Name: _____ Date: _____

Physics Happenings with Amusements, Newton's Laws, Triangulation, and Other Magic Park (PHANTOM Park)

SAMPLE DATA

Students of Shadowville General High School have collected the following data for the rides at PHANTOM Park. Some of this information was measured, while other data were gathered from the ride operators.

Non-Looping Roller Coasters

We decided to measure the more traditional "woodie" coaster, rather than a "steelie." The ascent of the first hill was 40°, while the descent was about 60°. The ascent was linear, but the descent seemed a bit parabolic. Certainly the first valley was parabolic. With a 15 m baseline, the survey team found the elevations of the first two hills to be:

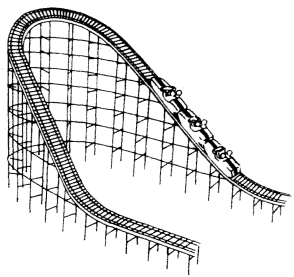


Figure 35.
Non-Looping Roller Coaster

Hill #1: $\theta_1 = 24°$ $\theta_2 = 21°$

Hill #2: $\theta_1 = 21°$ $\theta_2 = 25°$

The time of descent on the first hill was 3.8 s. Each car length was 1.9 m. The entire 8-car train passed the bottom of the first hill in 0.5 s.

Due to vibration, we thought the horizontal accelerometer reading of 30° to 35° with respect to the horizon was a reasonable estimate but not a reliable reading.

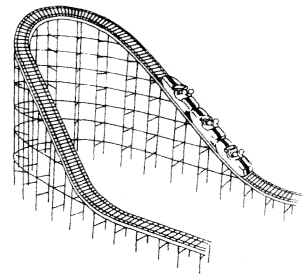
Roller Coasters

Requirements:
CP: 9 points
AP: 12 points

NON-LOOPING ROLLER COASTERS

Group A *1 point problems*

Note: Unless otherwise given, the mass of an 8-car roller coaster train is 6,000 kg.



Non-Looping Roller Coaster

1. Why is the second hill shorter than the first?
2. How long does it take the coaster to climb the first hill? descend the first hill?
3. Determine the angles of ascent and descent of the first hill.
4. Determine the shapes of the first hill and valley.
5. Identify at least three (3) sources of friction in this ride.
6. As compared with the beginning of the ride, do you expect friction and air resistance losses to be greater or less in the latter part of the ride? Why?
7. From a physics point of view, the passengers in the first car, middle car, and last car experience the ride differently. This is despite the fact that the whole train is being acted upon as a unit. Please explain the differences in the experiences of the three passengers listed above between the time of the first climb and reaching the top of the second hill.
8. "An empty roller coaster and a full roller coaster will take the same amount of time for a single trip." Is this statement true or false? Defend your answer.
9. Assuming no friction, how much work does the track do for one complete trip?
10. Describe the sensations of weight at the following points, and compare them with the readings on your spring accelerometer.
    a. climbing the first hill.
    b. at the top of the hill.
    c. going down the hill.
    d. at the bottom of the hill.
    e. ascending the second hill.
11. Make a diagram of the roller coaster track layout. Label the following: minimum potential energy, *G*; maximum potential energy, *X*; minimum kinetic energy, *K*; maximum kinetic energy, *M*; weightless sensation, *W*; heavy sensation, *H*.

(continued)

NON-LOOPING ROLLER COASTERS (continued)

Group B *2 point problems*

12. Determine the height of the first and second hills.
13. Determine the gravitational potential energy on the first and second hills.
14. Determine the maximum kinetic energy of the ride.
15. Determine the maximum velocity of the ride.
16. Determine the momentum of a fully loaded train.
17. Determine the acceleration of the roller coaster on the first drop in two different ways. State these answers in both g's and m/s^2.
18. Make a table of the following quantities: velocity, acceleration, potential energy, kinetic energy, momentum, and force on the train at the following points:
    a. the top of the first hill.
    b. one quarter of the way down.
    c. halfway down.
    d. three quarters of the way down.
    e. at the bottom.
    f. at the top of the second hill.

    Do this for the center of mass of the train.

(This question is considered a 3pt problem)

Group C *3 point problems*

19. Assuming the speed of the roller coaster is the same at the top of the first and second hills, determine the amount of energy lost due to friction.
20. Write an equation for the top of the first hill and the bottom of the first valley.
21. Calculate the loss in speed between the first valley and the second valley due to friction.
22. If the roller coaster had the same frictional losses for the whole trip as it does between the first two hills, would it reach the station? Support your answer.
23. An electric motor, which is 30% efficient, lifts a fully loaded roller coaster up the first hill.
    a. Calculate the power necessary to raise the train.
    b. If the electric company charges 8.5 cents per kilowatt hour, determine the cost of the electricity used to power this ride for one hour. Assume that it is a busy day with ridership at 1,800 patrons per hour.