Teacher: Laura Antunez Rodriguez **Manhattan Bridges High School** **AP Environmental Science Class** **Grade Level: 12** **Time Frame: 3 weeks, 15 periods. 1 period = 72 minutes.**	**Topic: Air Quality** **Title: Air Quality: Anthropogenic sources of Air Pollution**

- **What big ideas or major concepts do you hope to address through this unit?**

This lesson gives students the opportunity to investigate a phenomena that is very relevant to us: the air we breathe indoors and outdoors impacts ecosystems and human health. According to the Centers for Disease Control and Prevention, 25million of Ameriacans have Asthma (source: https://community.aafa.org/), and the World Health Organization (WHO) reports that 7 million people die every year worldwide due to air pollution. (source: https://www.who.int/air-pollution/news-and-events/how-air-pollution-is-destroying-our-health), Some of our students know this topic first hand because some of their loved ones live with air quality related diseases. This topic gives students a chance to investigate how anthropogenic actions impact our ecosystems, what have we done to reduce/ mitigate the problem, what is next for us to do, and how can we use technology, engineering and math to design ways to measure and tackle a problem such as air pollution: from global to local actions.

As the lesson integrates technology, engineering, math and science to solve a relevant problem, I am confident that my students will be engaged with this topic. Students will have access to several websites that offer valuable information and data on the topic.. Each student also has access to computers and lab materials.

Objectives:

- Students will investigate Criteria Air Pollutants.
- Students will compare NYC air quality with other international cities of their choice.
- Students will evaluate how political, economic and social aspects make an impact on air quality.
- Students will evaluate, and refine a current air pollution mitigation technology.
- Students will design a simple device to test particulate matter and tropospheric ozone in our school.
- Students will conduct an experiment that will allow them to evaluate the quality of air in space
- Students will collect data from their investigation.

- Students will write a formal lab report where they will draw conclusions from their investigation.

• What resources from this course do you intend to integrate with your unit plan?

The resources that I am intending to integrate with my unit plan are;

-The Air up there: making Space Breathable (https://www.jpl.nasa.gov/edu/teach/activity/the-air-up-there-making-space-breathable/) and

-Chemistry applied to climate change

• How will using these resources help your students better achieve your goals for the unit?

The goal of this unit is for the students to understand air criteria pollutants and how accelerated climate change is making an impact on the air quality that we breathe. By using the resource "The Air up there: making Space Breathable", I want students to experiment with the concepts of carbon dioxide, scrubbers and efficacy, as well as for them to understand the impacts that air pollution might have on human health. At the end of the unit, students would have created small devices to measure tropospheric ozone in the school, as well as particulate matter. Adding a lab on making the air breathable for astronauts will open my students' minds on the importance of clean air for all.

NGSS AND COMMON CORE STANDARDS:

- HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
- HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Science And Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models. **(HS-PS2-5) Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 and progresses to introducing more	**ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** Empirical evidence is required to differentiate between cause and

detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **(HSPS2-1) Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.. (HS-PS2-3) **----------**	(secondary to HS-PS2- 3)	correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5) Systems can be designed to cause a desired effect. **(HS-PS2-3) Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

Common Core State Standards Connections: ELA/Literacy –

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3),(HS-PS2-6)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6)
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating an understanding of the subject under investigation. (HSPS1-3)
- WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the

text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)

- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

Background:

Manhattan Bridges High School is a Bilingual and Dual-language school in the city. Our bilingual program accepts students who are newcomers and who have been in the country for less than 3 years; whereas our dual-language program, accepts students of Spanish heritage, whose main language is English, but have strong family ties with the Spanish language.

Our school also provides two tracks for students: we have a technology academy and an engineering academy. Students in both academies take 4 core classes in the specialty and are able to get certified in the field. Also, the school has partnerships with companies that work very closely with students, providing opportunities for students to become interns or to attend job fairs and shadowing events.

We share the building with five other schools. The Department of Education has tried to fix the AC system in our school for the last 10 years: new contractors come and go every two to four years, but the AC never works. Air quality in our building has been a problem for a long time now. In this unit, students will learn more about air quality, criteria air pollutants, US legislation and ways of monitoring and mitigating air pollution. Students will design ways to measure air quality in school, will collect and analyze data, and they will write a report on school air pollution. Throughout the unit, students will compare air pollution in NYC with other cities around the world, debate on how energy use and legislation impact air pollution, evaluate air pollution mitigation devices, and attempt to measure indoor pollution by creating their own “home-made” devices. Students will report on their data through a formal lab report write-up.

Materials:

-Chromebook

-Lab materials for particulate matter and tropospheric ozone lab.

Potassium Iodide	Corn Starch
Beakers	Spatulas
Large Graduated Cylinder	Test Tube Rack
Filter Paper	Microscope Slides and microscopes
Petroleum Jelly	Q-tips

-Lab materials for :The air up there lab

-index cards	-tissue paper
-cotton balls	-pipe cleaners
-hair-dryer	-scale
-black pepper	1 or 2 shoe boxes

Research questions addressed:

- What are “unhealthy” and/or “hazardous” Air Quality Conditions?
- Who are considered to be “Sensitive groups” in terms of air quality?
- What are criteria pollutants and why are these pollutants addressed in the Clean Air Act of 1963?
- How air pollutants affect human health and the health of the environment?
- How technology and engineering can work together to monitor and reduce the amount of Smog and air pollution that goes into the atmosphere?
- How the chemistry of SMOG determines the areas where Smog forms?
- What other factors might be responsible for the concentration of different pollutants in certain areas?
- How the use of politics, history and socio-economic factors help explain air quality in different countries?
- Can we create an artifact that helps us monitor air pollution in our school?
- Can we make air “more breathable”, even in Space?
- What is the relationship between air pollution and The Tragedy of the Commons, by Garret Hardin?

5E Unity Plan	
Engage The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding. (1 class period)	Students are given these images:  A  B  C  D **Preview/ Review: Activating Prior Knowledge.** **Instructional Goal:** The goal of this strategy is to train students to activate prior knowledge. This strategy is divided in three sections: **A) TAPPING PRIOR KNOWLEDGE (individual work)** ● Students preview the pictures by noting everything they see (colors, location, time of the day the pictures were taken, shapes, images...)

	● Then, students tap into prior knowledge by **reviewing** the specifics about what the pictures mean, what they already know about what they see, what makes them think or wonder about. In other words, students will make connections between the pictures and what students already know by using the 5Ws. **B) Partner/Small Group Discussion with Scaffolds**  ● A partner share provides students an opportunity to process what they are learning, learn from others, and repair misunderstandings. ● Students use the **sentence stems** to practice Preview/Review together, orally. **Preview sentence stems** ● *I see… I notice… I think this means that…* ● **Review stems** *I already know that ……This reminds me of… This relates to….. I wonder….* *Differentiation for ELLS: students are allowed to use their home language.* *After partner/small group discussions, students create posters where they collect the main takeaways from the group discussion.* *Rubric: https://docs.google.com/document/d/14N57tNj38nMaRE8P7I5MpIUgKgNLjL23hWSbFFr_Ujk/edit* **C) Whole group share-out** A student from each group will share something from their group discussion with the rest of the class. **Assessment: Exit Ticket** Based on your individual work and in the work discussion, choose one of the pictures and describe the causes and effects of what is happening in the picture. Add a historical context to the picture, and a way of reducing the effects of what is happening in the pictures, for extra bonus.

Explore
The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.

(2 class periods-72 minutes/each)

Day 1 and 2: Introduction to Air Pollutants and Air Quality
Students will learn about air quality conditions, AQI values and the Clean Air Act of 1963 by using the website: https://www.epa.gov/outdoor-air-quality-data/air-data-basic-information.
Once students get familiar with air pollutants will discuss in small groups what "unhealthy", "sensitive groups" "hazardous" and AQI mean. Also, they will review together the Clean Air Act of 1963.

Students will work in groups to investigate more about air pollutants, sources and human and environmental impacts. They will fill out the following chart. Students will be able to freely research the internet for this activity or clicking on this link "Criteria Pollutants" for more information about these pollutants.
A**ir Pollutants Data Table**

Air Pollutant (Chemical Formula)	Primary or Secondary Pollutant?	Sources	Harmful Impacts on Humans	Harmful Impacts on the Environment

Assessment: EXIT SLIP
Read the article below from the Fremont Free Press and answer the questions that follow.
Fremont City Council Considers Nitrogen Ban to Fight Smog!
At Tuesday's council meeting, Susan Lanza, a local environmental scientist, spoke about the role that nitrogen compounds play in the photochemical smog episodes that have recently plagued Fremont. Noting how successful the ban on the sale of phosphate detergents has been improving conditions in Lake Fremont, Councilman Peter Budd proposed a ban on the use of all nitrogen-containing fertilizers in Fremont to solve the local photochemical-smog problem.

	Councilwoman Nita Smith made a statement that "although nitrogen-based fertilizers can cause other environmental problems, the ban on nitrogen fertilizers won't solve the smog problem in Fremont." After a heated discussion, the council tabled the motion on the ban. (a) Identify one secondary pollutant that is a component of photochemical smog and describe the following. (i) How the secondary pollutant forms (ii) ONE human health effects of the pollutant (iii) ONE environmental effect of the pollutant **Rubric**: https://secure-media.collegeboard.org/apc/ap09_env_sci_sgs.pdf
Explain The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means. (3 periods)	**Day 1 and 2: Examining and explaining Trends in Air Pollutants Over a Year and over multiple years Jigsaw** Room is divided into 6 groups and each group will be assigned a criteria pollutant. Each small group of studetnts will go to https://www.epa.gov/outdoor-air-quality-data/air-data-basic-information to get data from their assigned criteria pollutant at different locations in NYC in the span of one year. These pollutants are tropospheric ozone, sulfur dioxide, particulate matter, nitrogen dioxide, carbon monoxide and lead. Each small group of students will go then to https://www.epa.gov/outdoor-air-quality-data/air-quality-index-daily-values-report to generate a report on their assigned pollutant, they will use a shared google spreadsheet to report seasonal findings by using graphs, data tables and mathematical representations. Groups draw evidence from the data to give explanation about the seasonal variations of the pollutant in different parts of NYC. Some guiding questions are: a) What trend, if any, can you see with your assigned pollutant over the course of a year? b) Is that trend stable no matter what year you choose? c) To what industrial activities is your pollutant related to? Is that activity more prominent in one area/ or specific time of the year? Why? d) Does the annual trend of your pollutant tell us something about human behaviour? Students will go to: https://www.epa.gov/outdoor-air-quality-data/air-data-multiyear-tile-plot and calculate percent changes in different pollutants in the last 20 years. Students also provide reasons for their findings by researching on the internet. **Assessment**: At the end of the class each small group will select one student who will present the group findings to the rest of the class + students will share the spreadsheet with the teacher.

	Rubric: https://docs.google.com/document/d/188O4OyBMtaSfoY4cVExZTCgPzghomHGqvfxecjcECSY/edit# **Day 3: Comparing Air Quality Between Cities Around the World** In pairs, students will go to Air Quality Index Website, choose 2 different cities and compare air quality between them. Also, find important information about those two cities such as: the number of inhabitants, the primary source of energy, the local environmental policies ... Create a Venn Diagram comparing and contrasting air pollution on those two cities. Students will go to **Deaths attributable to air pollution(Source: WHO)** http://apps.who.int/gho/data/node.main.156?lang=en to compare human health risks on those two cities. Students will debate in pairs two actions that local governments in urban areas could take to reduce outdoor pollution. Ideas are shared with the rest of the class. **Rubric**: https://docs.google.com/document/d/14N57tNj38nMaRE8P7I5MpIUgKgNLjL23hWSbFFr_Ujk/edit
Elaborate/Extend The purpose for the EXTEND stage is to allow students to use their new knowledge and continue to explore its implications. (6 periods)	**Day 1: Controlling Air Pollution** Students will research air pollution mitigation technology, such as: catalytic converters, scrubbers, and air purifying units. Students will then choose to either design a technological solution, evaluate or redefine an existing solution that reduces the input of air pollution sent to the atmosphere. Students will work in groups to think of the constraints, efficiency, cost and to the development and implementation of technologies that reduce/mitigate air pollutants. Worksheet: https://docs.google.com/document/d/1_tjlEb5XSfAKMeIyK1r4O_R5uh9-8m_XYebiPyR8gGg/edit

	Day 2: Peer-review Students will present their ideas to other groups and will get peer-feedback. Students will modify their design/evaluation based on feedback and at the end of the class, each group of students will present to the class. Peer feedback rubric: https://docs.google.com/document/d/1_2-kY3fhSOTOoarzrVT98ul3N6VYOFRxzQzF1OpR7Y4/edit Evaluation of design rubric: https://docs.google.com/document/d/10v1UC2oePHzhrrrWQg9hFBYclwUdQYIukvJecfT4_98/edit **From global actions to local actions:** from outdoors pollution to indoor pollution. **Day 3 and Day 4** The air quality of our school is very deficient. Students will think and take action on how to monitor certain air pollutants (ozone, particulate matter, CO, lead…) in our school. In small groups, students will gather materials and test different areas of the school for that specific pollutant. They will collect data after 24 hours on one pollutant and come back to the class to report. Students can get help from the lab "monitoring air pollution at MBHS", modified from https://secure-media.collegeboard.org/apc/ap03_apes_airquality__31149.pdf where they can get ideas to elaborate simple devices that allows them to collect data. **Day 5.** Students complete the lab "The Air Up There" and investigate the role of Scrubbers and catalyzer converters https://www.jpl.nasa.gov/edu/teach/activity/the-air-up-there-making-space-breathable/ Background: Whether they're aboard the International Space Station or on a future mission to Mars, astronauts require systems that can create breathable air from their harsh surroundings. And chemistry plays an important role: Currently, the International Space Station uses an absorption method to remove carbon dioxide (CO_2) from the air. The absorption is accomplished in a chemical reaction using a sorbent called lithium hydroxide (LiOH). This method relies on the exothermic reaction of lithium hydroxide with carbon dioxide to create lithium carbonate (Li_2CO_3)(s) and water (H_2O). Lithium hydroxide is an attractive choice for space flight because of its high absorption capacity for carbon dioxide and the small amount of heat produced by the reaction

	Day 6 Socratic Seminar: Students will participate in a Socratic Seminar where they will exchange new knowledge, ideas and findings they got during the unit. This will prepare the students for the group lab report write-up and for their final exam. The following are sentence starters that students are free to use during the Socratic Seminar. Socratic Seminars are an important part of my class and they are used in every unit, therefore, students are already familiar with the format of the Socratic Seminar. https://drive.google.com/drive/u/0/search?q=socratic%20seminar Socratic Seminar Rubric: https://docs.google.com/document/d/1tOh_HhwyGTrq9tf2VEz6jPV9hSuWIsfQUXZ9gpUJQxo/edit
Evaluate The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place. (3 periods)	**Day 1 and 2** Students in groups write a formal lab, following the formal lab write up. Students submit work through google classroom. https://docs.google.com/document/d/1FzWVeqJfQZVM-hTEZuLGj9Vy4iXw_LNRnIpTyrr7M9I/edit Rubric: https://docs.google.com/document/d/1qWKMJDBbeacLp69nn--ytdKMNnGxlZy13MVgPDyPp_A/edit **Day 3** **Final Exam**: As a final exam, students will answer one Air pollution related Free Response Question from the AP Environmental Science Exam. AP Free response #1, 2009 exam- 23 minutes allotted time. https://secure-media.collegeboard.org/apc/ap09_frq_environmental_science.pdf

Resources:

An Introduction of Design Process: https://dschool-old.stanford.edu/sandbox/groups/designresources/wiki/36873/attachments/74b3d/ModeGuideBOOTCAMP2010L.pdf

APES Free responses. College Board. https://www.collegeboard.org/

College Board AP Environmental Science. Monitoring Lab Quality. https://secure-media.collegeboard.org/apc/ap03_apes_airquality__31149.pdf

College Board AP Environmental Science Free Response 2009 https://secure-media.collegeboard.org/apc/ap09_frq_environmental_science.pdf

Engineering Design Process Worksheet modified from: tekbot.unl.edu/SPIRIT2/.../Engineering%20Design%20Process%20Worksheet.docx

Next Generation Science Standards https://www.nextgenscience.org/

Real Time Air Quality Index: http://aqicn.org/map/world/

Socratic Seminar Sentence Starters https://drive.google.com/drive/u/0/search?q=socratic%20seminar from NEWSELA https://newsela.com/

The Engineering Design. http://www.teacherstryscience.org/sites/default/files/engineering_design_process_worksheet_12.pdf,http://teachers.egfi-k12.org/wp-content/uploads/2010/05/Post-lesson-Student-Activities-Engineers-and-the-Engineering-Design-Process.pdf,

United States Environmental Protection Agency. Air Quality Data. https://www.epa.gov/outdoor-air-quality-data/air-data-basic-information

The air up there: making space breathable jpl.nasa.gov/edu/teach/activity/the-air-up-there-making-space-breathable/