Marquette University High School - C21
It's About Time
Design Log

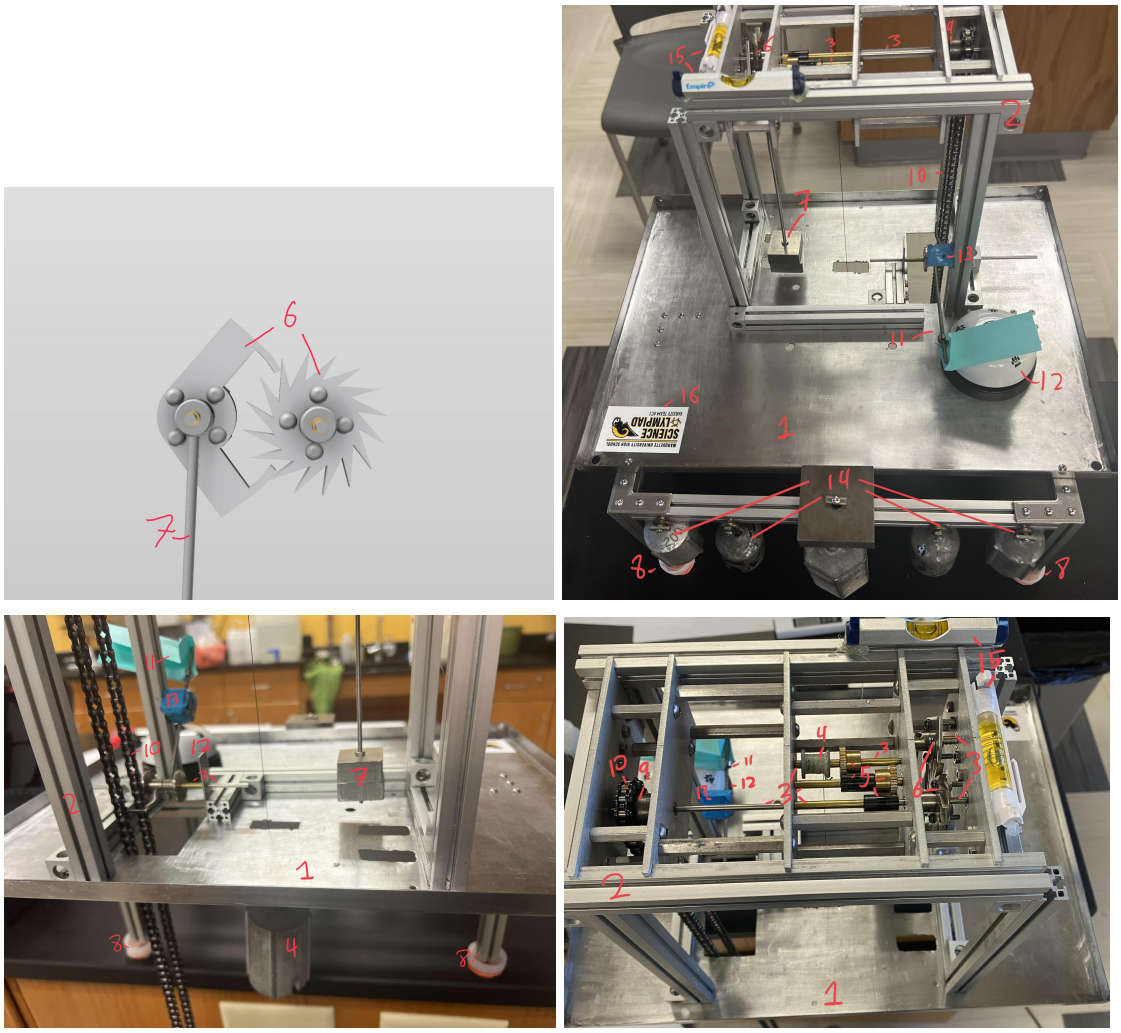
Materials:
The materials used for the making of the device are as follows:

Tripod Table
⅛" aluminum stock to make the plates
⅛" stainless steel to make the escapement wheel
1/16" stainless steel to make the escapement
Flanged bearings
7' of ¼" chain including a connecting link and a 2.4mm roll pin
½" steel to make pendulum mass and counterbalance weight
M3-0.5 threaded rod to make pendulum rod and signal arms
M3-0.5 brass standoffs to mount weights
3mm axel rod
4mm o.d. 3.1mm i.d. brass tube to make spacers
sprocket for chain
large gears
small gears
"motor mounts"
set collars
1" standoffs
2" standoffs
#8-32 screws
#4 screws
#4 nuts
M3 nuts
M3 screws
M3 hex screws
pieces of Makerbeam XL aluminum extrusion

Corner cubes for Makerbeam XL
Makerbeam XL L brackets
Stainless Steel table
Standard masses
Bottle caps
Foam circles
Bell
Levels
Magnet
Duct tape
Thread-loc
CA Glue
Hot melt glue
Vinyl label
Post-It note

Diagram:

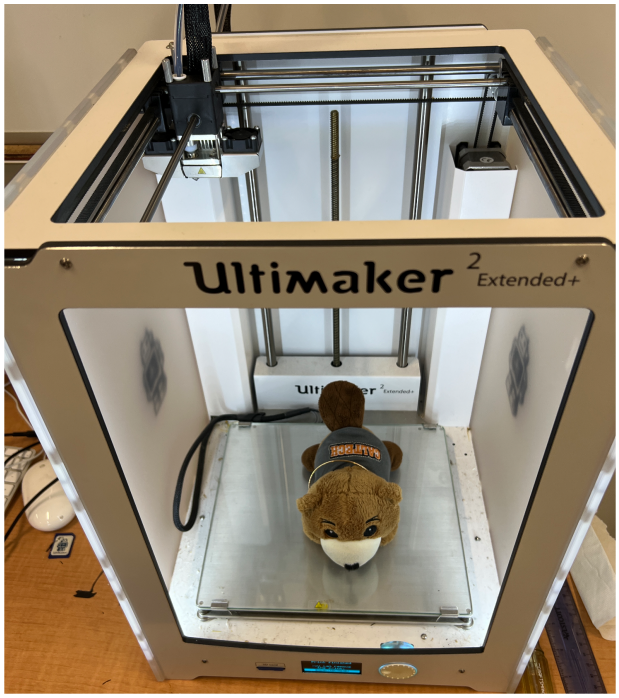
The following diagram serves as an accurate representation of the device. A key to the numbers has been given below the diagram.



1. Mini Table: tripod table (removed from tripod) screwed to a Makerbeam XL lower structure, provides a base and stand to overhang the edge of a table
2. Structure: made from MakerBeam XL, 1” and 2” vex standoffs, laser cut aluminum plates, and flange bearings; Holds the axels of the movement elevated and in alignment while allowing rotation
3. Axels and spacers: Axels constrain the gears and components to rotate and the spacers ensure that the components are correctly placed along the length of the axel
4. Spool + weight: 3D printed piece and standard weights; powers the movement as the spool unspools and the weights lower

5. Gears: transfer rotation between the axels; decreases torque by increasing the speed of rotation
6. Escape Wheel + Escapement: regulates the rate of rotation by allowing the escape wheel to advance 1 tooth for each swing of the pendulum; also provides impulses to the pendulum to keep it swinging
7. Pendulum: establishes the base frequency of the clock by its simple harmonic oscillation
8. Bottle Cap and Foam feet: allow for leveling the device
9. Sprocket: moves the chain at the rotation rate of the main axel
10. Chain: rotates around and triggers the signal after it has moved a chosen distance, corresponding to the desired duration
11. Signal Arm: Rings the bell when actuated by the chain
12. Bell: produces an audible signal when the signal arm is actuated
13. Magnet: retains the signal arm until actuated
14. Masses: dampens vibrations + counterbalances clock
15. Levels: aid in leveling the device
16. Vinyl Sticker: Identify team

3-D Printed Materials:

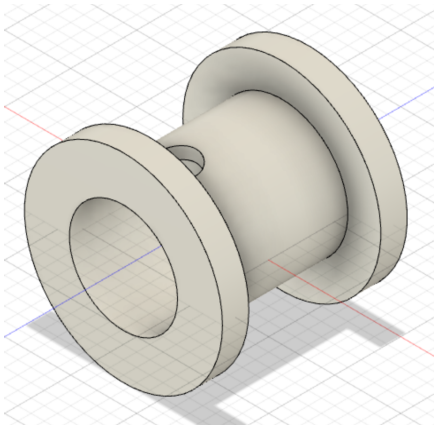


Printed on the team's Ultimaker 2 Extended+ 3D Printer

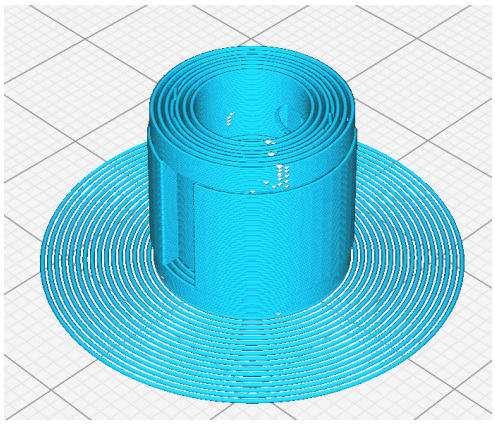
Printed from White colorFabb PLA/PHA

File Origin: Custom designed by competitors in Autodesk Fusion 360
Then exported to and sliced in Ultimaker Cura for the 3D printer

Spool: Support material and brim was removed then the 3D printed spool was then fitted with a set collar (friction fit, pressed in) that allowed it to be fixed to the turning axle, then mounted in the clock for the string to wrap around

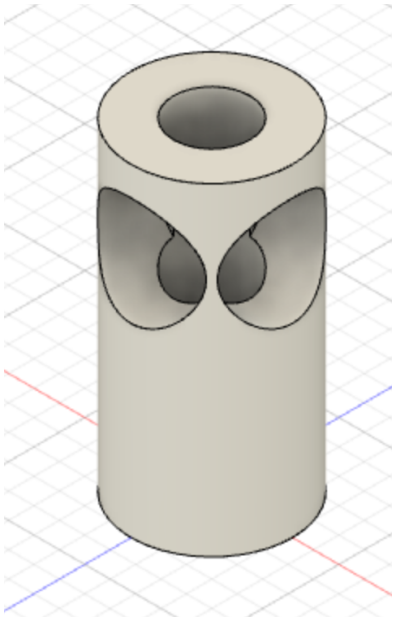


Spool.F3D

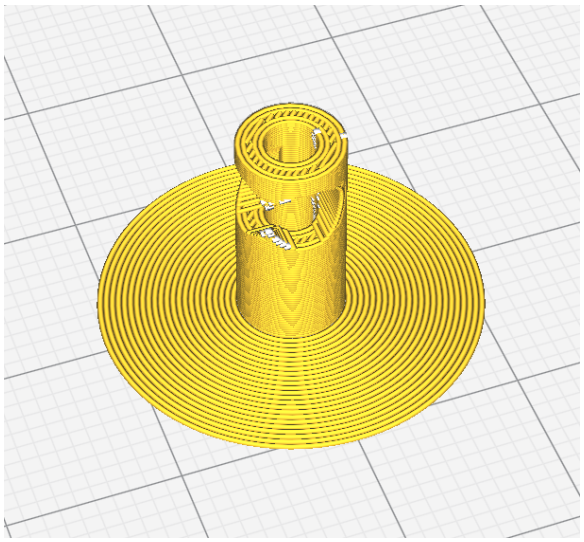


UM2E+_spol.gcode

Sprocket adapter: 3D printed piece adapts the ¼” sprocket i.d. to the 3mm shaft; used as is after brim removed



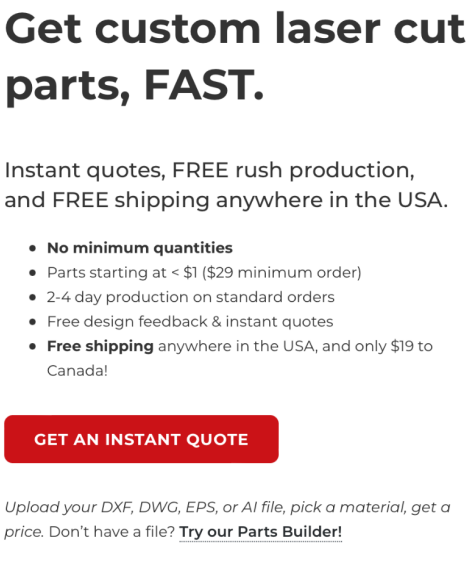
Sprocket Collar.F3D



UM2E+_collar.gcode

Laser Cut Materials:

Part Origin (same for all parts):
Laser cut to our files by sendcutsend.com using a fiber laser (.dxf files exported from Fusion 360 and uploaded to their website)



File Origin: Custom designed by competitors in Autodesk Fusion 360

Aluminum plates for structure: ⅛” 5052 Aluminum

The holes were expanded on one side to allow for countersinking bearings which were pressed into the openings. Then the structure was assembled around the axels using screws and the standoffs between the plates, and the makerbeam sections were screwed to the end plates.

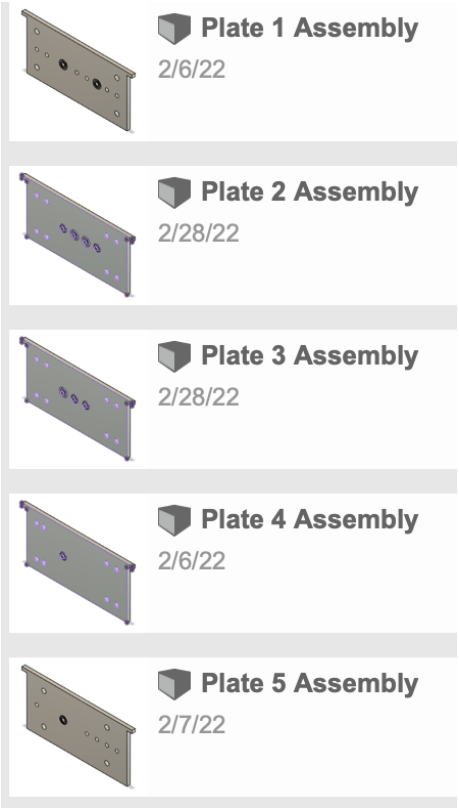
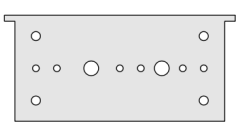
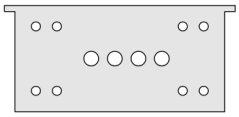


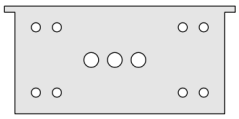
Plate 1 Assembly.F3D
Plate 2 Assembly.F3D
Plate 3 Assembly.F3D
Plate 4 Assembly.F3D
Plate 5 Assembly.F3D



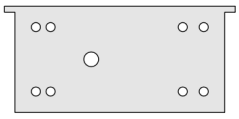
5052 Aluminum (.125")
plate1.dxf
110 x 50.8 mm



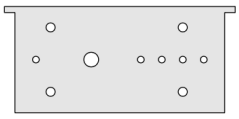
5052 Aluminum (.125")
plate2.dxf
110 x 50.8 mm



5052 Aluminum (.125")
plate3.dxf
110 x 50.8 mm



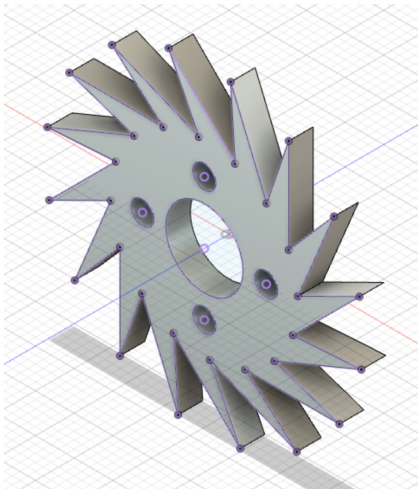
5052 Aluminum (.125")
plate4.dxf
110 x 50.8 mm

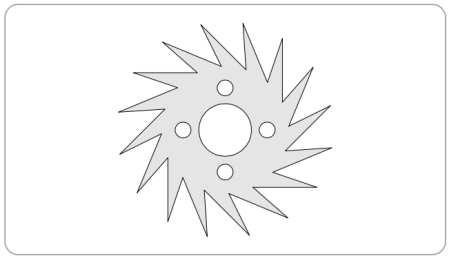


5052 Aluminum (.125")
plate5.dxf
110 x 50.8 mm

Escape Wheel: ⅛” 304 Stainless steel

Teeth were sanded to ensure minimal friction with the escapement, then the piece was screwed to a “motor mount” and placed on the axel



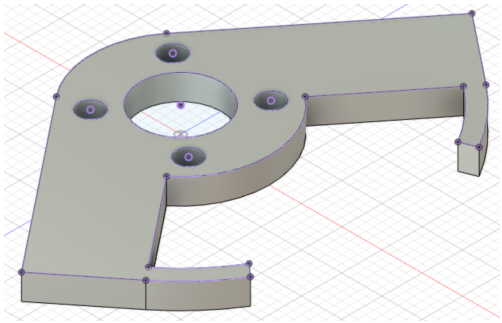


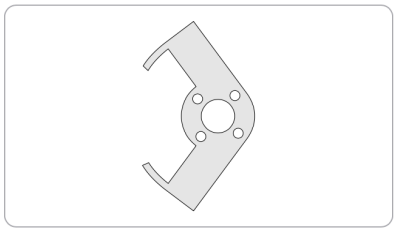
Stainless Steel (304 series) (.125")
escapement_wheel.dxf
Size: 40.581 x 40.581 mm

Escape Wheel.F3D

Escapement: ~1/16” 304 Stainless steel

Piece was screwed to a “motor mount” to be attached to the axel and pendulum. Then the escapement pallets were sanded to minimize friction and fine tune the interaction between escapement and wheel for optimal consistent ticking of clock





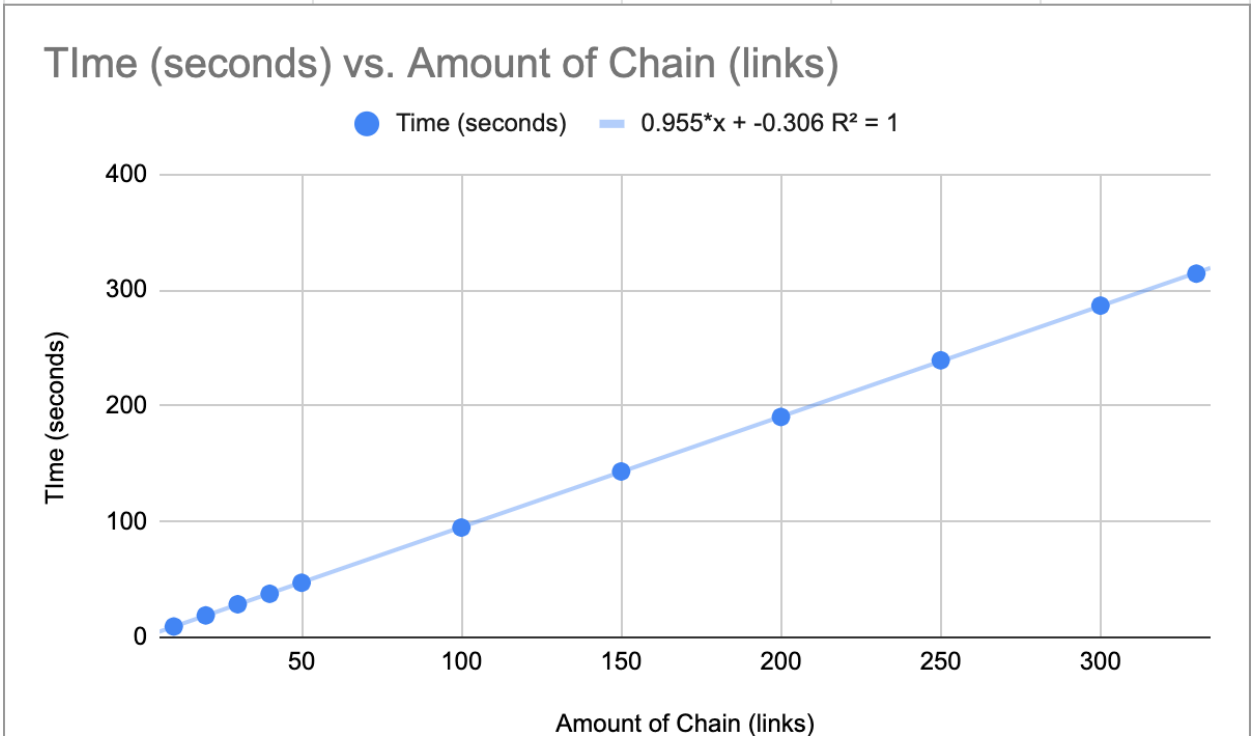
Stainless Steel (304 series) (.060")
escapement_skinny.dxf
Size: 33.676 x 56.431 mm

Escapement.F3D

Trials:

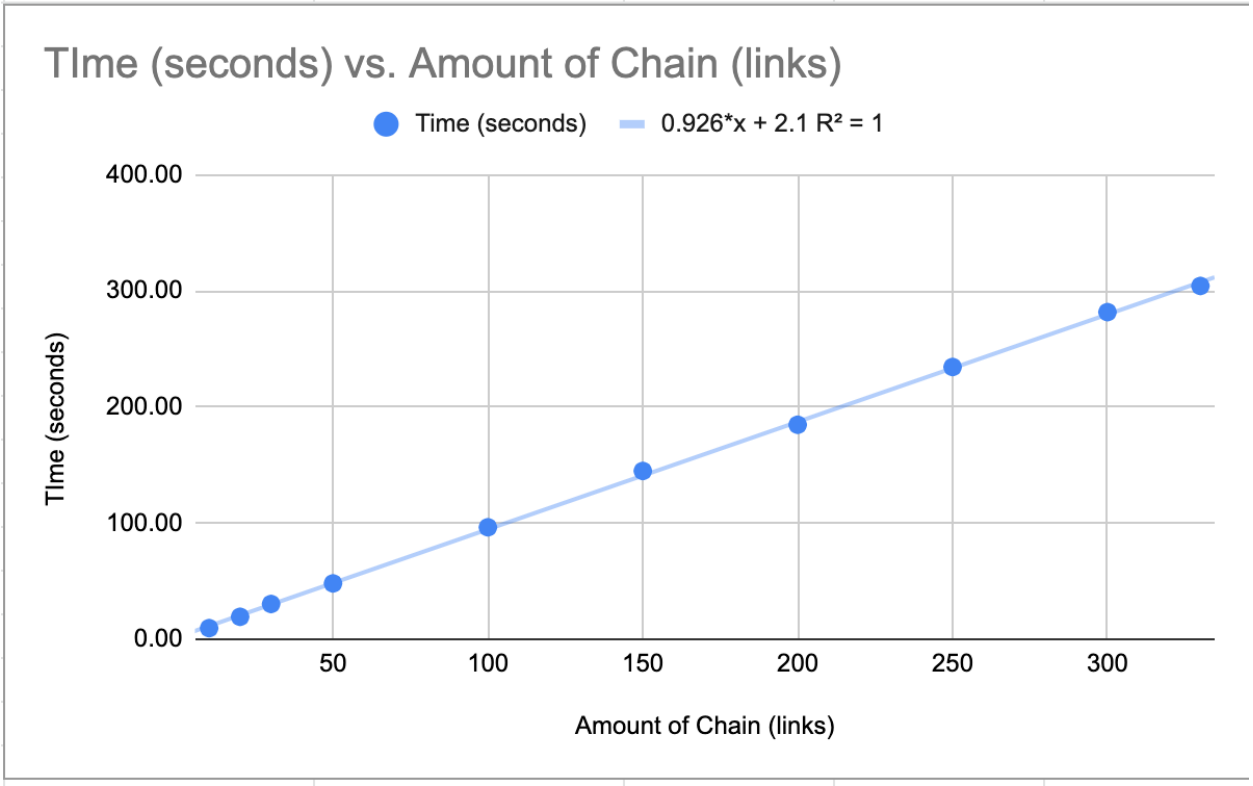
Data Set 1:

	Amount of Chain (links)	Time (seconds)		
	10	9.35		
	20	18.95		
	30	28.6		
	40	37.63		
	50	47.17		
	100	94.85		
	150	143.32		
	200	190.42		
	250	239.35		
	300	286.6		
	330	314.22		



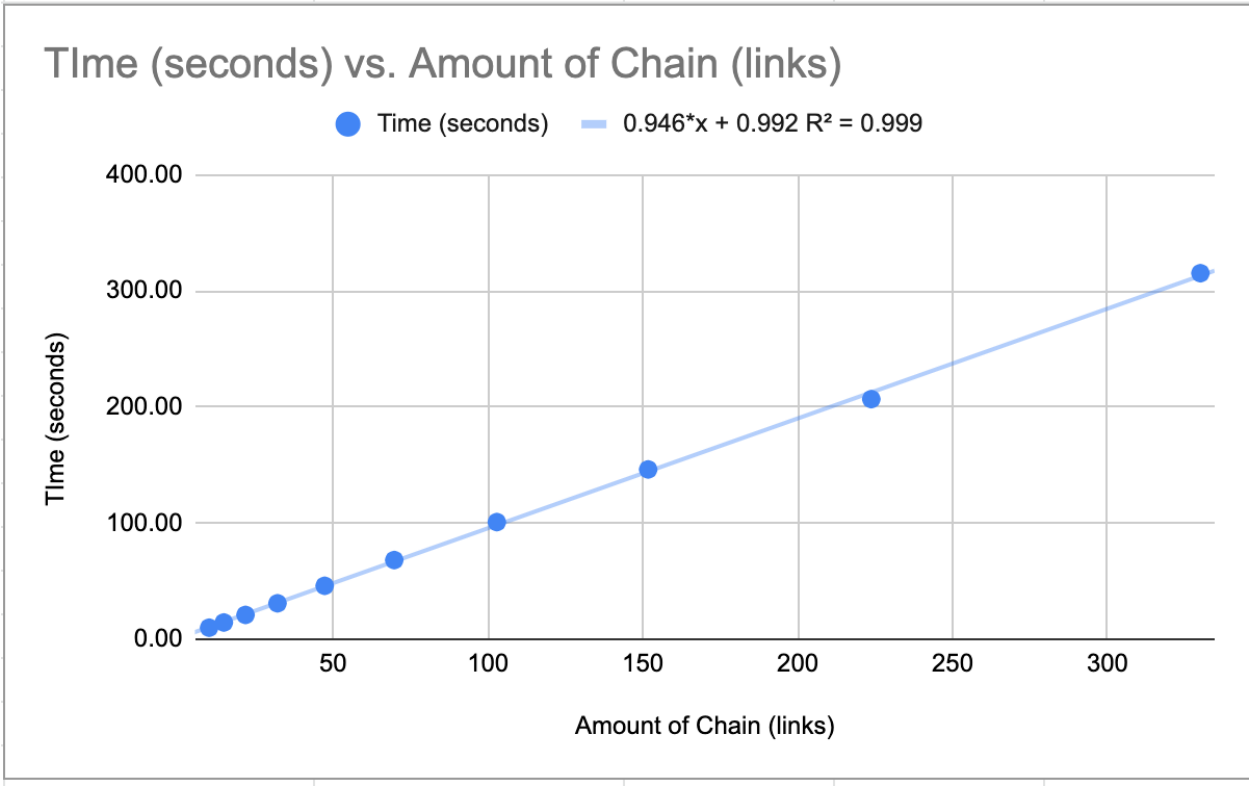
Data Set 2:

	Amount of Chain (links)	Time (seconds)		
	10	9.55		
	20	19.29		
	30	30.34		
	50	48.07		
	100	96.41		
	150	144.93		
	200	184.71		
	250	234.49		
	300	281.76		
	330	304.30		



Data Set 3:

	Amount of Chain (links)	Time (seconds)		
	10	9.90		
	15	14.39		
	22	20.93		
	32	30.93		
	47	46.00		
	70	68.16		
	103	100.89		
	152	146.24		
	224	206.81		
	330	315.29		



Data Set 4:

Amount of Chain (links)	Time (seconds)
10	9.89
30	29.04
50	48.77
80	78.14
115	110.78
150	144.18
220	211.23
250	238.45
290	277.24
315	302.26