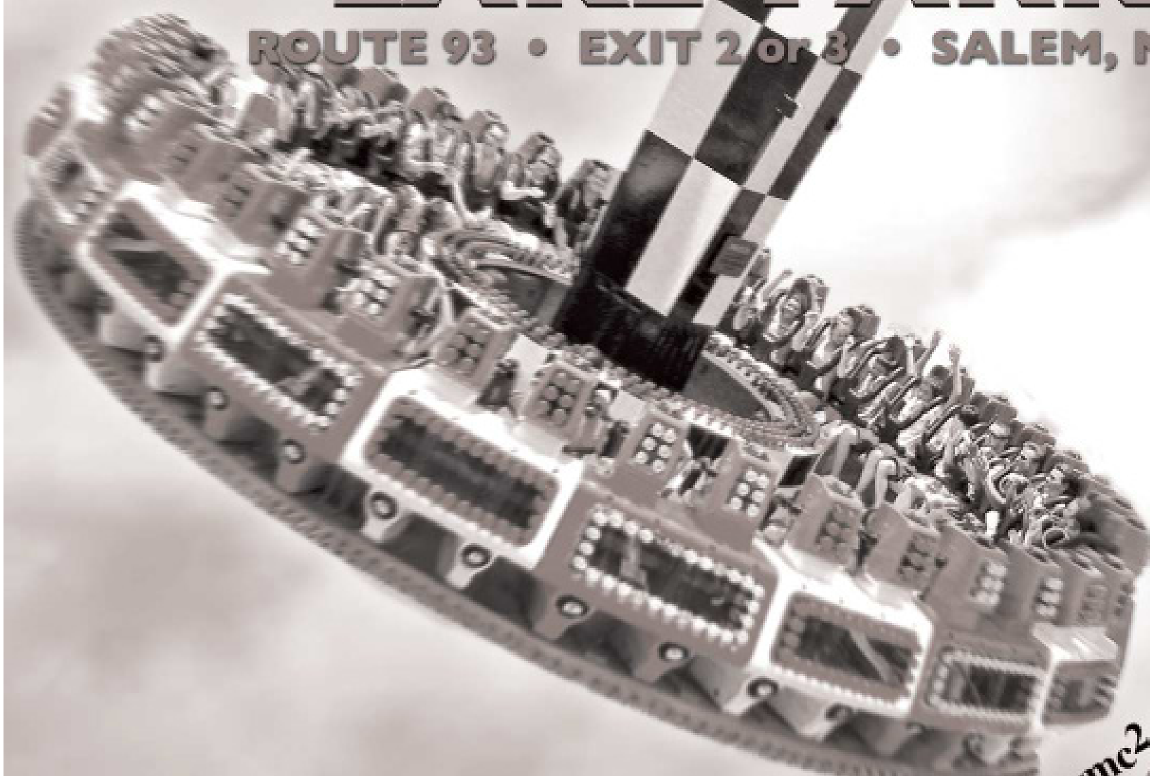
just for fun

CANOBIE LAKE PARK

ROUTE 93 • EXIT 2 or 3 • SALEM, NH



2015 Physics Day Workbook

PHYSICS DAY

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Fun Facts

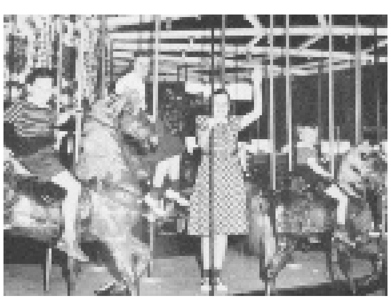
Yankee Cannonball Roller Coaster

Canobie Lake Park's classic wooden coaster was built by the Philadelphia Toboggan Company in 1930 for Lakeview Park in Waterbury, Connecticut. The coaster was purchased in 1936 by the owner of Canobie Lake Park and installed here as the "Greyhound." The 60 foot tall first hill was destroyed by a hurricane in 1954. In the mid-70's, the coaster was renamed the "Yankee Cannonball".

The Yankee Cannonball is known as an "out and back" coaster because of its large "L" shaped layout. The three-car train travels over a track length of 1,840 feet at a maximum speed of 35 miles per hour. The first and highest drop is 53 feet. With a ride time of 52 seconds from the top of the hill to the brakes and 1 min 52 seconds from station to station it has been rated as one of the top ten wooden coasters in the country!

The Antique Carousel

Built in the late 1800's, the Antique Carousel is the oldest attraction at the Park. The carousel was moved to Canobie Lake Park in 1906. At some point during the carousel's history, a third row of horses was added making it one of the few carousels operating with an outer step. Originally, the carousel was steam-powered but today is one of only two carousels driven by a rubber tire and an electric motor. Out of the fourteen carousels permanently installed in New England, ours is one of the oldest.



The carousel's music is supplied by a 1917 Wurlitzer Military Band Organ. This organ replaced the original steam-powered organ sometime in the 1920's or 1930's. Over 80 piano rolls similar to those found on the old style player pianos provide music. Some of the music rolls being played today date back to 1902.

PHYSICS DAY

The Canobie Corkscrew Roller Coaster

Canobie Lake Park's only movie star! Built in 1975 for "Old Chicago", an indoor amusement park in Chicago, Illinois, by Arrow Dynamics of Utah, the Canobie Corkscrew Coaster starred in the movie "The Fury". Purchased by Canobie Lake Park in 1988 from the Alabama State Fair, the Corkscrew sat in pieces for two years awaiting town approval for construction.

Thanks to the Corkscrew; flagpoles, church steeples, and amusement rides can now be 80 feet tall within the town of Salem! The Corkscrew opened completely refurbished in 1990 with a lift height of 73 feet and a first drop of 65 feet. The six-car train carries 24 people to a maximum speed of 32 miles per hour and through two 360 degree loops. It was only the second coaster in the world to turn upside down twice. The Corkscrew first installed at Knott's Berry Farm in Buena Park, CA was the first corkscrew roller coaster.

The Boston Tea Party Shoot the Chute

The area between the Old Canobie Skating Rink and Canobie's Famous Dancehall Theater is entirely themed to revolutionary war Boston. The centerpiece for this section is the "Boston Tea Party Shoot the Chute". This is a water ride that makes quite a splash! Known in the industry as a "Splash Down", each of the boats (weighing 4 tons each!) travels up a chain lift and then plunges through a cleat tunnel into a pond 48 feet below. The result is a wave almost 40 feet in height! For an added thrill, the exit for the ride goes over a bridge that is directly in the path of the gigantic splash.

The Starblaster

In 2002, the Starblaster, built by S&S Power, was installed between the Antique Cars and the Yankee Cannonball. The Starblaster is known as a "double shot" ride, shooting 12 riders from bottom to top TWICE with compressed air! It is closely related to a "drop tower" ride where you are elevated to the top first and then released.

In welcoming the new Starblaster, a green YAG laser was installed on the very top. This beam, manufactured in Washington, emits a laser beam up to 15 miles in 8 different directions and operates every night that the Park is open beginning at sundown.

daVinci's Dream

daVinci's dream is truly a work of art. Wood Design, Inc of Holland installed this "waveswinger" in 2003. Every panel of this magnificent ride was handcrafted and hand-painted in an Italian Baroque and Renaissance fashion in the Netherlands. As you sit in your seat, you are elevated 16 feet in the air while the cap tilts 15 degrees and begins to spin in the opposite direction of the mid-section causing a true "wave swing" feel.

The ornate fencing around the perimeter houses the statues of Canobie Lake Park's three women, the Goddesses of Spring, Summer, and Fall.

Park Map

Canobie Lake Park
just for fun
Canobie Lake Park is a smoke-free facility.
MAP KEY
REST ROOMS
TELEPHONE
LOCKERS
FIRST AID
AIR CONDITIONED
FOOD
FREE PARKING
STROLLER RENTAL
WHEELCHAIR RENTAL
CELL PHONE CHARGING STATION
GIFTS
AUTOMATED EXTERNAL DEFIBRILLATOR
DESIGNATED SMOKING AREA
UNTAMED
UNTAMED PHOTOS
BEAR LODGE
PAVILLION CATERING
NORTH GROVE CATERING AREAS
PSYCHO-DROME
AUTOBAHN
SKATER
CATERPILLAR
MINI-SKOOTER
LAKE ARCADE
BLUE HERON LAKE CRUISES
TRAIN STATION
DA VINCI'S DREAM
OVER THE RAINBOW
STARBLASTER
SKY RIDE
ANTIQUE CARS
YANKEE CANNONBALL
GAMES
PIZZERIA & SUBS
FIREWORKS
PORTOFINO RESTAURANT
DANCEHALL THEATRE
PONCHO CANTINA
KIDDIE LAND
MIDWAY STAGE
FLOWER POWER
JUMP AROUND
WAVE BLASTER
BOSTON HARBOR PATROL
MINUTEMAN CLAMS
INTERNATIONAL FOOD PLAZA
CRAZY CUPS
LEMONADE STAND
PALACE ARCADE
ZERO GRAVITY
DODGEM
EQUINOX
TIKI MAZE
JR. SPORTS CARS
TEMPORARY TATTOOS
BOSTON TEA PARTY
TURKISH TWIST
CANOBIE EXPRESS
WIPEOUT
CAROUSEL
GUEST SERVICES
GIFT SHOP
DRAGON COASTER
BE-BOP DINER
ROWDY ROOSTERS
THE TRELLIS
FRIED DOUGH
JUNGLE BOUNCE
3 POINT CHALLENGE
XTREME FRISBEE
TWIST & SHOUT
POPCORN
MAIN ENTRANCE
MINI DINOS
ALPINE SWING
FUNNEL CAKES
CANOBIE "500"
PAINTBALL
GIANT SKY WHEEL
ATM
CASTAWAY ISLAND
CORKSCREW
SEALAND RESCUE
LUMBER JACK'S ICE CREAM
OLD TIME PHOTOS
FLUME PHOTOS
ROCK WALL
PIRATE SHIP
WOODEN NICKEL ARCADE
CHICKEN COOP
KIDDIE CANOES
LOG FLUME
VILLAGE STAGE
MINE OF LOST SOULS
CANDY SHOPPE
DANCING BEAR CANTEEN
TIMBER SPLASH WATER COASTER

Ride Statistics

Xtreme Frisbee
The disc rotates at 15 RPM
The trajectory circle length is 89.9 feet
The tires that drive the kick move at 420 RPM
Height to center of axel is 47.9 feet
The diameter of the disc is 27 feet
The running angle this ride is operated at is 85 degrees

Yankee Cannonball
Vertical drop of first hill is 53 feet.
Total length of ride is approximately 1,840 feet.
Radius of bottom of first hill is 17.5 feet.
Average angle of bank is 30 degrees.

Pirata
Radial distance from pivot to bottom of the ship is 32.5 feet.
Maximum angle of swing is 110 degrees.
Length of ship is 40 feet.

Giant Sky Wheel
Diameter of the wheel is 80 feet.

Policy Pond Log Flume
Vertical height of tower is 35 feet.
Angle of slide is 50 degrees.
Length of one boat is 10 feet.
Weight of one boat is 600 lbs.

Ride Statistics

Turkish Twist
Diameter of drum is 14 feet.
Maximum rotation of speed 39 rpm.

Antique Carousel
Diameter of platform is 50 feet.

Starblaster
Weight of the carriage is 8 KN.
Height of tower is 80 feet.

Castaway Island
Operates at 25 hp
Bucket fills to 200 gallons before spilling over
The bucket flips once every minute
264,000 gallons of water are pumped through the ride each hour

Skater
Width of the base is 24 meters and goes up 11 meters to the top of the track
Operates at 14 RPM on rotation
The length of the carriage is 29 feet 6.3 inches
The width of the carriage is 6 1/2 feet

Wipeout
The top disc spins at 20 RPM in one direction
The bottom disc spins at 10 RPM in the opposite direction
The max boom angle is 45 degrees from the ground and 40 feet from the deck

Formulas

Area of a circle	$A = \pi r^2$
Circumference of a circle	C = 2*π*r
Work	W = F * D
Gravitational Potential Energy	GPE = m * g * h
g force	(Normal Force)/ Weight
Kinetic Energy	$KE = 1/2 * m * v^2$
Final Velocity	Vf = Vi + 2 * a * d
	$Vf^2 = Vi^2 + 2 * a * d$
Centripetal Force	$Fc = (m * v^2) / r$
Linear Velocity	v = (2 * π * r) / T
Period of Simple Pendulum	T = 2 * π * / F(L,G)
Frictional Force	Fr = u * F(Normal)
Angular Velocity	w = 2 * π * f
sine	opposite/hypotenuse
cosine	adjacent/hypotenuse
tangent	opposite/adjacent = sine/cosine
Work Energy Theorem	Total Mechanical Energy (original) = TME (final)
	Work (other) = Total Mechanical Energy
	Total Mechanical Energy = KE + PE
	$KE = .5mv^2$
	PE = mgh
	J = stress = F/(A(cross section))
	P = momentum = mv
	J = impulse = P = f * t
Conservation of momentum	$P_o = P_f$
Period	T = seconds/1cycle
Frequency	f = cycles/1second
Moment of inertia	mr^2 (larger moment, harder to move)

Constants:

Gravitational Acceleration: $G=9.8\ M/S^2$

550 Ft - Lbs/ Sec = 1 horsepower = 746 watts

MPH * 1.47 = Ft/Sec

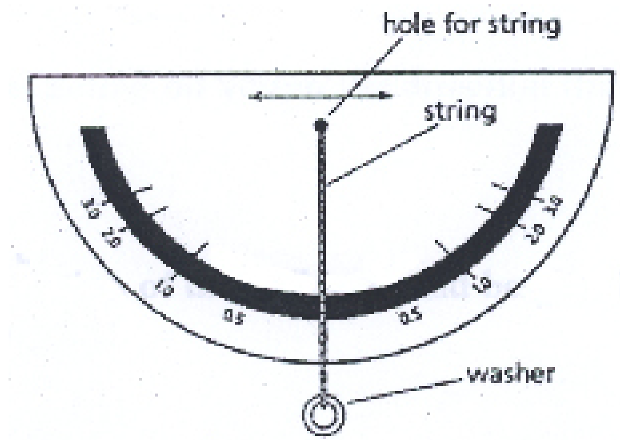
Km / Hr * .28 = Meters/Sec

Km / Hr * .62 = MPH

Standard Mass = 70 kg

Making a “G” Meter

A common unit to describe forces we feel is the “g”. One g is equal to the force of Earth’s gravity. When the space shuttle takes off, astronauts feel about three g’s of force (three times the force of earths gravity). How many g’s do you feel on the swings, on your bicycle, on an amusement park ride or in a car? You can make a “g” meter to measure these forces.

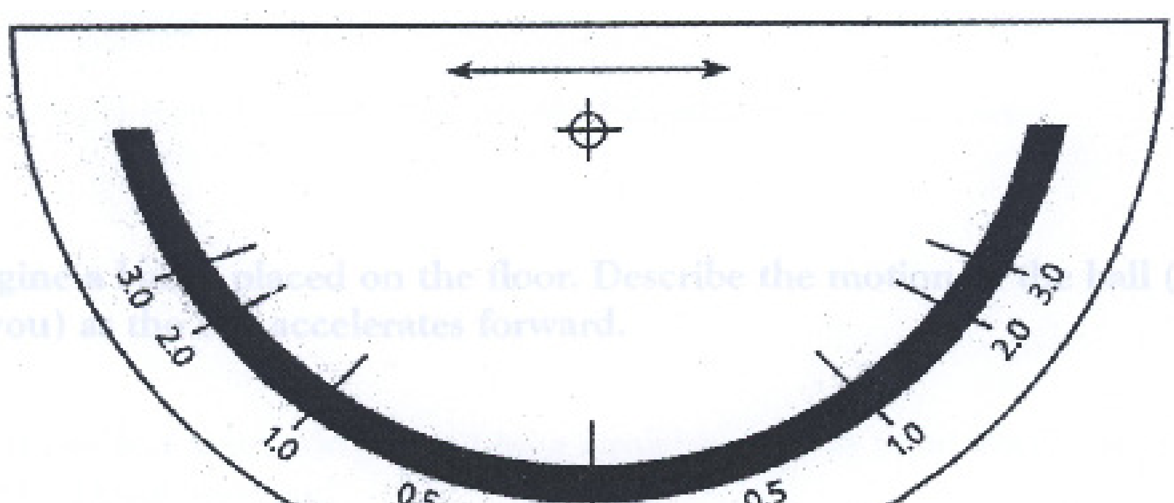


Materials:

- Copy of “G” meter
- Thin Cardboard
- Glue
- Scissors
- String or heavy thread
- Metal washer

Procedure:

- Make a copy of the “G” Meter and cut out.
- Glue the “G” Meter to a thin piece of cardboard and trim to size.
- Take about 6 inches of heavy thread and tie one end to a weight such as a key or washer. Tie the other end through the hole at the top of the “G” Meter.
- Hold the “G” Meter in front of you. Let the thread hang down so that it lines up with the 0g mark.
- If the “G” Meter moves in the direction of the arrows, the weight and string will tell you the force in g’s.
- In order to have the “G” Meter work properly, the top edge must be horizontal, level with the horizon.



Physics on the Bus

Why is it that you are pushed back into the seat when the bus accelerates? Which Newtonian law governs this?

What part of the bus absorbs the centripetal force during a turn?

A) The axel
B) The tires
C) The frame
D) The roof

If you were to throw a tennis ball in the bus at 30 MPH and the bus is traveling at 27 m/s, how fast is the ball traveling in reference to the ground? Calculate in m/s, MPH and feet/sec.

Draw a free body (a.k.a. force) diagram of yourself sitting in your seat while the bus is accelerating.

Imagine your bus was speeding along at 35 m/s (constant velocity) and a stationary police officer notices. He accelerates at a rate of 5 m/s^2 from rest when the bus passes. How far has the bus traveled from the time the police officer noticed until the officer pulls even with the bus? How much time has gone by?

Your bus goes over the crest of a hill at 10 m/s and the radius of curvature of the hill is 15m. Determine the force exerted by the car seat for a man of standard mass (75 kg). At what speed would you literally become weightless?

Yankee Cannonball

A full car weighs 6,300 Newtons with people in it. Use the formula as well as the work-energy theorem to find the work done by the motor to get the train (6 cars) to the top of the hill. (M) = 0.15, constant velocity.

Calculate the potential energy of the train at the top of the first hill.

Calculate **your** potential energy at the top of the first hill.

Calculate the speed of the train at the bottom of the first hill. Assume no friction.

Calculate your speed at the bottom of the first hill.
Assume no friction. Are the last 2 seconds the same?

Why are the curves banked?

Why is the second hill shorter than the first?

Calculate the average speed of ride given total distance.

How long does it take the coaster to descend the first hill?

Using this time and length of the first hill, how fast will you be going at the bottom of the first hill?

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 where you sat on the ride and your experience. Also, predict the experience of the passengers seated in the other sections listed above between the time of the first climb and reaching the top of the second hill.

PHYSICS DAY

Pirata (Pirate Ship)

Draw a free body diagram of the ship at its lowest point.

Derive an equation for the normal force at the lowest point in the ship's path. R=20m and the ship weighs 25 KN.

Assume the max height is 15 meters, find the speed at the bottom of the path. Assume no friction.

What is the main reason why it would take more work to start up the Pirate Ship than to slow it down?

Estimate the arc length covered by the pirate ship? (Hint: work in radians)

Measure the maximum angle of the swing.

Calculate the length of the pendulum arc? (formula)

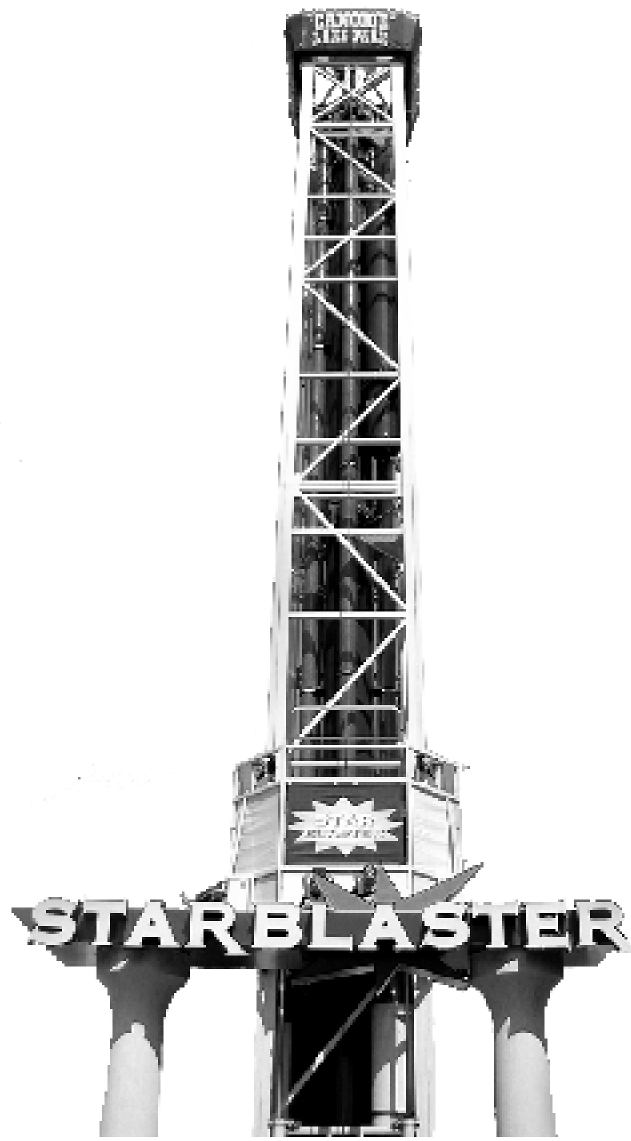
Describe your sensations of weight at various positions.

REAL Engineering
Consider the four main supports for the pirate ship. Each at approximately a 45 degree angle with the vertical. The diameter of the bars is about 0.5 m. If the safest allowable stress load is 50 KN, how fast can the pirate ship go? Is this even possible under frictionless conditions?

Starblaster

The carriage on the Starblaster weighs about 8 KN. If it takes about 1 second to get up to about 8 m/s from rest. What is the force supplied by the pneumatics? First find acceleration and don't forget weight.

When on the Starblaster, on the way down you may experience the feeling of weightlessness. Weightlessness occurs when what is no longer present?



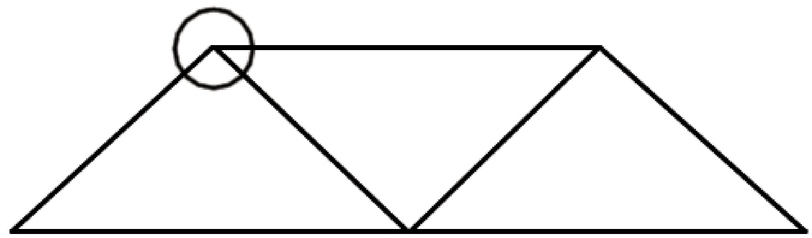
In order to achieve weightlessness, how fast does the carriage have to accelerate downward?

Draw two free body diagrams. The first of yourself while the starblaster is both accelerating and the second when decelerating. Remember you have a seat belt.

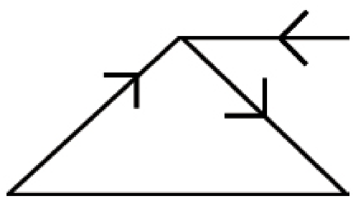
BONUS: What are the max. and min. g values attained during the ride? Assume m=70kg

REAL Engineering

A truss is a series of beams that are joined together in order to support something. You've seen trusses before in the Yankee Cannonball Roller Coaster and now…the Starblaster. Because a truss follows the principles of equilibrium, at a joint, all the forces in the beams must cancel each other out. For example:

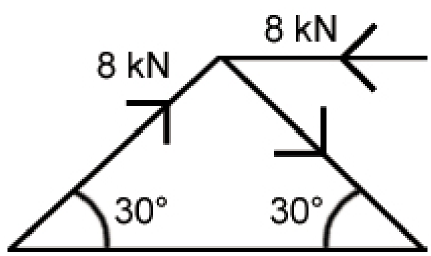


At the joint, consider some hypothetical forces in an isolated view



Some forces point toward or away from the joint depending on whether they are in compression (squeezing the ends) or tension (pulling them).

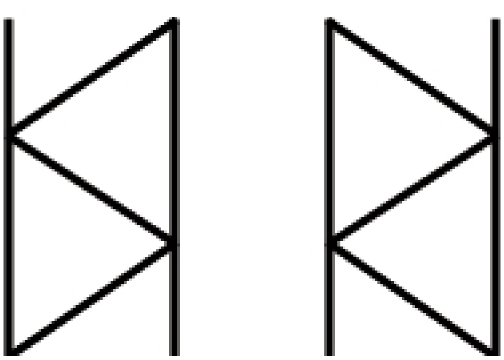
Example



If you have these values, find the third force.

Look at the truss of the Starblaster and think about the different forces in the beams and how they might cancel each other out.

The truss looks like this:



Hint: Look at one force at a time.

The Giant Sky Wheel

Measure how many seconds it takes for one complete revolution. What is this called? Calculate the frequency.

Why does the conservation of energy theorem not apply to a Ferris wheel?

How many revolutions would it take for the wheel to roll down to Boston's Logan Airport (about 30 miles)?

Using the angular acceleration in problem 2 and assuming that the deceleration is the same, and knowing the angular velocity, calculate the radial and linear distance covered in a 130 second ride.

Why does the conservation of energy theorem not apply to a Ferris wheel?

Find the diameter of the wheel using trig (with baseline).

Calculate linear velocity and centripetal acceleration.

How fast would you have to go to "float" at the top? Find the linear answer.
BONUS: Find the radial answer.

BONUS: Compute the tangential velocity of a rider. R=22m

BONUS: Compute the angular acceleration if it takes the wheel 4 seconds to get up to speed.

Policy Pond Log Flume

What is the main physical concept that keeps the log flume moving?

a) Gravity
b) Constant collisions between the water and the car
c) Centripetal Force
d) Acceleration

How fast should you be going at the bottom of the first hill? H=12m with no friction.

Observe how long it takes for the flume to go from its speed at the bottom of the hill (about 12 m/s) to equaling the speed of the water current (about 2 m/s). Find the impulse of the water on the log $m \approx 600$kg.

Turkish Twist

It takes about 10 seconds for the Turkish Twist to get up to max speed. If the max speed is 9.5 m/s, calculate the revolutions the twist went through during its acceleration. R=3m

Calculate the frequency of the twist.

Calculate the centripetal acceleration at full speed.

Calculate the tangential acceleration.

Calculate the resultant acceleration.

Draw a free body diagram of a rider while the ride is stopped.

Draw a free body diagram of a rider while the ride is in motion.

Calculate the speed needed for the floor to drop and the rider to remain pressed on the wall. Find m/s and RPM's. μ =0.4

At top speed, how many g's will a rider of standard mass have? (v=9.5 m/s, r=3m)

The Antique Carousel

If a rider doubles their distance from the center, how is their velocity affected?

a) It is halved
b) It doubles
c) Velocity is not affected

If a rider doubles their distance from the center, how is their centripetal acceleration affected?

a) It is halved
b) It is doubled
c) Centripetal Acceleration is not affected

How might the efficiency of the carousel be increased without altering the motor?

a) Increase the radius of the platform
b) Decrease the radius of the platform
c) Elevate the platform

If the motor stops and the guest wants to enjoy their ride as long as possible, should they move to the center or the outer edge? Why? What is the relationship?

A rider of standard mass is placed on the floor of the carousel. If the carousel accelerates uniformly from the rest position, at what speed will they slide off the edge? r=6m, (IMAGE) =0.30

daVinci's Dream

daVinci's Dream is a wave swinger ride typically known as a "flying carousel". This ride acts just as a carousel would, except the top of the ride elevates, tilts and spins in the opposite direction of the center superstructure. How will this affect your ride?

As the ride begins and the top begins to spin, what happens to the seats?

a) They flare outward
b) They flare inward
c) They remain still

Draw a free body diagram of the seat while the ride is in motion.

Draw the connection between the cable and the turning apparatus.

Using your free body diagram in problem 3, derive an equation for velocity.

Now that you have an equation for the velocity and you've experienced the velocity difference at high and low points, estimate the cause of the velocity difference.

Does the mass of the rider matter as far as speed goes?

Determine the tension in the chains that suspend the chair when a rider of standard mass is riding before the top tilts. The chains make a 20 degree angle with the center line. r=4, f=0.2Hz, there are two chains per chair.

The Dodgems

In order to be a dominant car, what are the two ways to increase momentum? Why?

The bumper cars are good illustrations of what type of collision? What part of the car is specifically designed for this type of collision?

If you drive into a wall at 5 m/s, rebound at 1 m/s, and make contact with the wall for 0.15 s, what force did the wall exert on the car? M (IMAGE) = 220kg

A bumper car with a mass of 220kg going 6 m/s collides with a stationary bumper car also with a mass of 220 kg.   After the collision, car #1 goes off in a 37-degree angle to the left while car #2 goes off at a 53-degree angle to the right. What are the speeds of both cars after the collision?

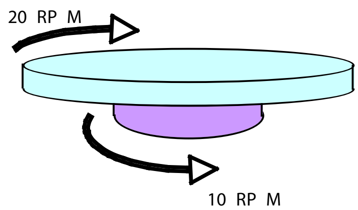
A car with a mass of 220kg moves at 7 m/s. How long will a braking force of 400 N take to stop the car?

Why would the rubber bumpers be warm after a collision?

Wipeout

When it first starts up, the Wipeout can be modeled as 2 horizontal disks, one atop the other. The upper disk rotates clockwise at 20.0 RPM and the lower disk rotates counterclockwise at 10.0 RPM as shown in the sketch on the right.

1. Calculate the net angular speed of the upper disk, ω, in relation to the ground (i.e. in the reference frame of the amusement park). Give your answer in rotations/second.



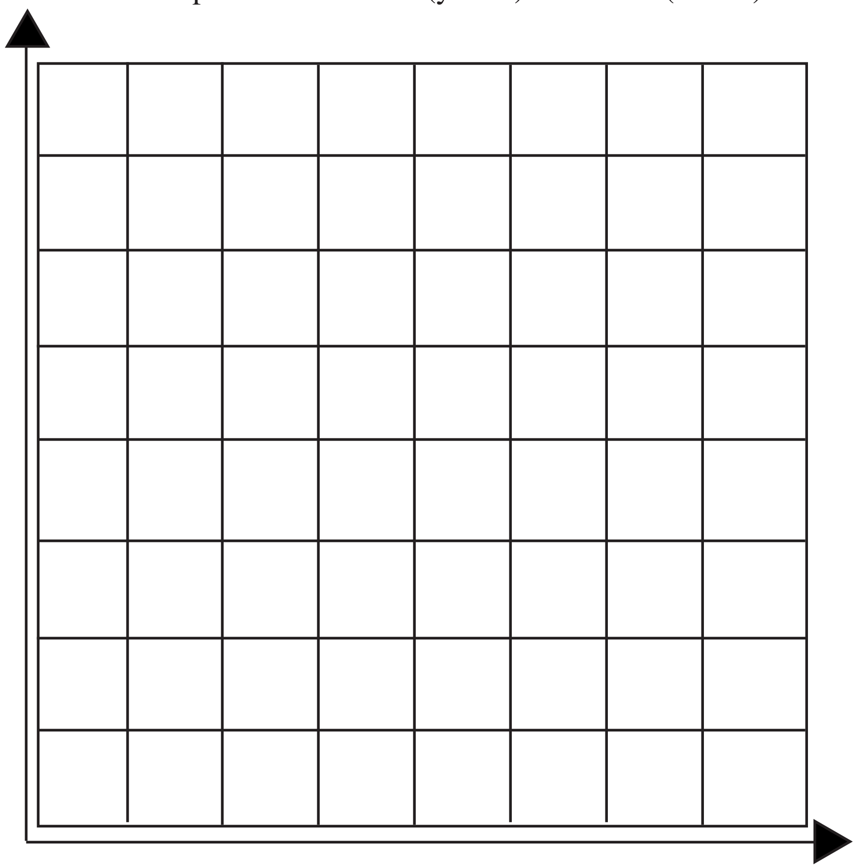
2. The centripetal acceleration felt by a rider in the above situation can be expressed as follows:

$$a_c = \frac{v^2}{r} = \frac{(w\,r)^2}{r} = w^2 r$$

Calculate the centripetal acceleration over a range of radii using this relationship and the net angular speed from Part 1. Summarize your results in the following table. What is the direction of the acceleration in each case?

Radius	Centripetal Acceleration
	0.0 m
	1.0 m
	2.0 m
	3.0 m
	4.0 m
	5.0 m

3. Plot the centripetal acceleration (y-axis) vs. radius (x-axis).



Referring to the graph, describe the mathematical relationship between circular radius and acceleration.

Use the graph to determine the centripetal acceleration you would experience if you were sitting 4.5 m from the center of rotation. Then, calculate the g's you would feel.

The Skater

1. While on the ride you may notice that at certain times it appears that you are momentarily at rest in the Reference Frame of the Amusement Park. How can this be?

2. Neglecting any Energy Dissipation (due to friction, air resistance, etc) what should be the linear speed of the Skateboard's center of mass as it rolls through the bottom of the arch in order for it to come to rest at a point 11.0 meters higher? [14.7 m/s]

3. Using the linear speed you determined above, calculate how high the Skateboard would go if 5% of its energy were dissipated between the lowest point and the highest point. [10.5 meters]

4. In which row of seats would a rider experience the greatest tangential speed? Ex plain your answer or justify mathematically.

5. The maximum angular speed of the spinning skateboard is 14.0 RPM's. A 55.0 kg rider in the outermost row sits with a bathroom scale between her back and the back of her seat. She is 4 meters from the center of the rotating skateboard.

   a. Draw a Free Body Diagram of the rider when the Skateboard is at its lowest point.

   b. What is the reading on the scale given in Newtons? [12N]

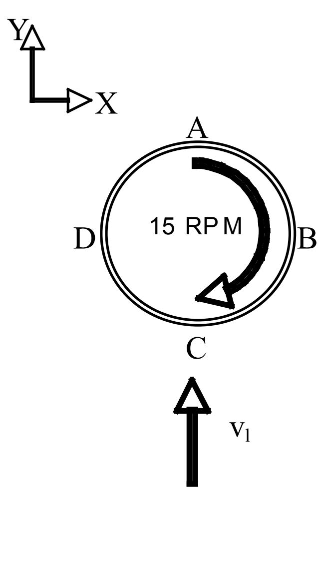
Xtreme Frisbee

1. The support arm that connects the center of the Frisbee with the axel above is 14.6 meters long. The maximum angle the support arm makes with the vertical is 85.0o. Calculate the maximum height of the Frisbee's center. [13.3 meters]

2. Neglecting any Energy Dissipation (due to friction, air resistance, etc) what should be the maximum linear speed of the Frisbee's center of mass as it passes through the bottom of its trajectory? [16.2 m/s]

3. The Frisbee rotates at 15 RPM's. A rider sits 4.00 meters from the center of the rotating Frisbee. What is his tangential speed? [1 m/s]

4. In the below diagram, the Frisbee is passing through its lowest point with the linear speed (vl) you calculated in part 2. The Frisbee is also rotating at 15 RPM as in part 3. Determine the total velocity (both magnitude and direction) of riders B and D relative to the ground (i.e. in the reference frame of the Amusement Park). [B: 15.2 m/s at 90 degrees, D: 17.2 m/s at 90 degrees]



Castaway Island

The Castaway Island attraction uses a 25 hp electric motor to drive a pump that delivers 264,000 gallons of water each hour. From the pump, the water passes through a 10-inch diameter pipe.

1. What is the speed on the water as it passes through the 10-inch diameter pipe? Ex press your answer in m/s. A useful conversion factor is 2.54 cm = 1 inch.

2. Calculate the electrical power requirement in watts.

3. Calculate the flow rate in cubic meters per second (m3/s). There are 264 gallons per cubic meter.

4. Assume that the efficiency of the pump/motor combination is 80%. Calculate the rate at which the pump is capable of doing work on the water.

5. Based on the work done on the water, how high up does the water get pumped?