Portable Cooling Box

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The Problem

There is a dire need in the world for sustainable cooling devices, specifically for the use of cooling vaccines in hot locations during transport.

The Initial Design

- Peltier models discarded as the intended cooling range was too low
- Decided on a scaled down refrigerator system
- Mini refrigerator was the obvious system need

Group Brainstorming

- Backpack to carry components
- Wall current and Car Adapter
- Rechargeable Batteries
- Insulation! Polyurethane
- Who→ World Health Org. & Red Cross
- Small Simple Technology (gutting mini-fridge components)
- Major Components: AC wall current to compressor unit, Direct DC current to inverter to compressor unit, Battery DC current to inverter to compressor

The Product

- Cool contents of a small refrigeration unit to a cool zone
- Our goals: cooling range (-1<>+3)°C
- Shelf backpack system
- Moderately heavy backpack unit in a range of 60-75 lbs
- Able to freeze vaccines that need to be frozen
- Sturdy design

Compression Cooling

- Works by compressing a fluid or gas and than expanding it in a separate chamber.
- When the substance decompresses the temperature drops.
- Most popular way to cool.
- It uses battery energy to power standard refrigeration components here.

Insulation

- Polyurethane
- Compared to fiberglass, 4 times the r-value per inch
- Fiberglass near 2.1/inch
- Urethane products near 9/inch some are even in the teen ranges
- R value indicates the tendency for hot or cold air to move through the material as it wants to according to the second law of thermodynamics
- The higher the R value the slower this happens

Electricity

- DC is optimum for short distance transportation, but AC is optimal for long distance transport
- Inductive motor on the compressor unit takes large amperage draw initially and then drops to 1.2 amps also a large wattage draw.
- Inverters take DC current from a standard battery 12V and convert it to a usable AC power source. Most inverters, however; output a modified sine wave.
- Some appliances don't operate with this current such as certain motors, laptops, and newer devices that have intricate parts
- Radio equipment often does and the inefficiency in the frequency and the wave will output a background hum in the speakers, because the stereos often do not have the filtration system to get rid of the 'dirty current'

Electricity cont.

- Batteries are rated in amp hours
- Deep cycle batteries are the best for our objective because of the deep discharge and thicker plates
- Putting a fair amount of money into the batteries and a pure sine wave inverter is expected
- An amp is one volt of current over one ohm of resistance

Quantitative Details

- Cool a box 6inx6inx3in to 2 degrees Celsius or lower.
- Weight no more than 30-35kg or 65 to 70 lbs
- Estimated cost, depending on battery type and components purchased 300-700 $.
- Operation for 24 hrs using battery power
- Estimated power need is around 60 amp hrs
- If constant running of a 1.2 amp compressor motor at 120 volts AC using an inverter with DC batteries requires about 14 amp hours of battery life, we know the conversion for AC amps to DC amps is roughly 1 AC amp to ten DC amps.
- TESTING WILL BE IMPORTANT AS LOSS OF POWER IS A FACTOR THAT COMES INTO PLAY AND IS VERY DIFFICULT TO ATTAIN MATHEMATICALLY

Qualitative Details

- Battery operation of cooling devices (compressor) and possible cooling fan for the outside compression coils
- Keeps vaccines from spoiling in hot climates (within the cooling range)
- Operate with sustainable energy and other non-renewable sources like wall current at the red cross
- Compartment for vaccines padded or small as to prevent breakage during transport
- Supportive backpacking frame with heaviest item (battery) at the bottom
- Weight without battery ~30lbs
- Technology isn't there yet for a light battery with a large output capacity~100 amp hrs

The Customer

- Large relief groups like the Red Cross who distribute vaccinations
- Corporate monsters to small hospital units this target group is quite large
- Purchasing desire due to effective sustainable method brought fourth otherwise not available
- The technology is designed for use “in the field”, i.e. away from traditional infrastructure.

Benefits

- Addresses a huge global issue
- Additionally with the issue of hurricanes close to home this technology is appropriate for diabetics as their insulin needs to be kept cold.

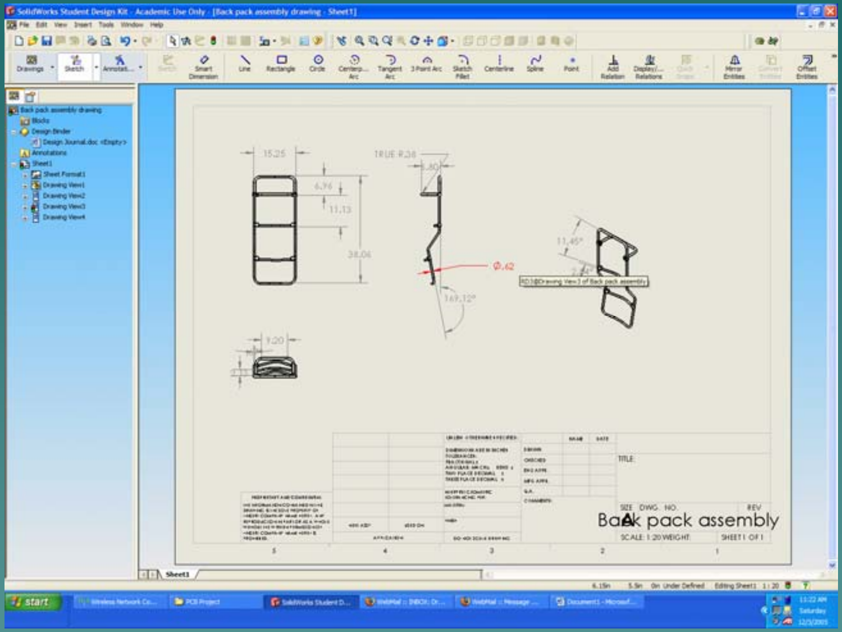
Complications

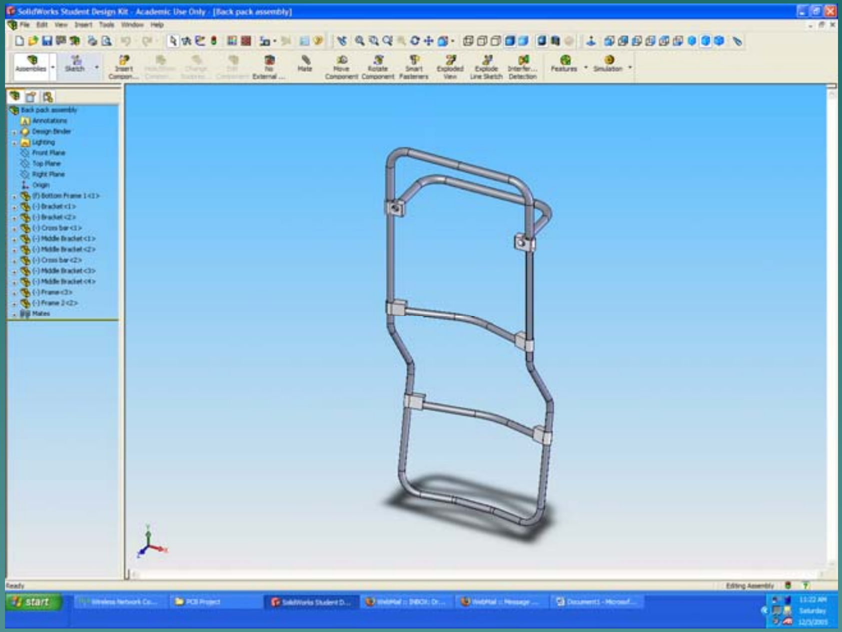
- Batteries ‘decay’ over time and eventually will need replacing
- Difficult getting a light battery as larger batteries have more output but with heavier weight
- Getting it built to specs with enough time to test and tweak
- Staying in budget
- REACHING THE GOAL efficient manufacturing
- Getting the necessary materials: powerful lightweight batteries are on the order of hundreds of dollars.

Our Design

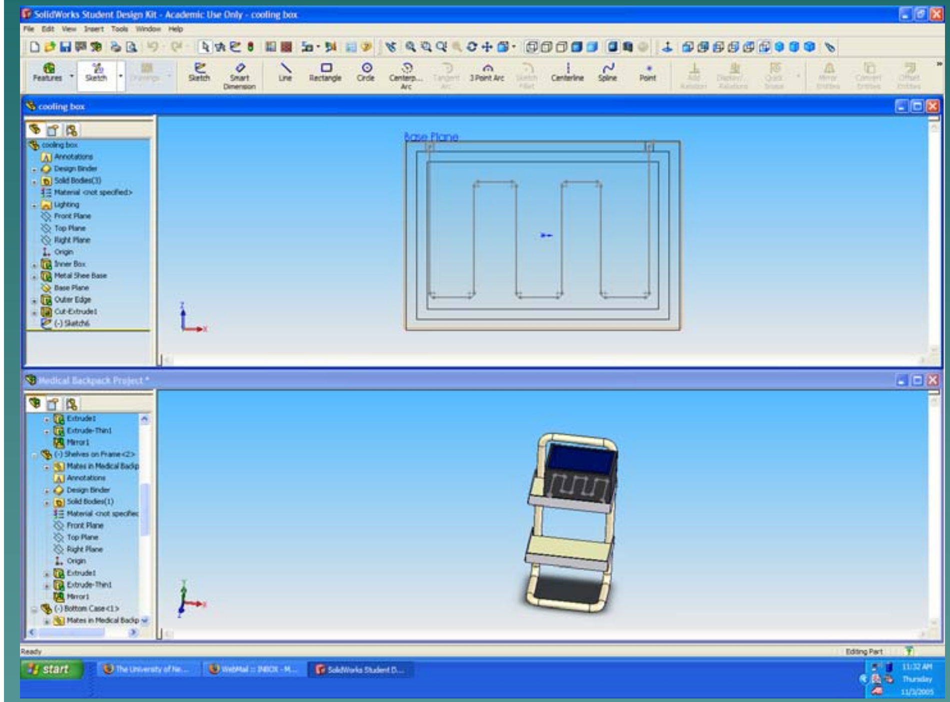
- Batteries for use during transport
- Charging capability when not in use
- Sensor that shuts the motor on and off
- Small cooling area
- Elaborations...

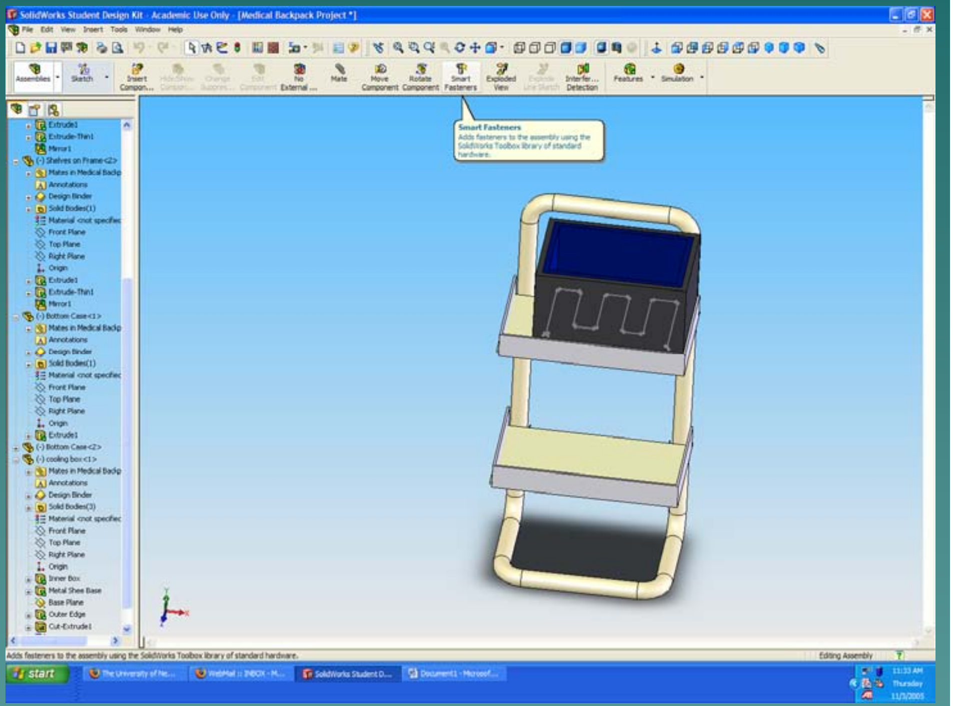
Our Design


SolidWorks Student Design Kit - Academic Use Only - [Back pack assembly drawing - Sheet1]
Back pack assembly


SolidWorks Student Design Kit - Academic Use Only - [Back pack assembly]

Our Design





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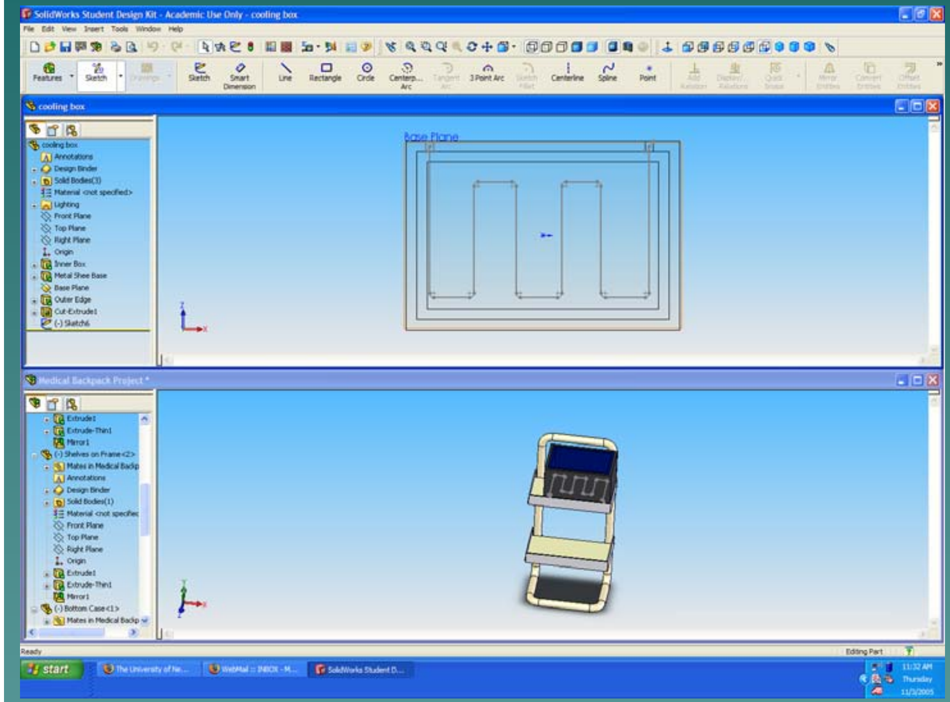
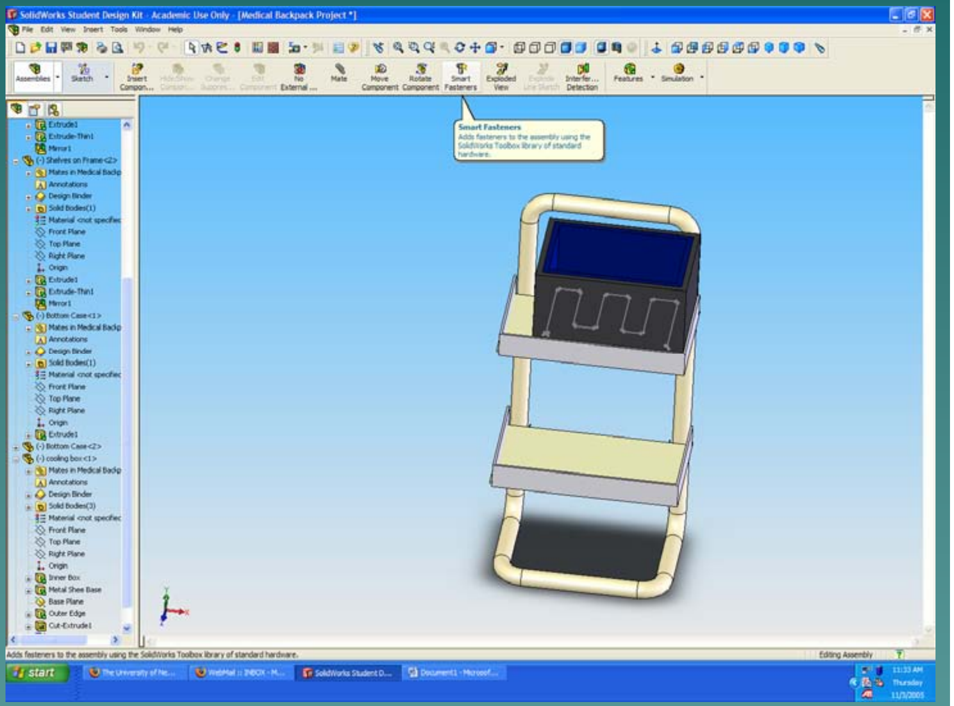
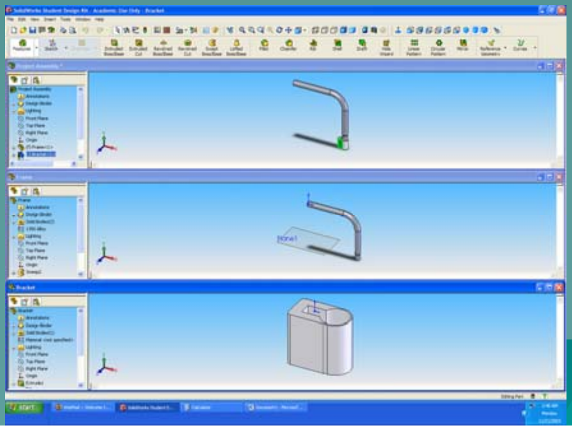

SolidWorks Student Design Kit - Academic Use Only - cooling box
cooling box
Base Plane
Medical Backpack Project *


SolidWorks Student Design Kit - Academic Use Only - [Medical Backpack Project *]
Smart Fasteners
Adds fasteners to the assembly using the SolidWorks Toolbox library of standard hardware.



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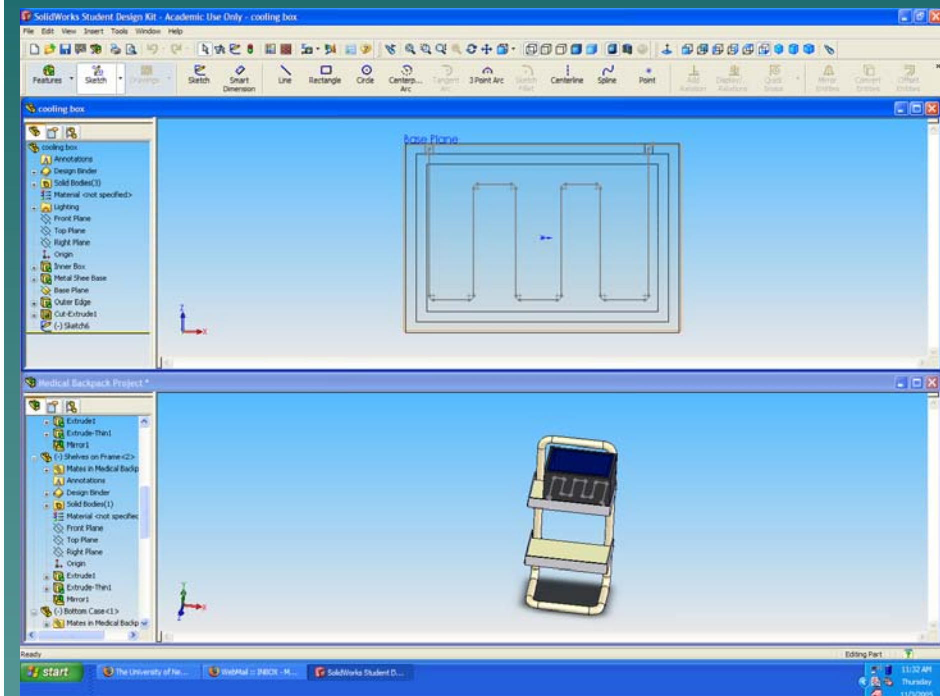
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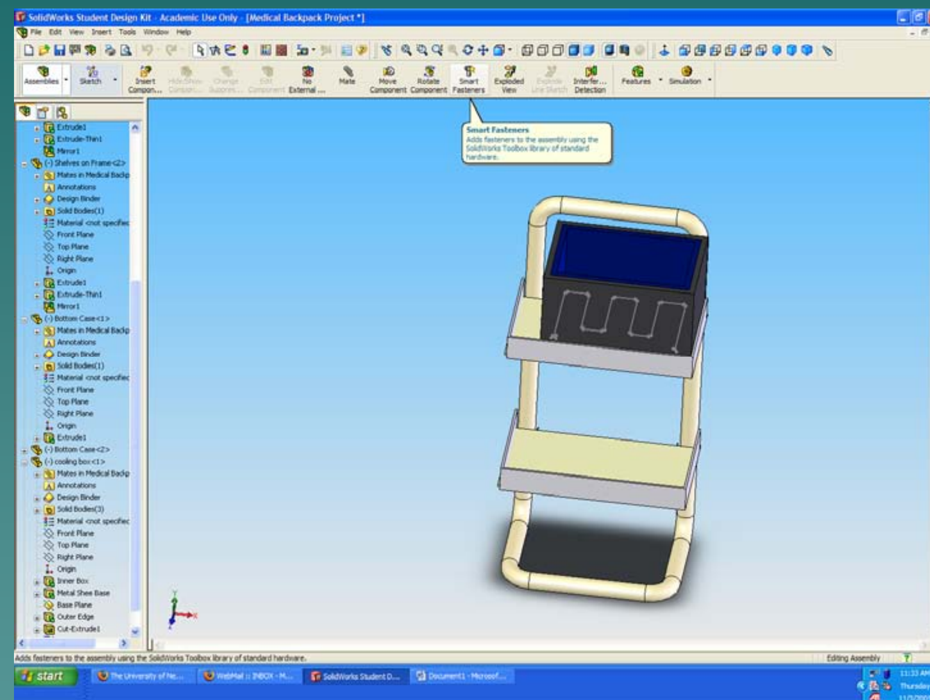
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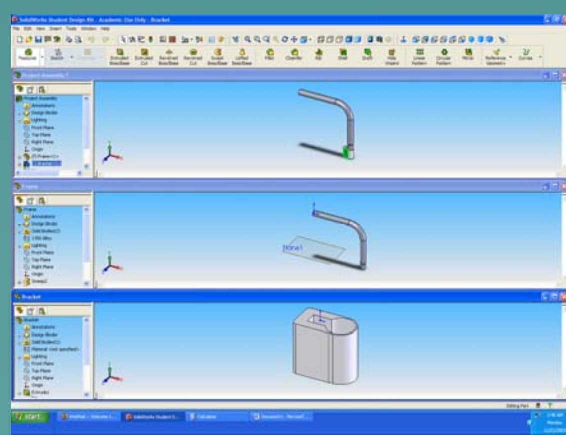

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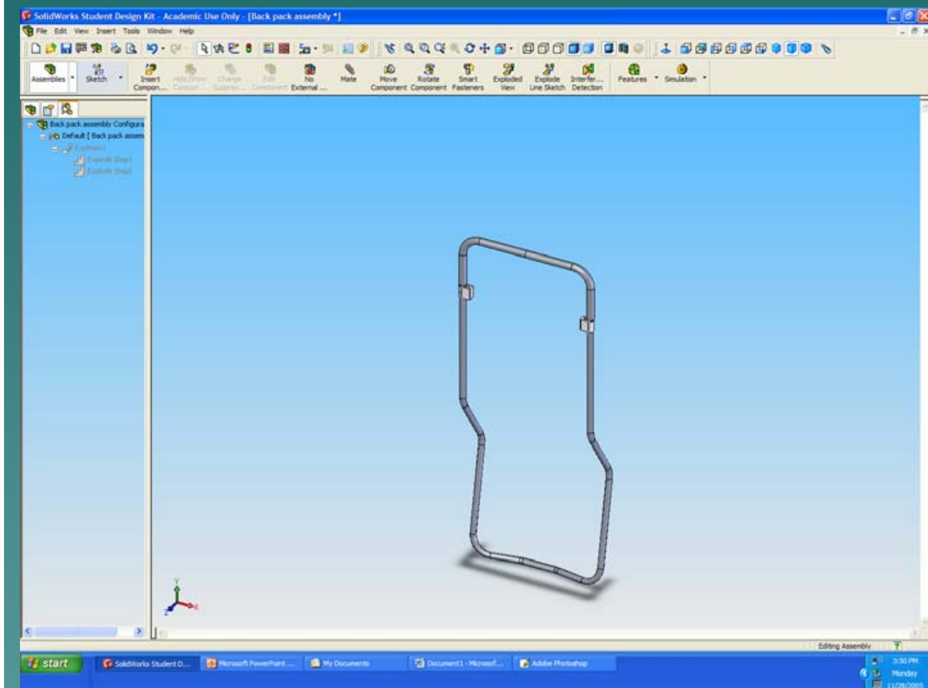
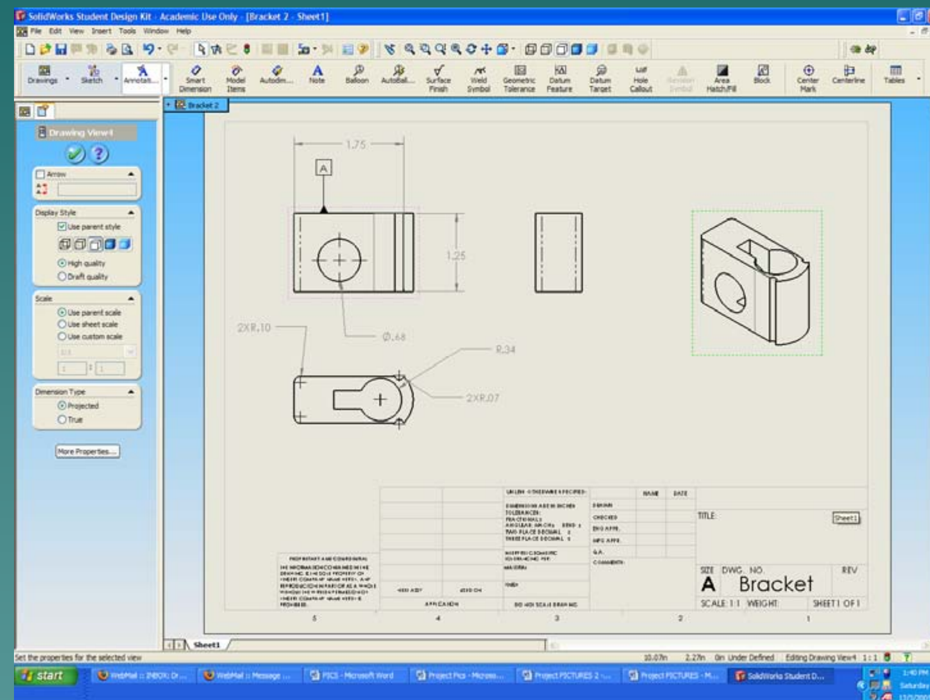

SolidWorks Student Design Kit - Academic Use Only - [Back pack assembly *]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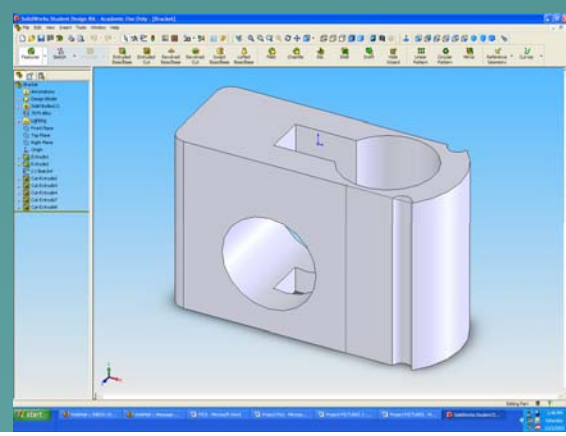
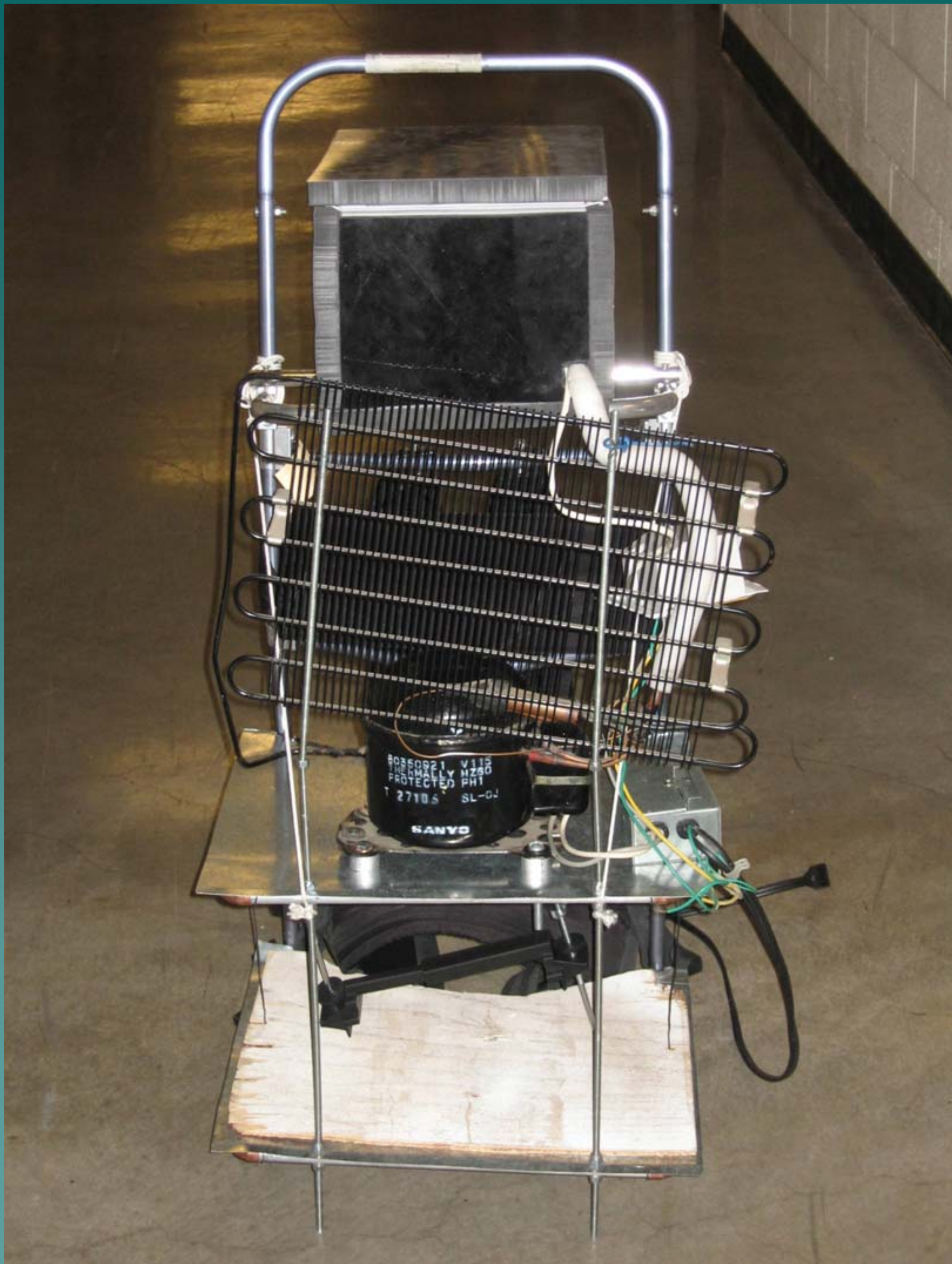


Construction

- Gutted mini-fridge
- Backpack
- Battery!! About one pound per amp hour for most
- 800 cold cranking amps
- Inverter needs 500 watt peak 150 watt continuous operation

Construction

- Shelves used to support individual components
- Sturdy, but not elegant
- Moderate weight 70lbs with a 40 lb battery mounted



The Product

The Product

Construction and Complications

Relative Electrical Equations

V=IR

I=V/R

The 8 amp startup is 110VAC/ 14 ohms of resistance

Because V=IR at 12V DC the 1.2Amps AC becomes ~roughly 13amps DC

(45amphrs/1.2amps)0.9efficiency=33.75hrs

Based on operation at a constant 1.2 amps our system should operate for 34 hours straight at the MINIMUM.

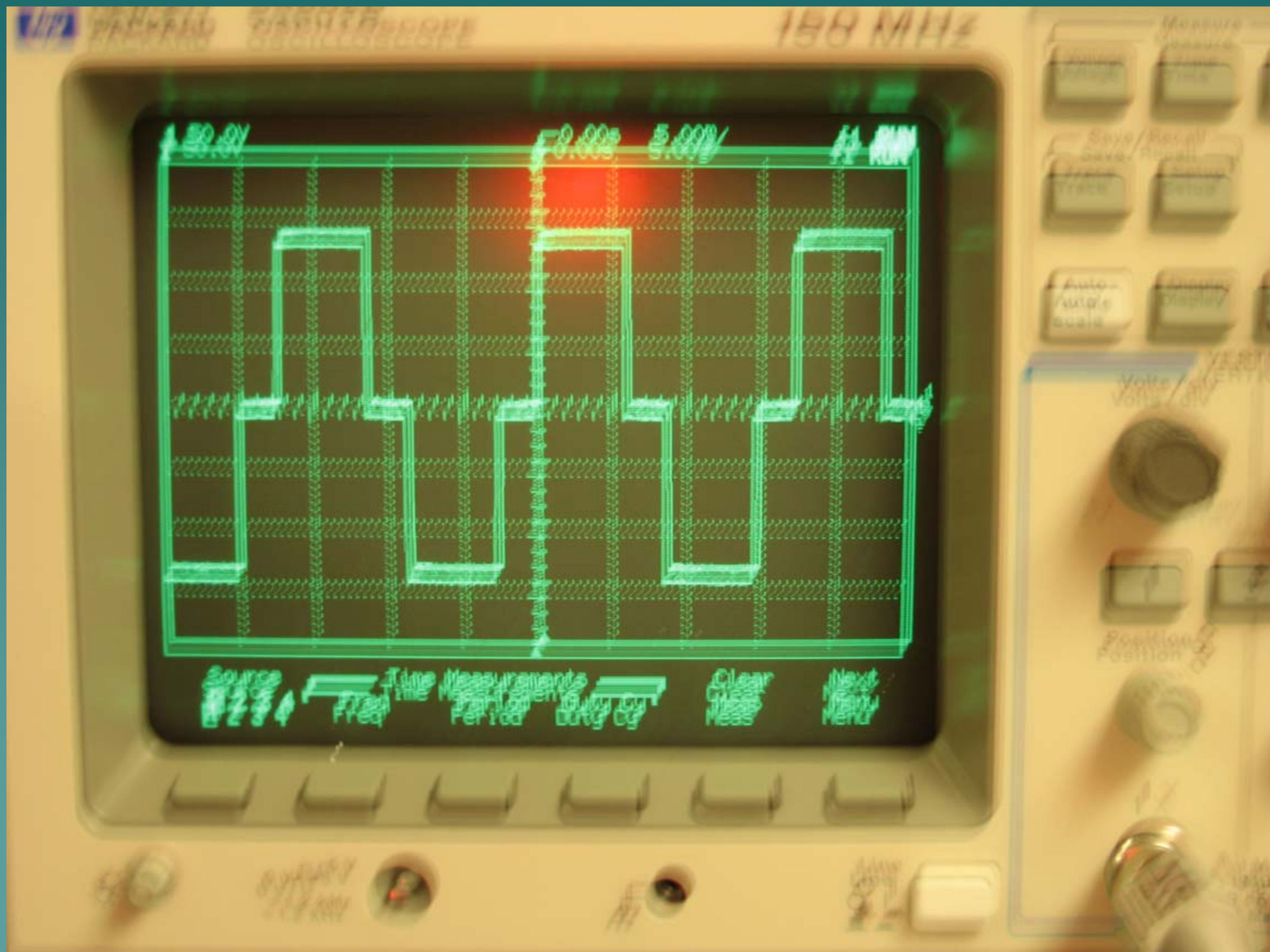
The Problem

- When tested our refrigerator did not operate off internal power
- The inverter did not appear to supply enough wattage, even though it was rated well above what was required
- However, it did power appliances that required more wattage than our refrigerator
- The battery, as well, did not supply enough power to even run the inverter, even though it should have had more than enough power to do so

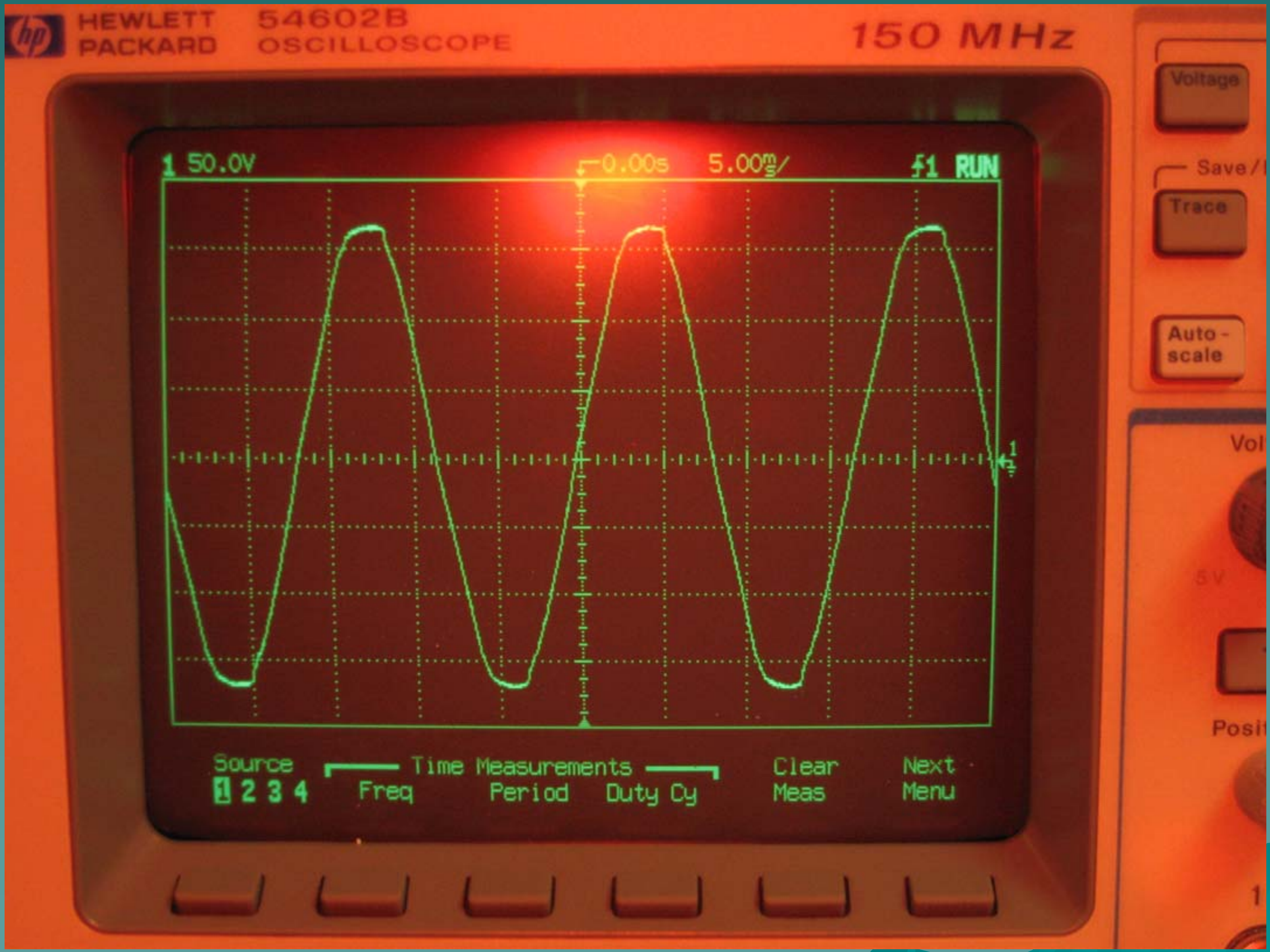
Our AH HA moment

- The problem lies within the output wave of the inverter which supplied a modified sine wave
- The solution involves acquiring a pure sine wave inverter
- According to tests run at NAPA Auto, Boulder RV, and with Tim May our battery, purchased online, holds a surface charge but has an internal short.
- In short the battery will not fully charge, and looses what charge it has once a load is applied

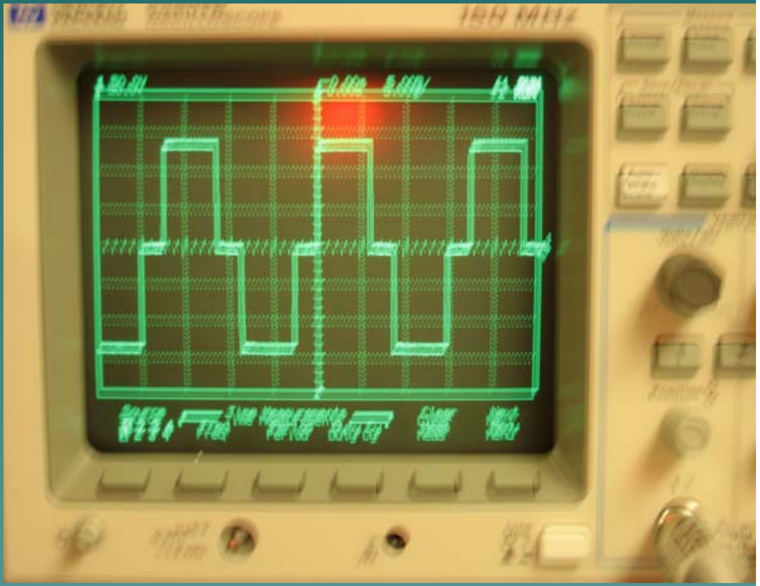
Modified sine wave



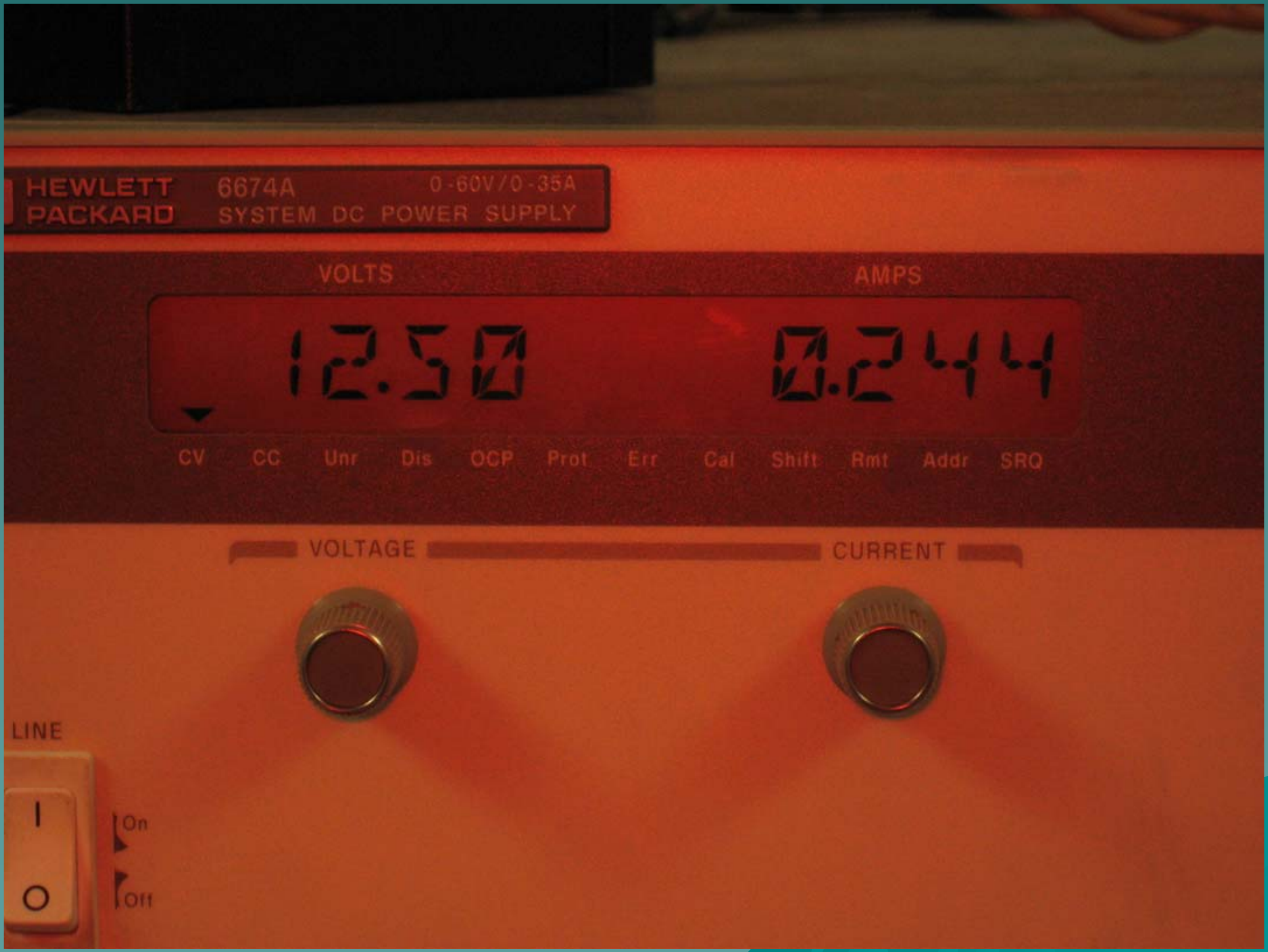
Pure wall sine wave



111.3 V AC, but not the same wave as wall current



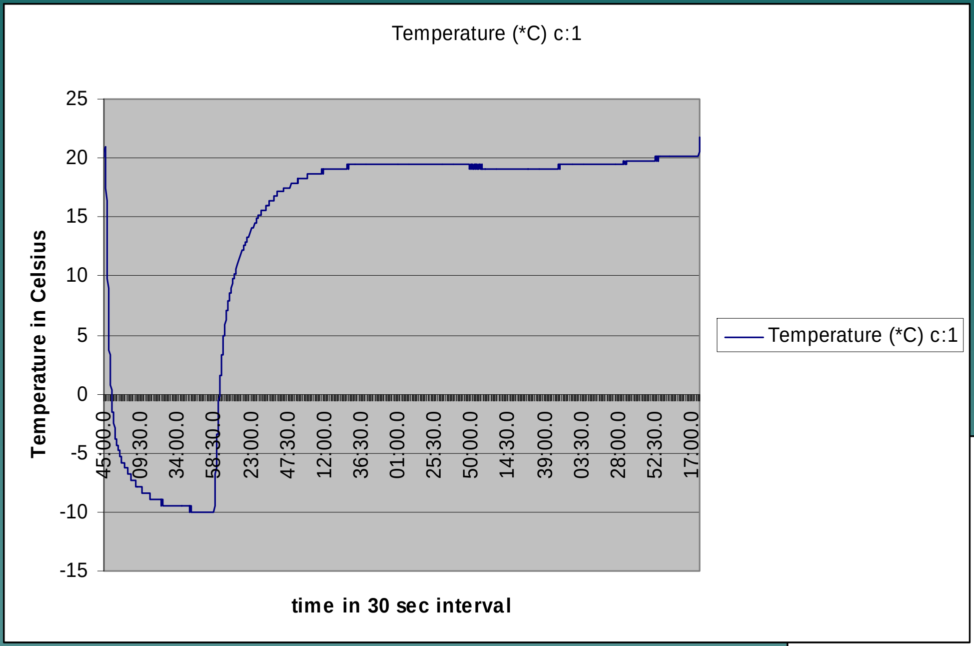
Our inverter plugged in to the "battery" 12 V power supply

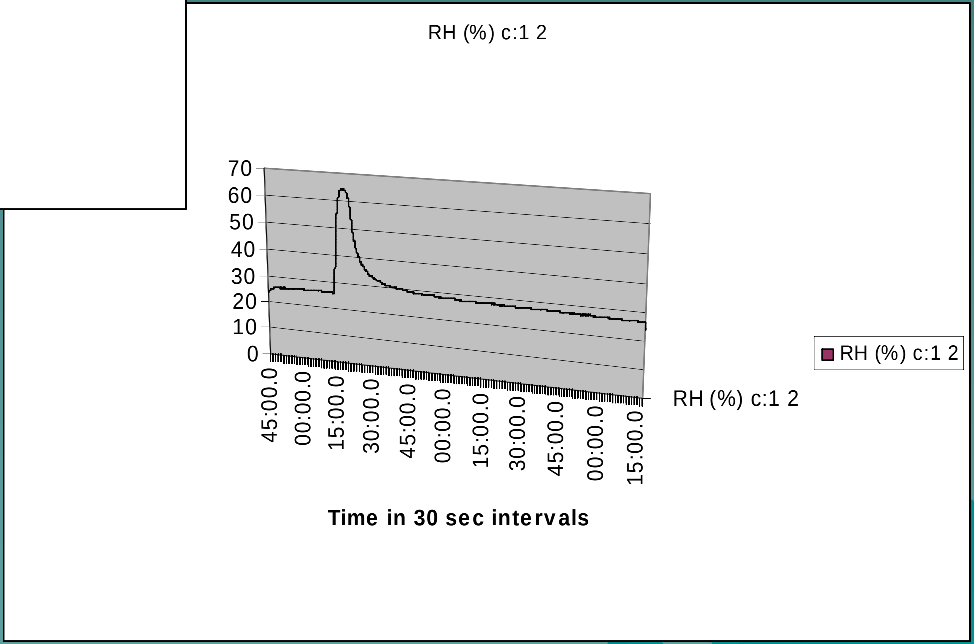


Operation of a heating fan off our inverter drawing near 20 Amps

Our system is picky and only runs off the wall current, requiring an 8 amp peak amperage upon start up, than levels off at 1.2 amps

Testing the system





Scrambling to improvise

- The inverter put out a ‘dirty’ wave
- Bought a new ‘pure’ sine wave inverter
- Trouble is it is roughly $0.60 per watt ~not very cheap
- The battery problem was unfixable within the short time of problem discovery, another battery had to be purchased

Cost includes shipping charges US$

Polyurethane	-281.00
Battery w/charger	-330.41
Structural pieces	-20.00
Assorted nuts n bolts	-10.00
Sheet metal and other construction materials	Donated
The cooling system	-40.00
Inverter	-243.99
Backpack	-5.00
Other fabrication materials	-60.00
EEF GRANT	+757.17
Grand Total:	-233.23

20-20 hindsight

- What we would of changed
- What we thought went well
- What went wrong
- Improvements…
  - More money from EEF such that low load refrigeration could be used
  - Our goal was to get it to 0 Celsius, which might have been overkill

The Future

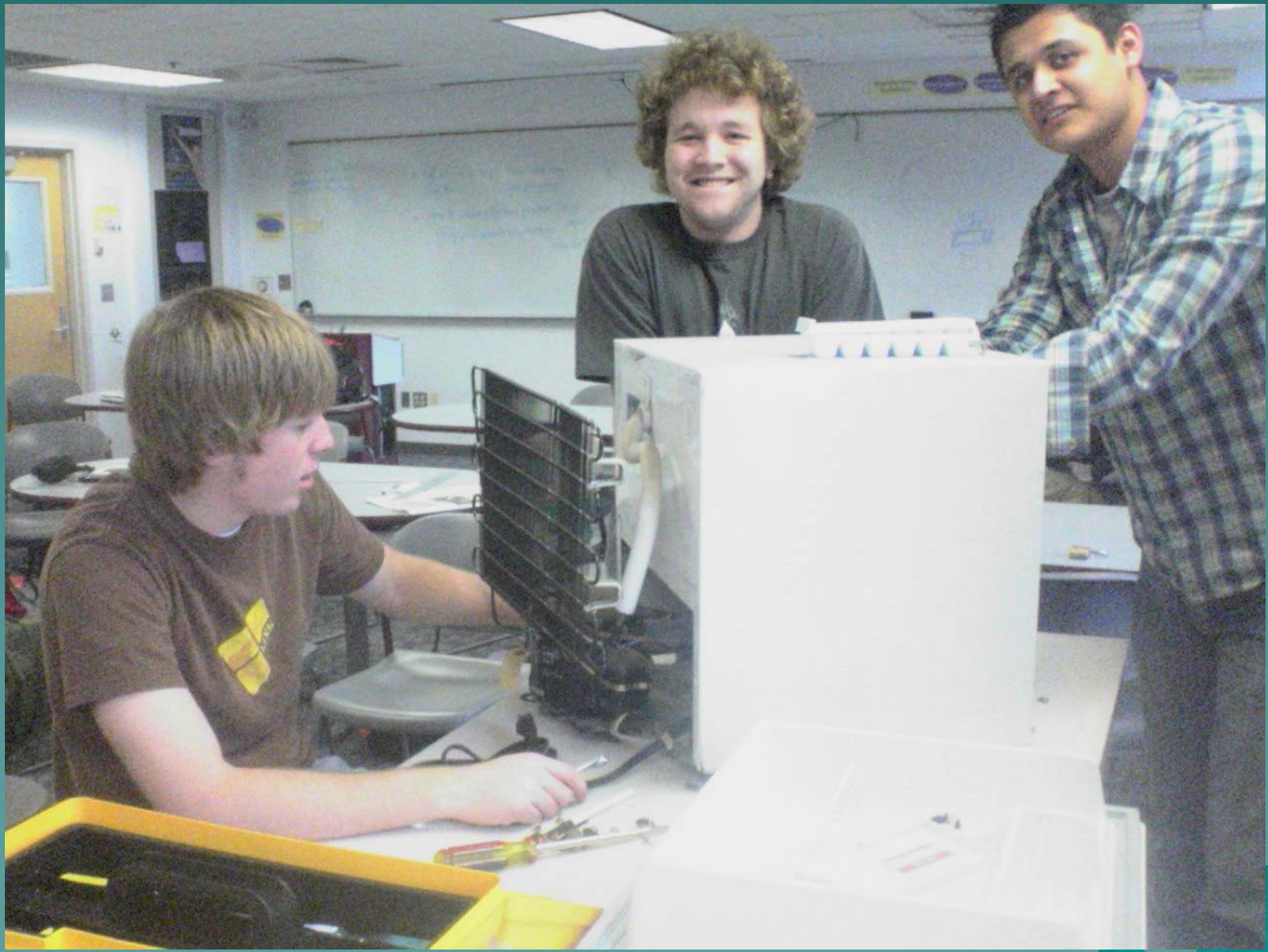
- Scaled down technology to match the exact needs of the vaccines
- Solar energy to charge batteries
- More efficient technology
- Manufacture some of our own components
- Marketable enterprise if successful
- Possible global impact

The Competition

- These are a couple of solar coolers made by Iliaktis
- Each model costs around $1300
- Expensive and not very portable



Some of the team

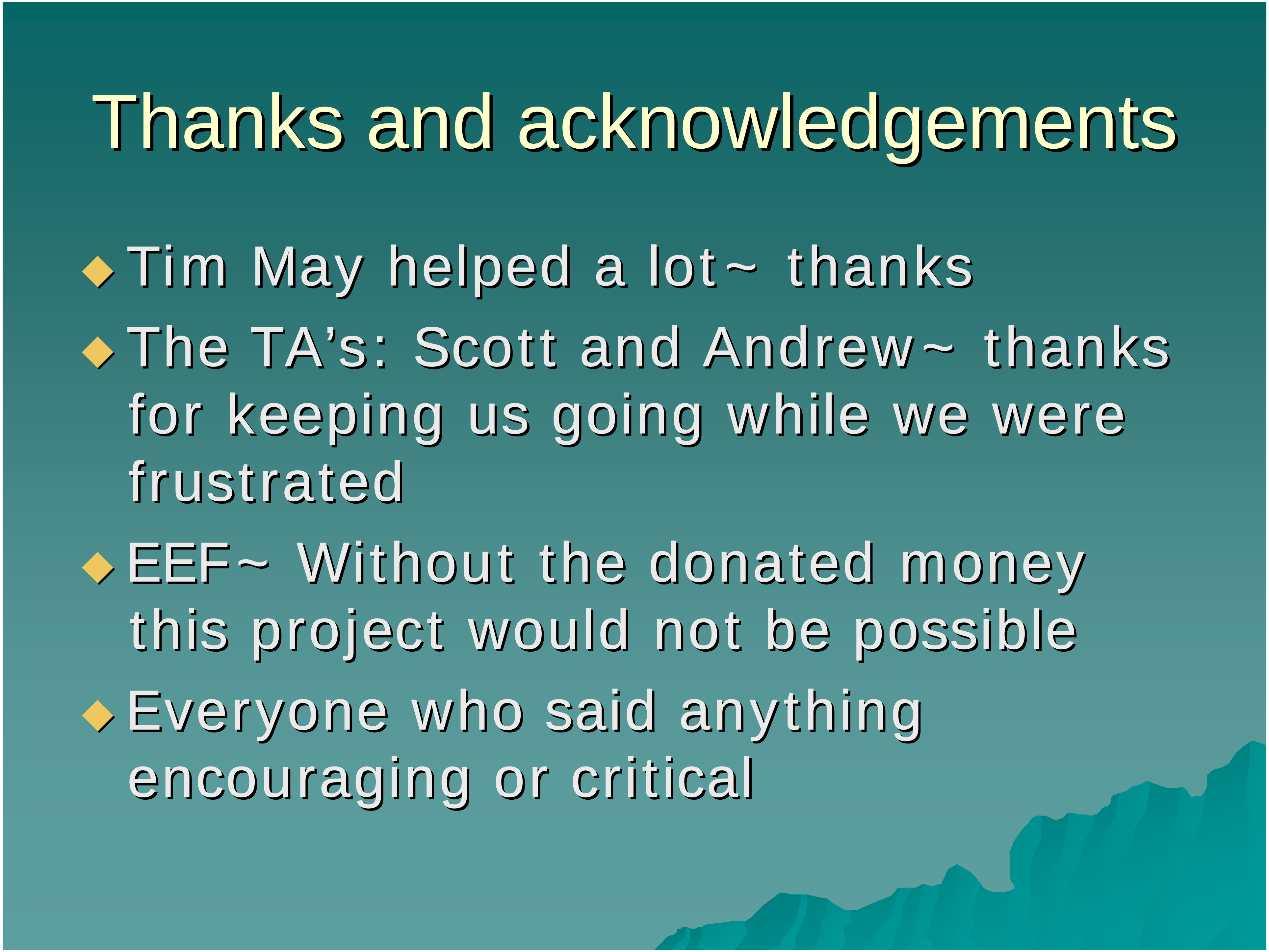


Team Strengths and Challenges

- Every group member contributed great ideas
- No major group challenges
- All members took an active interest in the project
- Communication was key to the success of the project
- Project moved along and major obstacles were overcome...mostly
- A little difficulty spreading the workload
- Some team members took anger out on others when things weren't going well

Annotated bibliography

- http://www.sunfrost.com/vaccine_refrigerators.html
- This site is where we gathered pictures of competition as well as some basic information
- http://www.batterystuff.com/tutorial_battery.html
- All of the information regarding electric components in our design was deduced from here
- Dictionary For The Electrician with Formulas. Tom Henry. Copyright 1997.
- Definitions for electricity and further research on electrical components
- http://www.windsun.com/Batteries/Battery_FAQ.htm
- Batteries research and facts, all electronics faqs and facts
- http://www.mit.edu
- Vaccine transport method and looking into graduate students' design at MIT
- http://cdc.gov
- Vaccine storage temperature and transportation information
- http://cires.colorado.edu/
- Information and specifications on many battery types: very good for large batteries, but not very much information on practical transportable batteries.
- http://vaccines.org/
- Self explanatory
- http://www.who.int/vaccines/
- SOP involving vaccines and other administrative procedures


Thanks and acknowledgements
Tim May helped a lot~ thanks
The TA's: Scott and Andrew~ thanks for keeping us going while we were frustrated
EEF~ Without the donated money this project would not be possible
Everyone who said anything encouraging or critical

Final Thoughts or Comments?