Sample Lab Report
Appendix B

Abstract:

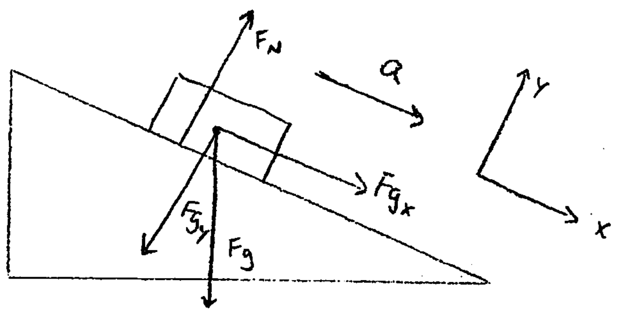
The purpose of this experiment was to show that acceleration is independent of mass so as to convince a group of friends to ride on a roller coaster when less people were on it. To prove this, a cart was released from rest at the top of an incline, while Data Studio recorded its position down the track to generate velocity and acceleration values. These values were then exported to Microsoft Excel, where the data was tabulated and acceleration vs. time graphs were generated for three different masses. The data showed that the acceleration did not depend on mass and therefore, the group of friends should be convinced to ride the roller coaster.

Procedure:

Based on earlier experiments, an appropriate angle was chosen for the "frictionless track" and calculated by measuring the length of the ramp, the height of the ramp and applying the proper trigonometric identity. After calibrating the motion sensor and choosing an appropriate sampling rate for said motion sensor in the Data Studio program, the data was taken. The cart was released from rest at the top of the incline and Data Studio recorded the motion of the cart after it was released; this data was then exported to Microsoft Excel, where it was tabulated and graphed. This process was repeated two times, with 100g added to the cart for each trial, for a total of three trials.

Theory and Derivations:

Gravity is a conservative (restoring) force, meaning that the work it does on an object is independent of the path taken by that object. In other words, if one objects falls straight down, while another rolls down a hill of the same height, the work done by gravity will be the same. The rate at which objects fall is commonly referred to as g, the acceleration due to gravity; it has an approximate value of 9.8 m/(s^2). This value is constant for all objects, regardless of how massive the object is. This can be proven by equating the weight of an object (mg) with the force that the earth pulls an object towards it (Newton's Law of Gravitation: G*Me*m/(Re^2)). By equating these two equations, it is shown that **g** = G*Me/(Re^2), which is independent of the falling object. However, this is the rate at which objects will freely fall at; if an object is on a ramp, then it will fall at some fraction of **g**. The rate at which an object accelerates down a ramp is also independent of how massive the object is. To verify this statement, consider a mass on an inclined ramp as shown:



Using Newton's Second Law of motion, we arrive at the following set of equations:

$$\sum F_y = m\vec{a}_y = 0 = F_N - mg\cos\theta$$
$$\therefore F_N = mg\cos\theta$$

$$\sum F_x = m\vec{a} = mg\sin\theta$$
$$\therefore \vec{a} = g\sin\theta$$

From the earlier argument, **g** is constant and since it is assumed that the angle will also be held fixed, **a** is therefore constant, independent of the mass.

Data and Calculations:

As mentioned earlier, all data was exported to Microsoft Excel. Attached to the end of this report are both the tabulated data and an acceleration vs. time graph, which shows trend lines for three different masses: 500g, 600g, and 700g.

Analysis and Questions:

Since it is difficult to mathematically compare trend lines, the average accelerations of the three runs were taken and a standard deviation calculation was performed on the averages:

$$\sigma = \sqrt{\frac{\sum_i^N (x_i - \bar{x})^2}{N-1}} = \sqrt{\frac{(-1.129+1.323)^2+(-1.127+1.323)^2+(-1.141+1.323)^2}{2}}$$

$$= .234$$

Since the standard deviation between the measurements is very small, the argument that acceleration does not depend on mass is justified.

According to theory, **a** = **g** sinθ. To further analyze the validity of the recorded data, percent error calculations were performed:

Percent Error = |Observed value – Accepted value|/|Accepted Value| x 100

= |-1.48 + 1.129|/|-1.48| x 100

= 23.7%

Acceleration	Percent Error
-1.127	23.9%
-1.141	22.9%

These errors are noticeably high, however, they can be explained. As with most experiments, there is an appreciable amount of error in this experiment. For example, there is always a certain amount of inaccuracy in measurements, both human and computer. There is systematic error in the motion sensor readings and the angle measurement; there is also random error in the angle measurement. Another source of error in this experiment is friction. The derived formula assumes both a frictionless surface and no air drag; however, this is not the case. Although there is minimal contact between the cart's wheels and the track, this is not negligible; nor is the resistive force between the cardboard and the air.

Conclusions:

Although the acceleration values calculated in this experiment did not match the theoretical value, the data does support the argument that acceleration down a ramp is independent of mass. This was accomplished by averaging the acceleration values for all three trials and calculating the standard deviation between the data. Since acceleration does not depend on mass, I would tell my friends that they are stupid and that they should go on the ride with me.

Run #1

Time (s)	Acceleration (m/s/s)
0.471	-1.1325
0.5373	-1.1499
0.6036	-1.1217
0.6699	-1.1277
0.7361	-1.0853
0.8024	-0.9185
0.8686	-1.0913
0.9347	-1.1186
1.0009	-1.3163
1.067	-1.1357

a ave = -1.129

Run #2

Time (s)	Acceleration (m/s/s)
0.5373	-0.9771
0.6036	-1.1472
0.67	-1.1092
0.7363	-1.1382
0.8025	-0.9265
0.8688	-1.1398
0.935	-1.0904
1.0012	-1.3308
1.0674	-1.1062
1.1335	-1.181
1.1996	-1.1547
1.2657	-1.3336
1.3317	-1.12
1.3977	-1.0209

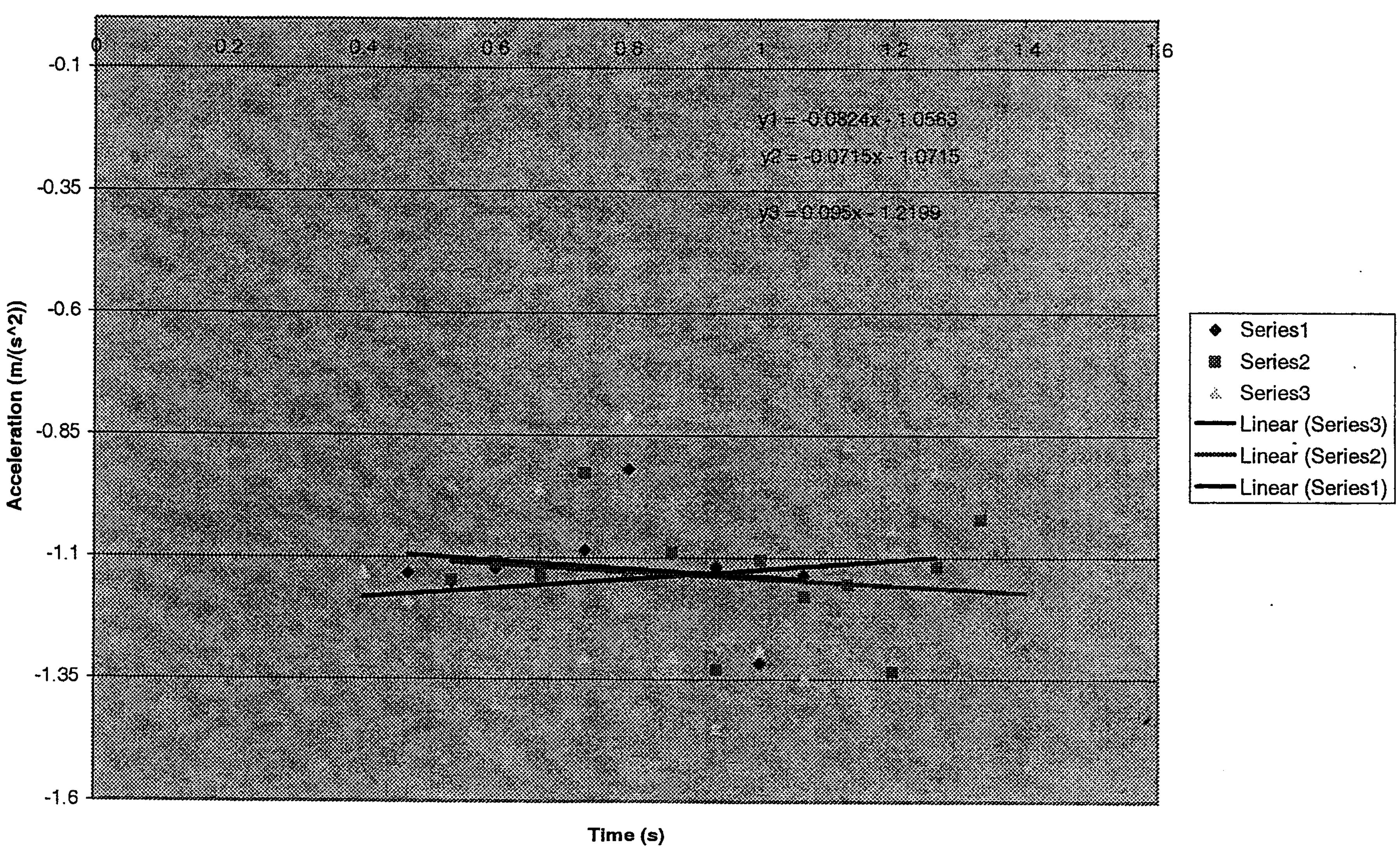
a ave = -1.127

Run #3

Time (s)	Acceleration (m/s/s)
0.4044	-1.134
0.4708	-1.1873
0.5371	-0.9521
0.6034	-1.3999
0.6696	-0.9567
0.7358	-1.3025
0.802	-0.8115
0.8682	-1.302
0.9343	-1.4499
1.0004	-1.2915
1.0665	-1.3474
1.1326	-0.8682
1.1986	-1.0425
1.2645	-0.9218

a ave = -1.141

Acceleration vs Time



TA ________

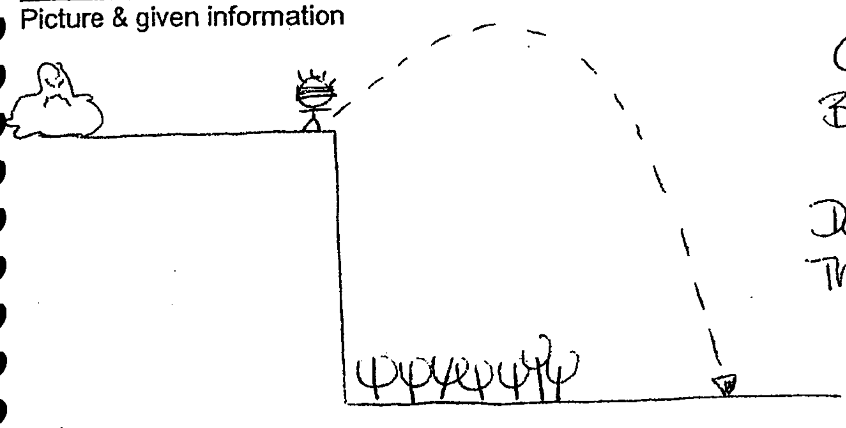
Problem ______

Score ______

Group Members	M	R	SK	SU
SOLUTIONS				
ADVENTURES OF SPIFF				

FOCUS the PROBLEM

Picture & given information



Gravity: $5\ m/s^2$

Booster pack: 30° from horizontal
10 m/s

Depth of precipice: 100 m

There's pitchforks for 50 m

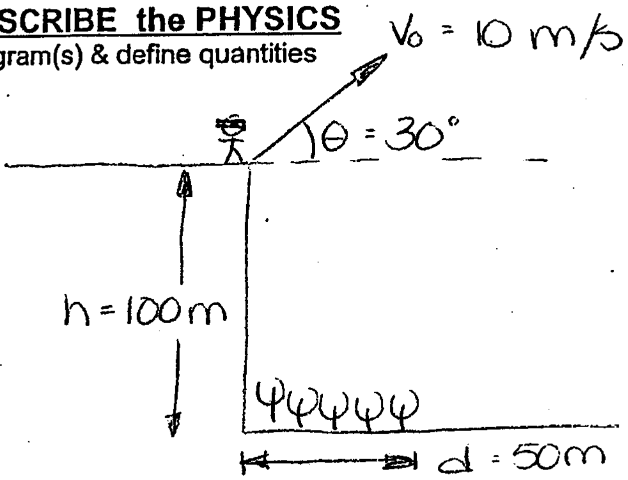
Question(s) Does Spaceman Spiff clear the pitchforks?

Approach

Projectile Motion with initial velocity.

DESCRIBE the PHYSICS

Diagram(s) & define quantities



$a = 5\ m/s^2$

Target Quantity(ies) Horizontal distance that Spiff travels during his fall.

Quantitative Relationships $x = x_0 + V_0 t + \frac{1}{2} a t^2$

PLAN the SOLUTION

Construct Specific Equations

Equations of Motion

In x direction: $x = V_{0x} t$; $V_x = V_{0x}$

In y direction: $y = V_{0y} t + \frac{1}{2} a t^2$

$V_y = V_{0y} + at$

① Find the time it takes to reach the bottom.

$y = h = V_{0y} t + \frac{1}{2} a t^2$

$\frac{a}{2} t^2 + V_{0y} t - h = 0$

$$t = \frac{-V_{0y} \pm \sqrt{V_{0y}^2 - 4(a/2)(-h)}}{2(a/2)} = \frac{-V_{0y} \pm \sqrt{V_{0y}^2 + 2ah}}{a}$$

② Distance he travels horizontally

$V_{0x} t = x$

PRECALCULATION WORK

$V_{0y} = V_0 \sin 30$

$V_{0x} = V_0 \cos 30$

We set the (0,0) at the edge of the cliff and consider positive directions of motion towards the bottom & towards the pitchforks.

Check Units

$\frac{m}{s} \cdot s = m$ ✓

EXECUTE the PLAN

Calculate Target Quantity(ies)

$$t = \frac{-(-5) \pm \sqrt{5^2 + 2.5.100}}{5}$$

$t_1 < 0$ → not a valid solu

$t_2 = 7.4$ s

$x = 10(\cos 30) \cdot (7.4) = 64.1$ m

Spaceman Spiff can de the pitchfors.

EVALUATE the ANSWER

Is answer properly stated?

YES

Is answer reasonable?

YES

Is answer complete?

YES

(Extra space if needed)