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P4_8 No Mr Bond, I Expect You to Drive

J Nelms, D Roberts, S Thomas, D Starkey

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

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Abstract

This paper analyses the physics of the ejector seat shown in the James Bond film *Goldfinger*. By looking at frames from the film and modelling the ejection mechanism as a piston providing constant force, the motion of the ejected henchman was calculated. The henchman was found to reach a height of 2.37m at the apex of his ejection; a height which would not leave him seriously injured. The force required to eject him was found to be 1,930N, corresponding to a pressure of 8,870Pa if applied across a modelled seat of cross sectional area 0.218m^2. With comparisons to a typical piston from an engine, this was found to be a reasonable pressure and force for a piston to be able to generate.

Introduction

In the 1964 film *Goldfinger*, the main character is engaged in a car chase with one of the villain's henchmen in his Aston Martin DB5. However, with the use of one of the modifications to the car, James Bond is able to eject the henchman from his vehicle and into the air [1]. By analysis of frames from the film along with modelling the ejector seat as a piston providing a constant pressure across the passenger seat, the force required to power the ejector seat is calculated.

Discussion

In *Goldfinger*, the ejector seat is seen to accelerate the passenger of the DB5 through an opening in the roof and into the air. This motion was modelled as being a result of a constant force, acting on the seat and passenger from its initial position to its roof; this could be achieved by a hydraulic piston. Beyond this, the path taken by passenger and seat was taken to be only under the influence of a constant gravity force.

In the acceleration phase of the motion, the velocity at which the henchman leaves the vehicle can be shown as,

$$v_1{}^2 = u^2 + 2as, \qquad (1)$$

where v_1 is the velocity exiting the DB5, u is the initial velocity of 0, a is the acceleration of the henchman and seat and s is the distance between the base of the seat originally and the roof height of an Aston Martin DB5 [2]. This distance s is taken to be 1.05m from the cars specifications [3].

Figure 1: Frame from the film *Goldfinger*, at the apex of the henchman's ejection [1]

Using the footage in Figure 1, the base of the passenger and seat were calculated to be at an elevation of 2.37m from the ground. This was achieved by measuring the pixels in the screenshot from the base of the henchman to the ground, and comparing it against the height of the car, which is known. Neglecting the effects of air resistance and using equation (1), the relationship,

$$v_2{}^2 = v_1{}^2 - 2gH, \qquad (2)$$

can be proven. Here, H is the distance between the maximum height of the henchman and the roof of the car, g is the constant acceleration due to gravity and v_2 is the velocity at the maximum of the henchman's flight, which is zero.

By making $v_1{}^2$ the subject of equation 2, it is possible to calculate the resultant acceleration from equation 1,

$$a = \frac{gH}{s}. \qquad (3)$$

Taking g to be 9.81ms^{-2}, with s calculated as 1.05m and H taken as 1.02m, this gives a resultant acceleration of 9.53ms^{-2}. This corresponds to a resultant force of 953N if a combined mass of 100kg is assumed for both passenger and seat.

Factoring in that this resultant force takes into account the balance between the ejector thrust and the force of gravity is important. The thrust required for the ejector seat to function as seen in the film would therefore incorporate the mass of the henchman. This thrust was calculated to be 1,930N by considering the work done by gravity against the initial acceleration.

As this force is taken to be applied over the entire base of the seat, it is also of interest to work out the pressure applied by the hydraulic piston. The authors were unable to find the dimensions of an Aston Martin seat, so instead a Lamborghini seat was modelled [4], with a pressure of 8,870Pa applied over a seat of area 0.218m^2. Given that a typical car piston can generate a pressure of around 5,000Pa [5], this seems to be a feasible pressure for a larger piston to be able to generate.

Conclusion

The authors found that the force and pressure required to eject a typical henchman from an Aston Martin DP5 were 1,930N and 8,870Pa respectively if he was ejected via a hydraulic piston exerting a constant force. This would safely eject the henchmen, and from a maximum height of 2.37m, it is unlikely that he would sustain major injuries in the process unless he was ejected from a faster moving vehicle.

There are a few areas in which this ejection could be modelled more accurately in future research. Firstly, as can be seen in the film, the passenger and seat are not attached to one another; as they fly through the air they will act as separate bodies. As a result of this, their motion will not act entirely as described in this paper.

There will also be a force imparted on the Aston Martin. This paper did not look into how this would affect its motion, and whether a force of this strength would be easily dampened by the suspension of a DB5.

References

[1] *Goldfinger,* 1964, motion picture, Metro-Goldwyn-Mayer Studios, USA,

[2] Tipler P.A & Mosca, *Physics for Scientists and Engineers, Sixth Edition, Page 39*, Freeman & co,

[3]*http://www.carfolio.com/specifications/models/car/?car=33594*, accessed on 19.11.12,

[4]*http://www.lambolounge.com/Interior/Seats/Seats/Seats.asp*, accessed on 20.11.12,

[5]*http://www.hcs.harvard.edu/~jus/0303/kuo.pdf*, accessed on 20.11.12.