Mike's Engineering Design Notebook

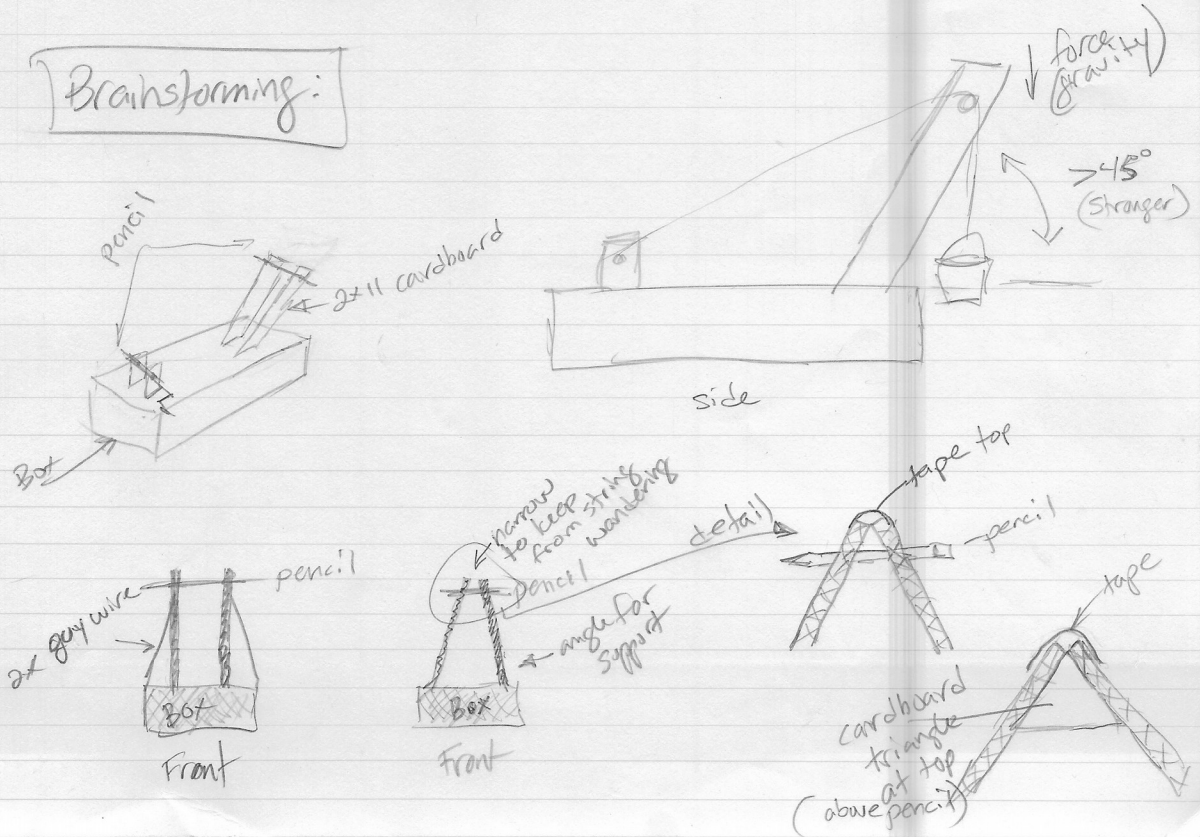
Heavy Lifting

Problem: To design and build a crane that will lift as heavy of a load as possible

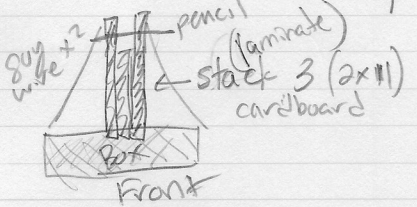
Constraints: materials - cardboard box
3 strips of corrugated cardboard 2"×11"
paper clip
paper cup
3 sharpened pencils
scissors
string
tape
weights

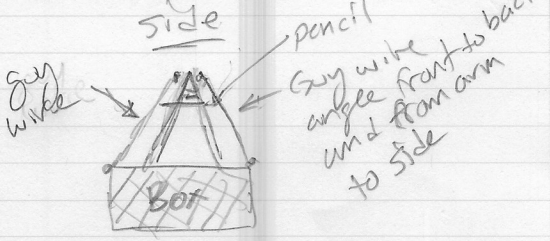
time - one hour

Brainstorming:



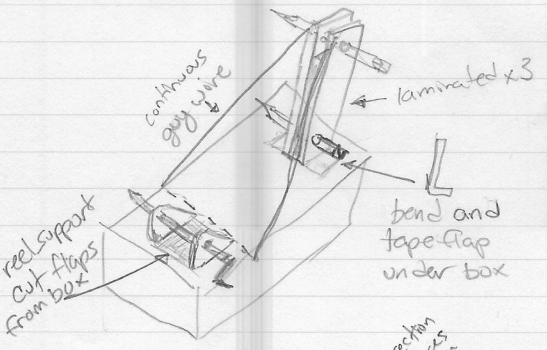
Brainstorming Cont.

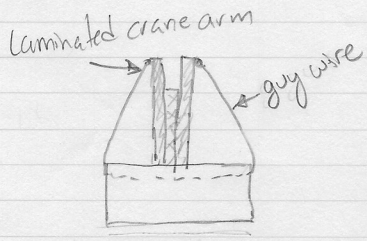


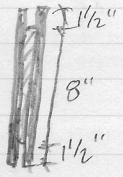


Design

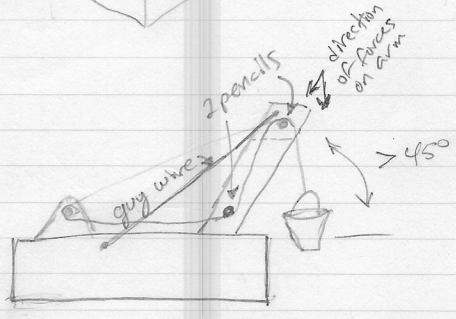
- Laminate arm (3)
- crane arm angle > 45°
- reel support angled base
- Guy wires angled front to back and side to side (continuous from crane arm through box and back up to crane arm)







laminate 3 layers



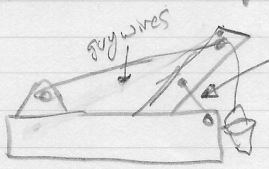
Build

- Laminate 3 - 2"x11" cardboard strips (tape together) cut center strip to 9" long.
- Find center (lengthwise) of box, measure out reel supports
- Cut out reel supports and insert pencil ¢ = 1"
- Measure and cut out crane arm hole in box, insert crane arm and mark angle on crane arm under box.
- Cut angled flaps at bottom of crane arm, insert arm into box, fold flaps outward and tape (see photo)
- Measure and cut hole for pencils (2-pullies)

oops! Realized a pulley system won't work because with the laminations, there is no room for the string to travel between the top pulley and bottom pulley of the crane arm.

Redesign #1

remove lower pulley and re-locate guy wires to oppose force on crane arm



- Remove lower pulley
- measure and locate guy wires, tie guy wires
- make bucket out of paper cup and string, fashion hook
- measure and tie crane main line

Test #1

100grams - no problems

200g - while reeling in (raising bucket) there is some deformation on top of box

250g - same result as 200g, at this weight it wants to unwind the reel a little

300g - rear of shoe box lifts 1/4" off table, otherwise slight deformation on top of box and noticable movement in crane arm when raising or lowering bucket. At this weight the reel will unwind on its own.

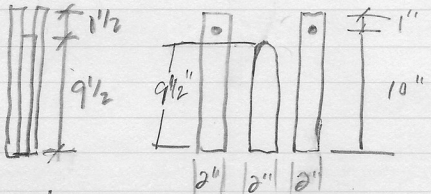
350g - if bucket is below table then box will tilt forward, otherwise same as 300g test.

370g - bucket with weight swung to one side causing crane arm to colapse (see photo) once the cardboard has folded it will not support weight

Observation - crane arm folded at unused lower hole at lower pulley hole from orginal design.

Redesign #2

Change laminated construction, eliminate 1 1/2" space at the bottom and round center piece at the top. to eliminate interferance with string. Remove lower hole.



laminated

(3 layers)

Test #2

200g – similar to test #1

300g – similar to test #1

350g – similar to test #1

400g – considerable movement, front to back, of crane arm from rest to lifting weight, weakened crane arm connection to box

450g – able to lift 450g but could hear tape tearing from underneath box securing crane arm.
2nd try at 450g tore tape off bottom dropping crane arm.

Notes: keep bucket from swinging
do not drop weight into bucket
guide wire tension must be equal, maybe tape to keep from moving

Photos of Mike’s Carne

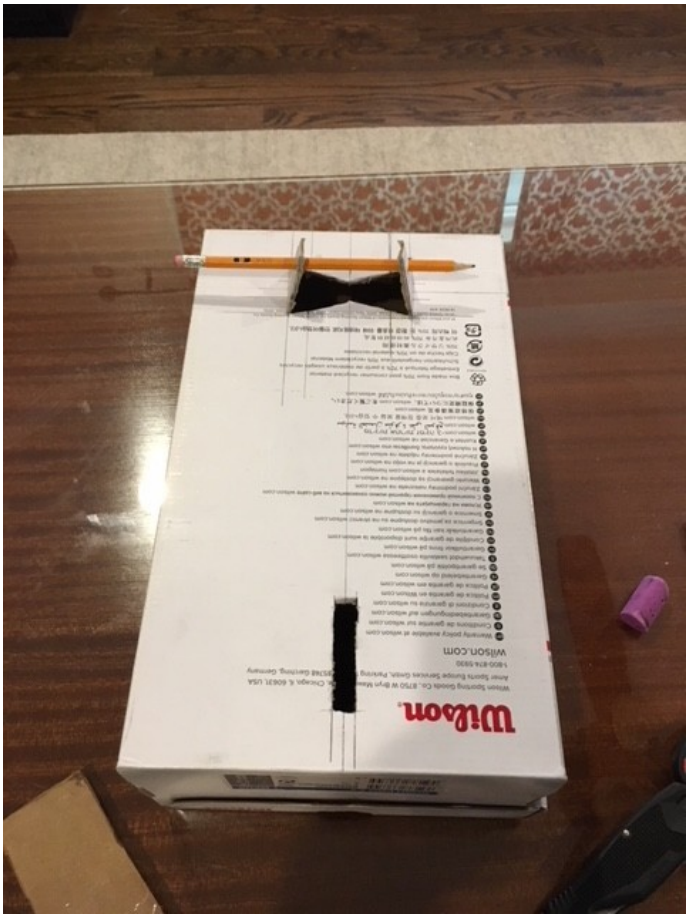
Materials

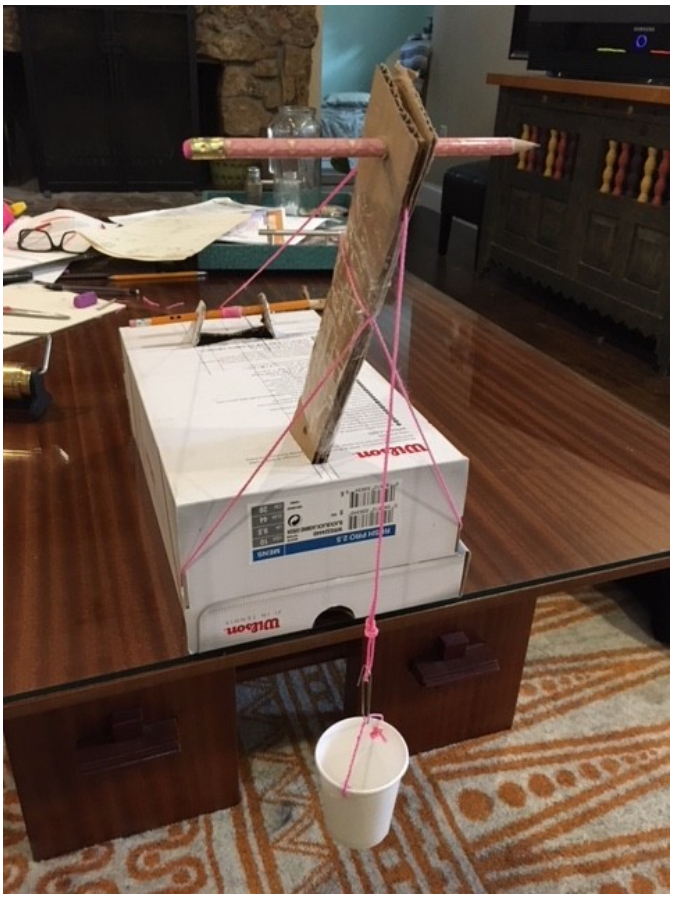
1st Test with hole in lower crane arm.

Re-design crane arm, removed lower hole (week point).

Cut outs for reel supports and crane arm.


HEAVY LIFTING


Wilson
Wilson.COM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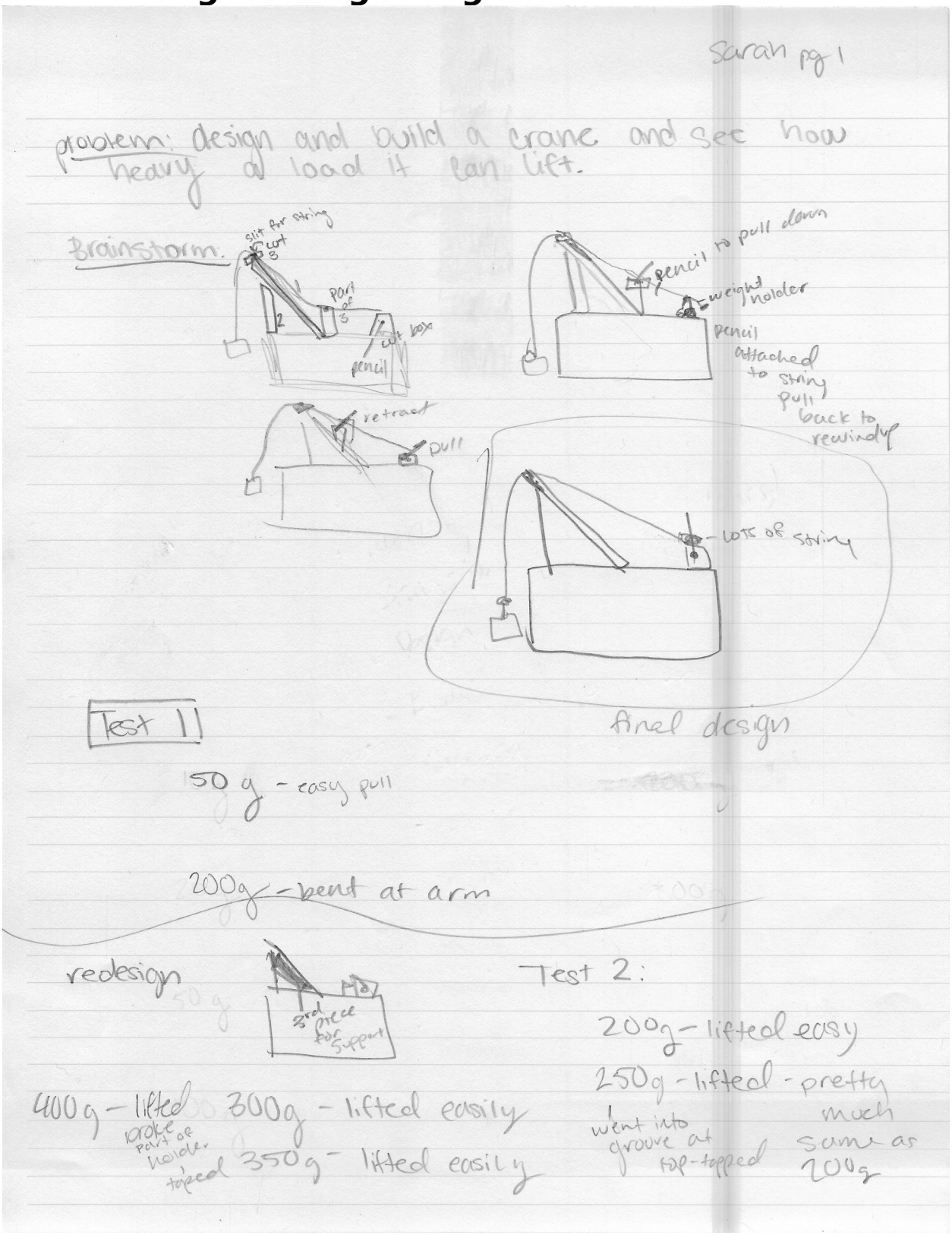
Final Test

Sarah's Engineering Design Notebook



450g - lifted easily no issues
went down on own

500g - lifted easily

550g - lifted

600g - real holder started coming off
still went up and down

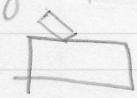
600g test 2 - everything stayed in place

- box's edges lifted
- tape at down
- arm top tape came off

650g - lifted - harder to pull but still went up

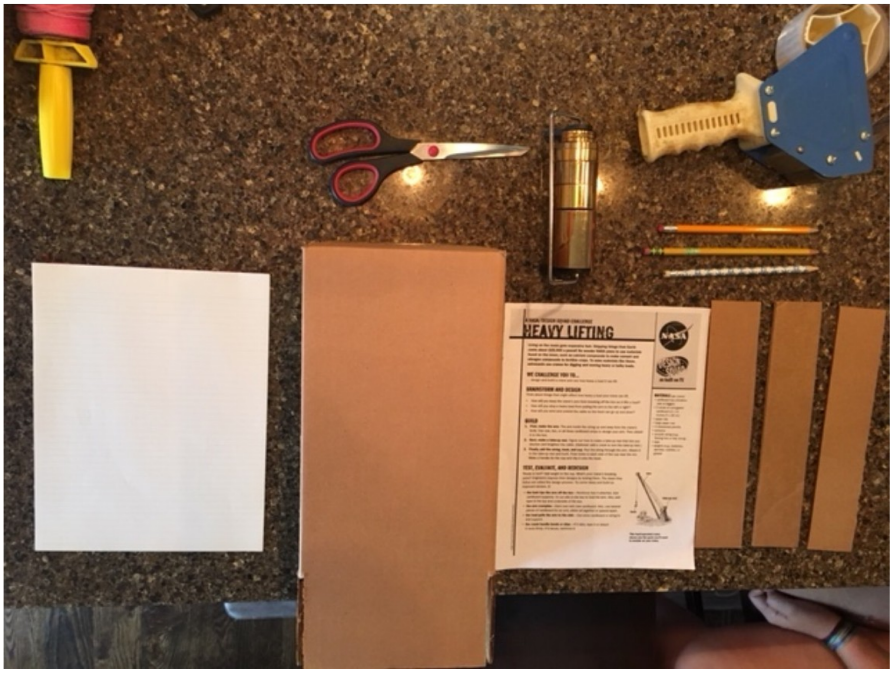
700g - top arm bent - tape at real loosened

If the cardboard is facing the same direction of the box then there is more of a chance of it bending than if it is



perpendicular

Photos of Sarah’s Carne



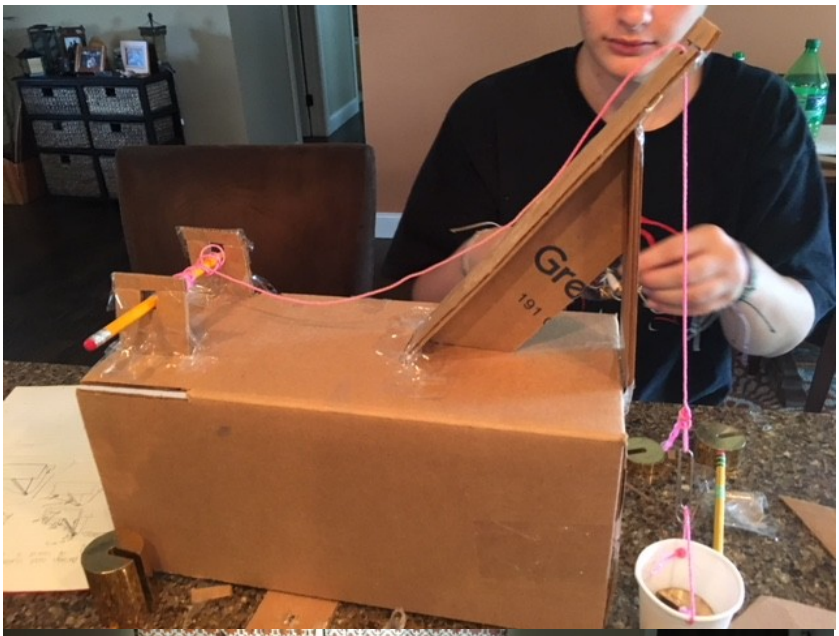
Re-design and Re-build

Materials

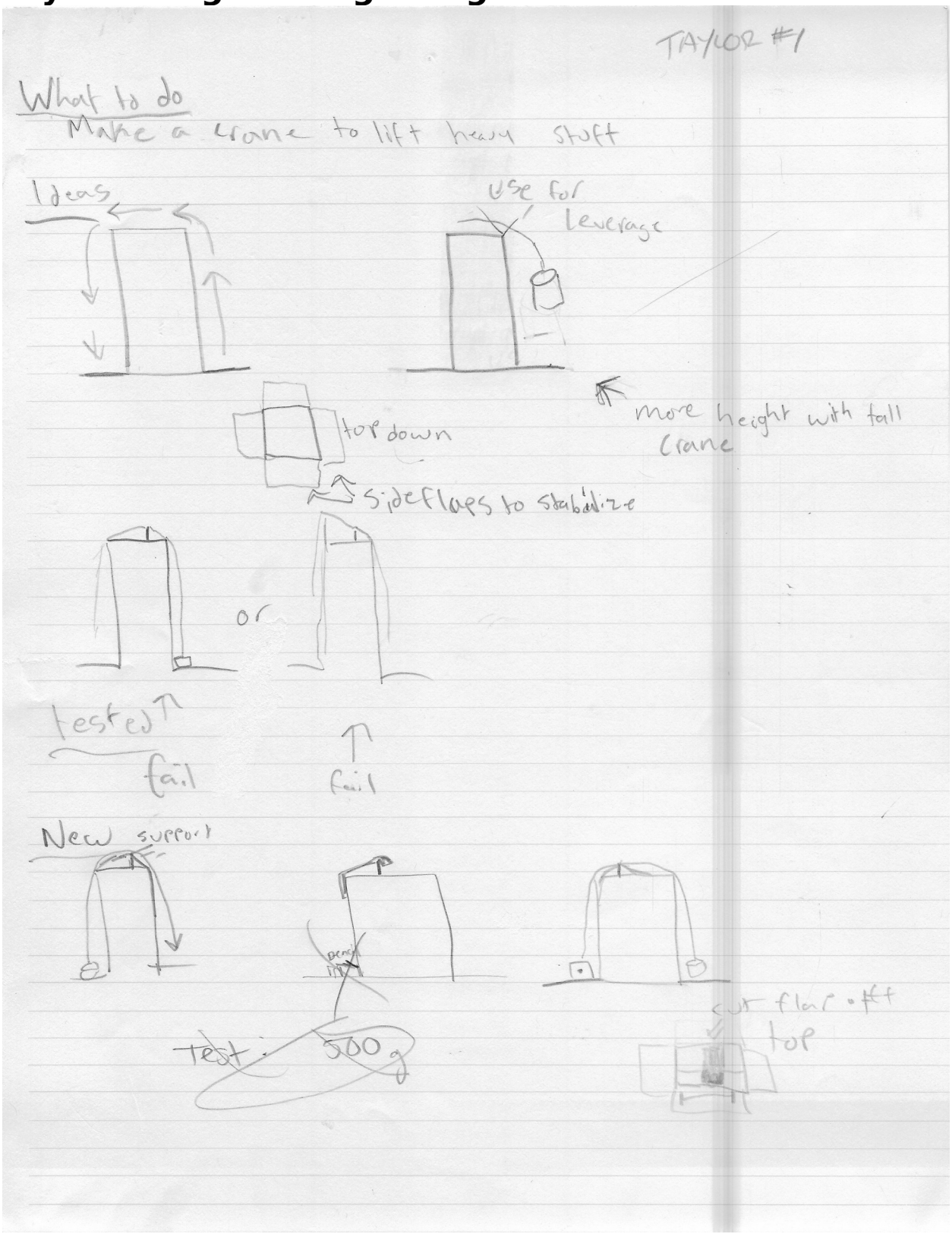
Final Test

1st Test

Support Failure



Taylor’s Engineering Design Notebook



TAYLOR #2

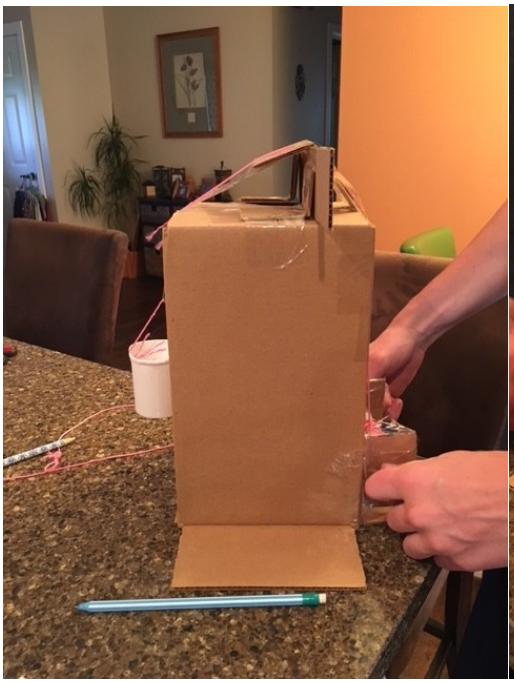
Test 2:

100g - easily went up
200g - " " "
300g - " " "
400g - " " "
500g - " " " tape loosened a little
600g - " " "
700g - A little struggle went up
800g - went up very slowly tape peeling
FAIL — 900g - very slowly - handle broke - half way up

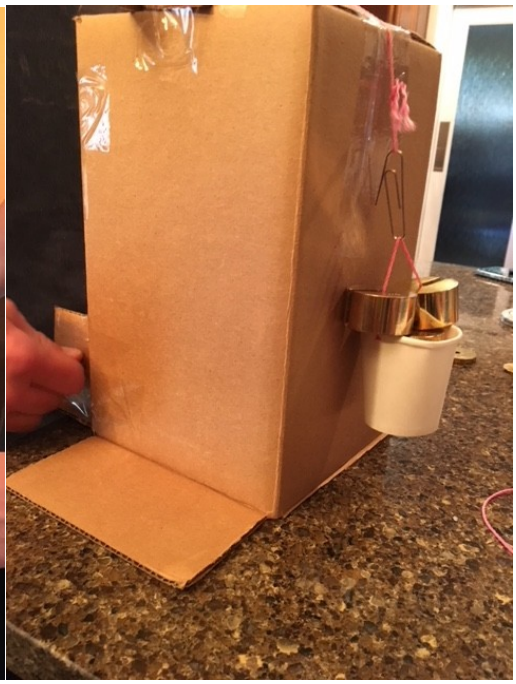
Having the box standing vertical made it so the string had four contact points, relieving pressure off of single parts that would've made the crane fail. The pencil spooling the string needed more support to the box to be able to bring more weight up.

Photos of Taylors's Carne

Materials



1st Test



Final Test (re-design not needed)