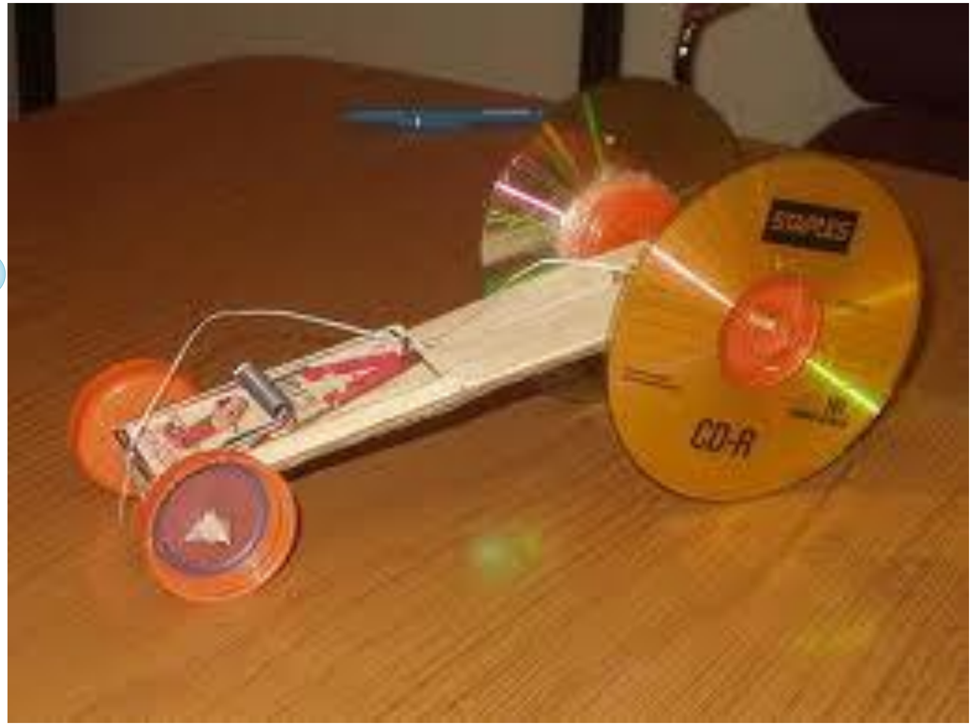
MOUSETRAP VEHICLE ENGINEERING DESIGN PROJECT

MTV EDP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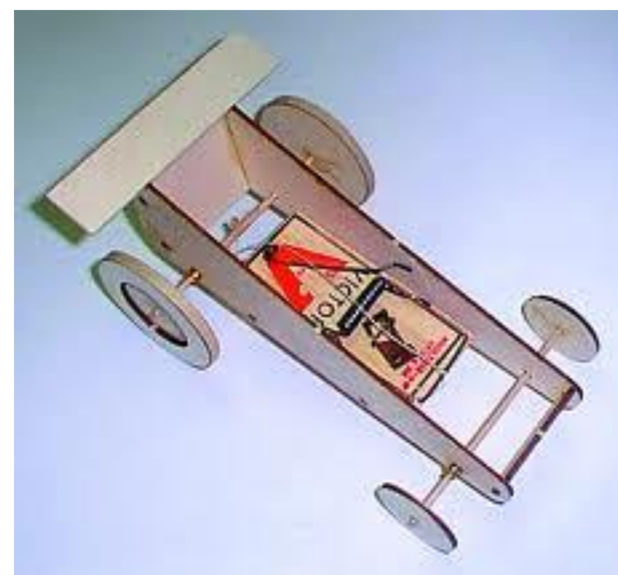


Materials

- Mousetrap
- Chassis: wood scraps, balsa wood, ice cream sticks, stiff wire
- Axles: wooden dowels, metal tubes (copper or brass), axles from old toys
- Wheels: Metal lids, CDs, wheels from old toys, other disk-shaped objects
- Pull Cord: String, cord or fishing line
- Glue (strong enough to withstand force of mousetrap)
- Use recycled materials whenever possible

Physics Concepts

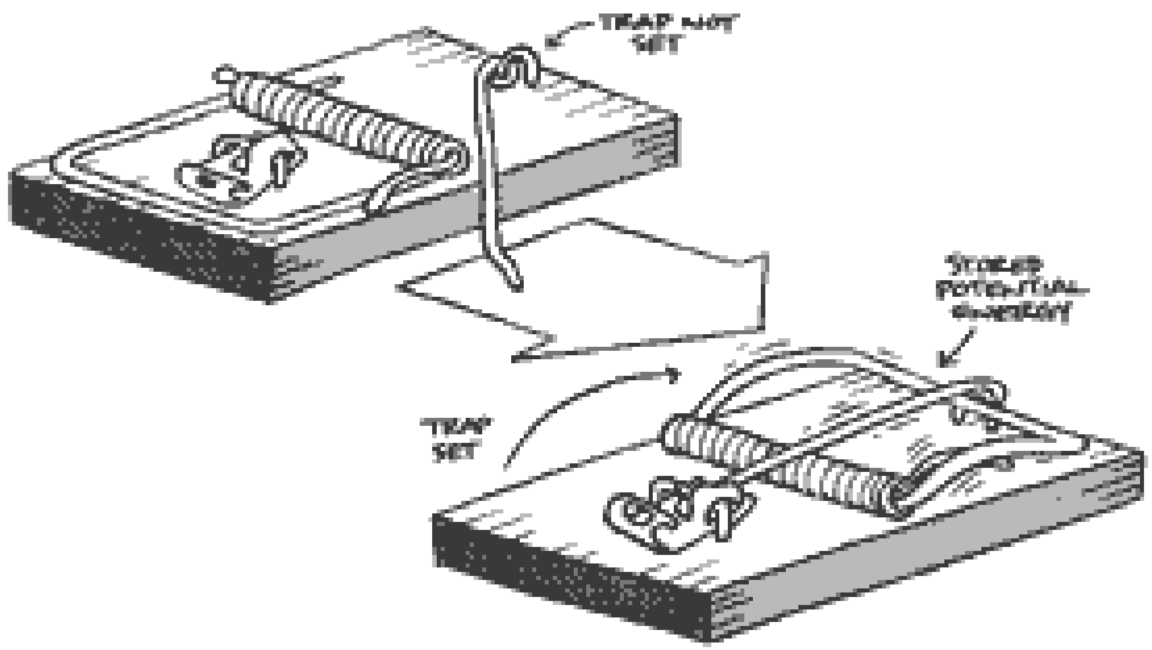
Energy

- Energy can be defined as the ability to do work.
- Work is the applying a force to an object, and actually moving that object. If the object is not moved, no work is done.
- The goal of the project relies on efficiently transferring the spring's energy to the car's wheels. Potential energy is changed into kinetic energy.
- The string transfers energy to the axle. The axle acts on the wheel as a second transfer of the energy.
- The energy is used to push the wheel against the floor, causing the car to move.
- Any friction or resistance in the transfer of energy, leads to a decrease in the efficiency of the machine and decreased performance.

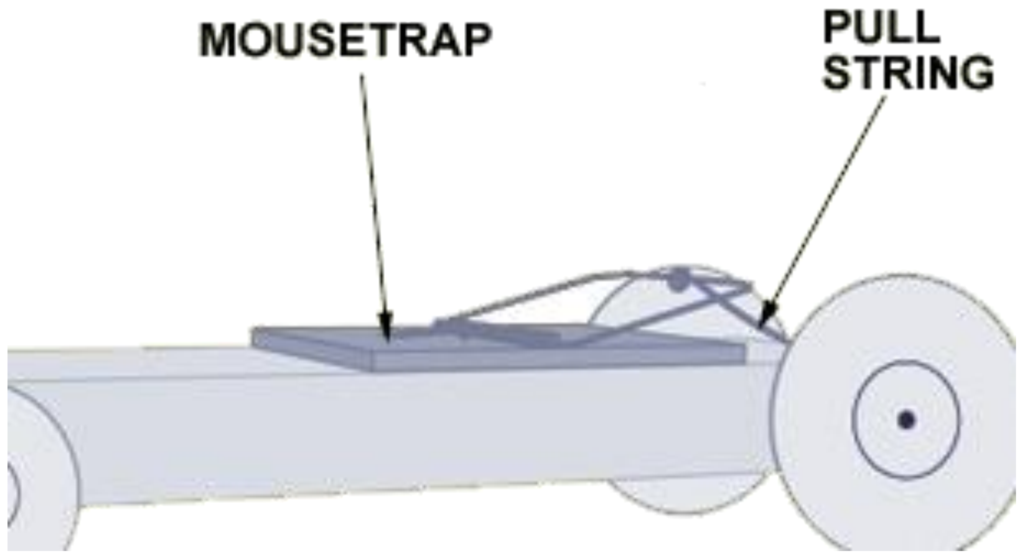
Potential Energy → Kinetic Energy

- Trap set = potential energy

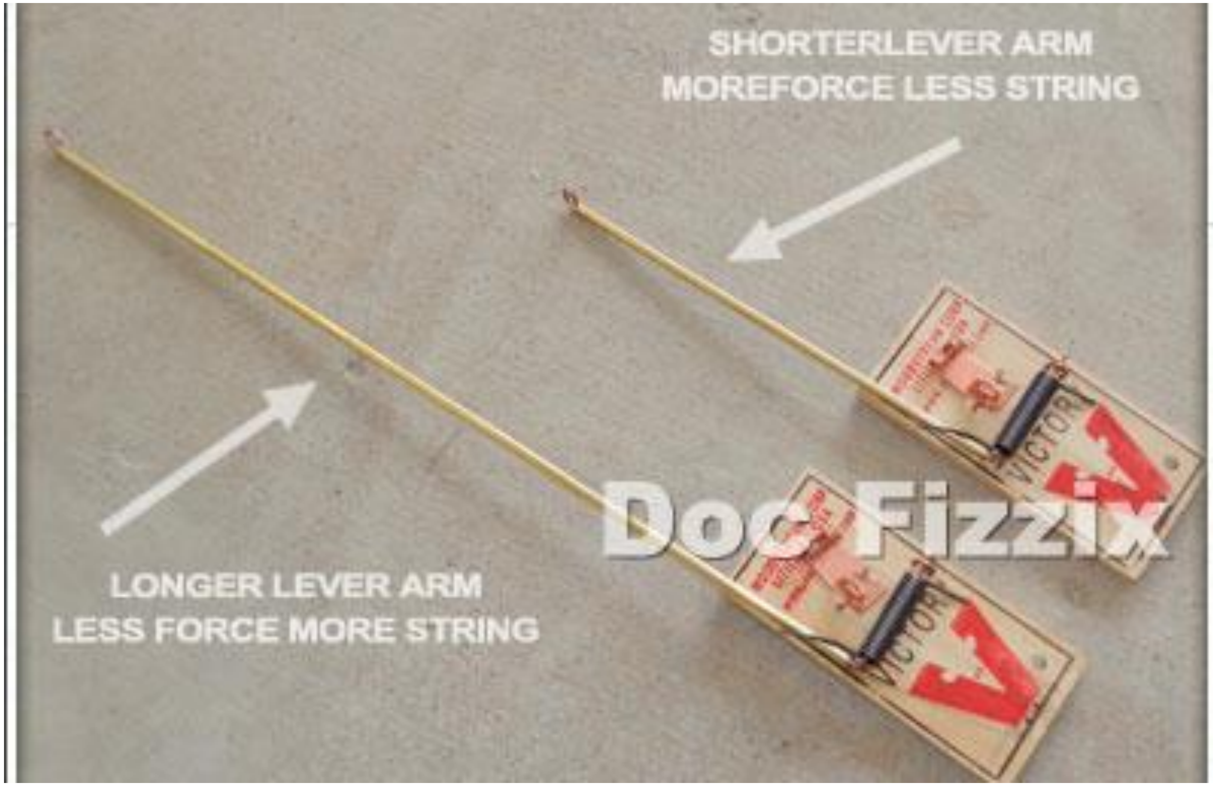
The amount of energy stored will depend on the spring and how much it is displaced. Full displacement of spring gives maximum energy.



- This potential energy is converted to kinetic energy by work. The amount of work that is done depends on how much energy you have. But since work is the product of force times distance, how you do the work is determined by design.



- Moving vehicle = kinetic energy and some potential still in the spring. Once lever arm stops moving, all energy is kinetic. Why does it slow down??



Some things to think about:

- ✓ Long lever vs short lever
- ✓ Length of string
- ✓ Location of engine (mousetrap)
- ✓ Attachment of lever arm
- ✓ Attachment of string

FRICTION

- **Friction is referred to as a dissipative force. Mechanical energy will be transformed in to heat or sound. This energy is not "lost" but it is difficult to use it in an organized fashion. In other words, it is less useful in doing work.**

- **Friction is the resistance of motion between two objects. Most friction between the materials in your car reduces the amount of energy that is used to move the car, so it would make sense that you want to reduce that friction.**

- **However, you actually rely on the friction between your wheels and the floor to help your car move. This is sometimes called traction. It provides the reaction force to the push of the wheels on the ground. Do you want more or less traction?**

- **Another form of friction involved in the performance of your car is air resistance (drag). Air resistance acts against the motion of the car and therefore should be reduced to increase performance.**

Some things to think about:

- ✓ Amount of friction between wheels and floor
- ✓ Friction where axles rub against chassis (bushings or bearings)

- ✓ Form drag – the shape of your car matters
- ✓ Surface conditions
- ✓ Does string rub as it releases?

Newton's Laws

Newton's First Law is also known as the law of inertia. Inertia is an object's tendency to resist change. It is related to mass.

The more massive an object is, the larger its inertia, and therefore the harder it is to change its motion. This can work for or against you.

Newton's Second Law is most commonly known in its equation form, $F_{net}=ma$. The more massive your car, the more force that will be required to begin moving the car. The net force acting on your car will be equal to the force you apply minus any friction forces. The force you apply will be determined by the design of your string/lever arm system (drivetrain).

Newton's Third Law states that for every action (force) there is an equal and opposite reaction (force). Your car makes use of this in all of the energy transfers. The pull of the string turns the axle, the push of the wheel on the floor causes the floor to push back, etc.

Some things to think about:

- **The mass of your car is critical in determining how easy it is to start and stop.**

- **Overall acceleration will be determined by how much force you apply (effectively) and by the mass.**

- **Friction will decrease the net force causing your car to move forward**

- **How much reaction force you get to an applied froce is often the result of friction**

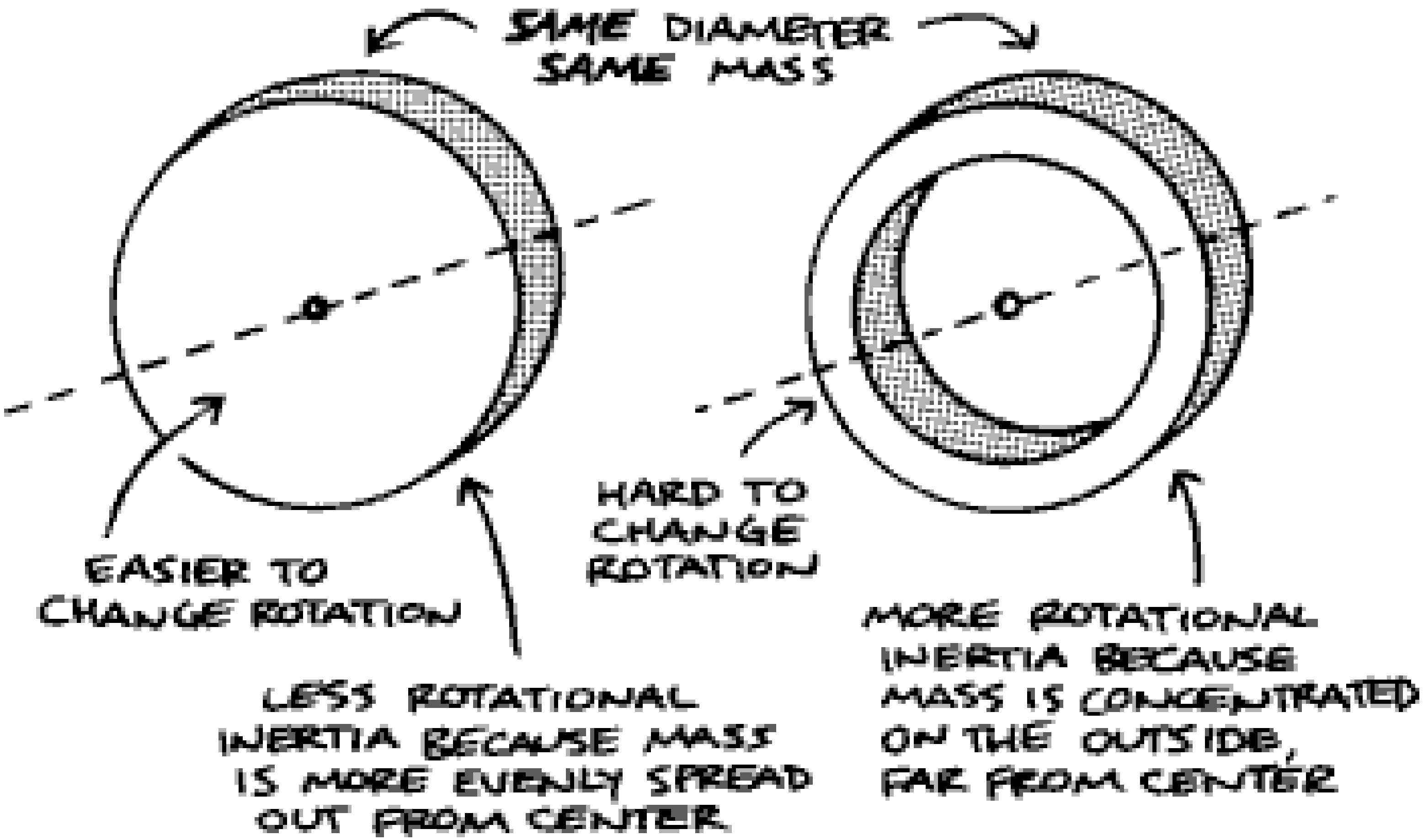
Rotational Inertia

- Inertia deals with an object's tendency to resist change of its linear motion; rotational inertia is an object's tendency to change its rotational motion.

- The rotational inertia of an object depends on two things
  1. Its mass
  2. How that mass is distributed from the axis of rotation.

- Since the wheels of your car are the parts that are rotating, you may want to decrease or increase their rotational inertia. Remember inertia makes it hard to start, but it also makes it hard to stop!!

- Rotation takes some energy too. The larger the moment of inertia, the more kinetic energy you will use for rotation. That can mean less energy available for forward motion.



If two objects have equal mass and radius, the one with more material located far from the center will have a larger moment of inertia

Torque

- **Torque** can be informally thought of as a"rotational force" or "angular force" that causes a change in rotational motion.
- Three factors determine how much torque is applied

  1. Size of the applied force

  2. Direction of the applied force. Maximum when at 90° to the rotation

  3. How far the force is applied from the axis of rotation. The further, the better.
- In your mousetrap car, the snapper arm applies a force to the drive axle through the pulling string. This in turn causes a torque to be produced around the drive axle.
- Friction is actually responsible for torque on one part of your car. Where?

Rotation
Some things to think about:

- The rotational inertia of your wheels is a big factor. It will determine how quickly your car starts AND stops. It also influences energy transformation.
- Any rotating part of your car has rotational inertia
- In rotation, torque plays the role of force and will influence what is called angular acceleration, or how quickly the rotation of your wheels or axle will increase or decrease.

Torque =(Rotational Inertia) X (angular acceleration)

Power

Power: the rate at which work is done or energy is used.

In a mousetrap car, the same overall amount of energy is used regardless of its speed – only the *rate* of use changes

For **distance**, you want to use energy slowly (energy goes into distance instead of speed)

For **power (rapid acceleration)**, you want to use it more quickly (lots of energy needed at the start to get the car moving up the ramp)

Stability and Alignment

- All objects have a center of mass; this is where the force of gravity can be thought of as acting. Any significant overall misalignment of vertical forces can cause tipping. Jut like in a real car, the location of your engine will shift the center of mass.

- Any sideways motion or up and down motion will use energy that would create forward motion and your distance will decrease. Equal torque and forces must be exerted on all wheels and wheels must be aligned.

A Few Tips to Get Started

- **Wheels:** Old CDs make great wheels, but have very little traction. Stretch a wide rubber band around each wheel; the rubber band can even be glued into place. The choice of 3 or 4 wheels is up to you.

- **Pull Cord:** Your pull cord needs to be strong enough to withstand the forces exerted by the mousetrap spring. Fishing line or strong string work well. Winding the pull cord in the wrong direction makes the car go backwards; painting a small arrow on the axle as a reminder can help.

- **Alignment:** A mousetrap car that always steers to one side will not be good for competition. Place shims (small pieces of scrap wood) in between the bushings or bearings of one or more of the wheels to align the wheels. It is very easy to do this with balsa wood.

- **Aerodynamics:** Keep the number of flat surfaces facing the front of the car down to a minimum. Sanding the body of the car smooth also helps cut down drag.