Issue 79 – September 2026

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Teaching gas pressure with a 'syringe balance'

Activity sheet

Pre-lesson task

Peter would like to weigh a bag of 5 kg rice bought from the supermarket. He borrowed from the lab technician some tools for the measurement. The tools are shown below.

Images: Newton meter: Menyhert/Adobe Stock; Syringe: Ed Cijs/Unsplash; Two-pan balance: Piret Ilver/Unsplash; Laboratory balance: ThisisEngineering/Unsplash

Please try to answer the following questions in your notebook:

- Which measurement tool will you choose to weigh a bag of 5 kg rice bought from the supermarket?
- Briefly elaborate on your choice above. Why you choose that tool for the measurement instead of any of the others?
- Are there any limitation(s) to the measurement tool you have chosen? Please briefly elaborate.

The ‘syringe’ balance demonstration

Objective: to determine the maximum weight that a syringe balance can withstand.

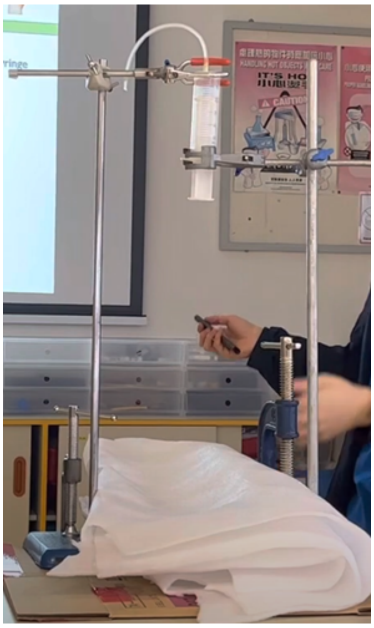
Materials and equipment

Material	Quantity
50 mL gas syringe	1 pc
10 cm fine rubber tubing	1 pc
0.5 kg hanger	1 pc
1.0 kg load	10 pcs
Vaseline	1 box
Material	Quantity
Stand and clamp	2 sets
G-clamp	2 sets
Clip	1 pc
Shock absorbing materials	Some
Cotton swab	Some

Procedures

Part I: Assembling the syringe balance

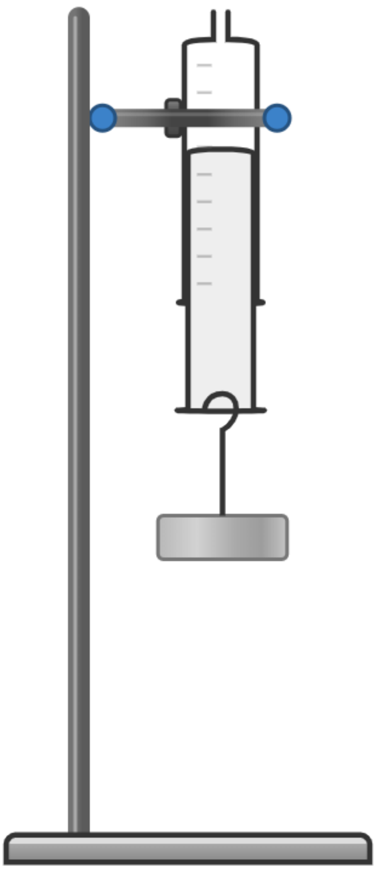
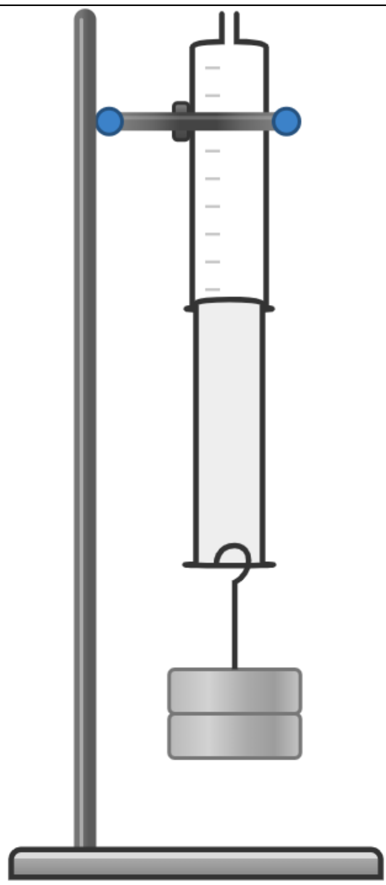
[This part has been completed by the lab technician.]



1. Prepare a 50 ml gas syringe. Pull off the plunger from the syringe. Use a cotton swab to wipe the surface of the plunger with Vaseline. Insert the plunger back to the syringe.
2. Insert a 10 cm fine rubber tubing into the mouth of the syringe. Set the plunger to the position where the reading is 20 ml.
3. Place some shock absorbing materials on the bench. Use 2 sets of stands and clamps to firmly secure the syringe above the bench. Use 2 G-clamps to fix the positions of the stand, clamp and the shock absorbing materials.

Part II: Testing the syringe balance without a clip

1. Hang a 0.5 kg hanger on the plunger of the gas syringe. Record the reading of the syringe.
2. Add a 1.0 kg load onto the hanger. Observe the position of the plunger and record the reading of the syringe.
3. Repeat Step (2) until the plunger of the syringe falls. During this process, keep observing the position of the plunger and record the reading of the syringe before the plunger falls.

<table>
<tr><td>Weight (kg)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Reading (ml)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Free body diagram before the syringe falls
(Focus on the forces acting on the plunger)</td><td colspan="4">Free body diagram when the syringe falls
(Focus on the forces acting on the plunger)</td></tr>
<tr><td colspan="5"></td><td colspan="4"></td></tr>
</table>

Part III: Testing the syringe balance with a clip

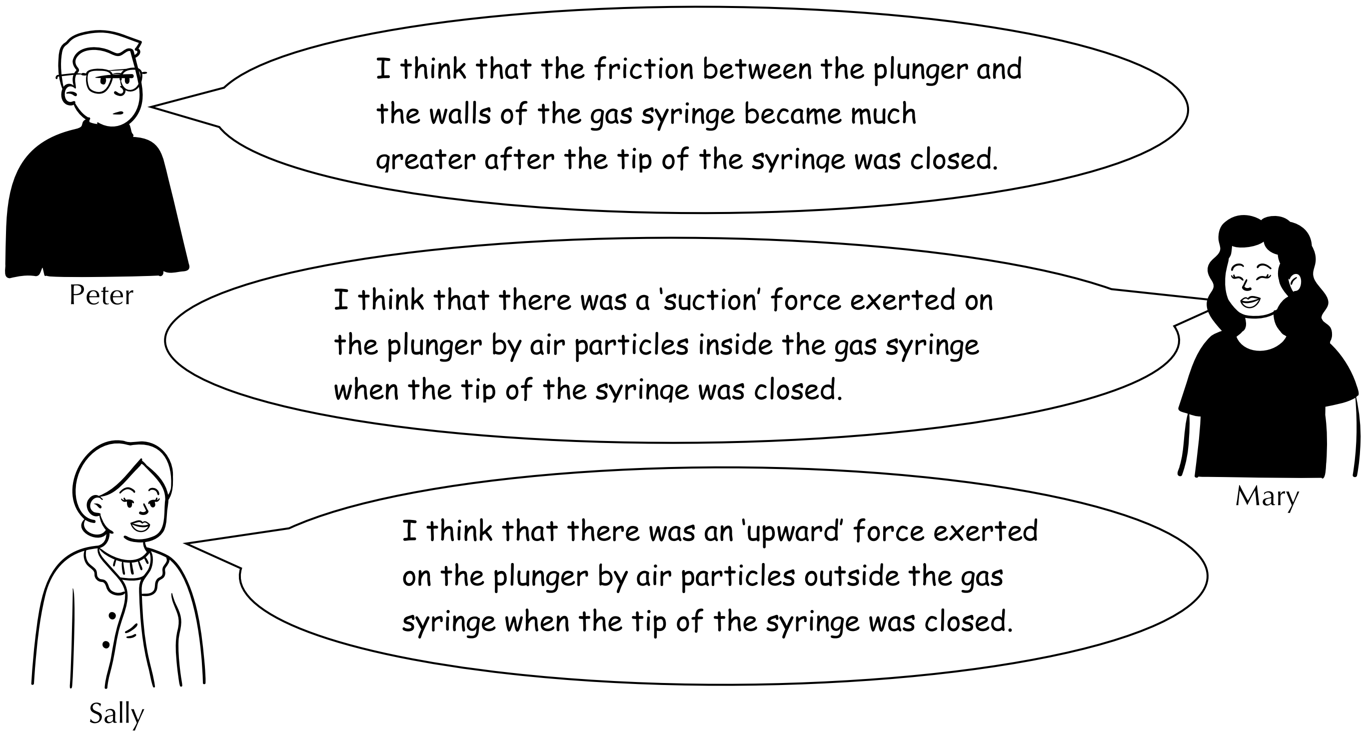
1. Apply a clip on the fine rubber tubing connected to the syringe.
2. Hang a 0.5 kg hanger on the plunger of the gas syringe. Record the reading of the syringe.
3. Add 1.0 kg load onto the hanger. Observe the position of the plunger and record the reading of the syringe.
4. Repeat Step (3) until the plunger of the syringe falls. During this process, keep observing the position of the plunger and record the reading of the syringe before the plunger falls.

Weight (kg)								
Reading (mL)								

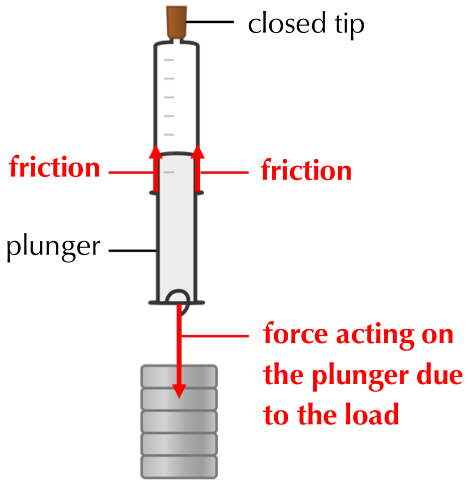
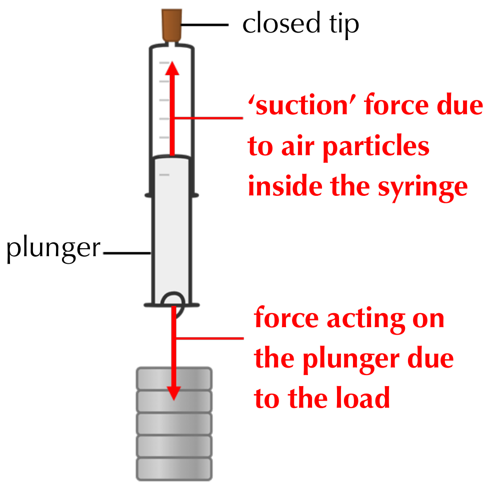
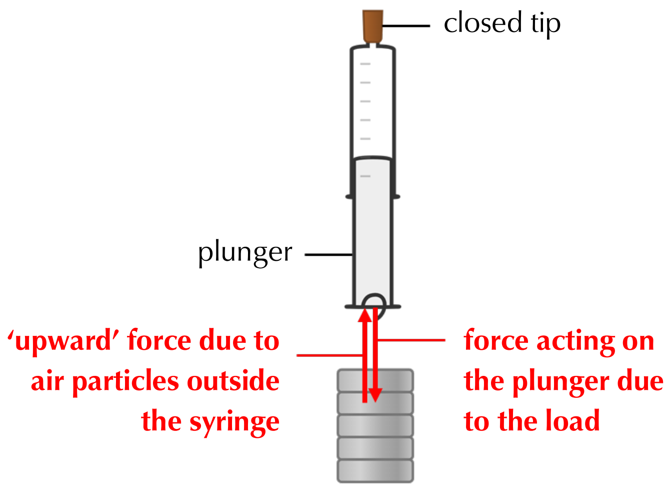
Post-demonstration discussion (science behind the gas syringe)

Background Information

A group of students used a gas syringe to hold some loads (see video demonstration: video 1). When the tip of the gas syringe was closed, the syringe could hold much more loads (see video demonstration: video 2). The students were wondering why the gas syringe could hold more loads after its tip was closed. They had the conversation below.



The group of students proposed three different free-body diagrams to explain why the gas syringe could hold more loads after the tip of syringe was closed. They agreed that the mass of syringe can be neglected as its mass was much smaller than that of the load.

<table>
<tr><td>Peter's free body diagram
(Focusing on the plunger)</td><td>
</td></tr>
<tr><td>Mary's free body diagram
(Focusing on the plunger)</td><td>
</td></tr>
<tr><td>Sally's free body diagram
(Focusing on the plunger)</td><td>
</td></tr>
</table>

Group task: evaluating the claims and free-body diagrams proposed by the students

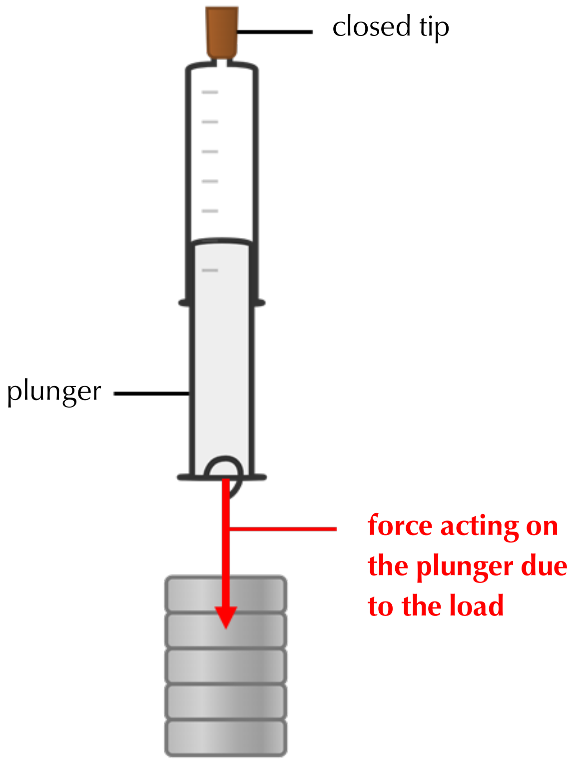
Form a group that consists of 3 students. Individually read and comment on ONE of the claims and respective free-body diagrams proposed by Peter, Mary and Sally. Write down some ideas in the table below. *(**Circle your choice)*

Comments on Peter's claim and diagram	I (agree / disagree / am uncertain)** with the proposed claim and diagram because
Comments on Mary's claim and diagram	I (agree / disagree / am uncertain)** with the proposed claim and diagram because
Comments on Sally's claim and diagram	I (agree / disagree / am uncertain)** with the proposed claim and diagram because

You may consider these questions when evaluating the claims and free-body diagrams:

- In what ways do the proposed claim and diagram align/misalign with your prior understanding (e.g. nature of forces, observations during the demonstration, daily life experiences etc.)?
- Can the proposed claim and diagram explain why the gas syringe could hold more loads after the tip of syringe was closed? Why or why not?

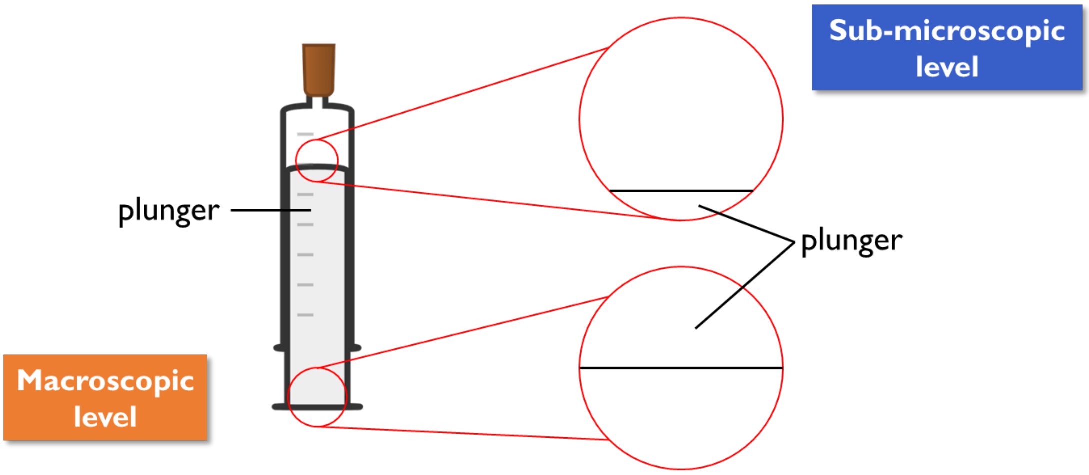
Discuss with your groupmates. Show all the force(s) acting on the plunger by sketching (with labels) on the free-body diagram below. Briefly explain your reason for indicating the presence of the force(s) on your diagram. The mass of the syringe is negligible.



We indicate the presence of __________________________ [type of the force(s)] on the diagram because:

Force, molecular collisions and pressure

Gas molecules move in __________ motion. They hit the wall of an object (e.g. the plunger) and exert a ________ on every unit ________ of the wall. The force per unit area resulting from these collisions is called **gas pressure**.



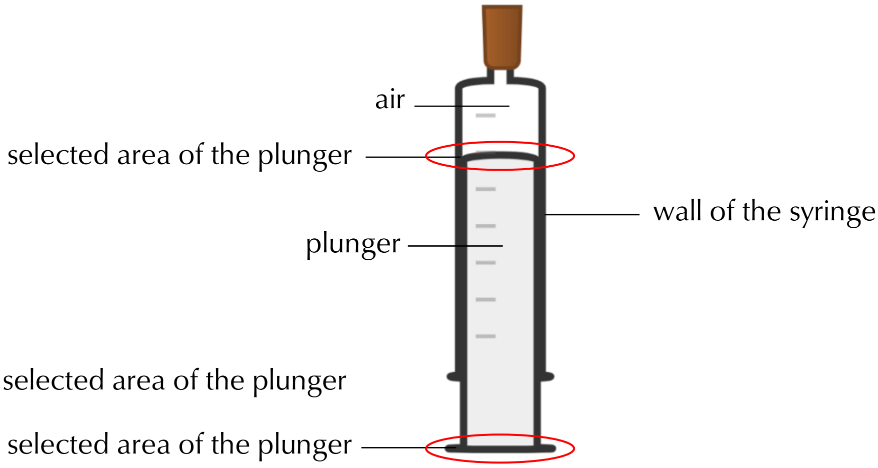
Example: Gas pressure in a balloon

Use ◯ to represent gas particles inside the balloon. Draw the gas particles inside the balloon below and show the direction of motions of those gas particles. With reference to your drawings, explain the origin of gas pressure inside the balloon.

Show, by drawing, the gas particles and the direction of their motions in the balloon below.	Explain, in sentences, the origin of gas pressure inside the balloon. You may use the following terms: *molecular collisions*, *force per unit area*, *wall of the balloon*
	

Checkpoint

Refer to the diagram below for a gas syringe with its tip closed.



1. Assume that the mass of plunger and the friction between the plunger and walls of the syringe are negligible. Sketch on the above diagram to show the forces acting on the plunger.
2. It is known that the selected area of the plunger is roughly 20 cm^2. (Atmospheric pressure = 10^5 Pa)
   a) Estimate the normal force acting on the selected area of the plunger.

      (Hints: 1 cm^2 = 0.0001 m^2; Pressure = $\frac{\text{Normal force}}{\text{Area of the surface}}$)

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      ....

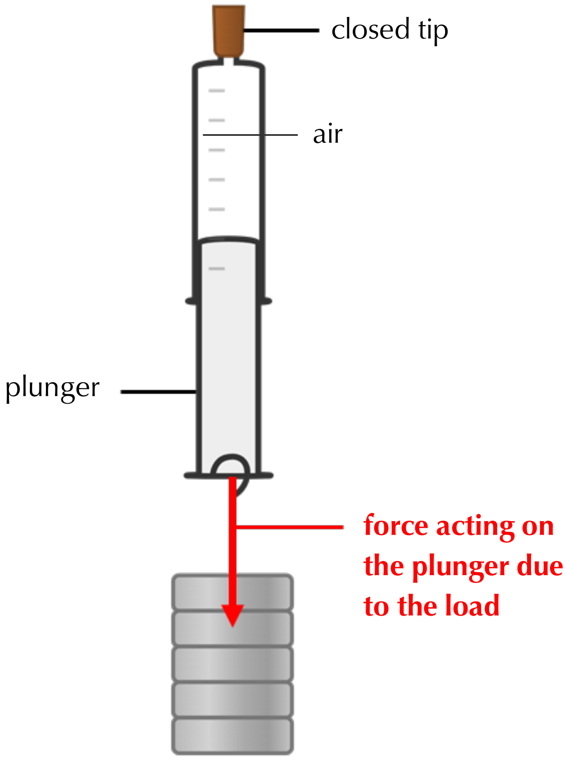
      ....

   b) Estimate the gas pressure (in Pa) inside the syringe.

      ....

      ....

3. The diagram below shows a gas syringe holding some loads with its tip closed.



a) The force acting on the plunger due to the load is 55 N. Assume that the mass of plunger and the friction between the plunger and walls of the syringe are negligible. Calculate the magnitude of the force acting on the plunger due to gas pressure inside the syringe.

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b) Estimate the gas pressure (in Pa) inside the syringe when the syringe is holding some loads. Note that the selected area of the plunger is roughly 20 cm^2.

....

....

Complete the table below using the following terms: *atmospheric pressure, gas pressure, smaller, larger*

Scenario	**Explanation**
The carton collapses when we drink the carton of juice.	This is because the ____________________ inside the carton becomes much ________ than the ____________________ outside. As a result, the **pressure difference** causes the carton to collapse.
The drink in the cup is 'sucked up' to our mouth when we drink with a straw.	This is because the ____________________ inside our mouth becomes much ________ than the ____________________. As a result, the **pressure difference** causes the drink in the cup to be 'sucked up' to our mouth.

Image credits: Unless otherwise stated, all images are courtesy of the authors.