

# Machine Racer: Rally

## Preparation

1. Print the Working Drawing of the design you created and simulated in the Mousetrap Car 2.0 STEM Application. You can find your Working Drawing in the "Outputs" tab of the Mousetrap Car 2.0 STEM Application.
2. Gather materials and tools for fabricating your Machine Car design.

### Materials

- Balsa Blanks: 2 side rails (plus 1 extra)
- 1-Mousetrap
- 1-1/8" Aluminum Rod (Axle Material)
- 1-3/16" X 8" Aluminum Tube (Lever Arm)
- 1-30" String
- 2-Rear Wheels
- 2-Front Wheels
- 2-Rubber Bands (Rear Wheel Traction)
- 4-Brass Washers
- 1-Plastic Bushing (Straw)
- 1-Wire for Axle Hook
- 3-Spools
- Nylon Screw/Washer/Bolt for Steering Arm
- Wood Glue
- Hot Glue (Low Temp. Preferred)

### Tools

- Safety Glasses
- Hobby Saw
- Hobby Knife
- Cutting Board
- Drill Press
- Tube Cutter
- Diagonal Cutter
- Pliers
- Needle Nose Pliers
- Wood Clamps
- Spring Clamp
- Ruler

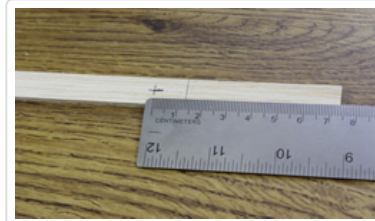


**Materials and Tools**

**YOU MUST WEAR SAFETY GLASSES DURING EACH STEP OF THESE INSTRUCTIONS**

## Frame Fabrication (without Pre-Drilled Rails)

1. Carefully review your Working Drawing. It contains all the measurements you will need to layout your parts for fabrication.
2. Working from your drawing, layout the length of the side rails and hole location.



**Hole Location**

3. Using a hobby saw, place the parts on a cutting surface and cut to the specified length.



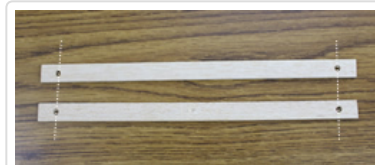
**Cut to Length**

4. Drill the axle holes on a drill press (or you can use a hand drill) using a 11/64" bit. A 11/64" bit will work with the straw bearing provided in the WhiteBox Learning kit. If you plan to use another type of bearing, check for the correct size hole for bearing fit before drilling.



**Drill Axle Holes**

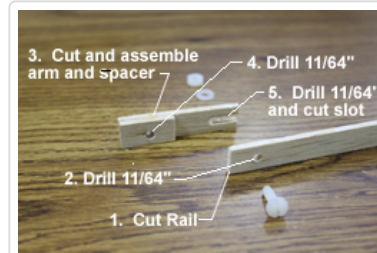
5. Unless you are using the steering arm option, you should now have two frame rails with an equal wheelbase for axles.



**Frame Rails**

## Steering Arm (Optional)

1. Cut the front end of one Rail 35mm shorter than the designed dimension to accommodate the length of the Steering Arm.
2. Measure the center 10mm from the front of the Rail and drill a 11/64" hole for the machine screw.
3. Cut a steering arm to a length of 55mm and a spacer to a length of 25mm, both from either the excess wood from your rails, or from the extra rail piece included in your kit. Glue the spacer to the end of the steering arm.
4. Measure the distance from the front of the other Rail (the one not being used for steering) to the center of its axle hole. Use this measurement to layout the axle hole on the Steering Arm. Drill a 11/64" hole in the Steering Arm for the axle and bearing.
5. Measure the center 15mm from the back of the Steering Arm and drill a 11/64" hole and cut the slot with a hobby knife. Use a straight edge (ruler) for an accurate cut.
6. Assemble the steering arm to the side rail using the machine screw, nut and washer (included in your kit). Hand tighten for now.



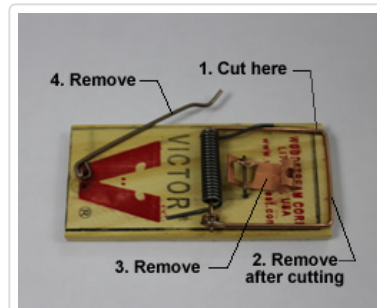
**Steering Arm Preparation**



**Steering Arm Assembly**

## Mouse Trap Preparation

1. The stock mousetrap that provides the propulsion force needs to be modified. Look over the image at the right. There are several parts that need to be cut and discarded. The procedure to follow is to start at step #1 and work clockwise through #2, #3 and #4. (See picture for more detail).



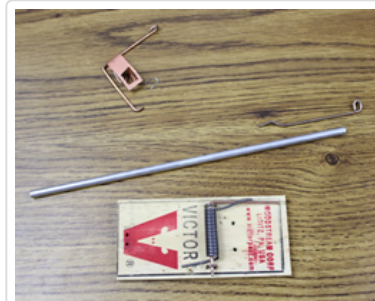
**Modify Mouse Trap**

2. Use diagonal cutters to snip the parts in the areas specified in #1 above. Be sure you are wearing your safety glasses.



**Snip Mousetrap Arm**

3. Follow through with steps #2, #3 and #4 to prepare the spring mechanism. Hold on to the part removed in step #4. It can be used for the lever arm hook.



**Prepare Spring Mechanism**

## Modification Option

1. After following the steps in "Mouse Trap Preparation", the mouse trap hammer arm is now ready for the lever arm. However, after you cut your axles, you might have additional material to work with. If so, as a modification option, cut a section of the 1/8" aluminum rod (also axle material) to approximately 100mm. Measure 50mm, clamp with pliers and bend to just over 90 degrees. The lever arm needs to align with the axle hook so the angle may need to be adjusted during final assembly.



**Bend Hammer**

2. Using diagonal cutter pliers, cut the trap's hammer to prepare for removal.



**Cut Hammer**

3. Carefully apply pressure to the spring to hold it in place. Remove the stock hammer and replace it with your fabricated aluminum hammer.



**Insert Custom Hammer**

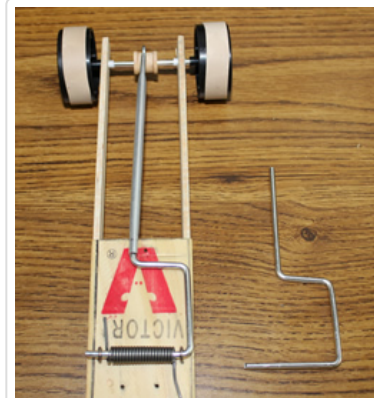
4. Your modified mouse trap is now the power plant for your vehicle. Replacing the original hammer with your aluminum hammer has several advantages.
- Lower friction coefficient. The friction coefficient for steel to steel is 0.8. For aluminum and steel it is 0.45.
  - Reduced mass for aluminum hammer and lever arm assembly.
  - The mousetrap is the engine. If you improve the power plant, you improve performance.

And...

5. If you want, you can be creative and experiment with innovative engineering design solutions that can improve your design. In this case, the hammer is designed to align the lever arm with the center of the axle.



**Completed Hammer**



**Customize Hammer**

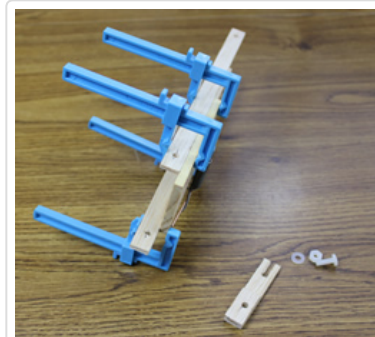
## Frame Assembly

1. Precisely measure the points where the rail will be attached to the bottom of the mousetrap. The axle holes must be aligned so that they are across from each other. Precision is important. The axle, when assembled, must be perpendicular to the rail or your car will not run straight.



**Rail Alignment**

2. Glue and clamp the rails in position with wood glue.



**Attach Rails**

3. Cut the bearings to a length so they cover the wood surface. Assemble the bearings (straw) in the holes of the rails. If the bearings fit too loosely in the hole, tack them in place with hot glue.



**Bearing Assembly**



## Lever Arm Mechanism

1. Using a tube cutter, cut the lever arm to your specified length.  
Your working drawing will have the exact dimensions.

Note: Tube cutters work by tightening the cutter against the tube and rotating it until it turns freely. Tighten again and rotate. Repeat until the tube is cut.



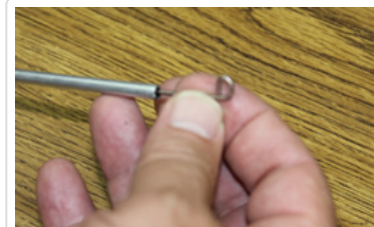
**Cut Lever Arm**

2. Cut off the bend of the hammer latch so the remaining shaft is straight.



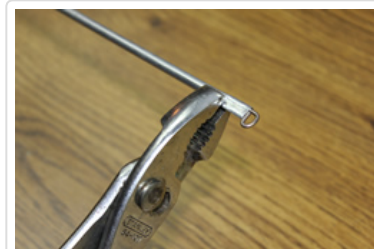
**Cut Off Bend**

3. Insert the hammer latch piece (the "string hook") that you cut in step #2 above (or alternatively use a screw eye) into the tube. Using pliers, crimp the end of the tube around the string hook to secure it in place.



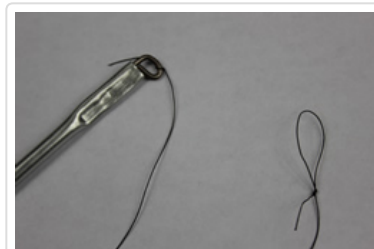
**Crimp String Hook to Tube**

4. Follow the same procedure to form the tube around the string hook along the length of the threads. Aluminum is a pliable material that is easy to form.



**Form Tube to String Hook**

5. Cut the string about 3" longer than your specified length. Tie a loop on one end of the string.
6. Measure the designed length of the string from the loop's end to the lever arm tying point, and tie the other end to the string hook. The total length after assembly should be the designed length specified in your working drawing.



**Tie String to Lever Arm Hook**

7. Assemble the lever arm to the hammer.



**Assemble Lever Arm**

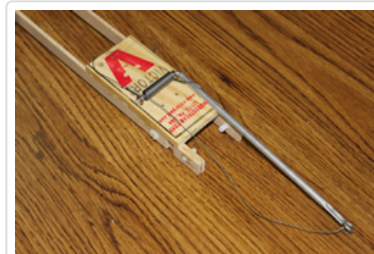
8. Using needle nose pliers, set the spring tension arm on top of the hammer and lever arm assembly.

Note: If the spring arm does not seat properly, crimp the lever arm to provide a flat surface to seat the spring arm.



**Assemble Lever Arm**

9. Your power plant is now ready. Potential energy will now be converted to kinetic energy.



**Power Assembly**



## Wheel and Axle

1. Inspect your wheels for excess material or tabs. Remove any imperfections with a hobby knife and/or sand paper.



**Inspect Wheels**

2. Place the rubber bands around the rear wheels. The rubber "tire" provides the friction (traction) needed to prevent wheel slippage.



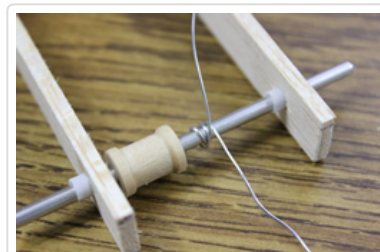
**Attach Rubber Bands**

3. Refer to your working drawing and layout the length of the axle on the aluminum axle rod. Cut the aluminum axles to length using diagonal cutters.



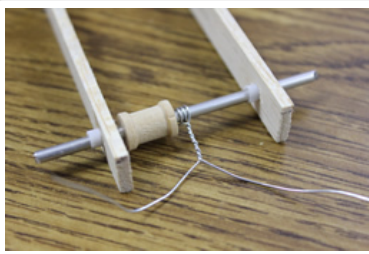
**Cut Aluminium Axles**

4. Thread the axle through the bushings. If a spool was used in your design, seat the spool on the axle during assembly. Position the spool so it aligns with the lever arm when in power position.
5. For the axle "hook", start by wrapping the wire around the axle three (3) turns.



**Spool Placement**

6. Twist the wire to form the axle hook. Cut the wire tie leaving approximately 1/8" for the hook. If a spool is used, slide the hook so it rests against the spool's surface.



**Twist Wire**

7. Tack all the components (spool and axle hook) in place with hot glue to prevent power loss from spinning. (You also may want to add glue to the axle before placing the spool, in order to secure it in place).



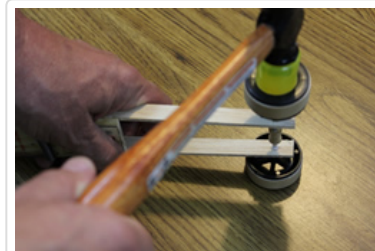
**Tack Components**

8. Slide the brass washers on the axles, then add your wheels to the axles. The brass thrust washer provides a bearing surface if/when the axle moves side to side



**Attach Wheels**

9. Assemble the wheels on the axles. The axles are supposed to fit snugly in the axle holes. So you may want to bore out the axle holes with a 1/8" drill bit, before inserting the axles into the wheels. And/or, it may also be necessary to tap them into place.



**Secure Wheels**

10. When assembled, there should be approximately 2mm clearance between the axle assembly and the frame. The thrust washers will provide a bearing surface when the wheels move side to side.



**Verify Axle Clearance**

11. You now have a completed Machine Racer ready for testing!



**Completed Machine Racer**

## Roll Test (Steering Arm Option)

1. Roll test the vehicle to determine if adjustments need to be made. In this case, the masking tape on the floor indicates straight travel. Align the vehicle parallel to the line and give it a push. If it deviates from the line, adjustments need to be made.
2. If the steering arm is adjusted forward, the vehicle will turn left; adjust backward, the vehicle will turn right. Given the results of your roll test, make the necessary adjustments and test again. Repeat until your vehicle travels straight.

Now you're ready to race.... Good Luck!



**Steering Adjustment**