Year 12 physics extended experimental Investigation

An experimental analysis of Dreamworld’s “Tower of Terror 2”.

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# Abstract

# Introduction

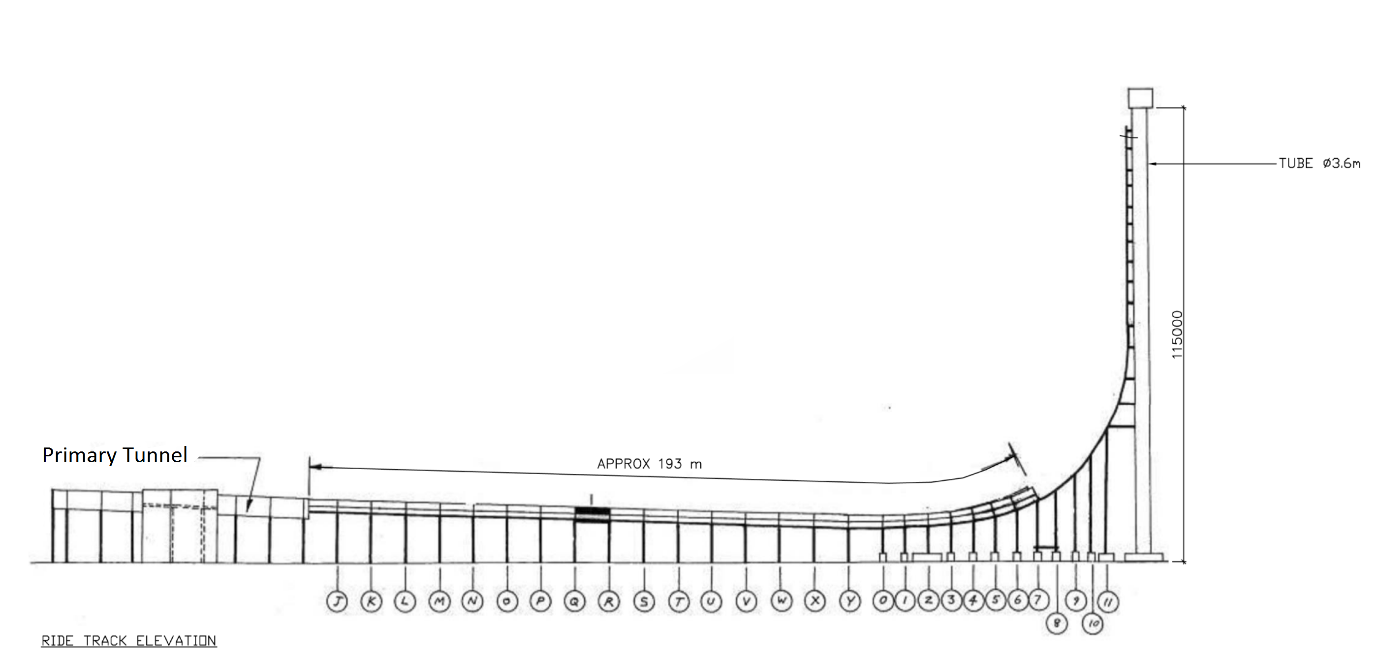


Figure : Tower of Terror 2 Schematics

The *Tower of Terror II* is a reverse free-fall ride, residing in the Dreamworld Theme park in the Gold Coast, Australia. Although there are a number of physics concepts that can be examined on this ride, the focus of the following investigation will be drag and energy. The investigation will focus on the kinetic and gravitational potential energy of the ride’s cart at various points, but will further evaluate the kinetic energy of the cart when it leaves and re-enters the primary tunnel (See Figure 1).

An object that possesses motion or a position also possesses mechanical energy. Mechanical energy is defined as the sum of potential and kinetic energy, or

Figure : Mechanical Energy. Equation from Physics Classroom Online

Where is potential energy, and represents kinetic energy. Since this ride only deals with gravitational potential energy, the formula for mechanical energy can be rewritten as

Figure : Modified Mechanical Energy Equation

Kinetic energy is energy possessed by an object in motion, and is defined as the work required to obtain a stated velocity through acceleration. In the Tower of Terror, the cart possesses kinetic energy at every point except for when the cart is momentarily paused at its maximum height. Since the cart is accelerated to approximately 44 during the initial stage (Data from Wikipedia), it exits the tunnel with a large amount of kinetic energy.

Kinetic energy for an object in motion is defined in terms of object mass and object velocity, or more specifically:

Figure : Kinetic Energy. Equation from Wikipedia

Where is the mass of the object, and is the velocity of the object.

Gravitational Potential Energy is potential energy possessed by an object that would be converted to other forms of energy if it were to be moved a fixed distance by the force of gravity. It can also be defined as:

Figure : Gravitational Potential Energy. Equation from HyperPhysics

Where is the mass of the object, is the acceleration due to gravity, and is height above the resting elevation of the object. Note that on earth, is roughly equal to .

The next section of this document deals primarily with forces due to friction and drag. Force is an action that will cause an object to move, assuming there are no opposing forces acting on that object. Isaac Newton defined force in his second of his three famous laws as

Figure : Force. Equation from Isaac Newton

Where is the mass of the object, and is the acceleration of the object in question.

On the Tower of Terror, a measurable amount of energy is lost due to frictional and drag forces. Due to this, the ride will most likely have lost total mechanical energy between the point that the cart exits the primary tunnel and re-enters it. The formula for drag is more complex than what is covered in the scope of this investigation, as it includes drag coefficients that need to be obtained experimentally. The formula for drag is:

Figure : Drag. Equation from NASA

Where is the density of the air, is the velocity of the object, is the drag coefficient, and is the affected surface area of the object. The drag coefficient is reliant on the speed of airflow, the skin friction and form drag of the object.

Dry friction (Hereon referred to as friction) is friction which opposes movement of two objects in motion, which is the secondary resisting force while on the Tower of Terror, the first being drag. Friction is defined in terms of , a dimensionless number, and the normal force of the two objects acting on each other:

Figure : Friction. Equation from Wikipedia

Where is the coefficient of friction, and is the normal force (The force perpendicular to the plane of contact between two objects). In the Tower of Terror’s vertical section, due to the majority of force being the force of acceleration due to gravity on the cart, and not the contact between the cart and the rail, is a small, and assumed negligible number. Once the cart enters the horizontal section, due to the entirety of the contact force between the cart and the rail being downwards, the normal reaction is , where is the mass of the cart, and is acceleration due to gravity. As the cart encounters the curve, the normal force increases due to the nature of objects travelling in a near circular motion.

Circular motion, while not the focus of this investigation, is a key factor in the friction experienced by the cart. The centripetal force on the cart as it enters and exits the curve is given by:

Figure : Centripetal Force. Equation from Hyper Physics

Where is the mass of the cart, is the velocity of the cart, and is the radius of the theoretical circle that the cart is moving in.

## Accelerometer Positioning

When data is to be collected, the following accelerometer setups are used:

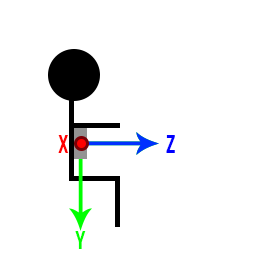


Figure : Accelerometer flat on chest (front)

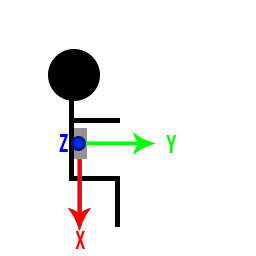


Figure : Accelerometer sideways on chest (side)

# Aim

To compare mechanical energy at various points on the Tower of Terror, mainly at the exit and re-entry of the primary tunnel.

# Hypothesis

The cart will have a smaller total mechanical energy when it re-enters the tunnel than when it first left the tunnel.

# Materials

|  |  |
| --- | --- |
| * Accelerometer | * Tower of Terror |
| * Clinometer | * Accelerometer Vest |
| * Person | * Accelerometer Straps |
| * Laptop |  |

# Method

1. The accelerometer was inserted into the accelerometer vest, and the accelerometer vest was then applied to the person.
2. The accelerometer was started, and the tower of terror was then ridden by the person.
3. The data from the accelerometer was transferred to the laptop, and the accelerometer was reset.
4. The ride was ridden again by the person, with the accelerometer oriented side on in the vest.
5. The data was transferred to the laptop, and the accelerometer was reset.
6. The accelerometer vest was removed and replaced onto the person’s leg, and the accelerometer straps were then applied to secure the accelerometer on the leg.
7. The ride was ridden, and the data was recorded.
8. The angle from the ground to the top of the Tower of Terror was recorded using the clinometer.