EDUCATION DAY WORKBOOK

Grades 9 – 12

It is with great thanks for their knowledge and expertise that the individuals who devised this book are recognized.

MAKING MEASUREMENTS

Time: Solve problems using a digital watch with a stopwatch or with a second hand. When measuring the period of a ride that involves harmonic or circular motion, measure the time for several repetitions of the motion.

Distance: Due to the locations and normal operation of the rides, you will not be able to directly measure heights, diameters, etc. All but a few of the distances can be measured remotely using one or another of the following methods. They will give you a reasonable estimate. Consistently use one unit of distance – meters of feet.

- **Pacing**: Determine the length of your stride by walking at your normal rate over a measured distance.
- **Ride Structure**: Distance estimates can be made by noting regularities in the structure of a ride. For example, tracks may have regularly spaced cross members. The length of the track can be estimated by estimating the length of one of the regularly spaced cross members of the track and then multiplying this by the number of cross members of track. This can be used for both vertical and horizontal distances of track.

Speed: The average speed of an object is simply the distance the object travels divided by the time it takes to travel that distance. To calculate the average speed of an object traveling in a circle, divide the circumference by the time for one revolution. To measure the speed of a train as it passes a particular point, time how long it takes the train to pass the chosen point. You may have to estimate the length of one car on the train and then multiply this length by the number of cars in the train to get an estimate of the train's length.

In the situation where friction is ignored and the assumption is made that total mechanical energy is conserved, speed can be calculated using energy considerations:

$U = mgh$ $K = 1 / 2mv^2$ $U_1 + K_1 = U_2 + K_2$ (subscripts 1 and 2 represent different locations)

Acceleration: The acceleration of an object is always in the direction of new force acting on an object. When the acceleration is in the direction of the motion, the object speeds up. When the acceleration is opposite to the direction of the motion, the object slows down.

When the acceleration is perpendicular to the motion, the object changes direction. Where there is a component of the acceleration parallel to the direction of the motion and a component perpendicular to the motion, the object changes both speed and direction. Acceleration is measured with an accelerometer. Two types are generally used:

- **The Vertical Accelerometer** is calibrated in g's and has a range from 0 to 3 g's depending on the device. You are accustomed to the force associated with one g – your own weight. If you experience two g's of acceleration, you will feel twice as heavy. The reading on the accelerometer multiplied by your mass is the force applied to you. You can use the vertical accelerometer when you are riding almost any ride at the park. Held vertically, it will help you in determining the g forces applied to you while going throughout the ups and downs of almost any ride. You can even use it to determine the g's experienced when starting or stopping – however – you will have to hold the accelerometer in the horizontal position for these purposes.
- **The Horizontal Accelerometer** is able to measure accelerations with a little better accuracy than the vertical accelerometer, but it has a more limited range. Use the horizontal accelerometer when your ride goes around in horizontal circles or when you want to measure accelerations less than one g. The acceleration is related to the angle that you read on the accelerometer according to the following equation. : $a = g \tan\theta$.

Use the following table for help during your day:

Angle	tan	sine	angle	tan	sine	angle	tan	Sine
0°	0.00	0.00	30p	0.58	0.50	60p	1.73	0.87
5°	0.09	0.09	35p	0.70	0.57	65p	2.14	0.91
10°	0.18	0.17	40p	0.84	0.64	70p	2.75	0.94
15°	0.27	0.26	45p	1.00	0.71	75p	3.73	0.97
20°	0.36	0.34	50p	1.19	0.76	80p	5.67	0.98
25°	0.47	0.42	55p	1.43	0.82	85p	11.4	0.996

ON YOUR WAY TO THE PARK

PART A: STARTING UP

Things to Measure:

As you pull away from school or from a stop light, find the time it takes to go from stopped to 20 miles per hour. You may have to get someone up front to help out on this. T = __________seconds.

Things to Calculate:

Show equations used and unit cancellations:

1. Convert 20 mph to m/s. (1.0 mph = 0.44 m/s).
v =__________m/s.

2. Find the acceleration of the bus in m/s^2.
a =__________m/s

3. Using your mass in kilograms, calculate the average force on you as the bus starts up. (1 kg of mass weighs 2.2lbs.).
F =__________N.

4. Using your mass in kilograms, calculate your weight in Newton's. (W = mg).
W =__________N.

5. How does this force (#3) compare to the force gravity exert on you (your weight in Newton's – (#4))?
Circle one: (more, less)

6. How many G's are you experiencing during the bus' acceleration?
G's = Force experienced (#3).
Force gravity normally exerts (your weight in Newton's)
= g's.

Things to Notice as you Ride:

7. As you start up, which way do you feel thrown, forward or backward? Why?

8. If someone were watching the bus accelerate from the side of the road, what would that person see happening to you in relation to the bus?

9. How can you explain the difference between what you feel as the bus start up and what the observer sees? (You may want to use the concept of FRAME OF REFERENCE).

PART B: GOING AT A CONSTANT SPEED

Things to Notice:

10. Describe the sensation of going at a constant speed. Do you feel as if you are moving? Why or why not? (You will have to try to ignore the effects of the bumps in the road).

11. Are there any forces acting on you in the direction that you are moving? Explain what is happening in terms of Newton's First Law.

PART C: ROUNDING CURVES

Things to Notice:

12. If your eyes are closed, how can you tell when the bus is going around a curve? Try it and report what you notice.

13. As the bus rounds a curve, concentrate on a tree or a building that would have been straight ahead. See if you can sense that you are going straight but are being pulled into the curve by a centripetal force.

14. What is supplying the centripetal force that is helping you round the curve?

15. How does this change when the curve is tighter or if the bus is going faster?

RIDES THAT GO IN HORIZONTAL CIRCLES

DATA:

Time for 10 revolutions of the Carousel®:___________seconds.
Angle measured by horizontal accelerometer:___________degrees.
Acceleration measured using spring accelerometer:__________m/s².

QUESTIONS AND CALCULATIONS:

1. Where would you need to sit if you wanted to experience the greatest speed? Why?
2. If you were on a horse and were to drop a coin while the ride was in motion, where would it land relative to you? Describe the path of the coin until it reaches the floor.
3. Now suppose you stood near the edge of the Carousel® and dropped the coin off the side. When the coin hits the ground, where would it be relative to you?
4. Would you ride the Carousel® on the outermost horse if the frequency of the Carousel® were 1 Hz? Why / Why not?
5. Which direction would you imagine the force acting on you would be trying to push you…toward the center of the Carousel or away from the center of the carousel? Is there really force acting on you in this manner? What is the cause of feeling this way?
6. Find the frequency in rpm's (revolutions per minute) and in hertz.
7. Calculate the angular velocity. Does the velocity change from the center-most horse on the outside? What about linear velocity? Explain.
8. Calculate the linear (tangential) velocity of your horse.
9. Calculate your centripetal acceleration. Would it be the same for all horses or does it changes from center to outer horse?
Support your answer with mathematical analysis.
10. What is the direction of the net force acting on your horse?
11. Notice the way the floor tilts. What could be the reason for this tilt?
12. Your mass in kilograms is___________(found from the ON YOUR WAY TO THE PARK section of this packet) and your weight in Newton's is therefore___________. What is the net force acting on you?
13. What is your tangential acceleration?
14. What is your kinetic energy?

RIDES THAT GO IN VERTICAL CIRCLES

BEFORE YOU RIDE:

While waiting in line, record the time it takes for the train to complete its trip.
Time #1_________________s Time #2___________________s Time #3____________________s
Average time of travel =____________________s

AFTER YOU RIDE:

1. Where along the ride did you experience the largest g-force? What part of your experiences the greatest pressure?
2. Draw a free-body diagram for this location on the ride.

3. Dare Devil Dive contains 2099 feet of track. Using the average time of travel measured above; calculate Dare Devil Dive's average velocity.
v =_____________________ft. /s =________________________m/s
4. If the ride time were cut in half, how would this change the average velocity of the coaster?
5. How could this change in average velocity affect the amount of g-force that you feel during the portion of the ride that you mentioned in question #2?
6. In terms of safety measures, what concerns do the engineers have to address when designing and building a ride of this nature? Do you think that the different materials that make up the wheels of this ride come into play? How?
7. How much of a role does the mass of the passengers play in the average velocity of the ride? (Hint: Try to estimate the mass of passengers on a full train vs. the mass of the train itself).

ENGINEERING MARVELS

BEFORE YOU RIDE:

Notice that the wheels on Superman are not all the same.
1. Why do you think that different materials would be used to make the wheels? Come up with some physics reasons that might explain these differences.
While waiting in line, record the time it takes for the train to complete its trip. Time several trips to get an average time.
Time #1_________________s Time #2___________________s Time #3____________________s
Average time of travel =____________________s

AFTER YOU RIDE:

2. Where along the ride did you experience the largest g-force? What part of your experiences the greatest pressure?
3. Draw a free-body diagram for this location on the ride.
4. Superman contains 2,759 feet of track. Using the average time of travel measured above, calculate Superman's average velocity.
v =_____________________ft. /s =________________________m/s
5. If the ride time were cut in half, how would this change the average velocity of the coaster?
6. How could this change in average velocity affect the amount of g-force that you feel during the portion of the ride that you mentioned in question #2?
7. In terms of safety measures, what concerns do the engineers have to address when designing and building a ride of this nature? Do you think that the different materials that make up the wheels of this ride come into play? How?
8. How much of a role does the mass of the passengers play in the average velocity of the ride? (Hint: Try to estimate the mass of passengers on a full train vs. the mass of the train itself).
9. Do you notice a significant difference in the time it takes for the train to return to the loading dock with each ride? What are the chances that the mass of passengers in a full train is exactly the same with each load?

Teacher Evaluation:

1. How many students did you bring? ________________

2. Would you plan to do this again? Why or why not?

3. Were the activities and information contained in the workbook sufficient?

4. What did you enjoy most about your day?

Additional Comments:

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PLEASE TURN THIS EVALUATION INTO THE GUEST RELATIONS OFFICE LOCATED AT THE FRONT ENTRANCE. THIS FORM CAN ALSO BE MAILED TO:

SIX FLAGS OVER GEORGIA
ATTN: KAREN EUBANKS
275 RIVERSIDE PARKWAY
AUSTELL, GEORGIA 30168