GREAT AMERICA PROJECT
TIMELINE
2018

Project Component	Due Date
Group Members Key Question* Driving Questions*	4/24/18
Background* Backwards Planning*	5/1/18
Park Worksheet Developed*	5/3/18
Development of Presentation (Blog Post or SlideShow) Title Purpose Materials Procedures Data (set up data tables etc.)	5/7/18
Data & Calculations	5/8/18
Final Submission	5/10/18*

* See First Steps Worksheet Example

Amusement Park Project

Introduction:

Amusement parks provide an authentic opportunity to conduct *real* science and apply physics and math concepts in real-world situations. While visiting an amusement park, not only will you have a fun-filled day of riding rides, but you will get to *apply* what you have learned about estimation, measurement, motion, forces, gravity, energy, and systems. You will experience a true scientific process where you get to ask your own questions, gather data, and apply what you have learned to a real-life situation. The data collected may not be the most accurate, but the application of your new physics knowledge will be clearly evident.

Project Description:

Your group (3-4 people, NO EXCEPTIONS!) will choose one or more of the following sample questions, or you may develop question(s) of your own, to answer on your field trip to the amusement park*. Questions not listed below will need approval from your instructor before you begin any planning.* You will communicate your entire process and solution in an organized, scientific manner in a forum of your choosing (i.e. scientific journal article, live presentation, video presentation.)

Notes of Interest:

- *Pre-planning is paramount to your success in this project. You should have a clear, detailed, plan of what you need to DO at the park before leaving, including which calculations you will need to perform to obtain the answers to your questions.*
- *A significant amount of research may need to be conducted in order to "get the science right" before solving your problem.*
- *A rubric for your presentation has been included. This same rubric will be used for all forms of communication.*

Sample Questions: *You may choose from the following list of sample problems to solve,*

1. What is the power output of the motor that lifts a roller coaster train to the top of the lift hill?
2. What is the centripetal acceleration and/or centripetal force of a roller coaster *car* at the top of the first loop on the track?
3. How much energy is lost between the top of the lift hill and any defined point along the track of a roller coaster?
4. How much work is done by friction between the top and bottom of a hill on a roller coaster?
5. What is the acceleration (deceleration) of a roller coaster train at the end of a ride?
6. How much energy is lost to friction during the drop (BEFORE BRAKING BEGINS) for a free-fall ride?
7. How much force is required to stop a free-fall ride (DURING THE BRAKING SEGMENT?) *Note: You can assume that the braking force is constant once braking begins.)*
8. What is a typical force of impact between two cars on a bumper car ride.
9. How much power is needed to lift a full car of people to the top of an observation tower ride?
10. What is the speed of a ride after falling a defined vertical height?
11. What is the difference between the theoretical and actual values for the centripetal accelerations on any circular motion ride (pendulum ride, carousel, loops, or spinners?)

Amusement Park Project Rubric
(20 points)

Section	Full Credit	Half Credit	No Credit
Title (1 pt.)	Clear “Scientific” Title (addresses question, method, and answer)	Not “Scientific” in nature	Not Present
Purpose (2 pts.)	One complete sentence that clearly states the goal of the lab	Incomplete sentence or longer than one sentence	Not Present
Materials (2 pts.)	In organized list or table that indicates all equipment used in the lab	Some materials are missing	Not Present
Procedures (5 pts.)	A clear, detailed, explanation of the process to be followed in order to accomplish purpose. Procedures specifically state all measurements needed, and include instructions for all calculations that must be performed	Procedures may be missing, difficult to follow, and/or out of order. May not describe all measurements needed or may not include instructions for making necessary calculations	Not Functional for Following
Data/Calculations (5 pts.)	All collected data is clearly displayed in tables. Equations and work for all calculations are shown, clearly labeled and easy to follow. All calculated values are recorded in an additional data table.	Data is missing, work or equations for calculations are not shown, or data / calculations are difficult to follow	Not Present or unorganized to the point of being incomprehensible
Conclusion (5 pts.)	Five sentences: 1) restates purpose, 2) & 3) summarize major steps of procedure. 4) summarizes results using data, 5) indicates possible sources of error.	1 of the parts is missing or incomplete or final data is outside the margin of error	2 or more parts are missing or incomplete or no final data is provided

EXAMPLE PROJECT

Group Members: *(List each group member's name in a bulleted list below)*

- Polly Esther
- Gene Eric

Key Question: *(What is the primary thing you want to calculate at the park?)(Indent and **bold**)*

Determine the amount of energy that has been lost between the beginning of the first loop and just before braking begins on *The Demon.*

Driving Questions:*(If you were assigned the above task, what questions would you have?)(Bulleted list)*

- How will we find the energy at these two locations?
- What determines the energy at a particular location?
- Should we use kinematics or energy conservation to solve this problem?
- What do we know about what should happen to energy during a ride?

Background Physics Information Needed: *(In paragraph form, discuss the physics concepts you will use.)*

The Law of Conservation of Energy states that the total amount of mechanical energy for a system, say a rollercoaster, should remain constant. The total ME is comprised of Gravitational Potential Energy (GPE), Elastic Potential Energy (PE_{el}), and Kinetic Energy (KE). GPE is calculated by the formula GPE = mgh; PE_{el} is calculated by the formula $PE_{el} = ½ kx^2$; and KE is calculated by the formula $KE = ½ mv^2$.

Although the Law of Conservation of Energy states that total energy is conserved, this problem indicates that this may not be true if energy is lost. If friction (both the rollercoaster with the track and air resistance) are taken into account, then the Law of Conservation of Energy would be true.

In order to use this Law to solve this problem, we will need to determine the total amount of energy the roller coaster has as it enters the first loop, and again just before the braking begins at the end of the ride. The difference between these two values will be the amount of energy lost to friction with the track and air resistance.

To determine the energy at the two key locations, we will need to decide what **types** of energy the coaster has at each point. As the coaster enters the first loop, it is at it's lowest vertical point of the ride. If we consider this height to be "h=0 *m*" then the coaster does NOT have gravitational potential energy. There is no elastic potential energy for the coaster at this point, so the only type of energy it has is kinetic energy. As the coaster enters the part of the ride where braking begins, it is at a height *higher* than where it entered the first loop so it WILL have some GPE along with KE, but will still NOT have PE_{el}.

So, in order to solve this problem we will need to be able to have values of *m, g, h, and v* at each point. The acceleration due to gravity (*g*) is a constant, the heights (*h)* can be measured at the park, but mass and velocity prove more difficult. Upon further research, we can measure velocity of the coaster at each point using the definition of velocity. We will measure the total length of the train (*d*) and time how long it takes to pass a stationary point on the track at each of the locations. We also decided that mass can be ignored, because if we set up an Energy Conservation problem:

$$(mgh + ½ mv^2)_{initial} = (mgh + ½ mv^2)_{fnal}$$

the mass will cancel out on each side and the remaining theoretical statement is true:

$$(gh + ½ v^2)_{initial} = (gh + ½ v^2)_{final}$$

Therefore we will alter our original formulas for each type of energy to NOT include mass.

Backwards Planning: *(In a bulleted list, plan what you will need to calculate/measure to answer Key Question.)*

- Subtract the total energy at the final location from the energy at the initial location to get the amount of energy lost. $\mathbf{E_{total} = E_1 - E_2}$
- Calculate the energy at the initial location using $\mathbf{E_1 = \frac{1}{2} v_1^2}$
    - measure the length of the train (pacing?)
    - time how long it takes to pass a point on the track entering the loop
    - determine velocity by $v = d/t$
- Calculate the energy at the final location using $\mathbf{E_2 = gh + \frac{1}{2} v^2}$
    - measure the height of the track (structure method?)(triangulation?) where braking begins
    - measure height of track at beginning of first loop
    - Subtract the two heights to get height at braking location
    - measure the length of the train (pacing?)
    - time how long it takes to pass a point on the track just before braking
    - determine velocity by $v = d/t$

EXAMPLE PROJECT

Worksheet to Take to Park

Length of train:

____

(pace out entire train OR pace out one car and multiply by number of cars)

Time for train to pass point before 1st loop:

____

Time for train to pass point just before braking:

____

Velocity of train entering first loop:

____

$v_1 = d/t$

Velocity of train just before braking:

____

$v_2 = d/t$

Height of track entering 1st loop:

____

Triangulation: distance 1 from ride: ____________
distance 2 from ride: ____________
distance (D) between points: ____________
angle measured: ____________

$$h_1 = (D \sin 0_1 \sin 0_2) / \sin (0_2 - 0_1)$$

Height of track before braking:

____

Triangulation: distance 1 from ride: ____________
distance 2 from ride: ____________
distance (D) between points: ____________
angle measured: ____________

$$h_2 = (D \sin 0_1 \sin 0_2) / \sin (0_2 - 0_1)$$

Height of track before braking:

____

$H = h_1 - h_2$

Energy entering first loop:

____

$$E_1 = \frac{1}{2} v_1^2$$

Energy before braking:

$$E_2 = gH + \frac{1}{2} v_2^2$$

ENERGY LOST BETWEEN TWO POINTS:

$$E_{lost} = E_1 - E_2$$

PREPARING FOR GREAT AMERICA

REQUIRED DATA BEFORE GOING:

Mass in Kilograms: Convert your mass in pounds to kg (1 kg = 2.20 lb)

Weight in Newtons: Calculate weight using your mass (F=ma; use a_g to determine weight)

Eye-Height: Use a meterstick to measure from the ground to the middle of your eye when standing straight

Stride Length: Comfortably walk twenty steps (measure from same location on foot at both beginning and end) then divide by 20 to get the average length of one stride.

MY mass in kilograms (kg)	
MY weight in Newtons (N)	
MY “eye-height” in meters (m)	
MY stride length in meters (m)	

PRACTICE DATA COLLECTING TECHNIQUES:

Note: *You should take multiple sets of data and determine an average to eliminate error*

(you can do these on paper and submit images of your work OR do these in a spreadsheet and attach it to this assignment)

Determining Speeds

*Length of “standard” car (m) (NO PACING...too short a distance)	
*Time for car to pass stationary point along highway	
Average speed of car on highway	

Determining Long Lengths

*Number of Paces	
Length of Gymnasium	

Determining Heights

A) Accessible Features

*Number of Paces from Light Pole	
Distance from Light Pole	

*Angle to sight top of Light Pole	
Height from eye to top of Light Pole	
Total height of Light Pole	

Determining Heights

B) Inaccessible Features

*Angle to sight top of Telephone Pole† from Position #1	
*Number of Paces from Position #1 to Position #2	
Distance between Position #1 to Position #2	
*Angle to sight top of Telephone Pole† from Position #2	
Height from eye to top of Telephone Pole†	
Total height of Telephone Pole†	

†(NW corner of Reinway & Yosemite)

Determining Accelerations & Forces

*Angle read while spinning in a circle on scooter	
Centripetal acceleration (a_c=g tan θ)	
Centripetal force ($F_c = ma_c$)	

Group Members: *(List each group member's name in a bulleted list below)*

Key Question: *(What is the primary thing you want to calculate at the park?)(Indent and **bold**)*

Driving Questions:*(If you were assigned the above task, what questions would you have?)(Bulleted list)*

Background Physics Information Needed: *(In paragraph form, discuss the physics concepts you will use.)*

Backwards Planning: *(In a bulleted list, plan what you will need to calculate/measure to answer Key Question.)*

Park Worksheet: *(Create a worksheet where you can record all necessary data for your Key Question.)*

Eye Height		1.6125				
		m and angles	radians		m	ft
Flag Pole				Height:	9.710340332	31.85807196
Horizontal Distance		10				
Angle		39	0.6806784083			
Bleachers				Height:	7.861193519	25.79131732
Horizontal Distance		10				
Angle		32	0.5585053606			
Light Pole				Height:	9.710340332	31.85807196
Horizontal Distance		10				
Angle		39	0.6806784083			
Telephone Pole	(NW corner Reinway & Yosemite)			Height:	9.588302455	31.45768522
Distance between angles		10				
Close Angle		18	0.3141592654			
Far Angle		13	0.2268928028			
Top of Gym				Height:	10.98554028	36.04179881
Horizontal Distance		15				
Angle		32	0.5585053606			
Length of GYM		33.95		Length:	34.27	
	wall to zero	0.32				

These are measurements around my campus that I have students practice with to prepare for Great America. These are MY actual measurements and calculations so I can check their work.