360Storylines: Wind

Lab 1: Compressibility

IP: Are gas particles kept in a closed space far apart or close to each other? Write a possible explanation of this phenomenon.	**AP:** What are winds made up of, or what causes the wind to blow? Based on what you learned in this experiment, try to formulate an explanation to answer this question. What evidence did this experiment supply to aid in your understanding?
Students may recall from earlier courses and/or grades that gas particles are typically small relative to their container volumes, and that there is significant space between gas particles, which move about randomly. It is unlikely that they will have had explored this idea empirically, however. Some students may think that gases fill their containers, but not have a precise understanding of what that means.	At this point students will not be able to develop a completely informed answer to this question. They should note, however, that the air in the syringe is capable of exerting a force, because when the syringe plunger is compressed and then released, it rises back to its original volume. This happens because the gas (air) particles push against it. Students may thus reason that winds are made up of gas particles that move randomly. They will not yet have observed empirically what contributes to gas movement.
Revised Explanation: After performing the experiment, what revisions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation.	
Students should have observed that gases are much more compressible than liquids and solids. Students should have observed this quantitatively by noting the change in volume each of the three states of matter is able to undergo when subjected to a force. Based on the observation that the space occupied by a gas can be compressed, students should note that there is a great deal of empty space between gas particles in a confined space.	

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Lab 2: Relationships Between Gas Variables

IP: What happens to gas particles when they are heated or cooled? Write a possible explanation of this phenomenon.	**AP:** Do winds contain energy, and are they able to do work? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of wind?
Students may be aware of the ideal gas law, and the simple gas laws that can be derived from it. It is unlikely they will have related these ideas to weather or wind. Students may state that gas particles move faster when they are heated or bump into each other with more frequency. At this stage, it is important that students observe that temperature can affect how gas particles move.	At this point in the storyline students will know that gas particle behavior is dependent on variables including pressure, temperature, and volume. They should come away from this experiment with the idea that the movement of gas particles is somewhat dependent on temperature, and that gas particles exert forces on their container walls when in a confined space and against any object in their path when they are part of a prevailing wind. In other words, they are able to transfer energy and do work.
Revised Explanation: After performing the lab experiment, what revisions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Working Model:** Apply what you have learned in labs 1–2 to formulate an explanation of wind.
Students should note that there is a direct relationship between gas temperature and gas pressure, and an inverse relationship between gas pressure and gas volume. To answer the IP question directly, students should note that as gas particles are heated they move with more energy and exert greater forces against their container walls. Such a statement begins to get at the energy contained within a gas or wind.	At this point, students should note that winds are collections of gas particles whose collective behavior is somewhat determined by temperature. Students should also note that winds contain a great deal of energy in the form of gas particles that possess the kinetic energy of movement. When these gas particles collide with other objects they transfer their kinetic energy to those objects. In the case of wind, this energy transfer can be quite destructive.

Lab 3: The Ideal Gas Law

IP: How do the properties of a gas change as the amount of gas particles increases? How is it possible that the *R* in the ideal gas equation does not change? Write a possible explanation of this phenomenon.	**AP:** Do winds contain energy, and are they able to do work? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of wind?
Students will likely intuit that as the number of particles in a gas increases, the pressure the gas exerts increases and the volume the gas expands to fill also increases. Students will have a harder time understanding how the variables in the ideal gas equation adjust to maintain a constant *R* value. They may reference the ideal gas equation and if comfortable with math, demonstrate how it can be manipulated to show that *R* remains constant as the volume, pressure, temperature, and number of moles change. For example, they may note that as *n* increases while *T is constant, R stays the same because V* and *P* increase.	Students should begin to connect the variables used to describe a gas to wind. For example, students may note that atmospheric pressure is an expression of the amount of force the gases around us exert on anything in their path, including humans. Students may mention that when they watch the weather, meteorologists often reference low-pressure and high-pressure fronts. They may now be able to articulate what exactly is meant by pressure. They should also know that if a collection of gas particles is constantly increasing in size its collective energy will increase. They will also know that as gas particles move faster, they exert more pressure and thus high-speed winds are more destructive than fair-weather winds.
Revised Explanation: After performing the lab experiment, what revisions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Working Model:** Apply what you have learned in labs 1–3 to formulate an explanation of wind.
Students should observe that as the number of particles that comprise a gas increases, the gas expands to fill a larger volume. Students should note that the gas expands to fill a space by exerting a pressure, or force, against things its particles come into contact with. Students should be able to explain how changes to one or more gas variables do not require a change in *R.* For example, students will have changed the number of moles of the gas generated under constant temperature conditions. They should observe an increase in volume and pressure. Some manipulation of the ideal gas equation will show that increasing *n*, *P* and *V* does not change *R*.	Students should note that winds are collections of gas particles that move with an average amount of kinetic energy dependent on temperature. The gas particles in a wind transfer their kinetic energy via collisions. The things that impact gas behavior, and thus wind behavior, include temperature, amount, and volume (occupiable space). Changes to these variables result in changes to the pressure a gas exerts against objects in its path. Students may note that winds that move at high speed carry significant amounts of energy that can be destructive or harnessed to create electricity.

Lab 4: What's in a Container?

IP: How do gases transfer their energy? Write a possible explanation of this phenomenon.	**AP:** Why are hurricane-force winds so destructive? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of wind?
Student answers may reference pressure because this idea has been developed in the previous labs in this storyline. Moreover, it is intuitive that when things collide there is an associated energy transfer.	Students now have direct, dramatic evidence that shows gas particles are capable of exerting strong forces. These forces are strong enough to support the weight of a student. Students may reason that such forces, magnified by orders of magnitude such as they would be in an unpredictable hurricane, would be very destructive.
Revised Explanation: After performing the lab experiment, what revisions or additions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Working Model:** Apply what you have learned in labs 1–4 to formulate an explanation of wind.
Students should now indicate that gas particles are in fact capable of doing work. In this experiment they see that gas particles do the work of maintaining the structural integrity of an aluminum can by exerting pressure against the interior walls of the can. They should note that when they open an aluminum can and release some of the gas pressure, the can's ability to bear a heavy load immediately diminishes.	Student explanations should note that winds are collections of gas particles whose movements are influenced by temperature. Gas particles move in random paths and collide with anything in their paths. These collisions result in the exertion of pressure, or a force applied over a distance. They are able to do work, such as moving a cylinder in an engine or supporting the structure of an aluminum can. When very large numbers of gas particles move together at high speeds, such as in a wind, they can be destructive.

Lab 5: Gas Diffusion

IP: Why do gas particles move? Why don't they just stay in place like the particles in a solid? Write a possible explanation of this phenomenon.	**AP:** Why do winds move the way they do? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of wind?
Students may reference temperature at this point, given they have seen that increasing the temperature of a gas causes its volume to increase in a syringe. That means that increasing temperature must cause gas particles to spread out.	Students may note that wind movement is complex and difficult to predict. The scale they are working on, though small, shows that gas or wind movement is affected by changes in temperature and changes in pressure. Winds move from areas of low concentration to areas of high concentration. The heat energy distributed throughout the Earth system contributes to wind and weather patterns because it causes gas particles to move. When gas particles absorb energy they spread out and their concentration decreases. Colder gas particles move to fill the space left behind.
Revised Explanation: After performing the lab experiment, what revisions or additions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Final Model:** Apply what you have learned in labs 1–5 to formulate an explanation of wind.
Students may use the observation that heating a gas causes it to diffuse faster, to refine their model with respect to how temperature impacts gas particle movement. They will know that increasing the temperature of a gas causes it to move faster. They will also know from this experiment that gas particles move across concentration gradients, from areas of low pressure (low concentration) to high pressure (high concentration). The kinetic energy inherent to gas particles causes them to spread out.	Students should note that winds are collections of gas particles that move in response to temperature changes that result from the absorption or release of energy. Winds move from areas of low pressure to high pressure and collide with things in their path. When a gas particle collides with an object, it exerts a force on that object. Gas particles can thus do work and, when present in large quantities and moving at high speeds, contain a lot of energy and can be destructive.