007's Exciting Escapades:
Physically Feasible or Technologically Tempered?

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Physics 131 Section 02

Purpose:

The original purpose of the project was to analyze the stunt scenes from James Bond movies made in different time periods in the hopes of determining the answers to two predominant questions. First, did the audience readily believe the stunts in older Bond films more because they were limited to the physically possible by the lack of advanced special effects technology? Second, do the stunts in modern James Bond movies actually adhere to the laws of physics, or do they just appear possible due to special effects work?

Problems arose in the analysis of the older movies, however. The older movies were not stunt based, and nothing met the modern audiences' interpretation of Webster's definition: " stunt (n) - an unusual or spectacular feat.".[1] The movies consisted of more acting and less action. This "obstacle" led to an alteration of purpose.

The modified purpose is to determine the plausibility of the seemingly impossible stunts that take place in more modern James Bond films. By comparing the motions undergone by actors participating in the stunts to the theory set forth by the laws of physics, it is hoped that the stunts can be analyzed to determine the physical feasibility of the actors' actions.

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[1]Mish, Frederick C. ed. The New Merriam-Webster Dictionary. Springfield, Mass: Merriam-
Webster, Inc.,1989.

Theory:

The basis of the project was the kinematic equation for the position of a body in motion (in the y-direction).

$$y = \frac{1}{2}at^2 + v_o t + y_o$$

The derivative of the position equation with respect to time yields the equation for the velocity of a body in motion (in the y-direction):

$$y' = at + v_o$$

Since the velocity of a body in motion is the vector quantity denoting both the speed and direction in which the body travels, it is of much use when comparing the motions of two bodies.

The final derivative of the position equation with respect to time (the derivative of the velocity equation with respect to time) yields the acceleration of the body in motion (in the y-direction):

$$y'' = a$$

The acceleration of a body due to the gravitational force of the earth is 9.8 m/s^2. (This is the acceleration factor with which the group is primarily concerned for the purposes of this project.)

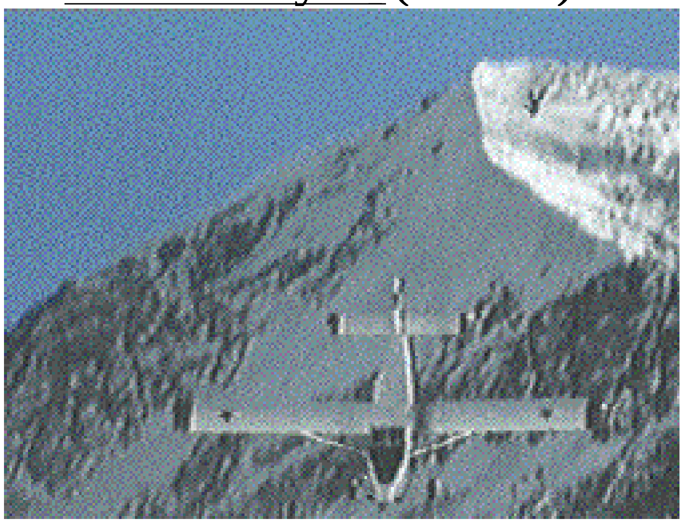
Since the motions analyzed in the chosen stunts take place in aerial environments, the coefficient of air friction, or drag, also needs to be considered as a factor contributing to the actors' theoretical and actual motion. The Drag equation, used for determining the resistance force on a sky diver is as follows:

$$D = \frac{1}{2}CAv^2$$

where C is the drag coefficient and A is the effective cross-sectional area.

(Average human terminal velocity is 54 m/s or 120 mph.)[2]

Goldeneye (1995)



"The Impossible Plane Scene"

Procedure:

For this scene, the video point movie was analyzed to determine the velocity of both the plane and the falling Bond in two different sets of digitized frames. In both sets of frames, a moving origin was created so that the position of the plane and actor would have the same point of reference. The movie was scaled by the approximate height of the actor playing James Bond (as given in a presentation of Movie Magic, Mr. Brosnan is approximately 6 feet in height). The information taken is then put onto a spreadsheet to allow us to calculate velocity and acceleration. Also allows use to make a theoretical model involving all relative forces.

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[2]All kinematic equations, the value of acceleration due to gravity, and all other equations and other information, can be found in the follow text:

Halliday, Resnick, and Walker. Fundamentals of Physics Fifth Edition. New York: John Wiley & Sons. Inc., 1997.

Data:

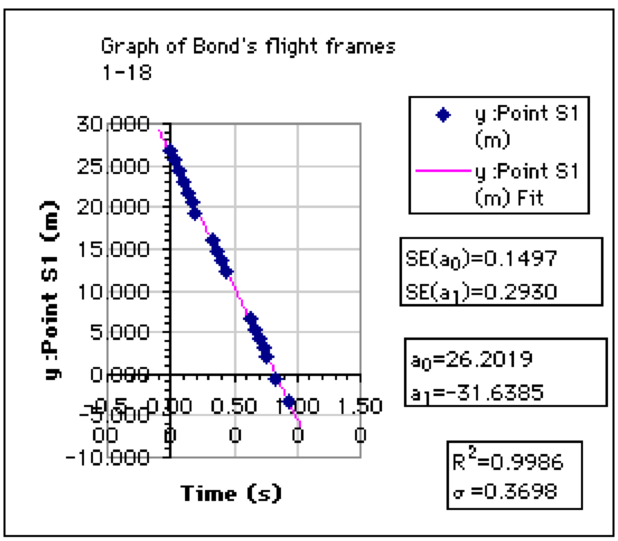
Frames 1-18

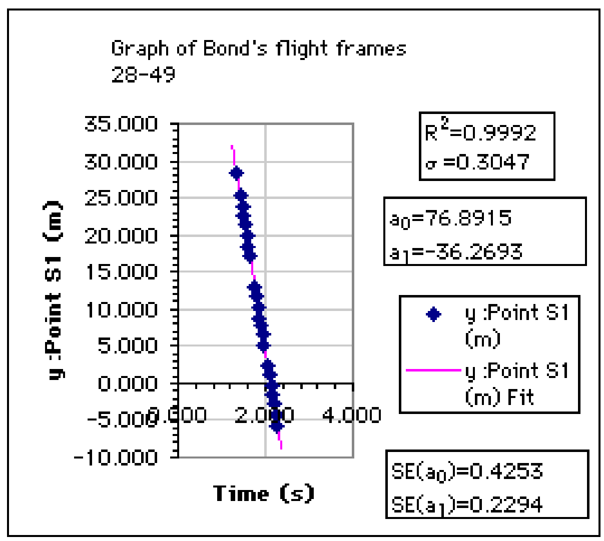
Time (s)	y:Point S1 (m)	y:Point S2 (m)
0.000	26.760	7.984
0.033	25.730	7.193
0.067	24.230	5.731
0.100	22.920	4.506
0.133	21.660	3.360
0.165	20.510	2.213
0.198	19.130	1.186
0.332	15.970	-1.897
0.365	14.580	-3.478
0.398	13.600	-4.229
0.432	12.250	-5.533
0.632	6.521	-10.710
0.665	5.375	-11.780
0.698	4.269	-12.730
0.732	3.122	-13.750
0.765	2.095	-14.860
0.833	-0.593	-17.270
0.933	-3.201	-19.600

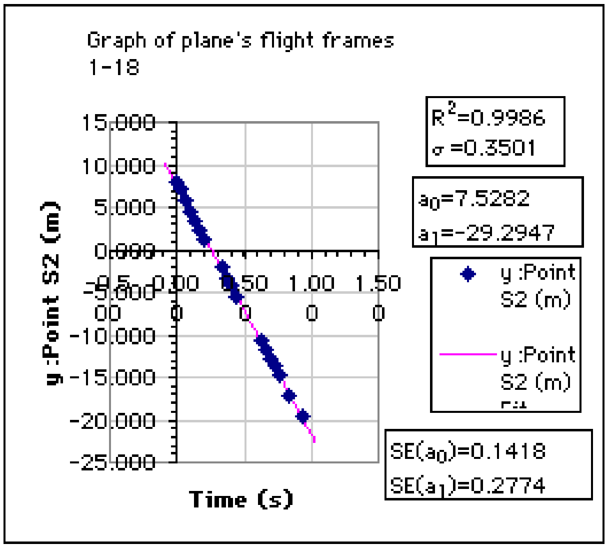
Frames 28-49

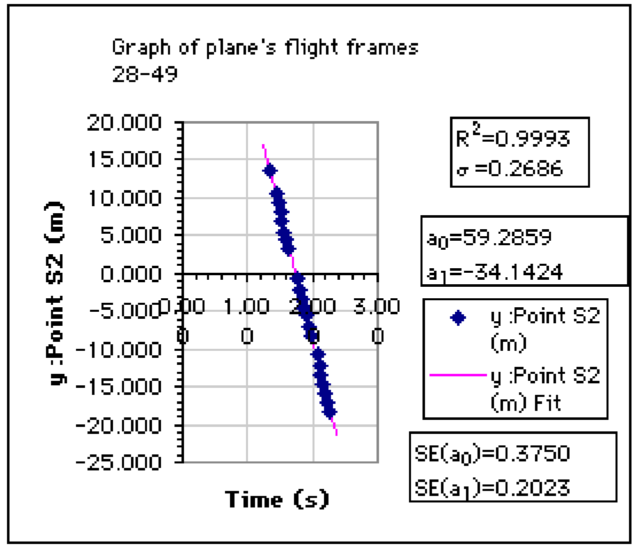
Time (s)	y:Point S1 (m)	y:Point S2 (m)
1.333	28.460	13.640
1.433	25.370	10.710
1.467	23.950	9.446
1.500	22.690	8.261
1.533	21.340	6.956
1.567	19.760	5.533
1.600	18.460	4.427
1.635	17.190	3.162
1.767	13.080	-0.751
1.800	11.740	-2.095
1.833	10.360	-3.320
1.867	8.814	-4.743
1.900	7.905	-5.612
1.933	6.561	-7.075
1.967	5.138	-8.261
2.067	2.490	-10.790
2.100	1.067	-12.130
2.133	-0.277	-13.360
2.168	-1.541	-14.540
2.202	-2.846	-15.730
2.235	-4.348	-17.230
2.268	-5.691	-18.420

Graphed results:



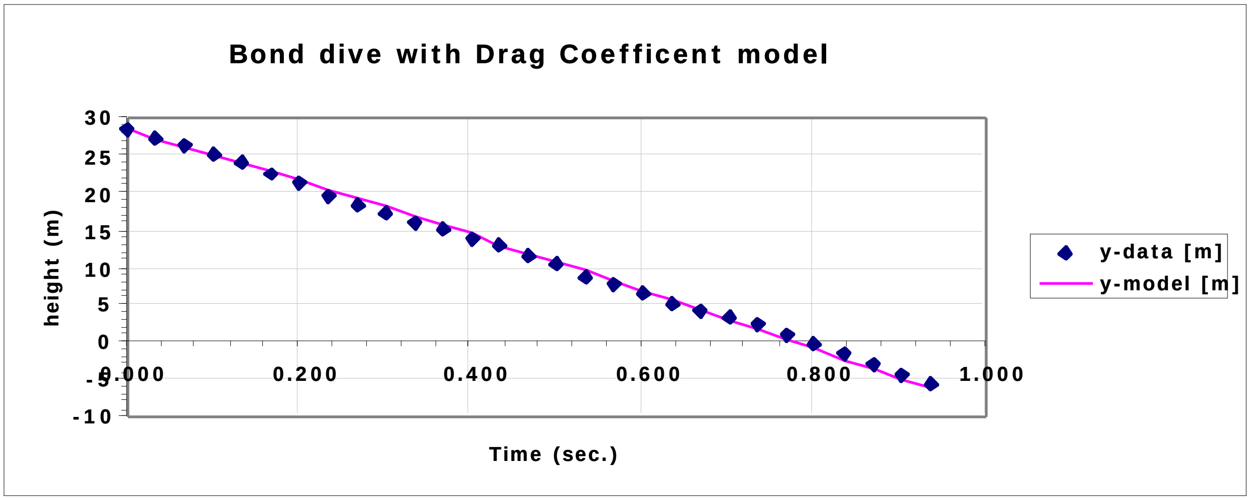






Preliminary Conclusions:

To determine the velocity and acceleration of the falling objects, it is first critical to realize that the slope of the position graph is equal to the first derivative of the first (position) kinematic equation. Therefore, the second variable (a_1) in the equation is the velocity of the object whose motion is graphed. By graphing the motion data taken in Videopoint, the velocity of the falling bodies could be determined by the Excel 5.0 fit feature, which assigns the "best fit" equation to the graph plot. According to the data taken, Bond travels at a velocity of -31.6 m/s while the plane travels at a velocity of -29.3 m/s. Likewise, in the second frame selection, Bond travels at a velocity of -36.3 m/s as the plane travels at a speed of only -34.1 m/s. Since Bond is traveling at a higher velocity than the plane, it is indeed possible that he could have both overtaken and boarded the plane. We also know that because he is falling and because Bond has not reached terminal velocity, there should be some type of acceleration, but the position versus time graph for Bond shows a straight line - which would indicate no acceleration. This can be explained by the time and speed at which the person is moving. Because the time frames are so small and the speed is so great, the graph gives the illusion of no acceleration, but in reality if small segments of each graph are taken an acceleration can be seen.



The above graph demonstrates Bond's actual fall data and a model that takes into consideration the force of air friction, or drag force. The two coincide, proving that the stunt is possible according to the laws of physics.

Goldeneye (1995)

"The Bad Guy Bites the Big One Scene"

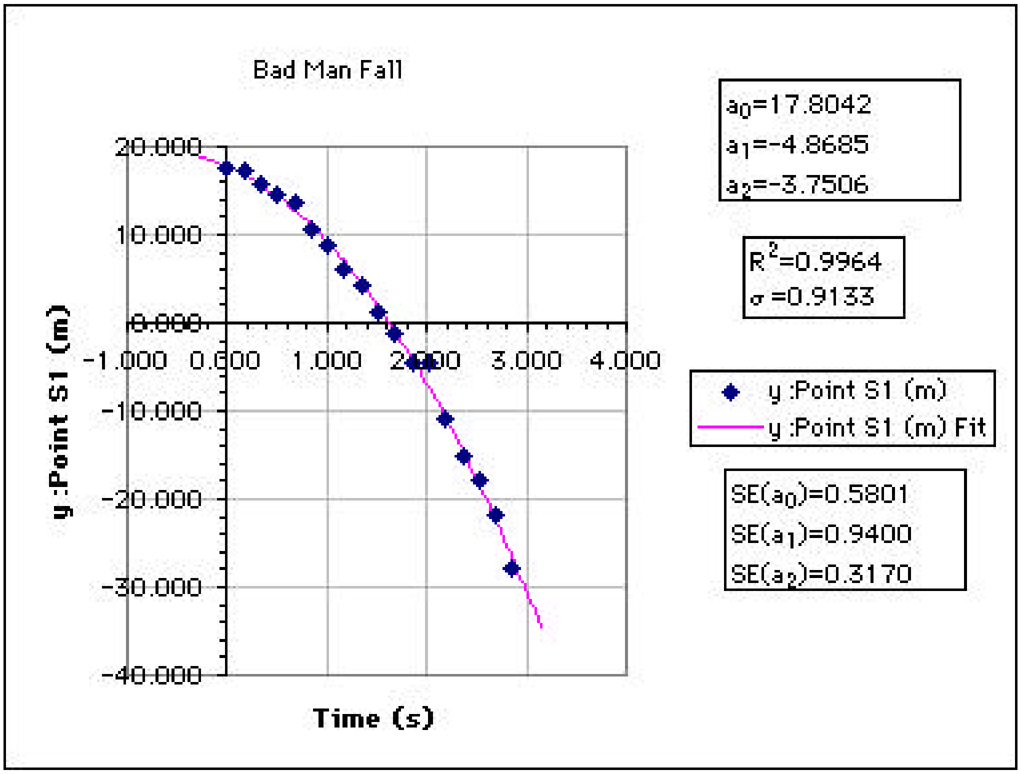
Procedure:

In this scene, the video point analysis system was used to determine the acceleration of the Bond villain as he plunged to his death. Since the acceleration of the falling actor is the result of force of gravity acting upon his body, the body should fall at a rate of 9.8 m/s^2. By analyzing the motion of the body in the y-direction, the acceleration of the falling actor can be determined from the kinematic equation depicting said motion. If the stunt was performed in fact rather than pieced together with special effects techniques, the acceleration resulting from the kinematic equation should match the theoretical value of the acceleration due to the force of earth's gravity. This video point movie was also scaled using the actor's height. (Since the "bad guy" was approximately the same height as Bond, the previous 6-foot scale was used again.)

Data:

Time (s)	y:Point S1 (m)	y:Origin 2 (m)
0.000	17.620	-0.549
0.168	17.250	-0.671
0.337	15.610	-0.183
0.505	14.510	0.244
0.673	13.780	0.671
0.842	10.670	2.987
1.010	8.717	4.572
1.178	6.157	6.340
1.347	4.206	8.230
1.515	1.219	10.180
1.683	-1.341	12.250
1.852	-4.694	14.390
2.020	-4.572	14.390
2.188	-10.910	19.020
2.357	-15.000	21.820
2.525	-17.980	23.470
2.693	-21.880	25.360
2.862	-27.980	27.620

Graphed results:



Preliminary Conclusions:

To determine the acceleration of the falling actor, it is important to understand that the first variable (a_2) of the position graph is equal to the second derivative of the first (position) kinematic equation. Therefore, the value given for this variable in the equation is the acceleration of the object whose motion is graphed. Using the fit feature of the Excel 5.0 worksheet, the best variables for the kinematic equation describing the motion of the falling villain were determined. This fit produced an acceleration value of -7.50 m/s^2, which is divergent from the gravitational acceleration value of -9.8 m/s^2. Since only the force of gravity is acting upon the man plunging to his death, his acceleration should match the theoretical value for gravitational acceleration within the limits of uncertainty. However the data portrays an acceleration that is not within accepted values of deviance, leading to the conclusion that this stunt fall was technologically tempered and not completed in actuality. This may be an effect of the use of blue screen technology to create a fall scene without the use of a non- existing object, such as the enormous satellite used in this fight scene.

Final Conclusions and Summary:

Based on the data taken and the careful analysis of the digitized movie scenes, the group came to the following conclusions to two previously stated questions:

1.Were the stunts in older Bond films more readily believed by the audience because they were limited to the physically possible by the lack of advanced special effects technology?

The results of this project demonstrate that the audience more readily believes the stunts carried out in older James Bond movies because they are known to be physically possible. The previous stunt crews had less special effects technology and appeared, therefore, to attempt stunts which needed little technological tempering - such as driving a car at a speed which was not commonly achieved by everyday drivers. (Therefore, modern audiences no longer view feats that were considered stunts in the older movies with the same awe.)

2. Do the stunts in modern James Bond movies actually adhere to the laws of physics, or do they just appear feasible due to special effects techniques?

Upon analysis of the digitized scenes from Goldeneye, the data taken demonstrates that some, although possibly not all, of the stunts in modern James Bond movies are, in fact, in violation of some of the fundamental laws of physics. For example, since the velocity of the falling Bond is greater than the velocity of the falling plane, it is indeed feasible for Bond to both overtake and board the plane while hurtling towards the rocks below. However, the villain could not be undergoing an acceleration less than that of gravitational acceleration unless an outside force was acting upon him and causing him to also have an upwards acceleration. Since no such force is present, the stunt appears to have been technologically altered behind the scenes, either for a smoother shot or a greater impact upon the audience.

This project had many sources for possible uncertainty, most of which stemmed from the analysis itself. Due to cinematic filming techniques, such as camera drawback, zoom, and viewpoint changes, it was difficult to choose both scenes to analyze and consistent ways to gather data. The use of moving origins also made the project more complicated and increased the sources of uncertainty. Likewise, the inability of the group to obtain more specific measurements increased the sources of uncertainty stemming from scaling the video point movies. This project could be improved by comparison of more stunt scenes from both older and more recent James Bond films. The possibility of uncertainty in analysis could also be reduced by the location of more exact sources for movie information, for example, the height and weight of actors involved.

Bibliography / Materials Used:

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Dr. No. UMGM Studios, 1962.

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Video point system - as licensed to Workshop Physics program of Dickinson College, Carlisle, PA, 1995.

Excel 5.0 program - as licensed to Workshop Physics program of Dickinson College, Carlisle, PA, 1995.