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| **Lesson Title : Pressure System Design** | **Unit #:****1** | **Lesson #:****1** | **Activity #:****1** |
| **Activity Title: Pressure System Design** |

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| **Estimated Lesson Duration:** |  |
| **Estimated Activity Duration:** | **3 x 45 minute classes** |

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| **Setting:** | **Classroom** |

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| **Activity Objectives:** |

After completing the activity, students should be able to do the following:

* Make Basic Calculations using the ideal gas law
* Identify how gas laws affect a real industrial system
* Creatively brainstorm basic engineering solutions to chemical problems
* Design a solution to the selected challenge
* Modify that solution from feedback provided by the instructor based on specific criteria
* Present the solution to their peers providing justification for their chosen solutions

**Activity Guiding Questions:**

* How can we safely transport industrial gasses that may pose serious environmental health and safety problems if released into the atmosphere?
* How can we calculate changes to a gas system?
* How can we construct a basic engineering solution to a problem?
* How can we modify the solution based on instructor feedback?
* How can we communicate solutions to our peers?

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| **NGSS Practices of Science and Engineering / Crosscutting Concepts** |

| **Practices of Science and Engineers (Check all that apply)**  | **Crosscutting Concepts (Check all that apply)** |
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| [ ]  Asking questions (for science) and defining problems (for engineering) | [ ] Patterns |
| [x]  Developing and using models | [ ]  Cause and effect |
| [ ]  Planning and carrying out investigations | [x]  Scale, proportion, and quantity |
| [x]  Analyzing and interpreting data | [x]  Systems and system models |
| [x]  Using mathematics and computational thinking | [x]  Energy and matter: Flows, cycles, and conservation.  |
| [x]  Constructing explanations (for science) and designing solutions (for engineering) | [x]  Structure and function.  |
| [ ]  Engaging in argument from evidence | [x]  Stability and change.  |
| [ ]  Obtaining, evaluating, and communicating information  |  |

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| **Unit Academic Standards (Ohio State Revised Science Education Standards and/or NGSS Content, Common Core etc.):** |

* HSETS1-1,2,3 – Engineering Design
* HS-PS1-7 – Chemical Reactions
* HS-PS2-3 – Forces and Interactions

**Cognitive Demands (Ohio State Revised Science Education Standards)**

| **Expectations for Learning Cognitive Demands (Check all that apply)**  |
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| [x]  Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| [x]  Demonstrating Science Knowledge **(D)** |
| [x]  Interpreting and Communicating Science Concepts **(C)** |
| [ ]  Recalling Accurate Science **(R)** |

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

**Handout: Pressure System Design Worksheet**

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| **Teacher Advance Preparation:** |

Read through handout and mentally familiarize with the variety of solutions available.

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| **Activity Procedures:** |

Activity 1: Pressure Safety System

Day 1:

* Students will be presented handout pages 1-3
* Present the students with a short lecture on material on page 1.
* Use the picture on page 2 to illustrate what a typical chemical facility visually looks like.
	+ Put a physical picture to the chemical reactions and concepts that the students are learning throughout the class.
	+ Equipment: Tanks, heaters, pipes, towers, roads, river
	+ Ask students why this facility might be located next to a river
		- Transportation, also cooling water (have to be able to cool down after heating up)
* Class discussion on industrial gas transportation
	+ Why do we do this?
		- Lots of uses for industrial gases
	+ How do we do it safely?
		- Poison
		- Fire
* Split the students up into groups of 3-4
* Have the students work through the calculations on page 3 of the handout
	+ Handout answers:
		- 1: 648,316 Kg
		- 2: 0.422, or one barge roughly every 2.4 days
		- 3: 28,963 kPa
		- 4: Yes
		- 5: The steel would break, and the tank would explode (fire/explosion)

Day 2 (or the end of day 1):

* Give students handout page 4.
* Talk through the project with the class as a whole framing why it’s important and what they’re being asked to do in their groups.
	+ Students will come up with ideas, brainstorm, sketch
	+ Provide the students with any materials needed for effective brainstorming
* Optionally assign initial brainstorming as homework for the students individually and collect the ideas they come up with. You may also collect the page 3 worksheet as part of the grading.
* Critically evaluate the options they first present, providing additional information to aid them in the reiterative portion of the design.

Day 3:

* Given the first set of designs, have the students reiterate their designs including additional calculations
* The students will then present their final solutions along with any other ones they considered to the class as a whole. After each presentation, get feedback from the class as a whole on the design
* Also have them complete the instructions on page 5, don’t yet pass out page 6
* Present to the students what is industrially practiced (flare systems)
* At the very end, have the students work on the final question in their own individual groups to turn in before the end of class.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

The calculations that the students conduct on day 1 serve as a formative assessment.

At the end of the second day, students should have had a good period of brainstorming. The teacher should use a few minutes at the end of this period to ask each group questions about where they are at with their solutions, challenging the different aspects of what they present. This will serve in a formative assessment in shaping how the teacher approaches the second day of the activity.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

The summative assessment for this activity is based on the presented solutions which the students provide. See details in the grading rubric document, worksheet 2.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.Refer to Activity Template for details. |

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

The activity did a wonderful job of engaging students who typically feel that classroom work is abstract and irrelevant. It allowed many students to shine and it developed the critical thinking skills of all involved in a really immeasurable way. The direct ties between classroom material and a real life problem helped inspire may students. One student quote was “An interesting background made the activity feel more like a real world solution instead of just a math and chemistry problem.”

 I do also have some ideas for how to improve the activity. The structure for feedback to the students could be improved to take advantage of more principles in the engineering design process. I am unsure how to do this effectively without significantly lengthening the activity. This would help promote ownership within the groups. Also, the activity could be revised to a full challenge activity where the students devise the guiding questions. This would also help with student ownership of the project.