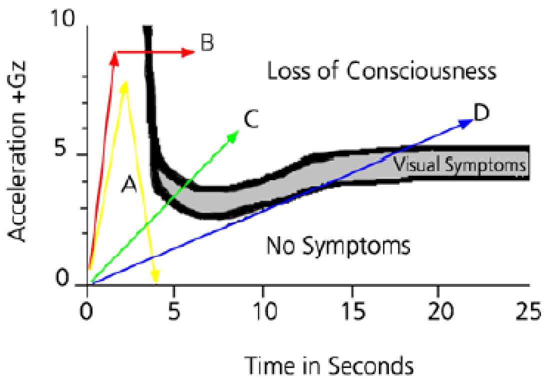

Figure 1 Tolerance to g acceleration [3].

Conclusion

The factors determining the physiological effects of the g force are the magnitude of the acceleration, its duration and where on the body it acts. The calculations performed have found that the g force experienced by a jumper at the Macau Tower, 1.7g *in* will not be significant to cause any major physiological effects.

References

[1]http://www.macautower.com.mo/en/dining_shopping_entertainment/adventure/bungy_jump/index.html [Accessed 13 November 2011]

[2]M. Voshell, High Acceleration and the Human Body,2004,p.7, http://csel.eng.ohio-state.edu/voshell/gforce.pdf [Accessed 13 November 2011]

[3]M. Voshell, High Acceleration and the Human Body,2004,p.11, http://csel.eng.ohio-state.edu/voshell/gforce.pdf [Accessed 13 November 2011]