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Rube Goldberg Machine

Design Project

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11/3/03

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Water Calculator

You want to do what?!

Objective:

To design a simple machine that engages in a complex chain reaction to accomplish a simple task…

Given Criteria:

- There must be at least 20 steps in the process
- The machine must accomplish its purpose
- It can only occupy an area 1.5 m x 1.5 m on the floor
- It cannot take too long to accomplish its ends
- It must be complete in 3 weeks time

Personal Goals:

- Be interesting and complex
- Be new, seldom or never done before
- Exploit and compliment each group member
- Use the cool Lego set
- Get a good grade

Kicked to the curb…

Alternate ideas:

- trap > overdone
- letter head writer > too complicated
- fish feeder > dumb
- light switch > too simple

Water Calculator

What we came up with…

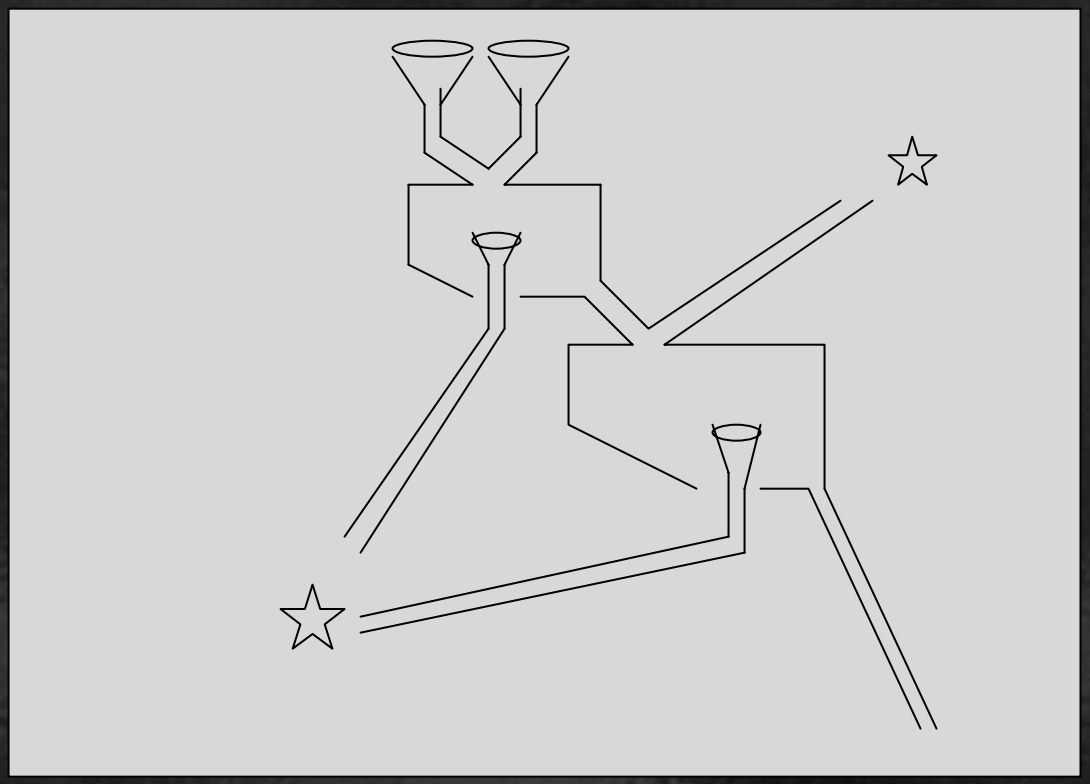
A **water calculator** that will be able to add an ‘x’ amount of bits together through a series of binary representations that are processed through a device that channels water.

Water Calculator

…and this is why…

- The idea fit the given criteria and personal goals
- The theoretical concept often differs from the realistic implementation, therefore a prototype design was needed

Original Prototype Design



The colored water would flow down the various plastic tubing's.

It would either end up in the final result or the carry over.

The process is repeated for the number of bits that need to be calculated.

The Number System

- Decimal Numbers
- 6357 has 4 digits.
- 7 is filling the 1’s place
- 5 is filling the 10’s place
- 3 is filling the 100’s place
- 6 is filling the 1000’s place

- So mathematically it could be expressed:
- (6*1000)+(3*100)+(5*10)+(7*1) = 6357
- Or it can be expressed in the powers of 10
- (6*10^3) + (3*10^2) + (5*10^1) + (7*10^0) =6357
- Since we have 10 fingers we naturally used the base 10 system.

- Computers however, tend to use binary digits. It is easily represented by either, current going through the wire, or not going through the wire.
- So just like it is in Decimal;
- The number 1011 in binary would be:
- (1*2^3)+(0*2^2)+(1*2^1)+(1*2^0) =
- 8 + 0 + 2 + 1 = 11

Boolean Logic

- Now that we know how Binary numbers work, there are various rules to simple “switches” (gates)
- Simplest of all gates is called a NOT gate. Whatever is inputted 1/0 , it will output the exact opposite.

- The gate we used in this adder is called the AND gate.
- The AND gate effectively takes 2 values and gives a Boolean result with these values.

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

- Another gate we used is called an OR gate
- Just like the AND gate, it takes 2 values and returns 1 value
  - A | B | Q
  - 0 | 0 | 0
  - 0 | 1 | 1
  - 1 | 0 | 1
  - 1 | 1 | 1

Binary Math

- Binary math is just like decimal math, but lets start with decimal addition
- 452
- +751
- 1203
- First its 2+1=3; then its 5+5= 10, so we carry over the 1. 1+4+7= 12, so we carry over again, 0+0+1 = 1, so that is the result

- Binary math is exactly the same except for we only use 0's and 1's.
- 010 2
- +111 +7
- 1001 9
- First 0+1=1; then 1+1=10 , so there is a carryover of 1. 1+1 = 0, another carryover, 0+1 = 1.
- If we convert that back to Decimal it would be (1*2^3)+(1*2^0) = 9

Our Water Calculator Solution

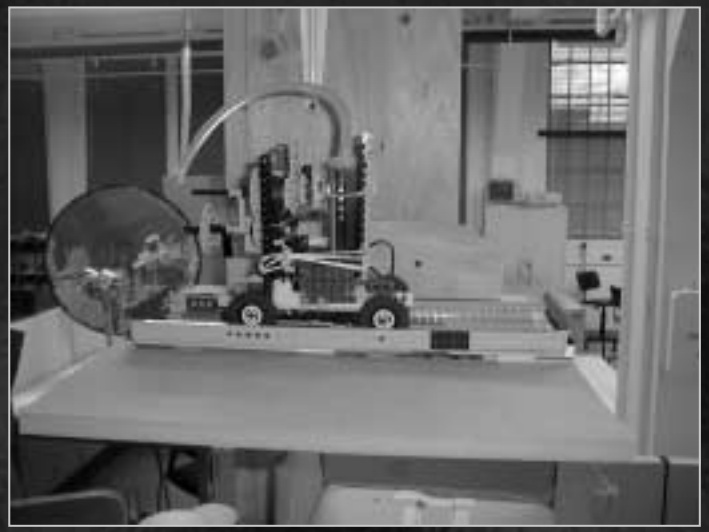
- We decided to use a simple AND OR combination (x2) to create a simple 1 bit adder + a carryover bit. We could serialize the components to do an unlimited amount of bits , just by reading the carryover bit and repeating the process.

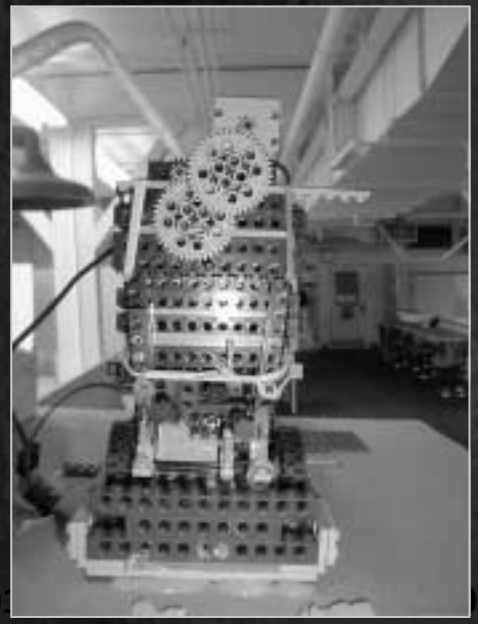
Actual Design

LEVEL1- Water Reservoir:

- A 2-liter bottle with a hole cut out towards the “top”
- 1/4” tube attached to the neck of the bottle

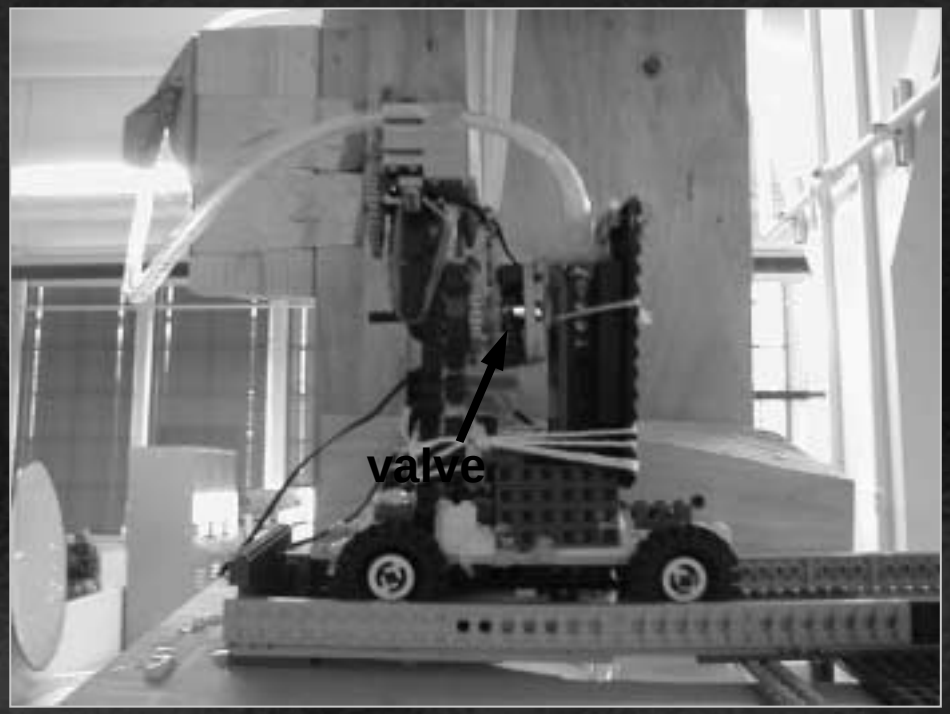
LEVEL2- Water Dispenser:





- ¼ turn valve
- Lego Mindstorm software
- Motor mounted to a plane so that shaft of motor is perpendicular to platform
- Gears, large and small
- Intake tube and directional tube

Water Dispenser cont…

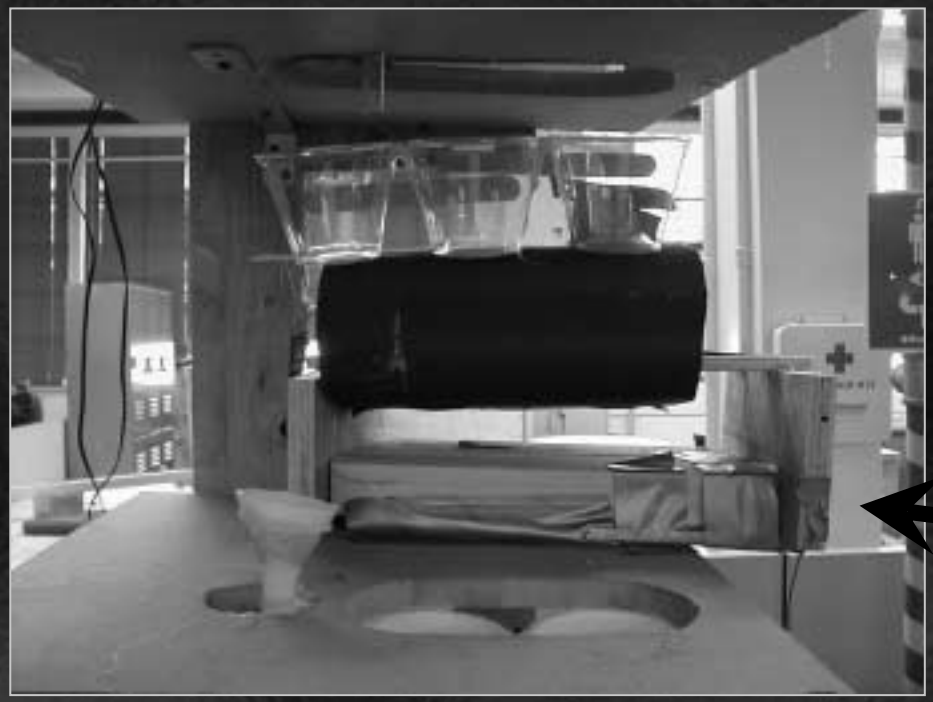


- Proponent mounted on a “cart”
- Dispenser moves on 4” x 18” Lego track
- All materials adhered by hot glue gun

LEVEL3- Belt:

- 10” x 32” rubber belt
- Lego skeleton powered by 2 Mindstorm motors
- 3” wheels
- Gears- 3 large, 3 small
- Line of 3 cups mounted onto belt with popsicle sticks, hot glue gun, wiring

Belt cont…

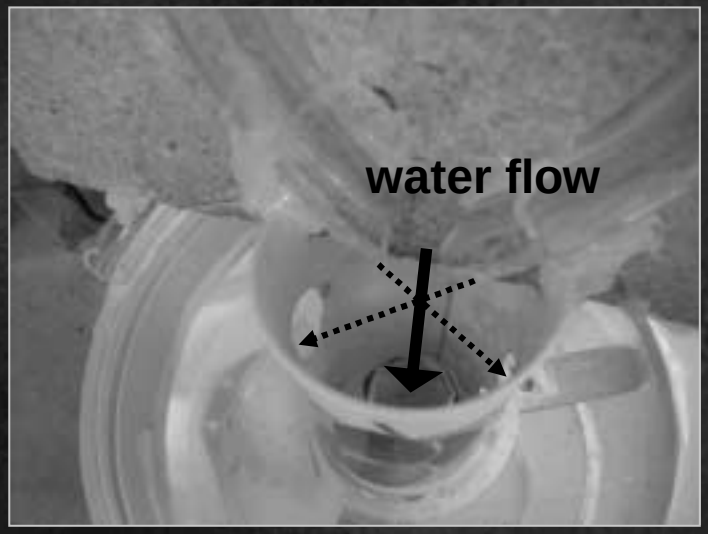


- Belt apparatus mounted on top of wood box-like frame 4” x 12” x 14” with 2 14” wooden sticks

LEVEL4- Water “Switch” 1:

- Two 4” funnels, one 3” funnel mounted with popsicle sticks
- Two 1/2” tubes cut to 6” in length
- 7” x 10” wood board to set tubes at an 135% angle
- One 6” plastic bowl with 2” of bottom cut off sitting on top of 6” funnel

Water “Switch" 1 cont…

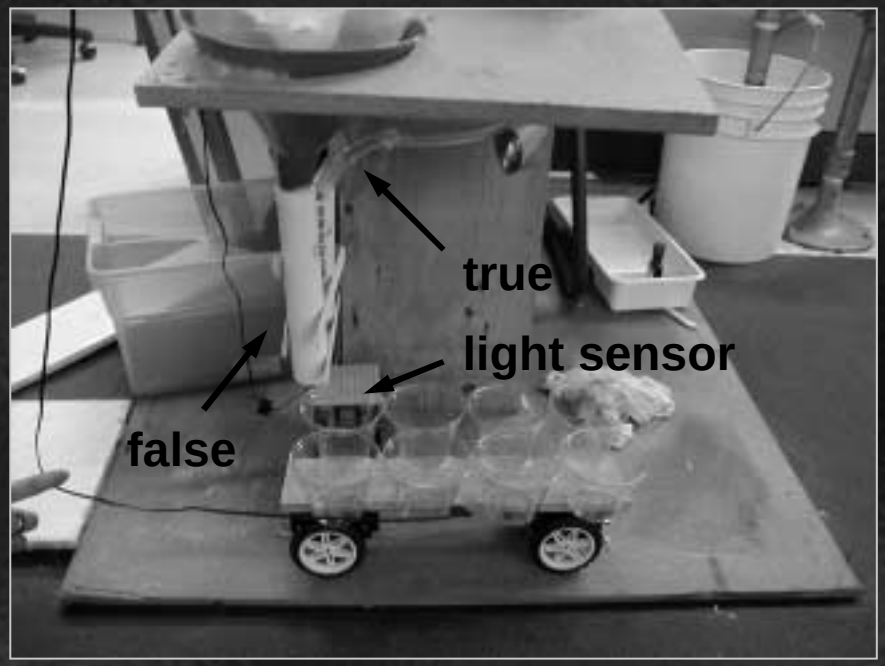


- One defect overflow funnel
- One 8oz cup with 1.5” holes on both sides and at bottom for water
- Two 3/8” tubing at 30” length
- Two RCX Bricks
- Rotary sensor for input mechanism
- All materials adhered with hot glue gun

LEVEL5- Water “Switch” 2:

- One 6” plastic bowl with bottom cut off
- One 6” funnel, one 3” funnel mounted with popsicle sticks
- 3” x 6” wood board holding “switch” 1 “true” tube and overflow tube in place
- All material adhered with hot glue gun

LEVEL6- Results/ Carry Over:



- 1 – 18” x 4 “x ½” Particle Board
- Eight, 8oz cups
- Lego, 4 large wheels
- RWD motor/ Mindstorm
- Mindstorm light sensor mounted in a Lego tower
- Two 1” pipes 6” in length encapsulating “true” and “false” tubes held by popsicle sticks

Prototyping

- One of the most important prototype performance failures we ran into was the timing portion of the software. It was critical that every timing element was correct down to the 1/100th of a second. This was one of the expected prototype failures that we would need to iron out. Otherwise, the only other failure was the unexpected fluid dynamics of the water streams when they collided with each other.

Conclusion

- In starting the project, we made a conscious decision to incorporate a simple, very sequential adder. This was achieved by having the least amount of physical "switches"; however, after doing this design, we think it would be better to make a wide, parallel design.
- It would cut down on the timing aspect of the project, thus greatly increasing the reliability of the system.

Conclusion continued

- On the downside, it would require at least 8x more switches, at the expense of that reliability.
- Overall, it was a good learning experience of how water could theoretically replace electricity for Boolean logic. Since the timings were greatly reduced for transmission, it was very difficult to use the resources we had, to implement a way to get it to correctly function.