# *SIX FLAGS GREAT ADVENTURE PHYSICS DAY REVIEW & SAMPLES*

***DIRECTIONS:***

For your assignment you will answer Multiple Choice questions and Open Ended Questions. All students must do the Great American Scream Machine, then you will choose and complete 3 out of the 6 remaining rides. Academic Students must answer the corresponding Open Ended Question; Accelerated Students must answer ALL open ended questions. Open Ended Question Answers must be typed and properly identified. For the Multiple Choice problems you must show your work on separate sheets of paper and attach them to the Open Ended Question Answer sheet(s).

Most measurements can be made while waiting in line for the ride, such as timing specific events. Force meter readings must be made during the course of the ride.

Answer the multiple choice questions using the measurements you have taken. **Realize that the answer you calculate may not exactly match a potential multiple choice answer.** These potential answers have been created using actual measurements from previous years. Therefore, you should choose the multiple choice answer **that most closely matches** what you have calculated using your measurements.

The rides listed in this packet are for review purposes only and are no longer available at Six Flags Great Adventure.

## FORCE FACTORS

**force factors (ff):** A force factor enables you to express the size of a force you are experiencing as a multiple of your weight. Remember, your weight is the force, mg, which is exerted on you by gravity. (This is also referred to as the g force or simply how many “g’s.”)

To measure a force factor: The force meter must be held in the direction of acceleration. If you are moving in a circle, the force meter should be pointed so that it is pointed towards the center of the circle.

**To calculate a force factor:** divide the force being applied to a person or object by the normal weight of that person or object.

**force factor = applied force / weight**

## EXAMPLES OF HOW TO USE A FORCE FACTOR

When you are experiencing a force factor:

**EQUAL to 1,** you feel **NORMAL. RIGHT NOW** you feel a force on your seat exactly equal to your weight as the seat supports you.

**GREATER than 1,** you **FEEL HEAVIER** than normal and feel pressed into the chair. In reality, the chair is pressing up on you which you interpret as being pushed down.

**LESS than 1**, you **FEEL LIGHTER** than usual and can feel as if you are almost lifting out of the chair. This is how you feel when an elevator starts down suddenly. At a given point on a ride, everyone, regardless of mass, experiences the same force factor.

For example: On a certain ride a 50 kg girl is being pushed with a force of 1500 Newtons.

What force - factor is she experiencing?

If we round g off to 10 $m/s^2$ she weighs 500 Newtons.

**force factor = applied force / weight =** 1500 Newtons / 500 Newtons = **3**

If her friend weighs 120 pounds, what force in pounds is her friend feeling?

They will feel the **same force factor**. This time, the number given is the person's weight. Her normal weight is 120 pounds, but she is experiencing a force factor of 3 and is therefore feeling a force of 3 times her normal weight. The force on her must be 3 x 120 pounds = 360 pounds.

# USING THE FORCE METER

To make an object move in a circle an unbalanced force directed toward the center of the circle must be applied. The sum of the forces is fixed.
$SF_r = F_c = mv^2/r$ with $F_r$ considered POSITIVE TOWARD THE CENTER OF THE CIRCLE
When a person rides in a vertical circle, as on a roller coaster the centripetal force which controls the motion is the vector sum of the force of gravity and the force exerted on the rider by the chair.

**RIDER AND METER | FREE BODY DIAGRAM | EQUATIONS**

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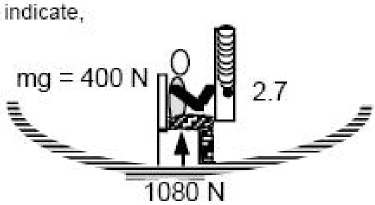
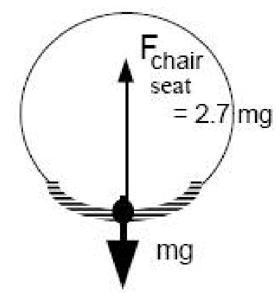
A 400 N student calculates that she will feel a force of 1080 N at the bottom of a roller coaster. What force factor will the meter indicate,




$ff = \frac{1080N}{400N} = 2.7$

RIDER AT THE BOTTOM




$\Sigma F_r = \frac{mv^2}{r}$
$\Sigma F_r = F_{chair} - mg$

$F_{chair} - mg = \frac{mv^2}{r}$

$F_{chair} = mg + \frac{mv^2}{r}$

$ff = \text{force factor} = \frac{F_{chair}}{mg}$

Rider feels heavier than usual since $F_{chair}$ is greater than mg.

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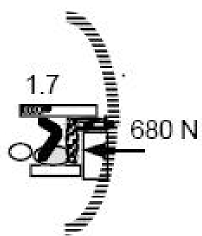
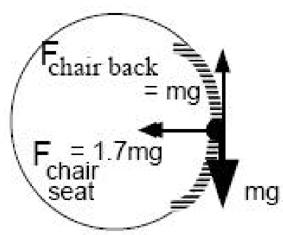



$ff = \frac{680\ N}{400\ N} = 1.7$

RIDER AT THE SIDE




$\Sigma F_r = \frac{mv^2}{r}$
Since mg is perpendicular to the radius it does not contribute to $F_r$
$\Sigma F_r = F_{chair}$

$F_{chair} = \frac{mv^2}{r}$

$ff = \text{force factor} = \frac{F_{chair}}{mg}$

Being at the sides feels like going up or down hill.

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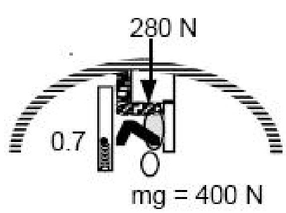
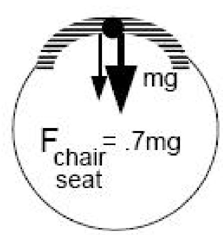



$ff = \frac{280\ N}{400\ N} = 0.7$

RIDER AT TOP OF ARC




$\Sigma F_r = \frac{mv^2}{r}$
$\Sigma F_r = F_{chair} + mg$

$F_{chair} + mg = \frac{mv^2}{r}$

$F_{chair} = \frac{mv^2}{r} - mg$

Rider will feel right side up as long as $F_{chair}$ is positive. The force coming from the seat makes down seem up.

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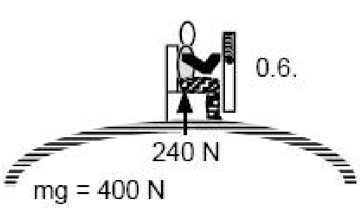
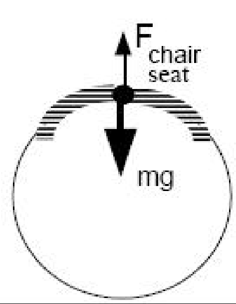



$ff = \frac{240N}{400N} = .6$

RIDER OVER TOP OF HILL




$\Sigma F_r = \frac{mv^2}{r}$
$\Sigma F_r = mg - F_{chair}$

$mg - F_{chair} = \frac{mv^2}{r}$

$F_{chair} = mg - \frac{mv^2}{r}$

Rider feels lighter than usual and can even lift up off the seat. Then $F_{chair} < 0$ and a seat belt holds rider on.

## ***STUNTMAN'S FREEFALL***

Measurements to Make:

Rise time: **9.0 s, 8.9 s, 9.1 s** Average time up, $t_{up}$: **9.0 s**

Freefall time: **1.8 s, 1.6 s, 1.7 s** Average freefall , $t_A$: **1.7 s**

Force Meter Reading on the way up: **1.5**

Force Meter Reading during freefall: **0**

Provided Values:

Mass of car plus riders: 800 kg

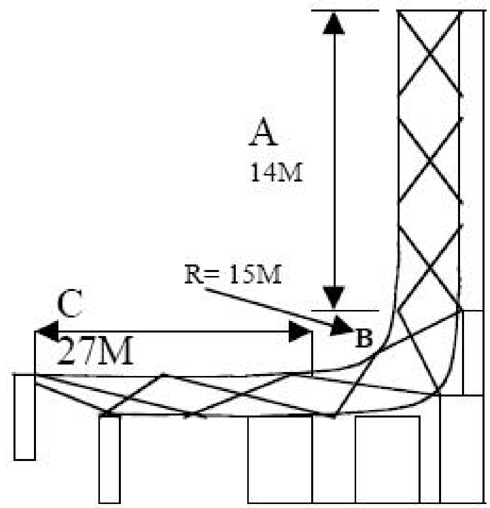
Mass of one rider (you): 60 kg

Ascension Height: 30 m

Freefall Distance: 14 m

Radius of Curve: 15 m

Stopping Distance: 27 m


1. When the car is raised from the ground to the top of the drop platform, it travels a total vertical distance of 30 m. The average mass of the car (including passengers) is 800 kg. What is the work required to lift the car and passengers?
   a) 2,400 J
   b) 24,000 J
   c) 240,000 J
   d) 360,000 J

2. Based on your measurement of lift time, what was the power used to lift the car and passengers?
   a) 5,200 W
   b) 26,500 W
   c) 117,600 W
   d) 470,000 W

3. Great Adventure wants to increase the number of riders per hour that they can move through the ride. They can't make the cars drop any faster, so they decide to cut the time it takes to raise the cars in half. What is the best choice for motor size that they should purchase to do this?
   a) 35 hp
   b) 75 hp
   c) 140 hp
   d) 280 hp

4. During freefall the car falls a vertical distance of 14 meters. What is the change in energy of the car during the drop?
   a) 8000 J
   b) 11,200 J
   c) 92,400 J
   d) 110,000 J

5. What is the maximum velocity of the car during the freefall? (Hint: compare you answer using your measured freefall time and kinematics vs. the answer using conservation of energy.)
   a) 5 m/s
   b) 15 m/s
   c) 25 m/s
   d) 35 m/s

6. In the stopping section of the track, the car travels through a curve and gets turned horizontal so that the brakes can be applied. What is the Centripetal Force acting on the car as it goes through the curve of radius = 15m? Assume that there is no friction between the car and the track.
   a) 8,000 N
   b) 15,000 N
   c) 30,000 N
   d) 42,000 N

7. How does the calculated force factor ($F_{centripetal}$ / Your Weight) through this curve compare to the force factor you measured during freefall?
   a) Greater
   b) Equal
   c) Less

8. Calculate the work done by the brakes to stop the car.
   a) 10,000 J
   b) 25,000 J
   c) 50,000 J
   d) 100,000 J

9. What is the coefficient of friction between the brakes and the car on the 27 meter long stopping track?
   a) 0.1
   b) 0.5
   c) 0.9
   d) 1.5

10. What is the average force exerted on a <u>60 kg rider</u> while it is being brought to rest on the 27 meter long stopping track?
   a) 25 N
   b) 250 N
   c) 2500 N
   d) 25000 N

OPEN ENDED QUESTION:

ACADEMIC – Examine the design of the freefall car. To achieve a true "freefall" all types of friction must be minimized. What are some design elements to the car you rode in that are intended to reduce frictional forces during the drop?

ACCELERATED – A new Great Adventure engineer wants to make the ride more exciting by tripling the height of the freefall. However, the engineer does not plan to modify any other part of the ride. Explain why this is a bad idea based on the comfort concerns of the rider. How many times is the magnitude of braking force on the rider increased?

***THE SPIN MEISTER***

Utilize the force meter to take readings at three points-

a) Right before the ride tilts
b) At the bottom of the ride (after it tilts)
c) At the top of the ride (after it tilts)

The force meter must be pointed in the radial direction!

The radius of the rider's seat at top speed is 7.9 meters

Assume the mass of the rider is 60 kg

Time for 4 revolutions at top speed: **16.4 s**

Period of the ride in seconds: **4.1 s**

Force meter reading just before tilt:**1.8 s**

Force meter reading at bottom: **3.0**

Force meter reading at top: **0.9**

11. What is the force meter reading at the bottom of the ride after it has tilted?
    a) between 0 and 1
    b) between 2 and 4
    c) between 4 and 5
    d) between 5 and 6
    e) over 6

12. What is the force meter reading at the top of the ride after it has tilted?
    a) between 0 and 2
    b) between 2 and 3
    c) between 3 and 4
    d) between 4 and 5
    e) over 5

13. Where do the riders feel the heaviest?
    a) at the top of the ride
    b) at the sides of the ride
    c) at the bottom of the ride
    d) at the end of the ride
    e) they never feel heavy

14. Where do the riders feel the lightest?
    a) at the top of the ride
    b) at the sides of the ride
    c) at the bottom of the ride
    d) at the end of the ride
    e) they never feel light

15. What is the velocity of the ride in meters per second when it is vertical?
    a) 2.0
    b) 12.0
    c) 21.0
    d) 32.0
    e) 38.0

16. What is the centripetal force experienced by the rider ($F_c$) in Newtons?
    a) 1100
    b) 2200
    c) 3300
    d) 4300
    e) 8600

17. What is the force of the seat on the rider in Newtons on the bottom of the ride?
    a) 600
    b) 1200
    c) 1700
    d) 2600
    e) 4200

18. What is the force of the seat on the rider in Newtons on the top of the ride?
    a) 200
    b) 500
    c) 1200
    d) 2600
    e) 3000

19. How does the force factor before the tilt compare to the force factor at the top after the tilt?
    a) It is greater
    b) It is the same
    c) It is less

20. If the velocity of the ride doubled, how would the force factor before the ride tilts change?
    a) It would not change
    b) It would increase by 2x
    c) It would increase by 4x
    d) It would increase by 8x
    e) It would be less

OPEN ENDED QUESTION:

ACADEMIC – Compare the calculated force factors to the ones measured on the ride. Explain why the force factors experienced by people of different masses should be the same.

ACCELERATED – When you are stationary a seat exerts a force on you equal to your weight. You therefore experience a force factor of 1. Explain why riders do not feel upside down when they are at the top of this ride.