BME Design-Spring 2023 - Joshua Varghese
Complete Notebook

PDF Version generated by

Sydney Polzin

on

May 03, 2023 @04:16 PM CDT

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Team contact Information

Joshua Varghese - Mar 01, 2023, 4:44 PM CST

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Kinney	Melissa	Advisor	melissa.kinney@wisc.edu		
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Parmenter	Nicole	BSAC	nparmenter@wisc.edu	262-420-8635	
Polzin	Sydney	BWIG	sapolzin@wisc.edu	763-607-2309	
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Project description

NICOLE PARMENTER - Jan 27, 2023, 1:16 PM CST

Course Number: BME 301

Project Name: Reducing whole-body vibrations on neonatal transport

Short Name: Neonatal Transport

Project description/problem statement:

Whole-body vibrations, translational forces, rotational moments, and excessive sound from a medical transport vehicle can cause brain injuries to critically-ill neonates that lead to neurodevelopmental impairment or death. Mitigating these physiological stressors has the potential to drastically improve transport outcomes including increased survival rates and decreased brain injury. The current transport setup neglects the effects of the stressors aforementioned by including a collection of rigid parts and only a single mattress to dampen vibrations. Thus, the client has tasked the team with developing a vibration-reducing device with mitigating mechanical forces and sound as secondary foci. The device must reduce each physiological stressor, so the neonate does not sustain injury, must fit within the dimensions of a standard ambulance and helicopter without interfering with the movement of the transport team, and must be compatible with current incubator setup or include all the associated functions and equipment.

About the client:

Dr. Ryan McAdams is the Neonatology Division Chief for UW Health and a professor for the UW School of Medicine and Public Health. Dr. Joshua Gollub is a fellow at the University of Wisconsin School of Medicine and Public Health specializing in neonatal medicine.

2023/1/27 - Fall 2022 Notebook

Joshua Varghese - Jan 27, 2023, 12:53 PM CST

Title: 2023/1/27 - Fall 2022 Notebook

Date: 1/27/2023

Content by: Joshua Varghese, Joseph Byrne, Sydney Therein, Greta Scheidt, Neha Kulkarni, and Julia Salita

Content: This entry contains the notebook from the Fall 2022 team

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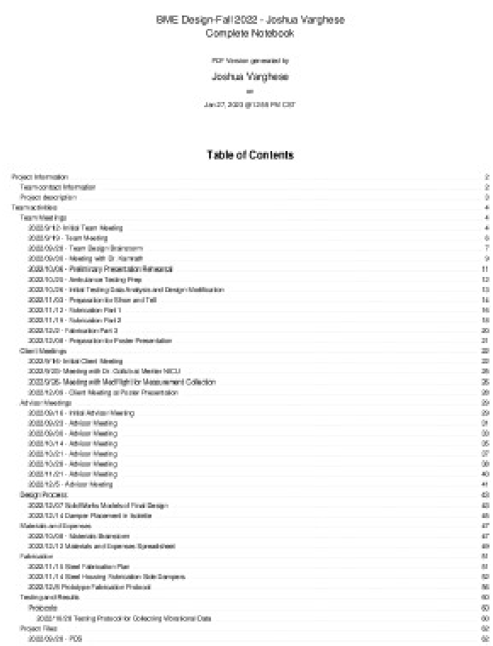
Joshua Varghese - Jan 27, 2023, 1:19 PM CST



BME Design-Fall 2022 - Joshua Varghese
Complete Notebook

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2023_01_27_notebook_68047.pdf (27.9 MB)

2023/01/31 - Client Meeting 1

NICOLE PARMENTER - Jan 31, 2023, 12:35 PM CST

Title: Client Meeting 1

Date: 1/31/2023

Content by: Full Team

Present: Full Team

Goals: Meet the clients and establish direction of project and expectations for this semester.

Content:

- Notes:
- Collect a lot of data this semester (5-10 runs)
- End goal: purchased by a company or manufactured
- Use a nicu mannequin to understand vibrational data
    - Strap, sensor, easily replicated
    - Accelerometer - potentially have on runs with real babies but be fixed on outside of incubators
        - Look into regulations and requirements for working with live subjects
- Improve materials, better seal, better adjustments of design
    - Layers/holes in material
- Likes insert design
    - If we COULD redesign an entire component, what would it be?
        - Not ideal due to cost but would be a good starting point to think about
- Brainstorm at beginning: what do we already know, what should we focus on in the beginning, set milestones
- Talk to a professor about determining if we're collecting the “right” type of data

Conclusions/action items:

Reach out to professors to make a testing plan. Visit hospital to tour and get a sense of the equipment used.

2023/02/01 - Advisor Meeting 1

NICOLE PARMENTER - Feb 01, 2023, 12:33 PM CST

Title: Advisor Meeting 1

Date: 2/1/2023

Content by: Full Team

Present: Full Team

Goals: Project updates and complete progress report as a team.

Content:

- Worked through weekly progress report and discussed goals for next week.
- Notes:
    - Consider just making a design matrix for a part of the design, not necessarily the entire design.
    - Add long-term testing specifications to PDS, remove some components such as sound
    - Add/update quantitative values in PDS
    - Decided on notebook check in middle and at end of semester.

Conclusions/action items:

Meghan will send the progress report to the client. The team will work on the PDS and continue researching.

2023/02/08 - Advisor Meeting 2

NICOLE PARMENTER - Feb 08, 2023, 12:21 PM CST

Title: Advisor Meeting 2

Date: 2/8/2023

Content by: Full Team

Present: Full Team + Advisor

Goals: Project updates and complete progress report as a team.

Content:

Notes:

- Our product is class 1 even though the incubator is 2 because it's not interacting with the baby
    - Can define it as we would like - explain rationale for both, just as long as we describe our thought process in choosing one
- Look through PDS to verify quantitative measurements are included in majority of sections
- Cost and safety required in design matrix
    - Beyond that, we can include as many categories as we would like that make sense for the project
- Start working on the design matrix for next week
    - Each create 1-2 design ideas to add to the lab notebook
- Just focus the design matrix on the design, not necessarily the testing mechanism (which may be able to be purchased)
    - In the future, create a pros/cons list or mini design matrix for deciding which accelerometer (or testing mechanism) to buy
    - Can maybe add a small section in PDS for it

Conclusions/action items:

Finish revising PDS. Individually create 1-2 designs to compare.

2023/02/15 - Advisor Meeting 3

NICOLE PARMENTER - Feb 15, 2023, 12:25 PM CST

Title: Advisor Meeting 3

Date: 2/15/2023

Content by: Full Team

Present: Full Team

Goals: Discuss PDS feedback and design matrix.

Content:

- Notes:
    - Narrow PDS specifications to be things we can test this semester specifically
    - Continue reaching out to professors on campus to find accelerometers or potential options
    - Try to have design set by end of next week rather than continuing to engineer the system
        - Meeting with other professors is beneficial but only if it's applicable to future semesters
    - Don't bother creating our own CAD files - don't even need CAD files, can use sketches from notebook
        - Need to add dimensions
        - Should have picture of whole system integration but they don't have to be CAD files in general
            - Could be iPad drawings, computer drawings, neatly drawn on paper - as long as they are understandable and the context is apparent
            - Have enough labels to describe what is going on
    - Send slides by Wednesday at 5pm to check

Conclusions/action items:

Write explanations of design criteria. Continue searching for an accelerometer for testing. Begin preliminary presentation.

2023/02/17 - Incubator Measurements

Meghan Horan - Feb 17, 2023, 5:16 PM CST

Title: Incubator Measurements

Date: 2023/02/17

Content by: Meghan Horan

Present: Full team + Dr. Gollub & Dr. Lepp

Goals: To obtain measurements of equipment to understand limitations our device must abide by.

Content:

See images

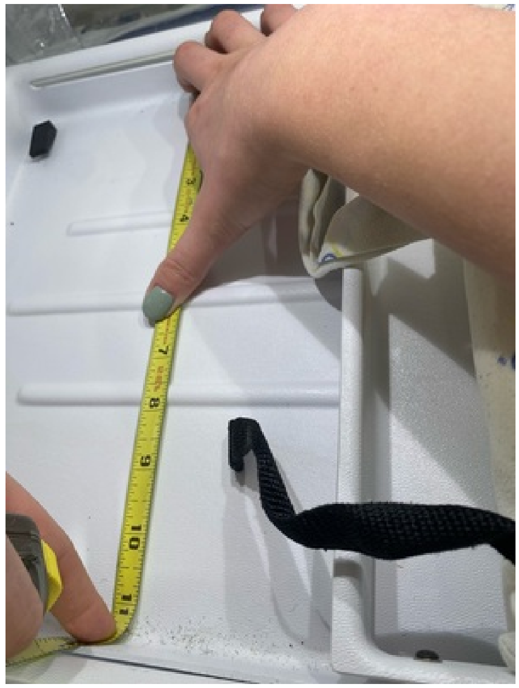
Conclusions/action items: Set dimensions of chosen preliminary design accordingly. May need to make modifications to placement of design to accommodate.

Meghan Horan - Feb 17, 2023, 5:17 PM CST

Download

length_of_outer_tray.jpg (549 kB)

Meghan Horan - Feb 17, 2023, 5:18 PM CST



Download

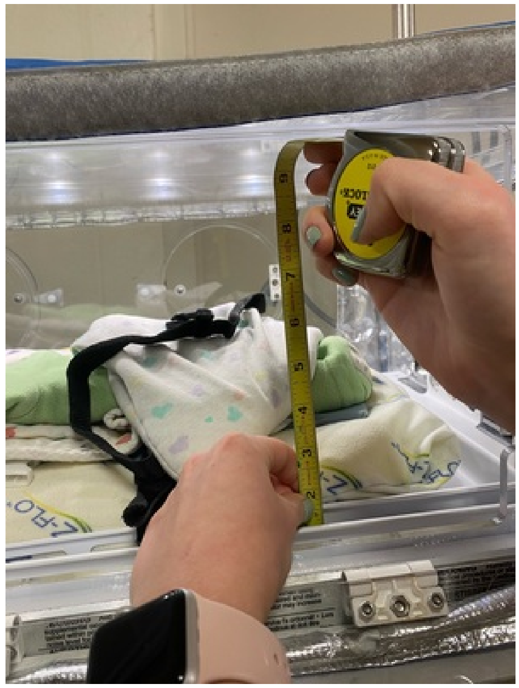
Width_of_outer_tray_.jpg (463 kB)

Meghan Horan - Feb 17, 2023, 5:18 PM CST

Download

distance_begween_baby_and_top_of_incubator.jpg (539 kB)

Meghan Horan - Feb 17, 2023, 5:19 PM CST



Download

distance_from_bottom_tray_to_top_of_incubator.jpg (543 kB)

2023/04/14 - Updated Incubator Measurements

Sydney Polzin - Apr 17, 2023, 6:08 PM CDT

Title: Updated Incubator Measurements

Date: April 14, 2023

Content by: Sydney Polzin

Present: Joshua Varghese and Nicole Parmenter

Goals: Share updated measurements taken of the inner/outer trays

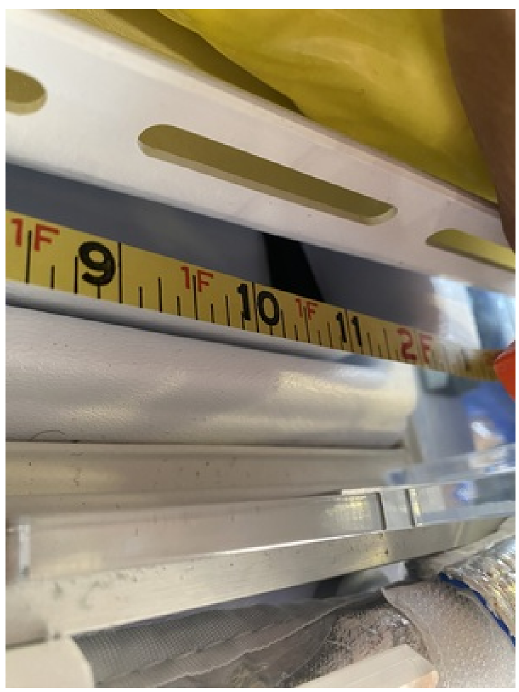
Content:

See images below.

Conclusions/action items:

Use these dimensions to modify the design in future work.

Sydney Polzin - Apr 17, 2023, 6:27 PM CDT



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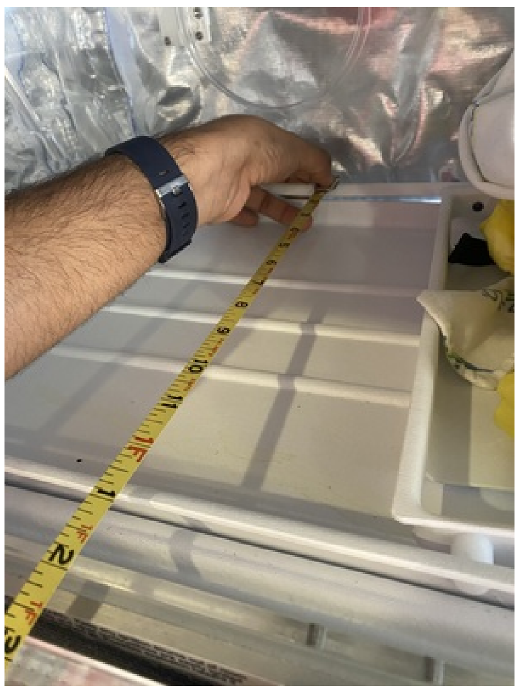
IMG_1162.jpeg (2.72 MB)

Sydney Polzin - Apr 17, 2023, 6:27 PM CDT

Download

IMG_1160.jpeg (2.88 MB)

Sydney Polzin - Apr 17, 2023, 6:27 PM CDT



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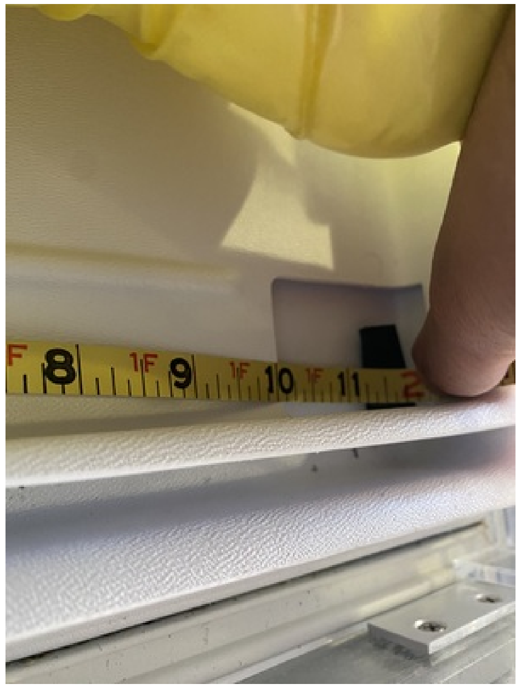
Sydney Polzin - Apr 17, 2023, 6:27 PM CDT



Download

IMG_1159.jpeg (2.73 MB)

2023/05/01-Updated Expense Table

Joseph Byrne - May 01, 202

Title: Expense Table for All Purchases Made During the Spring 2023 Semester

Date: 5/1/2023

Content by: Joseph Byrne

Present: Team

Goals: To document and explain purchases made during the Spring 2023 semester.

Content:

Below is a screenshot of the expense table:

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Category 1 (Accelerometer)										
9-Axis Accelerometer	Measures vibrations in the incubator during transport.	Wit Motion	WT901 mpu9250	Amazon	B083R3Q5K 8	3/17/2023	1	$53.99	$53.99	Accelerometer
Category 2 (Other)										
FOCHEW Portable Charger	External Battery Pack for charging accelerometer during testing.	FOCHEW		Amazon	B0BCQKB67J	3/17/2023	1	$29.95	$29.95	Charger
								TOTAL:	**$83.94**	

The links for the accelerometer and charger can be accessed here:

Accelerometer: https://www.amazon.com/WitMotion-WT901SDCL-Inclinometer-Accelerometer-Magnetometer/dp/B083R3Q5K8

Charger: https://www.amazon.com/dp/B0BCQKB67J/ref=twister_B0BQ6VSYGL?_encoding=UTF8&th=1

Conclusions/action items:

The above table summarizes all purchases made this semester. Only purchases related to testing were necessary because all spring and damper components were received through free sam table should be updated for any additional purchases.

2023/02/28 - Preliminary Fabrication Plan

Sydney Polzin - Feb 28, 2023, 11:17 PM CST

Title: Preliminary Fabrication Plan

Date: February 28, 2023

Content by: Nicole Parmenter and Sydney Polzin

Present: NA

Goals: Share the preliminary fabrication plan for the Spring and Damper Design

Content:

After obtaining materials, the spring dampers were fabricated and attached to the outer tray of the isolette according to the following steps.

1. Attach the spring around the damper. The top flat piece of the damper will secure the spring in place.
2. Attach 10 mounting brackets to the inside of the outer tray using screws. These mounting brackets will provide a method of attachment for the spring dampers.
    a. Four mounting brackets will be spread evenly across the bottom of the outer tray and there will be two on each of the three sides of the outer tray (no brackets on the side where the inner tray needs to slide out).
3. Install four spring dampers evenly spaced under the inner tray by attaching them to the mounting brackets. The remaining six spring dampers will be placed on the three sides between the inner and outer trays of the incubator (two on each side).
    a. Alternatively, epoxy glue can be used to secure the spring dampers to the inside of the outer tray.
4. For fabrication of the redesigned inner tray, the width and length of the tray will be reduced by the minimum dimensions necessary to fit the spring dampers.
    a. Cut a 26 cm x 30 cm rectangle out of cardboard.
    b. Cut two additional cardboard rectangles that are 30 cm x 6 cm and two cardboard rectangles that are 26 cm x 6 cm to attach as walls of the fabricated inner tray with 2 cm below the bottom of the cardboard base.
5. Adjust the sliding mechanism that attaches the inner and outer tray. This mechanism will need to be readjusted on the inner tray to line up with the outer tray.
    a. Cut a rounded slit in the two walls of the cardboard inner tray in the 2 cm of cardboard that is below the base piece of cardboard. This will allow the tray to still slide in and out and will increase vertical space between the bottom of the inner tray and the bottom of the outer tray.

Conclusions/action items:

The team will continue to modify the fabrication plan as the initial prototyping stages begin. During fabrication for the final prototype, detailed notes will be taken.

2023/04/15 - Final Prototype Fabrication

Meghan Horan - Apr 15, 2023, 12:09 PM CDT

Title: Final Prototype Fabrication

Date: 2023/04/15

Content by: Meghan Horan

Present: full team

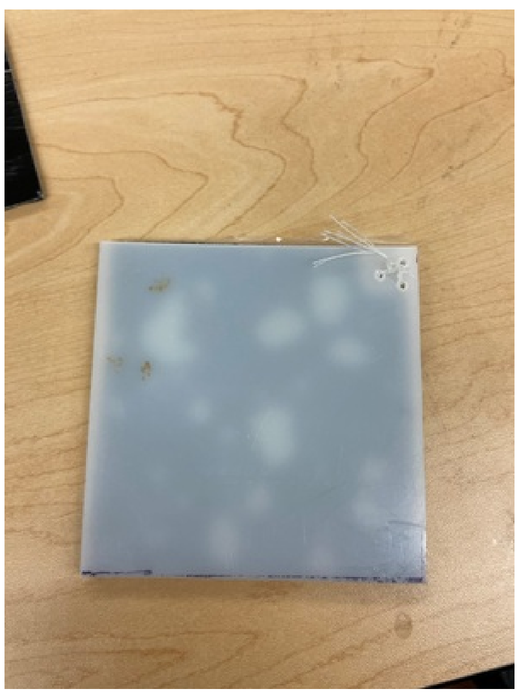
Goals: To fabricate final prototype now that all materials have arrived

Content:

- 4"x4" HPDE squares will serve as the base that will sit between inner and outer tray
- Sorbothane 40 DURO Black Sheet 1/10"x12"x12" (0212010-40) is used as the damper with square cut out for spring
- smalley spring: https://www.smalley.com/wave-spring/c037-l1
- used thin white thread
- drilled 3 holes with 7/64" drill bit in equilateral triangle in the corner of each HPDE sqaure
- tied three pieces of thread to three "contact points" of each spring
- fed thread through holes and tied the 3 (6) pieces together
- superglued string knot to keep it fixed together
- placed naturally sticky sorbothane over top
- left plastic cover on for storage

Conclusions/action items: complete testing with the design to compare to preliminary data

Meghan Horan - Apr 15, 2023, 12:10 PM CDT



Download

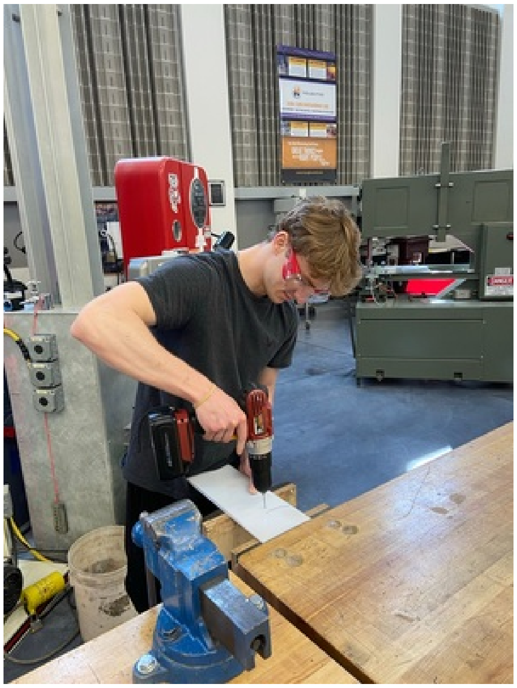
Bottom.jpg (476 kB)

Meghan Horan - Apr 15, 2023, 12:11 PM CDT

Download

Top.jpg (682 kB)

Meghan Horan - Apr 15, 2023, 12:11 PM CDT



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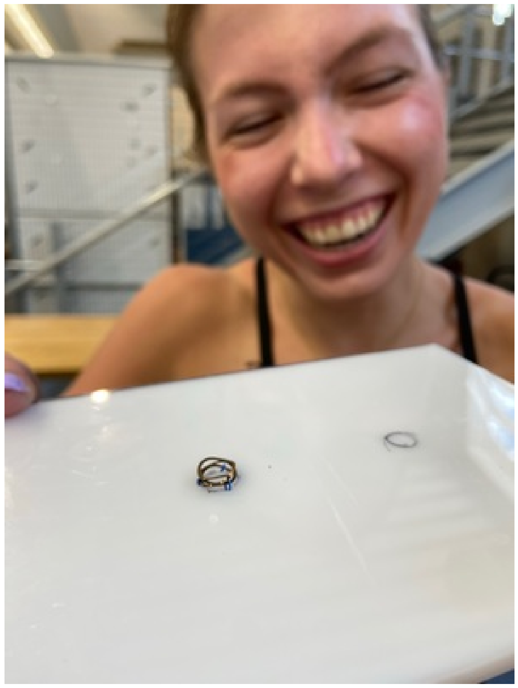
Joey_drilling.jpg (679 kB)

Meghan Horan - Apr 15, 2023, 12:12 PM CDT



Download

Experimenting_with_knot_tying.jpg (219 kB)

2023/05/01 - Ambulance Testing Protocol

NICOLE PARMENTER - May 01, 2023, 7:35 PM CDT

Title: Ambulance Testing Protocol

Date: 5/1/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Lay out steps of testing prototype in ambulance.

Content:

1. For data collection with prototype:
    1. Insert prototype into isolette.
    2. Place one spring damper combination in each corner of the outer tray under the inner tray.
    3. Stick the adhesive Sorbothane to the bottom of the inner tray to prevent sliding.
2. Launch Witmotion software and configure settings.
    1. Select measure time, acceleration, velocity, angle
    2. Calibrate time, acceleration, height, angle
    3. Bandwidth = 188 Hz, Output rate = 200 Hz, Baud rate = 115200
3. Begin recording data on accelerometer.
4. Secure accelerometer under gel mattress in inner tray of isolette with command strip.
5. Follow pre-planned route: https://goo.gl/maps/Mv577qgnyUtgr7sx5
6. Stop data recording on accelerometer.
7. Obtain .txt files from accelerometer to analyze.
    1. Convert files in Witmotion software. Conversion rate = 200 Hz.

- One ambulance run without prototype and one with prototype following the same route.
- WitMotion WT901SDCL Accelerometer was used to gather acceleration data in the x, y, and z directions.
    - 32 GB SD card, sampling frequency = 200 Hz

Conclusions/action items:

Follow this protocol during testing in the ambulance with and without the prototype.

2023/04/08 - Accelerometer Data (no prototype)

NICOLE PARMENTER - May 01, 2023, 7:26 PM CDT

Title: Accelerometer Data (no prototype)

Date: 4/8/2023

Content by: Nicole Parmenter

Present: Full team

Goals: Collect and analyze vibration data in incubator without prototype.

Content:

- The accelerometer was placed at the bottom of the inner tray, under the mattress pad, in the isolette from 4/3/2023 - 4/6/2023.
- Attached are the raw data files and analysis from MATLAB code (script attached)
- When checking on the accelerometer and battery pack during the testing period, they were off and needed to be turned back on at various points, affected data collection
- Data is split into three separate text files with a new file beginning each time the accelerometer was plugged in
  - 1. WIT27_New.txt: plugged into laptop to begin recording
  - 2. WIT28_New.txt: plugged into battery pack in isolette
  - 3. WIT29_New.txt: plugged into laptop to end recording
- MATLAB data included here is only for WIT28_New.txt
- Mean Acceleration (x, y, z): (-0.137375, -0.240090, 0.972364)
- Standard Deviation Acceleration (x, y, z): (0.012270, 0.011887, 0.008904)
- P-values:
  - for Pxx, Pyy: 0.3901
  - for Pxx, Pzz: 0.1884
  - for Pzz, Pyy: 0.2084

Conclusions/action items:

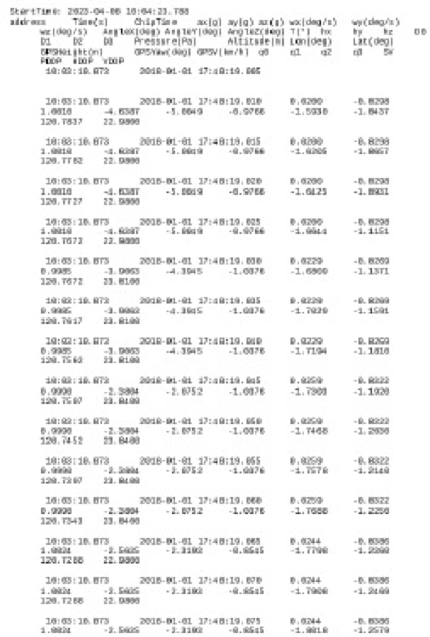
Using the WitMotion WT901SDCL accelerometer, vibrational data was collected in the isolette without the prototype.

NICOLE PARMENTER - Apr 08, 2023, 9:46 PM CDT

Download

WIT28_New.txt (100 MB)

NICOLE PARMENTER - Apr 08, 2023, 9:46 PM CDT



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    D1    D2    D3    Pressure(Pa)    Altitude(m) Lon(deg)    Lat(deg)
    GPSHeight(m)    GPSYaw(deg) GPSV(km/h) q0    q1    q2    q3    SV
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Download

WIT29_New.txt (14.9 MB)

NICOLE PARMENTER - Apr 08, 2023, 9:46 PM CDT

TXT W

Download

WIT27_New.txt (72.6 MB)

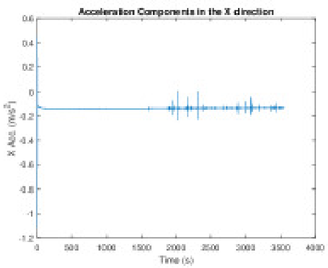
NICOLE PARMENTER - Apr 08, 2023, 9:46 PM CDT

DATA

Download

TestScript.mlx (210 kB)

NICOLE PARMENTER - Apr 08, 2023, 10:02 PM CDT



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MATLAB_graphs.pdf (506 kB)

2023/04/14 - Accelerometer data 50 min ambulance no prototype

NICOLE PARMENTER - May 01, 2023, 7:26 PM CDT

Title: accelerometer data 50 min ambulance no prototype

Date: 4/14/2023

Content by: Nicole Parmenter

Present: Josh, Sydney, Nicole

Goals: Collect vibration data in isolette without design.

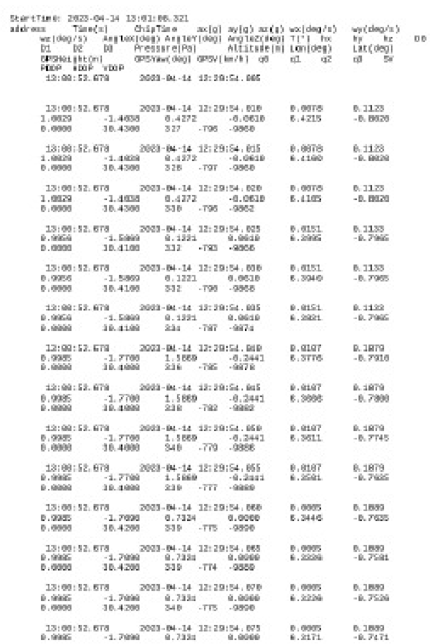
Content:

- 50 minute ambulance ride to collect data
    - data collected only until 30 minutes
- Measurements began at 12:34pm and were stopped at 12:59pm
- Route driven: https://goo.gl/maps/Mv577qgnyUtgr7sx5
- MATLAB code, raw data, and graphs from code are attached
- Larger spikes in acceleration towards the beginning and end are due to placing and accelerometer in the incubator and removing it and should not be included in analysis.

Conclusions/action items:

30 minutes of vibration data was collected without our design in the ambulance and this data will be used as a reference point.

NICOLE PARMENTER - Apr 14, 2023, 3:04 PM CDT



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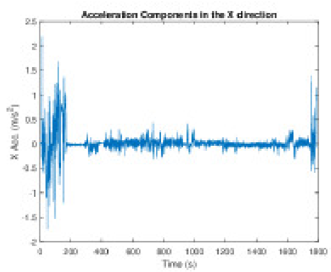
WIT48_New.txt (2.77 MB)

NICOLE PARMENTER - Apr 14, 2023, 3:04 PM CDT

Download

TestScript.mlx (197 kB)

NICOLE PARMENTER - Apr 14, 2023, 3:09 PM CDT



Download

graphs.pdf (838 kB)

2023/04/21 - Accelerometer data 50 min ambulance with prototype

NICOLE PARMENTER - May 01, 2023, 7:26 PM CDT

Title: Accelerometer data 50 min ambulance with prototype

Date: 4/21/2023

Content by: Nicole Parmenter

Present: Nicole, Josh, Joey, Meghan

Goals: Collect vibration data in isolette with prototype to assess its effect on vibrations.

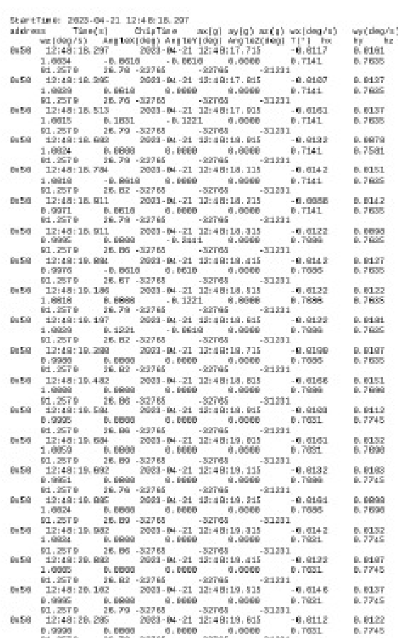
Content:

- 50 minute ambulance ride to collect data
- Measurements began at 12:48 pm and were stopped at 1:40
    - 12:48 start
      12:50 readjust and start driving
      1:27 not moving
      1:30 not moving
      1:32 not moving
      1:35-8 not moving/moving a little
      1:38 train tracks
      1:40 park, end
- Route driven: https://goo.gl/maps/Mv577qgnyUtgr7sx5
- MATLAB code, raw data, and graphs from code are attached
- Larger spikes in acceleration towards the beginning and end are due to placing and accelerometer in the incubator and removing it and should not be included in analysis.

Conclusions/action items:

50 minutes of vibration data were collected in the isolette in the ambulance and these results will be compared to the data without the prototype.

NICOLE PARMENTER - Apr 21, 2023, 2:33 PM CDT



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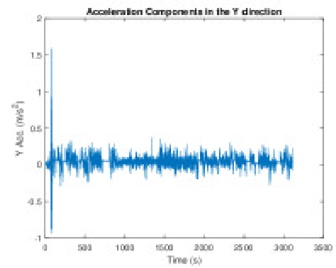
NICOLE PARMENTER - Apr 21, 2023, 2:35 PM CDT



Download

graphs.pdf (625 kB)

2023/05/01 - Final MATLAB Analysis Script

Joshua Varghese - May 01, 2023, 10:16 PM CDT

Title: Final MATLAB Analysis Script

Date: 5/1/2023

Content by: Joshua Varghese, Nicole Parmenter, and Sydney Polzin

Present: Joshua Varghese

Goals: To document the final testing code that created the figures and statistical calculations for the poster and report.

Content:

The code has been attached below.

Conclusions/action items:

This code will be used to create the visuals for our report and poster.

Joshua Varghese - May 01, 2023, 10:16 PM CDT

```
clear all;
close all;

filename_f = "FinalData.txt";

fid_f = importdata(filename_f, "\t");
data_f = fid_f;

% Convert the time strings to datetime format
start_time_f = datetime(data_f.textdata(3:end,3), 'InputFormat', 'yyyy-MM-dd HH:mm:ss.SSS');
time_f = datetime(data_f.textdata(3:end,2), 'InputFormat', 'HH:mm:ss.SSS');
time_f = time_f(1620:end);

% Calculate the time elapsed since the start of the recording
time_elapsed_f = seconds(start_time_f - min(start_time_f));

acc_x_f = data_f.data(:, 1);
% Find indices of NaN values
nan_idx_f = find(isnan(acc_x_f));

% Replace NaN values with average of values before and after
for i = nan_idx_f
acc_x_f(i) = (acc_x_f(i-1) + acc_x_f(i+1)) / 2;
end
```

Download

FinalScript4.html (2.17 MB) Final Testing Script

2023/05/03 - PSD Results Analysis

Sydney Polzin - May 03, 2023, 4:13 PM CDT

Title: PSD Results Analysis

Date: May 3, 2023

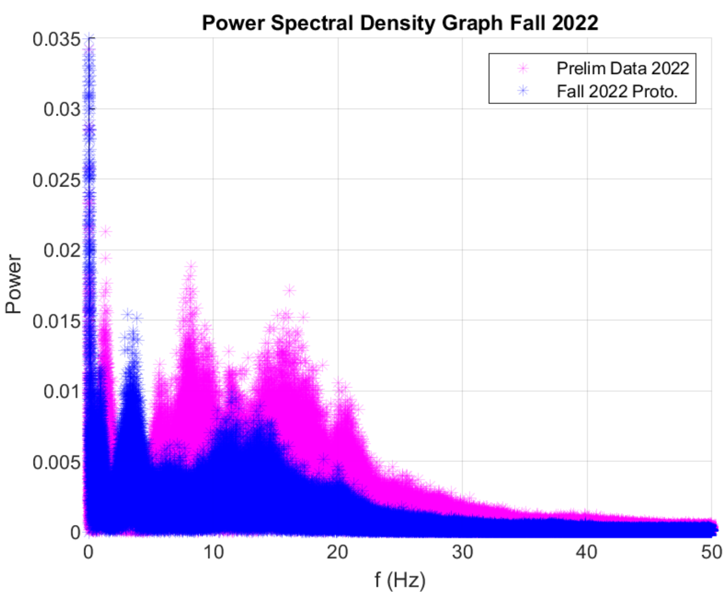
Content by: Sydney Polzin

Present: Team

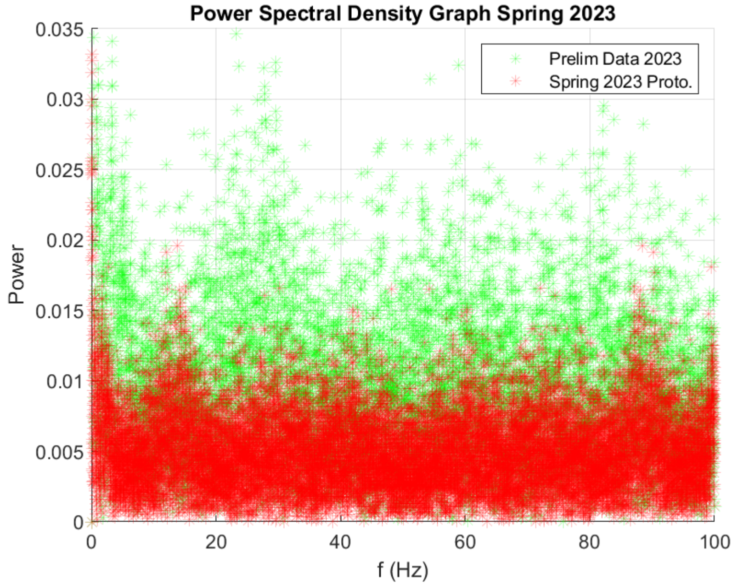
Goals: Share the results from the accelerometer and data collection

Content:

- The graph below shows the power spectral density graph from the data from fall of 2022
- Blue shows the data with the prototype and pink is the data without the prototype
- Clear shift in the frequencies felt within the isolette with a slight decrease in power
- Collected at a sampling frequency of 100 Hz and using an iPhone accelerometer
-



- The graph below shows the power spectral density graph from this semester's data
- Green is preliminary data without the spring and damper device, and red is the data with the spring and damper
- Clear decrease in amplitude of the power, which is the desired outcome
- Collected at a sampling frequency of 200 Hz and using the WitMotion accelerometer



Conclusions/action items:

Although the PSD from last semester shows a shift in the frequencies, the reduction in amplitude as seen from this semester is the desired outcome. This proves that using both a spring and a damper do a better job at reducing the amplitude of the frequencies, rather than just one component. Future work will involve continuing to modify the spring and dampers in order to reduce the vibrations even further.

2023/05/03 - Accelerometer Results Analysis

NICOLE PARMENTER - May 03, 2023, 4:15 PM CDT

Title: Acceleration Results Analysis

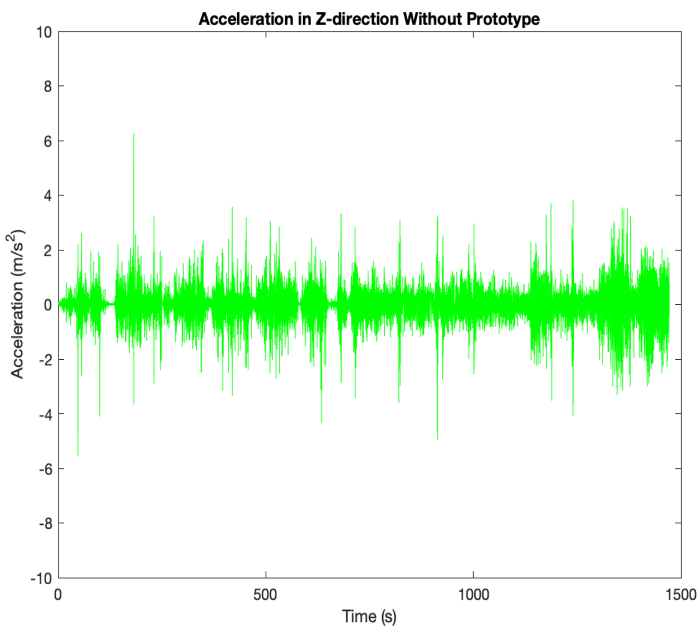
Date: May 3, 2023

Content by: Sydney Polzin & Nicole Parmenter

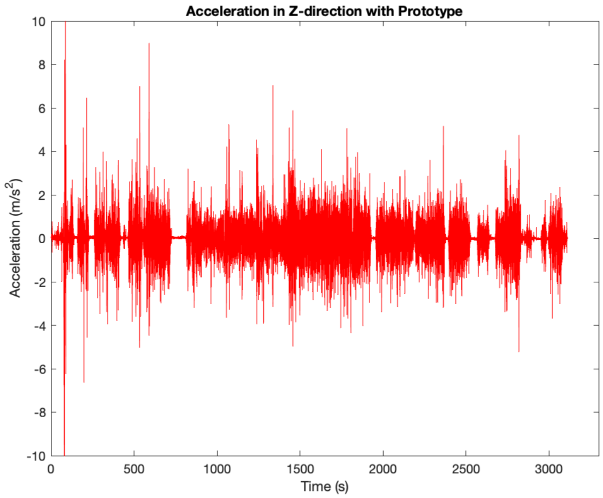
Present: Team

Goals: Share the results from the accelerometer, specifically acceleration

Content:

- 

- The graph above is the raw acceleration in the isolette without the prototype in m/s^2.



-
- The graph above is the raw acceleration in the isolette with the prototype in m/s^2.
- Acceleration was not decreased below the threshold from literature of 0.315 m/s^2.
- The percentage of acceleration samples exceeding the recommended threshold increased slightly with the prototype.
- The data without the prototype is only for half the amount of time as the data with the prototype because of accelerometer technology difficulties.
    - Factors such as the difference in ride length, stopping at red lights, and traffic patterns also had an impact on the acceleration periods in the data collected
- More testing samples from additional rides are required to confirm the significance of the presented findings.

Conclusions/action items:

Use these acceleration plots and conclusions to drive further testing.

2023/05/03 - Statistics

Sydney Polzin - May 03, 2023, 4:14 PM CDT

Title: Statistics

Date: May 3, 2023

Content by: Nicole Parmenter

Present: Team

Goals: Analyze the statistics of the PSD plots of data with and without the prototype.

Content:

	# of Number of Significant Bins	**% Significant**
Fall 2022 Prototype	163	65.2%
Spring 2023 Prototype	106	42.4%

- Each data set was split into 250 bins and a Welch's t-test was performed on corresponding data points from the two PSDs for each bin.
- A bin is significant if the p value is less than 0.05

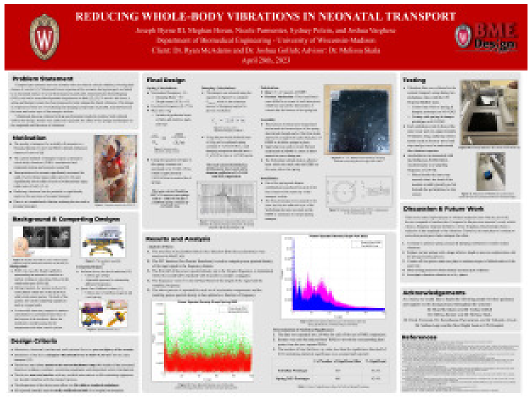
- The prototype from last semester had 163 significant bins out of the 250 bins and this semester's prototype had 106 significant bins out of the 250
    - indicates there was a more distinct change in vibrations when last semester's prototype was used compared to this semester's
    - The more significant change when the Fall 2022 prototype is used is due to the shift in large power amplitudes to lower frequencies.
    - When the Spring 2023 prototype is used, the change is less significant, as the power is reduced across all frequencies and not moved to a different frequency.

Conclusions/action items:

The 2022 prototype had more significant bins than the 2023 prototype, but this is due to the 2022 prototype shifting the high power amplitudes to different frequencies while the 2023 prototype reduced power over all frequencies.

Final Poster - S23

Meghan Horan - Apr 30, 2023, 2:18 PM CDT



Download

Spring_2023_Final_Poster.pptx_1_.pdf (2.6 MB)

2023/01/30 - Client Meeting Prep

Meghan Horan - Jan 30, 2023, 6:31 PM CST

Title: Client Meeting Prep

Date: 1.30.23

Content by: Meghan Horan

Present: Meghan Horan & Josh Varghese

Goals: To prepare for initial client meeting tomorrow to discuss the direction of the design for this semester.

Content:

- Prep client agenda provided in Google drive
- Lots of repeat questions from initial meeting last semester -- won't need to ask them all again
- PDS will be similar to PDS from last semester -- need to copy in and revise it
- Meeting to see hospital & equipment on Friday, Feb. 3

Conclusions/action items: Inform team to review agenda before meeting tomorrow.

2023/02/03 - Meeting with Dr. Arvelo

Sydney Polzin - Feb 03, 2023, 1:51 PM CST

Title: Team Meeting/Meeting with Dr. Arvelo

Date: 2/3/2023

Content by: Full team

Present: Full team & Dr. Arvelo

Goals: Narrow the scope of testing with Dr. Arvelo's help to clearly define numeric testing goals for this semester.

Content:

- How could we use accelerometer data to see if the vibrations have reduced? Or is there another type of sensor that we should be using to get this data?
    - Separate the data into x, y, and z components > Apply an fft to isolate frequency components > Use detrend to remove the best straight-fit line > PLot amplitude vs. frequency
    - Process seems right. We can send the code to Dr. Arvelo once we get that together.
- Are there any metrics in addition to the accelerometer data that we should collect during testing?
    - Accelerometer should be enough. Maybe we can map this to the speed of the ambulance if we can get that data from the hospital.
- How much data do we need to collect? How many trials should we run?
    - A couple of weeks should be enough to get the data to converge
- If we have some trials that are different lengths of time (5 minutes vs. 45 minutes) or different paths (side streets vs. highways), can these be combined?
    - Again, find convergence
- https://www.amazon.com/Extech-VB300-Vibration-Data-Logger/dp/B007ICEJTQ?th=1
- https://www.pcb.com/industrial-sensors/industrial-hygiene/human-vibration#:~:text=The%20HVM200%20is%20a%20small,needed%20to%20measure%20human%20vibration.
- http://www.larsondavis.com/docs/librariesprovider2/brochures/ld-hvm200-human-vibration-meter-(md-0394).pdf?sfvrsn=fa5d672c_12
-

Notes:

- Research frequency of vibrations and if there are any values that are damaging
    - Last semester collected 0 to 50 Hz
- High value at 0 Hz indicates bias in measurement
- Include the x, y, and z data separately
- Smooth function that envelopes peaks - percentage reduction
- Normalize data collection so that when comparing the data sets conclusions can be drawn without other variables altering the data
- Show what frequencies work well and which don’t to determine which frequencies should be damped
- Look more into the physics of it

Conclusions/action items:

Collect more data with an accelerometer but split the data into x, y, and z parts. Possibly buy one of the linked accelerometers.

2023/02/09 - Meeting with Dr. Nimunkar

Sydney Polzin - Feb 09, 2023, 12:02 PM CST

Title: Meeting with Dr. Nimunkar

Date: 2/9/2023

Content by: Nicole Parmenter, Sydney Polzin, Joey Byrne

Present: Nicole Parmenter, Sydney Polzin, Joey Byrne

Goals: Discuss accelerometer purchase for testing.

Content:

Notes:

- Did accelerometer lab (didn't do lab but have slides) in 310 - have code and sensor
    - $12 sensor sparkfun triple axis sensor
        - Use breadboard initially and get BCB board eventually
        - Capacitive based
- Labs at ECB or morgridge institute - connect with them
    - Team Lab
    - Have devices that measure vibrations when they install equipment in labs to make sure their values aren't altered
- Figure out tolerance of vibrations that client is looking for
- Figure out ambulance acceleration
- Doesn't think we should keep focusing energy on looking for an accelerometer
- Vibration sensor - measure Hz
- Look into potentially measuring both vibrations and acceleration

Conclusions/action items:

Probably don't buy an accelerometer yet and focus efforts on the actual design. Potentially use a phone again.

2023/02/10 - Meeting with Dr. Frank Fronczak

Sydney Polzin - Feb 10, 2023, 2:51 PM CST

Title: Meeting with Dr. Frank Fronczak

Date: February 10, 2023

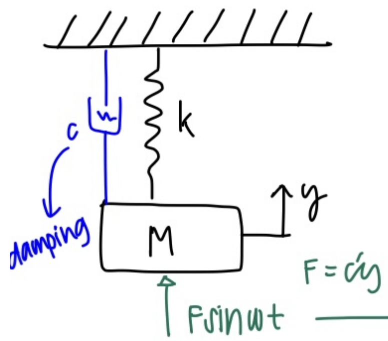
Content by: Full Team

Present: Full Team & Dr. Fronczak

Goals: To learn more about vibrations

Content:

- Attenuation vs. Damping
  - Attenuation: reducing levels of vibration
  - Damping: dispersing energy
- Viscous Damping - damping proportional to velocity
  - Easiest differential equations
- Other options: dry damping, aerodynamic damping
- Damper is a subtype of vibrational attenuation system
  - Design last semester was a system that attenuated vibrations
- Knowledge, skill, and attitude
- Mass, compliance (stiffness f = kx, k = stiffness), damping all in a dynamic system (cantilever beam)
  - Vibration decays over time due to damping (friction between fibers)
  - Q factor is a measure of internal damping
    - High Q (quiescent = quiet) means a lot of internal damping
- Natural frequency = the level of frequency at which there is no effect of friction
- Natural frequency is different from damping frequency
- Get familiar with modeling systems - Simulink
- For 2 masses: between n1 and n2, there is a place where is 0 at 2M2
- Chapters 6-8 of introduction to dynamic system analysis



"natural frequency"

$$\omega_n = \sqrt{\frac{k}{m}} \leftarrow \text{mass}$$

$$\omega_n = \sqrt{\frac{lb/in}{lb \cdot s^2/in}}$$

$$\omega_n = \frac{1}{s^2} \quad (rad/s)$$

gives the relationship between ω and f → $f \ \frac{cyc}{sec}$ Hz

$$\omega \ \frac{rad}{sec} = 2\pi \ \frac{rad}{cyc} \cdot f \ \frac{cyc}{sec}$$

$W_T = mg$

$$m = \frac{W_T}{g} = \frac{lb}{386 \ in/s^2}$$

$$m \ \frac{lb \ s^2}{in}$$

$$c = \frac{F}{V} = \frac{F}{\dot{x}}$$

$F = ky$

$$K = \frac{F}{x}$$

$$lb = \frac{lb}{in} \cdot in$$

$m\uparrow = \omega\downarrow$

K unchanged

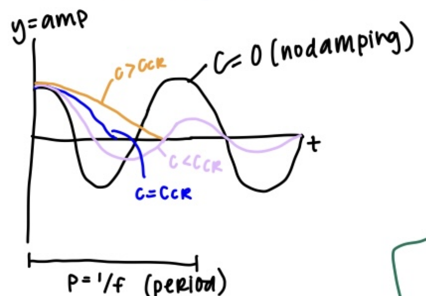
↑ length = change K

= ↓ω

$\omega = 2\pi f$

$F = ma$

if there is damping, the frequency changes a bit



*natural frequency is a hypothetical value

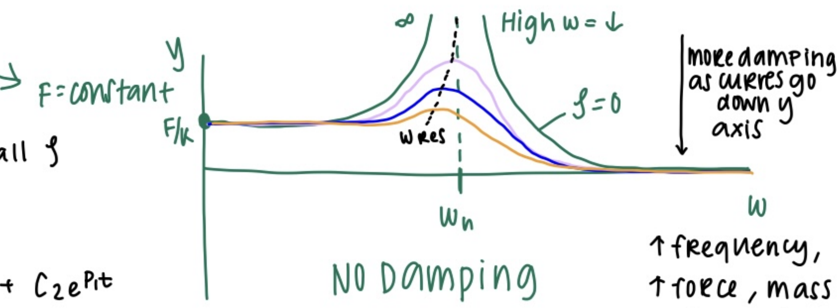
$$\omega_d = \omega_n \sqrt{1 - \zeta^2}$$

$$\zeta = \frac{c}{c_{cr}}$$

↑ damping ratio

$\omega_d \approx \omega_n$ for small ζ

$y = C_1 e^{P_1 t} + C_2 e^{P_2 t}$ OR $C_1 e^{P_2 t} + C_2 e^{P_1 t}$

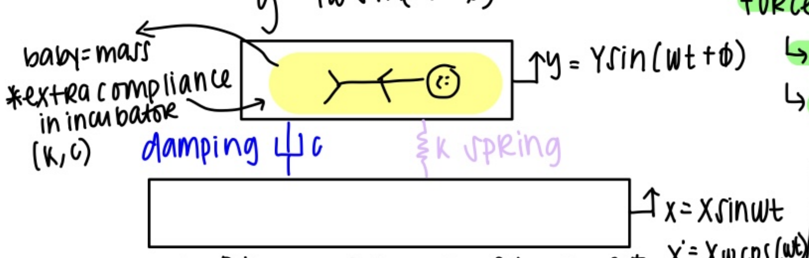


↑ frequency, ↑ force, mass does not move

$$\omega_{res} = \omega_n \sqrt{1 - 2\zeta^2}$$

power

$$\ddot{y} = Y\omega^2 \sin(\omega t + \phi)$$



$y_1 = C_1 e^{P_1 t} + C_2 e^{P_2 t} + C_3 e^{P_3 t} + C_4 e^{P_4 t}$

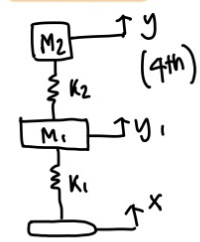
ω_{n1} — if complex conjugates — ω_{n2}

force greater than tissue

↳ reduce acceleration

↳ can't change ω (excitation frequency)

multiple Degrees of Freedom

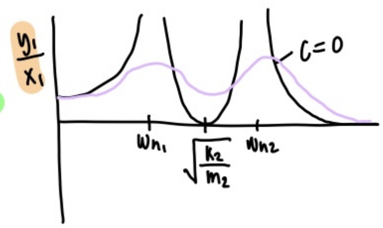


m, k, and c

*can adjust k and C to alter output/input ratio

*want 1 degree of freedom: 1 input, 1 output

*change resonant freq and amplitude



Conclusions/action items:

Continue to understand the physics behind frequency and vibrations and how this applies to our project.

2022/02/14 - Design Matrix Meeting

Sydney Polzin - Feb 14, 2023, 7:48 PM CST

Title: Design Matrix Meeting

Date: February 14, 2022

Content by: Sydney Polzin

Present: Full Team

Goals: Share the design matrix and notes from the team meeting

Content:

The team met to discuss designs and evaluate the design matrix. Each team member created two designs prior to the meeting and presented them to the team. The team then discussed the designs and determined which characteristics individuals liked and disliked, and based on those conversations, three designs were chosen to be put into the design matrix. These three designs included a spring and damper design, a spring viscous damper design, and the original design from last semester.

The team then proceeded to create six criteria to evaluate the designs against and determine their importance to the project. Ranked from highest importance (greatest ranked) to lowest, the criteria were efficacy of vibration reduction, accessibility to neonate, compatibility with equipment, ease of fabrication, safety, and cost. Each of the three designs were evaluated against these criteria, and the winning design ended up being the Spring and Damper design with a score of 84, just beating the original design from last semester. Attached below is a screenshot of our working design matrix.

Conclusions/action items:

Advisor Questions:

- Do we need CAD models?
    - Can we use already existing models and then cite them in presentations and reports?

- Start working on preliminary presentation
- Get CAD models created or find online if given permission to

Sydney Polzin - Feb 14, 2023, 7:48 PM CST

		Spring & Damper Design 		Spring Viscous Damper		Composite Gel Damper Continuation 	
	Weight	Score	Total	Score	Total	Score	Total
Efficacy of Vibration Reduction	25	5	25	4	20	3	15
Accessibility to Neonate	20	4	16	5	20	4	16
Compatibility with Equipment	20	4	16	3	12	5	20
Ease of Fabrication	15	3	9	2	6	4	12
Safety	10	5	10	4	8	5	10
Cost	10	4	8	3	6	5	10
TOTAL	**100**	**84**		**72**		**83**	

Download

Screenshot_2023-02-14_at_7.48.05_PM.png (192 kB)

2023/03/03 - Meeting with Dr.Thevamaran

Meghan Horan - Mar 03, 2023, 11:23 AM CST

Title: Meeting with Dr. Thevamaran

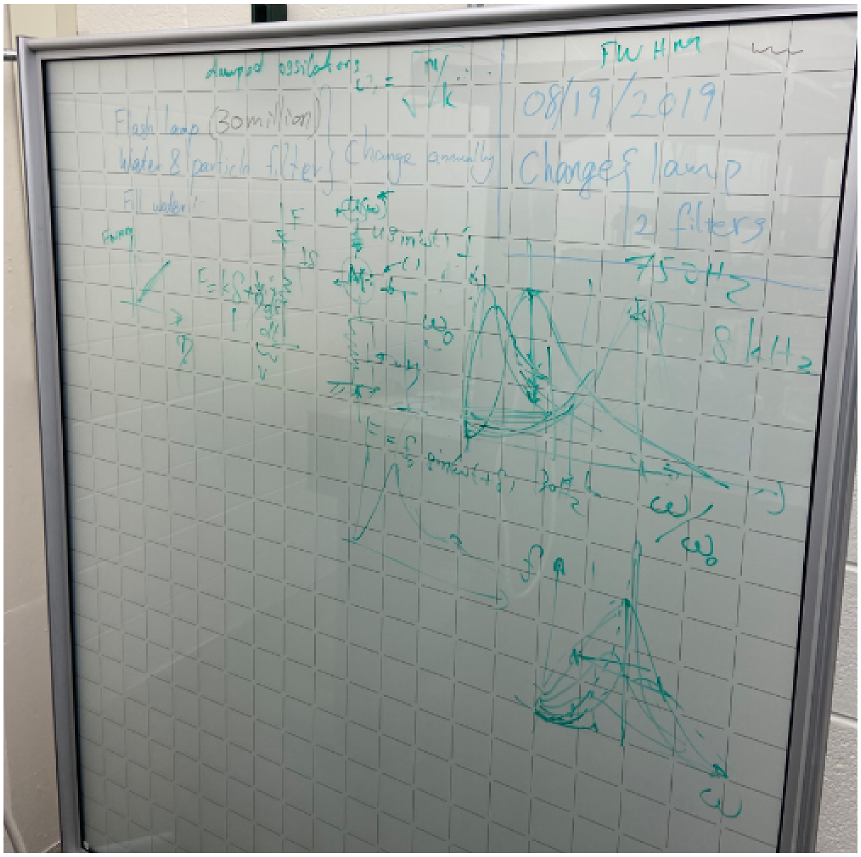
Date: 3/3/2023

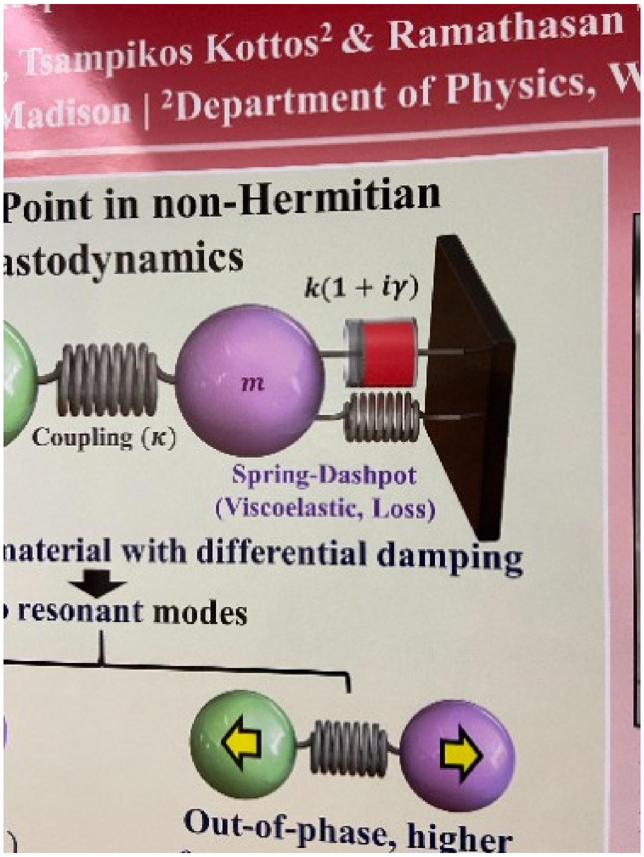
Content by: Full Team

Present: Meghan Horan, Josh Varghese, Sydney Polzin, Nicole Parmenter

Goals: To narrow down methods for testing and learn about spring damper systems.

Content:

- Dr. Thevamaran showed us his lab and said we could conduct vibration testing there.
- He went over some theory behind spring damper systems (shown in photo below).
    - Increasing the mass of the tray by a significant enough amount could make the variable masses of the neonates insignificant
    - We can have a more basic mass design where the baby and tray are one mass or a more advanced design where the baby and tray are separate masses and a spring separates them.
    - He thinks we will be able to move the large peak to a low enough frequency (~1Hz) which won't be harmful to the neonate.
- We discussed testing methods and he thinks accelerometers are one of the best ways to test.
- He offered to put us in contact with some of his students who are working on magnetic damping systems and know about purchasing accelerometers
- 



Conclusions/action items:

We will use the theory we discussed in our design and look into accelerometers we discussed. Also, we will likely use the lab for testing before testing in an ambulance because the lab testing reduces variables.

2023/03/28 - Design Consultation with Prof. Fronczak

Meghan Horan - Mar 28, 2023, 6:13 PM CDT

Title: Design Consultation with Prof. Fronczak

Date: 2023/03/28

Content by: Meghan Horan

Present: Full team + Prof. Fronczak

Goals: To pick springs and spring constants to use in design

Content:

- movement is coupled
- 6 degrees of movement in any rigid object
- need bearings to fix motion in other 5 directions so we can just work in the z-plane
- definitely want the damper and spring in parallel
- Series - involves one first order equation and one 3rd order equation
- first try to design it as a single degree of freedom with 2nd order differential equation
    - try to achieve without exterior hardware -- not likely to work :(
    - need to reduce 6 degrees of freedom into one with kinematic constraints
    - also allows you to estimate mass as a point mass
        - e.g. include linear bushings
            - rod goes through hold in platform and pushes directly on spring (could be on top and bottom)
            - put 4, one on each corner
        - Other ways to do it: can use leaf spring to prevent roll (but not pitch)
- Springs
    - Coil Springs
        - flat wire (what we have) -- lesson common because there is a shear stress in torsion
        - round wire (more common because it is more efficient use of the material)
        - conical
    - Beam Spring
        - cantilever
        - leaf (takes away 3 degrees of freedom, and only have to worry about pitch and roll)
            - https://www.swisco.com/Leaf-Spring/pd/Panel-Insert-Replacement-Tension-Springs/70-194?gclid=CjwKCAjwoIqhBhAGEiwArXT7K4t-RLCC57ZbFiGew8IS8oecdQH_QNeeirMGEaDG8EfB3ZhaeX6_uBoC-ZEQAvD_BwE
        - air
        - air/oil
- Damping
    - no damping gives best vibration isolation response (w = sqrt(k)/m) but this isn't the best for if it gets hit and needs to absorb shock
    - once it gets knocked, it will vibrate at damped natural frequency and will continue bouncing forever with zero damping
        - critical damping will stop vibration without overshooting/oscillation
        - you want it equal to one to get critical damping
        - this is at odds with the best vibration isolation response
    - you have to find a balance between the two based on which is more important
- Could add second mass and spring between base and tray to reduce vibration to zero at all frequencies (potential for future work?) = **vibration absorber**
- realogical currents = changes viscosity based on voltage applied to it (future work with active suspension system)
- want a sqrt(k)/m about 3x greater than Wn (graph on page 144 is the solution to the differential equation 715) -- Joey wrote it down
- Wn = sqrt(4k)/m for 4 springs
- Wn does not change when we add dampers
- random but remember to cite this textbook in the final paper
- zeta = c/c(critical)
- use zeta from that same chart, c(critical) = 2*sqrt(mk)
    - m = moving mass
    - k = spring constant effective (of all 4 springs) AKA 4k
- Do this for both 17Hz and 7Hz -- see what spring works experimentally

- put damping (zeta) at 0.2
- zeta = sum of all 4 zetas from dampers -- could also put one in the middle

Conclusions/action items: Look at chart to find spring constant that we want. Calculate what damping coefficient we need accordingly. Order sorbothane durometer based on that. Construct prelim prototype. Investigate options to limit motion in other 5 directions

2023/04/15 - Fabrication Meeting

Sydney Polzin - Apr 17, 2023, 6:37 PM CDT

Title: Fabrication Meeting

Date: April 15, 2023

Content by: Sydney Polzin

Present: Full team

Goals: To share information supporting the fabrication of the design

Content:

See the Fabrication section for further details on the elaborate fabrication process.

- Initial idea was to super glue the springs onto the pieces of plastic
    - Concern with reducing the functionality of the springs
    - Springs also would not stick to the plastic when glued
- Decided to drill three holes into the plastic and use a string to secure the spring through those three holes.
- Used the adhesive from the sorbothane material to secure the damping material onto the plastic on the side of the spring
- Placed the spring in a corner in series
- Covered the majority of the surface with sorbothane material

Conclusions/action items:

Test in the ambulance with the device.

2023/04/25 - Design Review with Prof. Fronczak

Meghan Horan - Apr 25, 2023, 6:53 PM CDT

Title: Design Review with Prof Fronczak

Date: 2023/04/25

Content by: Meghan Horan

Present: Meghan, Josh, & Prof Fronczak

Goals: To make plan for design improvements next semester

Content:

- stiffness is inversely proportional to the length of the spring
- thicker material = less stiffness
- try with just spring & take damping material off
  - right now our damper is being both a damper and a spring because it comes back
- try free response testing -- try doing it without any damper at all
  - just push down on plate and let it rebound
  - accelerometer is sitting on top
  - you will get a graph like Fig 6-6 (textbook)
    - damping = frequency will change a little bit
    - no damping = will oscillate forever
  - would give damped natural frequency
  - reduction in amplitude between peaks
    - delta = natural log (yn/yn+1)
    - zeta = delta / sqrt (4pi^2 + delta^2)
- we will need a true viscous damper -- you can make one fairly easily???
  - little piston that moves up and down in a little container with fluid
    - less damping = less viscous fluid
    - more damping = bigger diameter/smaller gap
  - alternatives to dry viscous damper
  - dry friction damper
    - sintered bronze absorbs oil to lubricate it -- depending on what oil you put on, you could have viscous damping
    - aluminum on bronze works well
  - leaf spring leaves have friction so you could have one component with two things (damping and spring)
- Instron testing
  - take small sample piece
  - impart motion or force (either one) to sample
  - measure velocity and force
    - F = c* y_dot -- to get damping coefficient of a given area
- damping is likely function of area and thickness

Conclusions/action items: Aims for next semester include recalculating and optimizing spring constants, purchasing taller springs (to prevent mounting issues), recharacterizing damper & potentially building a viscous damper, doing Instron testing

2023/03/01-Whole Body Vibrations In Neonatal Care

Joseph Byrne - Mar 01, 2023, 1:22 AM CST

Title: Whole-Body Vibration Exposure from Incubators in the Neonatal Care Setting

Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: Understand the prevalence of whole body vibrations in neonatal transport and the consequences.

Link: https://www.jenvoh.com/jenvoh-articles/wholebody-vibration-exposure-from-incubators-in-the-neonatal-care-setting-a-review.pdf

Citation: M. McCallig and V. Pakrashi, “Whole-Body Vibration Exposure from Incubators in the Neonatal Care Setting: A Review,” Journal of Environmental and Occupational Health, vol. 11, no. 2, pp. 37–46, Feb. 2021.

Content:

Prevalence:

1 in 10 babies (roughly 15 million) are born prematurely worldwide each year. That's one premature baby every 116 minutes. These numbers do not even count critically ill neonates due to birth defects. With this included, the need for neonatal transport becomes apparent.

Limits:

ISO2631-1:1997 sets comfort limits for whole body vibrations as summarized in the following table:

Vibration Emission (ms^2)	Comfort Scale Rating
<0.315 ms^2	Not uncomfortable
0.315 ms^2 to 0.63 ms^2	A little uncomfortable
0.5 ms^2 to 1 ms^2	Fairly uncomfortable
0.8 ms^2 to 1.6 ms^2	Uncomfortable
1.25 ms^2 to 2.5 ms^2	Very uncomfortable
>2.5 ms^2	Extremely uncomfort-able

Conclusions/action items:

Improving vibrations (i.e. reducing vibrations) has the potential to impact a large population. Using the standards in the table, the team can design a device which maximizes comfort levels.

2023/03/01- Neonatal Head and Torso Vibration Response

Joseph Byrne - Mar 01, 2023, 1:44 AM CST

Title: Neonatal head and torso vibration exposure during inter-hospital transfer

Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To understand the effects of vibrations on neonates and why they are so susceptible to injury.

Content:

Inter-hospital transport of critically ill neonates is associated with increased morbidity and brain injury. The most common brain injury due to vibration is intraventricular hemorrhaging (IVH), which is most commonly found in outborn and transferred neonates (compared to inborn). The mechanism for this injury is fluctuating blood flow to the brain and can be the result of vibrations. In animal studies, it was found that vibrations can cause adverse consequences on the respiratory system and cardiovascular status. Another study regarding mechanical resonance in adult brains concluded that there is a dangerous frequency (somewhere in the range of 5 - 20 Hz) of vibrations where brain motion is maximized. Additionally, there is an association between road transport and higher heart rates and peripheral blood leukocyte counts.

Conclusions/action items:

The effects of vibrations on human brains and morbidity are numerous. This background information is good to know for understanding the importance of the project and underlying mechanisms for neonatal injury during transport.

2023/03/01- Infant care transport device

Joseph Byrne - Mar 01, 2023, 2:26 AM CST

Title: Infant care transport device with shock and vibration system

Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Link: https://patentimages.storage.googleapis.com/b8/34/55/d31a977ac1c80f/US10555858.pdf

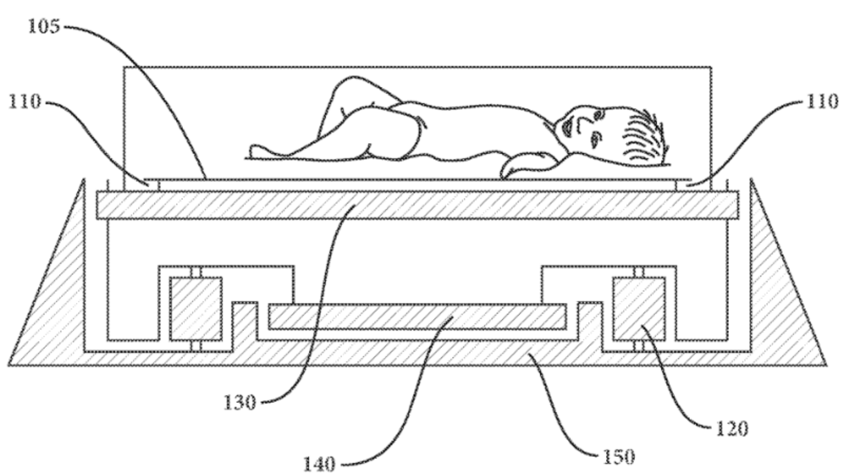
Citation: P. D. Sabota, “Infant care transport device with shock and vibration system,” 11-Feb-2020.

Goals: To analyze a competing design to identify what it does well and where it could use improvements.

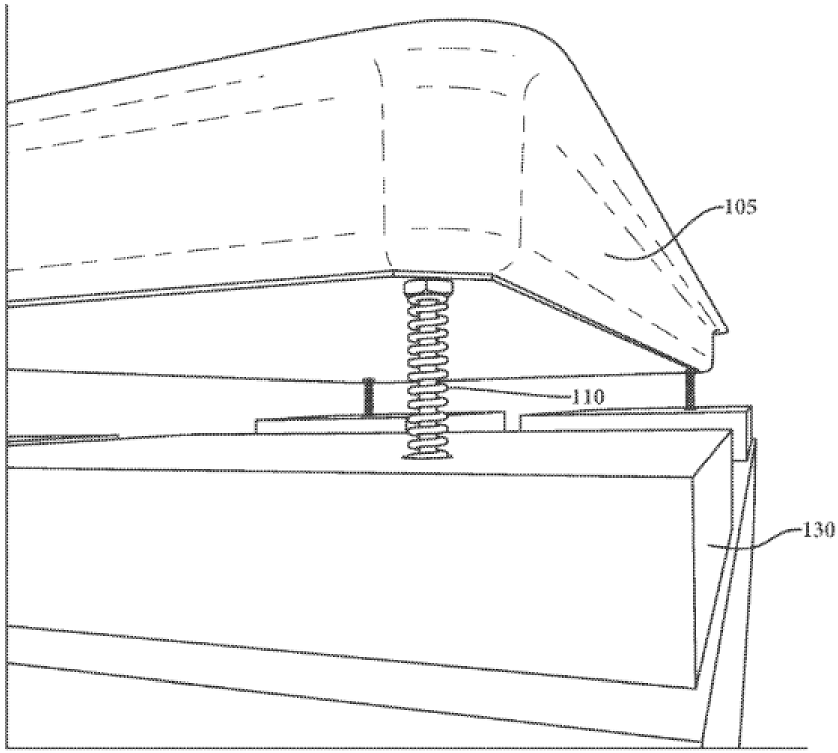
Content:

The infant care transport device with shock and vibration system, as designed by Peter Sabota, features multiple shock and vibration damping systems incorporated in the main structure (i.e. incubator control box) of the incubator setup. There is a set of z-, x-, and y- axis dampers to attenuate vibrations in each direction. Additionally, a floating patient support system allows the patient to move along with motion rather than being attached to a rigid frame as seen in current setups. The floating system includes a fail-safe mode where, under extreme conditions, the free movement along each axis is limited. Schematics for this design are shown in the images below. This design is protected by U.S. Patent US10555858B2.

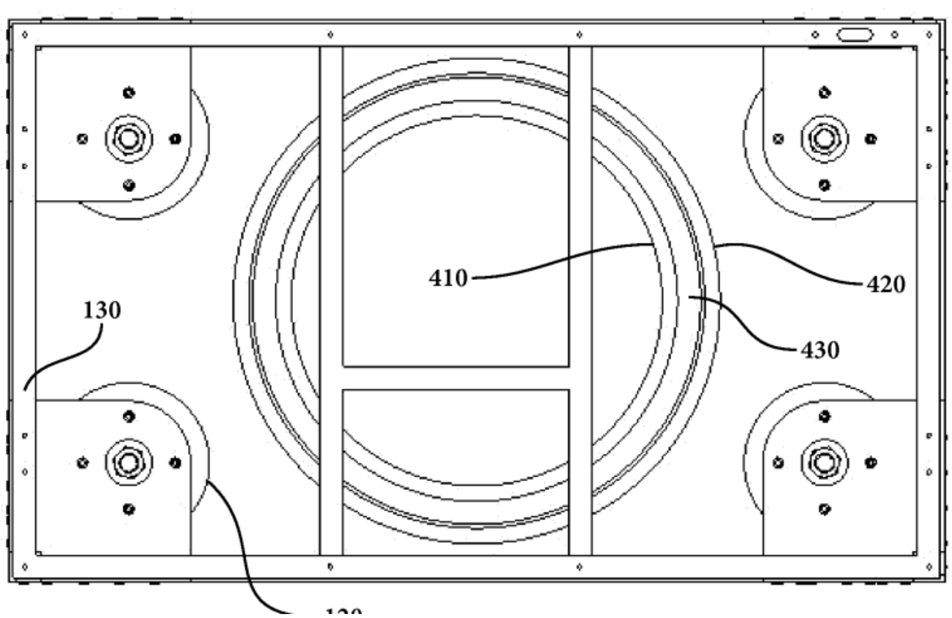
The diagram below depicts the overall layout of the design, where 110 is z-axis bed dampers, 120 is z-axis isolators, and 140 is a radial x-,y-axis damper.



The image below shows a conceptual view of the z-axis bed dampers (shown as springs, #110 in image above) creating a free-floating support system.



The subsequent image is a top-view of the radial x-y axis damper.



Conclusions/action items:

This design features several dampers, isolators, and design concepts which may effectively reduce vibrations in transport. Since a lot of the components are similar to our chosen design, it may be useful to refer to this design for further ideas.

2023/02/07- Class II Medical Devices

Joseph Byrne - Feb 07, 2023, 9:32 PM CST

Title: Class II Medical Devices

Date: 2/7/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To understand the special requirements that class II medical devices must meet.

Link: https://www.fda.gov/medical-devices/guidance-documents-medical-devices-and-radiation-emitting-products/class-ii-special-controls-documents

Citation: Class II Special Controls Documents (no date) U.S. Food and Drug Administration. FDA. Available at: https://www.fda.gov/medical-devices/guidance-documents-medical-devices-and-radiation-emitting-products/class-ii-special-controls-documents (Accessed: February 7, 2023).

Content:

Class II medical devices are the second tier of regulated medical devices. Whereas Type I medical devices must follow the requirements of the "general controls," class II devices are subject to both general and "special controls."

General controls are explained under Section 513(a)(1)(A) of the Federal Food, Drug, and Cosmetic Act and outline basic safety and efficacy standards.

Special controls are explained under Section Section 513(a)(1)(B) of the Federal Food, Drug, and Cosmetic Act. These are more in-depth safety and efficacy standards including declared performance standards, post-market surveillance, and development and dissemination of guidelines.

In some cases where a device is not exempt from premarket notification, a substantial equivalence determination must be received as explained in sections 510(k) and 513(i).

Conclusions/action items:

While there are many more specific requirements for a class II medical device, these are the broad sections which can be further studied for more detail. Since our prospective device is likely a class II device, these standards should be followed in the design process.

2023/02/07- Quality System Regulation

Joseph Byrne - Feb 07, 2023, 9:42 PM CST

Title: 21 CFR Part 820- Quality System Regulation

Date: 2/7/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To acknowledge and understand a standard which our device will need to meet.

Link: https://www.ecfr.gov/current/title-21/chapter-I/subchapter-H/part-820

Citation: “21 CFR Part 820 -- Quality System Regulation.” https://www.ecfr.gov/current/title-21/chapter-I/subchapter-H/part-820 (accessed Feb. 07, 2023).

Content:

This section details requirements for the manufacture, packaging, labeling, storage, installation, and servicing of medical devices. It primarily sets standards for manufacturers of finished medical devices. In general, it describes guidelines for quality, organizational structure, responsibility, resources for employees and the device, management, review, planning, and system procedures.

Conclusions/action items:

This section outlines the manufacturing requirements of medical devices. As we fabricate our prototype, it will be important to keep these guidelines in mind.

2023/02/22- Magnetic Vibration Damper

Joseph Byrne - Feb 22, 2023, 1:04 AM CST

Title: Passive Electromagnetic Devices for Vibration Damping and Isolation

Date: 2/22/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Link: https://www.hindawi.com/journals/sv/2019/1250707/

Citation: E. Diez-Jimenez, R. Rizzo, M.-J. Gómez-García, and E. Corral-Abad, “Review of passive electromagnetic devices for vibration damping and isolation,” *Shock and Vibration*, pp. 1–16, Aug. 2019.

Goals: To understand the benefits and mechanisms for how magnetic damper systems work.

Content:

Passive electromagnetic devices for vibration, damping, and isolation (PEDVDI) provide good damping capacity, low cost production, null power consumption, and high reliability. The three most commonly used materials for these devices include (a) paramagnetic, (b) soft ferromagnetic, and (c) hard ferromagnetic.

Paramagnetic: Paramagnetic metals include aluminum, titanium, copper or some polymers. The conductivity of the material must be considered because while paramagnetic materials are weakly affected by external static magnetic fields, they are reactive to alternant magnetic fields.

Ferromagnetic: Ferromagnetic materials are not affected by external magnetic fields. Soft ferromagnetic materials are characterized by low remanence and low coercive field while hard ferromagnetic materials are characterized by large remanence and a large coercive field. Hard ferromagnetic materials are difficult to demagnetize.

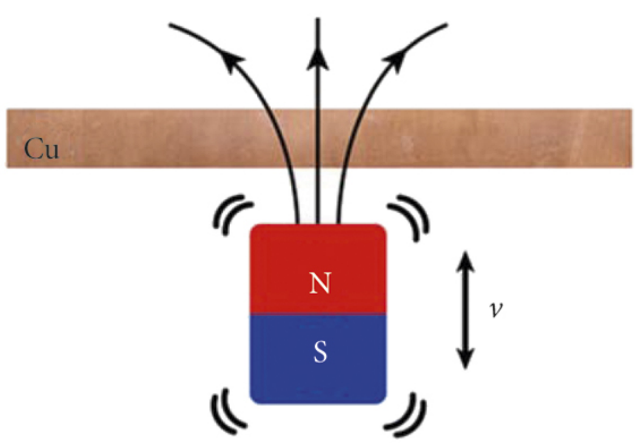
Magnetic materials exert forces between one another characterized by: (B=Magnetic Flux Density, M*Vol = volumetric magnetization, H=coercivity)

$$\overrightarrow{F_{12}} = \nabla\left(\overrightarrow{m_2}\cdot\overrightarrow{B_{\text{applied by 1}}}\right) = \nabla\left(\overrightarrow{M_2}\cdot \text{Vol}_2\cdot\mu_0\cdot\overrightarrow{H_{\text{applied by 1}}}\right)$$

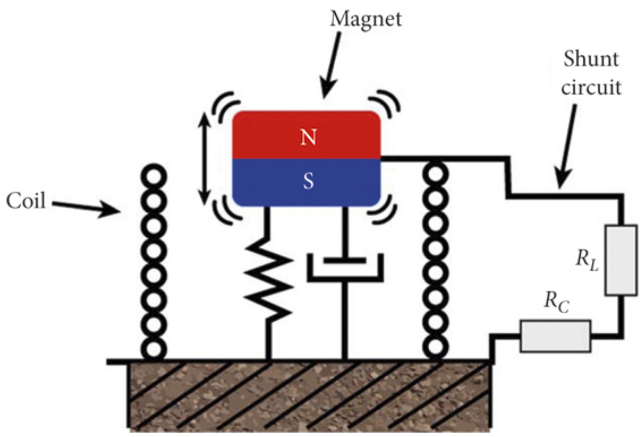
Additionally, magnetic materials produce Eddy currents. The generation of such currents is linked to mechanical damping. The mechanical power loss from a viscous damper can be described as: (P= power loss, FD= damping force, v= moving mass speed)

$$P = F_D \cdot v$$

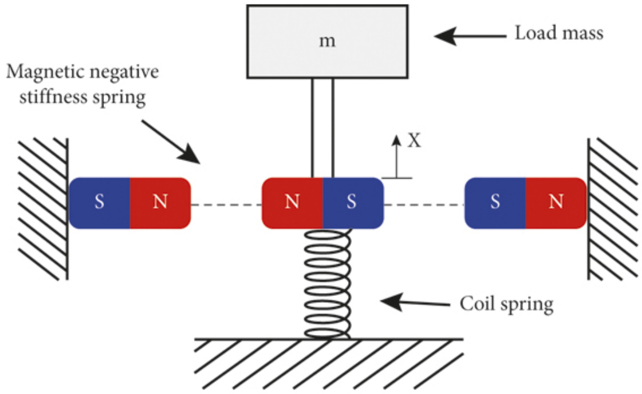
Therefore, one kind of damper that can be made is an Eddy Current Damper which utilizes the interaction of a nonmagnetic conductive material (e.g., copper) and a time varying magnetic field created by a moving magnet. As the magnet moves towards the material, Eddy currents are generated which induces a magnetic field of opposite polarity, thus generating a repulsive electromotive force. Due to the internal resistance of the material, the movement is dissipated into heat and energy is removed.



Another kind of damper outlined is a Electromagnetic Shunt Damper. The energy from mechanical oscillation of a magnet on a spring is converted to electrical energy via a electromagnetic motor. The shunt circuit allows for easy design, passive control, energy harvesting, and motion multiplication.



A third type of damper is the Magnetic Negative-Stiffness Dampers. These type of dampers employ a unique mechanical concept in low-frequency vibration isolation. A stiff spring oriented vertically supports a weight load and vertical-motion isolation. Three magnets placed in the same horizontal plane create a negative-stiffness spring for displacements above and below a preload equilibrium point. With this design, dynamic stiffness is minimized, resonance frequency is lowered, and vibration damping is enhanced for higher frequencies.



Conclusions/action items:

These magnetic damper concepts can be used for a similar design which reduces vibrations in neonatal transport. The final design, the Magnetic Negative-Stiffness Dampers, might be particularly useful because it accounts for motion in the vertical and horizontal planes. These concepts should be reviewed when finalizing the details for the spring damper design.

2023/03/01- Radial Damper

Joseph Byrne - Mar 01, 2023, 3:09 AM CST

Title: Squeeze Film Damper Modeling

Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

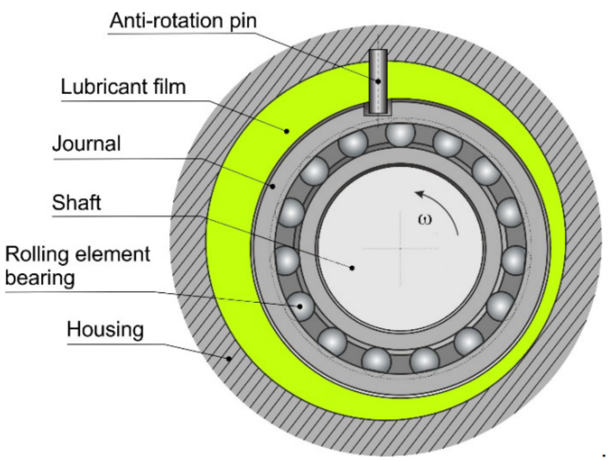
Goals: To understand a commonly used damping technique that could potentially attenuate vibrations in a radial plane.

Link: https://www.mdpi.com/2075-1702/10/9/781

Citation: E. Gheller, S. Chatterton, A. Vania, and P. Pennacchi, “Squeeze film damper modeling: A comprehensive approach,” Machines, vol. 10, no. 9, p. 781, Sep. 2022.

Content:

Squeeze film dampers are a common mechanism for reducing vibrations in rotating machines. The machine, located in the middle of the damper, has a layer of rolling bearings surrounding it which allow movement and rotation in all directions. The vibration from the machine is transferred to the external ring of the bearing which squeezes the lubricant film, therefore generating high dynamic pressures. Dynamic forces oppose this lateral displacement which generates the damping effect. A anti-rotation pin can be applied as well to reduce spinning motion.



Conclusions/action items:

Although this idea applies to rotating machines (as opposed to the incubator which will not be rotating), parts of the design could be used to potentially create a radial, planar damper to reduce motion in a flat plane. For example, the incubator could rest on a radial damper which allows movement in the horizontal plane (without rotation), but is slowed due to a lubricant film damper. This possibility has important implications regarding the effects of rotational and translational forces (i.e. acceleration and deceleration) in neonatal transport.

2023/03/01- How Isolation Works

Joseph Byrne - Mar 01, 2023, 1:56 PM CST

Title: How Isolation Works

Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Link: https://www.kineticsystems.com/how-isolation-works/

Citation: “How Isolation Works,” Kinetic Systems, 11-Oct-2019. [Online]. Available: https://www.kineticsystems.com/how-isolation-works/. [Accessed: 01-Mar-2023].

Goals: To understand how isolation and damping work in vibration attenuation systems.

Content:

- Natural Frequency:
  - periodic sinusoidal oscillations (or free vibration) at a specific frequency after a stimulus has been removed.
  - For simple isolation systems (e.g. the one depicted at the bottom of the page), the natural frequency can be described by: $f_n = 3.13\ (K/W)^{1/2}$
- Damping
  - Serves as an energy dissipation dashpot to limit magnification.
  - Critical damping is the value of damping necessary for a system to not oscillate after being disturbed.
    - Critical damping of a simple isolation system can be represented by: $c_c = 78.96\ (mf_n{}^2)$
  - Damping is proportional to velocity
    - Forces due to damping are desirable at resonance to oppose magnification but are less desirable at high frequencies because it tends to negate vibration attenuation.
- Forced Vibration, Transmissibility and Resonance
  - Transmissibility is the absolute value of the mass response amplitude expressed as a ratio.
    - $$|y/x| = T = \left\{ \frac{1 + [2(f/f_n)\ (c/c_c)]^2}{[1 - (f/f_n)^2]^2 + [2(f/f_n)\ (c/c_c)\ ]^2} \right\}^{1/2}$$
    - Maximum transmissibility can be represented by $T\ max = Q = 1/2\ c_c$
  - Resonance occurs if an external vibration is applied at a frequency that corresponds to the natural frequency.
- Air Spring Stiffness and Natural Frequency
  - Compressed air provides low stiffness properties for efficient broad frequency band isolation.
  - Air spring stiffness (K) is represented by $K = PA^2 / V$
  - Increasing air volume in the spring leads to lower system natural frequency.

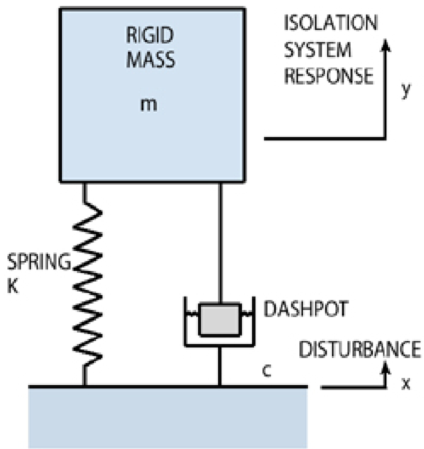


FIGURE 42.1
Typical Isolator Represented as a Mass, Spring and Dashpot

Conclusions/action items:

Isolation systems are useful ways to attenuate vibrations passively. These ideas and equations can be used to effectively design and fabricate our spring and damper prototype.

2023/04/06-Unconstrained and Constrained Layer Damping

Joseph Byrne - Apr 06, 2023, 4:01 PM CDT

Title: Unconstrained Versus Constrained Layer Damping

Date: 4/6/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To understand the type of damping we will use by inserting a layer of damping material into our design.

Link(s):

https://www.sciencedirect.com/science/article/pii/B9780128199541000137

https://pubs.acs.org/doi/pdf/10.1021/bk-1990-0424.ch001

Citation(s):

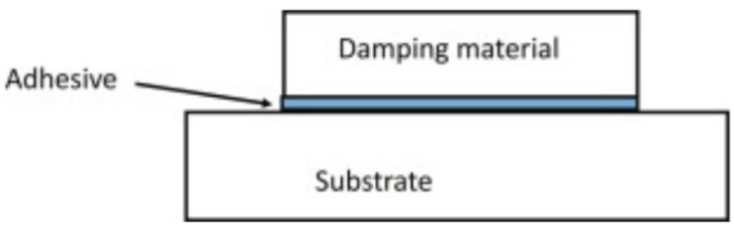
M. Hildebrand and R. D. Adams, "12 - Vibration damping," in *Adhesive Bonding (Second Edition)*, R. D. Adams, Ed., Second Edition.in Woodhead Publishing Series in Welding and Other Joining Technologies. Woodhead Publishing, 2021, pp. 367–384. doi: https://doi.org/10.1016/B978-0-12-819954-1.00013-7.

L. H. Sperling, "Sound and vibration damping with polymers," ACS Symposium Series, pp. 5–22, 1990.

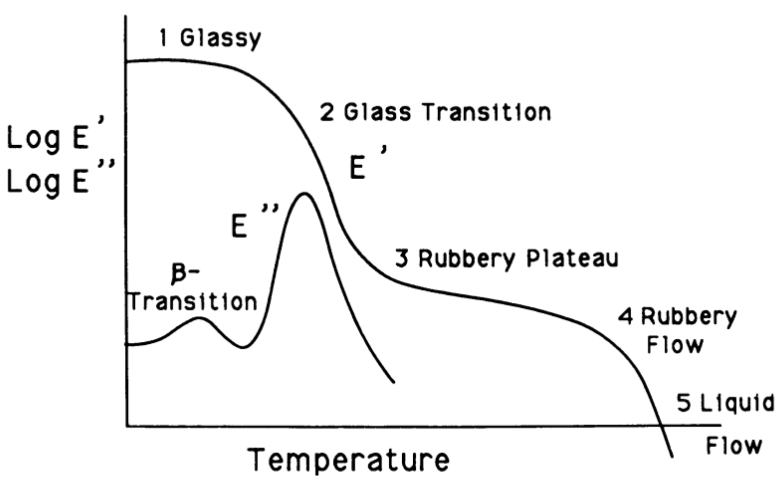
Content:

Both unconstrained and constrained layer damping involve a layer of damping material.

- **Unconstrained Layer Damping**
  - Involves bonding a damping layer to a stiffer object using an adhesive (see diagram below)

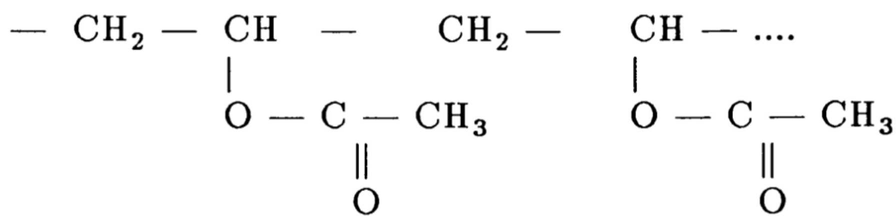


  -
  - The damping coefficient for this system depends on the ratio of total energy dissipated to total energy stored.
  - Polymer materials can be blended together
    - Damping is effective over limited frequency range when material is below its glass transition temperature (see below). This is the temperature at which bond rotation and intramolecular movement ceases.



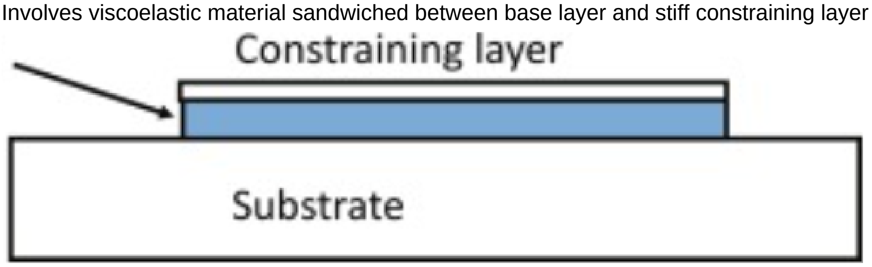
    -
    - Polymers that can be used include poly(vinyl acetate) (inorganic), poly(dimethyl siloxane) (inorganic), polyethylene (organic), cis-polyisoprene (organic, natural rubber), cellulose (organic), and poly(methyl

methacrylate) (organic).
- (Below) Structure of poly(vinyl acetate) commonly used in damping materials.



- Polymers can be synthesized using condensation or addition reactions.
  - Condensation requires two monomers which form covalent bond with elimination of small molecule
  - Addition requires polymer with double bond or an initiator molecule.

- **Constrained Layer Damping (CLD)**
  - Considered more effective than unconstrained layer damping
  - Involves viscoelastic material sandwiched between base layer and stiff constraining layer (see schematic below):



  - Temperature and frequency range considerations also apply for CLD as applied for ULD.

Conclusions/action items:

The above systems describe the implementation of layer dampers. Since we are planning to use damping material between two rigid trays, the system of our design is more like the constrained layer damping system. One concern with these systems is they often describe flexural systems and stresses whereas we are dealing with translational stresses.

2014/05/01-Sorbothane Damping Material

Joseph Byrne - May 01, 2023, 12:10 AM CDT

Title: Sorbothane Damping Material

Date: 5/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To understand how Sorbothane works as a damping material.

Link(s):

https://www.sorbothane.com/technical-data/material-properties/

https://www.sorbothane.com/wp-content/uploads/Sorbothane-EDG.pdf

Citation:

“Engineering design guide: Your enhanced guide to sorbothane shock & vibration solutions,” *Sorbothane*, 2018. [Online]. Available: https://www.sorbothane.com/wp-content/uploads/Sorbothane-EDG.pdf. [Accessed: 01-May-2023].

Content:

Sorbothane is a thermoset, polyether-based, polyurethane material. It is considered viscoelastic with a high damping coefficient. Benefits of Sorbothane include its shock absorption, good memory, vibration isolation, low creep rate, and damping abilities. Its operating temperature range is -20° to +160° Fahrenheit (-29° to 72° Celsius).

The material properties of Sorbothane are included in the table below:

Material Properties of Sorbothane®

PROPERTY	DUROMETER (SHORE 00)			UNITS	NOTES
	30	50	70		
Tensile Strength at Break	26	107	191	psi	ASTM D 412-06a
Elongation at Break	334	765	388	%	ASTM D 412-06a
Compression Set	10	3	2	%	ASTM D 395
Bulk Modulus	4.5	5.0	4.3	gPascal	
Density	83	84	85	lb/ft³	ASTME D 792-13
Optimum Performance Temperature Range	-20° to +140°	-20° to +150°	-20° to +160°	°F	Reduced strength and damping up to 200°F. Increrased spring rate down to glass transition temperature.
Fungal Resistance	No Growth				ASTM G 22

While Sorbothane has many uses, its uses relating to vibration damping follow the behavior described by the following equations:

$$\text{Compressive Modulus} = \frac{\text{Cs}}{\text{Assumed Percent Deflection}/100}$$

• See Figu
• See Page

$$\text{Corrected Compressive Modulus} = (\text{Compressive Modulus}) \times [1 + 2 \times SF^2]$$

$$\text{Compressive Modulus} = \frac{\text{Cs}}{\text{Assumed Percent Deflection}/100}$$

• See Figu
• See Page

$$\text{Corrected Compressive Modulus} = (\text{Compressive Modulus}) \times [1 + 2 \times SF^2]$$

$$\text{Dynamic Spring Rate } (K_{dyn}) = \frac{E_{dyn} \times (1 + 2 \times SF^2) \times \text{Loaded Area}}{\text{Thickness}}$$

$$\text{System Natural Frequency } (f_n) = \frac{\sqrt{K_{dyn} \times \text{gravity} \,/\, \text{Load per Isolator}}}{2\pi}$$

Example calculations for Sorbothane in a vibrational analysis are shown below:

VIBRATION

Assumptions:
- Total load is 1720 lbs
- Excitation frequency is 50 Hz
- Load is evenly distributed across all pads
- Use 4 pads in each corner
- 4 inch by 4 inch by 2 thick pads
- 70 Durometer
- 15% compression

$$\text{Shape Factor} = \frac{(4\text{ in}) \times (4\text{ in})}{(4\text{ in}) \times (2\text{ in}) \times (4\text{ sides})} = \boxed{0.5}$$

$$\text{Compressive Modulus} = \frac{20.3\text{ psi}}{15/100} = \boxed{135.33\text{ psi}}$$

$$\text{Corrected Compressive Modulus for SF} = (135.33\text{ psi})(1 + (2)(0.5^2)) = \boxed{203\text{ psi}}$$

$$\text{Static Deflection} = \frac{\left(\frac{1720\text{ lbs}}{4\text{ parts}}\right) \times (2\text{ in})}{(203\text{ psi})(4\text{ in} \times 4\text{ in})} = \boxed{0.2648\text{ in}}$$

$$\text{Percent Deflection} = \frac{0.2648\text{ in}}{2\text{ in}} \times 100 = \boxed{13.2\%}$$

Assume a Natural Frequency of 8 Hz

Dynamic Compressive Modulus (E_{dyn}) = 217 psi

$$\text{Dynamic Spring Rate } (K') = \frac{(217\text{ psi}) \times (1 + 2\,(0.5^2)) \times (4\text{ in} \times 4\text{ in})}{(2\text{ in})} = \boxed{2600\text{ lb/in}}$$

$$\text{Natural Frequency} = \frac{1}{2\pi} \times \sqrt{\frac{2600\text{ lb/in} \times 386\text{ in/sec}^2}{430\text{ lbs}}} = \boxed{7.69\text{ Hz}}$$

$$\text{Frequency Ratio} = \frac{50\text{ Hz}}{7.69\text{ Hz}} = \boxed{6.50}$$

$$\text{Transmissibility} = \sqrt{\frac{1 + 0.37^2}{\left(1-(6.50^2)\left(\frac{217\text{ psi}}{334\text{ psi}}\right)\right)^2 + (0.37^2)}} = \boxed{0.04}$$

$$\text{Percent Isolation} = (1 - 0.04) \times 100 = \boxed{96\%}$$

Conclusions/action items:

Sorbothane is a damping material with a high damping coefficient commonly used in vibration reducing applications. Its damping abilities and operational temperature range make it a good choice for the spring and damper design used in a hot environment (the incubator).

2023/02/26-Spring and Damper Physics

Joseph Byrne - Feb 27, 2023, 12:03 AM CST

Title: Spring And Damper Physics

Date: 2/26/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Link: https://ccrma.stanford.edu/CCRMA/Courses/152/vibrating_systems.html

Citation: G. P. Scavone, "Vibrating Systems," 1999. [Online].
Available: https://ccrma.stanford.edu/CCRMA/Courses/152/vibrating_systems.html. [Accessed: 26-Feb-2023].

Goals: To understand the physics of springs and dampers in order to effectively design a vibration-attenuation device.

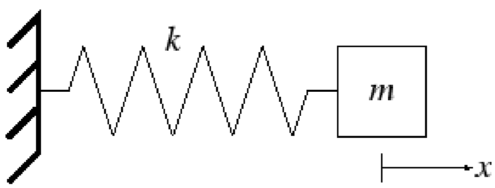
Content:

Ideal springs have no mass or internal damping. They have no energy losses and thus, the total energy of a mass-spring system is constant. The general equation for the force generated by a spring is Hooke's Law, where a spring's equilibrium is when x=0.

$$F = -kx$$

In the equation above, k is the spring constant and x is the displacement. In a mass-spring system, the force of the mass and the force of the spring can be demonstrated by the following second-order differential equation and diagram:

$$m\frac{d^2x}{dt^2} + kx = 0$$



Where m is the mass. The general solution is as follows:

$$x = A\cos(\omega_0 t + \phi)$$

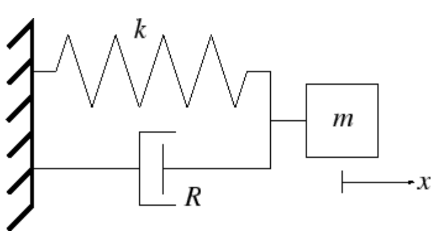
In this equation, A is the amplitude of the oscillation, Wo is the angular frequency, t is time, and phi is the phase constant.

For dampers, the force due to mechanical resistance or viscosity is typically proportional to velocity and can be represented by:

$$F = Rv = R\frac{dx}{dt}$$

where R is resistance and v is velocity. A damper-spring-mass system can be represented by the following second-order differential equation and diagram:

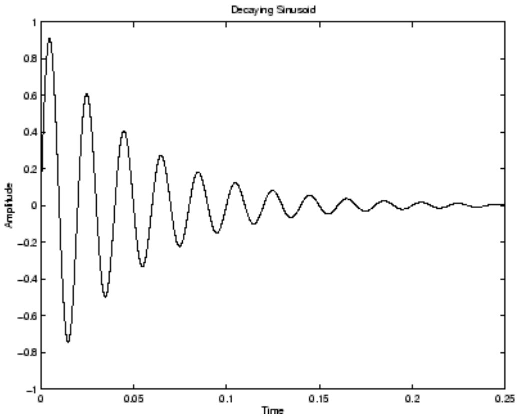
$$m\frac{d^2x}{dt^2} + R\frac{dx}{dt} + kx = 0$$



Which has the general solution:

$$x = e^{-\alpha t} A\cos(\omega_d t + \phi)$$

The result of a damper-spring-mass system is a damping effect shown in the following figure:



Conclusions/action items:

The equations above can be used for general spring-damper systems. The chosen final prototype for this semester was the spring and damper design, so these equations can be useful for determining which springs and dampers need to be used.

2023/03/29- Fronczak Physics

Joseph Byrne - Mar 29, 2023, 8:18 PM CDT

Title: Spring and Damper Physics

Date: 3/29/2023

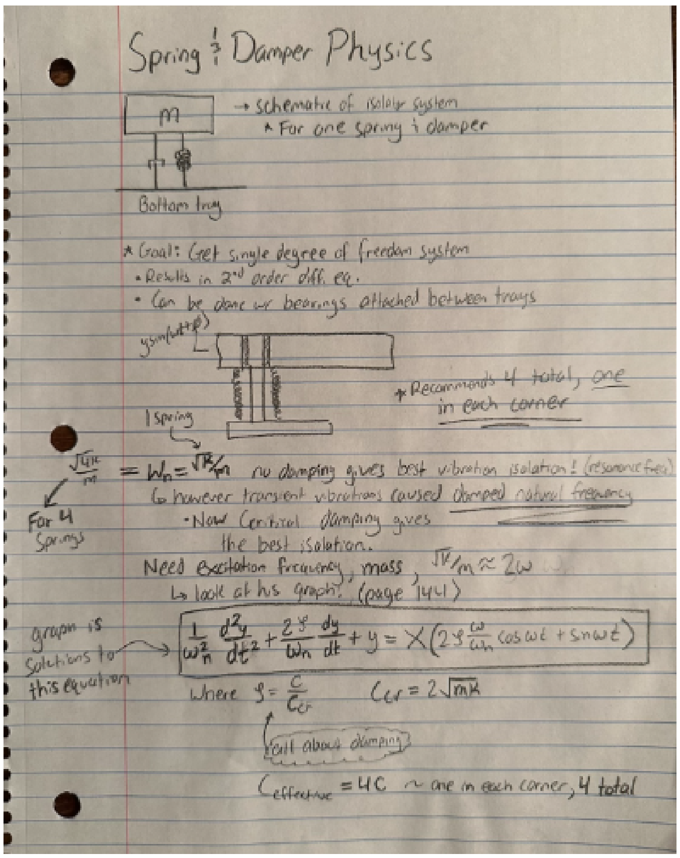
Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To understand the necessary diagrams, equations, and concepts to calculate the necessary constants relating to the spring and damper design.

Content:

The notes below were taken during a meeting with professor Frank Fronczak, an expert in vibrational mechanics:



Conclusions/action items:

The schematics and equations in the notes are for a one degree of freedom spring and damper system. This type of system is possible for our design and simplifies the calculations. Using the equation and an associated table in a textbook which Fronczak shared with us, we can calculate the spring constant in order to buy the right springs.

2023/04/02-Spring Constant Calculation

Joseph Byrne - Apr 02, 2023, 10:46 PM CDT

Title: Calculation for Spring Constant

Date: 4/2/2023

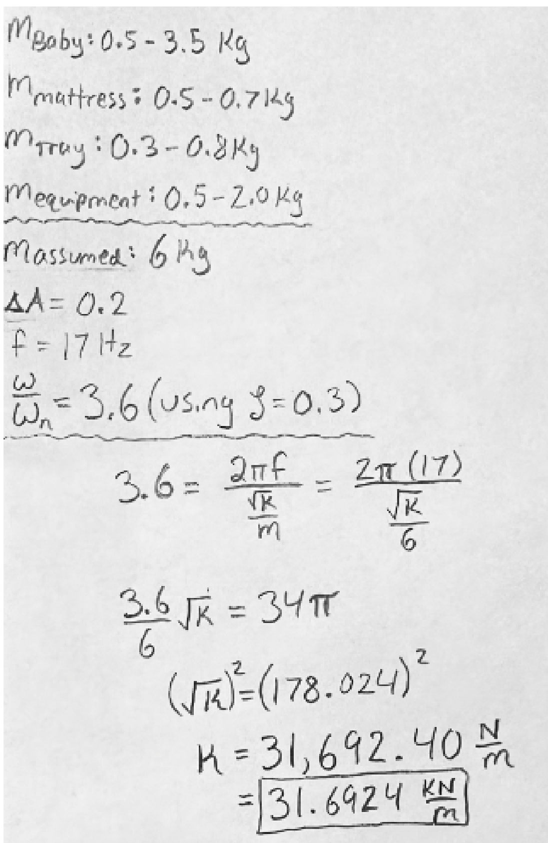
Content by: Joseph Byrne

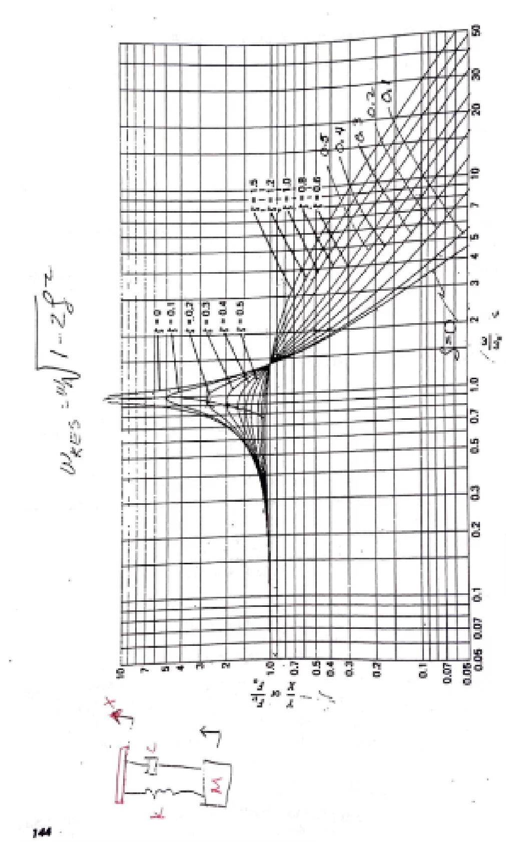
Present: Joseph Byrne

Goals: To calculate the spring constant so we can purchase the necessary springs.

Content:

The calculations below were used to calculate the necessary spring constant for the springs we use. The mass used was determined by summing the mass ranges of the various things that will be pressing down on the springs. Delta A is the change in amplitude desired and the y-axis of the graph used to determine the w/wn ratio (see graph in second picture). "f" is the excitation frequency and was determined using data from last semester, which indicated large peaks in power for 17 Hz frequency. The ratio w/wn is the x-axis of the graph on the right and was determined to be 3.6 given a change in amplitude of 0.2. From these values, the mathematical relationships, w = 2*pi*f and wn= sqrt(k)/m, were used to derive the spring constant. Note this is the total spring constant for the system. We will use 4 total springs in our design, so the final value needs to be divided by 4. Therefore, the spring constant of each spring should be 7.923 kN/m.





Conclusions/action items:

The calculations above were used to solve for the spring constant of the springs used in our design. Four springs with constants of 7.923 kN/m should be purchased for use in the design.

2023/02/13- Magnetic Spring Attenuator

Joseph Byrne - Feb 13, 2023, 9:43 PM CST

Title: Magnetic Spring Attenuator Design

Date: 2/13/2023

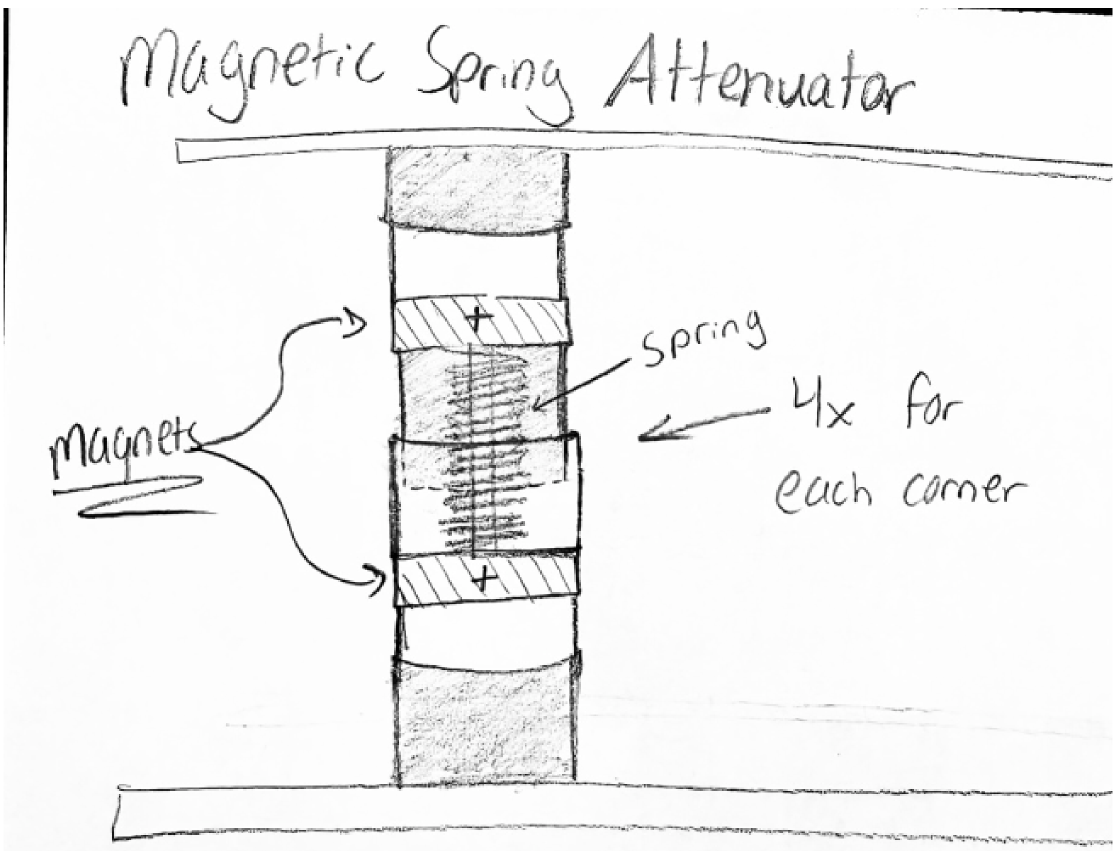
Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To explain and understand a potential design idea for reducing vibrations.

Content:

The magnetic spring attenuator uses a pair of repelling magnets attached by a spring in a vertical column of sliding cylinders. As seen for one cylinder in the schematic below, the magnets are stacked vertically and contain the same charge; When vibrations cause the magnets to move towards each other, they act to reduce the vibrations by causing motion which opposes the vibration. The central compression spring aids in reducing both upwards and downwards motion caused by vibration by stretching and compressing itself. Four cylinders can be created for each corner of a platform which the neonate rests on.



Shown below is a conceptual, simplified prototype of the design:

Conclusions/action items:

The magnetic spring attenuator has all the pieces needed to oppose motion caused by vibrations. The design should be considered by the team and compared to other designs.

2023/02/13-Active Damper System

Joseph Byrne - Feb 13, 2023, 10:34 PM CST

Title: Active Damping System

Date: 2/13/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To analyze a potential design idea for its merits and downfalls.

Helpful Links:

1. https://www.herzan.com/resources/technology/active-vibration-control.html#:~:text=Active%20vibration%20control%20systems%2C%20also,virtue%20of%20their%20mechanical%20structure.

- Look under "PRINCIPLES OF OPERATION" section

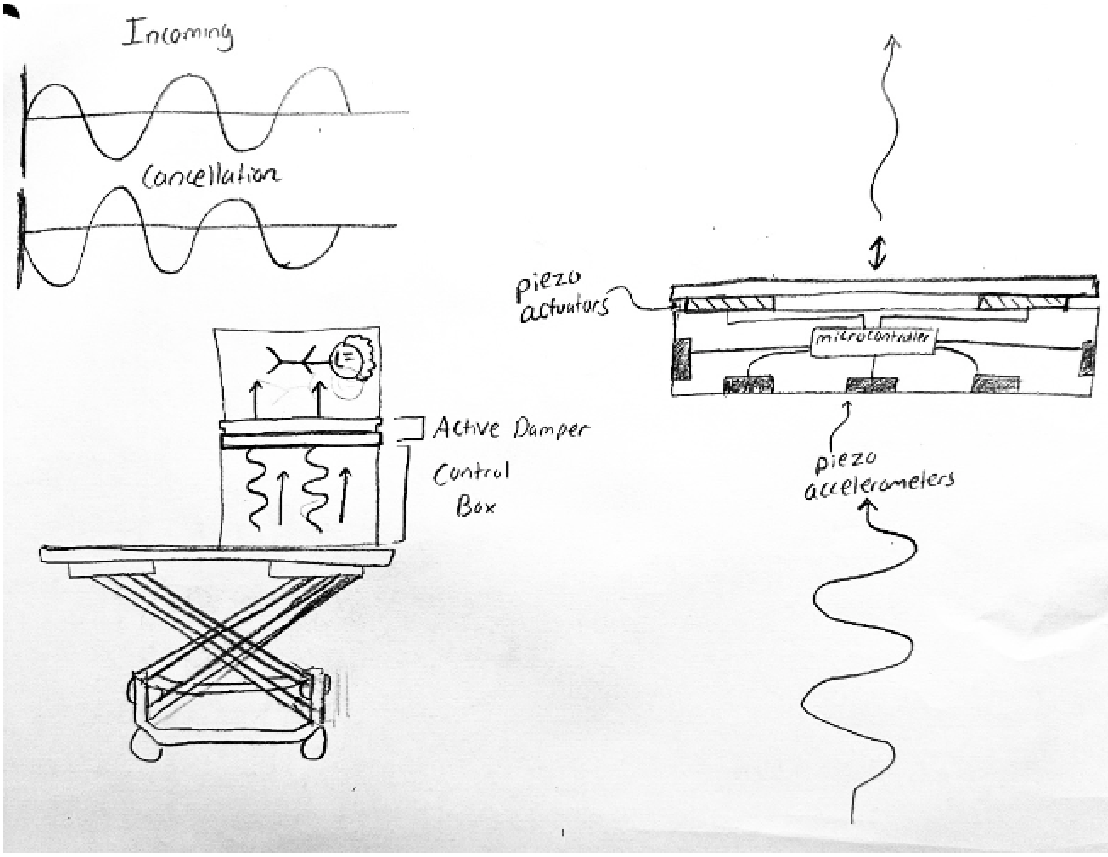
2. https://www.herzan.com/products/active-vibration-control.html

- Similar Active Vibration Systems

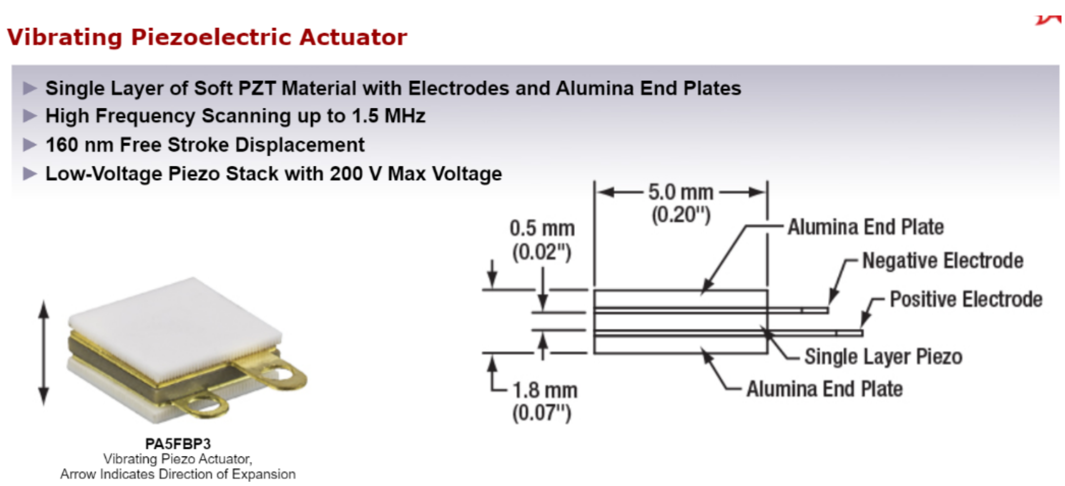
Citation: *Active vibration control* (2016) *Active Vibration Control*. Herzan. Available at: https://www.herzan.com/resources/technology/active-vibration-control.html (Accessed: February 13, 2023).

Content:

The Active Damper idea uses cancellation techniques (e.g., those used in noise-cancelling headphones) to reduce vibrations felt above its platform. The Active Damper can be placed underneath the isolette in order to reduce all vibrations felt by the structure and therefore the neonate. It works by using piezo accelerometers in various configurations to sense vibrations in several degrees of freedom. The kinetic vibration energy is transformed to an electrical signal which is processed by a microcontroller. A specific algorithm can be written to effectively calculate what output vibrations need to be made to cancel the incoming vibrations. Finally, the microcontroller will send the output to piezo actuators, which vibrate out of phase in order to reduce overall motion.



An example of a piezo actuator is shown below:



Conclusions/action items:

While an active system is more complicated to make, it has the potential to be the most effective as it can completely diminish the effects of vibrations. This design should be analyzed by the team and compared to other designs.

2023/04/30-Ambulance Testing and Notes on Analysis

Joseph Byrne - Apr 30, 2023, 11:41 PM CDT

Title: Ambulance Testing and Notes on Analysis

Date: 4/30/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To show the testing procedure and outline the analysis from the data collected.

Link(s):

https://blog.endaq.com/vibration-analysis-fft-psd-and-spectrogram

https://ntrs.nasa.gov/api/citations/19970034695/downloads/19970034695.pdf

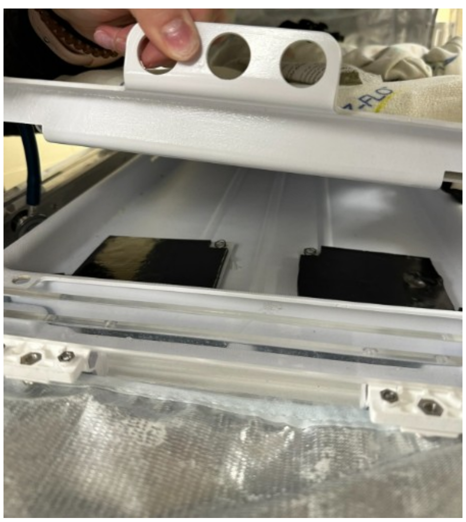
Citation(s):

Hanly, S. (no date) *Vibration analysis: FFT, PSD, and Spectrogram Basics*, *enDAQ Blog for Data Sensing and Analyzing*. Available at: https://blog.endaq.com/vibration-analysis-fft-psd-and-spectrogram (Accessed: April 30, 2023).

U.S. Department of the Interior, M. J. Rogers, K. Hrovat, K. McPherson, M. E. Moskowitz, and T. Reckart, National Aeronautics and Space Administration, 1997.

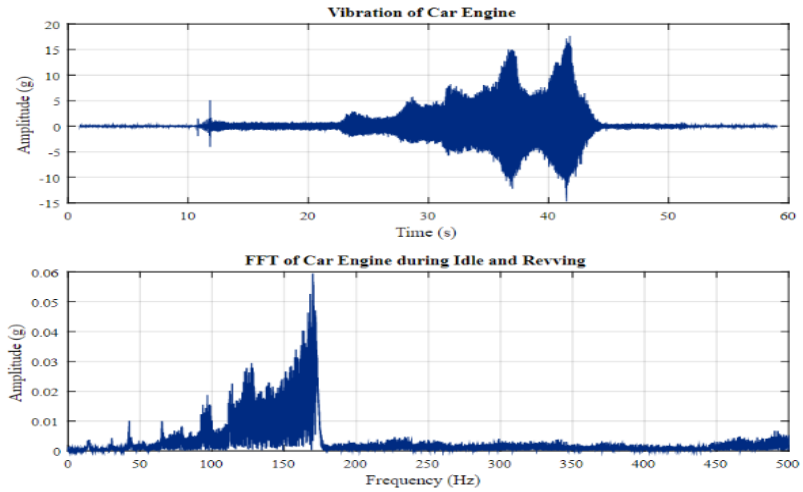
Content:

Final device testing included insertion of the prototypes between the inner and outer trays of the incubator as shown in the pictures below:



An accelerometer was placed on the tray (being lifted up in the photo above) which rested on the four spring and damper pieces to measure vibrations with the device in place.

Data was collected in the format of an acceleration versus time graph for the duration of the testing runs. From this data, a Fast Fourier Transform (FFT) can be constructed. To do this, the time domain must be converted to a frequency domain by calculating a frequency response function which is (accelerometer data) / (excitation) and then plotting this against frequency. Alternatively, Matlab can do this transformation for you. An example of this transformation is shown below:



In order to draw more meaningful conclusions, a Power Spectral Density (PSD) versus frequency graph can be generated from the FFT to gain information about the power of vibrations at different frequency values. To compute this, the following calculations can be carried out (or alternatively, Matlab can do this for you using `dspdata.psd(Data) or pwelch(x) commands):`

For even N:

$$PSD(m) = \begin{cases} \dfrac{2|F(m)|^2}{N\,U\,f_s} & [\text{units}^2/\text{Hz}] \quad \text{for m} = 1,2,\ldots,(N/2)-1 \\ \dfrac{|F(m)|^2}{N\,U\,f_s} & [\text{units}^2/\text{Hz}] \quad \text{for m} = 0 \text{ and m} = (N/2) \end{cases}$$

and for odd N:

$$PSD(m) = \begin{cases} \dfrac{2|F(m)|^2}{N\,U\,f_s} & [\text{units}^2/\text{Hz}] \quad \text{for m} = 1,2,\ldots,(N-1)/2 \\ \dfrac{|F(m)|^2}{N\,U\,f_s} & [\text{units}^2/\text{Hz}] \quad \text{for m} = 0 \end{cases}$$

where

$$U = \frac{1}{N}\sum_{n=0}^{N-1} {w_n}^2$$

From the PSD vs. Frequency graph, each frequency can be analyzed to determine if there was a reduction in power versus the baseline test run. Additionally, frequencies of high power can be identified or shifts in powerful frequencies can be observed.

Conclusions/action items:

By taking the accelerometer data from the testing runs, a FFT and subsequent PSD can be created to draw meaningful conclusions between baseline and final testing runs. The team should analyze the PSD's from both runs to see if there was a reduction in power, signifying a successful prototype. The team may also be able to identify particularly powerful frequencies which can then be targeted for future designs by changing spring and damping coefficients.

2023/03/01- Chemical Safety and Biosafety Training

Joseph Byrne - Mar 01, 2023, 1:49 AM CST

Title: Chemical Safety and Biosafety Training Certification

Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To document completion of the chemical safety and biosafety training courses.

Content:

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Joseph Byrne has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz	10/26/2021	10/26/2026
Chemical Safety: The OSHA Lab Standard	Final Quiz	10/26/2021	

Data Last Imported: 01/25/2023 07:27 PM

Conclusions/action items:

These certifications and the knowledge from them should be used to complete any necessary laboratory procedures related to the project.

2023/03/01- Red and Green Pass

Joseph Byrne - Mar 01, 2023, 1:53 AM CST

Title: Red and Green Permits - Team Lab

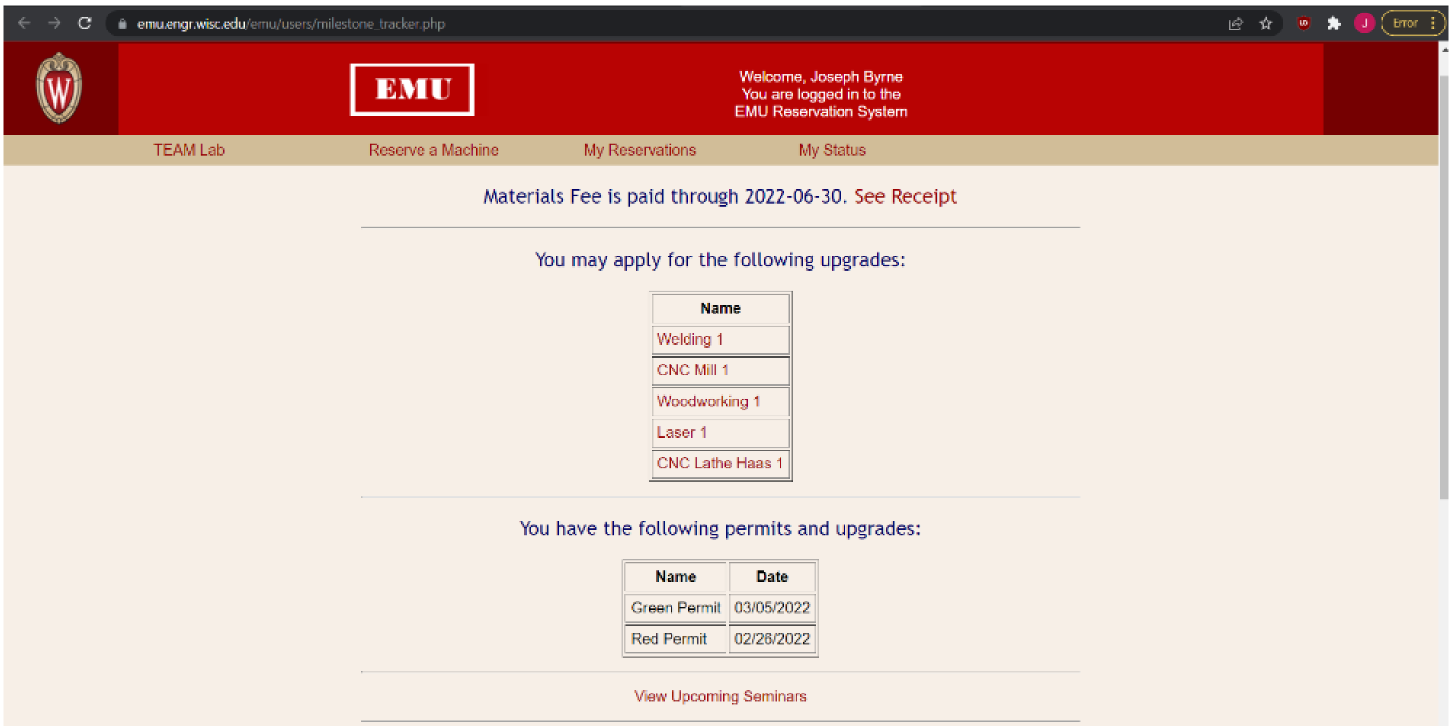
Date: 3/1/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To document completion of the red and green permit training courses.

Content:



Conclusions/action items:

These permits allow usage for a variety of tools and equipment in the UW TeamLab. These permits can be used for any machining or fabrication necessary for the project.

2023/03/10- WARF Lecture Notes

Joseph Byrne - Mar 10, 2023, 12:18 AM CST

Title: WARF Lecture Notes

Date: 3/10/2023

Content by: Joseph Byrne

Present: Joseph Byrne

Goals: To learn about intellectual property considerations that could apply to our design project.

Content:

- Warf Organization
  - Intellectual property organization
  - Governed by independent board of UW-Madison alumni
  - Chancellor has a seat on the board
  - Specifically supports UW- Madison research and helps put it out into the world
  - Uses cycle of innovation process
    - UW Research and Discovery --> IP Protection --> Licensing and Startups --> Funding to support research
    - Mainly specializes in getting patents
  - Warf puts funds back into UW-Madison through grants.
- IP General Info
  - Patents- machines, devices, compounds, processes, methods
  - Copyrights- webpages, software, literary works
  - Trademarks- Words and phrases, colors, logos, sound
  - Trade Secret is 4th type- weakest protection
    - Ex: Coca-Cola
    - Not protected once secret is out
- Prior Art
  - Any references, products, or things that exist before your idea
  - Your idea will be compared against all prior things
  - Grace Period is 12 month period where your own publications are not prior art
    - You have a year to file a patent
    - Only in the United States!
- Public Disclosure
  - Telling the public about something but not revealing all the background behind it.
    - This way no one else can copy it but they know what it is.
  - Journal publications, conference, seminars, etc.
- Requirements for patentability
  - Three key pieces
    - Eligible
    - New (novel)
    - Non-obvious
  - Others
    - Useful
    - Enabled
    - Described
  - Takes a long time to get a patent (3-5 years)
    - Costs about $30,000
- WARF's IP Management Process
  - Have you fill out 4 page document about your invention
  - A committee evaluates the document
  - Will get accepted if they think it could get a patent
  - WARF pays the $30,000 for you
  - While patent is pending, WARF markets invention
- Licensing Considerations
  - Chance- WARFS success in different areas (lots of success in medical area)
  - Timeline- What stage is the technology? How much data is available for the invention.
  - Strategy- What companies are in the market and how do they do things?

  - Plan for the next year- how much will get done?
  - Revenue Projections- how much return will be made for the university?
- What is a license?
  - Contract with company to use patent
  - Company develops technology and then gives return
  - Money comes in the form of royalties
  - Companies are given deadlines to meet or license can be terminated
- WARF Accelerator Program
  - Provide milestone based funding
  - More funding for technologies that are more promising and can be developed faster/more.
- Finding a company to license to
  - Going to companies with high promise and experience in a related field to the design
- Factors for starting a company
  - Is invention a part of a product or the whole product?
    - Whole product is easier
  - How much development and funding is needed?
  - What is the size of the market?
  - How can you get investors?
  - Resources
    - Discovery2Product is a UW resource for entrepreneurship
    - Entrepreneurons is a seminar series

Conclusions/action items:

WARF is an excellent resource for people who have novel inventions that are seeking patents and licensing. For our project, if we are able to develop a device which reduces vibrations below the target value and have adequate testing to back it up, then we could apply for a patent for our design. We would have to make sure our design meets the patentability criteria of eligibility, novelty, and not being obvious. While this type of device would likely be eligible for a patent and is likely novel seeing as there are no current devices used for this purpose, we would have to make sure that it is not obvious due to springs and dampers being common in many devices.

2023/02/06 - Neonatal head and torso vibration exposure during inter-hospital transfer

Meghan Horan - Feb 06, 2023, 8:06 PM CST

Title: Neonatal head and torso vibration exposure during inter-hospital transfer

Date: 2023/02/06

Content by: Meghan Horan

Present: Meghan Horan

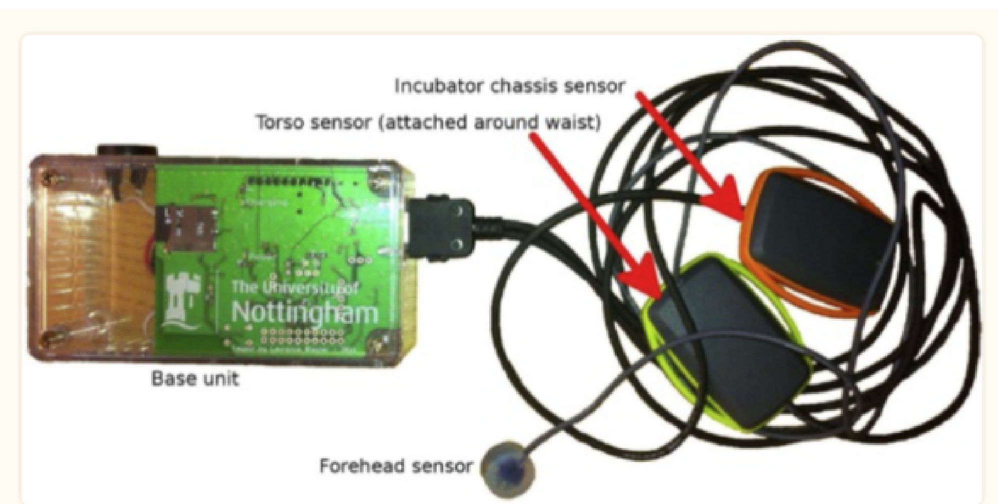
Goals: To understand what vibrations neonates are exposed to during emergency transport

Content:

- resonant frequency of mattress and harness system currently used to secure neonates is ~9Hz
- 9Hz vibration couples with vehicle chassis vibration
- direct injury from linear head acceleration was negligible
- vibration increased with vehicle speed only above 60 km/hr (37.3 mph)
- Root mean square vibration power spectral density showed that vibration exposure was high compared to adult workplace limits

sensor used = MEMS

Forehead	Accelerometer	STMicroelectronics	LSM330	1600
	Rate gyro scope and temperature			380
Torso and chassis	Accelerometer	Analog Devices	ADXL345	100
	Rate gyro scope and temperature	InvenSense	ITG-3200	100



- used LifeForm Micro-Preemie to simulate during testing
- most vibration energy was concentrated between 5-20Hz = most hazardous vibration

- likely due to engine and resonance of vehicle suspension
- vibration amplified in this range

- ISO 2631 standard says that comfort limit for maximum acceleration for human comfort in a vibrating environment is 0.315 m/s2
- WBV = quadratic mean of the weight horizontal plane and vertical axis vibration
    - EU says daily exposure action value is 0.5m/s2
- not currently standardised assessments for neonatal vibration hazards
- replacing mattress with gel or sponge just causes new issues

Conclusions/action items: Add numerical stats to PDS. Compare to other sources.

2023/02/08 - Dr. Fronczak Consultation

Meghan Horan - Feb 08, 2023, 12:56 PM CST

Title: Dr. Fronczak Consultation

Date: 2023/02/08

Content by: Meghan Horan

Present: Meghan Horan

Goals: To gain an insight into previous work with vibrations during neonatal transport.

Content:

- looking for active or passive approach?
- has anyone taken ME 340?
- Nature of vibration reduction -- wants to meet with group to give 1hr tutorial of vibrations & then we can zero in on approach to tackle specific frequencies we are looking at
- Vibration transmission from source to object
  - interject a spring and a damper between source and the thing you are trying to isolate
  - magnitude of spring constant and amount of dampening you have will determine response of mass that is moving up and down
  - only so much you can do by adjusting these values -- if you want to go further use a vibration absorber
  - tune mass and spring to a specific frequency & the absorber vibrates but the mass doesn't
  - increase range of effectiveness of frequency range but would decrease magnitude of vibration decrease
  - have a tunable vibration absorber
    - change spring stiffness
    - change effective length of cantilever beam
- Active systems
  - might be out of scope with our skill set / goal
- THIS FRIDAY!! @ 1pm
- Email: send to wisc email & frank195078@gmail.com
- CC our team members on these!

Conclusions/action items: Send out meeting location info to Prof Fronczak

2023/02/12 - Vibration Absorbers

Meghan Horan - Feb 12, 2023, 1:23 PM CST

Title: Vibration Absorbers

Date: 2023/02/12

Content by: Meghan Horan

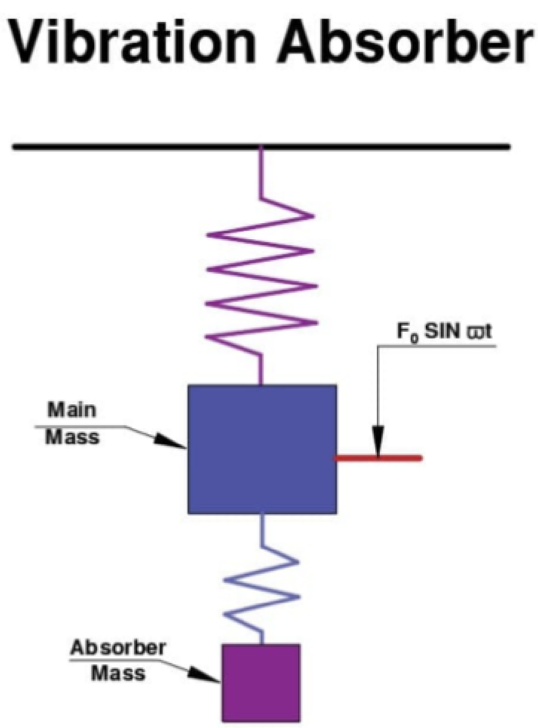
Present: Meghan Horan

Goals: To understand different passive and active mechanisms to absorb vibrations

Content:

https://www.iqsdirectory.com/articles/vibration-absorber.html

- Vibration Absorber = single degree of freedom spring-mass system that eliminates or reduces the vibration of a harmonically excited system
    - Normally attached to vibrating body and designed to produce anti-resonance to the system

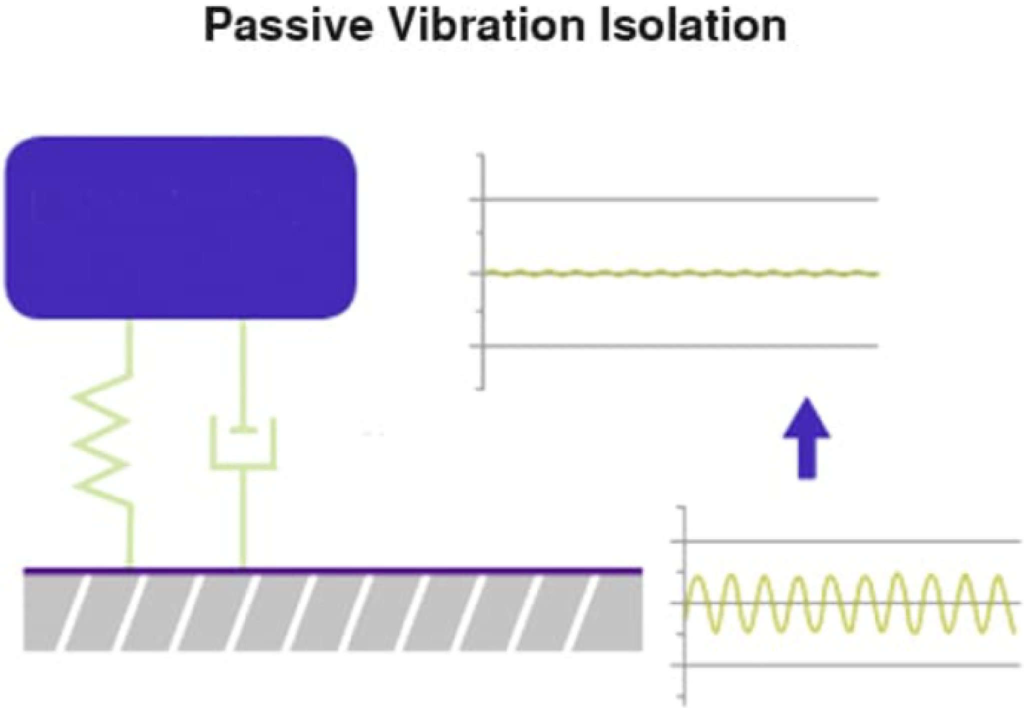


- Resonance = increased amplitude that occurs when the natural frequency of a system is in tune with frequency of periodically applied force
- Energy absorption - process involved when magnitudes of strength of random motions (vibrations) are reduced

Vibration Absorber Set-Up

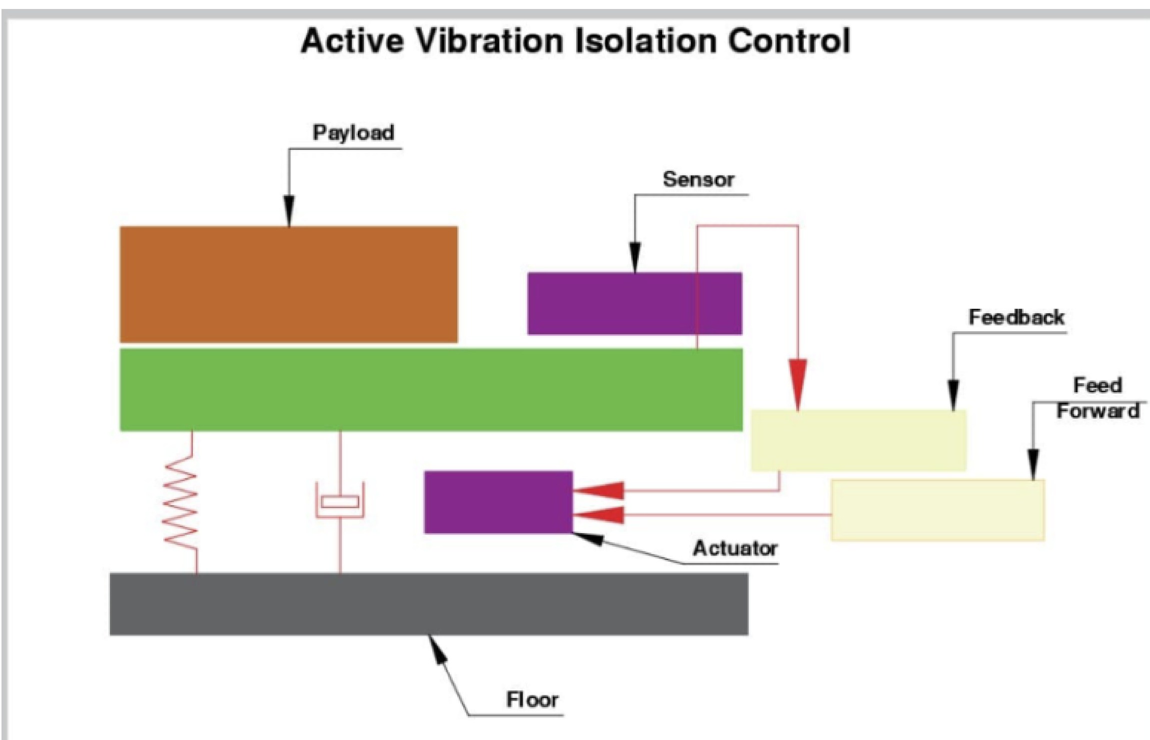
- The Primary System (Payload)
    - system that experiences unwanted frequencies which need to be controlled/neutralized
- The Absorber
    - AKA the support because it helps primary system by reducing the vibration encountered in it
    - involved components like rubber mounts, springs, pads, etc.
    - could be hydraulic
    - Usually springs, rubber, or a combination of the 2
- **Dampening** = eliminating or reducing unwanted vibratory movements from a system (absorption of kinetic energy from a system)
    - We want to focus on Critically Damped Systems where the object returns to an equilibrium position in a short period
    - **Unconstrained Damping** = place a pad between the moving parts causing vibrations that conforms to motion of the parts and releases absorbed energy as heat
    - **Constrained Damping** = use viscoelastic material such as Sorbothane; used for closer attention and vibration control
    - **Tuned Viscoelastic Damping** = eliminate ranges of certain wavelengths/frequencies
- **Vibration Isolation**
    - separate machinery from source of vibration using a vibration isolator placed between source of vibration and material being protected
    - **Passive:** comprise spring, mass, and damping material
        - spring and mass used to create a natural frequency

    - transfer of energy at natural frequency produced
  - natural frequency amplification is reduced by damping



  Active

    - comprises electronic components like circuits, feedback configurations, controllers, sensors, actuators, springs etc
    - vibrations are transferred to the control system which is fed into an actuator and based on the program, vibration gets neutralized



Types of Vibration Absorbers

- Air Springs
  - sect of air confined within a fabric and rubber container shaped like a bellow
- Bushings
  - provide interface between two parts of absorb vibrations between the surfaces
- Cam Follower
  - follows the motion of a cam shaft
- Dash Pots
  - use fluid to create resistance
  - common in small devices and instruments

- Helical Isolators
    - multidirectional wire rope structure designed to absorb shock and vibration
    - commonly use dot transport sensitive and delicate materials in harsh weather conditions
- Rubber pads
    - placed between materials or moving parts to absorb vibrations
- Shock Absorbers
    - absorb vibration and jolts
    - mainly used in vehicles

Conclusions/action items: Research more into the highlighted vibration absorbers. Integrate ideas into preliminary designs.

2023/02/12 - Reducing Vibration with Helical Vibration Isolators

Meghan Horan - Feb 12, 2023, 6:26 PM CST

Title: Reducing Vibration with Helical Vibration Isolators

Date: 2023/02/12

Content by: Meghan Horan

Present: Meghan Horan

Goals: To understand a potential mechanism for reducing vibrations

Content:

- helical isolators provide more shock protection than other isolation devices
- diminish transmissibility
- Advantages
    - operate in compression, shear, and roll assemblies
    - provide protection across all 3 axes simultaneously
    - can withstand extreme environments
    - requires little to no maintenance
    - able to cushion a range loads
    - can be made with high quality stainless steel
- Devices that can benefit from vibration isolators
    - COTS firmware
    - Shipboard electronics
    - pumps
    - mobile carts for medical care
    - electronics in rough terrain vehicles
    - optical devices
    - computers and electronics in air crafts

https://springcompany.com/news/reducing-vibration-with-helical-spring-isolators

Conclusions/action items: Request a quote. Investigate options to use as our device.

2023/02/12 - Tuned Mass Dampers

Meghan Horan - Feb 12, 2023, 7:07 PM CST

Title: Tuned Mass Dampers

Date: 2023/02/12

Content by: Meghan Horan

Present: Meghan Horan

Goals: To understand another passive system option to reduce vibrations.

Content:

- Vibration Isolation = preventing vibration energy from entering the machine
- Vibration damping = reducing the amount of type or vibration energy transmitted to the machine
    - one type is the tuned mass damper (TMD)
- TMDs
    - consists of mass, stiffness elements (springs), and a damper
    - damper = hydraulic dashpots, viscoelastic materials, and magnetic dampers
    - TMD vibrates at the same frequency as the structure but out of phase with it
    - inertial force of TMD reduces the vibrational energy transmitted to machine and dissipates that energy as heat
    - masses and springs can be "tuned" or adjusted to the natural frequency to be damped
- Effectiveness of TMD depends on...
    - Mass ratio: ratio of TMD mass to structure mass
    - Frequency ratio: ratio of frequency of TMD to natural frequency of structure (ideally it is 1)
    - Damping coefficient of TMD: how well TMD dissipates energy (lower coefficient = better damping)

https://www.motioncontroltips.com/what-is-a-tuned-mass-damper-and-how-is-it-used-in-motion-control/

Conclusions/action items: Figure out how to do math that you would need to do to know what springs and stuff to buy.

2023/02/12 - Sorbothane as Vibration Damping Material

Meghan Horan - Feb 12, 2023, 7:20 PM CST

Title: Sorbothane as Vibration Damping Material

Date: 2023/02/12

Content by: Meghan Horan

Present: Meghan Horan

Goals: To find additional materials for use in the existing design from last semester

Content:

- damping material used to reduce or eliminate noise caused by resonance and vibration
- viscoelastic polymer = exhibits both elastic and viscous behavior
  - elastic = stores energy during a load and all energy is returned when load is removed
  - viscous = doesn't return any energy
  - viscoelastic = stores some energy and then the remainder is released as heat
- works by changing the natural vibration frequency of the vibrating surface and therefore lowering radiated noise and increasing transmission loss of the material

https://www.sorbothane.com/technical-data/articles/vibration-damping-material/

Conclusions/action items: See if this material can be embedded in past device. Consult Josh & Joey

2023/02/23 - Dr. Thevamaran Consult

Meghan Horan - Feb 23, 2023, 9:34 PM CST

Title:

Date: 2023/02/23

Content by: Meghan Horan

Present: Meghan Horan

Goals: To find resources to explore accelerometers on campus.

Content:

Email correspondence with Dr. Thevamaran:

Accelerometers are the common route when you want to just attach to a structure and measure. We typically use dynamic force sensors for vibration measurements of materials when the material is pressed between the force sensor and an actuator (see an image from one of our experiments). A more sophisticated way of doing this is using a laser vibrometer. This is a non-contact measurement where a laser is shined on to a reflective surface and the velocity is measured from doppler shift. Then integration will give the displacement. We don't have a single point vibrometer. But, UW has a research facility of a multi-point vibrometer. It may be an overkill for this problem because of the complexity of the instrument.

Conclusions/action items: Have in person meeting with Dr. Thevamaran on Friday, 3/3 at 10am in ERB

2023/03/23 - Series vs Parallel Damping

Meghan Horan - Mar 23, 2023, 11:04 PM CDT

Title: Series vs Parallel Damping

Date: 2023/03/23

Content by: Meghan Horan

Present: Meghan Horan

Goals: To investigate the most effective placement of damper to reduce vibrations within setting of the device.

Content:

- "Soft" system - small elastic restoring force
- "Damped" system - dissipates energy quickly
- Parallel Spring-Mass-Damper System
  - opposite behavior as series
  - ***you want a looser spring to get more damping

$$Q \approx \sqrt{mk}/c.$$

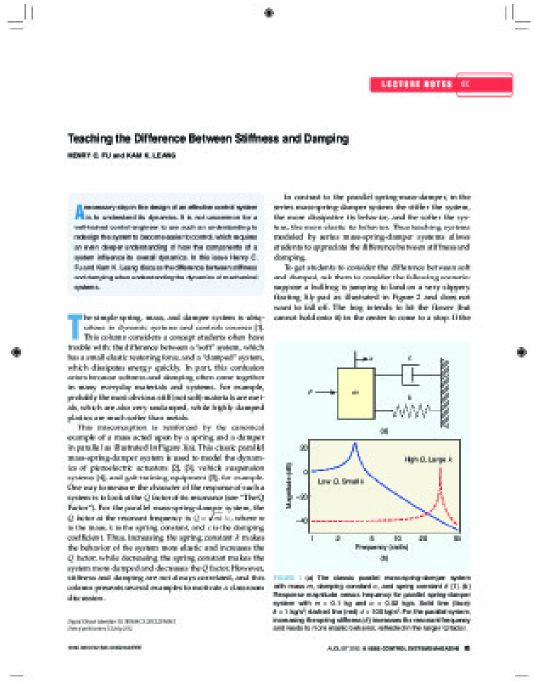
- Series Mass-Spring-Damper System
  - the stiffer the system, the more dissipative its behavior
  - softer the system = more elastic behavior
  - more damping for a stiffer spring constant
  - ***you want a stiffer spring to get more damping

$$Q \approx c/\sqrt{mk}$$

- softness and damping don't necessarily go together
- The Q Factor
  - m = mass
  - k = spring constant
  - c = dampng coefficient

Conclusions/action items: Figure out which system will work better for our design.

Meghan Horan - Mar 23, 2023, 11:04 PM CDT


LECTURE NOTES

Teaching the Difference Between Stiffness and Damping

HENRY C. FU and KAM K. LEANG

[Download](#)

FuHC_2012a-Teaching-the-difference-between-stiffness-and-damping.pdf (1.37 MB)

2023/03/25 - Spring Constant Notes

Meghan Horan - Mar 25, 2023, 3:31 PM CDT

Title: Spring Constant Notes

Date: 2023/03/25

Content by: Meghan Horan

Present: Meghan Horan

Goals: To understand how to choose spring constant values, how many springs are needed, and how much damper to use in design

Content:

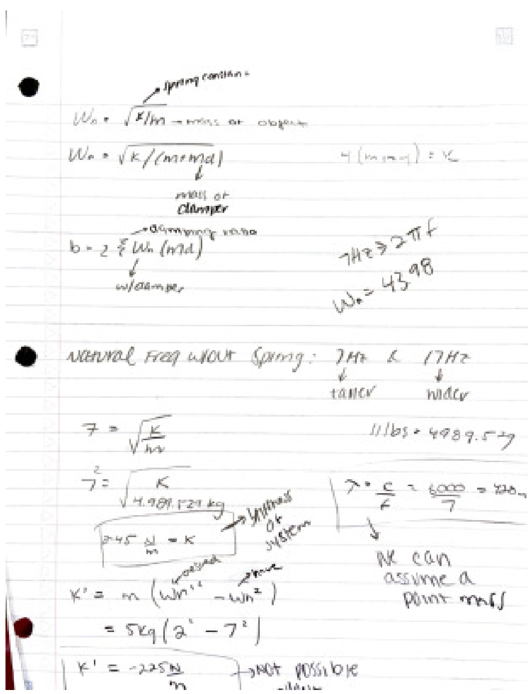
See attached pdf

Note: initial spring constant calculations do not factor in damping. The numbers are also wrong because I was using frequency in Hz instead of rad/s. The equations are right but the calculations would need to be redone

The last equation on the second page of the pdf should be used to figure out the mass of the damper that should be used.

Conclusions/action items: Email Sorbothane people to determine its damping coefficient

Meghan Horan - Mar 25, 2023, 3:31 PM CDT



Download

spring_constant_notes.pdf (665 kB)

2023/03/30 - Calculation Notes from Fronczak

Meghan Horan - Mar 30, 2023, 12:30 PM CDT

Title: Calculation Notes from Fronczak

Date: 2023/03/30

Content by: Meghan Horan & Prof. Fronczak

Present: Meghan Horan

Goals: To confirm calculations for spring constant

Content:

Emailed notes on calculations from Fronczak:

the values for Zeta and Y/X were somewhat arbitrary. I think you need to decide what are realistic values. That being said, while I didn't put too much thought into it, these values seem to be feasible. That is, they would appear to give a substantial reduction in the vibration level, without having an excessively soft system. Keep in mind that you also have to deal with transients (that is, the free vibration response) as well as the forced vibration response. While the amplitude ratio Y/X is reduced by having a soft system with zero/minimum damping, these conditions (soft with no damping) can typically cause transient problems. Remember, the total response is the sum of the transient (free) and steady-state (forced) responses. (In mathematics terminology you should recall from your Differential Equations course that the total solution is the sum of the complimentary and particular solutions). (Actually, unfortunately, imo, Y he way math is taught, it is divorced from physical reality, so you may in fact, if you are like me, you may not really have gotten much from your DE course - I know I didn't, but gortunately I developed an understanding of DEs in my engineering courses and career.) We have been focusing on the steady -state/particular response/solution, but we can't ignore the transient/complimentary response/solution. This transient response also dependent upon the system stiffness and damping. So, we can't just go with a very very soft system (low natural frequency) with no damping. So, the values I gave for Zeta and Y/X may be a reasonable starting point for a reasonable compromise.

With respect to calculating K - off the top of my head, I'm not sure where the equations you show for K come from, but I don't think that this K is the spring constant, but is a different K completely. The k (note lower case k) value that you need is simply calculated from knowing M and omega_n (the natural frequency). That is omega_n = (k/M)^.5 ie omega_n^2=k/M so k= M(omega_n^2). (it's late and I'm tired so please be sure to check/verify my algebra here).*

Conclusions/action items: Share notes with team. Perform calculations independently and compare. Confirm consistently in calculating omega_n. Use this reasoning to validate choice for Y/X and zeta values in final report

2023/02/02 - How to Use Accelerometers to Measure Vibration

Meghan Horan - Feb 02, 2023, 10:04 PM CST

Title: How to Use Accelerometers to Measure Vibration

Date: 2023/02/02

Content by: Meghan Horan

Present: Meghan Horan

Goals: To find a device that can be used to detect vibration measurements in testing

Content:

- Accelerometer - small electromechanical device that is used to measure acceleration as well as other forces acting on the object
    - can monitor static & dynamic forces
    - measure vibration using electrical signals which allow insights regarding the condition of the machine
    - 4 main types

1. Piezoelectric - instrument produces an electrical charge after being put under stress

- much more sensitive than other types
- most used sensors for measuring vibration & shock in industrial applications
- AC coupled so cannot measure static forces

2. Piezoresistive - increases its resistance in proportion to the forces acting upon it

- less sensitive
- helpful in the auto industry & vehicle crash testing to identify measurable quantities of force

3. Capacitive - measure alteration in electrical capacitance (ability to store energy in form of electrical charge)

- when acceleration is detected, the sensor's diaphragm begins to move changing the distance between capacitor plates

4. Microelectromechanical Systems (MEMS) - operate on the nanoscale

- capacitance based
- used in cell phones to determine orientation
- often paired to capture low frequency (<2000 Hz) and another for high frequency (>1000 Hz)
- in triaxial arrangement to measure acceleration in 3 directions

Accelerometers to Measure Vibration

- mounted on equipment to measure vibrations on machines operating at greater than 60Hz

Conclusions/action items: Find accelerometer for purchase if applicable. Consult with professors about right equipment.

2023/02/03 - Accelerometer Sensors

Meghan Horan - Feb 03, 2023, 12:36 PM CST

Title: Accelerometer Sensor

Date: 2023/02/03

Content by: Meghan Horan

Present: Meghan Horan

Goals: To find existing accelerometer sensors that may be feasible for testing.

Content:

https://blog.endaq.com/6-ways-to-measure-vibrations

TI's Sensor Tag

- Bluetooth low energy system
- less than $30
- connect device to phone & see all 10 sensors including triaxial accelerometer
- samples up to 10Hz (samples per second)

Extech's VB300 Vibration Recorder

- less than $300
- quantifying vibration environment
- sample rate up to 200Hz
- 4Mbit total storage
- provides real time feedback
- can be bought off Amazon
- https://www.amazon.com/Extech-VB300-Vibration-Data-Logger/dp/B007ICEJTQ?th=1

***The rest on this list are over $2k so we won't use those

Conclusions/action items: Consult this technologies with Dr. Nimunkar

2023/02/03 - HVM200 Human Vibration Meter

Meghan Horan - Feb 03, 2023, 1:54 PM CST

Title: HMV200 Human Vibration Meters

Date: 2023/02/03

Content by: Meghan Horan

Present: Meghan Horan

Goals: To find existing technologies used to measure and record vibration data.

Content:

- small rugged vibration meter with built in Wifi
- used to measure hand-arm, whole body, and general vibration
- 3 channels
- used to demonstrate compliance with human vibration regulations
- free app to control measurements and view data
- transport data used USB, Wi-fi, or SD memory card (included)
- data stored in 24 bit format
- files can be read with Matlab
- battery works continuously 8-12 hours

http://www.larsondavis.com/docs/librariesprovider2/brochures/ld-hvm200-human-vibration-meter-(md-0394).pdf?sfvrsn=fa5d672c_12

Conclusions/action items: Get quote back from company. Share with Dr. Nimunkar to get his thoughts.

2023/02/27 - Mag Soar Z-Dampers

Meghan Horan - Feb 27, 2023, 5:24 PM CST

Title: Mag Soar Z-Dampers

Date: 2023/02/27

Content by: Meghan Horan

Present: Meghan Horan

Goals: To learn about existing technologies that use magnets as a means of damping vibrations

Content:

- magneto mechanism matching mechanical impedances and providing a multiplier effect to damp vibrations of both low and high-frequency ranges more effectively
- slow and fast stages
- magnetic teeth whose orientation controls the difference between slow and fast stages
- fast stage moves faster, slow stage exerts more force
- results in optimized damping at ultra-small size and weight (of magnet itself I am assuming?)
- excitations difficult to isolate are internally transformed into high-speed vibrations to be more effectively damped
- more common in large, heavy structures like aeronautics or defence

Conclusions/action items: Honestly there are a lot of spelling issues on this website so lowkey I am skeptical. Investigate if it could be used on a smaller scale.

2023/02/13 - Spring & Damper Design

Meghan Horan - Feb 13, 2023, 6:35 PM CST

Title: Spring & Damper Design

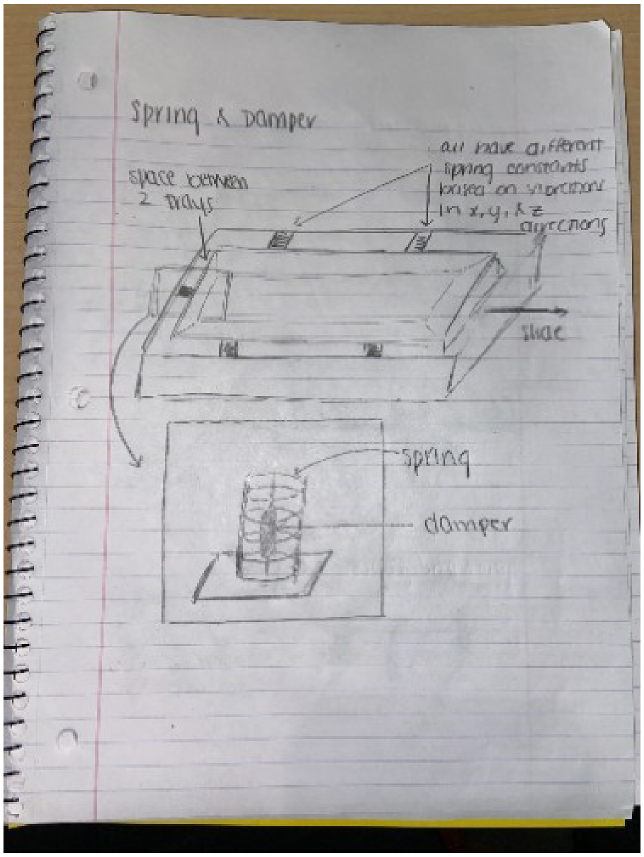
Date: 2023/02/13

Content by: Meghan Horan

Present: Meghan Horan

Goals: To submit preliminary design ideas for consideration into design matrix

Content:



Conclusions/action items: Share with team during design evaluation meeting on 2/14

Meghan Horan - Feb 17, 2023, 12:21 PM CST

I chose this design because it allows you to reduce vibrations as close to where the infant is experiencing them as possible. Also the placement of the spring/damper components can be moved to order to optimize the placement. Additionally, the spring constant of the spring will be determined based on the force, or weight, of the structure (AKA the infant + the inner tray)

The damper could either be an air pocket damper with a twisting piece that adds more or less resistance, or it could be magnet based. In this design, two matching polarity magnets would be placed facing each other so that they repel.

2023/02/13 - Helical Isolator Design

Meghan Horan - Feb 13, 2023, 6:37 PM CST

Title: Helical Isolator Design

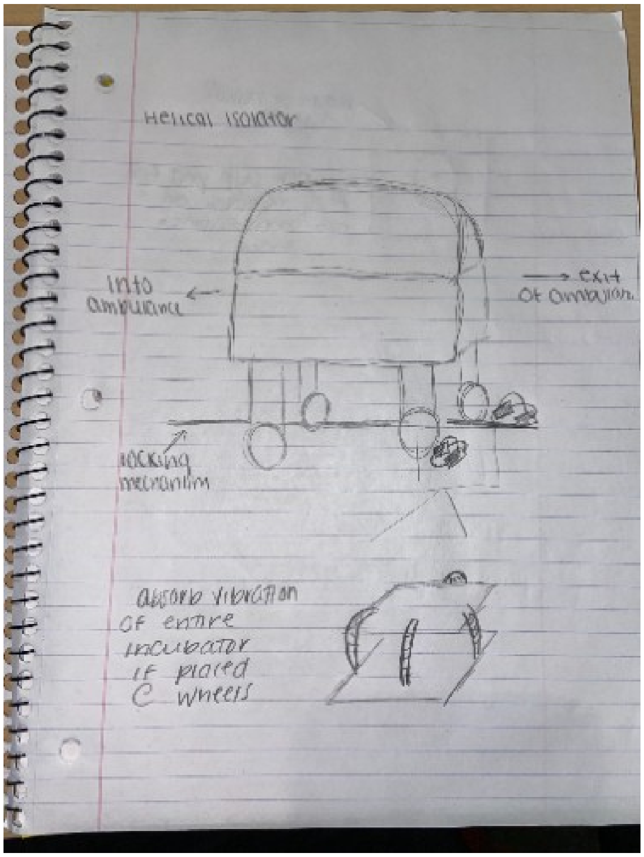
Date: 2023/02/13

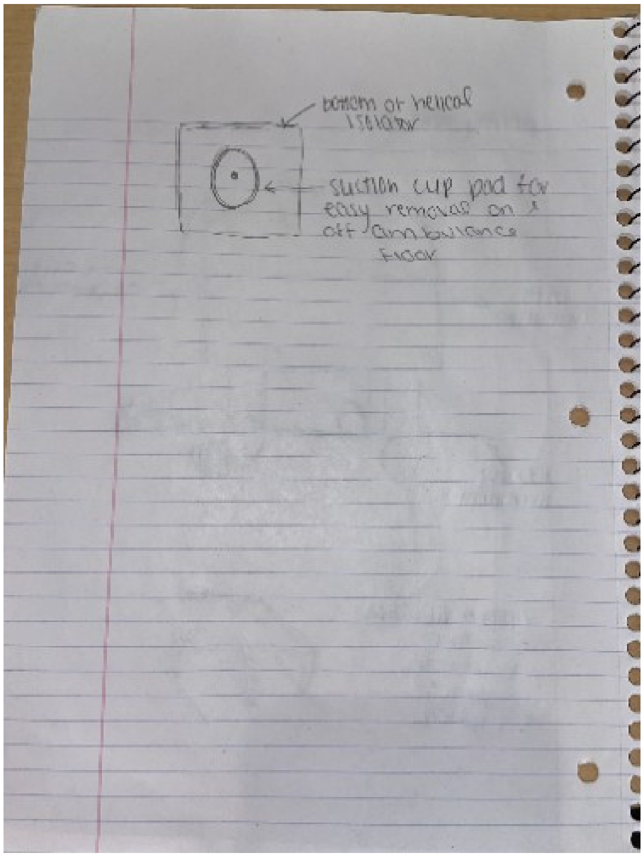
Content by: Meghan Horan

Present: Meghan Horan

Goals: To create and submit preliminary design ideas into the design matrix

Content:





Conclusions/action items: Discuss and share with team during design evaluation meeting

Meghan Horan - Feb 17, 2023, 12:36 PM CST

The goal of this design is to stabilize the isolette externally rather that just in the trays. This allows us to mitigate the issue from the outside in. The width, strength, and flexibility of the wires making up the helical isolator can be changed to accommodate different weights of the equipment

The devices can be pulled in and out, and placed when needed. This makes it more flexible and can easily be accommodated to other rigs.

2023/02/14 - Spring & Damper CAD File

Meghan Horan - Feb 14, 2023, 7:13 PM CST

Title: Damper & Spring CAD File

Date: 2023/02/14

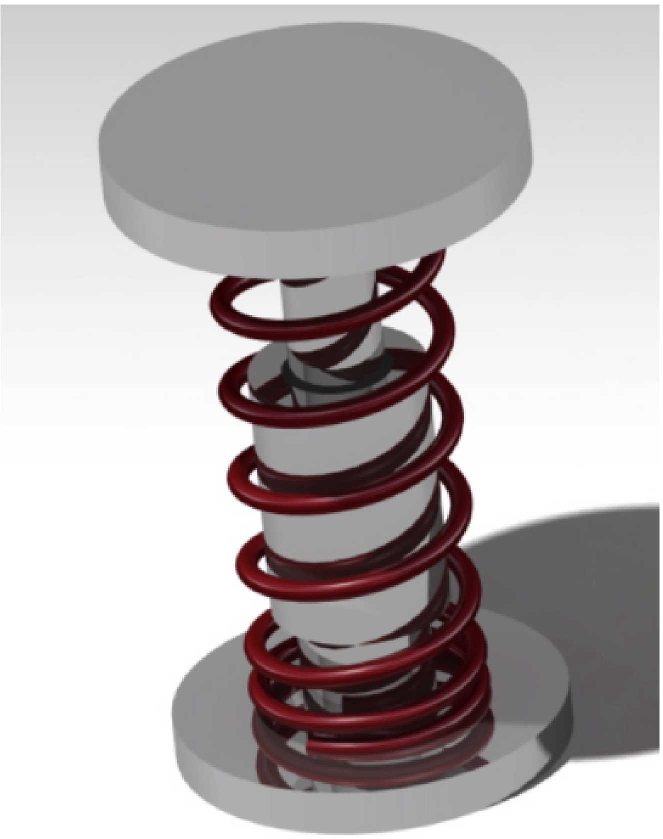
Content by: Meghan Horan

Present: Meghan Horan

Goals: To use previously created CAD files for 3D rendering of one of our design matrix ideas

Content:

- will properly cite creator of file
- will not be using to print actual design -- just for purposes of envisioning
- will save time on something that won't be directly used in the creation of the device itself



Conclusions/action items: Confirm usage is acceptable with advisor

2023/02/25 - Wave Springs

Meghan Horan - Feb 25, 2023, 5:33 PM CST

Title: Spring & Damper Materials Research

Date: 2023/02/25

Content by: Meghan Horan

Present: Meghan Horan

Goals: To begin looking for materials that can be ordered for use in preliminary designs

Content:

- flat wire compression springs engineered to optimize space in an assembly
- multiple waves per turn can offer the same spring force as a traditional round wire coil but at 50% of its operating height
- reduces spring cavity size
- good for tight radial and axial spaces
- can be personalized
- diameter range from 0.188" to 16"

https://www.smalley.com/industries/medical

Conclusions/action items: Request samples online for use in a preliminary prototype fabrication

2023/02/25 - Confined Space Conical Compression Springs

Meghan Horan - Feb 25, 2023, 5:46 PM CST

Title: Confined Space Conical Compression Springs

Date: 2023/02/25

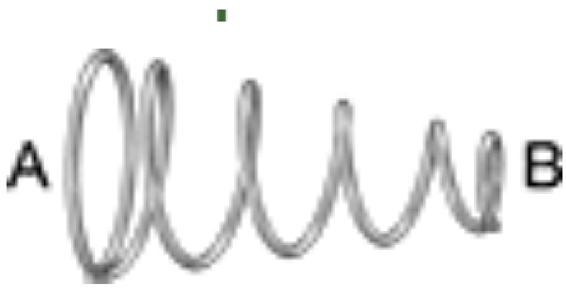
Content by: Meghan Horan

Present: Meghan Horan

Goals: To search for materials for use in spring component with preliminary design prototype

Content:

- good for tight spots
- when pushed together, the coils are nested within each other
- compression length that's equal to about 2 widths of wire
- smallest uncompressed length option is 1/4"
- smallest diameter is 0.125"
- Wire diameter in smallest wire is 0.026"
- max load needs to be less than 1000 lbs



https://www.mcmaster.com/spring-dampers/confined-space-conical-compression-springs/

Conclusions/action items: Do calculations to figure out spring constant and what size spring is needed. Contact McMaster Carr for pricing.

2023/02/25 - Spring Constant Calculations

Meghan Horan - Feb 25, 2023, 6:26 PM CST

Title: Spring Constant Calculations

Date: 2023/02/25

Content by: Meghan Horan

Present: Meghan Horan

Goals: To understand how to calculate a spring constant so we know which springs to purchase for use in preliminary design

Content:

- Hooke's Law explains Simple Harmonic Motion which describes the oscillatory motion of object
- The force required to compress or extend a spring is proportional to the length stretched
- When spring is pulled, Newton's Third Law states that it returns with restoring force
- Spring Force = -(Spring Constant) x (Displacement)

$$F = -KX$$

- Spring Constant = force needed per unit extension
- easily calculate how much force is required to deform the spring
- Potential Energy of a spring (elastic potential energy) is equal to the force multiplied by distance travelled

$$P.E. = 1/2\ KX^2$$

- only applicable in the elastic region

https://www.geeksforgeeks.org/spring-constant-formula/

Conclusions/action items: Use this equation to calculate what spring constant is needed based on force from baby (from mass of neonate) and distance spring can displace (distance between two trays)

2023/02/28 - Real World Spring and Damper

Meghan Horan - Feb 28, 2023, 7:44 PM CST

Title: Real World Spring & Damper

Date: 2023/02/28

Content by: Meghan Horan

Present: Meghan Horan

Goals: To further research and motivation behind spring and damper design

Content:

Similar designs are used in car suspension systems to function as shock absorbers. Irregularities in the road can exert forces to the wheels of a car, causing them to move up and down perpendicular to the road's surface. Therefore, a system is needed to absorb this energy such that it is not transferred to the frame causing the wheels to lose contact with the ground [26].

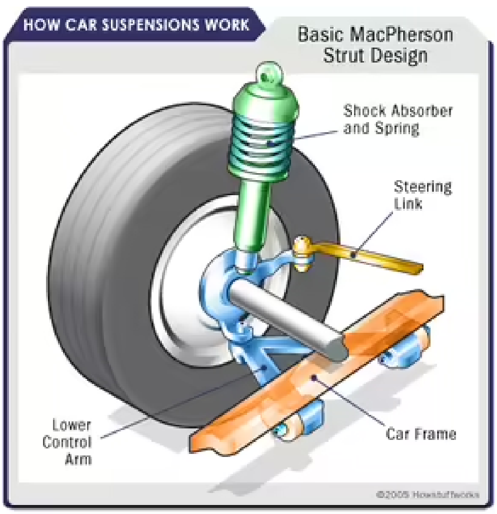


Figure XX: Illustration depicting common strut design, which is a common dampening structure in a vehicle's wheels.

The stiffness of the spring determines how the car responds to the energy, either providing a smoother or bumpier ride. In other words, they absorb energy. Dampers are the component that then dissipate this energy, stopping the spring from bouncing at its natural frequency until all the energy put into it is used.

Conclusions/action items: Add to preliminary report

2023/03/03 - Testing Design Mechanism

Meghan Horan - Mar 03, 2023, 11:22 AM CST

Title: Testing Design Mechanism

Date: 2023/03/03

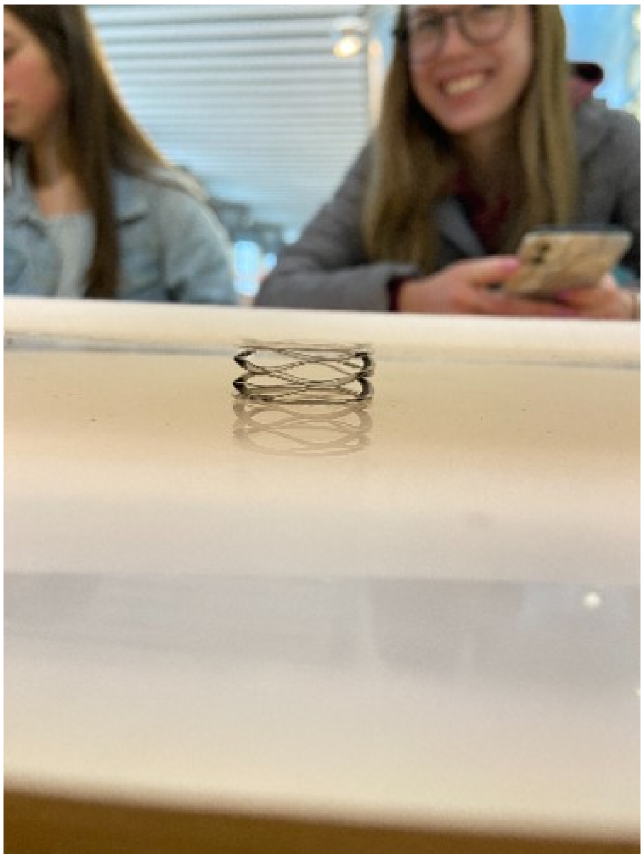
Content by: Meghan Horan

Present: Meghan Horan

Goals: To mimic the inner tray and its components in mass so we can complete isolated frequency testing before field testing

Content:

- material on bottom doesn't inherently matter but we would need to find a way to fix spring and damper components to it
- material on top should be of the same mass as the inner tray, mattress, stabilizing beanbag with a roughly equal mass distribution



Conclusions/action items: Get mass information from clients/try to find it online. Begin fabricating mass stuff for top

2023/03/03 - PCB Triaxial Accelerometers

Meghan Horan - Mar 03, 2023, 12:27 PM CST

Title: PCB Triaxial Accelerometers

Date: 2023/03/03

Content by: Meghan Horan

Present: Meghan Horan

Goals: To find a data collection mechanism to complete frequency response testing

Content:

- triaxial accelerometers provide simultaneous measurements in 3 orthogonal directions
- 3 sensing elements oriented at right angles with respect to each other
- https://www.pcb.com/sensors-for-test-measurement/accelerometers/general-purpose/triaxial
- these are all more than $1k -- a little expensive for our purposes
- where/how would we connect the

Conclusions/action items:

- check with Dr. Theva to see there are cheaper alternatives

2023/03/03 - Stainless Steel Shock Absorber

Meghan Horan - Mar 03, 2023, 12:35 PM CST

Title: Stainless Steel Shock Absorber

Date: 2023/03/03

Content by: Meghan Horan

Present: Meghan Horan

Goals: To look for damper options in design

Content:

- Housing: V4A / DIN 1.4404 / AISI 316L
- Piston rod: DIN 1.4125 / AISI 440C
- Integrated end stop
- Special seals: -50°C - +120°C
- Special oils: Food-grade according to USDA-H1
- Applications:
  - Foot industry
  - Medical
  - Outside machinery

Conclusions/action items: Find a free sample to order online

2023/03/03 - Sorbothane Samples

Meghan Horan - Mar 03, 2023, 1:12 PM CST

Title: Sorbothane Samples

Date: 2023/03/03

Content by: Meghan Horan

Present: Meghan Horan

Goals: Find a material to use as a damper

Content:

- https://www.sorbothane.com/sorbothane-products/standard-industrial-products/
- ordered free samples of isolation pads (with and without pva) and sheet stock with pva
- tried at 30, 50, and 70 durometer ranking in the 5-14 pound range

Conclusions/action items: wait for free samples to arrive so they can be used in tandem with springs. order springs

2023/03/21 - Preliminary Prototype Fabrication

Meghan Horan - Mar 21, 2023, 6:23 PM CDT

Title: Preliminary Prototype Fabrication

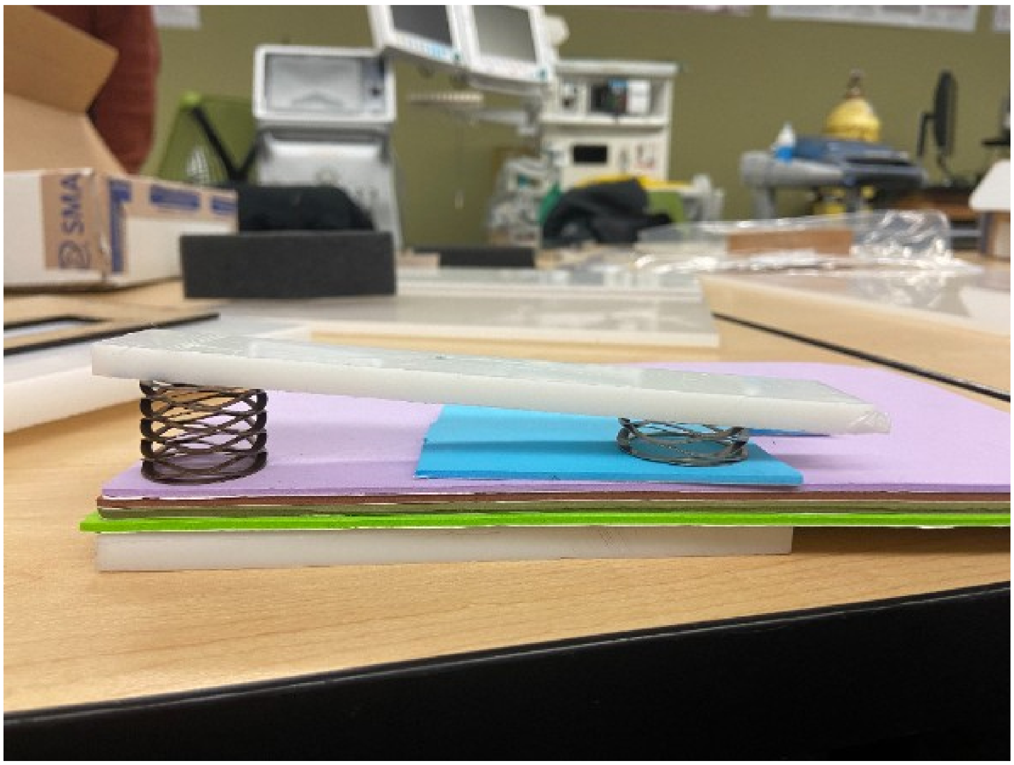
Date: 2023/03/21

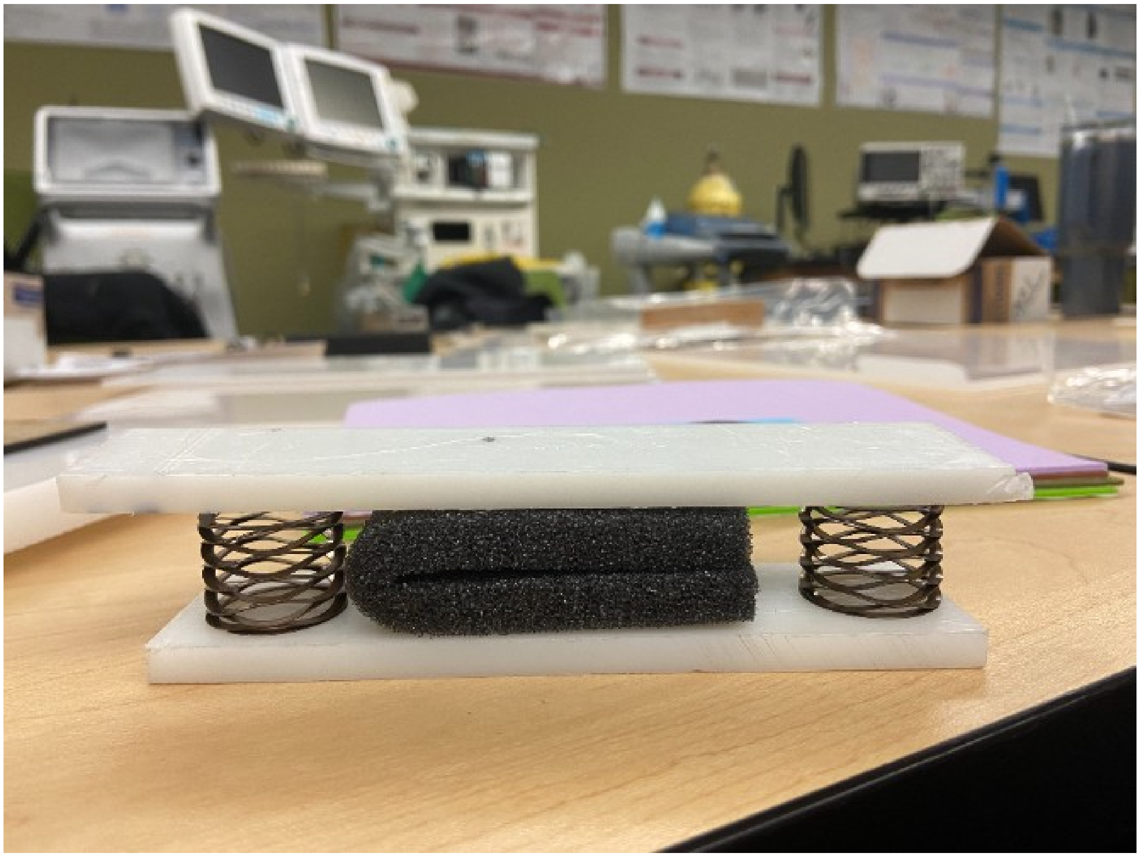
Content by: Meghan Horan

Present: Meghan, Nicole, Sydney, Josh

Goals: To begin fabricating initial spring & damper design

Content:





Conclusions/action items: Share with Dr. Theva and Prof Fronczak to get feedback

2023/04/11 - Spring & Damper Plate Fabrication

Meghan Horan - Apr 12, 2023, 6:55 PM CDT

Title: Spring & Damper Plate Fabrication

Date: 4/11/23

Content by: Meghan Horan

Present: Meghan Horan

Goals: To create a base to fix spring and damper components to before we are able to redesign inner tray

Content:

- need 4, 4"x4" plates to put in each of the four corners
- will still need to figure out a way to fix these four in place without raising too much in vertical direction
- Just a placeholder until we can do a better redesign of bottom tray
- made of white HPDE
- cut in the TEAM lab

Conclusions/action items: fix to spring & damper components

Meghan Horan - Apr 12, 2023, 6:54 PM CDT

Download

square_base_plates.jpg (375 kB)

2023/04/25 - Instructions for Spring & Damper Calculations

Meghan Horan - Apr 25, 2023, 6:55 PM CDT

Title: Instructions for Spring & Damper Calculations

Date: 2023/04/25

Content by: Meghan Horan

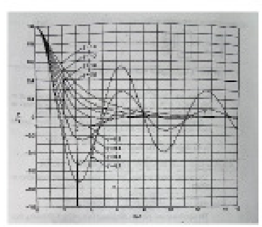
Present: Meghan Horan

Goals: To make a comprehensive instruction guide for completing consistent spring constant calculations moving forward.

Content: See attached file with teammates.

Conclusions/action items: Share with teammates & reoptimize calculations.

Meghan Horan - Apr 25, 2023, 6:55 PM CDT



Known Values: m, ω[illegible] & ω ω[illegible]

Needed Values: k & c

m is the mass that is oscillating. In this case, it is the combined mass of the neonate, tray, mattress, and involved equipment treated as a point mass.

The ω[illegible] value will be the 17 Hz frequency (from Fall 2022 testing) multiplied by 2π.

ω ω[illegible] can be found once you have determined a displacement (Y/X) and a ζ value. We assume both to be [illegible]0.2. For displacement, this means that the amplitude of vibrations is approximately 20% of their original magnitude. For ζ, 0.2 is chosen as it shows a termination of oscillation after approximately 2 cycles (as illustrated in **Figure 1**). However, these values are based on judgment and may need to be optimized.

Figure 1: Free-vibration characteristics of a single-degree-of-freedom mass-spring-damper system and other dynamic second-order systems

[Download](#)

Spring_Damper_Calculations.pdf (578 kB)

2023/03/10 - Required Patent Lecture

Meghan Horan - Mar 10, 2023, 11:23 AM CST

Title: Required Patent Lecture

Date: 2023/03/10

Content by: Meghan Horan

Present: Meghan Horan

Goals: To review the asynchronous patent lecture.

Content:

One thing I learned from the patent lecture was that WARF does not really do trade secrets. Because students present their work and write so many papers throughout the design project, it makes sense that it would be hard to keep this information a secret. I also learned that there are 3 filters that are used when selecting designs for a patent: new, obvious, and eligible. Having already gone through this process with WARF for my Fall 2021 design project, I am a bit more familiar with the requirements. I am excited that we have filed for a patent, and look forward to seeing if we get it!

Conclusions/action items: Discuss with current design team to see if this is something we want to pursue with our project this semester.

Biosafety Training

Meghan Horan - Apr 25, 2023, 6:58 PM CDT

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Meghan Horan has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 100: Bloodborne Pathogens for Laboratory and Research	Biosafety 100: Bloodborne Pathogens Safety in Research Quiz 2021	1/10/2022	
Biosafety 105: Biosafety Cabinet Use	Biosafety 105: Biosafety Cabinet Use Quiz	2/8/2021	
Biosafety 107: Centrifuge Safety	Biosafety 107: Centrifuge Safety Verification Quiz	2/8/2021	
Biosafety Required Training	Biosafety Required Training Quiz	1/29/2021	
Chemical Safety: Cryogen Safety Training	Part 1 Final Quiz	2/12/2021	
Chemical Safety: Cryogen Safety Training	Part 2 Final Quiz	2/12/2021	
Chemical Safety: Personal Protective Equipment	PPE Final Quiz	2/8/2021	
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/14/2021	
Laser Safety 2020-2021	2020 Laser Safety Training Quiz	2/8/2021	
Responsible Conduct of Research	RCR Certification	2/1/2021	

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Training_Information_Lookup_Tool.pdf (115 kB)

Green Permit

Meghan Horan - Apr 25, 2023, 7:00 PM CDT

You have the following permits and upgrades:

Name	Date
Green Permit	02/23/2022
Lab Orientation	02/17/2021
Red Permit	11/04/2021
Laser 1	03/02/2021

Download

Screenshot_2023-04-25_185906.png (74.3 kB)

2023/01/29 - Investigating Vibration Levels in Neonatal Patient Transport

NICOLE PARMENTER - Jan 30, 2023, 10:29 AM CST

Title: Investigating Vibration Levels in Neonatal Patient Transport

Date: 1/29/2023

Content by: Nicole Parmenter

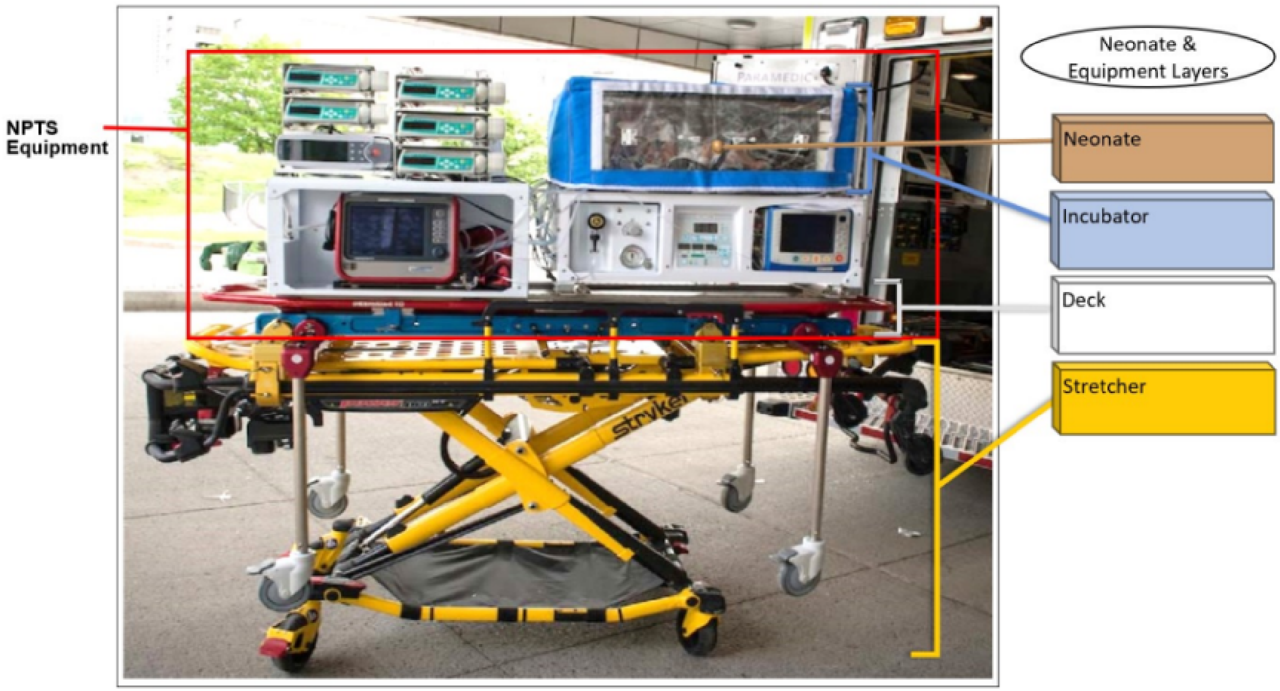
Present: Nicole Parmenter

Goals: To learn about the vibration levels during neonatal transport.

Link: https://curve.carleton.ca/system/files/etd/405aa798-1f34-43e9-95c3-d8bdc0f9efe4/etd_pdf/e7360bd1710b259a57676c7778e11320/darwaish-investigatingvibrationlevelsinneonatalpatient.pdf

Content:

- On-road results show an amplification of vibrations at the neonate's head, relative to the floor, most notably at frequencies surrounding 9.5 Hz.
    - Neonates experience vibration levels greater than levels recommended for adults. There are no specific standards for neonates.



-
    - This is a picture of the standardized Neonatal Patient Transport System (NPTS).
- This thesis is the beginning of the development of a standardized test environment using a shaker table to simulate neonatal transport.
- One way to measure vibrations is from the tray of the transport incubator during in-house transport using a vibration meter, which is a type of accelerometer that provides root mean-square acceleration.
- When neonates are exposed to intense vibrations, it can affect their heart and/or breathing rate and their blood oxygenation levels.
- Neonates with lower weights can have a higher risk of higher vibration exposure.
- Variables for neonatal vibrations:
    - mattress type
    - mode of transportation
    - neonatal weight
    - road type
    - duration of exposure
- Using a shaker table helps standardize testing and allows for more reproducibility.
- A loosened tray leads to larger vibration amplitudes.
- Using a gel mattress and putting a foam pad between the track and the tray reduces vibrations.
- The vibrations at the neonate were greater than the vibrations on the floor of the ambulance.
- The shaker-table tests in this paper determined the shaker-table was able to reproduce on-road transportation with acceptable fidelity.
- 3 types of tests were performed with the shaker-table: 1) low frequency sine sweeps (1-5 Hz), 2) high frequency sine sweeps (4-50 Hz), and 3) random sine sweeps (3-150 Hz).
- Power spectral density (PDS) is the measure of signal's power content versus frequency.

Conclusions/action items:

This paper contains multiple ideas for standardizing neonatal vibration testing and for reducing neonatal vibrations that we may be able to apply to our project. I will use this paper as a resource during our brainstorming sessions.

2023/01/30 - Decreasing sound and vibration during ground transport of infants with very low birth weight

NICOLE PARMENTER - Feb 01, 2023, 10:23 AM CST

Title: Decreasing sound and vibration during ground transport of infants with very low birth weight

Date: 1/30/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Link: https://www.nature.com/articles/jp2014172

Goals: To learn more about an already existing design that was tested to see whether or not it reduced vibrations for neonates.

Content:

- "Gel mattresses significantly reduced the vibration of infant cardio-pulmonary resuscitation mannequins weighing approximately 2000 g."
    - For mannequins with lower weights (<300g), though, the gel mattress is not as effective.
- Other research shows air-foam mattresses can decrease vibrations as well.
- Adding mass is also used to because it can decrease vibrations when acceleration remains constant.
- Usually, hands-on care of infants being transported prevents full coverage of the incubator.
- This study used mattresses filled with air, gel and foam
- They used 3-inch square custom components consisting of polyurethane vibration isolation washers, polyurethane Silent Feet, and vibration control polyurethane washers under the incubator mattress tray to reduce vibrations.
- They collected their vibration data as acceleration and calculated RMS values and mean peak acceleration.
- Collected data at a rate of 360 data collection points/min and analyzed the vibration frequency components
    - used a Fast Fourier Transform, weighting accelerations according to the frequency when comparing values with ISO guidelines
- Used an airport runway for data collection to reduce variability of roads.
- Phase 1 consisted of baseline measurements of sound and vibration inside the incubator during five 1-min trials with the ambulance traveling the length of the 6099-feet runway using only foam mattress.
- Phase 2 focused on testing the effectiveness of different incubator mattresses in reducing mean RMS and peak acceleration.
    - The air and gel combination had the lowest RMS and peak acceleration, as well as the lowest standard deviation of all mattresses and combinations.
- Phase 3 combined the most effective mattress configuration from Phase 2 with vibration isolation pads under the incubator mattress tray, under the incubator wheels and lining the clamps that lock the incubator to the truck floor.
    - Also added a mass addition bean bag to the model/mattress unit.
    - No significant difference between industrial felt ($M=1.71$ m s^{-2}, s.d.=0.056), custom vibration isolator plates ($M=1.67$ m s^{-2}, s.d.=0.068) and appliance-vibration isolators ($M=1.57$ m s^{-2}, s.d.=0.008) on model vibration ($F=3.07$, $P=0.12$).
    - Appliance vibration isolator had the lowest RMS acceleration and the lowest s.d.
- Overall: significantly decreased the level of vibration from ‘extremely uncomfortable’ to ‘uncomfortable’ according to the ISO guidelines.
- A gel mattress alone did not significantly decrease vibration, but a combination of an air chambered mattress with a gel mattress on top did significantly decrease vibration.
- The effectiveness of mattresses in decreasing vibration levels depends on infant weight, with different types of mattresses needed for infants of different weights.
- The effectiveness of vibration isolators is influenced by the isolators’ compression, which is determined by the load (weight) on the isolators.
    - Could we standardize weight by included an adjustable weight in our design that goes with the neonate? Weighted blanket to at least increase weight?

Conclusions/action items:

We can base our test plan off of the one in this study and use similar materials for our testing.

2023/02/01 - Long-term outcomes of children with neonatal transfer: the Japan Environment and Children's Study

NICOLE PARMENTER - Feb 17, 2023, 11:57 AM CST

Title: Long-term outcomes of children with neonatal transfer: the Japan Environment and Children's Study

Date: 2/1/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Link: https://link.springer.com/article/10.1007/s00431-022-04450-7

Goals: To learn about long-term outcomes of current neonatal transfer.

Content:

- This paper concluded that neonatal transfer was associated with a higher risk of neurodevelopmental impairment at 3 years of age.
- This paper describes the Japan Environment and Children's Study.
    - This dataset includes 104,062 fetuses from a wide geographical area in Japan between 1/2011 and 3/2014
    - Neonates with congenital or chromosomal anomalies, or those with incomplete data of neonatal transfer, GA, birthweight, sex, or maternal information were excluded, so 82,543 neonates were eligible for the study
    - 3468 (4.2%) were transferred to different institutes in the neonatal period, and the remaining 79,075 controls remained and were discharged from the institute where they were born
- The exposure of interest was neonatal transfer, which was defined as inter-facility transport of the neonate.
- The study assessed correlations between neonatal transport and 3-year outcomes
    - Children who had neonatal transfer were significantly associated with a lower GA and birthweight, a higher incidence of male sex, and asphyxia at birth
    - Indications of neonatal transfer (all < 10% in the term and preterm cohorts) were jaundice, infection, maternal complications, hypoglycemia, vomiting, asphyxia, heart murmur or arrhythmia, hypothermia, persistent pulmonary hypertension of the newborn, intraventricular hemorrhage, seizures, and unknown or others
    - The incidence of neurodevelopmental delay, motor developmental delay, and cerebral palsy was significantly higher in 3-year-old children in the neonatal transfer group compared with that in the non-neonatal transfer group according to Supplementary Table 2
- Results of this study:
    - Two possible disadvantages in neonates with neonatal transfer are resuscitation quality in the birth hospital and medical transport in the vulnerable period
    - Inter-hospital transfer may induce physiological deterioration in neonates due to additional handling, temperature instability, noise and vibration exposure, and suboptimal monitoring and ventilator management

Conclusions/action items:

This paper provides longer term results about the potential risks to neonates of neonatal transport and we will keep these risks in mind as we build our design.

2023/02/17 - Vibration isolation in neonatal transport by using a quasi-zero-stiffness isolator

NICOLE PARMENTER - Feb 24, 2023, 9:46 AM CST

Title: Vibration isolation in neonatal transport by using a quasi-zero-stiffness isolator

Date: 2/17/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Link: https://journals.sagepub.com/doi/pdf/10.1177/1077546317703866

Goals: To learn more about the quasi-zero-stiffness (QZS) vibration isolation method.

Content:

- The article proposes a solution to the problem of vibrations during neonatal transport, which can be harmful to newborns, especially those in critical condition.
- The solution proposed is to use a quasi-zero-stiffness (QZS) isolator to reduce vibrations during transport. A QZS isolator is a mechanical spring-mass system that has low stiffness at its equilibrium position, making it an effective solution for reducing vibrations.
- The study conducted tests on the QZS isolator using a vibration table and a mock incubator to simulate neonatal transport conditions. The tests showed that the QZS isolator was effective at reducing vibrations, with up to 95% reduction for frequencies below 20 Hz.
- The QZS isolator has several advantages over other vibration isolation methods. It is a simple, low-cost solution that does not require an external power source or control system.
- The study concludes that the QZS isolator is a promising solution for reducing vibrations during neonatal transport, but further research is needed to optimize its design and evaluate its performance under different transport conditions. In addition, the study suggests that the QZS isolator has the potential to improve the safety and well-being of newborns during transport.
- The article highlights that the proposed solution is not just applicable to neonatal transport but can also be used in other areas where vibration isolation is necessary, such as aerospace, transportation, and energy systems.

Conclusions/action items:

This potential solution will be kept in mind as we brainstorm designs. We may be able to use components or concepts from the QZS in our designs.

2023/03/08 - Design of a vibration isolation system using eddy current damper

NICOLE PARMENTER - May 03, 2023, 2:09 PM CDT

Title: Design of a vibration isolation system using eddy current damper

Date: 3/8/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Learn about the eddy current damper.

Link: https://www.researchgate.net/publication/275558442_Design_of_a_vibration_isolation_system_using_eddy_current_damper

Content:

- Design of a passive vibration isolation system using a magnetic damper with high efficiency and compactness.
- Damper consists of two elements:
  - outer stationary conducting tube made up of copper
  - a moving core made up of an array of three ring-shaped neodymium magnets of Nd–Fe–B alloy separated by four block cylinders made of mild steel that are fixed to a steel rod resistance causes the mechanical vibration to dissipate heat energy
- generation of eddy currents in the conductor and its resistance causes the mechanical vibration to dissipate heat energy
- The proposed magnetic damper achieves a maximum transmissibility value less thantwo for a natural frequency that is less than 10 Hz and the excitations at higher frequencies are successfully isolated.
- Important objectives when designing a vibration isolator:
  - low-resonance frequency (so that the damper isolates the system for a broad frequency range)
  - low amplitude of vibration at resonance
  - steep slope of the transmittability curve (high attenuation at higher frequency)

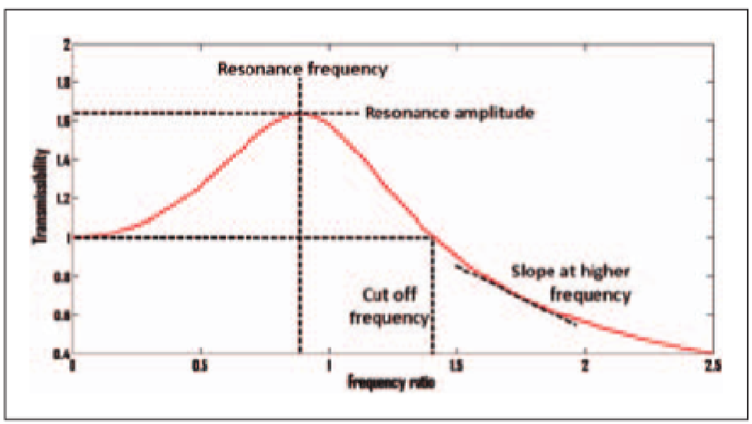


Figure 1. Salient features of a vibration isolator.

-

Outer diameter of the magnet ($2R_m$)	28 mm
Inner diameter of the magnet ($2r_m$)	10 mm
Thickness of the magnet (t_m)	12.5 mm
Outer diameter of the steel block ($2R_s$)	28 mm
Inner diameter of the steel block ($2r_s$)	10 mm
Thickness of the steel block (t_s)	10 mm
Diameter of the steel rod ($2s$)	10 mm
Outer diameter of the conductor ($2R_{out}$)	75 mm
Inner diameter of the conductor ($2R_{in}$)	29 mm
Length (l)	85 mm
Conductivity of copper (σ)	$5.96 \times 10^7 \text{ S m}^{-1}$
Air gap (a)	0.5 mm
Magnetization constant (M)	10^6 A m^{-1}
Mass to be isolated (m)	2.02 kg
Stiffness of the spring (k)	7.4 kNm^{-1}
Natural frequency (ω_n)	9.64 Hz
Cut-off frequency	13.63 Hz
Cut-off rate (per Hz)	0.125
Damping co-efficient per steel block	33.28 Ns m^{-1}
Total damping co-efficient (c)	99.84 Ns m^{-1}
Critical damping (c_c)	244.62 Ns m^{-1}
Damping ratio (ξ)	0.408
  - Specifications of the magnetic damper assembly used.

Conclusions/action items:

Use knowledge of eddy current damper when thinking of design.

2023/02/03 - Accelerometer Research

NICOLE PARMENTER - Feb 03, 2023, 1:39 PM CST

Title: Measuring vibrations with accuracy

Date: 2/3/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Learn about how accelerometers collect vibration data.

Content:

- There are three types of accelerometers: 1) Piezoelectric accelerometers, 2) Piezoresistive accelerometers and 3) Capacitive accelerometers
- piezoelectric:
  - The piezoelectric version utilizes the fact that piezoelectric materials produce electricity when being put under physical stress to be able to sense a change in acceleration/movement.
    - Pros: their recognition of being able to sense a wide frequency range, having no internal moving parts and that the acceleration signal can be used to sense velocity and displacement
- The piezoresistive accelerometer is way less sensitive and can't pick up details in the vibration as the piezoelectric version manages.
  - piezo element that increases its resistance to being in proportion with the amount of pressure/stress that it's being exposed to
- The capacitive version: when the accelerometer is being subjected to vibration, the distance between the capacitor plates changes and the distance is being measured

Conclusions/action items:

These sensor types could be used to collect data this semester.

2023/02/06 - Wireless Dynamics Sensor System

NICOLE PARMENTER - Feb 06, 2023, 8:49 PM CST

Title: Wireless Dynamics Sensor System

Date: 2/6/2023

Content by: Nicole Parmenter

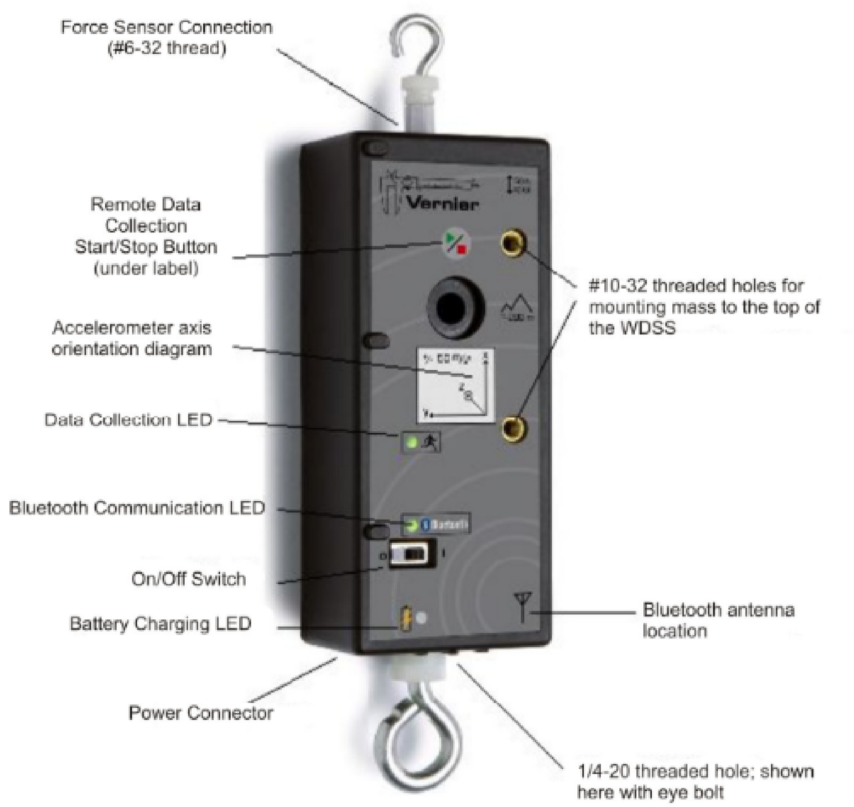
Present: Nicole Parmenter

Goals: To research an accelerometer to measure vibrations.

Link: https://www.vernier.com/product/wireless-dynamics-sensor-system/

Content:

- This accelerometer was the one used in the Decreasing sound and vibration during ground transport of infants with very low birth weight entry.



-
- It allows you to take data from a three-axis accelerometer, force sensor, and altimeter, using a Bluetooth wireless connection to a computer.
- It can collect over 100,000 readings over several minutes.
- It uses a dual-beam aluminum load cell.
    - A load cell is an electromechanical device with strain gages in a Wheatstone bridge configuration used to convert a force into a differential electrical signal.
- It reports force in two different ranges, ±10 N (more sensitive) and ±50 N
- There is no listed price.

Conclusions/action items:

This accelerometer could be purchased and used for testing.

2023/02/12 - Using High-Performance Mass-Spring Systems to Reduce Noise and Vibration in Track

NICOLE PARMENTER - Feb 24, 2023, 9:51 AM CST

Title: Using High-Performance Mass-Spring Systems to Reduce Noise and Vibration in Track

Date: 2/12/2023

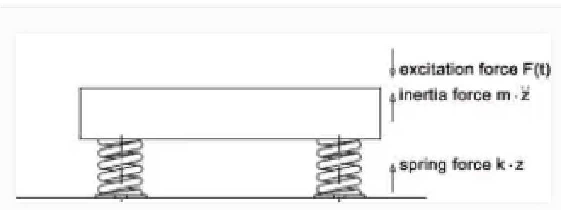
Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To learn about mass-spring systems for reducing vibrations.

Link: https://interfacejournal.com/archives/425

Content:

- The article discusses the issue of noise and vibration caused by railway lines in close proximity to residential and commercial buildings
    - Suggests that railway operators are now implementing measures to mitigate noise and vibration, including the use of mass-spring systems which are a very efficient method of reducing vibration at the source
- The mass-spring-systems represent the most efficient method of reducing vibration directly at the source for trains.
- 

    - This diagram is an idea of how springs can be incorporated to reduce vibrations.
- In order to provide a high level of attenuation, a mass-spring system requires an oscillating system consisting of a mass and a resilient layer
- It is essential to set the resonance frequency outside the relevant excitation spectrum area to mitigate vibration

Conclusions/action items:

This paper discusses a potential solution for reducing vibrations from trains. Some of these concepts and ideas can be incorporated into our designs.

2023/02/22 - Mass-Spring-Damper Theory

NICOLE PARMENTER - Feb 22, 2023, 1:38 PM CST

Title: Mass-Spring-Damper Systems: The Theory

Date: 2/22/2023

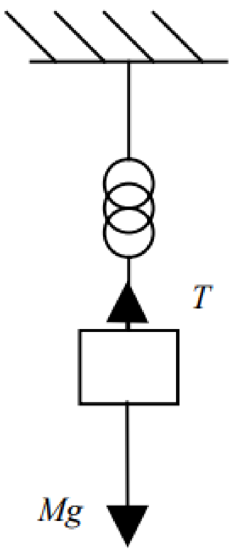
Content by: Nicole Parmenter

Present: Nicole Parmenter

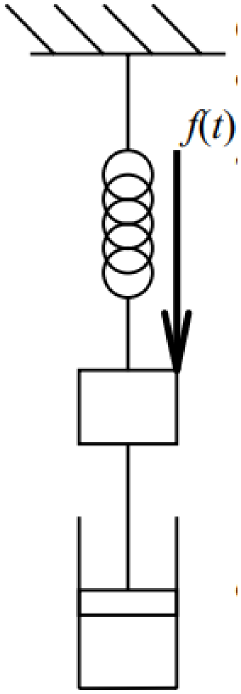
Goals: Learn about the theory of spring dampers.

Citation: “Mass-Spring-Damper Systems: The Theory.” Bournemouth University, 2001. Accessed: Feb. 12, 2023. [Online]. Available: https://faculty.washington.edu/seattle/physics227/reading/reading-3b.pdf

Content:

- Unforced Mass-Spring System
    - 

    - This results in a second order differential equation: $$M\frac{d^2y}{dt^2}+\frac{\lambda y}{l}=0$$
    - There are 2 initial conditions:
        - mass’s initial displacement
        - mass's initial velocity
    - Since the system above is unforced, any motion of the mass will be due to the initial conditions only
    - Unrealistic because this model does not take into account resistance to motion due to friction in the spring or air resistance
- Unforced Mass-Spring-Damper System
    - Resistance to motion is directly proportional to the velocity of the mass and, naturally, opposes the motion.
    - The damping force is described as $D=-R\frac{dy}{dt}$, where R is the damping factor.
    - The differential equation for this scenario is $$M\frac{d^2y}{dt^2}+R\frac{dy}{dt}+\frac{\lambda y}{l}=0$$
- Forced Mass-Spring-Damper System

- 

- In this situation, the mass is subjected to a force f(t) in the direction of motion.
- This case is most applicable to out project.
- $$M\frac{d^2y}{dt^2}+R\frac{dy}{dt}+\frac{\lambda y}{l}=f(t)$$
  $$M\frac{d^2y}{dt^2}+R\frac{dy}{dt}+ky=f(t)$$
- f(t), the force, can be many things.
  - It can be 0 for unforced system
  - It can be c for a constant applied force
  - it can be mt +c, at^2+bt+c, asinwt+bcoswt, etc.

- A heavily damped system is described by $\boldsymbol{R^2-4Mk>0}$ (or $R^2>4Mk$)
  - Produces an exponential decaying transient
- Lightly damped system: $\boldsymbol{R^2-4Mk<0}$ (or $R^2<4Mk$)
  - Produces a sinusoidal transient modulated by pure exponential decay
  - Fast response and corresponds to small values of R compared with M and k
- Critically damped system:
  - Linear function (A + Bt) modulated by exponential decay

Conclusions/action items:

The forced mass-spring-damper case is most relevant to our project. We will use the linear differential equations provided to solve for variables like the damping factor we want when we are purchasing/fabricating our spring dampers.

2023/02/26 - BASIC VIBRATION THEORY

NICOLE PARMENTER - Feb 26, 2023, 11:20 AM CST

Title: BASIC VIBRATION THEORY

Date: 2/26/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To learn about the physics behind vibrations.

Link: https://engfac.cooper.edu/pages/tzavelis/uploads/Vibration%20Theory.pdf

Content:

- Vibratory systems are composed of means for storing potential energy (spring), means for storing kinetic energy (mass or inertia), and means by which energy is gradually lost (damper).
- The vibration of a system involves the alternating transfer of energy between its potential and kinetic forms.
- In a damped system, some energy is dissipated at each cycle of vibration and must be replaced from an external source if steady vibration is to be maintained.
- Lumped parameter systems are considered, composed of ideal springs, masses, and dampers, wherein each element has only a single function.
- In translational motion, displacements are defined as linear distances; in rotational motion, displacements are defined as angular motions.
- The spring constant or stiffness is proportional to the change in length of the spring with respect to the force acting along its length.
- A mass is a rigid body whose acceleration is proportional to the resultant force acting on it.
- The applied force on a viscous damper is proportional to the relative velocity of its connection points, and the damping coefficient is the characteristic parameter of the damper.
- The elements of a mechanical system that moves with pure rotation of the parts are wholly analogous to the elements of a system that moves with pure translation.
- A single degree-of-freedom system consists of a mass attached to an immovable support by means of a spring and is constrained to translational motion in the direction of the X axis.
- The mass is described fully by the value of a single quantity x, making it a single degree-of-freedom system.
- Free vibration and forced vibration can occur in a single degree-of-freedom system.
- The free vibration of an undamped system is considered, with Newton's equation written for the mass m, resulting in the equation $m\ddot{x} + kx = 0$.
- The solution to this equation is $x = A \sin \omega nt + B \cos \omega nt$, where ωn is the angular natural frequency defined by $\omega n = (k/m)^{1/2}$.
- The period of oscillation is $\tau = 2\pi/\omega n$, and the natural frequency is the reciprocal of the period.
- The relationships between natural frequency, weight of the supported body, and stiffness of the spring are shown by solid lines in Figure 2.5.
- The initial conditions of displacement and velocity at $t = 0$ determine the subsequent oscillation completely.
- The phase angle θ can be calculated from A and B using $\theta = \tan^{-1}(B/A)$.
- The static deflection of a simple mass-spring system is $\delta st = mg/k$, where m is the mass, g is the acceleration due to gravity, and k is the spring constant.
- The relationship between natural frequency and static deflection only applies to linear and elastic systems, and is not applicable to nonlinear systems or those with dynamic stiffness differences.
- The article discusses a system of masses interconnected by springs and dampers, acted upon by external forces.
- The damping force acting on the jth degree-of-freedom is given by equation (2.80).
- The distribution of damper sizes in a system can couple normal modes together, making it difficult to separate equations of response into independent normal mode equations.
- Two types of damping distribution that do not couple normal modes are uniform viscous damping and uniform mass damping.
- Uniform damping is a suitable model for systems in which the damping effect is an inherent property of the spring material. The ratio of damping coefficient to stiffness coefficient is the same for each spring of the system.
- For uniform viscous damping, the damping force can be written as equation (2.82).
- Each mode of the system responds as a simple damped oscillator, and the damping term $2G\omega n2$ corresponds to $2\zeta\omega n$ in a simple system.
- The effective damping for a particular mode varies directly as the natural frequency of the mode.
- The applicable equation of motion for a system with uniform viscous damping that is disturbed from its equilibrium position and released to vibrate freely is equation (2.86).

- The solution of equation (2.86) for less than critical damping is given by equation (2.87), and the values of A and B are determined by the initial displacements and velocities.
- Each mode undergoes a decaying oscillation at the damped natural frequency for the particular mode, and the amplitude of each mode decays from its initial value.

Conclusions/action items:

I will use this vibration theory when designing the spring dampers we will use in our design.

2023/03/01 - I-Phone app to test vibrations during helicopter neonatal transport

NICOLE PARMENT

Title: I-Phone app to test vibrations during helicopter neonatal transport

Date: 3/1/2023

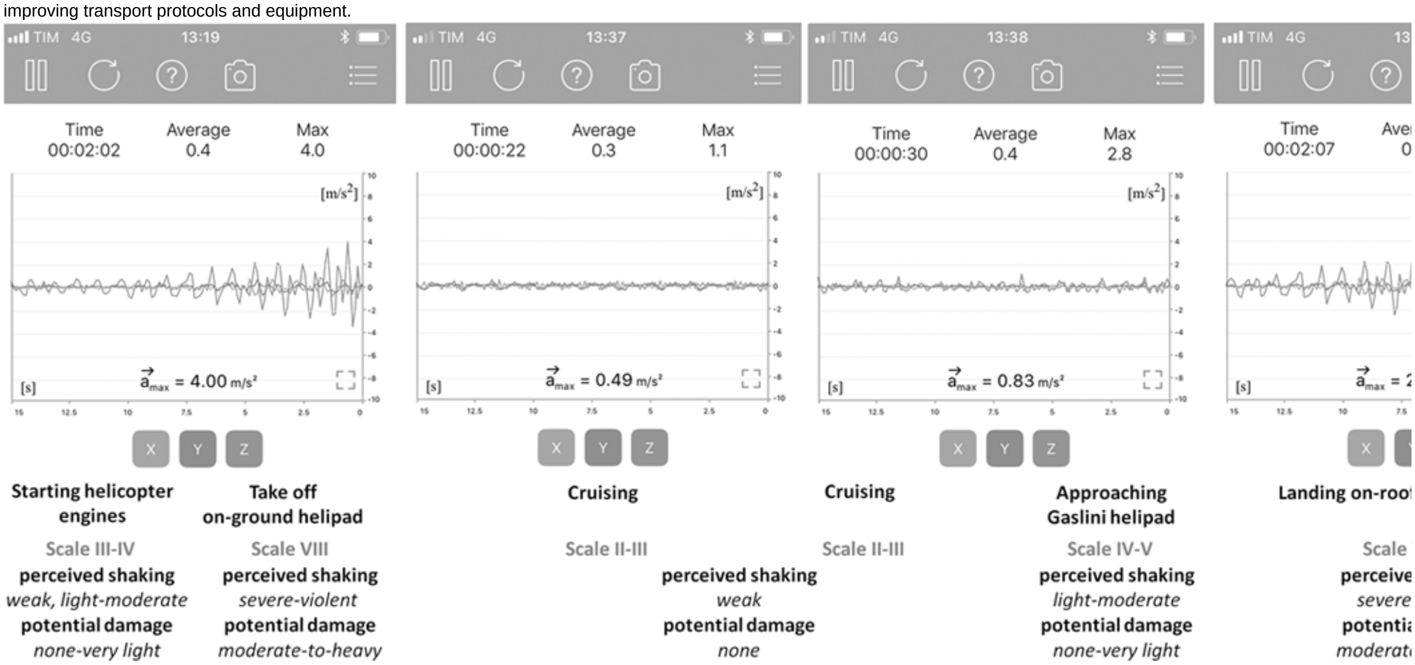
Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To research a cheap and efficient way to collect testing data.

Link: https://oce-ovid-com.ezproxy.library.wisc.edu/article/00063110-202106000-00016/HTML

Content:

- The article describes the development and evaluation of an iPhone app designed to test the vibrations experienced during neonatal helicopter transport.
- App was developed by the United States Geological Survey and uses instrumental intensity scale mapping peak ground acceleration and peak ground velocity on an intensity scale sim Mercalli scale
- It works by measuring the frequency and amplitude of the vibrations experienced by the iPhone during the flight and comparing them to a pre-determined threshold of safe vibration leve
    - Measures accelerating forces in the three space dimensions (x, y, z) expressed in m/s^2
- To date, no standards exist for safe levels of vibration exposure in neonates
- The app also includes a feature that allows users to record and submit data on the type of helicopter and transport conditions, as well as any adverse events experienced during the flig
- The authors conducted a series of tests to evaluate the accuracy and reliability of the app, including comparing the results of the app to those obtained by more traditional vibration mea
- They found that the app was highly accurate and reliable, with a correlation coefficient of 0.95 compared to the traditional measurement techniques.
- The app has the potential to be a valuable tool for ensuring the safety of neonatal patients during helicopter transport, as it allows for real-time monitoring of vibration levels and can pro improving transport protocols and equipment.
- 

    - Example data collected by the app

Conclusions/action items:

This app is a possible alternative to the MATLAB app or a more expensive accelerometer.

2023/03/01 - Design of a Magnetic Negative-stiffness-damper for Vibration Isolation

NICOLE PARMENTER - Mar 01, 2023, 10:17 AM CST

Title: Design of a Magnetic Negative-stiffness-damper for Vibration Isolation

Date: 3/1/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To learn about existing magnetic dampers used for vibration isolation.

Link: https://iopscience.iop.org/article/10.1088/1742-6596/1549/2/022063/pdf

Content:

- The article proposes a magnetic negative-stiffness damper (MNSD) for vibration isolation applications.
- The design uses magnetic forces to provide a negative stiffness effect to counteract the positive stiffness of conventional mechanical springs.
- The MNSD consists of a permanent magnet, a ferromagnetic core, and a coil.
- The magnetic negative-stiffness effect is generated when the coil current is adjusted to produce a magnetic force that opposes the force due to the permanent magnet and the ferromagnetic core.
- The MNSD can provide a low resonance frequency and high damping ratio, making it effective for isolating vibrations at low frequencies
- The article discusses the design considerations, including the magnetic circuit design, the selection of the coil material, and the optimization of the coil geometry.
- Performance was evaluated using a vibration isolation system, and the results showed that it effectively reduced the vibration transmissibility at low frequencies.
- The article also discusses the potential applications of the MNSD in various fields, including aerospace, automotive, and industrial machinery.
- Advantages over traditional vibration isolation systems include its simplicity, compactness, and ability to provide high damping ratios and low resonance frequencies.
- The authors suggest that further research is needed to optimize the MNSD design and to explore its potential applications in practical engineering systems.

Conclusions/action items:

Concepts from this design idea can be used when fabricating or modifying magnetic dampers for the team's design.

2023/03/28 - Fronczak Notes

NICOLE PARMENTER - May 01, 2023, 7:38 PM CDT

Title: Dr. Fronczak Meeting Notes

Date: 3/28/3023

Content by: Nicole Parmenter

Present: Full Team

Goals: Learn about vibration theory.

Content:

add linear bearings to prevent rotating motion - 1 in each corner, makes it a single DOF
single DOF system with second order diff eq

types of springs:

coil - flat wire or round wire

beam - cantilever or leaf (one side is fixed, one slides)

if you jump on car and it bounces, it's underdamped

increase mass & softer spring, no damping gives most vibration isolation possible (graph where y axis is output/input)

critical damping gives fastest response, want a little less (within a band) than c critical

vibration isolation: add another mass spring

omega_n is constant and is sqrt(k/m)
zeta = c/c critical (eq. in ch 6 for c critical, depends on m, etc.) c critical = 2sqrt(Mk)

zeta is sum of 4 damping components in 4 corners, just one if you put it in the middle
sqrt(4*(k/n)) = omega_n bc there are 4 springs in parallel

pg 144
eq. 715

1. solve for c critical

2. choose zeta from graph for how much damping you want

3. solve for c

4. solve for k

Conclusions/action items:

Follow these steps to solve for spring and damping coefficient and purchase spring & damper.

2023/02/13 - Design Idea 1: Spring Weight Design

NICOLE PARMENTER - Feb 13, 2(

Title: Spring Weight Design

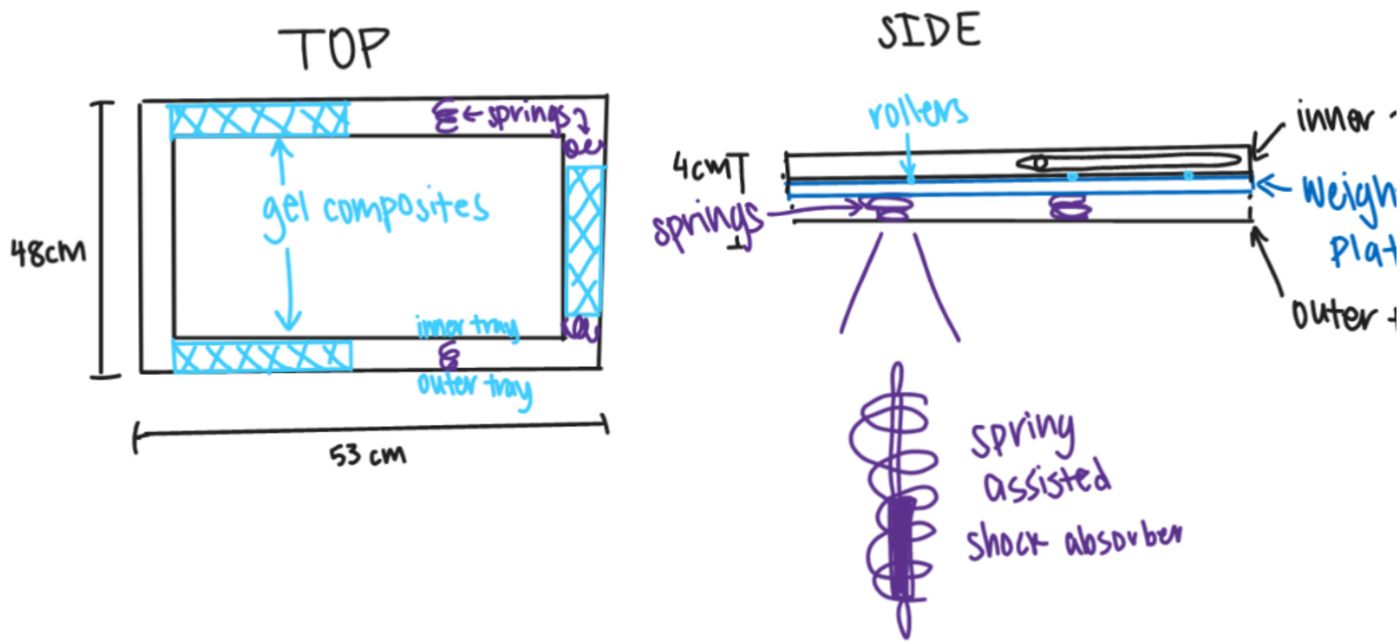
Date: 2/13/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Propose an initial design to reduce neonatal transport vibrations.

Content:



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- This design utilizes spring assisted shock absorbers to minimize vibrations in the inner tray.
- A weighted plate is placed between the springs and inner tray because increasing weight can reduce vibrations.
- There are rollers between the weighted plate and inner tray so the inner tray can still slide in and out.
    - Tracks for the rollers could replace the sliding mechanism between the inner and outer trays, but would require a redesign of the incubator trays instead of just a design to insert.
- The light blue rectangles are metal/gel composite dampers.

Conclusions/action items:

Share design with group to discuss and make design matrix.

2023/02/13 - Design Idea 2: Cantilever Beam Design

NICOLE PARMENTER - Feb

Title: Cantilever Beam Design

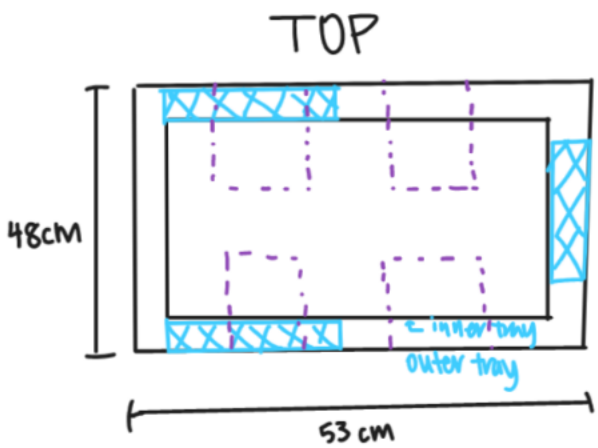
Date: 2/13/2023

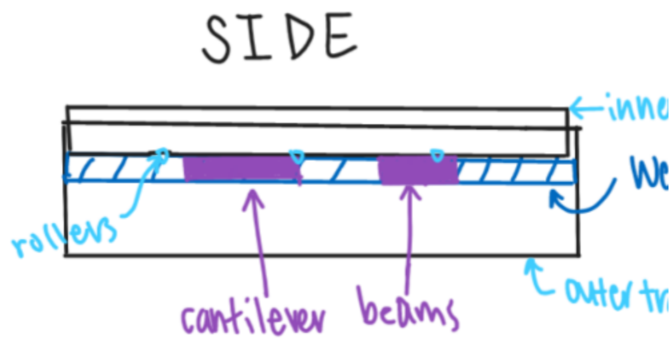
Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Propose an initial design to reduce neonatal transport vibrations.

Content:





- This design uses cantilever beams to reduce vibrations.
- Four cantilever beams support the inner tray.
- The beams are attached to the weighted plate that is connected to the inner tray with rollers.
- This design would likely require a redesign of the trays inside the incubator.
- The light blue rectangles are metal/gel composite dampers.

Conclusions/action items:

Share design with group to discuss and make design matrix.

2023/02/28 - Z-Damper: A new revolutionary vibration isolation technology

NICOLE PARMENTER - Mar 01, 2023, 9:46 AM CST

Title: Z-Damper: A new revolutionary vibration isolation technology

Date: 2/28/2023

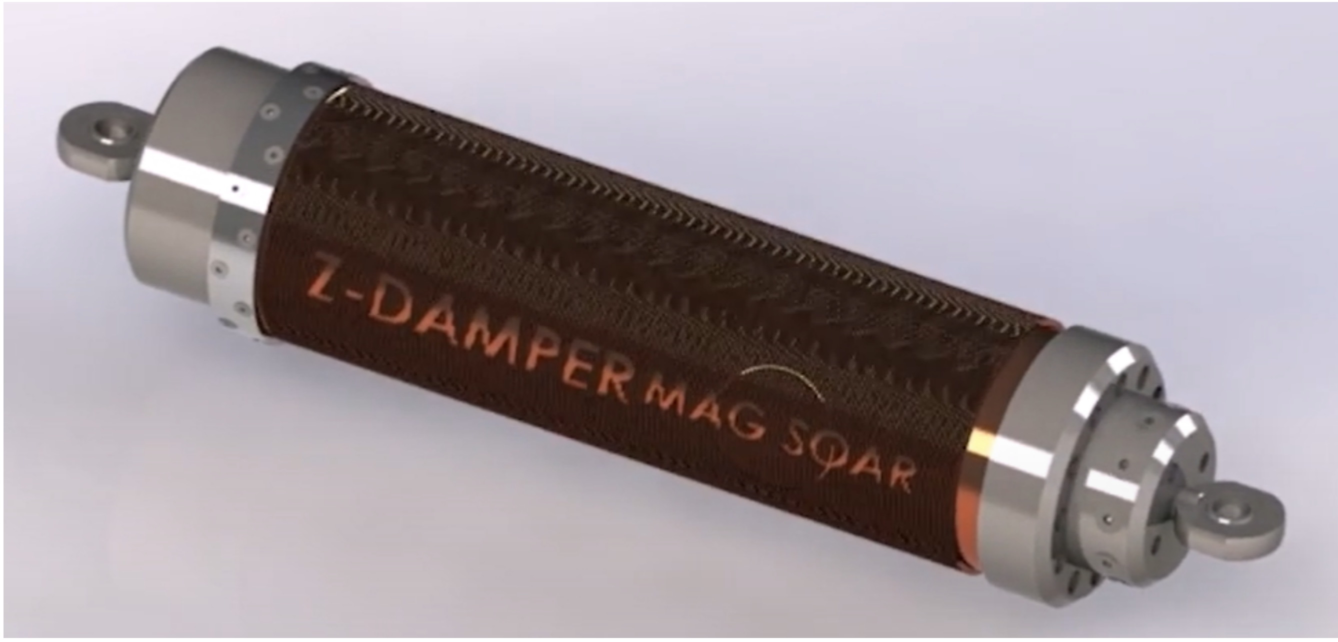
Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To learn about existing magnetic dampers.

Link: https://magsoar.com/magnetic-dampers/

Content:

- 

- Z-Damper is a new revolutionary vibration isolation technology that uses magnetic dampers to reduce vibrations in mechanical systems.
- Designed to be more effective and efficient than traditional vibration isolation systems, such as passive dampers and spring systems
- Uses a combination of permanent magnets and electromagnetic coils to create a magnetic field that dampens vibrations in the system.
- The magnetic field is controlled by a feedback control system that measures the vibrations and adjusts the magnetic field in real-time to reduce the vibrations.
- Z-Damper is capable of controlling vibrations in a wide range of frequencies and amplitudes
- Has several advantages over traditional vibration isolation systems, including its ability to adapt to changing operating conditions, its high efficiency, and its low maintenance requirements.
- Z-Damper can also be customized to meet the specific needs of different applications, such as by adjusting the strength and configuration of the magnets and coils.
- Z-Damper has been successfully implemented in several aerospace and defense applications, with significant reductions in vibration levels observed
- Relatively new technology, and further research is needed to optimize its performance and reduce its cost.
- The development of Z-Damper is part of a broader trend towards the use of smart materials and advanced control systems in mechanical engineering to improve the efficiency, safety, and reliability of mechanical systems.

Conclusions/action items:

This damper is likely too expensive for our team to purchase, but concepts from this design can be looked for in other potential viable purchases or used in any damper fabrication.

2023/03/08 - Miniature Shock Absorbers

NICOLE PARMENTER - May 01, 2023, 7:44 PM CDT

Title: Miniature Shock Absorbers

Date: 3/8/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Research potential shock absorbers to use in design.

Link: https://www.acecontrols.com/us/products/automation-control/miniature-shock-absorbers/mc5-to-mc75.html

Content:

-
- short overall lengths and low return forces
- The outer body of each shock, produced from one solid piece, is filled with temperature stable oil
    - offers a continuous outer body thread including a supplied lock nut
    - has an integrated positive stop
- wide range of energy absorption and effective weight
- react to changing energy conditions, without adjustment

Conclusions/action items:

Possibly get a sample of this mini shock absorber to use in a design.

2023/02/24 - Biosafety and Chemical Safety

NICOLE PARMENTER - Feb 24, 2023, 9:53 AM CST

Title: Chemical and Biosafety Training

Date: 2/24/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Get Biosafety and Chemical training certificates.

Content:

Training Information Lookup Tool **University of Wisconsin-Madison**

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Nicole Parmenter has completed training for the following course(s):

Expand All Collapse All

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2022	1/12/2022	
Chemical Safety: The OSHA Lab Standard	Final Quiz	1/17/2021	

Data Last Imported: 31/01/2022 05:04 PM

Conclusions/action items:

I completed my biosafety and chemical safety training.

2023/02/24 - Green Permit

NICOLE PARMENTER - Feb 24, 2023, 9:54 AM CST

Title: Green Permit Training

Date: 2/26/2022

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To get my green permit.

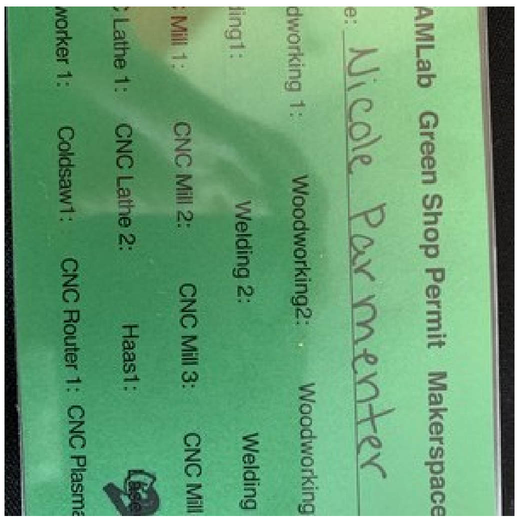
Content:

My green permit is attached.

Conclusions/action items:

I got my green permit from TeamLabs.

NICOLE PARMENTER - Feb 24, 2023, 9:54 AM CST



Download

Green_Permit_2.jpg.jpg (36.2 kB)

2023/03/06 - WARF Lecture Notes

NICOLE PARMENTER - Mar 08, 2023, 9:18 PM CST

Title: WARF Lecture Notes

Date: 3/8/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: To learn about WARF.

Content:

- The key piece of intellectual property protection that leveraged at WARF is patenting.
  - have over 2,000 issued US patents in our portfolio with another 700 patent applications that are pending
- The three biggest classes of intellectual property that we oftentimes hear about are patents, trademarks, and copyrights.
- The method of doing something can be programmed into a computer code that can be copyright protected and given a name.
- Patenting is used for discoveries on campus that involve a machine or device, a composition of matter, a process or a method, or improvements on existing processes or methods or compositions of matter.
- Trade secrets are not commonly used on campus because information is shared and disseminated, making it difficult to protect secrets once they are discovered by the public.
- Prior art is anything in the world that has been done before your invention and is evaluated against your invention to see if it meets the subject or requirements for patentability.
- Prior art can be created by other people or by yourself through public disclosure, such as class presentations or posters.
- The United States provides a grace period of 12 months from the date of the first public disclosure until you can file for patent protection in the United States.
- International countries, such as those in Europe, often have absolute novelty requirements and do not provide a grace period for public disclosures.
- In tech transfer, it is important to consider prior art and public disclosures when thinking about retaining international rights to inventions.

- Process for Patenting:
  - Inventor discovers and invents
  - Brings idea to WARF for consideration of intellectual property protection
  - Simple short form document (4 pages) asks questions about invention, novelty, funding, etc.
  - WARF receives invention disclosure report and meets with inventor to discuss idea
  - Evaluates novelty, potential for licensing, etc. in decision committee
  - If accepted, inventor assigns invention to WARF
  - WARF pays $30,000 for patent and costs associated with licensing
  - Inventor receives 20% of licensing revenue, 15% goes to department, and 65% goes to annual gift

- Process for Licensing:
  - WARF considers market viability of invention and potential for licensing
  - Considers WARF's track record in specific field
  - Considers stage of technology and timeline for licensing
  - Works with companies to market technology while patent is pending
  - Aims to get technology into hands of companies to turn into products and pay royalties back to WARF for research at university
- Consider how your technology plays within the market space.
- Determine if your invention is a component of a product or the entire product.
- Identify if there is a product pipeline that you can create for your new company or if it is a software component that needs to be embedded.
- Determine the amount of development time required and if there is enough funding opportunity for the product to enter the market.
- Identify the size of the market you are trying to meet and the potential for a return on investment.
- Determine who will be in the management of the company and what their role will be.
- Access available resources on campus such as Discovery 2 Product and Entrepreneurons.
- Consider programs such as Innovation Roadmap and Upstart for hands-on startup product development.
- Access resources such as the Law and Business Entrepreneurship Clinic for legal advice.
- After developing a product, license technology back from WARF, who then works out a license agreement with the company.

Conclusions/action items:

Our design might eventually be eligible for a patent if we can make a functional product that is novel and different enough from current competing vibration isolation systems. Using a magnetic damping system would distinguish our design from existing products.

2023/03/26 - Testing the Accelerometer

NICOLE PARMENTER - Mar 26, 2023, 9:40 AM CDT

Title: Testing the Accelerometer

Date: 3/26/2023

Content by: Nicole Parmenter

Present: Nicole Parmenter

Goals: Learn how the accelerometer works and do a longer trial of data collection.

Content:

- Did ~3 hour trial of data collection (part of it in a car) from 1:35 - 4:45
- Collected acceleration, time, velocity, angle
- Range bandwidth: 98 Hz
- Baud rate: 115200
- Calibrated acceleration and reset height and angle before beginning data collection
- 53.2 MB used at this point (29.6 GB remaining)
- Raw data attached

Conclusions/action items:

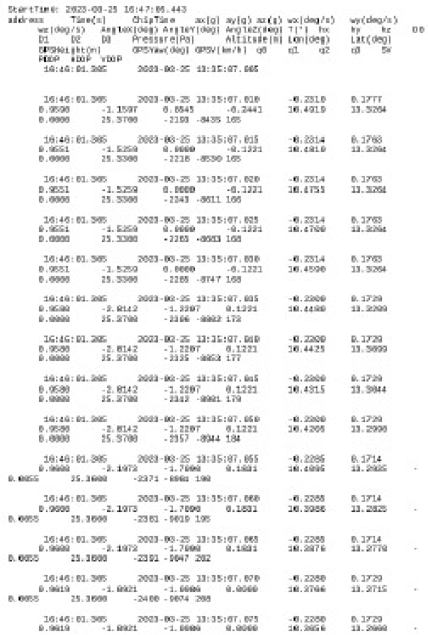
Now that we know how to get the data from the accelerometer after offline data collection, do another data collection test to see how long the battery lasts.

NICOLE PARMENTER - Mar 26, 2023, 9:30 AM CDT

Download

WIT4.TXT (12.8 MB)

NICOLE PARMENTER - Mar 26, 2023, 9:30 AM CDT



Download

WIT4_New.txt (22.4 MB)

NICOLE PARMENTER - Mar 26, 2023, 9:39 AM CDT

Download

WIT4_plots.fig (4.82 MB)

2023/04/26 - MATLAB Graphs

NICOLE PARMENTER - May 01, 2023, 8:08 AM CDT

Title: MATLAB Graphs

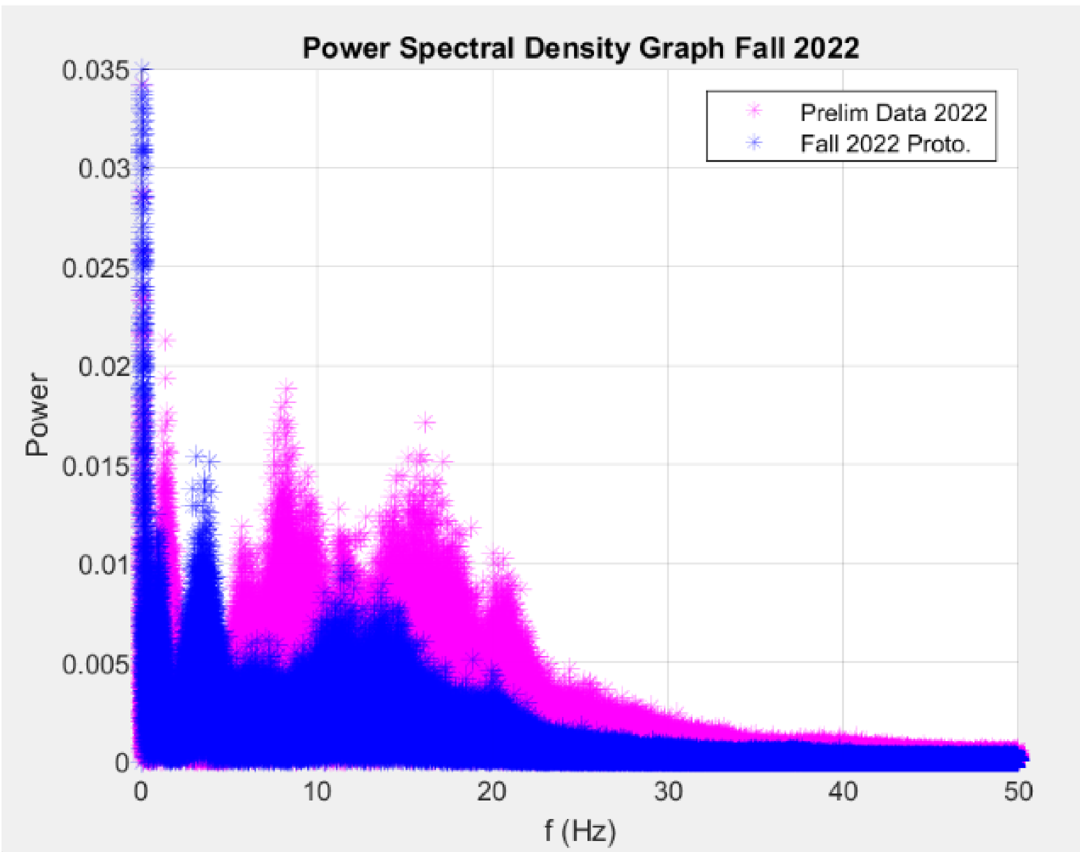
Date: 4/26/2023

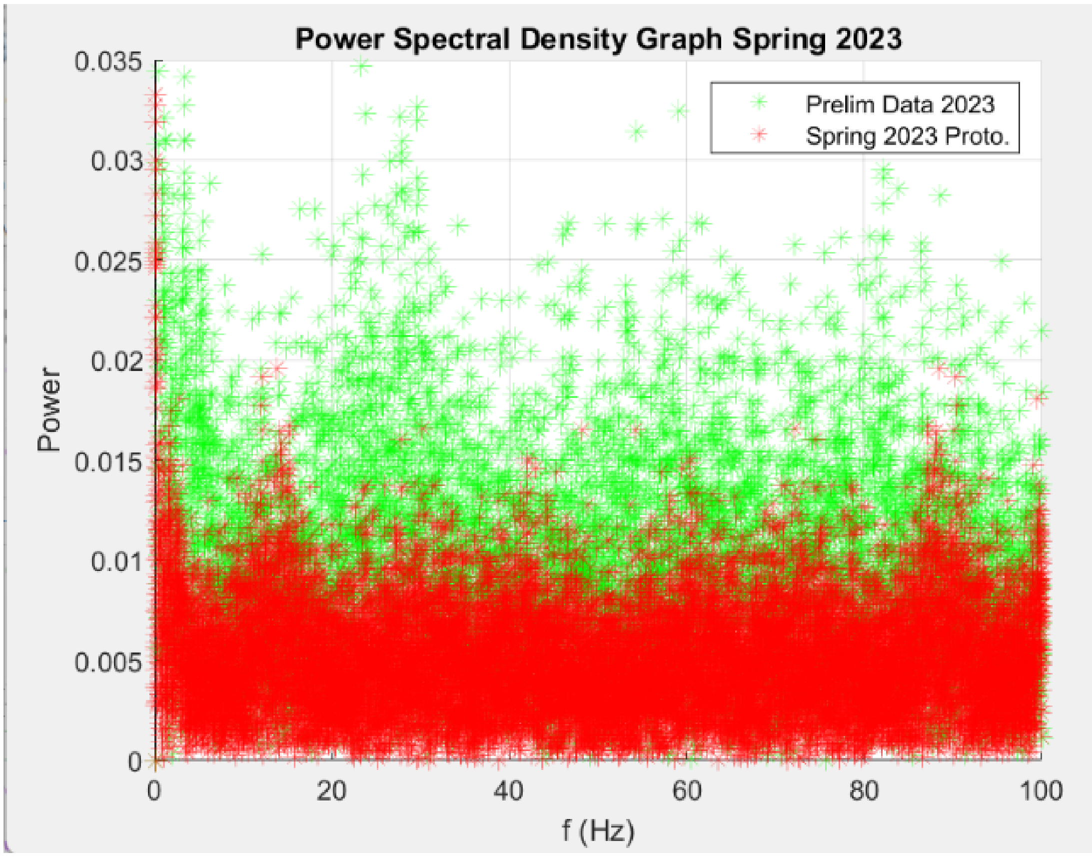
Content by: Nicole Parmenter

Present: Nicole Parmenter

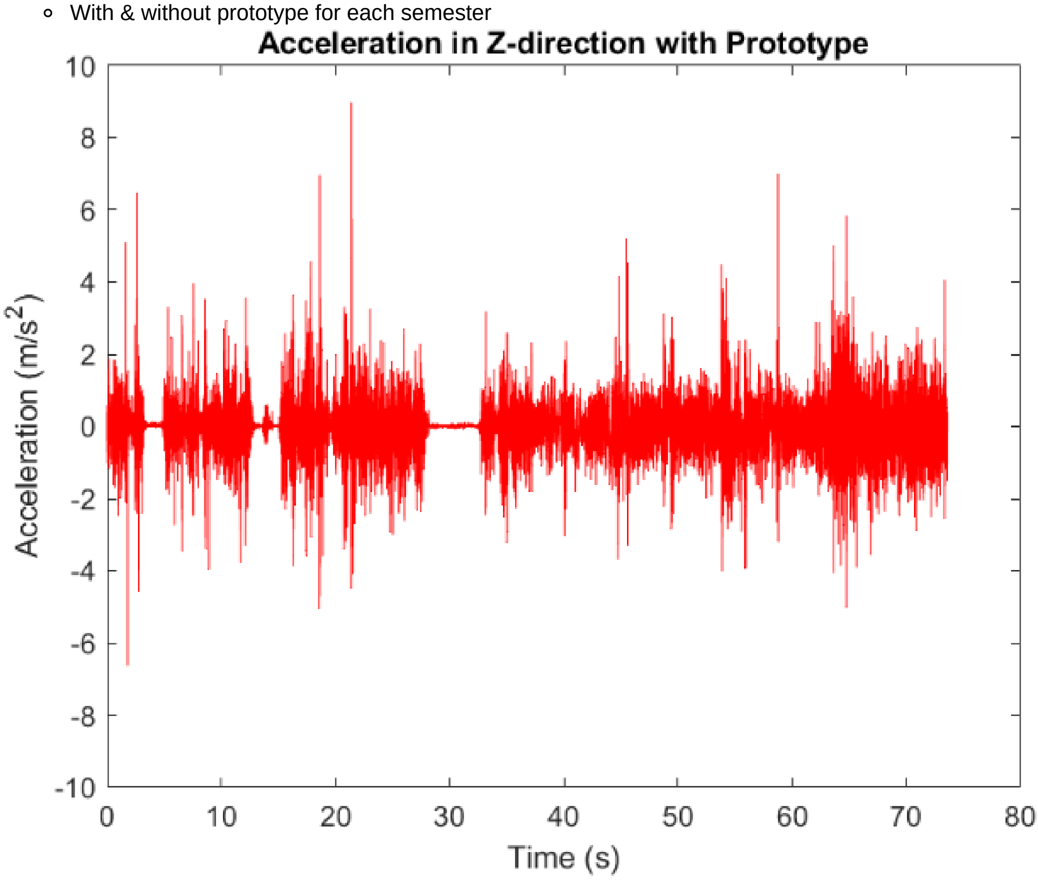
Goals: Make MATLAB graphs for final poster

Content:

- 

- 

- Changed MATLAB code by multiplying the data from this semester by 9.81 to convert the units from g to m/s^2
- Made two separate graphs, one with last semester's data and one with this semester's data
    - With & without prototype for each semester



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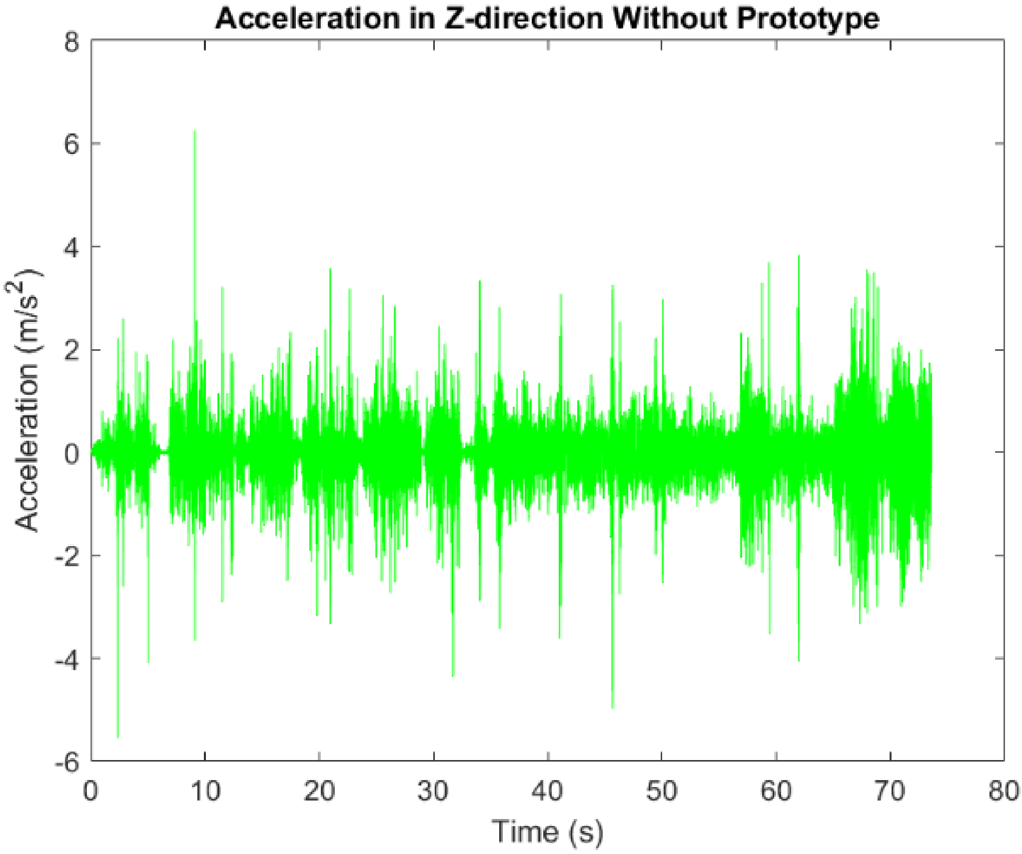
- 

Conclusions/action items:

Use these graphs on the final poster to display the change in last semester's data compared to this semester's.

2023.02.08 - Neonatal Incubators

Sydney Polzin - Feb 25, 2023, 12:08 PM CST

Title: Neonatal Incubators

Date: February 8, 2023

Link: https://www.sciencedirect.com/topics/nursing-and-health-professions/neonatal-incubator

Content by: Sydney Polzin

Present: NA

Goals: Discuss the functionality and purpose of neonatal incubators

Content:

- Incubators are important to regulate important vitals to a neonate, such as temperature, oxygen and humidity, and provide a screen output of relevant information about the health of the neonate so nurses know how to support the child.
- Incubators are in service for several years and experience significant shock and vibration during their lifetime.
  - They are mounted on a caster which is why they undergo so much stress
  - Damage to the incubator due to the stress they experience can alter the functionality of the incubator, such as temperature regulation.
- There are various models of incubators, which have different functionalities based on when they were developed. Older incubators often pose additional risks to the neonate.

Conclusions/action items:

Incubators are very important in maintaining proper vitals of the neonate. They experience significant stress during transport, which could ultimately affect the neonate. Proper maintenance of the incubator is essential to the safety of the neonate.

2023.02.08 - Ambulance Lifespan

Sydney Polzin - Feb 25, 2023, 12:23 PM CST

Title: Ambulance Lifespan

Date: February 8, 2023

Link: https://www.ccmhgiving.com/ambulance-replacement/

Content by: Sydney Polzin

Present: NA

Goals: Discuss the average lifespan of an ambulance.

Content:

- Ambulances, on average, last for approximately five years
- They typically have a range of mileage, but typically around 300,000 miles is standard for each ambulance.
- Approximately 6,000 patients are treated per year.

Conclusions/action items:

Ambulances are used very frequently and on a regular basis every year. They have a lifespan of approximately five years and drive approximately 300,000 miles before they are no longer viable. However, these values could potentially differ based on the location in which the hospitals and ambulances are located (e.g., rural vs. urban areas).

2023.02.08 - Medical Device Color Considerations

Sydney Polzin - Feb 25, 2023, 12:44 PM CST

Title: Medical Device Color Considerations

Date: February 8, 2023

Link: https://www.team-consulting.com/insights/the-role-of-colour-in-medical-devices-a-designers-perspective/

Content by: Sydney Polzin

Present: NA

Goals: Discuss the importance of choosing the aesthetics and appearance of a medical device

Content:

- Color is a very important part in creating a medical device, as the aesthetic of the product can tell a lot about the quality and functionality of the product.
- Color choices should be carefully considered and used in packaging and labeling.
- Color can trigger an emotional response.
    - Darker colors represent something heavier and weighing down, whereas lighter colors give a lighter feeling and emotional response.
    - White, aqua blues or fresh greens give the feeling of clean.
        - Example: toothbrushes
    - Colors can give a feeling of professionalism as well.
- Medical devices should have colors chosen that represent the product accurately, showing that it is reliable and valued.
- The shade of a color is very important to, beyond just choosing one generic color.
- There are some regulations that surround color selections based on pigmentation. Regulations must be completed and testing must be conducted to ensure reliability.
    - FDA potential for leachables and extractables

Conclusions/action items:

Color is an important consideration that needs to be taken into account for when creating a medical device. Beyond just the color selection, the specific shade of color that is chosen is important as well. Various colors and shades present different emotional responses, so the user and audience of the product should be carefully considered when deciding on the color.

2023.03.01 - How comfortable is neonatal transport?

Sydney Polzin - Mar 01, 2023, 12:29 PM CST

Title: How comfortable is neonatal transport?

Link: https://onlinelibrary-wiley-com.ezproxy.library.wisc.edu/doi/full/10.1111/j.1651-2227.2011.02467.x

Date: March 1, 2023

Content by: Sydney Polzin

Present: NA

Goals: To share a study conducted to measure pain level of neonates and infants during transportation

Content:

- There is currently no mechanism that assesses the pain and discomfort that neonates experience during transport
- Noise and vibration reduction tools used include "gel mattresses, ear muffs, harnesses, incubator covers, etc."
- The purpose of this study was to measure pain scores of neonates that are being transported by using the Premature Infant Pain Profile (PIPP) score
    - Transported by the Yorkshire Neonatal Transport Service
    - All infants transported with a "gel mattress, a nest set, and an incubator cover"
- For all ages that were measured, the max pain score observed was during their transport for both behavioral and physiological components
    - Majority of cases still experienced minimal pain but that is subjective
- Studies have shown that adults find transport uncomfortable due to noises and unwanted vibrations; therefore, it can be inferred that neonates, especially given their vulnerable stage of life, would find the transport to also be uncomfortable.
- Both decreasing noise and light exposure can positively influence neurological development.
- Transporting neonates of a very small birth weight can pose additional risk, as it increases their chances for intraventricular hemorrhage.

Conclusions/action items:

This study proved that neonates and infants undergo greater discomfort and pain due to transportation, using the PIPP score. This study was one of the first of its kind and proved that further research and development needs to be conducted in the area in order to improve the transportation comfortability for patients, especially neonates and infants.

2023.03.01 - Design and experimental investigation of ultra-low frequency vibration isolation during neonatal transport

Sydney Polzin - Mar 01, 2023, 10:38 AM CST

Title: Design and experimental investigation of ultra-low frequency vibration isolation during neonatal transport

Date: March 1, 2023

Link: https://www.sciencedirect.com/science/article/pii/S0888327020300194?casa_token=hNHc4uWa3mgAAAAA:ukdmcay8JSKyAHyNtp6xp-vRhY-uuxB4UV2Pz_v-DWXwRa5Nulk1iRBme-YPua_t8Fv_6fguyw

Content by: Sydney Polzin

Present: NA

Goals: Discuss a competing design that is an incubator with quasi-zero-stiffness (QZS) isolators

Content:

- During transport, the neonate is subject to vibrations from the ambulance, which can range from 3 to 18 Hz.
    - Vibrations between 1 to 80 Hz have an impact on humans, but vibrations within the range of 1 to 20 Hz (low-frequency) have the biggest impact.
        - Can result in injuries that are permanent and irreversible
- A linear vibration isolator can only do its job when the excitation frequency is greater than sqrt(2) * the natural frequency
- This design incorporates redesigning the entire incubator system to be the QZS incubator
    - Prevents mechanical vibrations
    - Utilizes an two mutually repelling magnet rings to act as negative stiffness (NS) and a coil spring in parallel
        - The coil spring is used to meet specification surrounding weight capabilities
        - The magnetic rings are used to introduce negative stiffness
        - Both the stiffness of the coil spring and the magnetic rings should be equal
    - Quasi-zero stiffness combines both the NS and the coil spring
    - Four QZS isolators are used and distributed evenly, accounting for 1/4 of the total weight inside the incubator
        - Placed in between the box of auxiliary equipment and the isolette to reduce vibrations from the auxiliary equipment and the ambulance
    - The position of the coil spring can be adjusted on a case to case basis (based on varying weights of neonates) by moving the screw nut
- To test the prototype, the prototype was placed on a shake table that shook at random harmonic excitation frequencies, ranging from 2 to 15 Hz with varying amplitudes. Four of the QZS isolators were put into position, and three accelerometers were attached to the model of the infant.
    - Results clearly showed a decrease in transmissibility when using the QZS isolator opposed to a linear isolator.
        - Specifically noticeable in the low frequency ranges.
        - Provided significant vibration attenuation.

Conclusions/action items:

The quasi-zero stiffness incubator is a promising design for reducing the vibrations that a neonate experiences during travel. The design includes a redesign of current incubators, by introducing four QZS isolators placed between the auxiliary equipment and the isolette. The QZS isolators incorporate two magnetic rings that introduce negative stiffness and a coil spring. The results showed that transmissibility was reduced in low frequency ranges with the QZS isolators.

The team is looking to reduce vibrations without redesigning the entire incubator system, which is why this design would not fulfill the requirements of the client.

2023.03.01 - Infant Care Transport Device with Shock and Vibration System

Sydney Polzin - Mar 01, 2023, 11:02 AM CST

Title: Infant Care Transport Device with Shock and Vibration System

Date: March 1, 2023

Link: https://patents.google.com/patent/US20200170866A1/en

Content by: Sydney Polzin

Present: NA

Goals: Discuss a patent pending competing design

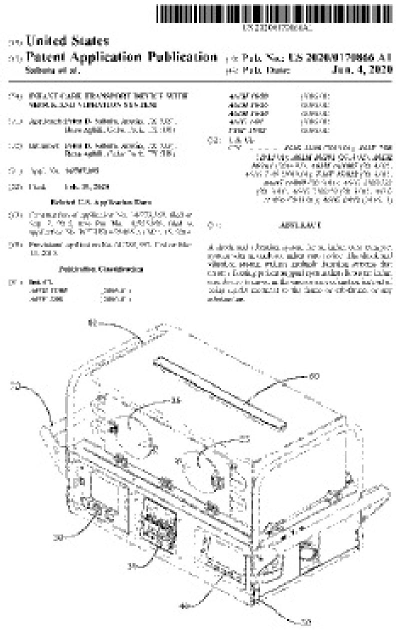
Content:

- Neonates are subject to significant shock and vibrations during transport due to a variety of sources, such as loading/unloading, roads, and overall movement during transportation.
    - Can cause serious life-threatening injuries
- Vibrations should be dampened in the x, y, and z directions
- This design incorporates vibration damping systems in the x, y, and x directions of the main component of the incubator, as well as a "floating patient support system" that allows the patient to safely move with the vibrations, rather than being strapped down like they are in current systems.
- There are eight figures drawn out that depict this design, which can be found in the attached patent below.
    - There are one or more z-axis dampers, which are attached to the surface the patient is supported on, and the main frame (free-floating). In addition, there are one or more z-axis dampers that are mounted in a second location connecting to the stretcher or cart to reduce the vibrations experienced by the ambulance or transportation system.
    - At least one x-y axis damper is also used to dampen the vibrations in those directions.
    - A variety of damping mechanisms/materials could be used for this application in any direction.
    - Each damper in the three directions acts independently of one another.
    - The system has a method to lock the damping system to reduce the ability of the axes to move free floating.
    - The transport device floats in the x-y plane and does not contact the plane until the dampers are activated when shock is observed.
    - There are mechanisms in place for extreme situations or catastrophes.

Conclusions/action items:

This patent-pending design incorporates a lot of similar design ideas to those presented through other research. The team will need to further look into this design.

Sydney Polzin - Mar 01, 2023, 10:44 AM CST


(19) United States
(12) Patent Application Publication
Saliba et al.
(10) Pub. No.: US 2020/0170866 A1
(43) Pub. Date: Jun. 4, 2020

ABSTRACT

Download

US20200170866A1.pdf (823 kB)

2023.03.01 - System design for isolation of a neonatal transport unit using passive and semi-active control strategies

Sydney Polzin - Mar 01, 2023, 4:35 PM CST

Title: System design for isolation of a neonatal transport unit using passive and semi-active control strategies

Date: March 1, 2023

Link: **https://www-sciencedirect-com.ezproxy.library.wisc.edu/science/article/pii/S0022460X04008946**

Content by: Sydney Polzin

Present: NA

Goals: Discuss a design for a system that uses both passive and semi-active control strategies

Content:

- This design focuses on transport via ambulance, and utilizes a standard cart that is used by children's hospitals, which does not have any mechanisms for reducing vibrations or shock absorption.
- Neonates are very sensitive to external stimuli, which can come from a variety of different forces. These forces can greatly affect the well-being of the neonate.
  - Ultimately can affect their heart rate and oxygen levels and increase their stress levels.
- Little research has been done in the area of neonatal transport, but significant research has been conducted for passengers of vehicles.
  - ISO 2631-1:1997 - Mechanical Vibration and Shock
    - Whole Body Vibrations (WBV)
    - A study conducted by Paddan and Griffin found that vibration levels of the majority of vehicles surpassed 0.47 m/s^2 rms. If this level is experienced for over 8 hours in one 24 hour period, according to ISO 2631, potential health risks could arise.
      - Transport of neonates is approximately around 1 hour.
    - Frequency between 1 to 80 Hz is desirable to maintain health and comfort.
    - WBV levels between 1.25 and 2.5 m/s^2 are considered very uncomfortable and levels exceeding 2 m/s^2 are extremely uncomfortable
- The goal of this paper is to model "the transport cart dynamics for design of an air-spring-based isolation system"
  - Neonatal transport cart system had a dominant frequency response of 10.25 to 17.09 Hz, and should therefore be attenuated to be above 10 Hz
- The data from testing the neonatal transport cart was used to fabricate the prototype, which utilized air springs, as they have low natural frequencies which can be reduced. These natural frequencies also do not change based on the load.
  - One large air spring was used in conjunction with four smaller air springs to support a load of 2000 N. Pressure selection of these springs was important as that determines the height of the springs and how they respond due to forces.
  - Modeled as a 2 degrees of freedom system.
- Passive vs. Active Systems
  - Passive: only use passive stiffness and damping
    - Cannot address all configurations on its own
    - Affects the amplitude at lower frequencies
    - Stable behavior without substantial damping
  - Active: stiffness or damping is active due to some stimuli
    - The neonate transport system would be active due to varying conditions

        - Modify the properties of the spring and damper in response to external stimuli
- The three proposed design configurations of a passive isolation system include:
    - One 11.43 cm diameter spring at the center
    - Four 3.4 cm diameter springs around the edges
        - Proved to be the best at isolation
    - One 11.43 cm diameter spring in the center and four 3.4 cm diameter springs around the edges

Conclusions/action items:

This study provided very important details surrounding the acceleration values that should be utilized and stayed within. The designs they proposed were very interesting and insightful, as well as the data they had provided from them. The prototype they developed will be implemented and tested in clinical trials.

The team will need to look into ISO 2391 for regulations surrounding whole body vibrations and levels that should and should not be reached.

2023.02.08 - Measuring Vibration with Accelerometers

Sydney Polzin - Mar 01, 2023, 9:38 AM CST

Title: Measuring Vibration with Accelerometers

Date: February 8, 2023

Link: https://www.ni.com/en-us/shop/data-acquisition/sensor-fundamentals/measuring-vibration-with-accelerometers.html

Content by: Sydney Polzin

Present: NA

Goals: Discuss the importance of accelerometers to the project and how they can be used to measure vibration

Content:

- Vibrations can be random or periodic
    - Expressed in units of m/s^2
    - Can be forced or free vibrations
        - Free Vibrations: an object is displaced but then is able to oscillate freely after impact
            - Natural frequency is the frequency in which the object wants to oscillate after impact
            - Resonance frequency is the desire of the object to oscillate at different intensities at varying frequencies
        - Forced Vibrations: cause energy to build inside the object or structure; the structure or object vibrates due to an applied force
            - If the object has a natural frequency that matches the environmental frequency, it is more likely to fail sooner due to more intense vibrations.
- The most common mechanism for measuring vibration is using a "ceramic piezoelectric sensor or accelerometer".
    - Voltage is generated across the components within the sensor when stressed
    - Piezoelectric accelerometers and Integrated Electronic Piezoelectric (IEPE) accelerometers are two common types of accelerometers that can be used for this application.
        - Piezoelectric accelerometers (Charge Mode):
            - Require amplification of the charge through some external mechanism
            - Lower output impedance
            - Reduce potential noise that could influence the signal
        - Integrated Electronic Piezoelectric (IEPE):
            - Internal amplifier built into the accelerometer
                - Constant current source and varying impedance depending on the charge of the internal elements
                - Measure change in impedance by measuring the change in voltage across the accelerometer
    - Proximity Probe is an alternative to measuring vibrations
        - Non-contact probes that measure the distance to the target
    - Accelerometers are often placed on high-frequency objects, and can be used to measure shock and low-frequency vibrations
- There are several accelerometers on the market, but each have different specifications so it is important to find the one that would be best for this application. Some specifications to consider are:

- Amplitude
  - If the amplitude that is wanting to be measured is greater than the capabilities of the accelerometer, the signal will be clipped and the data will be insignificant.
    - High vibration levels = use a lower sensitivity accelerometer
- Sensitivity
  - Calibration is usually found in the datasheet that is provided with a sensor
  - Frequency dependent
    - High amplitude = use a low-sensitivity accelerometer and vice versa
- Number of axes
  - Triaxial vs single axis
    - For the application of this project, a triaxial accelerometer would be best
- Weight
  - Although accelerometers don't weigh that much, they will still contribute to the weight of the structure, so that should be considered.
    - Keep the weight of the accelerometer under 10% of the entire structure or object
- Mounting options
  - Temporary attachment methods include magnets, adhesives, or handheld/probe tips
    - Each attachment method is intended for a specific range of frequencies
      - Handheld = 500 Hz limit
      - Magnetic = 2000 Hz limit
      - Adhesive = 2500 Hz to 5000 Hz limit
- Environmental constraints
  - Consider the maximum/minimum temperature, potential chemicals, and humidity that the accelerometer will be exposed to
  - In general, most accelerometers are very durable regardless of the conditions they are exposed to
    - Charge Mode accelerometers better withstand extreme conditions
    - IEPE accelerometers should be used in noisy conditions
- Cost
  - IEPE accelerometers are easier to use and cheaper to purchase

Conclusions/action items:

This article provided great information on how accelerometers are used to measure vibrations, and the different specifications that should be considered when purchasing or using an accelerometer. This source will be a good reference to come back to when the team decides to purchase an accelerometer. First, the team will need to figure out and evaluate the specifications that we will need to measure in order to ensure that the accelerometer can measure the values and data we are looking to find.

2023.02.14 - Vibration Absorber

Sydney Polzin - Mar 01, 2023, 12:00 PM CST

Title: Vibration Absorber

Link: https://www.sciencedirect.com/topics/engineering/vibration-absorber (Broad link with sources about vibration absorbers)

Individual Sources used relating to Vibration Absorbers:

https://www.sciencedirect.com/science/article/pii/B9780340645802500077

https://www.sciencedirect.com/science/article/pii/B9780127877679500155

https://www.sciencedirect.com/science/article/pii/B9780124058743000047

Date: February 14, 2022

Content by: Sydney Polzin

Present: NA

Goals: Share research regarding vibration absorbers

Content:

- There are several relevant equations to solve for various components of a vibration absorber system.
- Choosing the corresponding value for the damper can alter how the system operates and responds to various forces.
- It is really important to understand the constraints of the spring and dampers in order to make sure that it doesn't fail under the stress and strain it will be put through.
  - The failure of the spring or damper could significantly impact the entire system, and in the scope of this project, the neonate.
- Lanchester Damper: sacrificing the overall effectiveness of the absorber in order to reduce the effects of failure when it is likely to occur.
  - Springless damper has lessened effectiveness but is a better alternative to the sprung absorber when failure is likely to occur.
- There are multiple types of damped absorbers, including viscous and dry friction damping, but the set up of the two are different.
  - Both are common mechanisms.
- An impact damper is another alternative to a viscous or dry friction damper.
  - Energy is converted into heat and sound to reduce the vibrations when collisions occur.
  - A "hollow container with a loosely fitting body or slug" to reduce the vibrations
  - Cheap, easy to manufacture, but not as common or used as viscous and dry friction damping.
- Dynamic Vibration Absorber: helps to reduce the vibrations of a harmonically excited system.
  - Added to a mass spring system
  - Use a frequency that is similar to the excitation frequency in order to reduce the vibrations.
    - Change the shear modulus
  - Added to lightly damped systems
    - Used in a relatively narrow range of frequencies surrounding the resonant frequency

- Determine the degrees of freedom that the system undergoes in order to determine what the system of damping should be and how to determine the values for each component.
- An oscillator connected to a beam can also act as a vibration absorber.

Conclusions/action items:

There are several options to consider for how to absorb vibrations. These include, but are not limited to, viscous damping, dry friction damping, and impact damping. Each of these components have various components, and values for the components will need to be calculated based on the system and forces that are experienced.

The team will need to decide and evaluate which of these damping systems would work best for the project.

2023.02.14 - Reduce Vibrations

Sydney Polzin - Mar 01, 2023, 12:03 PM CST

Title: Reduce Vibrations

Link: https://www.sciencedirect.com/topics/engineering/reduce-vibration (broad link on how to reduce vibrations)

Individual Sources Used:

https://www.sciencedirect.com/science/article/pii/B9780081009642000277

Date: February 14, 2022

Content by: Sydney Polzin

Present: NA

Goals: Share research on various ways to reduce vibrations

Content:

- Helicopters are more unstable than airplanes and undergo "asymmetrical aerodynamics".
  - Devices such as vibration absorbers have historically been used to try and combat this problem.
  - Now, active vibration control systems have been introduced and are said to deliver virtually no vibrations.
  - RELEVANT to the project due to transportation via helicopter.
- An isolator (regardless of the kind) that is used to absorb energy is considered a damper and provides damping support.

Conclusions/action items:

Continue to understand how vibrations can be reduced during transport via helicopter and ambulance.

2023.02.14 - Vibration Isolation

Sydney Polzin - Mar 01, 2023, 12:08 PM CST

Title: Vibration Isolation

Link: https://www.sciencedirect.com/topics/engineering/vibration-isolation#:~:text=Coil%20springs%2C%20disc%20springs%2C%20slotted,applications%20(Rivin%2C%202003) (broad link of sources relating to vibration isolation)

Individual Sources Used:

https://www.sciencedirect.com/science/article/pii/B9780128194201000078

https://www.sciencedirect.com/science/article/pii/B9780128196014000035

https://www.sciencedirect.com/science/article/pii/B9780124058743000011

Date: February 14, 2022

Content by: Sydney Polzin

Present: NA

Goals: Share research on various ways to isolate vibrations and how to ultimately reduce them

Content:

- Vibration Isolation helps to reduce vibrations that are undesirable
    - Metal springs, rubber mounts, and pneumatic mounts
- Rubber isolation devices are the most commonly used isolation mechanisms
- Sliding isolation systems reduce vibrations by consuming energy from the sliding mechanism and friction
- Hybrid isolation system incorporates two or more isolation systems into one system in order to better reduce the vibrations
- Vibration isolation overall utilize materials that can provide both damping properties while still having an elastic behavior
    - Elastomeric materials are commonly used for vibration isolation
        - Example: Elastomeric Mounts
        - Natural rubber, neoprene, butyl rubber
    - Elastomers are a good option to be used for vibration isolation because they can be designed with different stiffnesses and damping properties and can withstand various environmental situations or conditions
    - Using different blends of elastomers is what allows for the varying physical and mechanical properties of the vibration isolation system, and what enables the design to be very specific to the requirements of the situation
- Metal springs are used in applications of vibration isolation due to their varying properties that can be applied based on different situations.
    - Offer low material damping
    - Coil springs, disc springs, slotted springs, etc.
- Since vibration isolation systems do not offer significant damping, an additional damper can be added to the design in order to have these characteristics as well

    - Viscous Dampers provide resistance to motion in between two different surfaces, and the surfaces are often separated by a fluid film
        - Temperature dependent
    - Magnetorheological (MR) dampers enable damping characteristics that are regulated by an input current to an electromagnet, which ultimately determines how the damper behaves
        - Control over the magnetic flux of the electromagnet
        - Semi-active system
    - Other dampers include friction dampers and electromagnetic dampers
- A test was conducted on a vehicle seat that was placed on a vibration platform and went through excitations to understand how the vibration isolation system was working in action
    - Both accelerometers and displacement sensors were used to measure the results
        - Would be interesting to look into displacement sensors

Conclusions/action items:

This article was very useful in explaining vibration isolation systems, and various applications of the system. The team will need to continue to evaluate what mechanisms will be the most beneficial to the project. It would also be to the team's benefit to look into displacement sensors in addition to accelerometers for additional data collection.

2023.02.14 - Step by Step Guide to Choosing Anti-Vibration Mounts

Sydney Polzin - Mar 01, 2023, 12:31 PM CST

Title: Step by Step Guide to Choosing Anti-Vibration Mounts

Date: February 14, 2022

Link: https://www.gmtrubber.com/guide-choosing-anti-vibration-mounts/#:~:text=Anti%2Dvibration%20mounts%20have%20excellent,their%20lifespan%2C%20efficiency%20and%20safety.

Content by: Sydney Polzin

Present: NA

Goals: Share various anti-vibration mounts and their applications

Content:

- Anti-vibration mounts are used to reduce vibrations on various machines and elements.
    - Are very effective in shock absorption and vibration dampening
- Mounts are usually made from rubber or some combination of materials that includes rubber.
    - Assist in preventing the transfer of vibrations that are generated.
- There are several types of Anti-Vibration Mounts:
    - Vibration Isolators:
        - Reduce vibrations transmitted outwards, and reduce the quantity of vibrations traveling from external sources
            - Incorporates both active and passive components
    - Rubber Vibration Mounts:
        - Vibration and shock protection in the x, y, and z directions
    - Wire Rope Mounts:
        - Made with stainless steel
        - Intended to be used in environments that require very durable systems
        - Isolate shock and vibrations in the x, y, and z directions
    - Conical Mounts:
        - Rubber cone mounts
    - Machine Feet:
        - Reduce vibrations and dampening shock loads simultaneously

Conclusions/action items:

This article provided great insight into the different types of anti-vibration mounts that could be used for this project. All seem like they would be viable options, so further discussion with the team will need to be conducted in order to determine the best option to proceed with.

2023.02.14 - Finding the Right Solution for Shock and Vibration Isolation

Sydney Polzin - Mar 01, 2023, 12:31 PM CST

Title: Finding the Right Solution for Shock and Vibration Isolation

Date: February 14, 2022

Link: https://www.isotechinc.com/solution-shock-and-vibration-isolation/#:~:text=Vibration%20isolation%20mounts%20protect%20machinery,and%20create%20unsafe%20working%20conditions.

Content by: Sydney Polzin

Present: NA

Goals: Share mechanisms that can be used for shock and vibration isolation

Content:

- Vibration Isolation Mounts are very useful in reducing the amplitude and frequency of vibrations and vibrational waves
    - Often used in industrial settings to prevent damage to expensive equipment
    - Acts "as a highly stable buffer between the source of the vibration and the object or surface being isolate"
        - Shock absorber
    - If a shock or force is exerted on one surface, the force will not be experienced by the other surface due to the buffer in between. Without the buffer in between the surfaces, both surfaces would likely experience the force and the vibrations.
- Wire Rope Isolators:
    - Provide low frequency but highly damped vibration isolation
    - Shock attenuation
    - Passive system
    - Function under a variety of conditions and are durable
- Spring Mount Vibration Isolators
    - Heavy duty
    - Limit the transfer of vibrations and shock due to equipment
- Neoprene/Elastomeric Vibration Isolation Mounts
    - Limit the transfer of vibrations due to the structure and potential impacts
    - Absorb shock and attenuate vibrations
- Vibration Isolation Pas Mounts
    - Materials include elastomers, rubber, cork, dense foam, and laminate materials
    - Reduce vibration transfer
    - High frequency attenuation
    - Prevent shock and vibration transfer
    - A good alternative for light to medium weight equipment, rather than the typical heavier duty equipment these are used for
- Seismic Mounts
- Ceiling Mounted Vibration Isolation Hangers
- Roof Mounted Vibration Isolators

Conclusions/action items:

This article was very helpful in explaining various types of isolator systems and their desired operating conditions. The team will discuss these options and decide on if any of the above are good options for solving the project.

2023.02.14 - Why Rubber is Used as Vibration Absorbers

Sydney Polzin -

Title: Why Rubber is Used as Vibration Absorbers

Date: February 14, 2022

Link: https://www.coirubber.com/rubber-vibration-absorbers/#:~:text=Rubber%20is%20used%20as%20vibration%20absorbers%2C%20because%20rubber%20has%20a,before%20it%20becomes%20perr

Content by: Sydney Polzin

Present: NA

Goals: Share the properties of rubber and why they can be used as vibration absorbers

Content:

- Rubber is a commonly used material for vibration absorption
  - Rubber has a high shear modulus, meaning that when it is put under stress, it can undergo significant stress before becoming deformed in comp other materials
    - In terms of vibration absorption, this entails that rubber can undergo and absorb greater vibrations before they are transferred or the mater deformed
- Vibration isolators and vibration dampeners are not equivalent
  - Vibration isolators are used to transfer vibrations from one component or surface to the next, but by absorbing the forces before transferring ther
    - Examples: hydraulic mounts, anti-vibration mounts
  - Vibration dampeners are used to disperse the forced experienced due to vibrations away from the system and into the environment, which is wh damping coefficient is needed.
  - Energy is dissipated as heat
    - Examples: vibration dampers for air conditioners, vibration damping pads

Conclusions/action items:

This article was very useful in explaining the difference between vibration isolators and vibration dampers. Both of those terms are very common to reduce v helpful to see the similarities and differences between the two.

2023.02.14 - Vibration Damping

Sydney Polzin - Feb 28, 2023, 11:12 PM CST

Title: Vibration Damping

Date: February 14, 2022

Link: https://www.techniconacoustics.com/products/vibration-damping/

Content by: Sydney Polzin

Present: NA

Goals: Share the properties of various materials that can be used for vibration damping

Content:

- Vibration damping is used to lower the total energy in a system that is being produced. Energy is then transferred through various paths to be dispersed.
- Rubber:
  - Absorbs the energy before being released as heat and therefore is a quick mechanism to isolate vibrations
  - Can be paired with a damper to compensate for the lack of damping characteristics on it's own
- Polyurethane:
  - Absorb additional unwanted energy in a system
  - Newer material
- Polyvinyl Chloride (PVC):
  - Sound barriers

Conclusions/action items:

There are several materials and combinations of materials on the market that could be used for this project, so continuing to research and discuss with the team will be valuable to determine an appropriate design.

2023.04.24 - Calculations for Spring

Sydney Polzin - May 03, 2023, 3:47 PM CDT

Title: System design for isolation of a neonatal transport unit using passive and semi-active control strategies

Date: March 1, 2023

Link: https://www-sciencedirect-com.ezproxy.library.wisc.edu/science/article/pii/S0022460X04008946

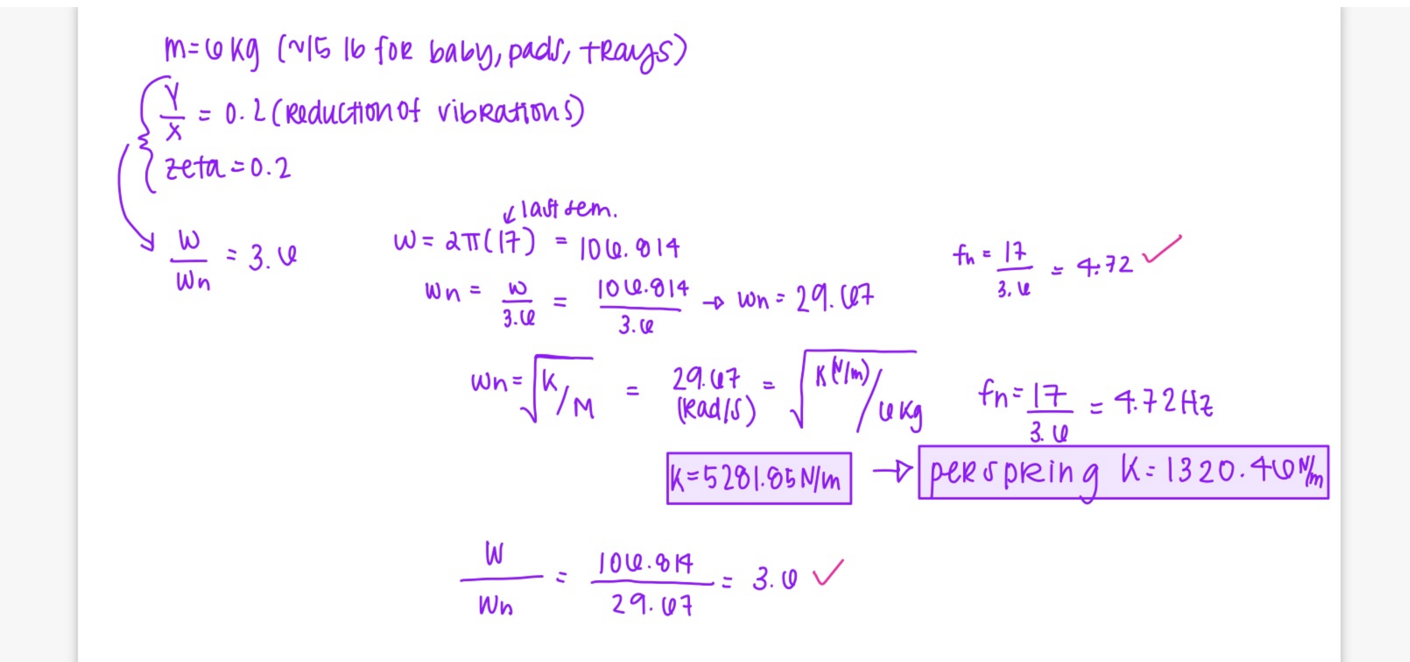
Content by: Sydney Polzin

Present: NA

Goals: Share updated calculations for spring and damper design for future semesters

Content:

- Attached below are the calculations to get an updated spring constant of 5281.85 N/m
- This spring constant is significantly less than the one calculated earlier in the semester, which will hopefully reduce the vibrations more
- The team will modify these calculations going into next semester as needed



Conclusions/action items:

The team will continue to modify these calculations in order to be as precise as possible with spring and damper calculations.

2022.02.14 - Spring and Damper Design

Sydney Polzin - Feb 14, 2023, 5:25 PM CST

Title: Spring and Damper Design

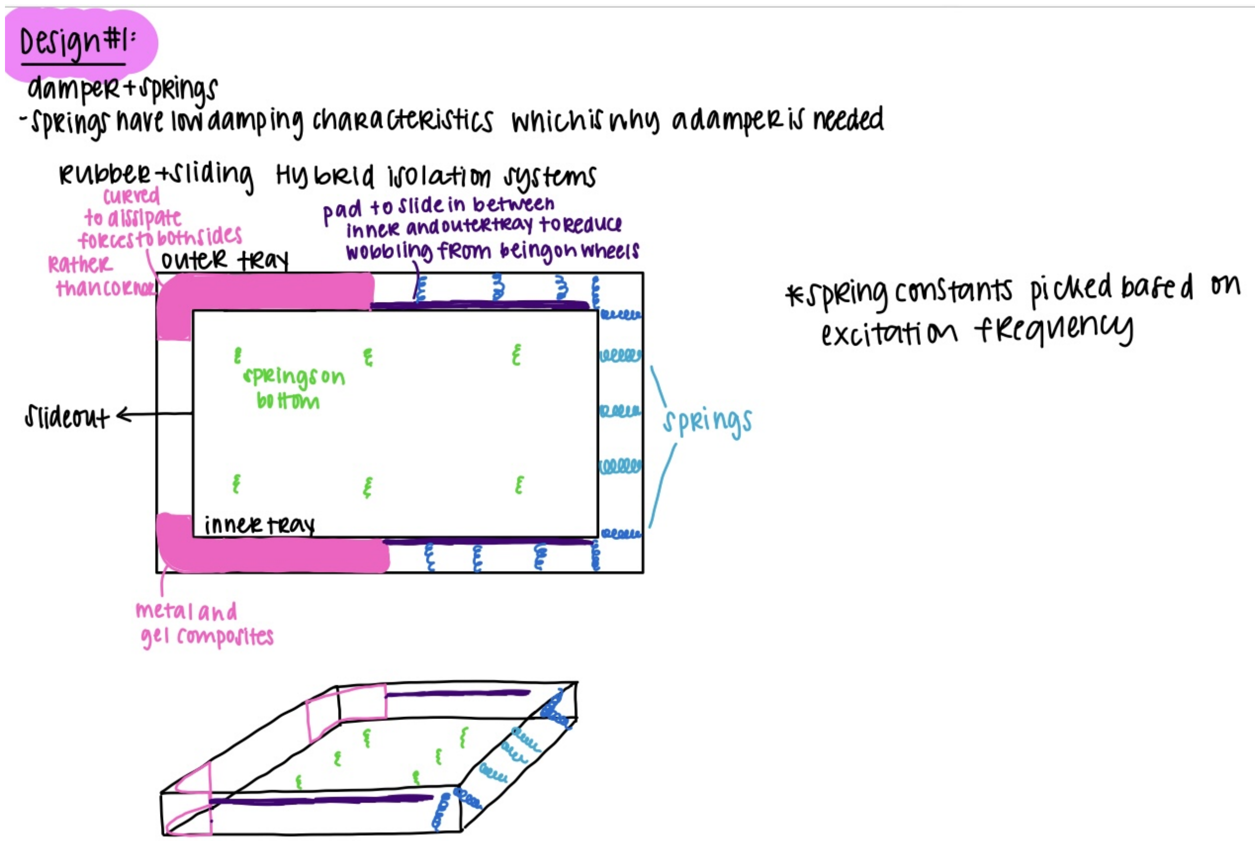
Date: February 14, 2022

Content by: Sydney Polzin

Present: NA

Goals: To share my first design to help reduce whole body vibrations of neonates

Content:



- This design incorporates last semester's metal and gel composites, as shown in pink, to act as a component of the damper
- Dampers and springs should be used in parallel as the springs don't have damping characteristics significant enough to reduce the effects, so the damper can assist in that aspect (spring is in the blue)
- The purple indicates an insert into the sides in between the outer and inner tray to prevent some support for potentially movement

Conclusions/action items:

Share the design with the team and discuss the design matrix.

2022.02.14 - Vibration Isolation Design

Sydney Polzin - Feb 14, 2023, 6:01 PM CST

Title: Vibration Isolation

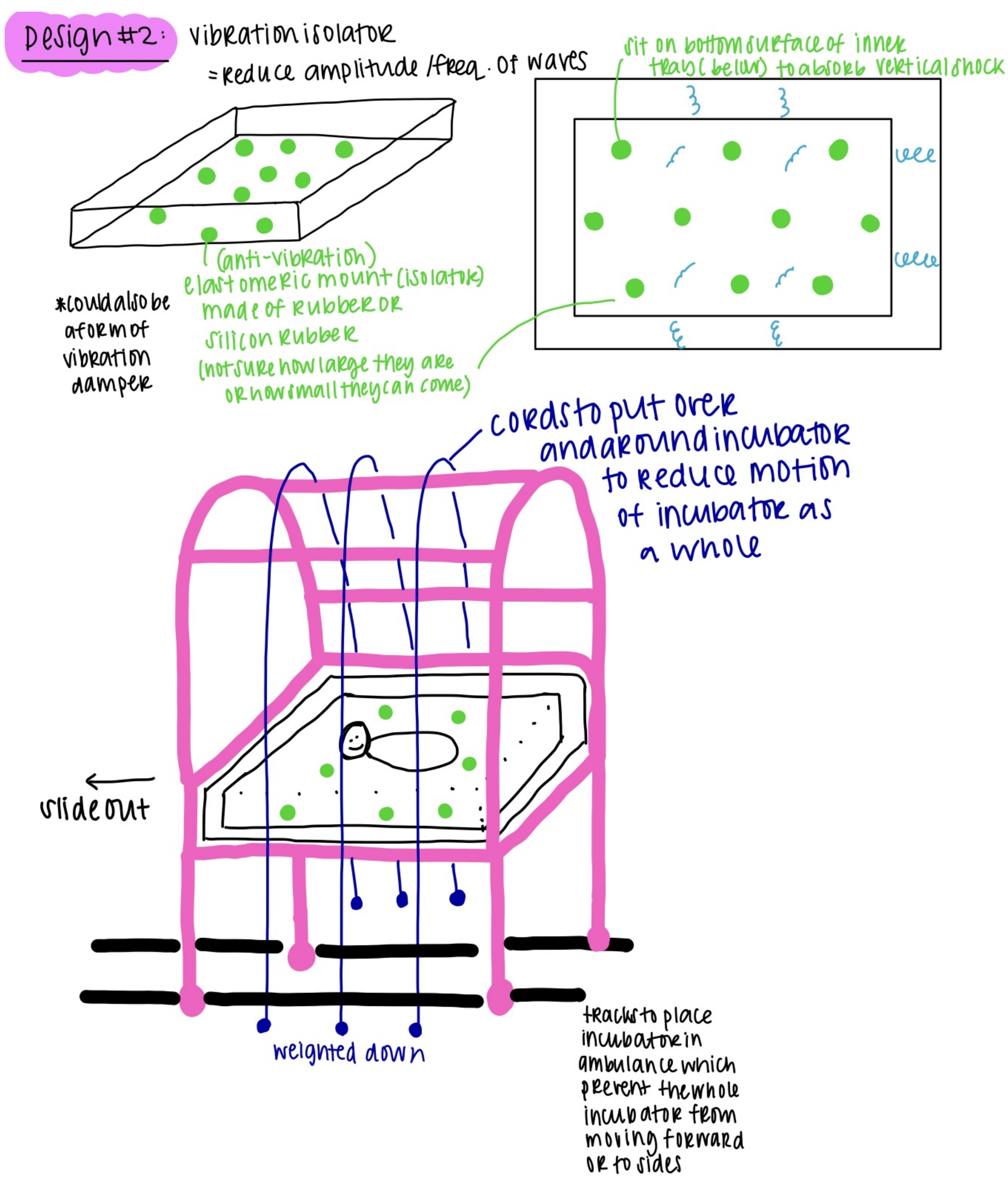
Date: February 14, 2022

Content by: Sydney Polzin

Present: NA

Goals: To share my first design to help reduce whole body vibrations of neonates

Content:



- This design utilizes elastomeric mounts (or anti-vibration mounts) which are isolate vibrations

    - They are helpful in absorbing shock or attenuating vibrations from a force
- These are placed on the bottom surface of the inner tray to absorb vibrations from vertical forces
- In addition, there is a component that has cords placed over the incubator to help secure the entire incubator and attempt to reduce vibrations and motion

Conclusions/action items:

Share the design with the team and discuss the design matrix.

2023.03.01 - Biosafety and Chemical Safety Training

Sydney Polzin - Mar 01, 2023, 12:37 PM CST

Title: Biosafety and Chemical Safety Training

Date: March 1, 2023

Content by: Sydney Polzin

Present: NA

Goals: Share the records for my completion of the biosafety and chemical safety training

Content:

Training Information Lookup Tool University of Wisconsin-Madison

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Sydney Polzin has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2022	1/20/2022	
Chemical Safety: The OSHA Lab Standard	Final Quiz	1/13/2022	

Data Last Imported: 03/07/2022 10:35 AM

Conclusions/action items:

Complete any additional training as needed.

2023.03.01 - Green Permit Documentation

Sydney Polzin - Mar 01, 2023, 12:40 PM CST

Title: Green Permit Documentation

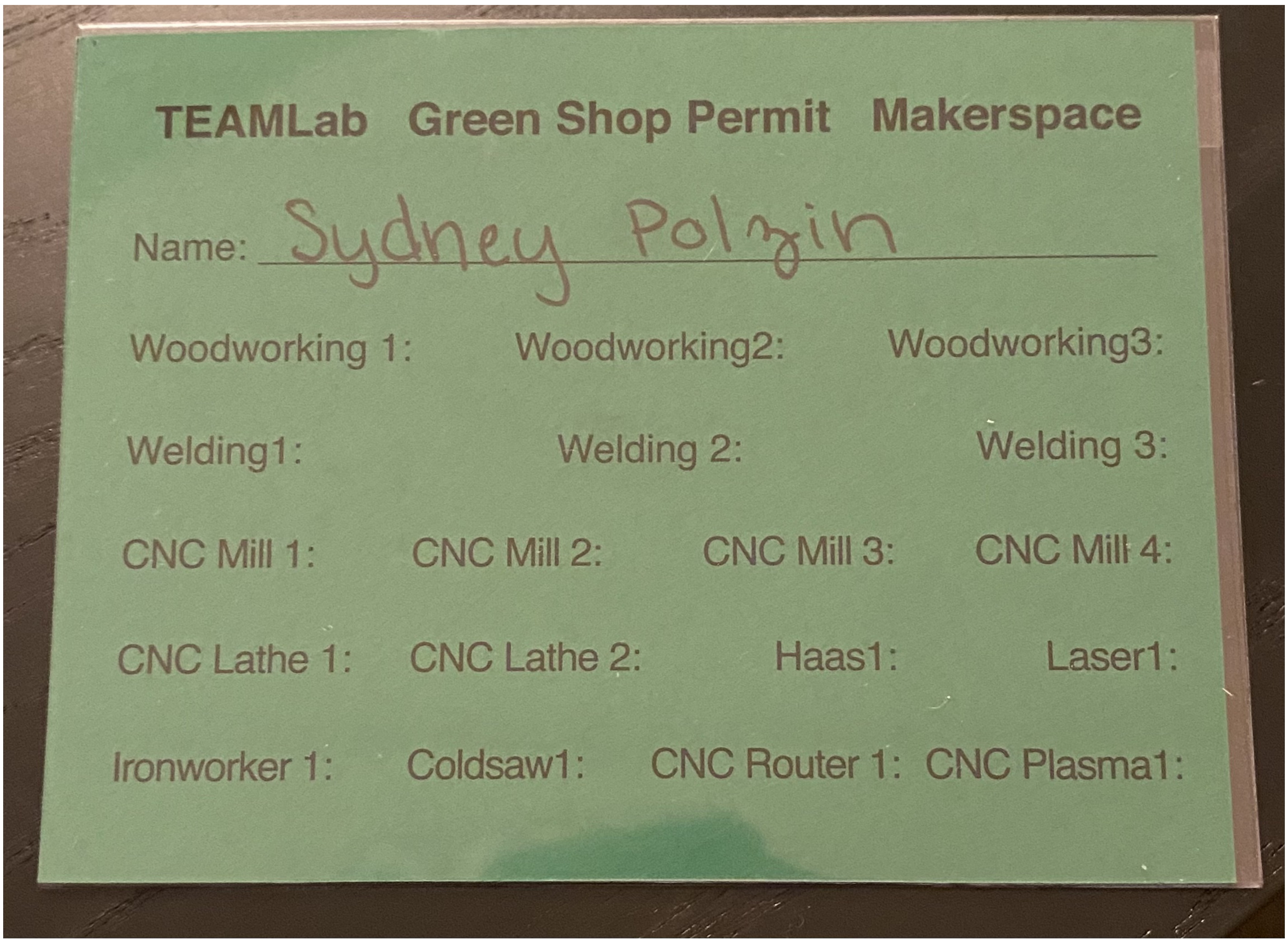
Date: March 1, 2023

Content by: Sydney Polzin

Present: NA

Goals: Share the records for my completion green permit.

Content:



Conclusions/action items:

Complete any additional training as needed.

2022.03.18 - WARF Lecture Notes

Sydney Polzin - Mar 18, 2023, 5:08 PM CDT

Title: WARF Lecture Notes

Date: March 18, 2023

Content by: Sydney Polzin

Present: NA

Goals: Share notes from the WARF lecture.

Content:

- WARF has been around since 1925 - patenting and licensing for over 20 years
  - One of the first universities to have a technology transfer office
  - Fully separate from university - governed by an independent board of UW-Madison alumni
- The vision: enable UW-Madison research to solve the world's problems
  - Provides financial support, actively managing assets, and moving innovations to the marketplace
- UW research and discovery -> IP Protection -> Licensing and Startups -> Funding to support research and discovery
  - 6th overall in research funding
  - 350-400 inventions disclosures per year
  - 2000 Issues US Patents and 700 pending patents
  - 50+ licenses annually
  - 125 faculty startups
  - Provide funds to departments and facilities on campus
    - Over $3 billion given back to the university
- Three biggest classes of intellectual property:
  - NOT mutually exclusive
  - Patents
    - Machines and devices
    - Compounds
    - Processes and methods
    - Improvements
  - Copyrights
    - Literary works
    - Webpages
    - Software programs
  - Trademarks
    - Words and phrases
    - Colors
    - Pictures or logos
    - Sound
  - Trade Secret (weakest protection in terms of IP)
    - Our ideas will likely be shared through presentations, papers, etc. so unlikely for us
- Prior Art
  - References created before a specific date
    - By the inventor: > 1 year before the filing date of the patent application

        - By author: before the filing date of the patent application
    - Your own publications are not prior art
    - 12 month grace year period from the date of first public disclosure until you can file for patent protection in the US
        - If it's out there before you it counts against you, even if it's during the one year grace period
    - Other countries have different rules than the US
- Public Disclosure and Prior Art
    - Examples:
        - Journal publication
        - Talk or poster at conference or professional meeting
        - Non-confidential department seminar
        - Open thesis defense
        - Catalogued dissertation
        - Some funded grant abstracts
        - Description on an internet site
    - Not public disclosure = not being able to recreate the invention
- Requirements for Patentability
    - Eligible
    - Useful
    - Enabled
    - Described
    - Novel
    - Non-obvious
    - Is it new, obvious, and is it eligible for patenting?
    - Examination = assessment of invention
    - Based on statutory requirements and application of prior art
    - Patent examiners can combine multiple references
    - Very time intensive
        - Three, five, ten years to get a patent
        - Also expensive!
            - Usually $30,000 for a single US patent
- WARF's AP Management Process
    - Disclose your intention to WARF
    - Disclosure Committee meets monthly to review new disclosures
        - If accepted: Assign invention to WARF, then they pay $30,000 to get the patent
        - Return 20% to us of any money made, 15% to BME department, and 65% back to annual gift
    - Patent application drafting, filing, and prosecution
        - Work with outside counsel on application and communicates with team
    - Technology marketing
    - Licensing
    - First phase takes 6-8 week - first to file vs. first to invent system in US
        - Application filed within 2 months ideally
- Licensing Considerations for New Disclosures
    - Chance of licensing
        - Potential applications, technology benefits and impact, state of the market, WARF's history in licensing
    - Timeling for licensing
        - Stages of the technology, patent status, position in WARF's portfolio
    - Licensing strategy

        - Companies (existing or start up), exclusive vs non, field limitations
    - Plan for the next year
        - Further technology development, proactive marketing, marketing materials
    - Revenue projections
        - Early revenue, patent reimbursement, lifetime royalty projections
- Licensing Innovation
    - Licensing is a contract that allows companies to use the patent on agreement
        - Agree to develop technology and provide financial return back to WARF
    - WARF provides: exclusive or non-exclusive rights to make, use, sell, or import
    - Licensee Provides:
        - Develop and commercialize
        - Reasonable fees: upfront, royalties, milestones, etc.
        - Fulfill obligations under Bayh-Dole
    - Timeline
        - Varies from months to years
        - Depends on technology and market readiness
- WARF's Accelerator Program
    - Milestone-based validation funding to speed promising technologies to a commercial license
        - Goal: accelerate commercialization prospects for WARF IP
        - Catalysts: expert consultants with significant business experience
        - Five Sectors:
            - Computer Science and Engineering
            - Medical devices and healthcare
            - CleanTech
            - Food and agriculture
            - Research Tools
    - 45% of funding back to COE
- Finding a Licensee
    - Internal: inventor contacts, meetings, sponsored research
    - External: technology descriptions on website, publications, technology portals, targeted outreach
- Factors to Consider in Starting a Company
    - Technology
        - Is it incremental or revolutionary?
        - How is the technology used in the final product?
        - How much development is needed?
        - Are government approvals needed?
    - Market
        - Is there a sizable market with a need?
        - Who are the competitors and the competitive products?
        - Are the margins attractive for a product?
    - Management
        - What should be your role subsequent to start-up phase?
        - Is team experienced in raising investment capital and successful exits?
    - Capital Requirements
- Start-Up Resources
    - Discovery to Product
        - Technology Innovation Funding
        - Seed Funding
    - Entrepreneurons - Seminar Series
    - Innovation Roadmap Series
    - UpStart Program for Minority and Women's Entrepreneurship

    - Law and Business Entrepreneurship Clinics
- Atrility Medical - startup company
- If your patent gets rejected, it never really ends. Fees can be paid to keep the patent as patent pending.
- Patent enforcement is very very expensive and very very selective.
- A patent is valid for 20 years from the day it is filed.

Conclusions/action items:

Our team could have intellectual property with our design as long as it is different enough from other products that are patented or on the market. Our design should include components that would solve the task at hand but also distinguish the design from potential competing designs.

2023/02/07: Canadian Review on Neonatal Transport Systems

Joshua Varghese - Feb 07, 2023, 8:04 PM CST

Title: 2023/02/07: Canadian Review on Neonatal Transport Systems

Date: 2/7/23

Source Link: https://curve.carleton.ca/405aa798-1f34-43e9-95c3-d8bdc0f9efe4

Citation:

F. Darwaish, "Investigating Vibration Levels in Neonatal Patient Transport," Master of Applied Science, Carleton University, Ottawa, Ontario, 2020. doi: 10.22215/etd/2020-14398.

Content by: Joshua Varghese

Present: N/A

Content:

1. The indication that the damped natural frequency of the neonate inside the incubator is at a similar frequency to that of the overall NPTS on the stretcher is an important finding that must be considered when developing a solution.
2. During the shaker table tests, the custom mattresses demonstrated better performance than the currently used Geo-MatrixTM mattress. These mattresses decrease the peak amplitude by a factor of 2-4 during random vibration testing
3. The head restraint (HR) harness is shown to be effective in reducing the vibrations experienced by the neonate in all test types, and for most mattress types. The HR decreased the peak amplitude by a factor of 1.7-3.3 during random vibration testing
4. The effect of transport on neonates has been examined in several studies, and an increase in mortality and morbidity rates of neonates following transport has been observed [12]. These negative effects of exposure to transport may be the result of the immaturity of the central nervous system in addition to the transport being in the highest risk period for physiological instability for the neonate
5. There is currently no standard for safe levels of vibration exposure for neonates. In the absence of appropriate standards, the standards established for vibration exposure for adults, such as the standard developed by the International Standards Organisation (ISO 2631-1) [18], are often applied to neonates [19]. The standard presents a health guidance caution zone for different exposure durations, and comfort levels that reflect the adult perception of vibration [18]. Safe levels of vibration for neonates are expected to be lower than those of adults.
6. They found that the mattress type and the weight of the manikin could influence the natural frequency. For example, when using a 2 kg manikin with a gel mattress, measured vibrations peaked in the frequency of 8-10 Hz. Replacing the manikin with a 300 g manikin caused the peak to shift to 15 Hz, which aligns with the damped natural frequency of the ambulance (2.5 Hz and 15 Hz). Their results suggest that neonates with lower weights could have a higher risk of vibration exposure.
7. They implemented modifications to the incubator tray by placing a foam restraint between the tray and the underlying track, and a foam pad beneath the tray. They found a decrease of vibrations measured at the neonate after modifications by performing one-way analysis of variance
8. They also experimented with different mattress types, including gel, foam, and air, and found that the gel mattress provided the least measured vibration. It was also shown that the use of different mattresses could

shift the natural frequency measurement of the incubator system away from the natural frequency of the ambulance. As a result, this could reduce resonance

9. An air-spring-based vibration isolation system was suggested by Bailey et al. [24] that fits between the incubator and the stretcher platform, and its isolator frequency can be controlled by changing the pneumatic pressure of the air-spring isolators
10. A study by Prehn et al. (2015) [25] focused on the use of different materials including polyurethane washers and anti-vibration pads to isolate the incubator. The vibration isolators were placed under the incubator's wheels but were deemed ineffective in reducing vibrations.
11. Repeatability examined on the stretcher suggests that the damped natural frequency of the neonate inside the incubator is similar to the damped natural frequency of the overall NPTS on the stretcher
12. The Geo-matrix mattress showed the highest amplification when compared to other mattresses, while the custom mattresses developed by Airtech Canada resulted in lowering the measured amplification. The HR harness lowered the vibrations when compared to the 5-point harness type. The PSD vibration measurements obtained were analysed to study the interplay between the different layers of the equipment. Ratios were created to see the highest amplifications occurring. The highest ratios were between the stretcher and the Power-LOAD®, and between the manikin's head and the incubator. These ratios provide information on where interventions should take place when designing mitigation strategies.
13. The custom mattresses developed by Airtech Canada showed a reduction in PSD amplitude at the manikin's head when compared to the Geo-matrixTM mattress currently in use. The 50 mm and 70 mm mattresses were the ones that were extensively tested. For example, during the random tests, the 70 mm mattress showed a
14. reduction by 2 to 4 times when compared to the Geo-matrixTM mattress. The head restraint harness type showed a reduction in PSD peak amplitude for all experiment types for most mattress types. For random tests, the HR has shown a reduction by 1.7 to 3.3 times when compared to the standard 5-point harness. The adoption of one of these mattresses and the head restraint inside the transport incubators is strongly suggested.

Conclusions/action items:

This was the most thorough article I have found related to our topic. This article concluded that a head restraint system was superior to a 5-point harness system and that a custom 70mm mattress was most effective compared to some of the mel mattresses advertised for neonatal transport.

2023/02/07: Whole-body vibration in neonatal transport

Joshua Varghese - Feb 07, 2023, 8:06 PM CST

Title: 2023/02/07: Whole-body vibration in neonatal transport

Date: 2/7/23

Source Link: **https://www-clinicalkey-com.ezproxy.library.wisc.edu/#!/content/playContent/1-s2.0-S0378378220302139?returnurl=null&referrer=null**

Citation:

> “Whole-body vibration in neonatal transport: a review of current knowledge and future research challenges - ClinicalKey.” https://www-clinicalkey-com.ezproxy.library.wisc.edu/#!/content/playContent/1-s2.0-S0378378220302139?returnurl=null&referrer=null (accessed Sep. 21, 2022).

Content by: Joshua Varghese

Present: N/A

Content:

1. Preterm newborns have a limited ability to coordinate autonomic and self-regulatory responses to deal with stress from external perturbations until 32 to 34 weeks postmenstrual age.
2. Shock refers to singular distinct acceleration versus time profiles that are typically of short duration and potentially high amplitude.
3. Vibration refers to sustained rhythmic (harmonic) acceleration versus time profiles that can occur at a single frequency, multiple distinct frequencies, or over a broad range of frequencies.
4. The translational motion occurs in the longitudinal (x axis – directed along the length of the incubator), lateral (y axis – directed from side to side), and vertical (z axis - directed perpendicular to the infant tray surface) directions.
5. Rotational motion includes roll (rotation about the x axis), pitch (rotation about the y axis), and yaw (rotation about the z axis), and are more pronounced in air transport
6. Only 10% of preterm infants (< 31 weeks) requiring transport in the first hours of life developed severe IVH (intraventricular hemorrhage) and there was no evidence of evolving severe IVH post transfer implicating the need for larger studies to further this information
7. As per ACGIH recommendations from 2018, workers/adults should not be exposed to a daily exposure >0.87 m/s^2
8. The estimated natural frequencies of the ambulance were around 2.5 Hz and 15 Hz, while the natural frequency of the incubator system without any mattress was 12–16 Hz
9. Using a gel mattress shifts the natural frequency of the system to 8–10 Hz which may reduce resonance
10. The systems natural frequency can also be altered by the weight of the infant. When using a 2 kg manikin with a gel mattress, the system had a natural frequency of 8–10 Hz, whereas replacing the manikin with a 300 g manikin changed the natural frequency to 15 Hz [38] suggesting that the hazards of vibration may be more significant in very low birth weight infants.
11. the mattress system amplified vibration magnitude by factors of 2–3 for a foam mattress and 1–2 for a gel mattress
12. Prehn et al. also reported that the combination of an air mattress with a gel mattress on top significantly decreased vibration

13. Their findings had poor generalizability due to the use of an airport runway instead of real-life driving and road conditions. Thinner wheels having a width of 1 in. on the stretcher were found to be inferior to thicker 1.4 in. rubber wheels

Conclusions/action items:

This article is a review of the situation in neonatal transport according to articles published before December 30th, 2019.

2023/02/07: Magnetorheological Dampers

Joshua Varghese - Feb 07, 2023, 8:07 PM CST

Title: 2023/02/07: Magnetorheological Dampers

Date: 2/7/23

Source Link: https://www.researchgate.net/publication/303849282_A_semi-active_vehicle_suspension_based_on_pneumatic_springs_and_magnetorheological_dampers

Citation:

A. L. Morales, A. J. Nieto, J. M. Chicharro, and P. Pintado, “A semi-active vehicle suspension based on pneumatic springs and magnetorheological dampers,” *Journal of Vibration and Control*, vol. 24, Jun. 2016, doi: 10.1177/1077546316653004.

Content by: Joshua Varghese

Present: N/A

Content:

1. The transfer function of a pneumatic suspension comprising an air–spring, auxiliary tank and several connecting pipes, can be modified simply by routing the air flow through the desired pipe.
2. Pneumatic systems have several advantages such as limited influence of sprung mass on natural frequency and the fact that the modification of its stiffness is quite straightforward
3. A high restriction (low Cr) tends to isolate the air–spring from the reservoir increasing the resonance frequency. The upper limit corresponds toa totally closed connecting pipe (Cr= 0). Conversely, a low restriction (high Cr) decreases the resonance frequency, where the lower limit corresponds to a configuration in which air–spring and reservoir pressures coincide at all times (Cr=∞), and behaves like an air–spring with the com-pounded air volume (spring and reservoir). Intermediate restriction coefficients yield intermediate resonance frequencies and, generally, higher damping. The increase in damping is due to the fact that, when the flow is not highly restricted nor freely allowed, viscous dissipation mechanisms become dominant
4. The MR/Pneumatic suspension described in this paper is based on:
   1. a pneumatic suspension with two adaptive configurations (compliant and stiff) in order to toggle between two different stiffnesses
   2. MR dampers with an adjustable continuous range of viscosities which can be used as a semi-active device
5.

Conclusions/action items:

This is a design for a suspension comprising a pneumatics system capable of controlling the suspension damping. This paper also contains a lot of equations that may be useful for calculating the effect of a variety of directional variables.

2023/02/13: Fluid Viscous Dampers

Joshua Varghese - Feb 13, 2023, 8:55

Title: 2023/02/13: Fluid Viscous Dampers

Date: 2/13/23

Source Link: **https://reader.elsevier.com/reader/sd/pii/S0267726118310856?token=353BADB98840C2AFE944FDEE47DC72558A2ACA1EAC555DF0D63FBA39D970E871EDDB2C8B9156BD855EAF1DE94D592251&originRegi east-1&originCreation=20230214023753**

Citation:

> “Design strategies of viscous dampers for seismic protection of building structures_ A review | Elsevier Enhanced Reader.” https://reader.elsevier.com/reader/sd/pii/S0267726118310856?token=353BADB98840C2AFE944FDEE47DC72558A2ACA1EAC555DF0D63FBA39D970E871EDDB2C8B9156BD855EAF1DE94D592251&originRegi east-1&originCreation=20230214023753 (accessed Feb. 13, 2023).

Content by: Joshua Varghese

Present: N/A

Content:

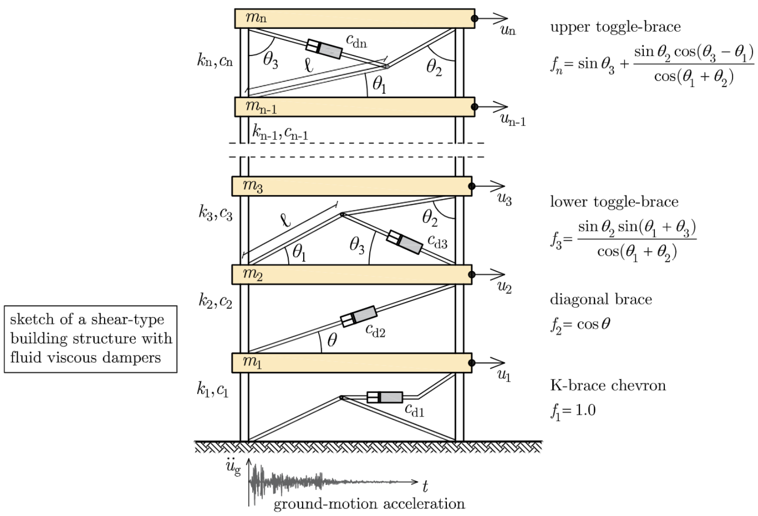
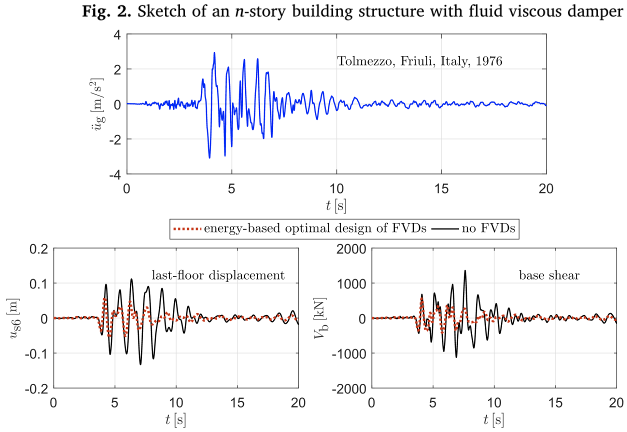
1. Fluid viscous dampers (FVDs) are supplemental energy dissipation devices that have been widely used for earthquake protection of structures.
2. 

Fig. 2. Sketch of an *n*-story building structure with fluid viscous damper devices.
3. 

4. Planar shear-type frames with linear elastic behavior, equipped with linear FVDs mounted on infinitely stiff braces represent the simplest option for the analysis among the possible alternatives

Conclusions/action items:

This article focuses on energy efficient fluid viscous dampers used in building construction.

2023/02/13: Spring Viscous Dampers

Joshua Varghese - Feb 13, 2023, 9:10 PM

Title: 2023/02/13: Spring Viscous Dampers

Date: 2/13/23

Source Link: **https://reader.elsevier.com/reader/sd/pii/S0141029618309738?token=8CDA639C645DD8438638D7E612D1E80ACD5912ECE5151D7FDC0A5446BA70244719CA362E705A8B1F41762B1840F15A77&originRegion=us-east-1&originCreation=20230214025651**

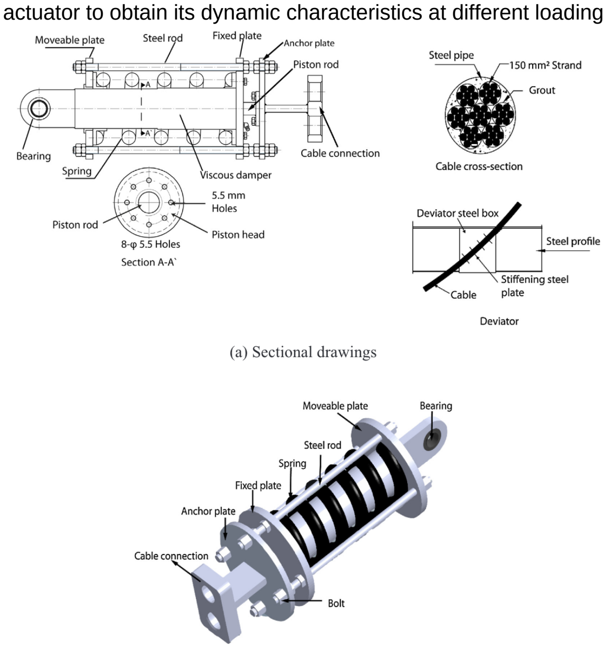
Citation:

> “Seismic performance evaluation of a spring viscous damper cable system | Elsevier Enhanced Reader.” https://reader.elsevier.com/reader/sd/pii/S0141029618309738?token=8CDA639C645DD8438638D7E612D1E80ACD5912ECE5151D7FDC0A5446BA70244719CA362E705A8B1F41762B1840F15A77&originRegion=us-east-1&originCreation=20230214025651 (accessed Feb. 13, 2023).

Content by: Joshua Varghese

Present: N/A

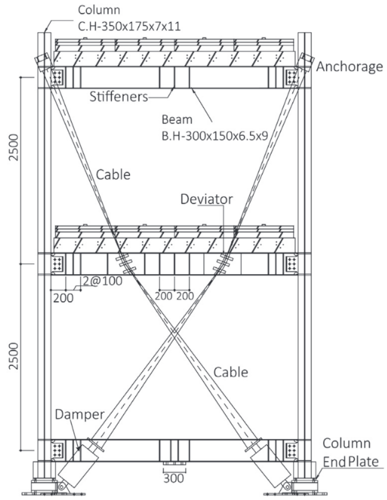
Content:

1. The application of passive energy dissipation devices for the seismic protection of new and existing structures is increasing due to their ease of manufacturing, installing, and the introduction of suitable design guidelines
2. One end of the spring viscous damper is attached to the bottom of a structure, and the other end is connected to a pre-stressed steel cable which is fixed to an upper part of the structure. A silicon gel type viscous damper with an external spring is manufactured and is tested using a dynamic actuator to obtain its dynamic characteristics at different loading frequencies.
3. 

(a) Sectional drawings

(b) 3-Dimensional illustration of damper

Fig. 1. Spring viscous damper.

4. 

5. 
(a) Spring viscous damper

(b) Deviator with cables

6. Before running the test with each set of earthquakes, structural identification test is performed using white noise ground motions. The natural frequencies of the test structure are determined by calculating the transfer function of the response acceleration measured from the accelerometer (A5) positioned at the top of the roof slab relative to the input acceleration at the base of the shaking table. The transfer function is calculated by the cross power spectral density function of the input and output signals.
7. The proposed seismic retrofit system was effective in reducing earthquake-induced roof and inter-story drifts, but not so effective in reducing floor accelerations and column axial forces.

Conclusions/action items:

This article focuses on spring viscous damper cable systems used in building construction.

2023/02/14: Current Damper

Joshua Varghese - Feb 14, 2023, 5:55 PM CST

Title: 2023/02/14: Current Damper

Date: 2/14/23

Source Link:
https://www.researchgate.net/publication/275558442_Design_of_a_vibration_isolation_system_using_eddy_current_damper

Citation:

P. Paul, C. Ingale, and B. Bhattacharya, "Design of a vibration isolation system using eddy current damper," *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, vol. 228, pp. 664–675, Mar. 2013, doi: 10.1177/0954406213489408.

Content by: Joshua Varghese

Present: N/A

Content:

1. The proposed magnetic damper achieves a maximum transmissibility value less than two for a natural frequency that is less than 10 Hz and the excitations at higher frequencies are successfully isolated.Numerical and experimental studies were carried out for a range of system parameters which show that isolators based on magnetic damping could be very effective for passive vibration isolation
2. Passive isolators commonly include passive elements such as metallic or non-metallic springs, viscous and friction-based dampers, elasto-damping materials and pneumatic/hydraulic elements
3. On the other hand, active damp-ing is less common in industrial applications and includes isolators such as active hydraulic network, electromagnetic damper, electro-magnetorheological fluids, sensors and control systems
4. For magnetic dampers it is known that the coefficient of damping is proportional to the conductivity of the conductor and the square of flux density. Hence, the damper assembly is designed in such a way that it has minimum flux leakage and the copper body is chosen as the conductor to facilitate eddy current generation

Conclusions/action items:

This article focuses on spring viscous damper cable systems used in building construction.

2023/02/26: Linear Springs

Joshua Varghese - Feb 28, 2023, 12:34 PM CST

Title: 2023/02/26: Linear Springs

Date: 2/26/23

Source Link: **https://www.smalley.com/wave-springs/linear-springs**

Citation:

"Linear Wave Springs," *Smalley*, Dec. 23, 2013. https://www.smalley.com/wave-springs/linear-springs (accessed Feb. 28, 2023).

Content by: Joshua Varghese

Present: N/A

Content:

1. Smalley Linear Wave Springs are a continuous wave formed (marcelled) wire length produced from spring tempered materials.
2. They act as a load bearing device having approximately the same load/deflection characteristics as a wave spring.
3. Axial pressure is obtained by laying the linear spring flat in a straight line.
4. The springs come in carbon and stainless steel options with over 200 different sizes
5. Applications:
    1. Detend Preload: Smalley linear springs are used to load pins that are positioned inside grooves so a rotating element can detent to specific positions. The springs are designed to exert a precise load to give the rotation a desired resistance
    2. Rotary Vane Pump: Smalley Linear Springs are used to radially load the bottom of the vanes in the pump. The springs energize the vanes against the bore for better sealing.

Conclusions/action items:

This article focuses on linear spring which are an alternative to the conventional circular springs. The linear springs are much thinner alternatives that should accomplish a similar function. I have asked for several samples of the product and have been in contact with their sales rep, Steve, in order to obtain an appropriate spring for our project.

2023/02/26: Viscous Dampers in Buildings

Joshua Varghese - Feb 28, 2023, 6:16 PM CST

Title: 2023/02/26: Viscous Dampers in Buildings

Date: 2/26/23

Citation:

D. De Domenico, G. Ricciardi, and I. Takewaki, “Design strategies of viscous dampers for seismic protection of building structures: A review,” Soil Dyn. Earthq. Eng., vol. 118, pp. 144–165, Mar. 2019, doi: 10.1016/j.soildyn.2018.12.024.

Content by: Joshua Varghese

Present: N/A

Content:

1. Viscous dampers are devices used to absorb seismic energy and reduce the structural response of buildings during earthquakes.The effectiveness of viscous dampers depends on their design parameters, including damping coefficient, yield strength, stroke, and installation location.
2. The damping coefficient is a measure of the energy dissipation capacity of the damper and should be optimized based on the characteristics of the building and the expected earthquake ground motion.
3. The yield strength of the damper should be selected to ensure that it can withstand the maximum seismic force that may be exerted on it without yielding or breaking.
4. The stroke of the damper should be sufficient to allow for the necessary displacement of the building during an earthquake, but not so large as to cause damage or instability.
5. The installation location of the damper should be chosen based on the structural characteristics of the building and the expected seismic demand.
6. Viscous dampers can be designed as passive or semi-active systems, with the latter using sensors and control systems to adjust the damping force in real-time.
7. The cost-effectiveness of viscous dampers as a seismic protection measure depends on the specific building and seismic hazard, as well as the availability of alternative strategies such as base isolation or structural strengthening.
8. Viscous dampers have been successfully used in a variety of building types, including high-rise buildings, bridges, and industrial facilities, and are a viable option for enhancing the seismic resilience of critical infrastructure.

Conclusions/action items:

This article focuses on viscous dampers within building design to reduce the impact of earthquakes. I will use the information from this article to create a connection within the report that will allow the readers to better understand the design concept.

2023/02/26: Power Spectral Density

Joshua Varghese - Feb 28, 2023, 6:21 PM CST

Title: 2023/02/26: Power Spectral Density

Date: 2/26/23

Source Link: **https://community.sw.siemens.com/s/article/what-is-a-power-spectral-density-psd**

Citation:

“What is a Power Spectral Density (PSD)?” https://community.sw.siemens.com/s/article/what-is-a-power-spectral-density-psd (accessed Feb. 28, 2023).

Content by: Joshua Varghese

Present: N/A

Content:

1. A power spectral density (PSD) curve is a mathematical representation of the distribution of power in a signal as a function of frequency.The PSD curve provides a way to analyze and quantify the frequency content of a signal, which is useful in many different fields, including engineering, physics, and biology.
2. The PSD curve is calculated by taking the Fourier transform of a signal and then squaring the magnitude of each frequency component.
   The resulting curve shows the power (or energy) of the signal at each frequency, with the horizontal axis representing frequency and the vertical axis representing power.
3. The PSD curve can be used to identify the dominant frequencies in a signal, which can help in understanding the underlying physical or biological processes that are generating the signal.
4. In engineering applications, PSD curves are often used in the design and testing of mechanical and electrical systems, where it is important to understand the frequency response of the system to different inputs or loads.
5. PSD curves can also be used in signal processing to filter out unwanted noise or interference from a signal, by selectively removing frequency components that fall outside a certain range.
6. The shape of the PSD curve can provide valuable insights into the behavior of the system being studied, including whether it is linear or nonlinear, and whether it exhibits random or periodic behavior.

Conclusions/action items:

In summary, the power spectral density curve is a powerful tool for analyzing and understanding the frequency content of signals in a wide range of fields, and can provide valuable insights into the underlying physics, biology, or engineering of the system being studied. It will be useful in analyzing and interpretting the data collected from the accelerometers.

2023/03/01: How to Use Accelerometers to Measure Vibration

Joshua Varghese - Mar 01, 2023, 11:35 AM CST

Title: 2023/03/01: How to Use Accelerometers to Measure Vibration

Date: 3/1/23

Source Link: **https://www.metrixvibration.com/resources/blog/how-to-use-accelerometers-to-measure-vibration**

Citation:

"How to Use Accelerometers to Measure Vibration | Vibration Measurement." https://www.metrixvibration.com/resources/blog/how-to-use-accelerometers-to-measure-vibration (accessed Mar. 01, 2023).

Content by: Joshua Varghese

Present: N/A

Content:

1. Accelerometers measure acceleration and different forces on an object, and can monitor both static and dynamic forces.They are easy to use and can operate across a broad range of frequencies.
2. They can be used to monitor a wide variety of machines, including motors, pumps, fans, compressors, turbines, and many other rotating and reciprocating machines across multiple industries.
3. Accelerometers work by outputting an electronic signal from a sensor installed to measure dynamic or static acceleration.
   There are four main types of accelerometer sensors: piezoelectric, piezoresistive, capacitive, and microelectromechanical systems (MEMS).
4. Piezoelectric accelerometers are the most used sensors for measuring vibration and shock in industrial applications, while capacitive accelerometers are the most common type of accelerometer.
5. MEMS accelerometers are often paired to capture different frequency ranges and assembled in a triaxial arrangement to measure acceleration in three directions due to their compact size.
6. Accelerometers measure vibration by monitoring acceleration and converting it into voltage, and are usually mounted on equipment to measure vibration on machines operating at greater than 60 Hz.
7. The ideal choice for measuring vibration in an industrial setting is most likely a piezoelectric accelerometer, with high impedance accelerometers suitable for high-temperature situations and low impedance accelerometers more commonly found in industrial settings to help identify vibration issues within rotating and reciprocating machinery.

Conclusions/action items:

One possible action item related to this information and implementing it in the neonatal transport unit project could be to research and select an appropriate type of accelerometer sensor for measuring the vibration levels of the equipment used in the unit. This could help to ensure that any potential issues with the equipment are detected early and addressed promptly, helping to improve patient safety and reduce downtime due to equipment failure.

2023/02/14: Design Idea 1

Joshua Varghese - Feb 14, 2023, 7:20 PM CST

Title: 2023/02/14: Design Idea 1

Date: 2/14/23

Content by: Joshua Varghese

Present: N/A

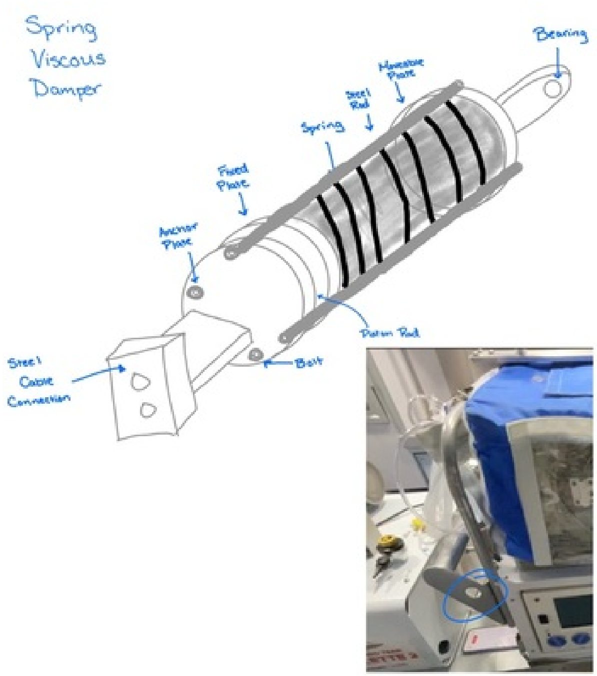
Content:

This design is called the Spring Viscous Damper and would be placed externally of the incubator in a diagonal arrangement from the whole circled in the picture to the clasp on the opposite side of the control box. The spring viscous damper is commonly used in buildings in order to protect them from earthquakes which often fall in the range of 0.5 - 10 Hz. The spring viscous damper is only around 4 inches long, but a steel cable extends from it in order to cover the distance from one end of the diagonal to the other. The cable will be in an extremely high tension so that the whole system will be taut.

Conclusions/action items:

Work on the design matrix

Joshua Varghese - Feb 14, 2023, 6:10 PM CST



Download

446DB80C-ACE8-4D0B-A05B-484FFC2DEC54.jpg (73.9 kB)

2023/02/14: Design Idea 2

Joshua Varghese - Feb 14, 2023, 7:12 PM CST

Title: 2023/02/14: Design Idea 2

Date: 2/14/23

Content by: Joshua Varghese

Present: N/A

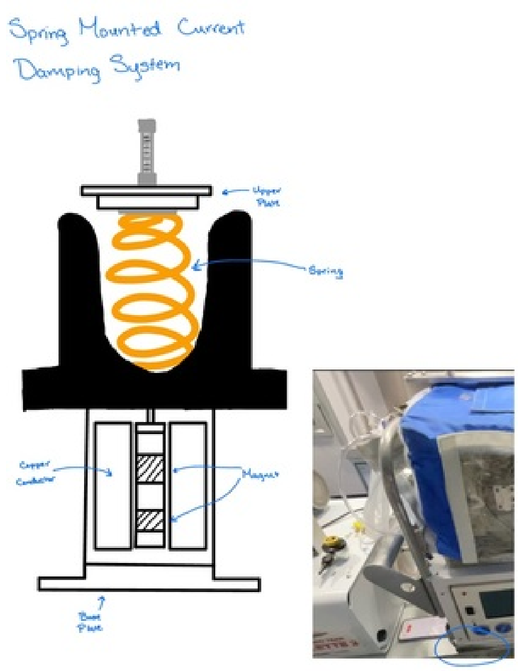
Content:

The image is attached below. This design focuses on using an electromagnetic field to act as a damper to reduce the vibrations in the plate. The design would be placed at each of the 4 corners underneath the control box and would likely be about 2in x 2in.

Conclusions/action items:

Work on the design matrix

Joshua Varghese - Feb 14, 2023, 6:11 PM CST



Download

1A2F5425-8970-4EE9-9ABA-4A4CB14D95BD.jpg (84.6 kB)

2023/03/16: WARF Lecture

Joshua Varghese - Mar 16, 2023, 7:55 AM CDT

Title: 2023/03/16: WARF Lecture

Date: 3/16/23

Source Link: https://mediaspace.wisc.edu/media/WARF+Presentation+-+3+15+2019+-+Anderson+and+Burmania/1_1ktwn14w

Content by: Justin Anderson and Janine Burmania (Joshua Varghese)

Present: N/A

Content:

1. WARF manages university's intellectual property including patenting and licensing.
2. WARF has been patenting and licensing innovations since 1925, making it the first technology transfer office in the country.
3. Harry Steenbock, who discovered irradiating food with light to enrich it with vitamin D, was seminal in the formation of WARF.
4. The university initially rejected the idea of patenting Steenbock's discovery, leading him to start WARF.
5. WARF is a non-profit organization fully separate from the university and governed by an independent Board of Trustees.
6. WARF reinvests proceeds from licensing technologies back into the university and the Morgridge Institute for Research to support students and researchers.
7. WARF's cycle of innovation starts with research and discovery on campus and leads to invention disclosures, which are protected with patenting.
8. WARF receives between 300 to 400 invention disclosure reports each year.
9. Patents are the strongest form of intellectual property protection and most of the university's discoveries lend themselves to patenting.
10. Trade secrets, such as the Coca-Cola formula, are difficult to maintain for most researchers on campus because the information is often shared in some way
11. Prior art is a term used by patent offices to describe anything that has been done before an invention is submitted for a patent.
12. The United States has a grace period of 12 months or one year from the date of the first public disclosure until a patent can be filed.
13. Most countries, including the USA, do not provide a grace period for prior art created by someone else, which counts against the inventor.
14. Absolute novelty requirements exist in some countries like in Europe, where prior art created by someone else or the inventor counts against the inventor's patent application.
15. Enablement is the idea of providing enough information in a public disclosure to enable someone else skilled in the field to reproduce the invention.
16. Classic examples of public disclosures include presenting an idea to a class, publishing a paper, or presenting at a research conference

17. The process starts with a simple four-page document called the invention disclosure report, which asks questions about the invention, what makes it different, and who may have helped with it.

18. The WARF disclosure decision committee evaluates 30-40 invention disclosures each month based on whether the technology is novel, not obvious, and can be licensed.

19. Once WARF accepts the technology, inventors need to assign the invention to WARF and in return, WARF pays $30,000 for the patent and associated licensing costs. Inventors receive 20% of any licensing revenue, with 15% going back to the department and 65% going into the annual gift.

20. WARF works with outside counsel, most of whom have a PhD and deep experience in the inventors' technical area, to draft the patent application.

21. WARF markets the technology while it's pending in the patent office, and once the patent issues and licensees agree to take licenses, WARF gets royalties back on their use.

22. WARF considers what companies are thinking about when they create a new product, where they're trying to address the market and the chance of licensing for the new technology, WARF's track record in a particular space, and the stage of the technology.

23. Faculty members and inventors who are interested in starting a company should consider several factors: how their technology fits within the market, whether it is a component or a whole product, the amount of development time and funding required, the size of the target market, and the management team.

24. The University of Wisconsin-Madison offers resources to foster entrepreneurship, including the Discovery to Product (D2P) initiative, the Entrepreneurons seminar series, and hands-on programs like the Innovation Roadmap series and Upstart.

25. The Law and Business Entrepreneurship Clinic provides legal advice to startups on campus.

26. WARF accepts technologies developed by students for patenting and has licensed them to startup companies, such as Trilogy Medical, which began as a BME student project.

Conclusions/action items:

Our design may contain intellectual property since it is potential the cheapest possible to an unsolved problem. Resources such as Discovery to Product (D2P) and the Law and Business Entrepreneurship Clinic can provide guidance and support for the entrepreneurial process.

2023/2/28: Neonatal Data MATLAB Code

Joshua Varghese - May 01, 2023, 10:18 PM CDT

Title: 2023/2/28: Neonatal Data MATLAB Code

Date: 12/28/23

Content by: Joshua Varghese

Present: N/A

Content:

I have attached the code necessary to analyze the data from last semester. Some changes will need to be made in order to work with the new testing setup and analyze the acceleration data since we are reducing the number of accelerometer from 6 to 1. The code includes plots for acceleration vs. time as well as a power vs. frequency derived from the Fourier transform.

I am updating other iterations of the testing code here as well.

Conclusions/action items:

I will need to contact Dr. Arvelo again in order to make sure my equations in the MATLAB code are correct. I have some uncertainty that I calculated power correctly and he should be able to help me with this. Additionally, I may try to explore some new visuals that may be clearer for the poster.

Joshua Varghese - Dec 12, 2022, 7:26 PM CST

Download

neonatal_fft_final.mlx (1.13 MB)

Joshua Varghese - Dec 12, 2022, 7:26 PM CST

```
clear;
clc;

% make a cell array of all data file names

DataNames = {'Neonate_Head_FinalComponents.mat'...
             'chest_cavity_device_test_3components.mat'...
             'Middle_sled_test_2components.mat'...
             'back_sled_finalComponents.mat'...
             'front_floor_finalComponents.mat'...
             'BackFloor_Test2Components.mat'};
legendNames = {'Head'...
              'Chest'...
              'SledMid'...
              'SledBack'...
              'FloorFront'...
              'FloorBack'}; % legend name corresponds to DataName in same
location

colorCell = {'r','g', 'b', 'c', 'm','y'};

figure
% run through each data file and do something

for i = 1:numel(DataNames)
    load(DataNames{i})  %load the data from each file

    Ax_all = [];
    Ay_all = [];
    Az_all = [];
    Amag_all = [];
    Tm_all = [];

    for j = 1:5
    %plot information from each data set

        ax = Ax;
        ay = Ay;
        az = Az;
        amag = Amag;
        tm = t;

        Ax_all(:,j) = ax;
        Ay_all(:,j) = ay;
        Az_all(:,j) = az;
        Amag_all(:,j) = amag;
        Tm_all(:,j) = tm;

    end


    subplot(4,1,1)
        plot(Tm_all, Ax_all, colorCell{i})
        hold on
        title('Acceleration Components at Each Location in Ambulance')
        xlabel('Time (s)')
        ylabel('X Acceleration (m/s^2)')
        xlim([0,2600])

    subplot(4,1,2)
        plot(Tm_all, Ay_all,colorCell{i})
        hold on
        xlabel('Time (s)')
```

[Download]

NeonatalPlotAccel.m (2.02 kB)

Joshua Varghese - Dec 12, 2022, 7:26 PM CST

```
clear;
clc;

%% load the data
[filename, pathname] = uigetfile('*.mat','MultiSelect', 'on');
%% extract the data arrays
for j=1: numel(filename)

close all;
fn = fullfile(pathname, filename{j});
load(fn);

Ax = Acceleration.X;
Ay = Acceleration.Y;
Az = Acceleration.Z;
T = Acceleration.Timestamp;
to = T(1);
t= T - t0;
t = seconds(t);

% magnitude of Acceleration
Amag = sqrt(Ax.^2 + Ay.^2 + Az.^2);
%Amag_cropped = Amag(110:1630);
%t_cropped = t(110:1630);

% figure
% % Plot
% plot(t, Amag)
% cont = 1;
% while cont
%     MPD = input('select a value for MPD : ');
%     findpeaks(Amag, 'MinPeakDistance', MPD);
%     drawnow
%     cont = input('continue with this MPD? 1=no , 0=yes');
% end
% [crops, ~] = ginput(2);

%% Find the peaks of the data
% cropstart = round(crops(1));
% cropend = round(crops(2));
% Amag_cropped = Amag(cropstart:cropend);
% t_cropped = t(cropstart:cropend);

% [pks, locs] = findpeaks(Amag_cropped,'MinPeakDistance', MPD);
% figure
%% Extract the data from peak to peak

%  for i = 1:size(locs,1)-1
%     peak1 = locs(i);
%     peak2 = locs(i+1);
%     t_cropped_o = t_cropped(peak1);
%     tm = t_cropped(peak1:peak2) - t_cropped_o;
%     Am = Amag_cropped(peak1:peak2);
%
%     plot(tm, Am)
%     hold on

%     Tm_cell{i} = tm;
%     Am_cell{i} = Am;
%  end
 savename = filename{j};
 save([savename(1:end-4) 'Components.mat'], "Ax", "Ay", "Az", "Amag", "t")
 end
```

[Download]

SaveAccelComponentsCode.m (1.47 kB)

Joshua Varghese - May 01, 2023, 10:18 PM CDT

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FinalScript.mlx (1.1 MB)

Joshua Varghese - May 01, 2023, 10:19 PM CDT

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FinalScript3.mlx (1.36 MB)

Joshua Varghese - May 01, 2023, 10:19 PM CDT

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FinalScript4.mlx (1.14 MB)

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: