Global Transport: Engineering a vacuum tube train

Students choose from a range of equipment to design a model tube train.

Subject(s): Engineering, Design & Technology, Science, Mathematics

Approx time: 50 mins

Key words / Topics:
> Topic: Transport
> Friction
> Forces
> Speed
> Magnetism

Suggested Learning Outcomes

> To design a model vacuum tube train
> To use a force diagram to show the forces interacting on a real vacuum tube train

Introduction

A costly, and sometimes very long, aeroplane journey is currently your only option if you intend to travel a long distance. However, what about in the future? One method that has been proposed is the vacuum tube train. This may be able to reach speeds of 4,000 mph, but is it a realistic option?

Purpose of this activity
In this activity students design a model vacuum tube train. They have to decide on how to get a ball to travel through a tube as quickly as possible without the help of gravity. They then look at the forces that would act on a real vacuum tube train.

Activity

Introduce the activity: students will be engineering a vacuum tube train. They work in small groups and are given the equipment they need: a 1m length of plastic tubing, magnetic ball bearings and marbles of various sizes, magnets of various shapes including strips, balloon / bicycle pump, stop clock, metal rods and springs. Their task is outlined on the handout **Designing a vacuum tube train.** Groups then draw their final designs on the handout. They should label the parts and how they work. *(30 mins)*

Ask groups to present their design and fastest speed. (5 mins)

Discuss the difficulties with building a full scale vacuum tube train using their ideas. They would have to think about a power source and how to generate enough force to overcome the friction between the train and the tube. *(5 mins)*

Display slide 2 from handout **Train forces** and invite students to draw arrows to represent forces on the vacuum tube train when it is accelerating to its maximum speed, travelling at maximum speed and decelerating.

Teacher notes

Groups need to design a way of getting a ball (the train) to travel from one end of the plastic tube to the other as fast as possible.

Supply the class with a variety of marbles and ball bearings in various sizes and let them choose which sizes they want (this will depend on the method they choose). Options may include using a magnet to pull the ball, using force from a metal rod or air from a pump to push it. They can't rely on gravity - the tubing needs to be placed on a level desk or floor.

Groups are asked to record the speed and then modify their design to make it faster. They will need to use stop clocks to measure time and then calculate speed. If you have data-loggers to measure speed these can be used instead. Students should see the need for repeating their measurements. They should record them in a table.

Groups can modify the ball if they wish. Ideas might be to make it more aerodynamic by using paper or use a lubricant.

Note that air resistance would not be a problem in the

Discuss the need to reduce the friction and increase the forward force and why this is important in terms of increasing speed and energy efficiency. (*10 mins*)

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full scale train because there would be very few air particles.

Alternatively, ask students to draw diagrams in their books.

Differentiation

Basic

Instead of using slide 2 on handout **Train forces** to check understanding, display slide 3 instead. Ask students which force diagram represents the train which is accelerating the fastest (answer is C). Discuss that this train would be the most energy efficient as less energy is wasted overcoming the friction.

Extension

Ask students to modify their design so it has a safe stopping mechanism.

Students write an explanation as to why air resistance is not a problem in a vacuum tube train and why this is an advantage.

Resources

- Projector/whiteboard

For each group:

- 1m length of plastic tubing
- Magnetic ball bearings and marbles of various sizes
- Magnets of various shapes including strips
- Balloon/bicycle pump
- Stop clock or data loggers with light gates
- Metal rods and springs

Required files

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Additional websites

- Ultra-efficient 4,000 mph vacuum-tube trains – why aren't they being built? (http://www.gizmag.com/terraspan-vacuum-tube-train-supersonic-ultra-fast/23267/): Article about vacuum-tube trains.

Assessment opportunities

- Questioning of groups during the planning stage
- The completion of tasks on slide 2/3 of handout **Train forces** provides an opportunity to assess understanding of forces