Welcome to our THRILLS WORKSHOP @Home!

Coming to you straight from the Island Like No Other, we've put together a bitesize version of one of our thrilling educational workshops for you to enjoy at home.

Launch yourself into the Science of Roller Coasters and learn about our record-breaking attractions, challenge your knowledge with hair-raising equations and explore the facts behind the thrills of our most exhilarating roller coasters!

Let us know how you did by finding us on our social platforms @THORPEPARK

THORPE PARK

MAKING MAGIC WITH MERLIN

The Science of Roller Coasters

Ages 11+

An Island Like No Other

With over 30 thrilling rides, attractions, Thorpe Park Resort is an Island like no other and is a must-visit for those looking to embark on an incredible adventure with friends and family!

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Record Breaking Rides

When it opened in 2009 SAW - The Ride held the record for the steepest drop in the world with a drop of 100° - that's beyond vertical!

It was also marketed as the world's first horror themed roller coaster.

Colossus was the world's first 10 looping coaster, opening in 2002.

It held this record until 2013 when the record was taken by The Smiler at Alton Towers Resort.

Nemesis Inferno is the only coaster of its type to have interlocking corkscrews.

It broke the Guinness World Record for the most naked riders in 2004 - don't worry we gave the seats a scrub!

Coaster Construction

Constructing a roller coaster is a very long process with lots of different stages.

It is essential that a team of physicists are involved with the whole process.

It takes on average 4 years from its initial conception for a coaster to open to the public!

THE SWARM

Head on to Youtube and search for 'THORPE PARK The Swarm Construction' for an awesome video!

Forces for Thought

Designed to deliver as much fun per m^2 as possible, there are a ton of physical factors that need to be taken into consideration when designing and building a roller coaster, including:

🤔

- *Velocity*
- *Time*
- *Force*
- *Mass*
- *Weight*
- *Gravity*
- *Distance*
- *Acceleration*
- *Momentum*
- *Energy*
- *Friction*

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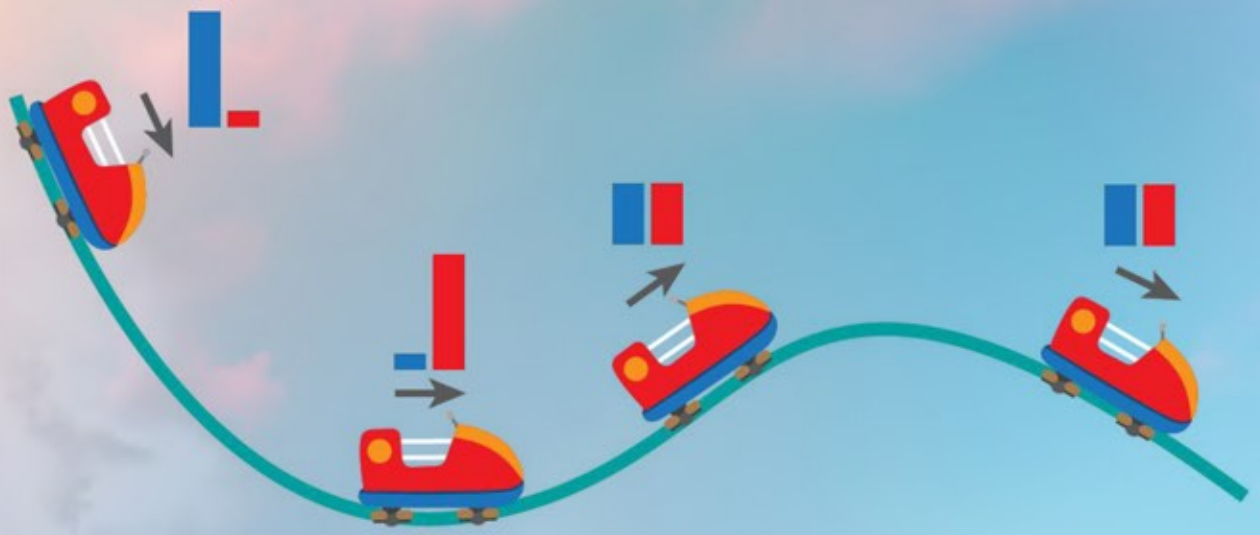
Exhilarating Energy

Potential energy
Kinetic energy



The roller coaster car gains Gravitational Potential Energy (GPE) as it travels up the lift hill.

Once over the lift the car gains speed as GPE is transferred into Kinetic Energy.

As it travels to another peak it gains GPE again, and the cycle repeats.

GPE can also be transferred as heat and sound energy.

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Roller Coaster Roundup

1. How steep is SAW - The Ride's record breaking drop?

2. Which coaster took the world record from Colossus for most inversions when it opened in 2013?

3. How long does a coaster typically take to open from the initial conceptualisation phase?

4. Name three physical factors that need to be considered when designing a roller coaster?

5. What kind of energy does a roller coaster train gain as it ascends the lift-hill?

6. What other kinds of energy can Gravitational Potential Energy be transferred as?

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Exhilarating Energy

GPE (Gravitational Potential Energy) can be worked out with the following equation:

M x G x H

Mass x Gravity x Height

Gravity is presented using around 9.8N/kg, however to simplify we will round this up to 10N/kg.

Car Weight: 5,000kg
Height: 30m

SAW THE RIDE

Using SAW – The Ride as an example the equation would look something like this:

5,000 x 10 x 30 = 1,500,000J

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Exhilarating Energy *Exercise*

Work individually or as a pair to calculate the GPE for THE SWARM & Stealth (go on, use a calculator or your mobile if you like.)

Notes:
Gravity (rounded): 10N/kg

THE SWARM

Car Weight: 10000kg
Track Length: 775m
Max G-Force: 4.5Gs
Height: 39m

?

STEALTH

Car Weight: 8000kg
Track Length: 398m
Max G-Force: 4.7Gs
Height: 62.5m

?

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Vivacious Velocity

How do we work out velocity?

$$\text{Velocity} = \sqrt{\frac{2 \times KE}{MASS}}$$

For example, SAW - The Ride's velocity can be worked out as follows:

$$\sqrt{\frac{2 \times 1{,}500{,}000}{5{,}000}} = 24.49 \text{m/s}$$

SAW THE RIDE

Car Weight: 5000kg
Height: 30m
GPE: 1,500,000
Kinetic Energy (KE): 1,500,000

Notes:
For the purpose of this example we will assume that all of the GPE is transferred as KE, however in reality a small portion of this would be transferred as heat and sound energy.

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Vivacious Velocity *Vocation*

Work individually or as a pair to calculate the vivacious velocity for THE SWARM & Stealth (use a calculator or your mobile if you like).

Notes:
For this we are using the rounded gravity answer from the previous equation.

For this example we will assume that all of the GPE is transferred as KE, however in reality a small portion of this would be transferred as heat and sound energy.

THE SWARM

GPE: Use the answer from slide 8
Car weight: 10000kg
Track Length: 775m
G-Force: 4.5Gs
Height: 39m

?

STEALTH

GPE: Use the answer from slide 8
Car weight: 8000kg
Track Length: 398m
G-Force: 4.7Gs
Height: 62.5m

?

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Kinetic Energy

KE (Kinetic Energy) can be worked out with the following equation:

$$KE = 0.5 \times MV^2$$

Notes:
M: Mass
V: Velocity

Car Weight (mass): 5000kg
Height: 30m
Velocity: 24.49m/s

Using SAW - The Ride as an example the equation would look like this:

$0.5 \times 5000 \times 24.49^2$
$=1,499,400.25J$

Kinetic Energy *Conundrum*

Work individually or as a pair to calculate the KE for THE SWARM & Stealth (use a calculator or your mobile if you like.)

Notes:
Gravity (rounded): 10N/kg

STEALTH

Car Weight (mass): 8000kg
Height: 62.5m
Velocity: (answer from slide 11)

THE SWARM

Car Weight (mass): 10000kg
Height: 39m
Velocity: (answer from slide 11)

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Braking *Force*

How do we work out the braking FORCE of a coaster?

First - we need to work out the deceleration. To do this we need to use the following equation:

$$\text{Deceleration} = \frac{\textit{Change in velocity}}{\textit{time taken}}$$

Using the facts we have for Stealth, this looks like:

$$\frac{35\text{m/s}}{1.2\text{s}} = 29.2\text{m/s}$$

STEALTH

Brakes in: 1.2 seconds
Hits the brakes at: 35m/s
Car weight (mass): 8000kg

To calculate the braking force use:

Braking force = mass x deceleration

Next - to calculate the braking force for Stealth:

8000kg x 29.2m/s^2 = 233,600N (Newtons)

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Braking *Distance*

How do we work out the braking DISTANCE of a coaster?

We combine the Kinetic Energy of Stealth and the Braking Force previously calculated to work out the distance it takes to come to a stop.

The equation for this is:

$$\text{Braking distance} = \frac{\textit{Kinetic energy}}{\textit{Braking force}}$$

So, for Stealth:

$$\frac{5{,}000{,}000\text{J}}{233{,}600\text{N}} = 21.4\text{m}$$

STEALTH

Kinetic Energy: 5,000,000J
Braking Force: 233,600N
Height: 205ft (62.5m)

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G-Force Explained

When it comes to our coasters, Thorpe Park Resort is home to some of the most intense coasters in Europe with each of our Top 5 pulling more than 4Gs each!

What do we mean by G-force?

The 'G' in G-force stands for 'gravity' and the number we put in front of it represents how many times the force of gravity is felt at a particular point.

In everyday life we experience 1G of force, which is the regular force of gravity when we're not accelerating.

When we talk about Nemesis Inferno, for example, pulling 4.5Gs of force that means riders are experiencing 4.5x the force of gravity when they ride!

G-force is really important when it comes to designing thrills as there's only so much our bodies can take!

A regular human body can withstand 9Gs without the aid of protective equipment but it's generally understood that sustained Gs of more than 5 is where things can get a bit uncomfortable, so our designers use this as a guide when creating our coasters to ensure we can push our rides to the ultimate limit whilst still allowing them to have an exhilarating experience!

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A Weighty Issue!

Traditionally coasters are pulled to the top of their lift hills by a chain, utilising 'dog teeth' to stop it rolling back.

Usually this means the only 'powered' part of a coaster is the chain lift! Meaning once you crest the lift hill gravity does the rest.

Due to this our coaster trains have to be heavy enough to make it around the track empty.

Adding the weight of around 30 riders affects the GPE meaning a faster ride!

Centripetal Force

G-force isn't just felt on coasters! Circular Motion is the movement of an object around the circumference of a circle or rotation along a circular path.

The smaller the radius of a circle, the greater the acceleration experienced and the greater the force felt - as those who have ridden our Enterprise ride 'Zodiac' can attest to!

ZODIAC

The force felt on Zodiac is known as centripetal force - reduce the radius or increase the speed of rotation and you increase the G-Force.

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G-Force *Task*

How do we calculate G-Force?

We do this by dividing the acceleration an object experiences by 'G' (10N/kg).

The equation for this is:

$$\text{G-Force} = \frac{\textit{Acceleration}}{\textit{10N/KG}}$$

Notes:
Remember for 'G' we have rounded this up to 10N/kg to simplify, however 'G' is typically used as 9.8N/kg.

ZODIAC

Zodiac spins at a maximum speed of 14rpm and experiences a centripetal acceleration of $37.5m/s^2$.

Using the equation, calculate the G-Force experienced by the riders on Zodiac?

?

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Industry Adaptations

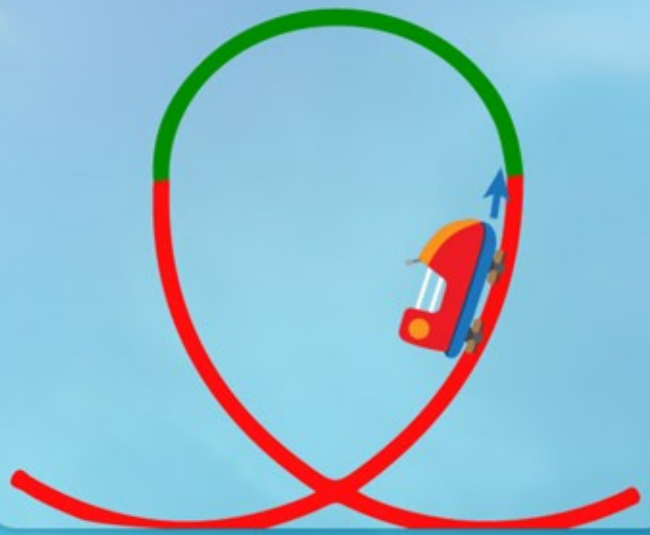
In modern coaster design 'vertical loops' are tear drop shaped. This helps to control the speed of the train, making the ride a more comfortable experience by reducing the time you are subjected to G-force when entering and exiting the inversion (loop).

Nemesis Inferno and Colossus feature vertical loops - check them out when you're getting your next thrill-fix!

From the diagram on the right you can see the red areas highlight the areas of positive Gs experienced during the inversion.

The green shows the area of the lowest (even negative) Gs which can be experienced as a floating sensation known as 'airtime' - this is where your bum lifts off the seat, making it feel like you're floating.

The industry term of this type of loop is a Clothoid Loop.



See you soon!

Throughout this workshop we have looked at:

1. The average time for construction for a coaster
2. Factors that need to be considered when building an attraction
3. Velocity, Potential and Kinetic Energy and how we calculate these
4. Braking Distance and Braking Force
5. How our coasters work
6. Centripetal Force and G-Force
7. Modern industry adaptations

We can't wait to see you at Thorpe Park Resort soon!

In the meantime, check out all our rides at thorpepark.com or download our FREE app!

Thrill, out.

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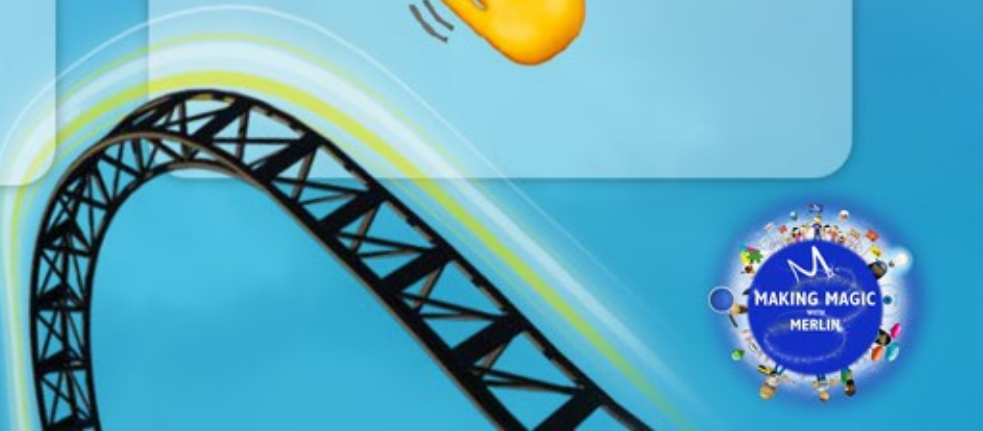

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