TABLE 3'S ENERGY HARVESTER

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WHAT WAS ASKED FOR

- Collects mechanical energy from unused or wasted available resources
- Utilizes collected energy in a useful manner
- Design must be compelling whilst expressing creativity
- Withstand one week in Patrick Taylor Hall

FINAL DESIGN

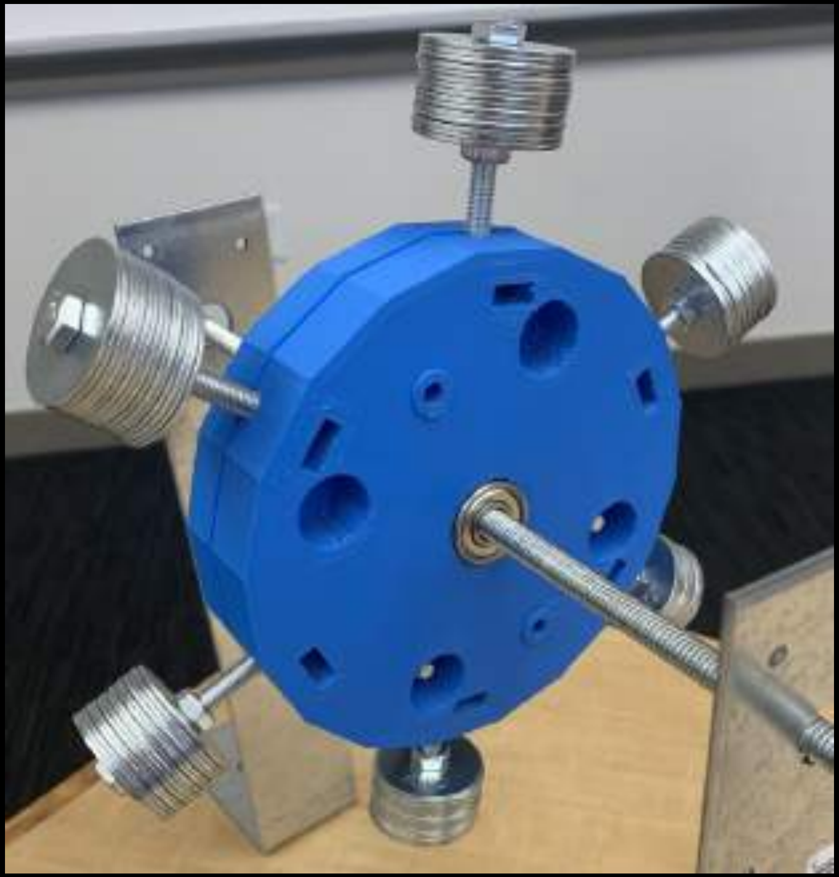
- Harvests energy from the opening of a door
- Blows air through door to increase room circulation
- Incorporates a flywheel and ratchet system to provide continuous air flow
- Adds little resistance for high convenience
- Attaches above the door to remain out of the way
- Features many custom parts to improve efficiency and convenience (like lower noise pollution)

RELEVANT PROBLEM

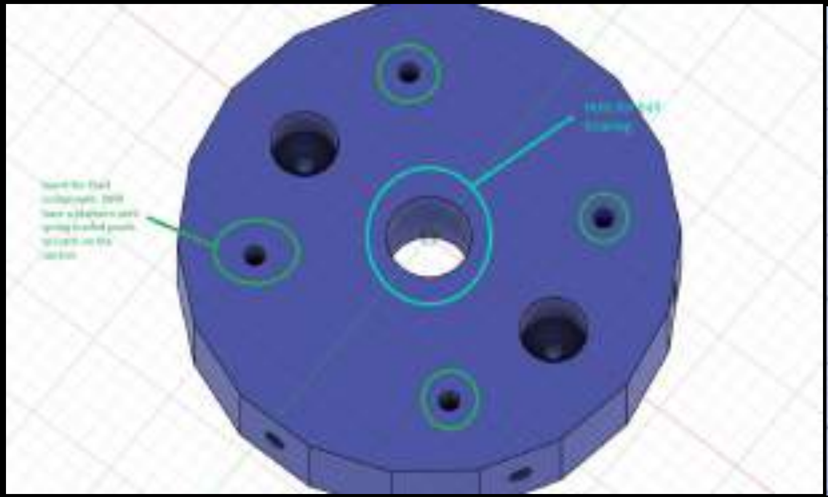
- This classroom is HOT!
- Not just student opinion…
  - “It's like 90 degrees in here.”
  - “Welcome to the greenhouse room.”

-Dr. Becnel

FLYWHEEL – THE "MECHANICAL BATTERY"



- Rotating mass that stores rotational kinetic energy (KEr)
- Also acts as a freewheel since it only rotates (with minimal resistance) in one direction
- Allows continuous airflow without continual input
- Mounted onto our central shaft with two ball bearings
- Uses washers, nuts, and bolts in order to add inertia



Key Features

Six masses each being 0.117 kg

Central bore for ball bearings

Front side with four 5mm inserts for pawl attatchment(s)

Back side with two 5mm inserts for pulley attatchment

DETERMINING MOMENT OF INERTIA

$$\Delta x = V_i t + \frac{1}{2} a t^2$$

$$\Downarrow \quad V_i = 0\,m/s$$

$$\frac{2\Delta x}{t^2} = a$$

$$\tau_{net} = F \times r$$

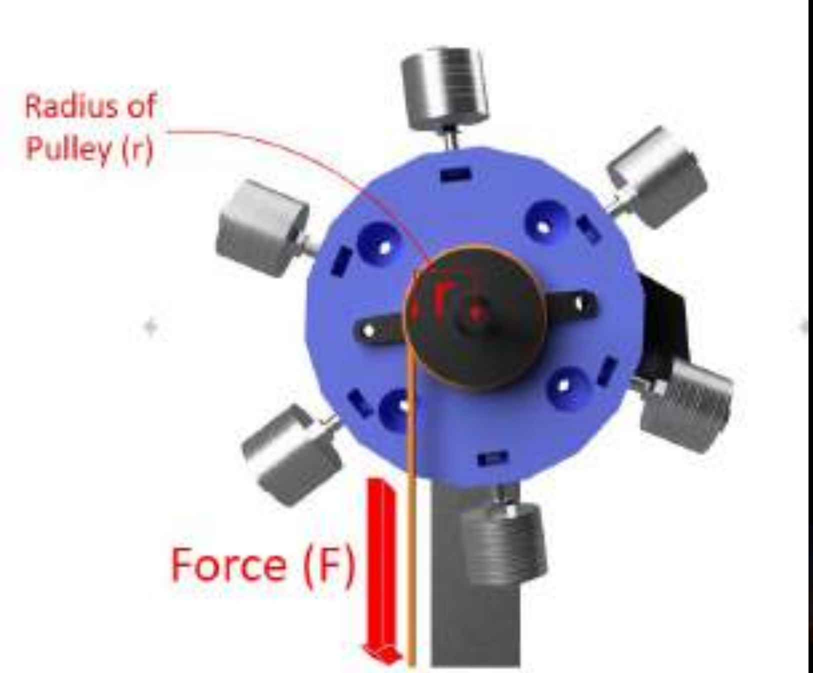
$$\tau_{net} = I \cdot \alpha$$

$$\alpha = \frac{a}{r}$$

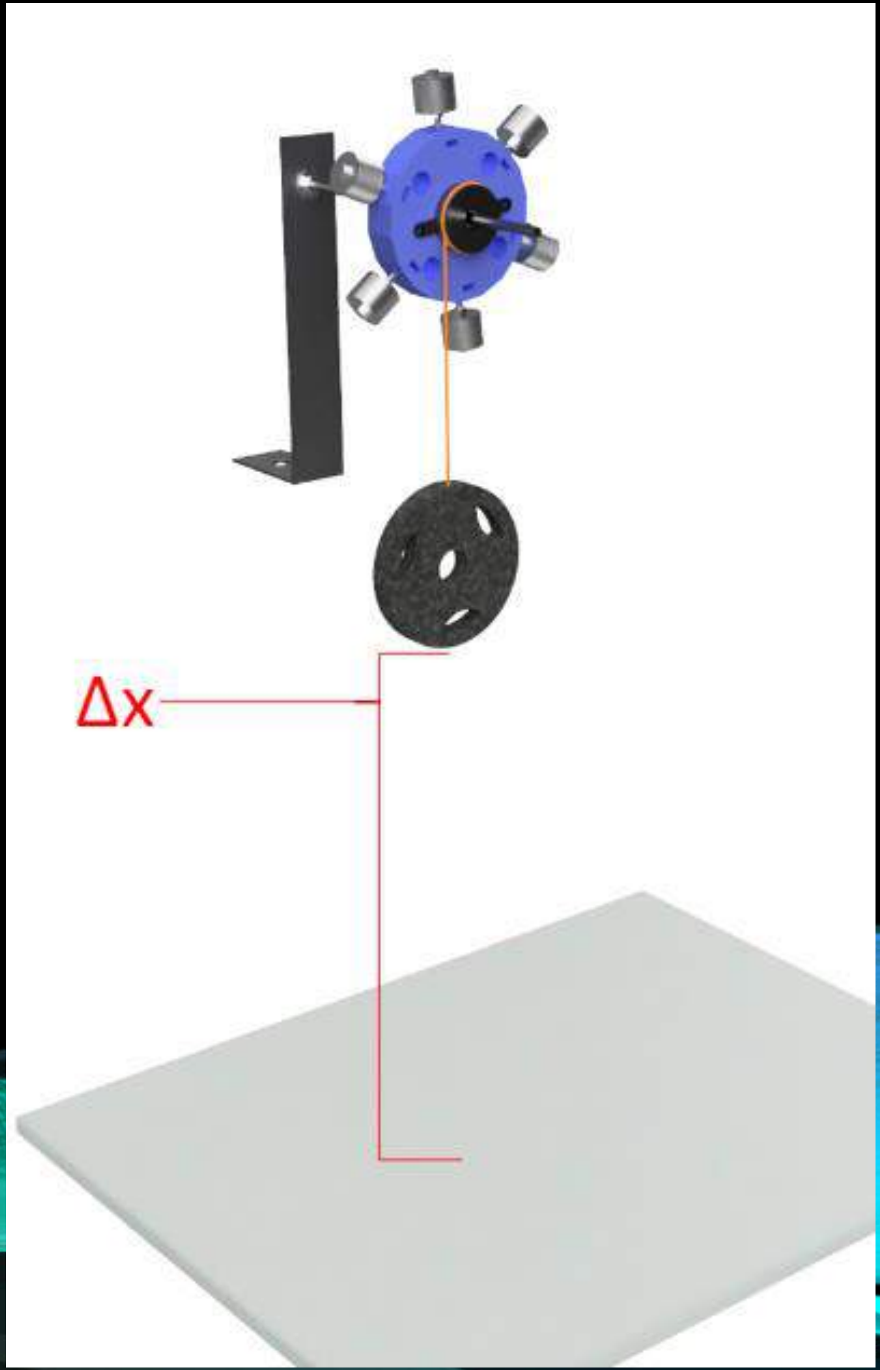
$$\Downarrow$$

$$\frac{Fr^2}{a} = I$$

- Moment of Inertia (I) was determined through a series of tests using principles of physics
- Uses an object with a known weight hanging at rest on a pulley with radius r
- Object falls a known distance
- Slow Motion camera used with a stopwatch to measure the time taken for the object to hit the ground
- Measured data used to find tangential acceleration and then the moment of inertia



Radius of
Pulley (r)
Force (F)



Δx

INERTIA TESTS

	Trial 1	Trial 2	Trial 3	Trial 4 (new height)
Height(m) (in)	0.584 m 23.0in	0.584 m 23.0in	0.584 m 23.0 in	0.321m 12 10/16in
Time(s)	1.03 s	1.07 s	1.06 s	0.74 s
Acceleration (m/s/s)	1.10 m/s/s	1.02 m/s/s	1.04 m/s/s	1.17 m/s/s
Inertia (kgm^2)	0.00452 kgm^2	0.00488 kgm^2	0.00479 kgm^2	0.00425 kgm^2

Object Weight
2.50 lb or 11.1 Newtons

Pulley Radius
0.0212m

Avg Inertia: 0.00461 kgm^2

$$\frac{|\text{measured} - \text{average}|}{\text{average}} \cdot 100$$

Trial 1 – 1.95%
Trial 2 – 5.86%
Trial 3 – 3.90%
Trial 4 – 7.81%

- All values of inertia are within 8% of the average
- 0.00461 kgm^2 is used as our value for inertia

ENERGY METRICS

- Door opened 21 times at beginning of class
- 7 Classes per Week
  - +Common study place for students

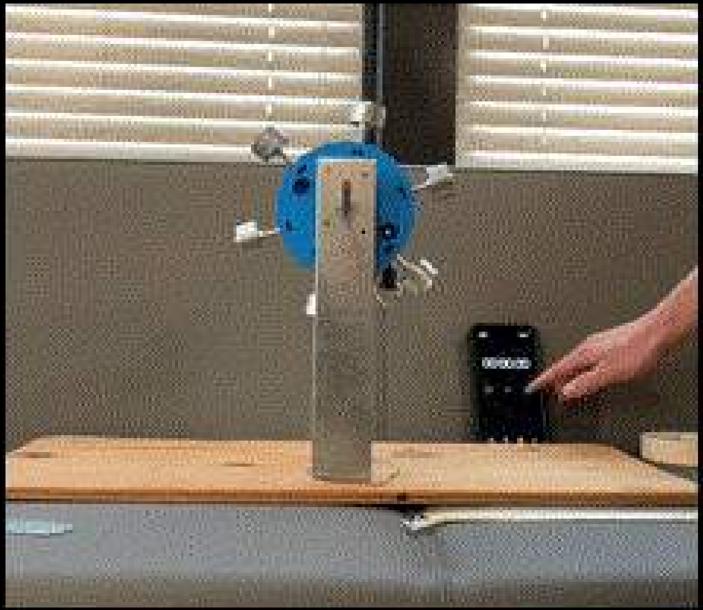
Weekly Energy Generated (Low Estimate)
7 Classes * 21 = 147 door opens per week
147 * 3.43J = 504 Joules per Week

- Estimate is low because it excludes data on # of door openings at end of class & students who come outside of class hours

Measured Variables
Spool Radius = 0.01585 meters
Moment of Inertia = 0.00461 kgm^2

Trials	1	2	3	4
Time (s)	1.42	1.40	1.34	1.39
Avg. Time = 1.39 seconds				
v=ωr	$\omega = {}^{v}/_{r}$	ω=38.6 rad/s		
$K_r = \frac{1}{2} I\omega^2$		K_r=3.43J		

Spool pulled 33 ¼ in, the estimated draw distance from observations



ENERGY STORAGE

- A slow motion video and stopwatch were used to determine angular velocity
- Video analyzed on a frame-by-frame basis to determine time taken to rotate one full rotation (2π radians)
- Angular velocity measured when the spool finishes driving the flywheel (start), one quarter the total time of rotation, one half, and three quarters through

	Start	1/4	1/2	3/4	End
Test 1	28.6 rad/s	26.2 rad/s	18.0 rad/s	9.50 rad/s	0 rad/s
Test 2	48.3 rad/s	31.4 rad/s	24.2 rad/s	11.2 rad/s	0 rad/s
Test 3	27.3 rad/s	19.6 rad/s	16.1 rad/s	11.4 rad/s	0 rad/s
Test 4	44.9 rad/s	37.0 rad/s	22.4 rad/s	11.6 rad/s	0 rad/s

$$K_r = \frac{1}{2} I \omega^2$$

	Start	1/4	1/2	3/4	End
Test 1	1.88 J	1.57 J	0.742 J	0.209 J	0 J
Test 2	5.38 J	2.27 J	1.35 J	0.290 J	0 J
Test 3	1.72 J	0.889 J	0.598 J	0.301 J	0 J
Test 4	4.64 J	3.15 J	1.16 J	0.312 J	0 J

TRENDS

- The speed and therefore energy stored decrease over time as expected due to friction and work done on the pawl spring by the flywheel
- Starting angular velocities between tests were different but ended up closer and closer the longer time went on
- Data can be improved by using a known pulling force every trial and a more precise stopwatch/camera

RATCHETING

Spool Rotates Clockwise (Engages)

- Occurs when the spool rope is pulled (door opens)
- The driver ratchet makes contact with the pawl and the pawl locks up and causes the flywheel to rotate
- The driving motion will cause the flywheel to accelerate clockwise until the spool disengages

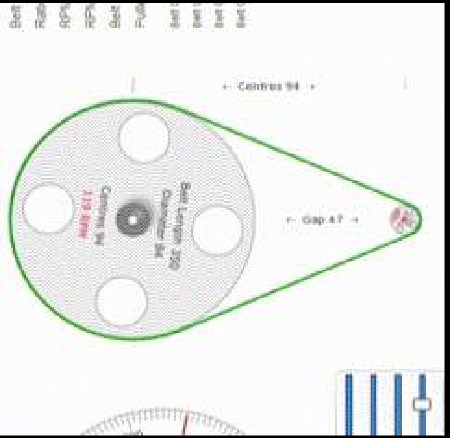
Spool Rotates Counter-Clockwise (Disengages)

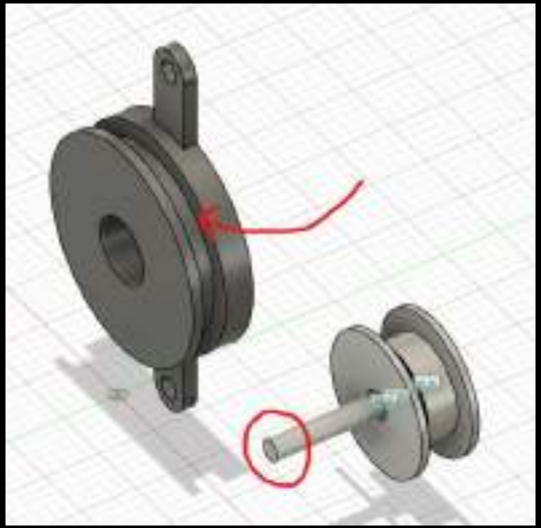
- Happens when the spool rope is retracted (door closes)
- The ratchet teeth slide under the pawl and move it out the way
- The pawl is moved back into place via a spring
- The flywheel will have little to no counterclockwise forces from the ratchet

Ratcheting In Action

PULLEY AND FAN

- As the flywheel spins, a rubber band spins the fan's pulley.
- Direct connection between the fan and the pulley by a taut rubber band
- Pulley Ratio (Driven/Driver): 1/8.47 (5mm/42.3mm)





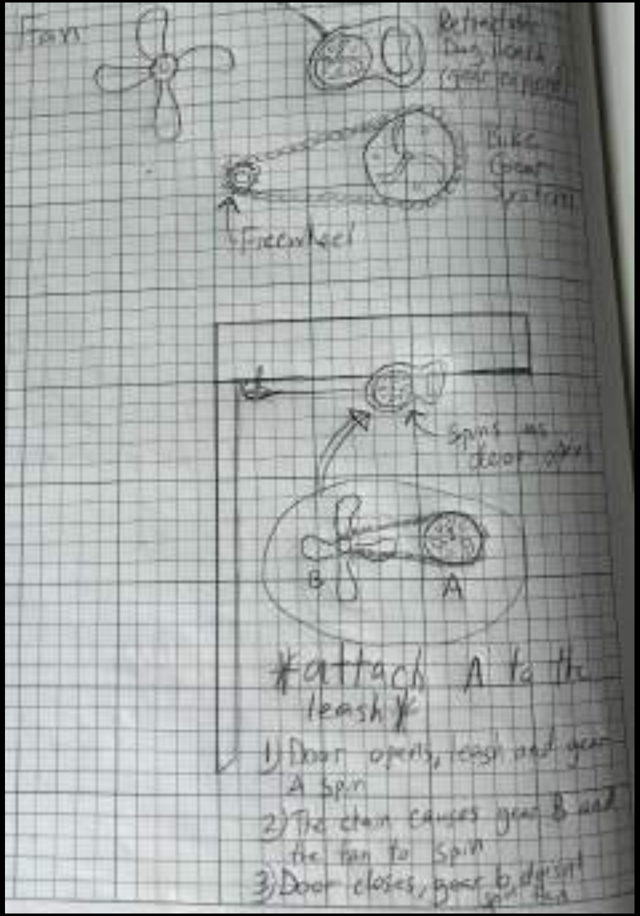
MOUNTING / LONGEVITY

Ideally, the steel angles would be bolted directly into the doorframe in order to ensure complete rigidity and strength.

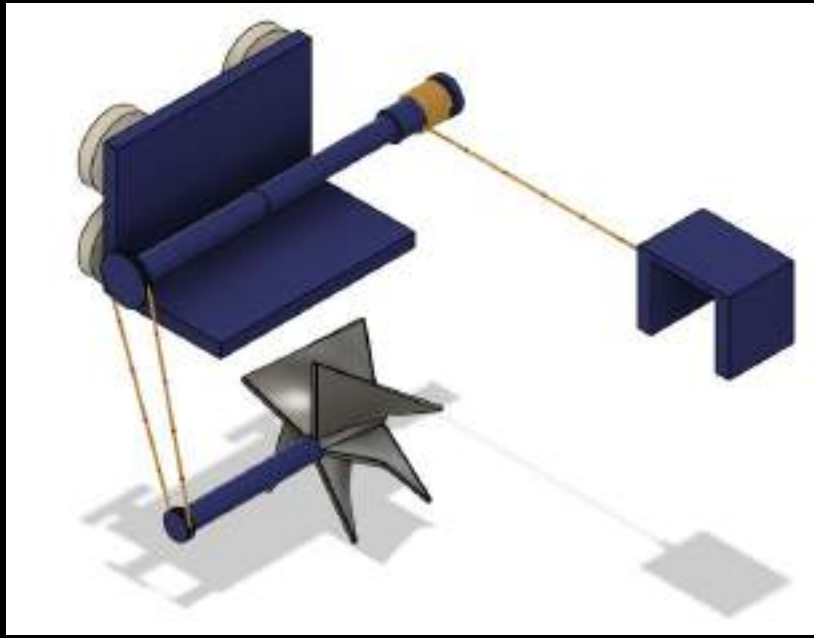
For testing purposes, we used ratcheting clamps to secure the angles to the surface

As the device would withstand torque and vibrations, nuts were fastened with plumbers tape and tightened with a wrench

ITERATIONS



Design that would have used a bike chain and gears in order to spin the fan



Design that attached outside of room & didn't use a ratchet system or flywheel

Original concept also used large suction cups to attach device above door

BILL OF MATERIALS

Bill Of Materials:

Material	Where	Cost per unit	Quantity	Total
Assorted Springs	Harbor Freight	$4.49	1	$4.49
Assorted Nuts/Bolts	Harbor Freight	$5.49	1	$5.49
Dog Leash	Harbor Freight	$5.99	1	$5.99
100 count 1/4in – 1 1/4in Fender Washers	Home Depot	$14.95	1	$14.95
Pawl	3d Printer	$2.04	1	$2.04
Pawl Holder	3d printer	$9.30	1	$9.30
Quick Setting Epoxy	Harbor Freight	$1.79	1	$1.79
Simpson Strong-Tie 3-5/8-inch x 11in x 2in	Home Depot	$7.28	2	$14.56
Everbilt 5/16in 1-foot threaded rod	Home Depot	$1.93	1	$1.93
Everbilt 5/16in Nuts Washers and Lock Washers	Home Depot	$4.57	1	$4.57
Large Pulley Attachment	3d Printer	$10.20	1	$10.20
Fly Wheel	3d Printer	$5.65	1	$5.65
Three Toothed Ratchet	3d Printer	$15.90	1	$15.90
			Total Cost	$96.86

End