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GIFTS: Project-Based Service-Learning for First-Year Engineering Students

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Fayekah Assanah is the team leader for ENGR 1166: Foundations of Engineering, a core course for all first-year engineering students at the University of Connecticut, consisting of over 400 students. She has designed, developed, and implemented multiple design projects and service learning project through the ”Corsi-Rosenthal Boxes” for all first-year engineering students at the University. Assanah's research focuses on synthesizing hydrogels to mimic the mechanical behavior of the brain matter and investigate the cellular response to injury.

Dr. Kristina Wagstrom, University of Connecticut

Dr. Kristina Wagstrom is an associate Professor in the Chemical and Biomolecular Engineering at the University of Connecticut in Storrs, CT. She specializes in applying chemical engineering principles to study atmospheric chemistry and air pollution with an emphasis on human and ecosystem health impacts. She is also interested in studying the impact of different educational approaches in engineering with a focus on experiential learning and career readiness.

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Marina Creed is an Instructor in the Department of Neurology at the University of Connecticut School of Medicine and practicing Neuroimmunology Nurse Practitioner in the Multiple Sclerosis Center at UConn Health. She has been engaged in translational public health efforts throughout the COVID19 pandemic to improve outcomes for her immunosuppressed patients by reducing exposure to infectious and non-infectious air pollution in public schools and community spaces throughout the State of Connecticut. She founded and is the director of the UConn Indoor Air Quality Initiative, a cross-campus, multidisciplinary team of scientists and clinicians studying low-cost air purifiers in both laboratory and real-world settings.

GIFTS: Project-Based Service-Learning for First-Year Engineering Students

Dr. Fayekah Assanah, Department of Biomedical Engineering, University of Connecticut

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Dr. Kristina Wagstrom, Department of Chemical and Biomolecular Engineering, University of Connecticut

Kristina Wagstrom is an Associate Professor in Chemical and Biomolecular Engineering at the University of Connecticut. Her research focuses on providing tools to improve the estimates of human and ecosystem health impacts from poor air quality. Her research portfolio has recently expanded to include indoor air quality by testing the effectiveness of Corsi-Rosenthal boxes (a low-cost, DIY air filter) to lower aerosol concentrations in occupied classrooms. In addition, she has substantial experience mentoring project-based service-learning teams.

Dr. Daniel Burkey, Department of Chemical and Biomolecular Engineering, University of Connecticut

Daniel Burkey is an Associate Professor in Chemical and Biomolecular Engineering and the Associate Dean for Undergraduate Education and Diversity at the University of Connecticut. His research interests include process safety education in chemical engineering, ethical development and decision-making in engineering students, and game-based and game-inspired pedagogies.

Marina A. Creed, Department of Neurology, UConn Health

Marina A. Creed is a Neurology and Immunology Nurse Practitioner, Adjunct Instructor in the School of Medicine, and Director of the University of Connecticut Indoor Air Quality Public Health Initiative. Within the UConn Health Division of Neuro-Immunology and Multiple Sclerosis Center, she treats people with chronic autoimmune neurological disorders and started the Initiative after seeing her immunosuppressed patients experiencing disproportionately worse outcomes due to COVID-19, many of whom were exposed by their school-aged children. After reviewing state public health policy regarding portable air cleaners as a mitigation strategy for COVID-19 transmission and the potential economic barrier to implementation, she led a multidisciplinary team within the University with the mission of studying and validating the performance of low-cost, highly effective Do-It-Yourself Air Cleaners, also called Corsi-Rosenthal Boxes, in controlled and accurate world settings, raising community awareness through University student and faculty Corsi-Rosenthal Box-a-thons to create hundreds of portable air cleaners for donation to public schools and vulnerable community spaces.

GIFTS: Project-Based Service-Learning for First-Year Engineering Students

Motivation

This Great Ideas for Teaching Students (GIFTS) paper describes a Project-Based Service Learning (PBSL) opportunity recently implemented in a first-year engineering course. PBSL is a vital instructional approach in contemporary engineering education. It encourages students to deepen their understanding while forging meaningful community ties. PBSL experiences are student-centered (yet tailored to the course objectives and community needs). They foster collaboration, nurture creativity, and build analytical skills while applying practical engineering solutions to real-life issues. This paper describes a short-term PBSL that we used in a core first-year engineering course (for all engineering majors across the University) to give them an experience of how they could contribute to the community using their engineering skills and knowledge. The activity involves the building and testing of Corsi-Rosenthal (C-R) boxes (DIY Air Purifiers) that trap ~60% of particles in indoor environments to improve indoor air quality. Students carried out the project in small groups (3-4 students) in the First-Year Design Laboratory for two to four weeks. At the end of the project, we distributed the C-R boxes to local elementary schools, housing for multiple-sclerosis patients, and veterans. We have implemented this project for three years allowing over 1200 students to participate in this PBSL. In their final portfolios, students highlighted how this learning experience helped them meet the course objectives. This GIFTS paper describes this project and our implementation strategies to allow others to similarly implement the project. We also include an analysis of the student perceptions towards this PBSL.

About the First-Year Engineering Course

We implemented this PBSL the Foundations of Engineering (ENGR 1166) course at the University of Connecticut, a large R1 public University as a short-term project at the beginning of the semester. This course is required for all first-year engineering students and the enrollment is typically just over 400 students. This course has three components that occur concurrently: a) lecture, b) major specific content (MSC), and c) design labs. The large lectures introduce students to crucial engineering concepts, software, and tools through active learning and small team projects. In MSC, students learn about engineering concepts and solve problems related to their major engineering fields asynchronously. In the design labs (16 lab sections, consisting of ~28 students each), students apply their knowledge and technical skills from the lecture and MSC to design, iterate, and build a prototype of a real-life project with given constraints. We incorporated the PBSL into the lab curriculum.

Objectives of the PBSL

The learning outcomes for the course address five of the ABET outcomes: 1) demonstrate an understanding of concepts and solve fundamental problems, 2) iterative design, 3) multidisciplinary teamwork, 4) effective communication, and 5) ethics. The PBSL involves the construction and testing of the Corsi-Rosenthal box, a DIY (do-it-yourself), portable, inexpensive solution to mitigate transmission of diseases like respiratory syncytial virus (RSV) and influenza. Both diseases are primarily spread through respiratory aerosols from infected individuals [1] [2] [3]. We have implemented this project for the last three years as part of the laboratory curriculum in the Foundations of Engineering Course to help students achieve all the learning outcomes mentioned above. Additionally, the objective of this PBSL is to teach the students how to build the C-R boxes using low-cost materials, suggest improvements in the design, analyze the airflow through the boxes, and collect and analyze data about the reduction of particles in the air.

The Corsi-Rosenthal (C-R) Box Project

The C-R Box approach to improve indoor air quality became important during the COVID-19 pandemic. Lower-cost, commercially available air purifiers do not effectively remove the aerosols most responsible for the transmission of COVID-19. Transmission is particularly acute in poorly ventilated indoor spaces, such as many public schools in the United States (particularly those in the Northeast) [4] [5] [6]. C-R boxes can fill this gap as they are cost-effective (~$75) and energy-efficient. Lab-based analyses of C-R boxes have demonstrated their effectiveness [7] and found ~60% reductions in aerosol levels when the fan is used in occupied classrooms air [8].

In this PBSL, students build C-R boxes of different sizes using either a 20” or a 10” box fan. The 20” C-R box is made from four MERV-13 (20"x20"x2") HVAC filters, a 20" box fan, duct tape, and cardboard (from the fan box). The 10” C-R box is made from five MERV-13 (12"x12"x2") HVAC filters, a 10" box fan, duct tape, and cardboard (from the fan box). To construct the C-R boxes, four filters are staggered to form a cube and taped with duct tape along the edges (ensuring the correct orientation of the filters). For the 20” C-R box, we construct a bottom from the cardboard from the fan box. We then tape the fan to the open side of the cube. Finally, we cut a shroud to improve airflow from the remaining cardboard from the fan box. For the 10” C-R box, we tape the fifth filter onto the bottom side of the cube to allow different orientations of the air purifier. For the 10” C-R box, we create a support using the cardboard from the box fan to reinforce and provide structural stability as we attach the fan to the other open side of the cube. Finally, we place the fan on top of the cardboard support and tape it securely using duct tape to ensure an airtight seal around all the edges (Appendix I).

Implementation Guidelines

During the first two years, we implemented the PBSL over three to four weeks of the course. We introduced students to the importance of indoor air quality and strategies to address poorly ventilated spaces. Guided by weekly lesson plans, students constructed and tested the 20” C-R boxes using the "Physics Toolbox Sensor Suite" app to record g-Force data to discern vibration variations across different fan speeds and measured noise levels at various distances from the fan using sound meter. Finally, students graphed the results to illustrate sound intensity over distance. They engaged with real-world experimental data, using Excel to graph aerosol concentrations with and without the C-R boxes to understand their efficacy in reducing particulate matter in the air. We donated the C-R boxes from the first two years to local schools and community settings. During the third year of the project (Spring 2024), students constructed 10” C-R boxes (described above), a departure from the previously utilized 20" C-R boxes. The downsized C-R boxes offer space efficiency and ease of construction. At the end of the PBSL, we donated all C-R boxes to the local Veterans Hospital for distribution among veterans to conduct a study geared towards preventive neurology. The project spanned two weeks, where students organized into groups of 4-5, mirroring previous years' arrangements as described below. We also provide a sample lesson plan for two weeks in Appendix II.

Week	Activity	Objective
1	The class toolkit provides students with background materials about indoor air pollution. Students construct the 10” C-R boxes in teams, guided by the lesson plans. Teams ensure construction accuracy by conducting peer inspections to verify proper duct tape usage and sealed edges through a quality control checklist.	Foster teamwork and instill ethical work practices behind proper construction techniques and skills.
2	Teams test the impact of the C-R boxes on the Air Changes per Hour (ACH) to estimate a Clean Air Delivery Rate (CADR) in a course-based undergraduate research modality. This analysis provides information about the effectiveness of the C-R boxes in removing particles from the air.	Evaluate the efficacy of C-R boxes in reducing particle concentrations (thus enhancing overall air quality).

Assessments

As part of their weekly group assignment, students submit engineering logs documenting their progress in constructing and testing the C-R boxes (sample engineering log is provided in Appendix II). These logs detail the design process, project advancement, teamwork, and division of labor via Gantt charts and suggestions for improving the design of the boxes. Additionally, the engineering logs prompt students to reflect on testing methods and ethical considerations. Students receive feedback on these logs from the instructors and teaching assistants. As part of one of the major assignments for our implementations of the project, students portrayed their PBSL experiences in their semester-end engineering portfolios, emphasizing insights gained in iterative design, teamwork, and scientific communication. The C-R box project resonated with students' remote learning experiences during the pandemic; they felt a personal connection and motivation to impact school children's lives positively. Students pointed to how this PBSL helped them achieve the course's learning objectives, demonstrating a positive learning journey and enhanced motivation and comprehension across cognitive domains.

Analysis of Student Perspectives on the Impact of the C-R Box Project

Every student submitted a final engineering portfolio video at the end of the semester. We tasked students to showcase two instances of how they fulfilled course learning outcomes. Each student meticulously detailed the activities undertaken, explaining how their engagement in each project aligned with the objective of the course. Building on the work-in-progress paper [9], we have quantitatively assessed students' perspectives on how the project helped them meet the course objectives by seeing how many students used the C-R box project to demonstrate each objective in the Spring 2022 and Spring 2023 semesters.

Table 1. The percent of students listing the C-R box project as an example for each learning objective. *For Spring 2022, N=24 out of the 411 students enrolled in the course. For Spring 2023, N=137 out of the 406 students enrolled in the course.*

Learning Outcomes	**Spring 2022**	**Spring 2023**
Iteratively design, build, and improve a device or a process to meet a specified need within given constraints	21%	9.5%
Work effectively in multidisciplinary teams	96%	59%
Communicate effectively by presenting work in a structured, clear, and engaging way to a range of audiences	67%	42%
Apply the ethical responsibilities of their profession to the design process	50%	67%

Students strongly associated the C-R box project with working effectively in multidisciplinary teams, particularly in 2022. Specifically, students mentioned working with other students in other disciplines whom they never met. They emphasized working with each other's strengths and weaknesses and how having multiple team members helped them complete the project on time. Students highlighted that inspecting each other's work helped them correct potential defects in the construction of the C-R box. The difference between the two semesters is likely related to the sample size. Many students also identified ways the C-R box project helped develop effective communication by creating graphs to convey data, Gantt charts to manage the timeline and ensure team coherence, engineering logs to articulate the process, and instructions alongside QR codes on the box to facilitate communication with end users. Students also linked this project to apply engineering ethics by raising the need to ensure that the design worked as, the need to consider the noise level, and the need to document their work and credit sources properly. Overall, students recognized the project's role in meeting the semester's learning outcomes, with varying viewpoints regarding its specific contributions.

Lessons Learned

The C-R box service-learning project is affordable and brief (two 75-minute laboratory periods). We have conducted this PBSL for three years so far. On our third implementation, we used the classroom toolkit to provide students with background information, and we shortened our lesson plans to two weeks. Additionally, students greatly benefitted from the quality control check between teams to design an effective C-R box. The data collection experiment on removing particles from the air using the CRB was helpful for the students in understanding the efficacy of the device. This PBSL is suitable for incorporation into the curriculum of a first-year engineering class of any scale. As the student feedback shows, this initiative renders a valuable experiential learning outcome across various course objectives. By allowing students to partake in ethical decision-making, problem-solving, and community service, projects of this nature help foster the growth of conscientious future engineers within their communities.

Acknowledgments

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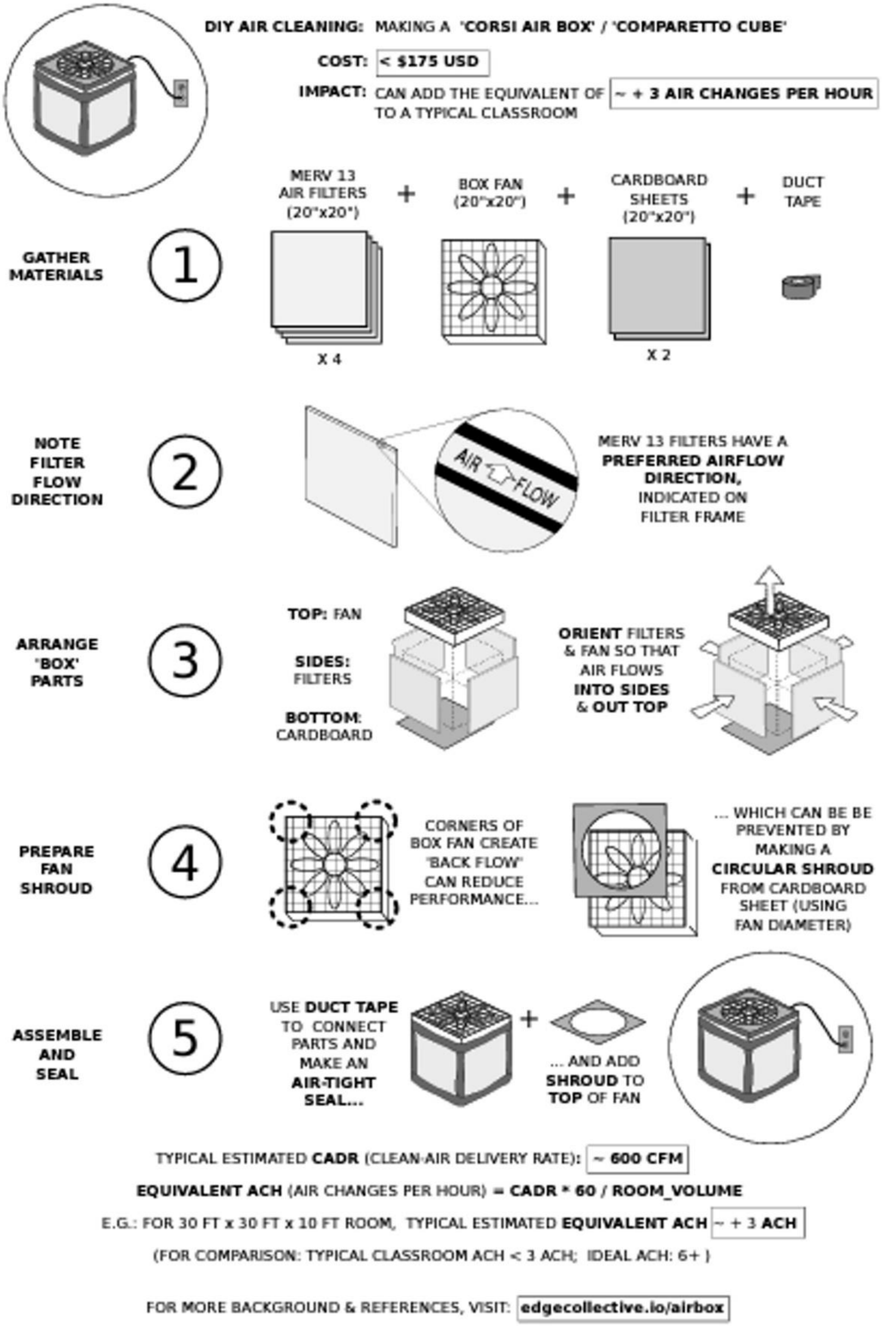
Appendix I

20 INCH CORSI-ROSENTHAL BOX



DIY AIR CLEANING: MAKING A **'CORSI AIR BOX' / 'COMPARETTO CUBE'**

COST: **< $175 USD**

IMPACT: CAN ADD THE EQUIVALENT OF **~ + 3 AIR CHANGES PER HOUR** TO A TYPICAL CLASSROOM

GATHER MATERIALS ①

MERV 13 AIR FILTERS (20"x20") X 4 + BOX FAN (20"x20") + CARDBOARD SHEETS (20"x20") X 2 + DUCT TAPE

NOTE FILTER FLOW DIRECTION ②

MERV 13 FILTERS HAVE A **PREFERRED AIRFLOW DIRECTION,** INDICATED ON FILTER FRAME

ARRANGE 'BOX' PARTS ③

TOP: FAN

SIDES: FILTERS

BOTTOM: CARDBOARD

ORIENT FILTERS & FAN SO THAT AIR FLOWS **INTO SIDES** & **OUT TOP**

PREPARE FAN SHROUD ④

CORNERS OF BOX FAN CREATE 'BACK FLOW' CAN REDUCE PERFORMANCE...

... WHICH CAN BE BE PREVENTED BY MAKING A **CIRCULAR SHROUD** FROM CARDBOARD SHEET (USING FAN DIAMETER)

ASSEMBLE AND SEAL ⑤

USE **DUCT TAPE** TO CONNECT PARTS AND MAKE AN **AIR-TIGHT SEAL...**

... AND ADD **SHROUD** TO **TOP** OF FAN

TYPICAL ESTIMATED **CADR** (CLEAN-AIR DELIVERY RATE): **~ 600 CFM**

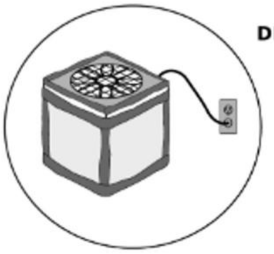
EQUIVALENT ACH (AIR CHANGES PER HOUR) **= CADR * 60 / ROOM_VOLUME**

E.G.: FOR 30 FT x 30 FT x 10 FT ROOM, TYPICAL ESTIMATED **EQUIVALENT ACH** ~ + 3 **ACH**

(FOR COMPARISON: TYPICAL CLASSROOM ACH < 3 ACH; IDEAL ACH: 6+)

FOR MORE BACKGROUND & REFERENCES, VISIT: **edgecollective.io/airbox**

10 INCH CORSI-ROSENTHAL BOX



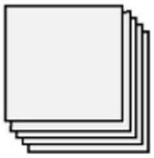
DIY AIR CLEANING: MAKING A **'CORSI AIR BOX' / 'COMPARETTO CUBE'**

COST: **< $175 USD**

IMPACT: CAN ADD THE EQUIVALENT OF **~ + 3 AIR CHANGES PER HOUR** TO A TYPICAL CLASSROOM

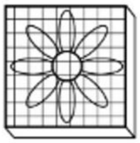
GATHER MATERIALS ①

MERV 13 AIR FILTERS (12" X 12") +

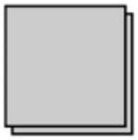


X 5

BOX FAN (10" X 10") +



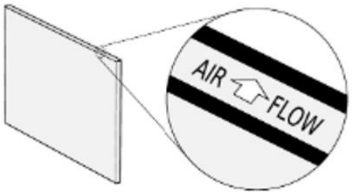
CARDBOARD SHEETS (12" X 12") +



X 2

DUCT TAPE

NOTE FILTER FLOW DIRECTION ②



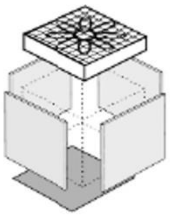
MERV 13 FILTERS HAVE A **PREFERRED AIRFLOW DIRECTION,** INDICATED ON FILTER FRAME

ARRANGE 'BOX' PARTS ③

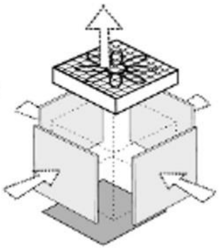
TOP: FAN

SIDES: FILTERS

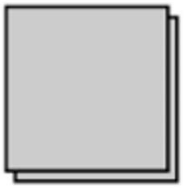
BOTTOM: 5th FILTER



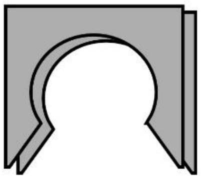
ORIENT FILTERS & FAN SO THAT AIR FLOWS **INTO SIDES** & **OUT TOP**



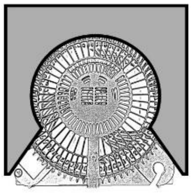
PREPARE FAN SUPPORT ④



CARDBOARD FROM FAN BOX (x 2)



CUT SUPPORT FOR THE FAN



Place the support to the back of the fan and it should be a snug fit

ASSEMBLE AND SEAL ⑤

Completed C-R Box!

Place the fan on the filter box and tape all edges firm with **DUCT TAPE**!

Appendix II

Corsi-Rosenthal Box Project: Indoor and Outdoor Pollutants and Filtration System Efficiency

Week 1 Lesson Plan – Background and Build

Group Assignment
Due Date:

Objectives

After completing this module, you should be able to:

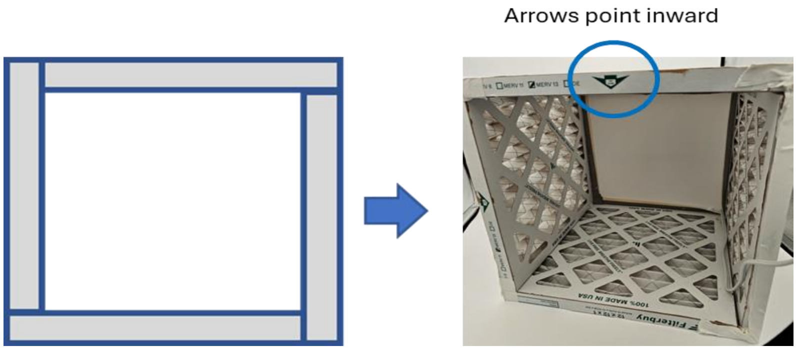
- Understand the design and build the Corsi-Rosenthal Box air filter
- Assess your design and suggest updates
- Understand the background behind Indoor Air Quality (materials provided in Classroom toolkit)
- Check Quality Control

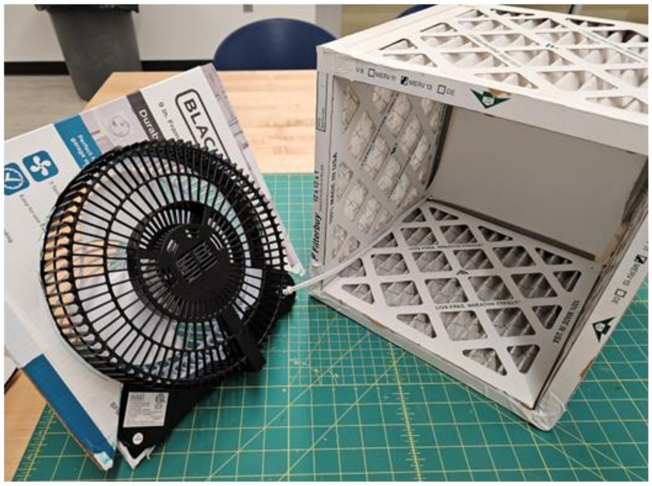
Tasks to be completed in Class as a Group:

- Gather parts list:
  - Box Fan - Black + Decker 9 inch Frameless Box Fan
  - Keep the cardboard box from the fan intact! Do not destroy it! You will need to use this!!
  - Five MERV13 12 inch filters
  - Duct tape
  - Template (available to you in the classroom, or ask the TA)

- Make basic filter structure:
  - Assemble four filters into a cube and attach filters with duct tape connecting the sides of the filter
  - ***Make sure that the "wire" side of the filters faces the inside of the cube! There are arrows on the sides of the filters to show the direction of air flow. Make sure the arrows point inwards (as shown).***
    - ***This is because the CRB will pull 'dirty' air through the filters and into the box, and then provide 'clean' air through the fan.***
  - ***The filters should be arranged on a staggered 90 degree angle as shown in the schematic below (sort of forms a spiral). The final shape should be a perfect square (instead of [barely] a rectangle if you don't 'spiral' the filters)!***
  - Connect filters with duct tape as indicated. Make sure it is air tight!

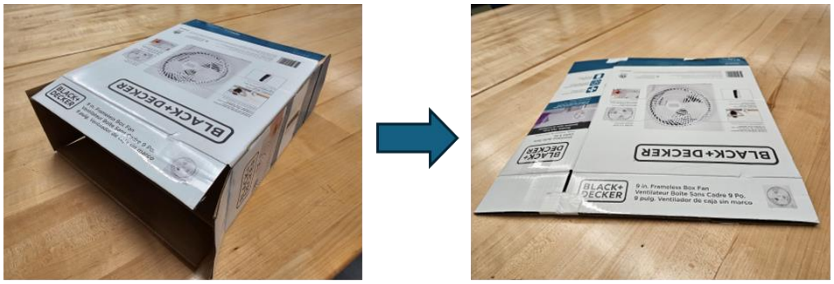
  - Before you connect and tape the fifth filter centered on the bottom of the 4 walls, make sure to feed the wire of the fan along the corner of the box as shown below. The fifth filter will technically be the bottom of the box.
  - Keep a log of the steps, take pictures of the build as you complete the various tasks. This will be IMPORTANT throughout the semester for all of your projects! - since you'll eventually need to talk about these steps in your Engineering Portfolio.





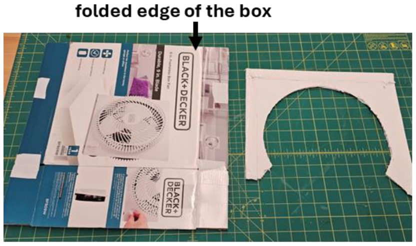
Feed the fan wire through the sides to the bottom of the filter box. *Remember there should be a fifth filter at the bottom, not shown here!*

- Prepare the support for the fan (measure carefully, and be careful not to damage fingers/tables/floors while cutting).
  - Take the intact box of the fan and collapse it. This will give you a double-layer flat piece of cardboard as shown. One side is the folded edge of the box and the other side is the glued edge of the box. Do NOT cut anything yet!



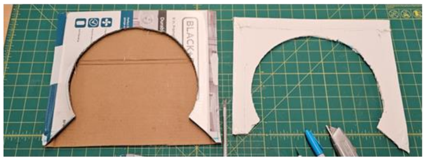
Make the box flat and tape the edges.
(Just as shown!)

- Use the template available in the room and trace the shape onto the flattened box.
- Collect a ‘cutting sheet’ and knife or scissors.
- Cut along the traced line. Make sure you do not cut the folded edge. This makes the support stronger!
- Follow the images below:

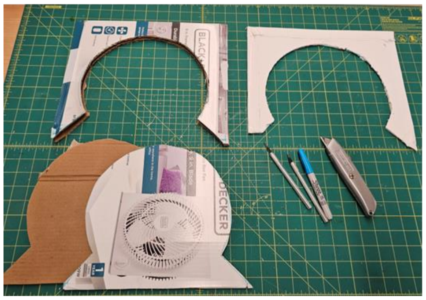


Use the template given to you and **trace** onto the flat cardboard.
Note: The folded edge of the box is at the top. Do not cut that side!

Cut the “glued” edge of the box as shown
Note: The folded edge of the box is at the top. Do not cut that side!



Cut along the traced line, there will be two layers to cut!



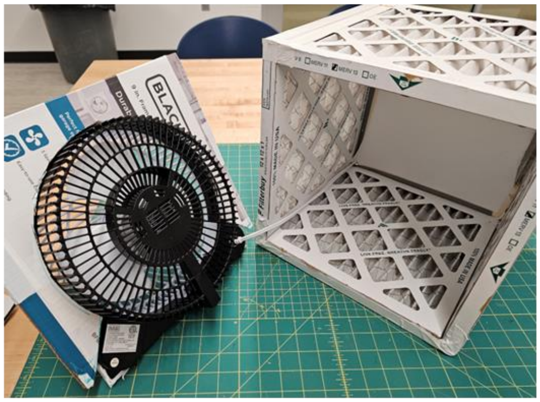
Cut the second layer of cardboard. The folded edge is on the top and should remain folded!

to cut the big cardboard (box fan packaging)

- Attach the support that you just cut to the back of the fan. It should be a snug fit as shown below:

    - Place the wire cord of the fan through the filter box and feed through the side and bottom filter.
    - Take pictures of the process!

Place the support to the back of the fan and it should be a snug fit



Feed the fan wire through the sides to the bottom of the filter box. *Remember there should be a fifth filter at the bottom, not shown here!*

- Attach this filter box assembly to fan with the support. **Use duct tape to ensure the openings are airtight.**
- Conduct a final visual check for leaks on the assembled unit and test to see if it works
- Keep logs for the design and tasks completed each week and remember to take pictures.
- **Plug in the unit and quickly check for any air leaks!**

Place the fan on the filter box and tape all edges firm with **DUCT TAPE**!

Completed C-R Box!

Quality Control Checklist:

- Switch teams!! Each team will have to assess another team's C-R box using the quality control checklist below. Your design instructors will assign you to the team where you will inspect their work. Any aspect that failed means that you failed inspection! You will have to rebuild the component so that your box passes inspection. Once all categories pass, the inspection team will add a sticker that indicates your C-R box has passed the inspection.
- Print outs of this inspection table will be given to you for check marks!
- Once you pass the inspection, put the University logo on your box (will be provided to you!).

NOTE: Below is just to show you what is the quality Control Check list. DO NOT WRITE IN HERE!! YOU HAVE TO CHECK IN THE PRINTED SHEET!!

Checklist	Pass	Fail
Use duct tape		
Filters oriented correctly		
Fan oriented correctly		
No gaps in the tape		
Cable is accessible		
Sturdiness		

Assignment: Engineering Log 1

Read the background materials and the video provided in the classroom toolkit to help you answer the questions below.

1. Why is it important to have a DIY, portable Air filter? Why are you building the C-R Box and where will the box be donated?
2. Create and include a 'Gantt chart,' which displays the timeline for each step of the building process. These charts are a common project management tool used to help engineering project teams identify milestones and deadlines, plan other obligations relative to the project timeline, and track performance. Important elements are based on:
    a. What are the key steps for planning, building, testing, and refining the CRB?
    b. Estimate how many hours of effort each step will take.
3. Describe the building process. Include some pictures that you took of your build, as appropriate. What aspects of the build were important and why?

4. Who is chiefly responsible for each part of the process (best practices are to always have one lead per main task and deadline–this shows up in the “Main Responsibility” column of the Gantt chart)?
5. Suggest 2 possible improvements to the functionality of the basic design (what do you suggest, and why). You might consider the filter type, the fan type, the overall design, etc.
6. Can you think of a way to update the design to accommodate relatively easy replacement of the filters (since they won’t last forever)?

Engineering Log Format

Your Engineering Log should be **2-3** (minimum-maximum) pages long (approximately 800 words, Times New Roman, font size 12), and it should include the following information:

- **Objective:** What was the objective of this laboratory assignment? - *short paragraph*.
- **Answers** to the 6 questions listed above in the “Deliverable: Engineering Log” section. Include the Gantt chart , and relevant pictures that you took during the planning and building process. - *short paragraph with respect to the questions above*.
- **Next steps:** What is your immediate next design step, depending on what you have done in this assignment? - *short paragraph.*

Corsi-Rosenthal Box Project: Indoor and Outdoor Pollutants and Filtration System Efficiency

Week 2 Lesson Plan – Testing the Corsi-Rosenthal Box

Group Assignment
Due Date:

Objective

After completing this module, you should be able to:

- Demonstrate operability of the CRB air filter

Tasks to be completed in Class as a Group:

- **Activities:**
  - **Group Learning**—At the beginning of class, TAs will walk through the vibration and noise test procedures with one or two groups. When you complete your test, you will teach the procedure you were just trained on to the next group of students before you move on to the next experiment.
  - **Air Flow Test**. Attach tissue paper strings with masking tape or scotch tape on the front of the fan and switch it on (any speed). Also, put a piece of tissue paper on the filter box. What do you observe and what does this tell you about the air flow? Take pictures!
  - **Using smartphone sensors** (e.g. try the app 'Physics Toolbox Sensor Suite').
    - **Vibration test**. Open the app. Go to the top left corner and select "g-Force Meter" from the drop-down menu. (You will see data being collected on your phone screen - but at this point it is not recorded.) Place the phone directly at the center of the CRB fan, then operate the unit at various power levels (from high to none). Record the magnitude of the primary peak caused by the fan operation. (x, y, z coordinates, Total g-Force).

      When you start the app, the graphs on the screen change. When you are ready to record the data press the **"plus"** sign on the top right corner. The **"plus"** sign changes to a **square**, and at the bottom, it will say, "Data recording started." Change the various power levels of the fan and record the data. When you are done recording the data, press the same red **square** button, and the app will ask you to save/share the data immediately. Share the data through email as a **.csv file**. You can download this .csv file onto your computer and plot the data in Excel.
    - **Noise test**: Use the 'Sound Meter' setting (from the drop-down menu like before) and record the noise at various power levels at several distinct distances (e.g. 1, 2, 5, 10, 20, 50, 100 cm). Repeat along a different axis (e.g., test the fan side and one of the 4 identical filter sides). Plot these results (Sound Intensity (dB) and Distance (cm)). Try log or log:log axis options to make the data more clear. Make sure to correct your axis labels! Which

axis should be which (sound intensity and distance)? Make sure your dependent variable is the y-axis, and the independent variable is the x-axis.

- **Data analysis**. You are provided with data showing the size of the particulate matter (pm) in a typical classroom setting while using the CRB. The Data is on a separate Excel file in HuskyCT under Corsi Rosen Week 4 titled **"CRB Particulate Matter Measurement Data"**. Two sizes of pm were monitored using a Dylos DC1100 pro:

1. particles larger than 0.5 μm (such as bacteria, mold, etc)
2. particles larger than 2.5 μm (such as pollen, etc)

Data was collected over 60 minutes with and without the CRB.

Plot these results in Excel (use appropriate axis labels), to determine CRB efficacy. **Explain** the graph and what your graph suggests. Does the CRB remove the particulate matter of various sizes in the same way? Why?

Ask yourself a few questions about improving this experiment or relevant future work, (you do not have to plot other data, but discuss the following) e.g.

- What other parameters may be helpful to measure the clean air delivery rate (CADR)?
- How do you predict the data would change using multiple CRBs?
- Do you think the placement of the CRB would impact its efficacy?

Assignment: Engineering Log 2

1. Now that you've completed building and testing, recommend improvements to: alleviate noise pollution generated when operating (sound power due to the duct, combined with the fan noise itself); improve the looks; automate its operation (fan speed, on/off, timers, particle sensors), etc. Be creative.
2. Include plots and descriptions summarizing the results of ALL your testing as outlined in the **activities** above. The instructions that you pasted on the CRB said "Use at low speed while teaching". From the tests that you have run, how do you validate this statement?
3. Prepare an updated Gantt chart with final tasks, primary actual responsibilities, and actual (realized) timeline. Explain any changes to the plan and timeline. Include whether those changes were caused by one-off challenges or are modifications you would need to incorporate for future implementations of this (or any other) design.
4. Self assess your key strengths/contributions for the overall project (design, planning, assembly, testing, iterating, writeups).

Engineering Log Format

Your Engineering Log should be **2-3** (minimum - maximum) pages long, (approximately 600 words, Times New Roman, font size 12) and it should include the following information:

- **Objective:** What was the objective of this laboratory assignment? - *short paragraph*.

- **Answers** to the 4 questions listed above: Engineering Log section. Describe how you have tested your CRB and what parameters were recorded. Include the Gantt chart in this section and any picture that you may have taken throughout this build - *short paragraph with respect to the questions above*.