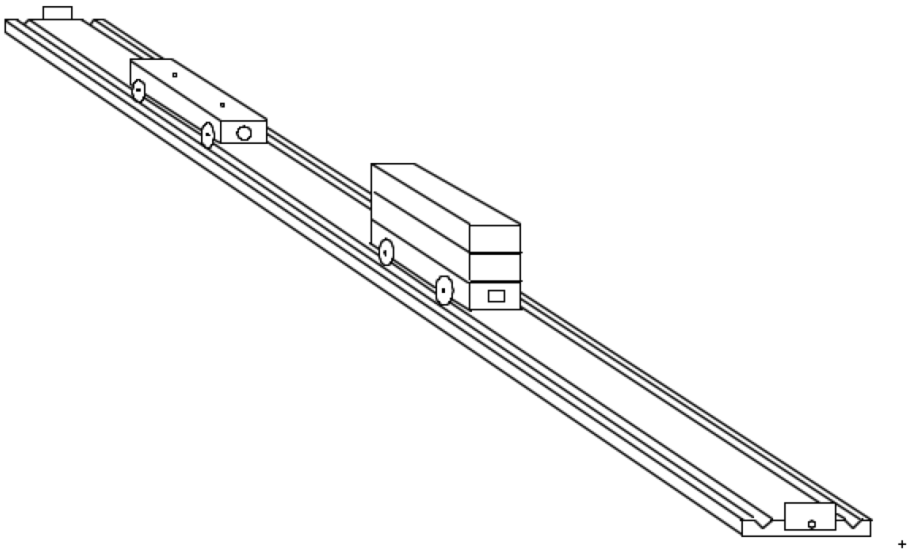
Construction of Cart and Track for Momentum and Energy Demonstrations

The Southern California AAPT has been conducting New Physics Teacher Workshops (NPTW) [1] for several years. One very successful piece of equipment that has been distributed to participants is a hand made track and set of carts that can be used to demonstrate momentum and energy conservation during elastic and inelastic collisions. The complete apparatus costs about $20 and by now about 150 have been constructed and distributed free to the new physics teachers, thanks to the generosity of the Bauder Endowment. [2] This paper will briefly describe how the apparatus is constructed.

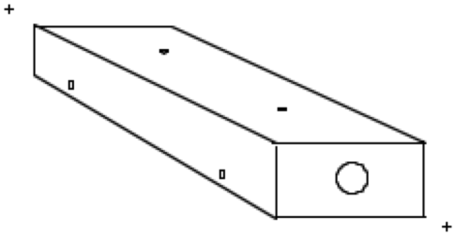


On the left is illustrated a sketch of the complete apparatus. The carts are made from 8" sections of "2x4" and the track is made with a 4 ft. piece of "1x6". The two carts with wheels have strong magnets on one end and Velcro on the other. The two stacked blocks act as weights and can be removed or added to the other cart. They are held together with small brads inserted in holes.

The V shaped slots in the track are filled with ½" aluminum angle and the wheels on the carts are from Pitsco [3] and have been attached to the 2x4 blocks with 4D box nails. The result is a fairly low friction track over which the wheeled carts move. The magnets on the carts beautifully illustrate the transfer of momentum and energy during an elastic collision and the Velcro on the opposite ends obviously show inelastic collisions.

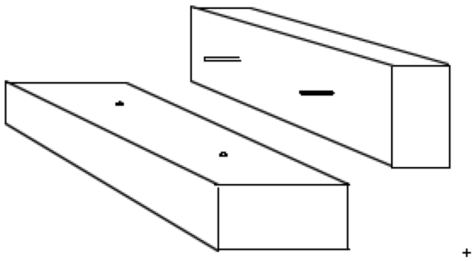
Construction of Carts

Select a straight 8 ft construction grade 2x4 to construct the carts and "weights". This will supply more than enough material to build 2 complete sets. Things will be easier if care is taken to cut the board into exactly 8" long sections. The magnets used were ½ x 1" neodymium from CMS Magnetics, Inc. [4] Choose two blocks for carts and drill a ½"



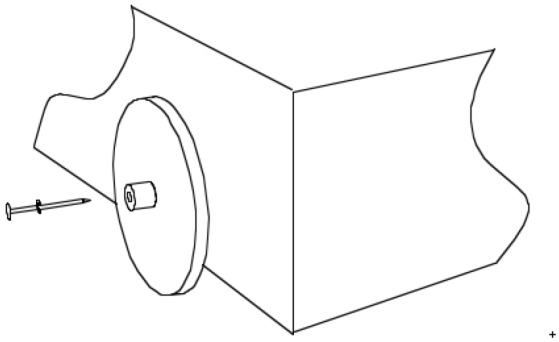
hole 1" deep in the center of one end of each block to accept the magnets. 4 holes should be drilled on the lower sides of the blocks slightly smaller than the diameter of a 4D box nail that will serve as an axle for the wheels. These holes should be 1 and ½ "from each end of the block and ¼" above the bottom of the block, The holes in the top of the block are the only ones that require repeat accuracy. These holes will receive the

Heads of #17 x ¾ ‘finish brads nailed into the weight blocks. It is advised that either a template be made to fit over the block to insure accurate drilling or a jig be built on a drill press to repeatedly drill these holes. The “female” holes to receive the brad heads should be made larger than the brad heads but only a mark should be made on the other side of the weight block to accurately drive the brads. The illustration below of the “male” and



“female” weight blocks should help to explain the above. These brads and holes are necessary to keep the blocks from sliding during collisions. The carts will each have two of the larger holes and one side of the weight blocks will have two larger holes and the other side should simply be marked so that the brads will be accurately located when they are nailed in place.

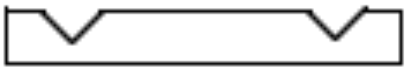
The illustration on the right shows how the 4D box nail is nailed into the pre-drilled hole on the bottom of the cart block. It is advised that a #4 flat steel washer be inserted on the nail under the nail head, and another #4 flat washer be placed on the nail on the other side of the wheel before driving. These washers on either side of the wheel will probably allow it to rotate more freely. Allow the head of the nail to be about 1/8 inch above the outside wheel washer so that the wheel will spin freely.



Small squares of hook and loop Velcro should be attached to one end of each of two carts and nailed in place with two flat head brads each. Keep the Velcro square small since it is amazing how well even two small pieces of Velcro will stick to one another. Finally, it is advised to place a dab of silicone glue on one end of the magnet before it is inserted into the ½” hole and, of course, make sure that the magnets are arranged so the will repel one another.

Constructing the track

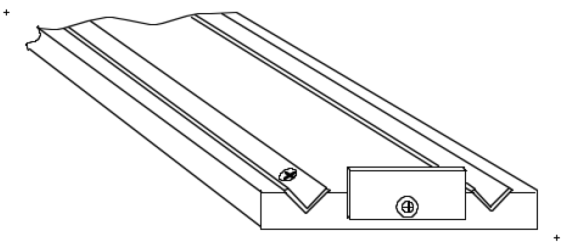
Select a piece of straight flat “1 x 6” pine or other soft wood 8 ft long. This will make two tracks. (Remember a “1 x 6” is really ¾” x 5and ½” and a “2 X 4” is really 1and1/2” x 3 and ½” in the following discussion. Dimensions in the following will be given as the should be.) Cut the 8ft piece in half to make two 4 ft. tracks. A cross-section of this board after preparing for it to accept the aluminum angle pieces is shown on the left below.



The centers of the two right angle “Vs” should be 4 and 1/8” apart but the best guide is to accurately measure the distance between the centers of the wheels on the cart you have constructed above. The depth should be to the center of the board.

Some may think these "V' grooves should be routed but our experience in making many of these suggest using a circular saw with the blade set at 45 degrees and making a double cut to form the groove. The technique is to set the rip fence and saw depth to cut one side of the near groove and then flip the board to start from the other end to cut the other near side. After all pieces have been cut this way, adjust the fence to cut the other side of the "V" groove and repeat. This procedure minimizes sawdust compared to using a router and makes clean "V" grooves.

Aluminum angle ½" x ½' x1/16" can be purchased at most metal supply houses and are usually available in 16 ft lengths that can be cut in half to fit in your car and cut again when you get home. [5] Or for a small charge they will cut them into 4 ft lengths for you.



On the left is shown one end of the track with the aluminum angle installed. A small #6 x ½ "inch FH Phillips at either end of each aluminum piece will hold the aluminum angle in place. Also, a small rectangular end piece of thin wood is screwed into the end of the track to stop the carts.

Notes:

1. NPTW is a part of SCAAPT and is supported by the Karl Brown Memorial Scholarship Fund. For more details go to: www.nptw.org

2. The Bauder Endowment regularly donates to physics related activities through the AAPT See: https://www.aapt.org/Programs/grants/bauderfund.cfm

3. Pitsco P.O. Box 804908 Kansas City, MO 64180-4908
4. CMS Magnetics, Inc. P.O. Box 251694 Plano, TX 75025-1516
5. In Los Angeles we used M&K Metals. A web search should reveal other locations.

Specific materials used in the above described cart and track construction.

The actual track and carts we produced were usually done in lots of 60. In the following, the quantities stated will be for lots of 2 complete sets. Quantity pricing may be different.

Magnets, 4 required: CMS Magnetics SKU ND0410-50NM N50 Dia ½ x1" $1.60 each
Wheels, 16 required: Pitsco Item Part # 36685 01 GTFX Wheel (100 for$11.65)
(You should remove the mold tab from each wheel before installing.)
½"X ½" X 16 ft. Aluminum Angle. About $10.00
Lumber, One 8ft "2x4" and one 8ft "1x6" Local prices will vary
Washers, 32 required #4 flat steel Lots of 100 can be had for about $3

Brads used in attaching weights and carts together: #17 x3/4’ 8 required,
Velcro 1”x1/2” rectangles, 2 pairs required,
Small brads to attach Velcro to back of cart, 8 required.
#6 FH wood screws ½” long, 8 required, for attaching aluminum to track. Price for the brads, screws and Velcro listed above will vary depending upon how they are obtained.