2021 Midwest Stage Machine Design Competition Design Specification

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Competition Design Specification

Competition Requirements:

- 2021 Stage Machine Design Competition: “Wisconsin Johnson and the Pop Up Dart Trap”
- Design a mechanism that will allow a “head” to lift from a base, shoot a dart from its mouth, and have the “head” lower back to its initial starting position
- Team must function professionally, ethically, and within the honor code of their university

Competition Submissions:

- Feb 1: Submit PDF of Design Proposal including Design Specifications and Concept Designs
- May 8th: Competition day including final Design Document of our team’s Design Proposal, Detailed Designs, and a working proposal of our team’s design to be tested at the competition

Competition Day:

- Complete the raise/shoot/lower sequence consistently 10 times without failure
- A team member will reload the dart in a under 5 minute time frame

Competition Site Available Resources:

- 10 NERF style darts being ½” in diameter and 2 ⅞” in length
- Darts may not be changed from their original state in anyway
- 15A 110-120VAC power available
- 100 PSI air pressure by ¼” tube or quick connect available upon request

Competition Regulations:

- Raise, fire, and lower sequence should be a single trigger
- No pyrotechnics or explosives may be used or our team will be immediately disqualified from the competition
- Ideally a mechanical means approach instead of using electronic sensors or pneumatics
- No culturally insensitive aesthetic designs to the mechanism, focus should be on the machine itself not the imagery on the mechanism

Mechanism Design Specification

Production Team/Stakeholders:

- Competition Hosts
- Design Team
- People entering the escape room

Context for Effect:

- Design team has been hired to help create an immersive escape room
- Based on the famous archeologist-explorer Wisconsin Johnson
- Wisconsin Johnson and his team of explorers must walk through a temple, watching their every step

Description of Effect:

- “One misstep will cause the statuary heads along the walls of the passage to rapidly rise upwards off the floor (as if the statues suddenly grow taller), propel a poison dart from their mouths, and then slowly descend back to the floor.”

Effect Details:

Column Initial Idle State:
18” diameter x 18” tall
Mouth opening 6” from floor
Trigger intact, device ready to fire

Column Max Height:
18” diameter x 36” tall
Mouth opening 24” from floor
Device Fires at max height

Column Final Idle State:
18”diameter x 18” tall
Mouth opening 6” from floor
Trigger inactive

- The rise, fire, and lower sequence should all be one fluid sequence
- A single “trigger” should initiate the sequence
- Head must rise to 18” in less than 2 seconds
- At maximum height of 18”, the dart should fire automatically
    - The dart should only be able to fire when the maximum height is reached
- After launch, the head should drop back to its starting position in 10 seconds
- The rising and lowering velocity of the “head” should be consistent with each launch

- Darts must fire at least a distance of 5', but should not exceed a distance of 10'
- The distance the dart is fired must be consistent with each rep

Head Assembly Dimensions:

- Head will be a cylinder shape: 18" in diameter and 18" tall
- One mouth being 6" from the bottom of the cylinder

Safety Considerations:

- The raise, shoot, lower sequence will occur multiple times throughout the busy day of the escape room, therefore the method must be safe and durable to be used for many months of operation
- The device may not pose any actual risk to the escape room participants
- Safety interlocks should be included for the loading and unloading of the darts
- Must ensure the dart does not launch during the loading process
- Dart can be safely unloaded without the device launching
- Dart will not fire at too fast a velocity to hurt anyone in the escape room
- No mechanical pieces that pinch or could be easily grabbed to arrest the motion of the head should be accessible to escape room customers at any time during device's idle or operational states
    - Reloading will be accomplished using a key or hidden latch to prevent potentially damaging access to device internals
- The head should not rise with enough force to injure a person
- Neither the head nor trigger should be movable by escape room customers
- Operation of the trigger cannot damage the internals in any way--fail safes in the trigger mechanism will prevent this
- Trigger mechanism should not cause tripping hazard

Budget:

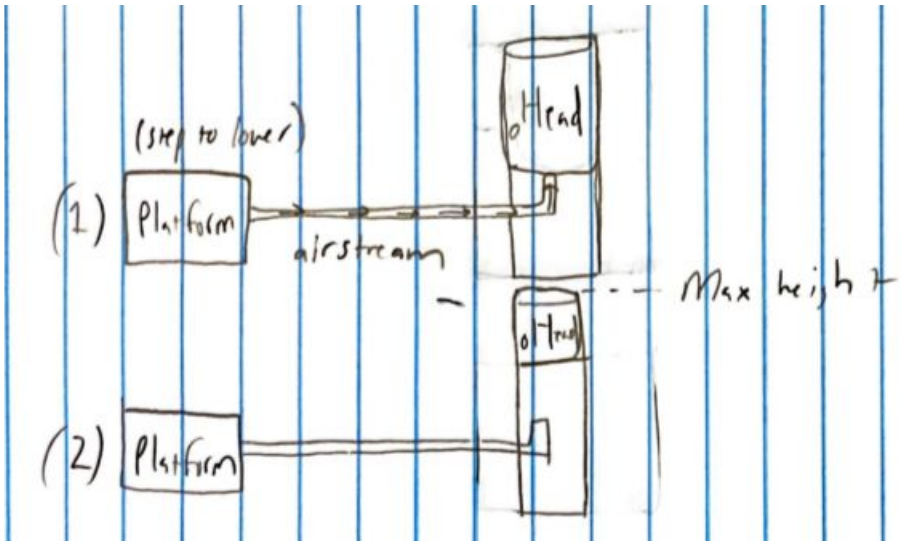
- Work to make the best possible mechanism at the most cost efficient price
- Our team has agreed to pay $30 per team member
- Maximum $120 total budget for all supplies
- If more money is needed, the team will vote on giving more money or changing the design approach to a cheaper option

Mechanism Wishlist:

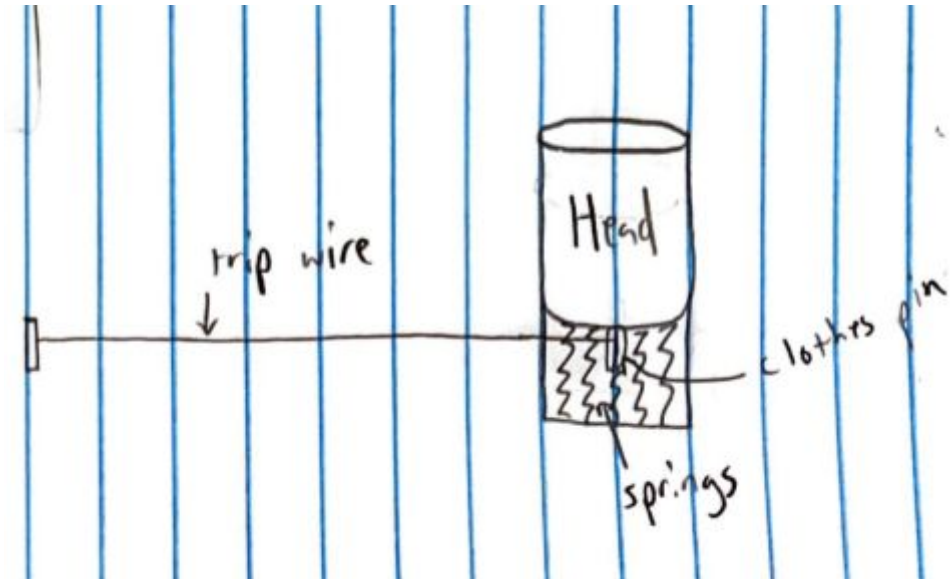
- Operation of the sequence is simple for anyone to use
- There is minimal sound from the rising and lowering of the "head"
- Triggering system will be hidden from the escape room participants

Design Concepts:

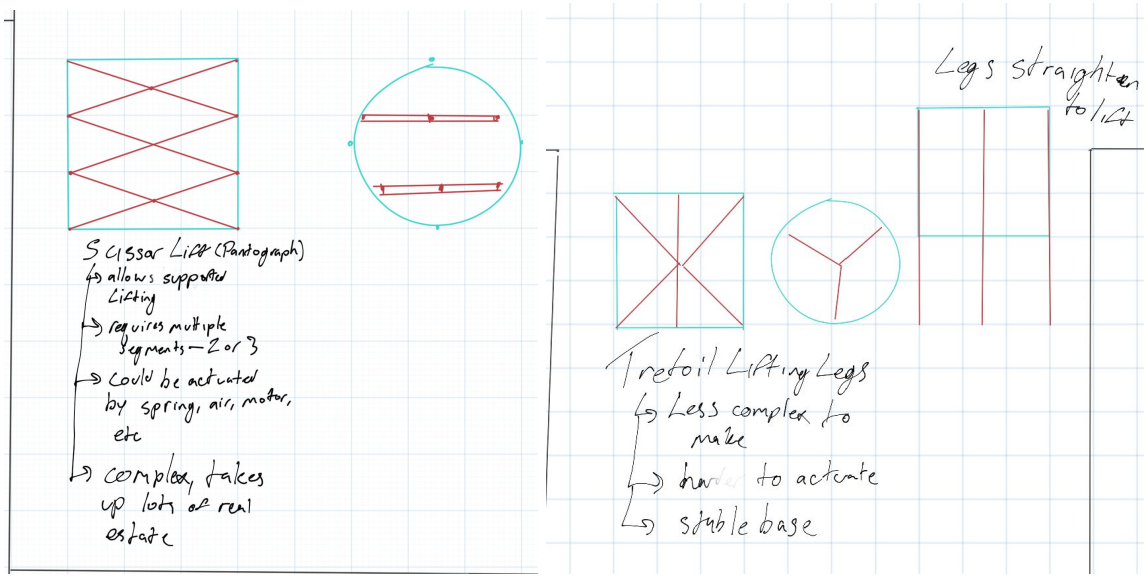
Raising:



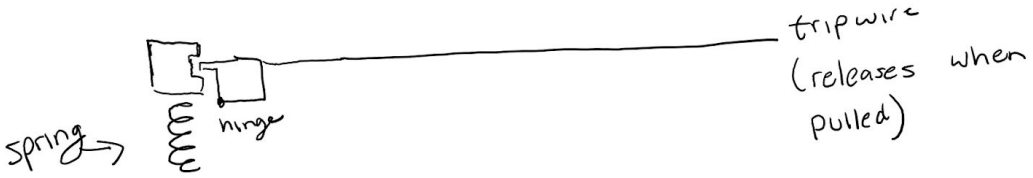
This design is similar to a stomp rocket where the individual in the escape room will step onto a plate and their weight on the plate will provide a rush of air into the head system to trigger the initial raising of the head. From the rush of air, the head will be able to reach its maximum height needed to proceed to the next step of the triggering process.



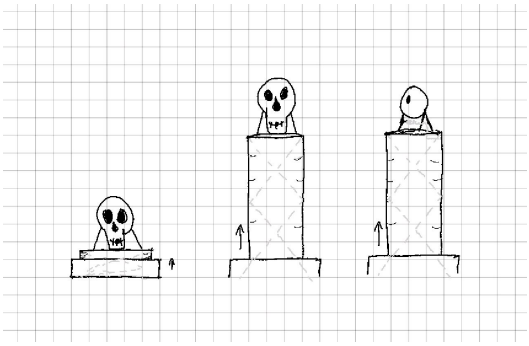
This design will involve a trip wire being the activating trigger where one end of the trip wire will be attached to the ground while the other end will be a clothespin attached to the head device. When someone activates the trip wire, the clothespin will open, releasing the head which will rise up since the springs will activate the head to move upward.



This concept shows a scissor lift attached to a mechanical power source. This mechanism will be stable both on the ground and in the fully raised position. Conversely, three legs with a single knee each will allow for more space inside the statue for firing machinery.

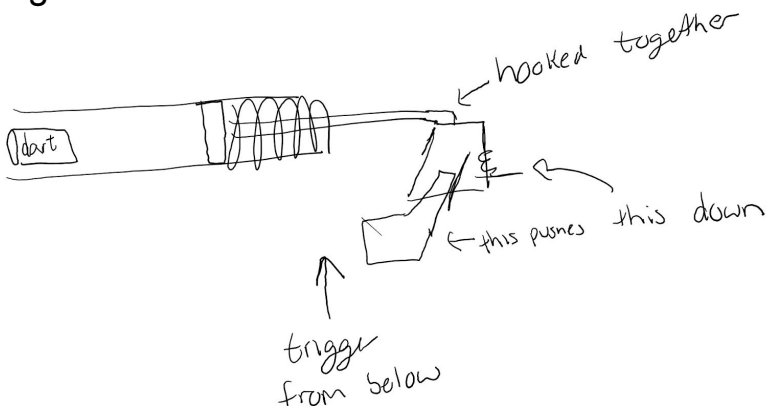


This concept involves the use of a tripwire connected to a latch and a spring. The tripwire would pull on a latch that was hooked to a spring. As the latch was pulled, the spring would pop up quickly pushing the head to its full height.

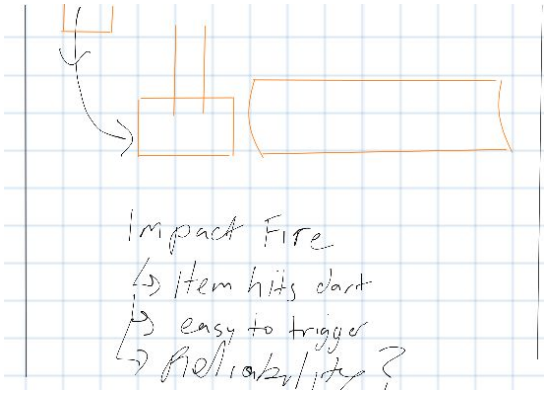


This concept involves utilizing a scissor lift to raise a flexible pillar (similar to a children's crawl tunnel) from a collapsed position to its full height. The firing mechanism is contained within a smaller structure attached to the tunnel's solid top that rises with the lift.

Firing:

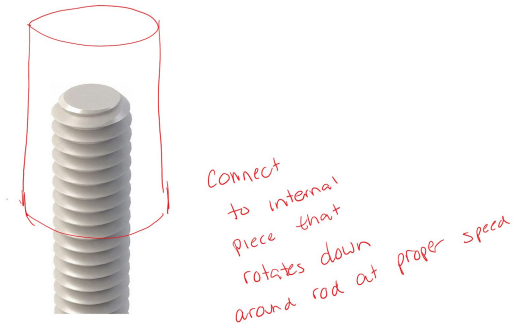


This concept involves the use of a piston, springs, and interlocking latches similar to the design of a NERF gun. When the lowest latch is triggered, it moves the second latch which releases the piston. The force from the piston propels the dart outward quickly. The lowest latch will be triggered when the head reached maximum height.



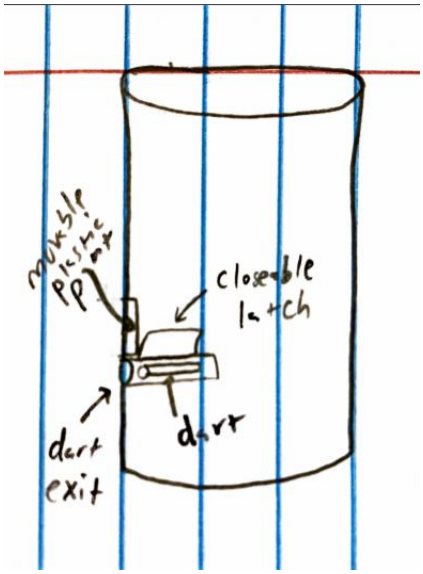
Impact based firing provides a simple solution wherein an object inside the head statue will hit the back of the dart and propel it. This allows for fewer moving parts.

Lowering:



This concept uses a threaded rod to allow the head to slowly move back down to resting position. An internal mechanism of the head would rotate around the rod as the head lowered down.

Safety Feature:



In order to have the darts be loaded and fired safely, a safety mechanism will be implemented that will be a movable plastic piece that one can attach to block the hole when the dart is being loaded so that the dart will not fire early. The dart will be placed into a capsule with a lid so that once the dart is in place, the dart will not be able to leave the capsule until at the maximum height.

Initial Proposal:

After evaluating the pros and cons of each of the above concept ideas, we decided to pursue a design that integrates a spring based raising system, a piston-style launching mechanism, and a counterweight for lowering. The trigger for the system, likely a pressure plate or tripwire, will release the spring causing the head to quickly rise upward. The head reaching its apex will trigger the piston launch system to shoot the dart. After the dart has been launched, a counterweight will drop inside the head, moving it slowly back down to the lowest position.

The spring was chosen as the raising mechanism because it would allow the platform to raise very quickly and consistently. The piston system for launching the dart has been proven by other products to be a very effective and consistent way to launch the dart, while taking up minimal space and being easily triggered. Using a counterweight to lower the head back down allows for easier control of the lowering speed and integrates best with the spring based raising system.