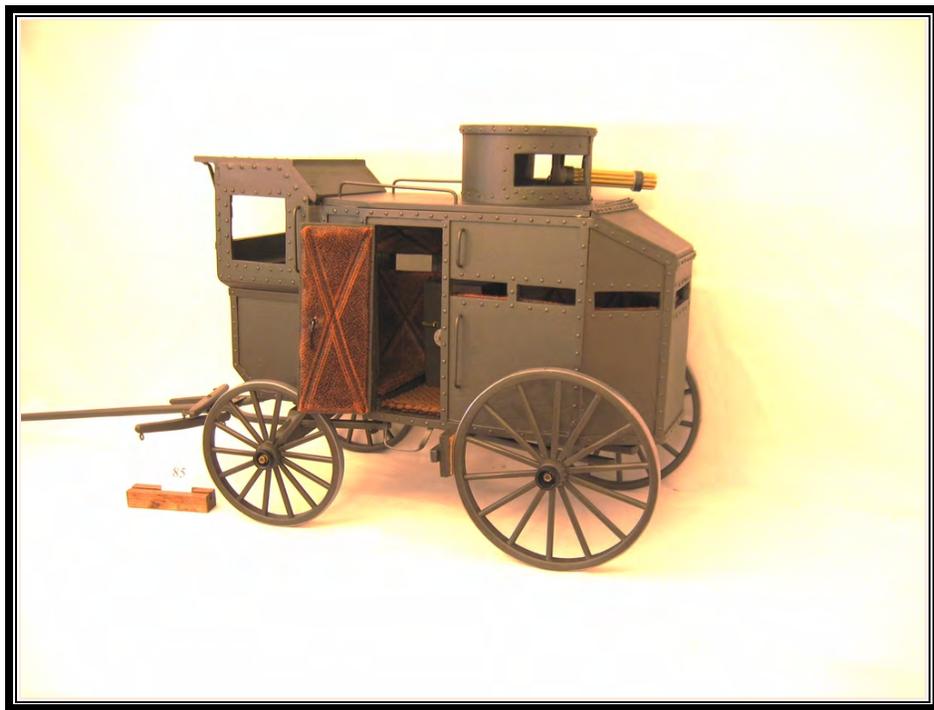


Silicon Valley Monterey Bay Council, BSA

Coyote Creek District Camporee 2019

# THE AMERICAN WEST CALIFORNIA GOLD



Troop Pioneering Challenge

# REBEL WAR WAGON

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# 2019 TROOP PIONEERING CHALLENGE

## Game Overview

### The History

*The War Wagon* is a 1967 Hollywood movie Western starring John Wayne and Kirk Douglas. The plot revolves around a man unjustly imprisoned, who seeks revenge by robbing a large gold shipment from an armored stage coach called the War Wagon.

The movie is pure fiction.

War wagons were used as far back as the 5<sup>th</sup> century by the Chinese to protect personnel and to carry heavy armaments. In the 15<sup>th</sup> century, war wagons were used in the Hussite Wars, a series of rebellions in Bohemia (present day Czech Republic). The Hussite wagon could carry a cannon, hand-gunners, or arbalests (crossbowmen).

Heavy wagons were used in the Civil War and the Old West, but mostly for transporting supplies. Army wagons were usually drawn by six-mule teams.

In 1877, the Cheyenne and Black Hills Stage Company constructed two steel-armored stagecoaches to protect gold shipments on the Deadwood-Cheyenne trail. The coaches were named *The Slaughter* (after Johnny Slaughter, a coach driver who was killed by bandits) and *The Monitor* (after the USS Monitor, an ironclad warship used by the Union in the Civil War). The coach did not carry heavy armaments, but sported several gun slots for firing shotguns.

The Slaughter and The Monitor did not deter thieves. The Monitor was soon robbed of \$27,000 in gold and all on board were killed in the assault.

Gatling guns were prominently featured in several movie Westerns: *The War Wagon*, *The Gatling Gun*, and *3:10 to Yuma*. In truth, Gatling guns were rarely used in the field. They were better suited for defending fixed fortifications. The guns were heavy to transport, difficult to set up, inaccurate to fire, and prone to jamming and overheating.

Heavy artillery cannon and mortars were also useless in the field. The army's preferred light artillery piece was the howitzer. The howitzer was pulled on its own carriage, not mounted on a wagon. In spite of its lighter weight, it was still difficult to transport the howitzer over mountains and across desert terrains.

### The Challenge

This year's troop challenge is to design, construct, and demonstrate a war wagon. The challenge consists of two parts.

- **Pioneering project** – Build a human-powered transportable wagon with a platform or support structure for one or more artillery pieces.
- **Engineering project** – Build a cannon, a Gatling gun, or both, capable of launching tennis balls or ping pong balls. Mount the artillery on the wagon.

The war wagon must perform the following tasks.

- Complete a marked course for speed and maneuverability.
- Fire the cannon for best distance and accuracy (if optioned).
- Fire the Gatling gun for best repeat rate (if optioned).

The wagon may support a cannon, a Gatling gun, or both. The two types of artillery are judged in separate categories. Units may compete in one or both categories. Note that the optimal launcher design and choice of ammunition for the cannon will probably be different than for the Gatling gun.

Units must gather materials and complete the design stage before arriving on site. Designs should be pre-tested and debugged before the competition. Launch devices may be prefabricated.

While winning the competitions is a desirable goal, remember that the primary benefit of the challenge lies in the design and build experience. Do not shy away from novel or interesting ideas.

## ***Game Overview***

### **The Technology**

Consider the following STEM topics as you design and build your machine.

- Simple machines (the wheel-and-axle)
- Ballistics (trajectory angles, gravity, air resistance)
- Pitching mechanisms (as applies to your launcher design)

Other simple machines (lever, pulley, screw, and so forth) will likely be integral to your design.

### **Contest Awards**

Ribbon awards are presented in the following categories.

#### **Design and Construction**

- Best wagon design
- Best wagon construction (pioneering skills)
- Best cannon design
- Best Gatling gun design

#### **Operation and Performance**

- Best course completion time
- Best cannon accuracy
- Best cannon range
- Best Gatling gun firing rate

### **Contest Stages**

The competition plays out in three stages.

- **Design Stage** (design and pre-build prior to camporee) – Determine the best design for your wagon. Gather all needed materials and assemble your design. Test and refine your design. Practice building and operating your wagon. Preassemble non-lashed components (wheel-axle assemblies and launching devices).
- **Build Stage** (on-site assembly and testing) – Deliver all materials to the designated build area. Construct your wagon on site in the time allotted.
- **Proof Stage** (presentation and demonstration) – Explain the design and function of your war wagon. Fire the artillery pieces under the direction of the rangemaster. Complete the speed and maneuverability course.

**NOTE:** Small troops may work jointly to enter the contest. Notify the camp director as soon as possible if you wish to collaborate with another small troop.

## ***The Design Stage – Concept, Planning, and Practice***

The design stage takes place offsite prior to camporee. This is a good activity for unit meetings. It may be helpful to assign a design team to steer the overall process and finalize the details.

Examples for designing your artillery pieces are provided under [Sample Launcher Designs](#).

These are examples only, not necessarily recommended designs. Use these examples as a starting point to design and customize your own wagon. You may simplify or enhance the basic designs, combine designs, or create something completely new.

### **Basic Requirements**

Following are general criteria for the design and build stages of the contest.

#### **The Wagon**

- The wagon must be moveable. A four-wheel design is recommended.
- The wagon may be manually propelled by pushing (push bar) or pulling (yoke or harness) or in combination (push-me/pull-me),
- The chassis and support structures must be constructed from wooden poles or beams using standard rope lashings.
- Hardware may be used only for the wheel-and-axle assemblies.
- Other fasteners and adhesives are prohibited for wagon construction.
- The wheel-and-axle assemblies only may be prefabricated prior to the event.
- The wagon must have a guidon that identifies the sponsoring unit.
- Theme decorations are encouraged, but not required.
- The design should be easy enough to assemble within the allotted time period.
- The design and construction must be safe and steady.
- All pioneering work must be completed on site within the prescribed time period.
- All work must be completed by Scouts. Adult leaders may observe, but not supervise.

#### **The Cannon and the Gatling Gun**

- The artillery pieces should fire tennis balls (recommended for the cannon) and/or ping pong balls (recommended for the Gatling gun). However, any soft rubber, fabric, foam, or plastic balls in the same size and weight range may be substituted.
- The cannon should be mounted with adjustable altitude and azimuth settings (recommended for accuracy).
- The artillery must be constructed from parts and not be purchased as finished unit.
- The artillery may be fabricated from any suitable materials (metal, plastic, wood, etc.), depending upon its design.
  - Parts may be purchased, found, salvaged, or cannibalized from other items.
  - The artillery may be prefabricated prior to the event.

- The artillery may operate using any combination of air pressure, water pressure, battery power, and stored mechanical energy.
  - Components may include springs (compression, tension, torsion, or flexion), bows, elastic bands, counterweights, flywheels, lever arms, plungers, pistons, diaphragms, impellers, paddles, cranks, ratchets, gears, hand pumps, ballast tanks, feed hoppers, conveyor belts, and the like.
  - Typical designs may include pneumatic or hydraulic barrels (air or water pressure), spring-loaded barrels, flywheel launchers, impulse wheels, trebuchets, ballistae, onagers, slingshot, and the like.
- No chemical propellants, steam, dry ice, flammable liquids, or explosives may be used (with the exception of baking soda-vinegar reactions).
- For pressurized air or water systems:
  - PVC schedule 40 or 80 is acceptable for plumbing. ABS and DWV-PVC should not be used.
  - Pressure may be generated using only a manual hand pump or gravity (head pressure).
  - Slip joints must be properly cemented. Threaded joints must be use thread tape or sealant and be adequately tightened.
  - Ballast tanks may be used to store pressure.
  - A pressure gauge and a relief valve are required.
  - Stored pressure may not exceed 70 psig.
  - Cloth wadding may be used with over-sized barrels.
- For mechanical systems, force may be applied using manual exertion, hand cranks, levers, ratchets, gear trains, pulleys, counterweights, and so forth.
  - Motors and solenoids may be used, but can only be powered by batteries (12 volts DC or less).
- Gatling gun repeat rates may be achieved using any type of hand-loading, self-feed mechanisms (such as a hopper), multiple chambers, multi-gun arrays, and so forth. Shotgun action is not allowed.
- Guards must be placed over any moveable parts that pose a strike, slap, pinch, crush, cut, entanglement, entrapment, or other physical hazard.

## Materials and Construction

### Poles

All structural elements must be constructed from wooden poles or beams.

- Any type of wood may be used, including logs, spars, staves, tree poles, landscaping timbers, fence posts, fence rails, broomsticks, and cut lumber.
- Round stock is recommended for general construction. Flat planks are best for decking.
- Any wood treated with creosote, such as railroad ties, is not acceptable.
- Steel or plastic pipe is not acceptable.
- Recommended pole diameter is 4 inches for the chassis and axles and 2 to 3 inches for general framing.

### Ropes

- Natural fiber rope (hemp or sisal) is recommended. Woven rope (cotton or cotton/nylon) is easier to work, but it provides less strength. Plastic rope (nylon or polyester) is slippery and does not hold knots well.
- Minimum required rope thickness is 3/8 inch.
- All rope ends must be whipped, fused, or taped to prevent unraveling.

## Knots and Lashings

Wagon construction must demonstrate proper use of the following lashings.

<b>Square lashing</b>	<i>Required: 4 or more (including those used for the chassis)</i>
<b>Floor lashing †</b>	<i>Required: 1 or more (may be single or double ‡)</i>
<b>Other Lashings</b>	<i>Required: 3 or more of the following (any combination)</i>
<b>Diagonal lashing</b>	<i>Choice</i>
<b>Shear lashing</b>	<i>Choice</i>
<b>Round lashing</b>	<i>Choice</i>
<b>Tripod lashing</b>	<i>Choice</i>
<b>Cloverleaf lashing §</b>	<i>Choice</i>

† *There is an easy way (loop method) and a hard way (follow-through method) to tie a floor lashing.*

‡ *A single or double floor lashing may be used. The double floor lashing is easy to tie and produces a sturdier platform (see [https://www.youtube.com/watch?v=2187ar0y\\_Z0](https://www.youtube.com/watch?v=2187ar0y_Z0)).*

§ *The cloverleaf is an interesting type of quadrapod (four-pole) lashing. It is easy to tie and provides superior flexibility (see <http://ropesandpoles.blogspot.com/2007/06/clover-leaf-lashing.html>)*

Additional knots and lashings may be used for both structural and ornamental purposes.

- All knots and lashings must be used for their intended purposes. All lashings must be tied properly and cinched tightly.
- Any loose rope ends must be tucked and secured so that they do not interfere with the wheels or pose hazards to the gun crew.

## Hardware and Plumbing

Hardware may be used only for the following purposes:

- Wheels, washers, bolts, and associated hardware may be used for the wheel-and-axle assemblies.
- Hardware and plumbing may be used for the launching devices (cannon and/or Gatling gun) and mounting brackets.

The following restrictions apply to launcher construction.

- No manufactured launching devices are permitted.
- Common hardware and plumbing items may be purchased, including shutoff valves, check valves, nozzles, O-rings, hoses, pulleys, chains, and cranks.
- Off-the shelf hand or foot-operated air pumps may be used to pressurize pneumatic or hydraulic launchers. Powered pumps are not permitted.
- Many components can be fabricated from PVC pipe or rain gutters and PVC fittings, but any suitable materials may be used.
- Useful parts may be cannibalized from assorted equipment and household items to be repurposed as a launcher parts. (Be creative!)

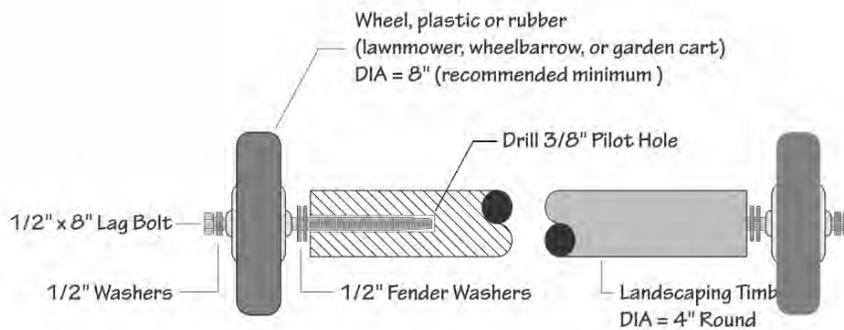
## Functional Elements

The wagon design should include the following elements.

- [Wheel-Axle Assemblies](#) (required, 2 each)
- [Chassis Assembly](#) (required)
- [Turret Deck](#) (deck and support structures; *as needed*)
- [Mule Train](#) (tow bar, push bars, or harnesses; *required*)
- [Artillery Pieces](#) (cannon and Gatling gun; *one required, two optional*)
- [Guidon](#) (required)
- [Armor and Accessories](#) (optional)

### Wheel-Axle Assemblies (2 required)

The wheel-axle assembly consists of one axle, two wheels, and connecting hardware. Refer to [Wheel Specifications](#) for dimensional requirements.



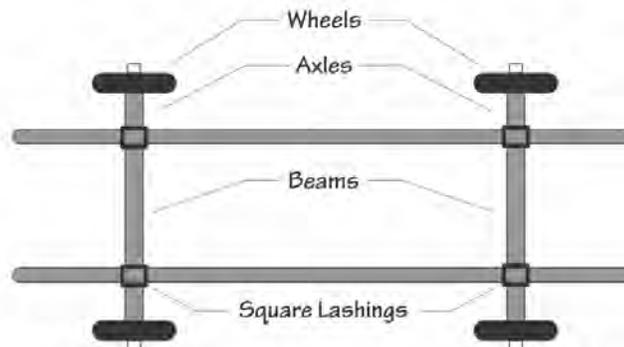
**Typical Wheel-and-Axle Assembly**

The wheel-axle assemblies may be preassembled prior to the camporee.

**NOTE:** Be advised to save your wheels for future camporee events.

### Chassis Assembly (required)

The standard truck chassis consists of a frame and four wheels (two wheel-axle assemblies and two or more connecting beams). Refer to [Chassis Specifications](#) for dimensional requirements.



**Basic Wagon Chassis (preassembled)**

### Turret Deck (required)

The artillery pieces must be mounted securely on the wagon.

- Provide a sturdy platform or support structure.
- Use stanchions, railings, cross-supports, ropes, chocks, as needed to secure the artillery pieces in place during transport and firing.

### **Mule Train** (required)

Some means is required to push or pull, steer, and brake to wagon. Several options may be used, alone or in combination.

- Rope harnesses
- Tow bars (tongue and yoke)
- Push bars

### **Artillery Pieces** (required)

One or both of the following ball launchers required.

- **Cannon** – Capable of launching a ball with good range and high accuracy
- **Gatling gun** – Capable of launching multiple balls in quick succession

### **Guidon** (required)

- The wagon must have a flag, guidon, or penant that identifies the regiment and troop (district and unit number).
- Do not use your official unit flag.

### **Armor and Accessories** (required/optional)

- The wagon must have a bucket or other container for holding ammunition (required).
- The wagon may be armored. Use cloth, plastic, leather, wood, or cardboard panels tied to the supporting structures.
- The wagon may have other theme-related decorative items.

## **Design Specifications**

### **Wheel Specifications**

The wheels may be commercially manufactured or self-constructed. Inexpensive plastic lawnmower, wheelbarrow, or garden cart wheels are available from most hardware stores.

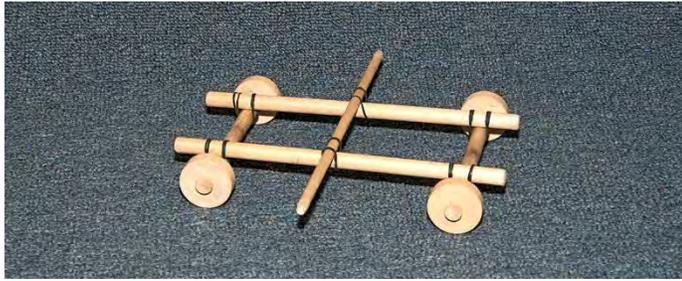
- Wheels may not have exposed spokes. Solid hubs are preferred, but fully-covered spokes are acceptable.
- Wheels should provide adequate ground clearance.

Minimum recommended wheel diameter	8 inches
Maximum allowed wheel diameter	24 inches

### **Chassis Specifications**

The chassis beams and axles must be wooden posts, either round or square. A fence post, landscaping timber, or framing lumber may be used.

Recommended beam diameter	4 inches
Recommended axle diameter	4 inches
Maximum chassis/axle width	32 inches (without wheels)
Maximum chassis length	72 inches



*Basic Chassis with Optional Stabilizer Bar*

## Ammunition

The cannon and Gatling gun may use the same or different types of ammunition. The following items are suitable as ammunition for either artillery piece.

- Tennis balls
- Ping-pong balls
- Other similar balls

If any other balls are used, they must be of similar size and weight and be constructed of safe materials such as soft rubber, soft plastic, fabric, or foam.

## Technical Information

The following data is provided for engineering reference.

Projectile	Caliber	Mass
Tennis Ball	6.54 – 6.86 cm (2.57 – 2.70 in.)	56.0 – 59.4 g (1.98 – 2.10 oz)
Ping-Pong Ball	40 mm (1.57 in)	2.7 g (0.095 oz)

## Design Tips

Prepare ahead. Practice for a solid build and an effective demonstration.

- Build a model to help visualize your wagon design. Use wooden dowels and orthodontic rubber bands to quickly build and evaluate different designs. (String lashings enhance the appearance of the model but they are not necessary for evaluation purposes.)
- Test and refine your wagon design prior to the camporee.
- Practice building and exercising your wagon prior to the camporee.
- Pre-cut and label all ropes and poles for quicker assembly.
- Determine the best order in which to assemble the pieces of the wagon.
- Divide the build into tasks that can be accomplished in parallel by multiple sub-teams. Individually built sections can be joined to complete the wagon.
- Decide which parts of the wagon are non-critical for structure and function. Non-critical and ornamental parts can be omitted if the build team runs short on time during the contest.

## ***The Build Stage – On-Site Construction***

The build stage occurs on Saturday morning while the patrol games are being readied.

The designated build area is at the lower campground (Shingle Mill Meadow). If that area is inaccessible due to road conditions, then the build area will be moved to the flag meadow.

If the flag meadow is used, do not set up on the volleyball court, near the large tree near the volleyball court, or next to the maintenance shed.

### **Build Preparation**

- All needed materials must be brought to the camporee by the competing units. All materials must be removed from the site at the conclusion of the camporee.
- All materials should be delivered to the build area prior to the opening flag ceremony on Saturday morning.
- Adequate separation should be left between the material stacks for the various units. Allow enough workspace to avoid interference while constructing and demonstrating the wagon.
- The wheel-and-axle assemblies and launching devices (non-lashed parts) may be pre-constructed, either before the camporee or prior to the start of the build competition.

### **Build Safety**

- Work gloves are recommended during construction to avoid splinters and rope burns.
- The build team must wear closed-toe shoes during construction.
- Goggles must be worn during testing of the launching devices.

### **Build Rules**

- All pioneering work must be completed entirely on site during the build competition (except specified preassemblies).
- All assembly and rope work must be completed within the allotted time period (60 minutes).
- No assembly may take place prior to the starting signal from the judge.
- All assembly ceases upon the ending signal from the judge.
- All work must be accomplished by Scouts. No adult assistance or supervision is permitted.
- The project shall be supervised by one Scout designated as the team chief. If necessary, the team chief may consult with an adult leader on a limited basis.
- Any unfinished construction work may be completed in the afternoon, after the build judging is completed and prior to the start of the proof stage (as schedules permit).

## ***The Proof Stage – Demonstration and Trials***

The troop challenge resumes after the patrol games have concluded. Build teams may make final inspections and adjustments to their wagon prior to the proof stage. All wagons must pass safety inspection.

The proof stage occurs on Saturday afternoon after the patrol games are completed.

## Demonstration

Operators must wear close-toed shoes, safety goggles, and work gloves. Following are the general requirements for the proof stage of the contest.

- Explain the design and operation of each launcher (the type of device, how energy is generated and stored, how repeat-firing is achieved, and any unique design features).
- Race the wagon for speed and maneuverability.
- Move the wagon into firing position.
- Fire the cannon (if optioned) three times for distance.
  - Adjustments may be made between shots (altitude, azimuth, power).
  - The greatest distance is recorded.

Research Question – What is the optimum altitude angle to maximize range?

- Fire the cannon (if optioned) three times for accuracy.
  - Adjustments may be made between shots (altitude, azimuth, power).
  - The nearest hit is recorded.
- Fire the Gatling gun (if optioned) for 15 seconds.
  - The number of rounds fired is recorded.
- Repairs may be completed as necessary during the demonstration.
- If a wagon is severely disabled while racing, all parts may be carried across the finish line in order to earn completion points.
- Spectators must remain clear of the course and gunnery range at all times.

## Artillery Company

Each competing unit should provide personnel to perform the following duties.

- **Gunnery Captain** – Directs the movement of the wagon and the operation of the launching devices (a senior Scout)
- **Gunnery Crew** – Moves the wagon and operates the launching devices under direction of the artillery captain (maximum of five Scouts)
- **Engineer** – Provides a brief presentation on the design and operation of the engine (one Scout, may also hold another position on the team)
- **Safety Sentry** – Observes all operations and monitors safety (a senior Scout or an adult leader)
- **Inspector General** – Assists the judge with task measurements and timekeeping (may be an adult leader).

## Required Equipment

In addition to the war wagon, the following items are required for completing the demonstration.

### Ammunition Rounds

- Provide tennis balls, ping-pong balls, or similar rounds.
- Mark all rounds with unit number
- Rounds of a single color are preferable for quicker identification.

## **Ammunition Quantities**

- **For the cannon** – Provide at least six balls.
- **For the Gatling gun** – Provide enough balls to feed the gun for a minimum of 15 seconds.

## **Ammunition Magazine**

Provide one of the following

- A bucket or other container to store ammunition (attached to wagon)
- A hopper or feed mechanism to hold ammunition (as part of the launcher)

## **Safety Equipment** (for gunnery crew)

- Goggles (required)
- Close-toed shoes (required)
- Work gloves (recommended).

Be sure to mark all equipment (including tennis balls and ping-pong balls) with your unit number.

## **Course Safety**

- All wagons must pass a safety inspection before they may be operated.
- Any loose rope ends must be tucked and secured so that they do not present trip and catch hazards to the operators, or interfere with wheels and other moving parts of the wagon.
- Wheel spokes (if present) must be covered.
- Mechanisms that move under non-manual power must have adequate guards to mitigate strike, slap, pinch, crush, cut, entanglement, entrapment, or other physical hazard.
- Stored pneumatic pressure may not exceed 70 psig.
- The gunnery crew must wear goggles for eye protection during operation of the launchers.
- The gunnery crew must wear closed-toe shoes during operation of the wagon.
- The gunnery crew may not wear any loose clothing that could become entangled in the wheels or moving mechanisms.
- Work gloves are recommended during operation to avoid splinters, abrasions, and rope burns.
- Launchers and moving parts of launchers must be adequately secured to prevent movement during wagon transport.

## **Course Rules**

- All spectators must remain clear of the course and the gunnery range.
- Each artillery crew shall be directed by an artillery captain and be monitored by a safety sentry.
- Crew members must wear all required safety gear.
- Repairs may be completed as necessary during the event.
- If a wagon is severely disabled, all parts may be carried in order to complete the course.

## **Tear-Down**

- Wagons may be disassembled at any time following the conclusion the competition.
- All materials must be removed from the site at the conclusion of the camporee. Do not dispose of materials at the camp.

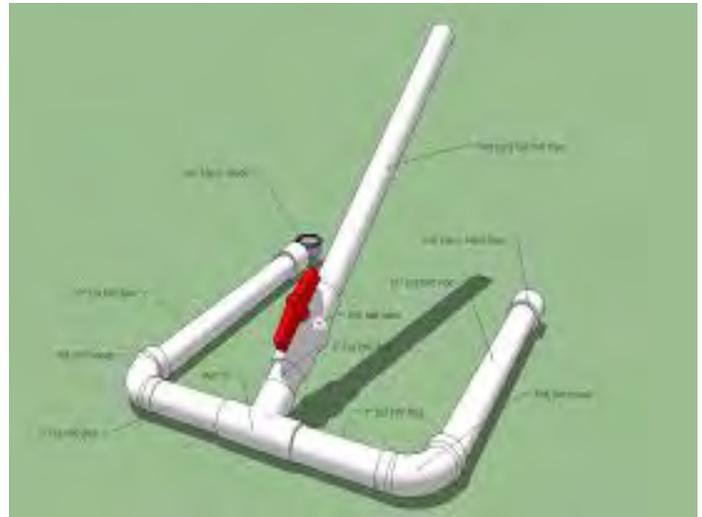
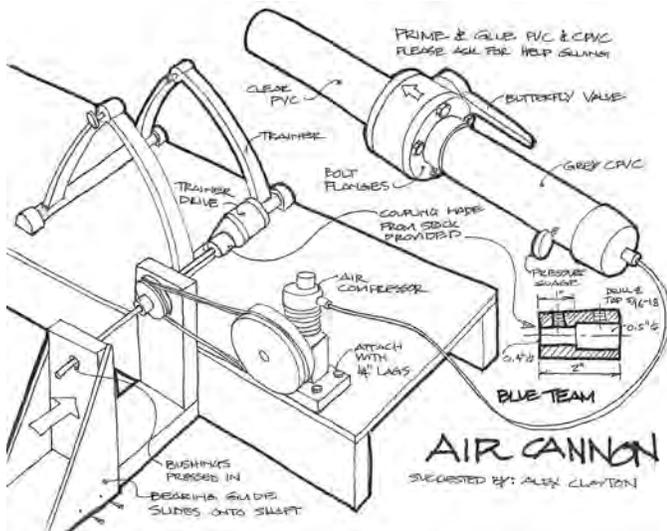
# Sample Launcher Designs

A variety of design ideas for launchers are available from Internet sources, so no detailed discussion is offered here. However, a few sample illustrations are provided below.

You are not limited to these designs. The intent is to provide general ideas that inspire new ideas. Be encouraged to experiment and improvise. Details must be worked out by your design team.

The following line sketches are from the MIT Build Challenge 2.009 (other figures as cited).

See <http://web.mit.edu/2.009/www/experiments/nwpassage/plans.html>

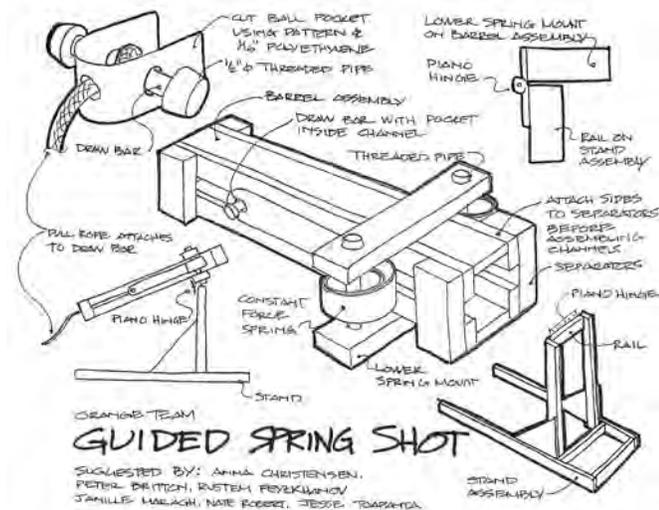


<https://www.pinterest.com/pin/427771664584637581/>

Note: A manual air pump is required (no compressor), but a ballast tank can improve performance.

## Air Cannon Design

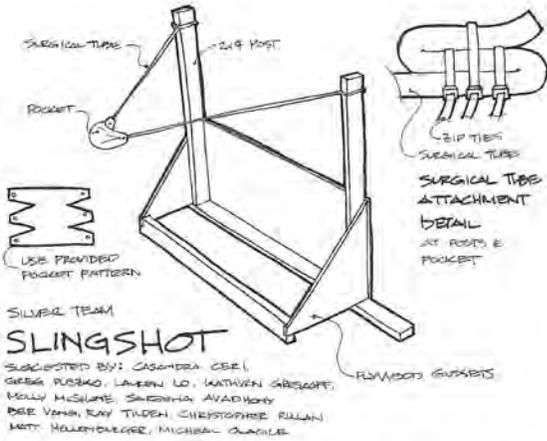
## Air Cannon Example



<https://www.instructables.com/id/Bungee-Bazooka/>

## Spring Launcher Design

## Elastic Launcher Example



**SILVER TEAM  
SLINGSHOT**

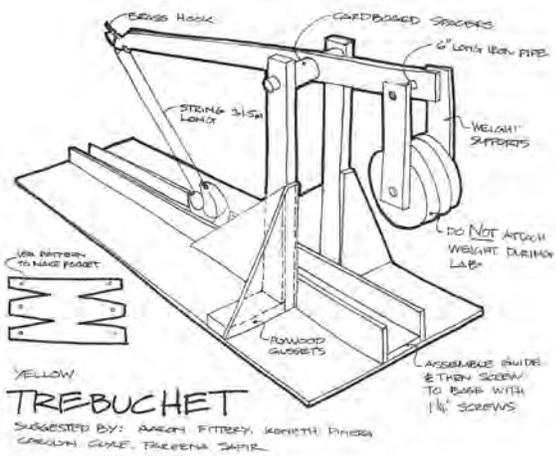
SUGGESTED BY: CASANDRA CEEI,  
GESSIE RUSKINS, LAUREN LO, KATHY GREGORY,  
MOLLY HUSLUM, SHERIDAN AVADHONY,  
DREW VAN DER WOUDE, CHRISTOPHER RULAN,  
MATT HALLMAYER, MICHAEL QUARLES



<http://pictarics.pw/golf-ball-trebuchet-build-a-pvc-pipe-trebuchet-with-easy-to.html>

**Slingshot Design**

**Slingshot Example**



**YELLOW  
TREBUCHET**

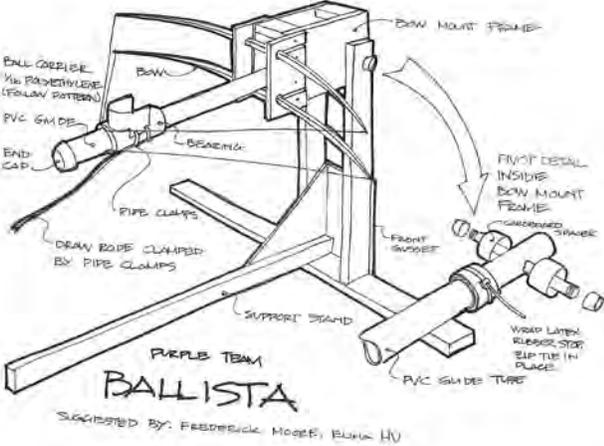
SUGGESTED BY: ANTON FITZROY, KENNETH PRINCE,  
CAROLYN GUYE, TEREENA SAPIR



<http://liyionline.me/homemade-tennis-ball-launcher/>

**Trebuchet Design**

**Trebuchet Example**



**PURPLE TEAM  
BALLISTA**

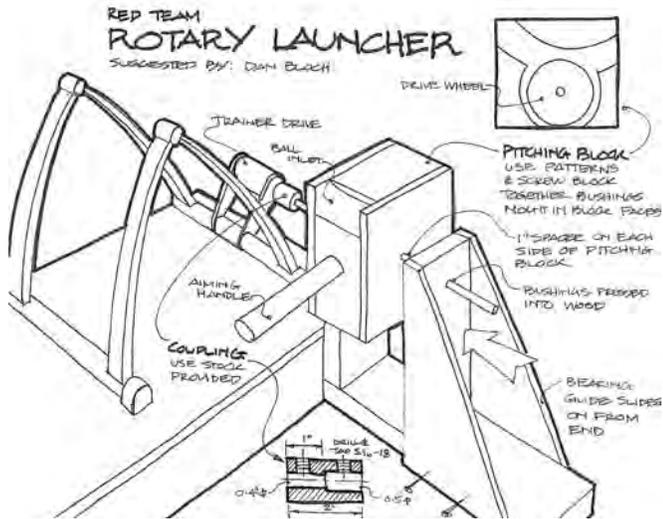
SUGGESTED BY: FREDERICK MOORE, BLANK HV



<http://pictarics.pw/golf-ball-trebuchet-build-a-pvc-pipe-trebuchet-with-easy-to.html>

**Ballista Design**

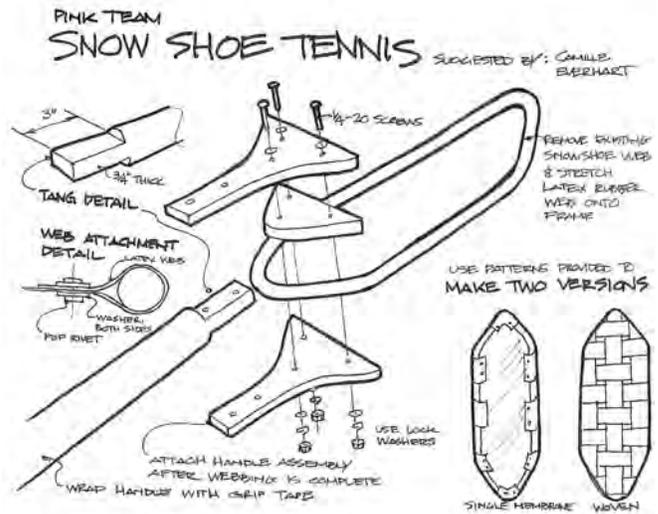
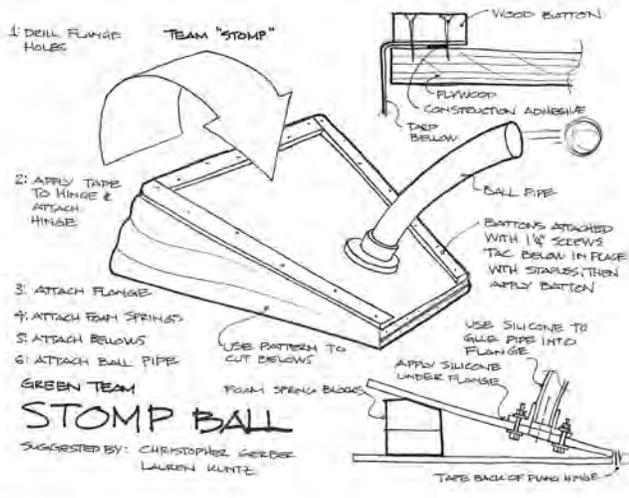
**Ballista Example**



Note: A manual crank is required (no motors), but a large-diameter flywheel can improve performance.

**Rotary Impulse Design**

**Rotary Impulse Example**



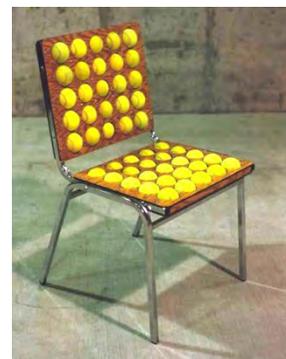
**Stomp Bellows Design**

**Throwing Arm Design**



<http://liyionline.me/homemade-tennis-ball-launcher/>

**Water Rocket Ball Launcher**



<https://www.creativespotting.com/page/309/?so=mrs>

**Ball Storage Unit**