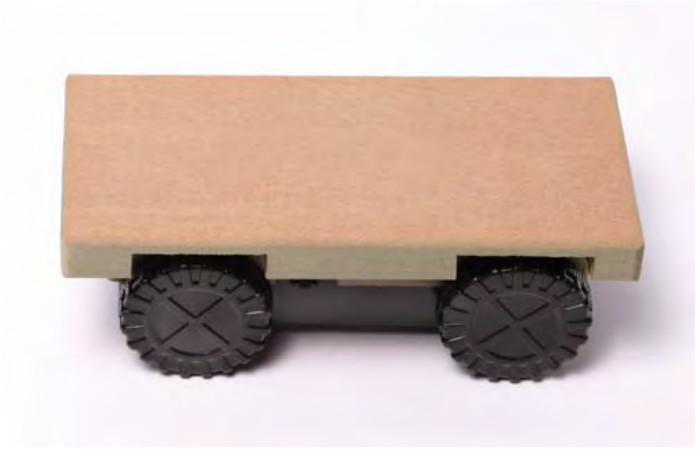
10-103 CONSTANT SPEED VEHICLE

Purpose:
To provide a means of moving and towing objects with constant speed (zero acceleration) in one direction.



Additional Required Materials:
Two (2) C-cell batteries, String, Tape
Paper Clips, Weights, Card Stock
Optional Materials: A second Const Speed Vehicle

General Description:

This constant speed vehicle performs the functions of pulling, and carrying at a constant speed. A ring is located on one end of the vehicle to allow towing a sheet of paper or plastic, other devices or vehicles. A simple hook can be fashioned from a paper clip to attach the load.

This vehicle is versatile and can be used in a variety of laboratory settings. It can be powered by two 'C' cell batteries or if a slower speed is required, one battery can be replaced with the enclosed battery spacer.

Friction/Traction:

Tie a short length of string to a paper clip and staple the opposite end of the string to a large note card (5x7" or larger). The card will perform the function of a skid and can be dragged along the floor (but not on carpet) or bench top by the constant speed vehicle. To connect the skid to the vehicle simply hook the paper clip attached to the string through the ring at the rear of the vehicle.

Add weight in even increments to the card stock skid. Notice how the vehicle will pull the skid with low weight, but after enough weight is added to the skid, the vehicle begins to slip. This is because there is not enough friction between the vehicle's wheels and the bench top to overcome the friction between the skid and the bench top. By adding weight to the top of the vehicle, you will see that it is again able to move the skid. Adding weight to the vehicle increased the amount of friction between its wheels and the bench top.

A similar experiment can be performed using two vehicles. The vehicles can be pointed in opposite directions and tied together by a short length of string between the rings of the two vehicles. When set in motion, each vehicle tries to pull the other backwards and the result is often a stalemate with neither vehicle making any headway. As in the previous example, if weight is added to one of the vehicles, the frictional forces between its tracks and the bench top will be increased, thus giving that vehicle an advantage over the other.

Vectors:

A constant speed vehicle can be used to demonstrate motion in a moving media. For example, when a boat moves in a stream, its speed is reduced relative to the shore when it moves against the current, while its speed is increased relative to the shore when it is moving with the current. This is a simple vector addition problem that can easily be demonstrated with a long strip of shelf or wrapping paper (8 to 10 feet long and approximately 1 to 2 feet wide) and the constant speed vehicle.

Place the paper on a clean bench top. Place the vehicle on the paper near you and position it so that it will move away from you when turned on. As it begins to move away from you, gently pull on the paper strip that it is resting on. Moving the paper represents the current in the stream. As you can see, if you pull on the paper with the same speed that the vehicle is moving, to your audience it appears that the vehicle is essentially standing still. On the other hand, if the vehicle is placed on the opposite side of the table from you, and set in motion toward you, the speed of the vehicle will appear to be much faster to your audience as you pull the paper toward you.

A more interesting situation is when the vehicle is set into motion directly across the paper strip (perpendicular to the motion of the paper). Can you describe what happens in this case? Using two vehicles, one can pull the paper while the other runs on the paper, as before. Yet another exploration consists of having one vehicle pull the paper while the other vehicle starts off the paper, crosses the paper and leaves the paper on the other side. Notice in this case the change in the direction while on the paper and that the entrance and exit paths are parallel.

Energy/Power:

An estimate of the constant speed vehicle's power can be made by timing the vehicle as it moves up a ramp. You will need to know the weight of the vehicle and the total vertical height traveled as the vehicle climbs up the ramp. Power is energy divided by time. The energy we can measure in this experiment is the gain in gravitational potential energy which is mass times gravitational constant ($9.8 m/sec^2$) times the gain in height.

Mathematically, this can be written as:

$$E_p = m \cdot g \cdot h$$

where

E_p is the gravitational potential energy (J)
m is the mass of the vehicle plus its load (Kg)
g is the gravitational constant ($9.8 m/sec^2$)
h is the change in height of the cart (m)

The power that the vehicle is capable of producing is this energy divided by the time, in seconds, it takes to move the vehicle from the bottom to the top of the ramp.

Try using different amounts of weight on the vehicle. Tape can be used to temporarily attach suitable objects to the platform. What happens as the weight is increased? It takes longer to climb the ramp doesn't it? Does the power calculation change much for this new experiment? How about running the vehicle on one battery instead of two, using the included metal spacer? You might try plotting the result from the power calculation as a function of the weight of the cart for both situations.

Position/Velocity/Acceleration

The constant speed vehicle can be timed as it runs across floor tiles or along a meter stick to give students data for making motion graphs. The vehicle can carry a "Blinky" (The Science Source #12517) so the motion can be photographed in a darkened room, or it can be used with photo gates, an ultrasonic motion probe (a.k.a. "Sonic Ranger"), or be used with a digital camera and video capture software under ordinary room light. Interesting results have been seen using the vehicle on an inclined ramp in this way. Can you predict when and where a one-battery cart and a two-battery cart will collide when initially separated by a know distance if the second one is
released after a know time interval?

Time Allocation:

No prior assembly is required for this product, other than placing batteries. Individual experiment times will vary depending on chosen methods of instruction and needs of the students, but normally a given activity will not exceed one class period. The versatility of this unit might find it applicable at several times during the year.

Feedback:

This is an improved product. If you have a question, a comment, or a suggestion that would further improve this product, you may call our toll free number**.**