

## Introduction

The LEGO® Pneumatics Set from LEGO Education is a great way to teach and learn about the science of compressed air and how it relates to the real world.

### Who is it for?

The LEGO Pneumatics Set is designed for use in middle school and junior high school classrooms. Focusing on grades six through eight, the pneumatics curriculum can easily be adapted and used at the high school level as well.

Teacher materials provide step-by-step guidance to effectively relate pneumatic principles to students through a variety of hands-on activities and class-lead discussions. Student materials use instruction, investigative questioning, and helpful hints to ensure progress and provide scientific understanding. Both you and your students will be successfully guided through the curriculum as you explore the world of pneumatics.

### What is it for?

LEGO Education science and technology solutions enable students to behave as technical investigators by providing them with tools and tasks that promote scientific inquiry. By using LEGO solutions, students are encouraged to pose ‘What if...?’ questions. They make predictions (hypotheses), test behaviors of models, and record and present findings.

The ‘Pneumatics’ curriculum pack presents scientific and technical concepts in a motivating and exciting way that will encourage creativity and teamwork among students. These activities allow for the integration of a wide range of science, design, technology, and mathematical concepts, thus supporting a highly efficient learning experience. These activities also enable teachers to partially cover the following Crosscutting Concepts and overall Science and Engineering Practices, which have been set forth in the Next Generation Science Standards (NGSS).

Science and Engineering Practices:

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information



**Crosscutting Concepts:**

- Patterns
- Cause and Effect (Mechanism and explanation)
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter (Flows, cycles, and conservation)
- Structure and Function
- Stability and Change

**What is in it?**

The set consists of 31 elements including pumps, cylinders, and valves – many of which are unique to this product. All of the elements and the building instruction booklets fit into the bottom section of the storage box.

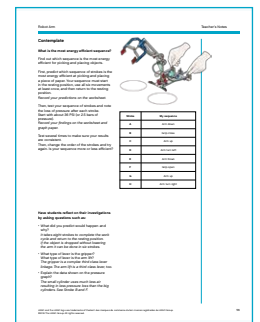
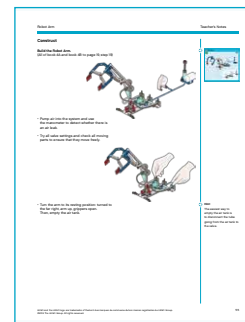
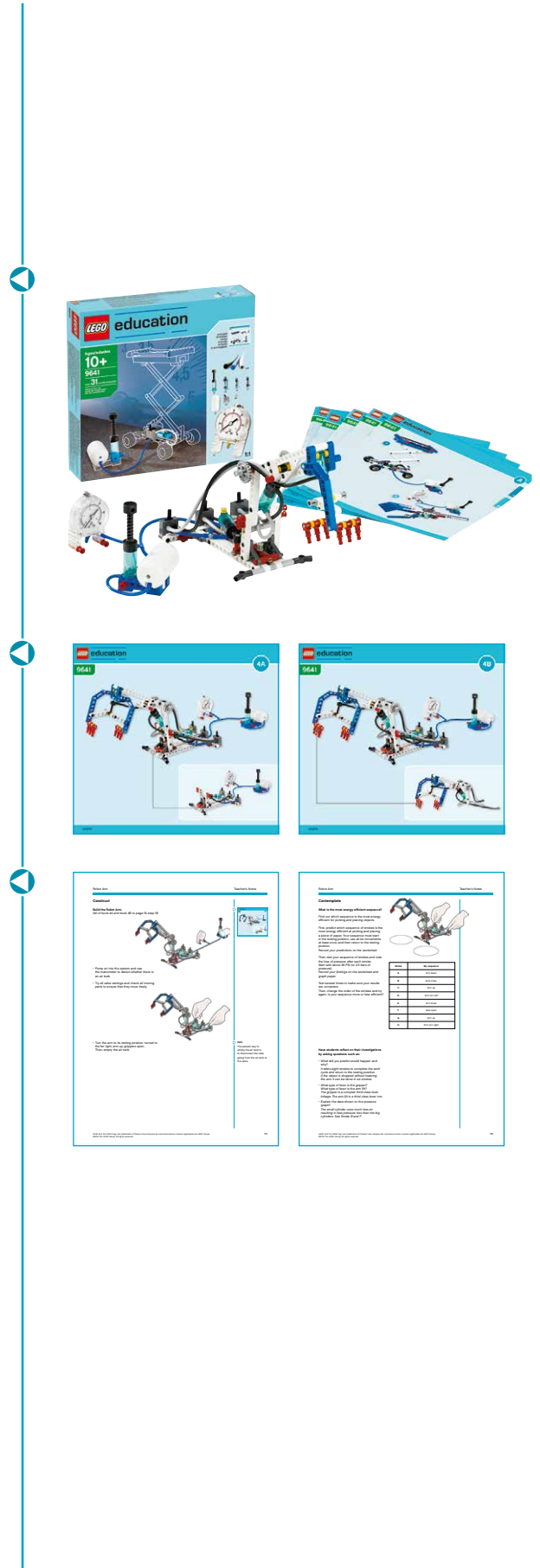
The activity pack consists of 14 principle model activities, four main activities, and two designing and making activities. The set is both easy to use and easy to manage within a classroom setting, providing the ideal tool for effective hands-on learning!

**Building Instructions Booklets**

Unique to LEGO® Education science and technology solutions is the Buddy Building instruction booklet. Combining teamwork with learning, these booklets are designed for groups of two students. Each buddy (student) is provided a booklet (A or B) and is required to build only half of the model. After each buddy completes his or her portion of the assembly, the two work as a team to construct the final, more sophisticated and powerful model.

**Teacher's Notes**

In the Teacher's Notes, you will find activities as well as questions, answers, hints and ideas for further investigations. Every activity is carefully linked to the overall objectives of the science, and design & technology curriculum. At the start of each activity, we list the outcomes unique to that particular activity. The outcomes that are common to all activities are listed in the section called 'What are the curriculum highlights?'. We also list the specific vocabulary focus and the additional materials needed for each activity.



### Student Worksheets

The student worksheets guide the students through the investigations without requiring too much assistance from you. They will predict, test, take measurements and record data, and change the models to compare and contrast findings, and finally draw conclusions.

You can ask the students to compare their worksheets and share their findings with each other for a greater understanding of the concepts they have just explored. You could also use the students' findings as an opportunity to discuss concepts, such as fair testing and variables.

At the end of each activity, the students are challenged to invent and sketch a device that applies the major concepts they have just explored. This is ideal as an extra challenge or homework project.

### Assessments

Assessment materials are provided for all four of the activities and the six problem-solving activities.

#### What learning goals are assessed?

- **Activity Assessment**

Practices of Scientists & Engineers and Crosscutting Concepts: A rubric page on which students can evaluate their activity work according to learning goals based on two NGSS Practices and one theme from the NGSS Crosscutting Concepts.

- **Problem-Solving Assessment**

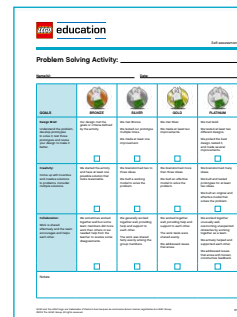
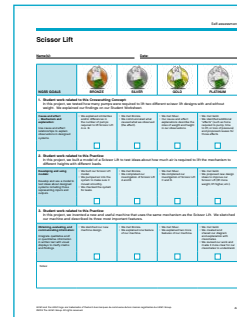
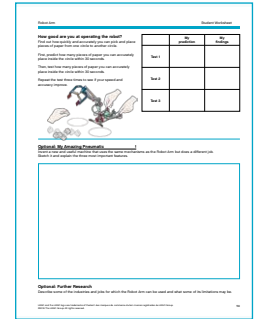
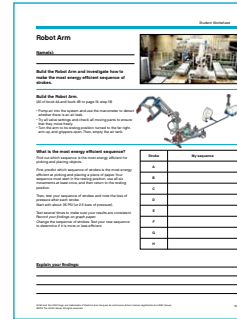
Evaluate Design, Creativity, and Collaboration: A rubric page on which students can evaluate their problem-solving work according to the engineering-related learning goals from the NGSS and a set of learning goals that are prominent in both the Common Core State Standards and 21st century skill set, specifically:

- How well did their design meet the requirements of the design brief?
- How creative was their solution?
- How well did their team work together?

Each rubric includes four levels: Bronze, Silver, Gold and Platinum. The intention is to help students reflect on what they have done well in relation to the learning goals and what they might do better. Students can write comments or questions in the 'Notes' column.

Students should mark the rubric. If you prefer to emphasize formative assessment, ask the students to record dates in the rubric that correspond to their completion of each level.

You can also use the rubrics for your own evaluation of the students' work, marking in the appropriate column, and writing optional comments in the 'Notes' column.



• **Observation Checklist**

If a more science and engineering practices based approach to assessment is required in the problem-solving activities, you can use the Observation Checklist provided in the Teacher’s Notes to record your students’ grades.

You can use the Bronze (1), Silver (2), Gold (3), and Platinum (4) proficiency level descriptions, or use one that is relevant to your school context.

**Where can I find the assessment materials?**

You can find the assessment materials in the Teacher’s Notes for each activity and problem-solving activity.

**Three Levels of Progression**

The “Advancing with Simple & Powered Machines” curriculum pack consists of fourteen principle models, six activities, and two designing and making activities. Each of these three components represents one level of progression, and each of these is described in more detail below.

**Principle Models**

The principle models introduce students to the basic concepts of pneumatics and provide an opportunity to gain an understanding of pneumatics. Students experiment with easy-to-build models using progressive building instructions and activities. Each principle model comes with a student worksheet that presents a selection of words that will encourage students to use the correct terminology associated with pneumatics, both in their investigations and explanations.

**Activities**

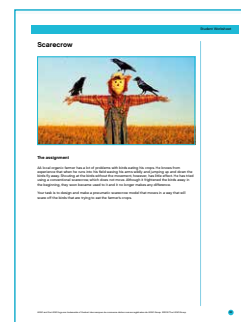
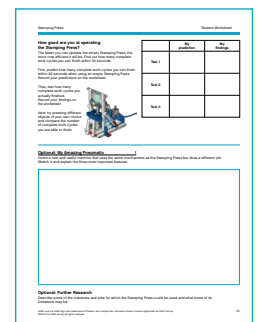
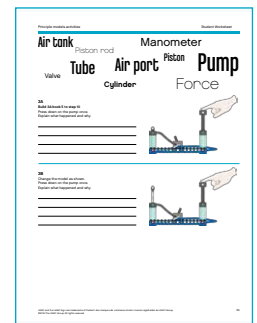
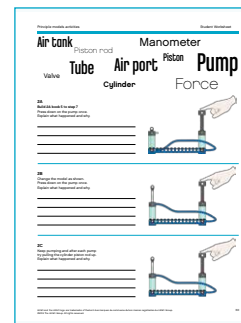
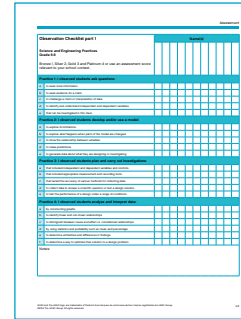
The six activities allow students to apply and develop their knowledge of science and engineering design. These activities create a positive learning environment and offer a complete scientific learning process in which the students are able to make predictions, build models, run tests, record data, make comparisons, and improve their models in order to create a better solution.

These six activities connect with the concepts introduced by the principle models and help students to prepare for the increasingly difficult challenges they’ll meet in the problem-solving activities.

**Designing and Making Activities**

The goal of these activities is for students to design their own solutions to various real life needs. Students learn to design and create a solution, evaluate the process used, and communicate the focus used to meet the design criteria. Each activity builds on the knowledge, skills, and understanding gained from both the principle and main activities.

The Teacher’s Notes for each designing and making activity provide advice on how to evaluate the proposed solution. A picture of a model solution is provided. You may use this to help students who get stuck in the design process. Note that it is not the one and only solution. You should always encourage students to design their own solutions.



The LEGO® Pneumatics Set provides students with the opportunity to obtain an in-depth understanding of pneumatics through hands-on activities.

The sections 'What is pneumatics?' and 'principle models' will guide you and your students through the basics of pneumatics. The four main activities let students explore pneumatic concepts at work and two designing and making activities that deal with pneumatics. Also included is a curriculum section that pinpoints the key learning concepts covered,

### What is pneumatics?

This section presents the basics of pneumatics: what it is, how it works, and how it is used. The section also features a guide to the design and function of each of the elements, and includes four pages you can print and display in your classroom. You may choose to use this section as part of your own preparation and/or give it to your students.

## Classroom Management Tips For Your First LEGO® Education Activity, and Beyond

### 1. Before Class

- Open one of the LEGO® brick sets and sort the bricks by following the sorting suggestion on the back of the top card.
- Label the boxes so that you can recognize which box belongs to which student(s).
- Download the curriculum pack from the URL that is printed on the lid of each set.
- Try to complete the activity using the student worksheets.

### 2. During Class

- Let the students sort their LEGO brick sets at the beginning of the first lesson.
- Have the students use the lid of their set as a working tray.
- Use a jar to collect stray pieces.
- Make adjustments in order to challenge the students who are ready to improve and develop new skills.

### 3. After Class

- Plan to stop the lesson with enough time to allow the students to tidy up.
- If you did not finish the activity, store the LEGO sets and the models so that they are ready for the next lesson.
- Evaluate the lesson.
- Book a LEGO Education training session if you need further inspiration.

### How do I handle the building instructions booklets?

For easy classroom management we suggest storing the building instructions booklets in binders so that they are close-at-hand and ready to use at the beginning of each lesson.

You can also ask your students to download the building instructions booklets from the URL that is printed on the lid of each set, and save them to their devices.



**How much time is needed?**

Students should be able to do all of the principle activities within two 45-minute class periods.

When working with each of the main activities, most students will be able to build, test, explore, and put away the parts within 45 minutes. A double period is ideal for more in-depth investigations of the key learning areas.

For the designing and making activities, students may need more time to build and explain their models.

**What is needed in my classroom?**

Tables may be pushed aside to allow models to roll across a smooth floor. Ideally, a computer or computers should be available so that students can explore the activity videos.

Students need to be able to construct in pairs facing each other or side-by-side. From teachers and classrooms we have learned that cafeteria-type trays are ideal to build on, and to stop elements rolling onto the floor. It is also an advantage to have a cupboard or shelves to store the sets lying flat with any unfinished models on top of them.

## LEGO® Education 4C Approach

The lessons follow LEGO® Education's 4C approach; Connect, Construct, Contemplate, and Continue. This enables you to progress naturally through the activities.

### Connect

Connect a new learning experience to those you already have and you add to your knowledge. An initial learning experience is a seed stimulating the growth of new knowledge. Real-life photographs with a short text are provided to help students identify and connect to the chosen activity and the main model.

We suggest using the text and photograph as a starting point for a class discussion or draw on your own experiences to provide an engaging introduction to the activity. Please also consider involving current events related to the topic, both near and far, to set the scene for the students.

### Construct

The construction of models engages both hands and minds. Using the building instructions, students build models embodying the concepts related to the key learning areas. Tips are provided for testing and ensuring each model functions as intended.

### Contemplate

Contemplation provides the opportunity to deepen the understanding of previous knowledge and new experiences. The scientific nature of the activities encourages the students to discuss and reflect on their investigations and adapt ideas to the task at hand. This phase provides the opportunity for you to begin evaluating the learning outcome and progress of individual students.

### Continue

Continued learning is always more enjoyable and creative when it is adequately challenging. Maintaining a challenge and the pleasure of accomplishment naturally inspires the continuation of more advanced work. Extension ideas are therefore provided to encourage the students to change or add features to their models and to investigate further – always with the key learning area in mind. This phase allows the students to operate at different speeds and levels conducive to their individual capabilities. Activities challenge the students to creatively apply their knowledge and reflect on model design and the effect of changing certain variables.

