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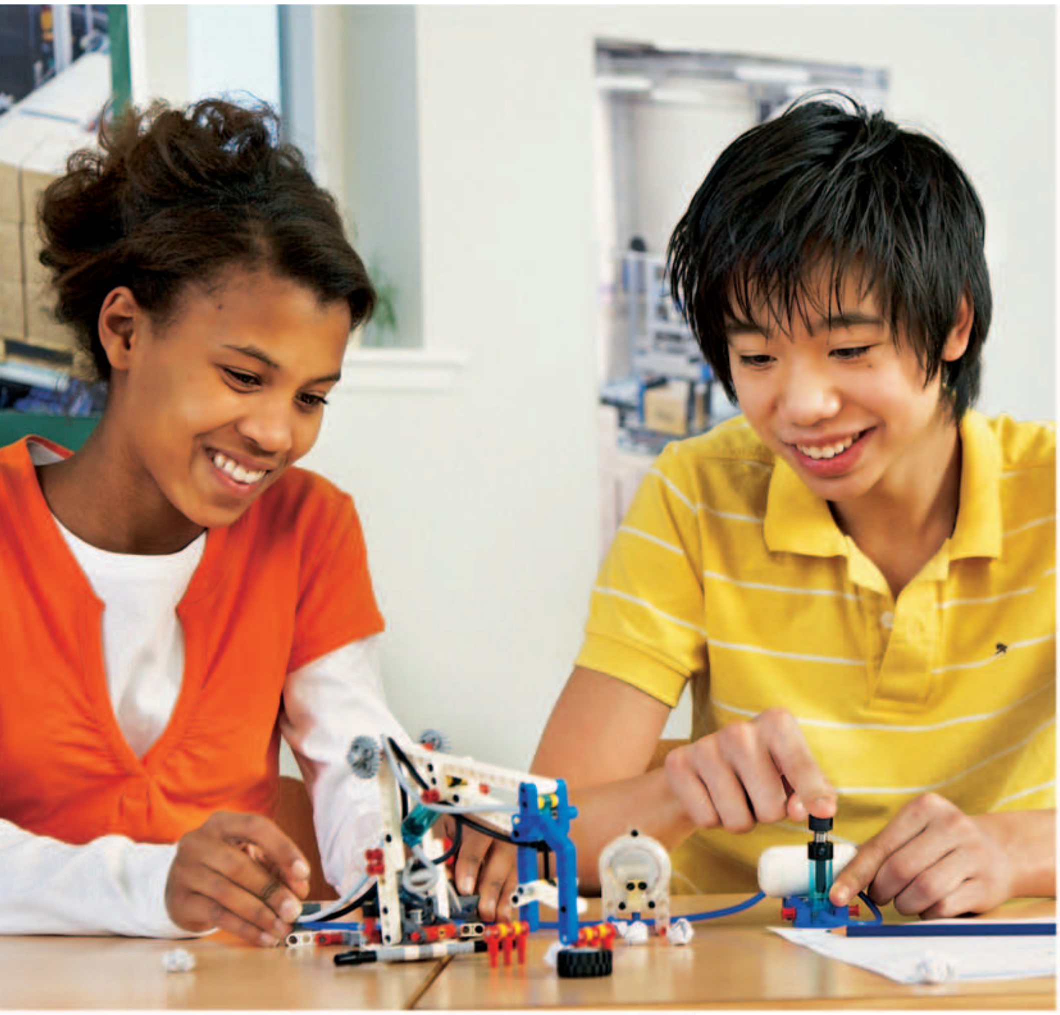
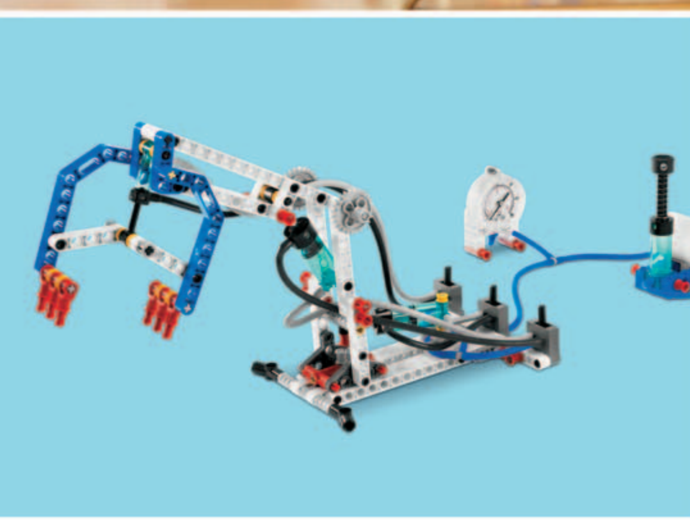
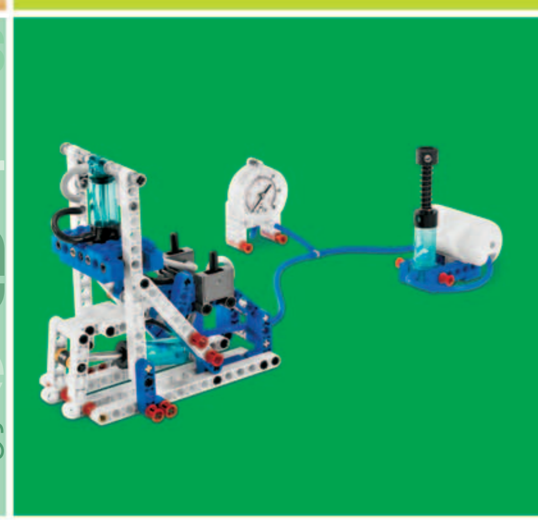
LEGO education





Pneumatics
Piston rod
Cylinder
Force
Explore
Compress
Piston



Teacher's Guide

LEGO education

Table of contents

Introduction

The LEGO® Pneumatics Set from LEGO Education is a superb way to learn and prepare for the Science and Technology in the real world.

Who is it for?

The material is designed for use in key stage 3, but also has relevance in key stage 2. The teacher materials give full and complete guidance, plus explanations, and the student materials use instruction, questions and hints to ensure progress. Both you and your students will be guided through the material.

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 enquiry. Using our solutions, your students are encouraged to pose 'What if ...?' questions. They make predictions or hypothesis, test the behaviour of their models, and then record and present their findings.

What is 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 10 building instruction booklets fit into the bottom section of the 9632/9686 storage box.
The activity pack consists of 14 principle model activities, four main activities and two designing and making activities.
The set is designed for ease of use, easy classroom management, and lots of learning!

What's new?

Hands-on pneumatics

The set provides an opportunity for your students to get an in-depth understanding of pneumatics through hands-on activities.

The sections 'What are pneumatics?' and 'Principle models' will guide you and your students through the basics of pneumatics. The four main activities let your students explore pneumatic concepts at work. The activities present scientific and technical concepts in a motivating and exciting way that will encourage creativity and teamwork. They allow for the integration of a wide range of science, design & technology and mathematical concepts, thus supporting highly efficient learning.

How to use it?

Building instructions

Unique to LEGO® Education Science and Technology solutions, the Buddy Building instruction booklets are designed for two buddies, so that each buddy builds only half a model. Using separate booklets (A and B), the buddies create their own sub-assemblies then collaborate to quickly bring the two together to create a single, more sophisticated and powerful model.

What are pneumatics?

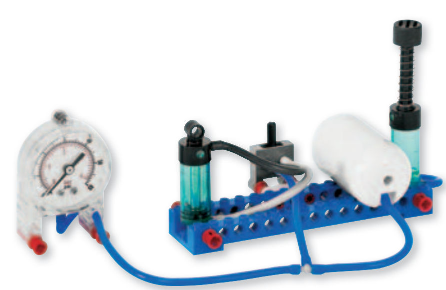
This section presents the basics of pneumatics: what it is, how it works and how it is used. The section also features a guide to the design and function of each of the elements, and includes four pages you can print out and display in your classroom. You may choose to use the section as part of your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


education

What are pneumatics?

Principle models

The principle models introduce the students to the basic concepts of pneumatics and provide an opportunity to gain an understanding and knowledge of how pneumatics work. They allow the students to experiment with easy-to-build models according to the progression of the activities and building instructions. Each principle student worksheet presents a selection of words that will encourage the students to use the correct terminology associated with pneumatics, in their investigations and explanations.



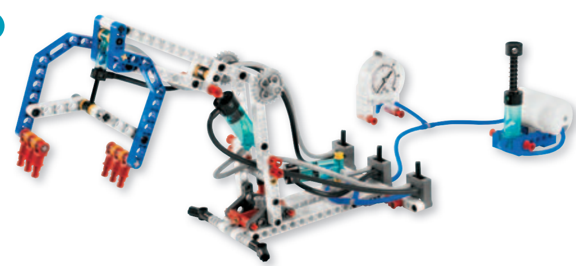
Teacher's Notes
In Teacher's Notes, you will find activities as well as questions, answers, hints and ideas for further investigations.
Every activity is carefully linked to the overall objectives of the Science, and Design & Technology curriculum. At the start of each activity, we list the outcomes 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.


education
Robot Arm

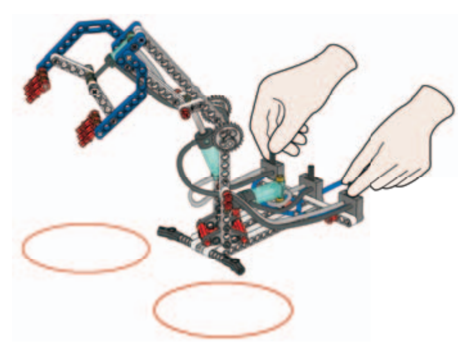
The Teacher's Notes follow LEGO Education's well-tested methodology – the 4C approach; Connect, Construct, Contemplate and Continue. This methodology enables you to naturally progress through the activities.

Connect
A short text provides insight into the purpose and function of the specific model. The text is supported by a short movie of a real life machine similar to the LEGO® model. Use the text and movie as a starting point for a class discussion or you could draw on your own experiences. You can also draw from current events both near and far to set the scene for the students.

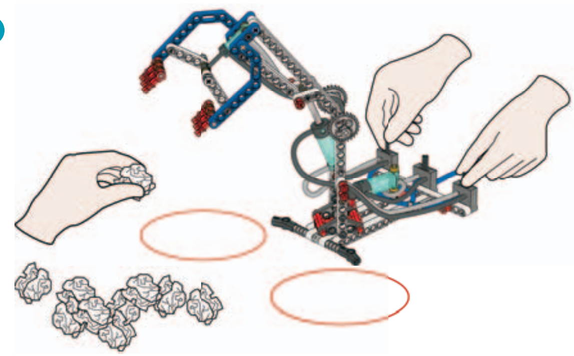
Construct
Using the building instructions, students build models embodying the concepts related to the key learning areas. Tips are provided for testing and ensuring each model functions as intended.



Contemplate
Through investigations based on scientific inquiry, the material encourages the students to discuss the specific technology learning areas, and to reflect and adapt their ideas to the task at hand.
Each activity requires the students to predict an outcome and record their findings. You can ask the students to present their findings together with their explanations and rationales.
A series of questions are included to further deepen the students' experience and understanding of their investigations.
This provides an opportunity for you to begin evaluating the learning and progress of the individual student.

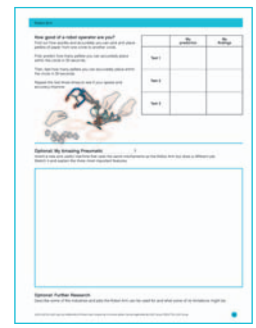


Continue
Ideas are provided for additional investigations that draw on the students' previous investigations. The students will experiment with, design additions for, or focus on a specific model function. Ideas are also provided for the students' own investigations and inventions relating to real life machines and mechanisms.



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.

Robot Arm



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.

The worksheets can help you in assessing the individual student's level and achievement. They also form a valuable part of a student log book.

Designing and making activities
The aim of these activities is for the students to design their own solutions to different real life needs. The students learn to design and create a solution. Then they evaluate and communicate the process they used and what they focused on to meet the design criteria. Each activity builds on the knowledge, skills and understanding gained from the principle and main activities.
The Teacher's Notes for each activity provide you with a lot of advice on how to evaluate the proposed solution.

A picture of a model solution is provided. You can use this to help if students 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.

How much time do I need?
The students should be able to do all of the principle activities within two 45-minute lessons.
When working with each of the main activities most students will be able to built, test, explore and have the parts put away again within 45 minutes. A double lesson is ideal for more in-depth investigations of the key learning areas.
For the Designing and making activities the students may need more time to build and explain their models.

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What are the curriculum highlights?

The process of students actively building, exploring, investigating, inquiring and communicating together develops a huge range of benefits. Here is an overview:

Science
Carrying out practical and investigative activities; testing ideas and explanations; obtaining, recording and analysing; and evaluating scientific evidence and working methods.

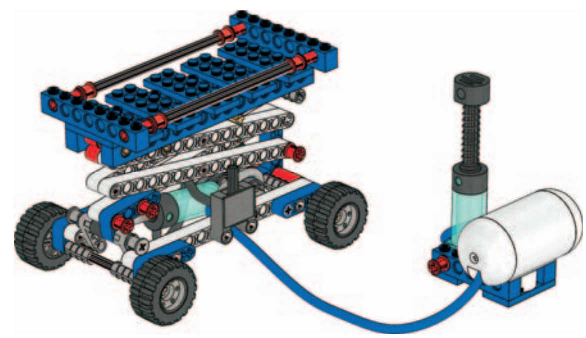
Design & Technology
Using appropriate strategies for planning and organising activities; solving technical problems; reflecting critically when evaluating and modifying design ideas and proposals to improve products; responding creatively to design briefs; developing own proposals and producing specifications for products testing prototypes for performance against a specification; evaluating; and assessing quality of construction and finish.

Mathematics
Making accurate mathematical diagrams, graphs and constructions on paper; estimating, approximating and checking work; recording methods, solutions and conclusions; forming convincing arguments based on findings and making general statements; making connections between the current situation and outcomes, and situations and outcomes they have already encountered; communicating findings effectively.

There is increasing complexity and demands placed on the student as they move through the sequence of the four main activities: Scissor Lift, Robot Hand, Stamping Press and Robot Arm.

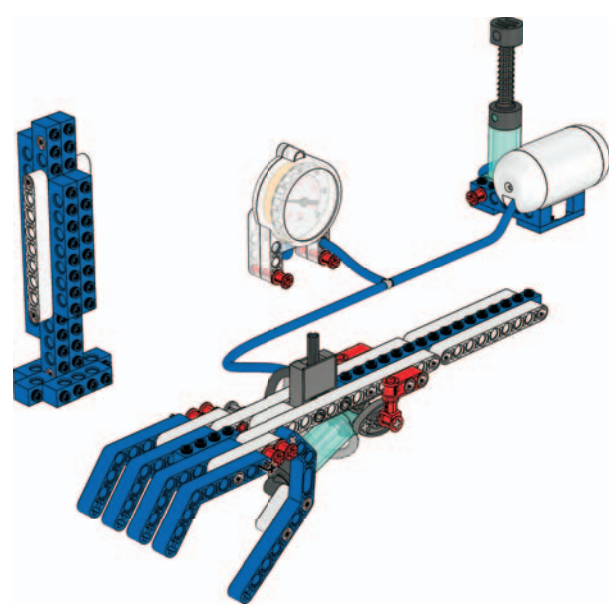
Scissor Lift

The Scissor Lift is relatively simply to construct and involves only one switching unit. The investigation explores how the performance of the lift (in terms of pumps needed/pressure required) changes according to the weight the lift is trying to move and the height it is trying to lift the weight through. The students are required to present predictions and actual results in a table.



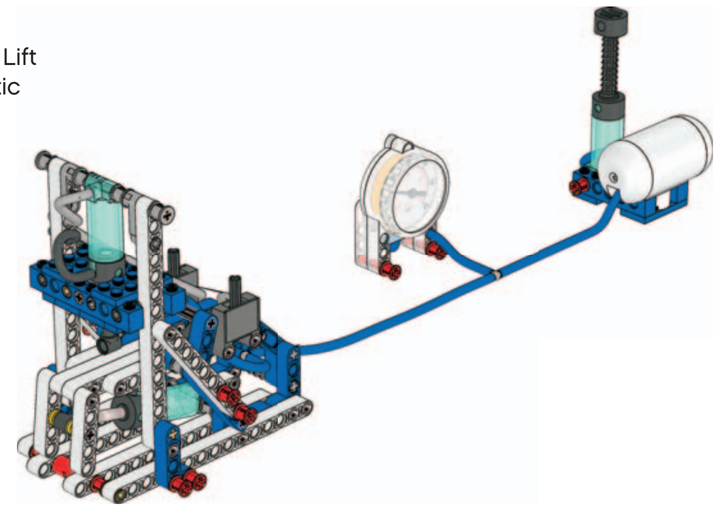
Robot Hand

The Robot Hand is more complex than the scissor lift to construct but still involves only one switching unit. The investigation is more demanding in that there are two variables in the object being gripped – the nature of the surface and weight. The investigation is extended to consider the pressure needed to achieve gripping without crushing. The students do not consider numbers of pumps as a preliminary measure of pressure but are instructed to use the manometer from the outset. The students are required to present predictions and actual results in a table.



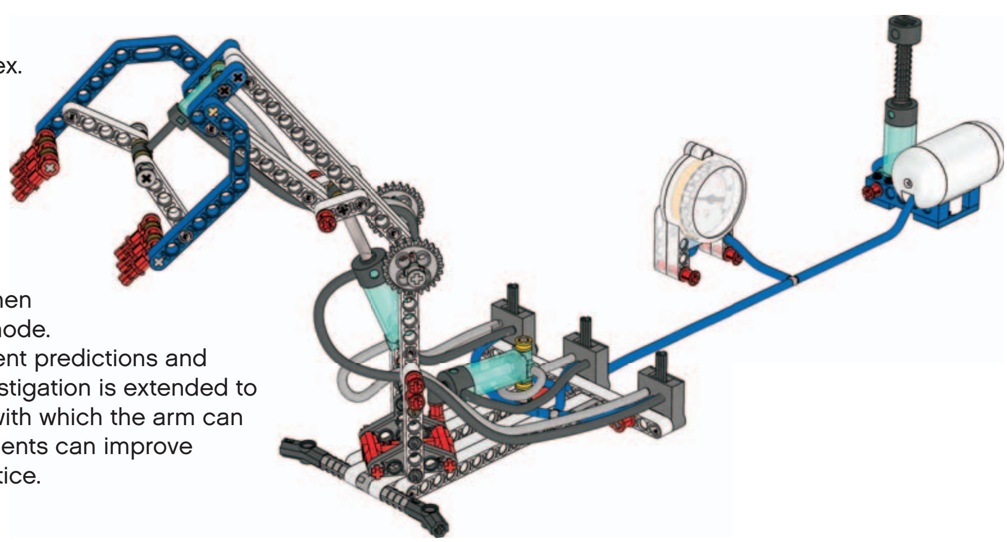
Stamping Press

The Stamping Press is more complex than either the Scissor Lift or the Robot Hand in terms of construction and the pneumatic circuit. It requires two circuits, each with its own cylinder and switching unit. One circuit is responsible for the stamping operation, the other circuit for ejecting the item after stamping. The investigation explores the efficiency of the Stamping Press in terms of the number of complete stamping cycles that can be completed starting with 2.5 bars of pressure. The students are required to present predictions and actual results graphically. The investigation is extended to explore the speed at which the students can operate the Stamping Press.



Robot Arm

The Robot Arm is the most complex. It has three circuits, each with its own cylinder and switching unit. One circuit is responsible for turning the arm, one for raising and lowering the arm, and one for opening and closing the hand. The investigation explores the efficiency of the work cycle when the robot acts in pick and place mode. The students are required to present predictions and actual results graphically. The investigation is extended to explore the speed and accuracy with which the arm can be operated and whether the students can improve the robot's performance with practice.



Using the LEGO® Pneumatic set to meet the requirements of the program of study for design & technology

You can use the LEGO Pneumatic set to engage with the following key concepts for design & technology

Designing and making
- Applying knowledge of materials and production processes to design products and produce practical solutions that are relevant and fit for purpose.

Creativity
- Making links between principles of good design, existing solutions and technological knowledge to develop innovative products and processes.
- Reinterpreting and applying learning in new design contexts and communicating ideas in new or unexpected ways.
- Exploring and experimenting with ideas, materials, technologies and techniques.

Critical evaluation
- Analysing existing products and solutions to inform designing and making.
- Evaluating the needs of users and the context in which products are used to inform designing and making.
- Exploring the impact of ideas, design decisions and technological advances and how these provide opportunities for new design solutions.

You can use the LEGO Pneumatic set to engage with the following key processes for design & technology
- Generate, develop, model and communicate ideas in a range of ways, using appropriate strategies
- Respond creatively to briefs, developing their own proposals and producing specifications for products
- Apply their knowledge and understanding of a range of materials, ingredients and technologies to design and make their products
- Plan and organise activities and then shape, form, mix, assemble and finish materials, components or ingredients
- Solve technical problems
- Reflect critically when evaluating and modifying their ideas and proposals to improve products throughout their development and manufacture.

You can use the LEGO® Pneumatic set to meet the requirements of the following range and content for design & technology in systems and control

- The practical application of systems and control in design proposals
- Electrical, electronic, mechanical including pneumatic, microprocessor and computer control systems and how to use them effectively
- Using systems and control to assemble subsystems into more complex systems

You can use the LEGO Pneumatic set to meets the following features of curriculum opportunities for design & technology

- Analyse products to learn how they function
- Undertake focused tasks that develop knowledge, skills and understanding in relation to design and make assignments
- Engage in design and make assignments in different and progressively more complex contexts, including for purposes and uses beyond the classroom
- Work individually and in teams, taking on different roles and responsibilities
- Make links between design and technology and other subjects and areas of the curriculum.

LEGO education

Using the LEGO® Pneumatic set to meet the requirements of the program of study for science

You can use the LEGO Pneumatic set to engage with the following key concepts for science

Scientific thinking

- Using scientific ideas and models to explain phenomena and developing them creatively to generate and test theories.
- Critically analysing and evaluating evidence from observations and experiments

You can use the LEGO Pneumatic set to engage with the following key processes for science

Practical and enquiry skills

- Use a range of scientific methods and techniques to develop and test ideas and explanations
- Plan and carry out practical and investigative activities, both individually and in groups.

Critical understanding of evidence

- Obtain, record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations
- Evaluate scientific evidence and working methods.

You can use the LEGO Pneumatic set to meet the requirements of the following range and content for science

In Energy, electricity and forces

- Forces are interactions between objects and can affect their shape and motion

In Chemical and material behaviour

- The particle model provides explanations for the different physical properties and behaviour of matter

You can use the LEGO Pneumatic set to meets the following features of curriculum opportunities for science

- Research, experiment, discuss and develop arguments
- Make links between science and other subjects and areas of the curriculum

What are pneumatics?

What does pneumatic mean?

The English word pneumatic is based on the Greek word 'pneumatikos', meaning 'coming from the wind.' The word pneumatic now means the use of pressurized air to do work. Pneumatic machines have been used for many years. 2,000 years ago a famous Greek inventor, Hero of Alexandria, made a large variety of pneumatic machines including a pneumatic catapult.

Why use pneumatics?

If you have ever been to the dentist and had your teeth drilled or polished, you might have had a close encounter with pneumatic machines, without even knowing it. Pneumatic dental instruments are often the preferred choice of dentists and they are valued for their high momentum and smooth operation.

Some of the benefits of using pneumatic systems are:

- Pneumatic machines can be very small, light, fast, and powerful
- Air is light and free compared to hydraulic fluid
- You can store compressed air very easily
- They are safe even when the air hoses or machine parts get wet
- If a pneumatic machine is overloaded, the machine will either stop, continue compressing or the air can leak out of a pressure release valve. If there is a hose leak in hydraulic machines, fluid will cause the surrounding area to become slippery and dangerous
- Note that any fluid, even air, under high pressure can potentially be dangerous!

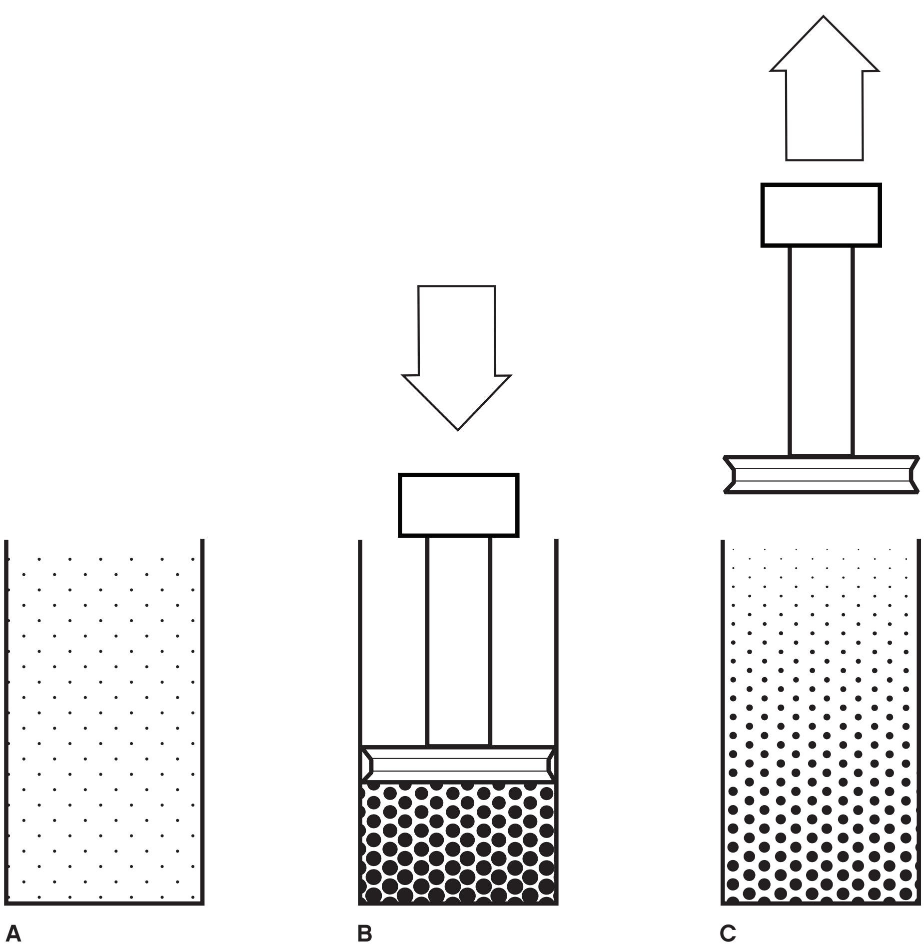
How does it work?

Consider a container, such as container A. Even though it might look empty, it never is – it is full of air molecules. Air molecules are invisible, but they still have weight and mass, and exert pressure. Container A's pressure matches the air pressure of the room it is in. Once the container is sealed (B) the molecules trapped inside exert pressure when squeezed or 'compressed' into a smaller area as they collide with each other and the sides of the container. It is the empty space and the elasticity of the impact between the air molecules and the container that allows for the air to be compressed. The force of the air molecules acting on a surface, such as the piston, is called pressure.

The amount of pressure the air molecules exert depends on the number of molecules and collisions that occur between the molecules and the inside surface of the container. Air molecules that are compressed contain potential energy.

If the hand and piston are removed (C), the compressed air will expand until pressure inside and outside the container is the same.

Using a controlled airflow circuit, the force of expanding air can be converted it into kinetic energy that can power and operate a system.



Hint

For explanations of specific words, turn to the glossary.

Did you know?

If you want to know more about how to calculate pressure, we suggest you start with Boyle's Law.

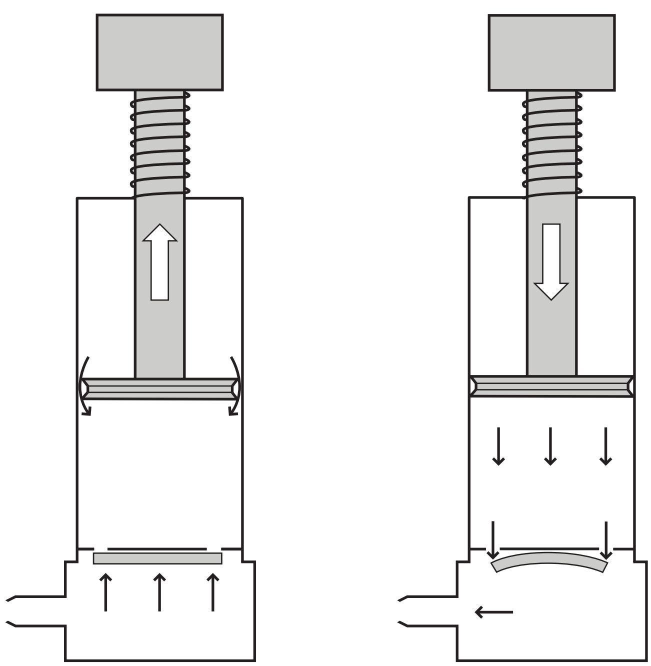
Inside the LEGO® pneumatic elements

Pumps, cylinders and valves are the basic components of any pneumatic system. Even though industry uses a much larger variety of components, most operations can be performed with just these three basic components.

The Pump
The pump is used to compress air. To control the airflow inside the pump it uses a specially designed piston and a flexible diaphragm.

On the down stroke, the pump's piston seal becomes air tight, forcing the compressed air to bend the flexible diaphragm allowing air to flow through to the outlet port.

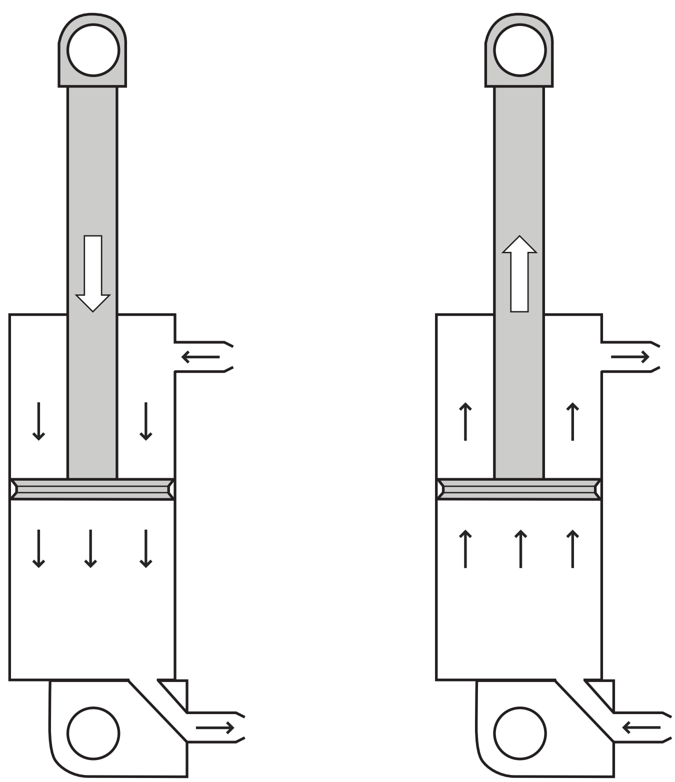
On the return stroke the piston seal allows air to flow past the piston and back into the barrel of the pump. At the same time, the flexible diaphragm snaps back into place and stops any compressed air from flowing back into the pump barrel.



The Cylinder

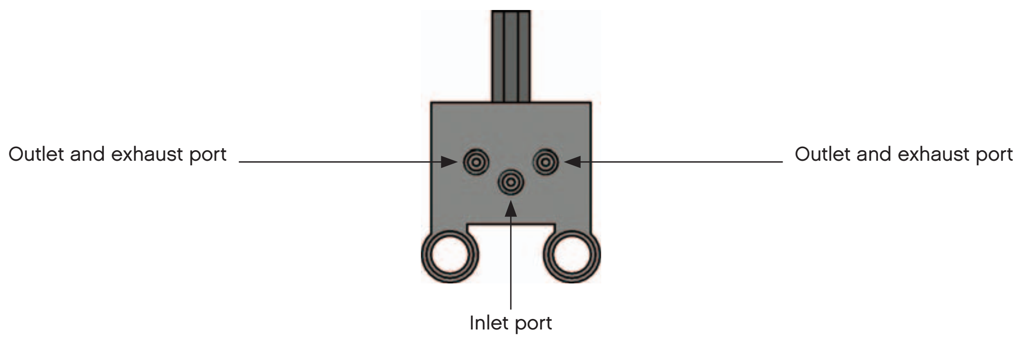
The pneumatic cylinder works by converting the force of expanding air (potential energy) into movement (kinetic energy). When air enters the cylinder, the force of the expanding air will either force the piston up or down, depending on which air port the air has entered from. All LEGO® cylinders are double-acting cylinders, which means that compressed air can enter the cylinder through two air ports.

Did you know?
The smaller the cylinder the greater the pressure it needs to operate. This is due to the smaller area of the piston. Pressure is force divided by area. As the area gets smaller, dividing the force by the area leads to a greater value for the pressure.

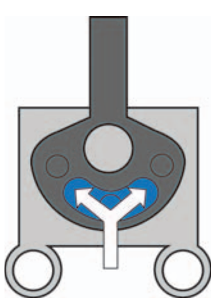


The Three Position Valve
The valve receives compressed air from the pump or tank through the inlet port and directs the air flow through one of the two outlet ports on to other pneumatic elements or simply stops the air flow. The rubber valve seal has a specially designed chamber to direct air from the inlet port to one of the two outlet ports.

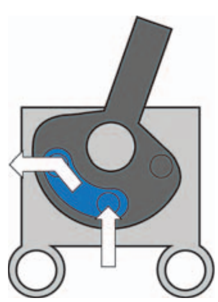
The outlet port that is not being used for compressed air is automatically opened, allowing air from a cylinder to escape through it to the atmosphere.



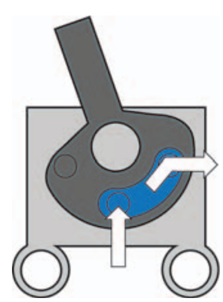
Valves controlling the direction of the compressed air



Off position



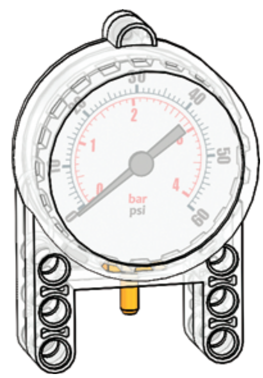
On position



On position

The Manometer

A manometer is a pressure measuring instrument. Using the manometer allows you to follow the rise or drop in air pressure created by your actions. The LEGO® manometer gives you a pressure reading in both bar and psi.

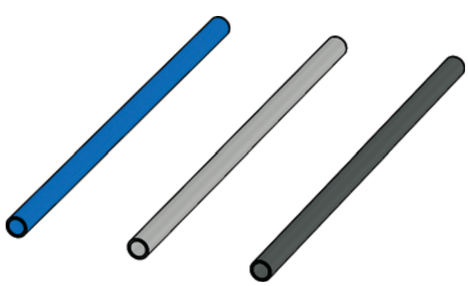


Tubes, T Pieces and Air tank

The flexible tubes, which come in different lengths and colours, are used to transport the compressed air between the pneumatic elements. The colours help you find errors, trace and describe the air flow. The tubes are specially designed to leak air at the connections if the pressure becomes too high.

T pieces allow air to flow to several tubes at the same time.

The air tank is used for storing air under pressure.



Tubes

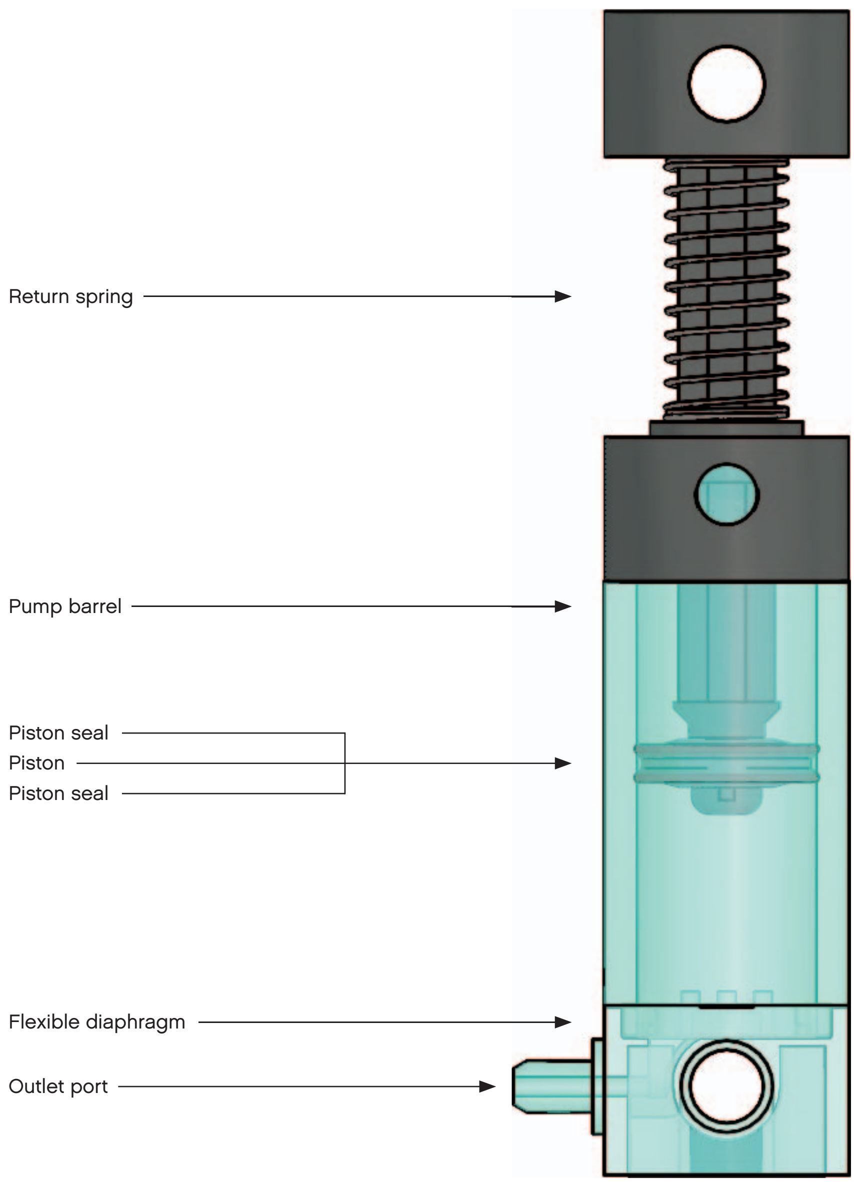
Air tank

T piece

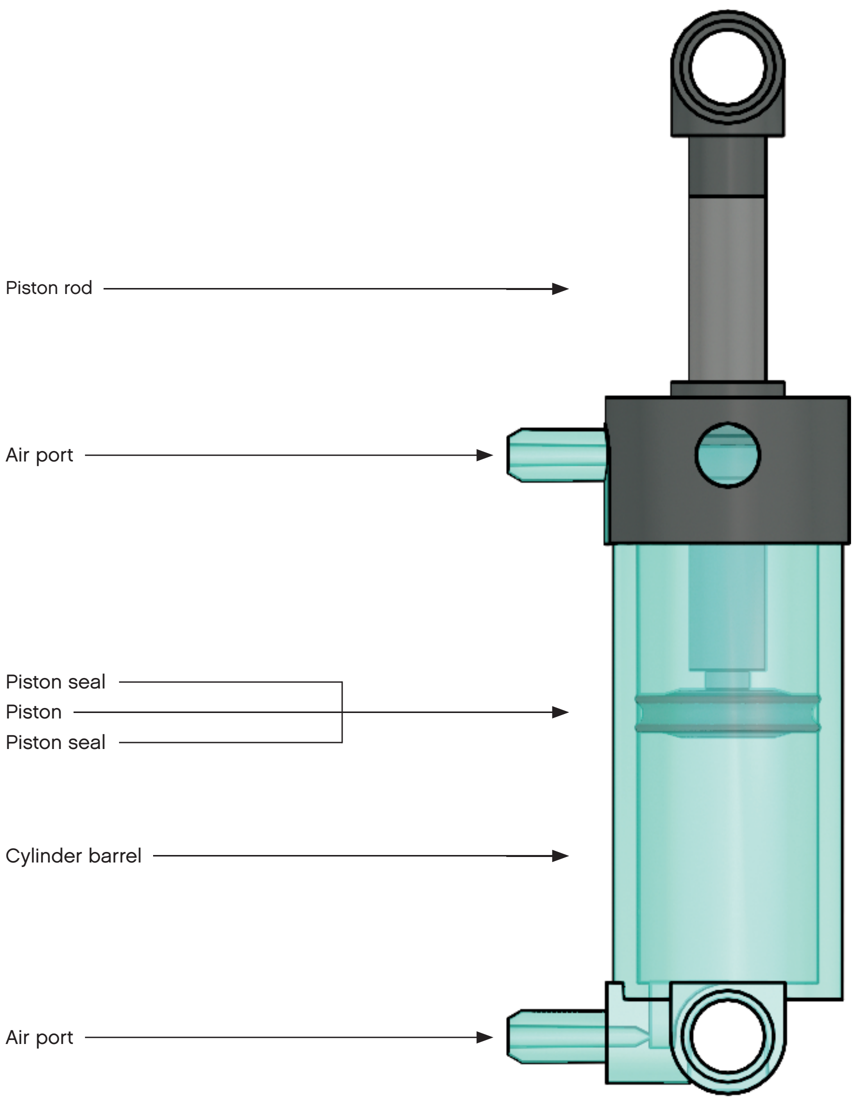
Hint

The LEGO models use tubing according to the following rules:
Blue tubes are used to transport air between the pump, air tank and valve.
Light grey tubes are used to transport air between the valve and bottom cylinder air port.
Black tubes are used to transport air between the valve and top cylinder air port.

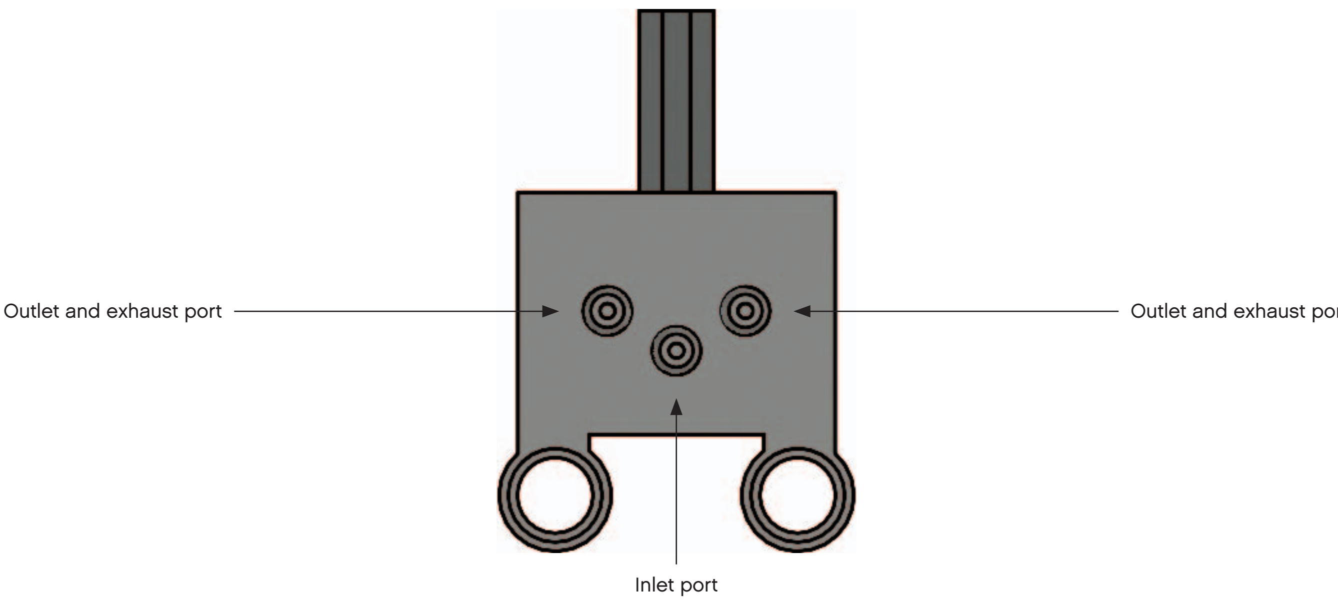
The Pump

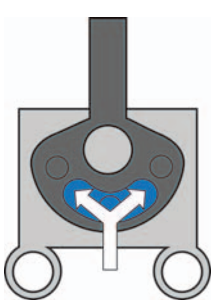

Return spring
Pump barrel
Piston seal
Piston
Piston seal
Flexible diaphragm
Outlet port

The Cylinder

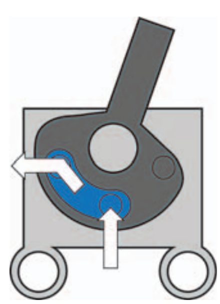


The Three Position Valve

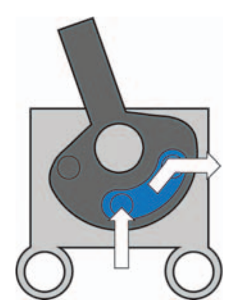




Off position



On position



On position

Principle models

A quick guide to the components and the principles of pneumatics
The principle model building instruction booklet is full of small, quick-to-build and easily changeable models. The principle model activities provide an insight into how pneumatic components work. They can be used to gain a greater understanding of the more complex main activities and the designing and making activities.

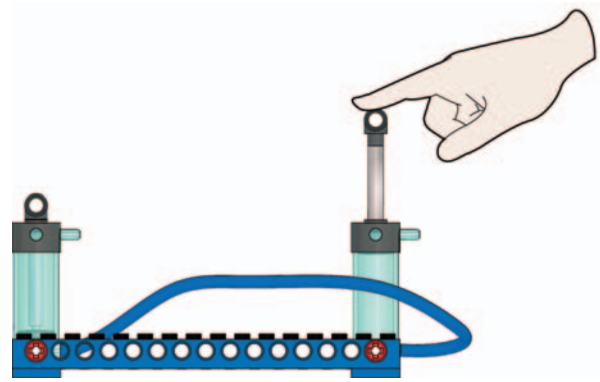
Who are they for?
They are designed for the students! Through the natural progression of activities, the students will experience the magic of pneumatics, letting them explore, understand and feel first-hand how pneumatics work. The student worksheets guide the students through the investigations and basic principles of pneumatics, enabling them to document their findings.

When can I use the models?
Use the activities when you introduce pneumatics to the students. By using these models the students will also become familiar with the construction techniques and the terminology associated with pneumatics. The experience the students gain from the principle model activities can be used as a point of reference when they begin working with the main activities and the Designing and making activities.

1A

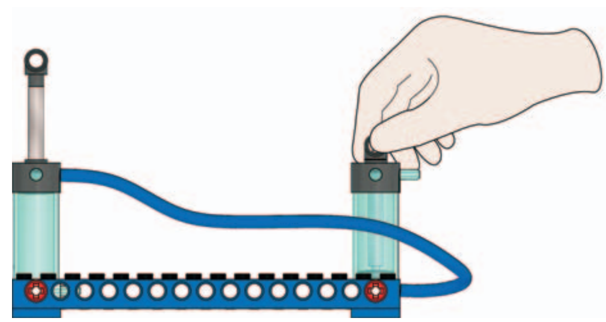
Build 1A book 5 to step 5

As you press down on the piston rod, the piston will force the air out of the bottom air port, into the tube and then into the bottom air port of the second cylinder. The force of the expanding air will force the piston of the second cylinder to move up, thereby extending the piston rod.



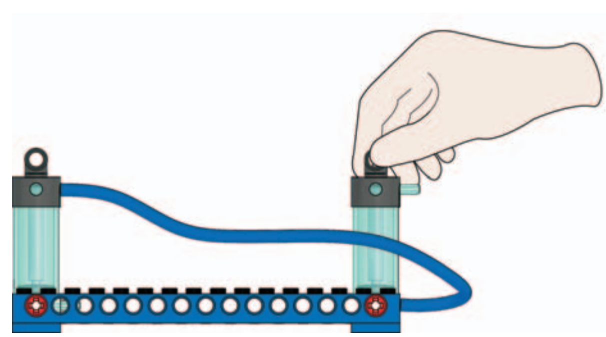
1B

As you pull up on the piston rod, you create a vacuum inside the cylinder and tube. As you then let go again the force of the pressure returning to its initial state forces the piston and piston rod down again.



1C

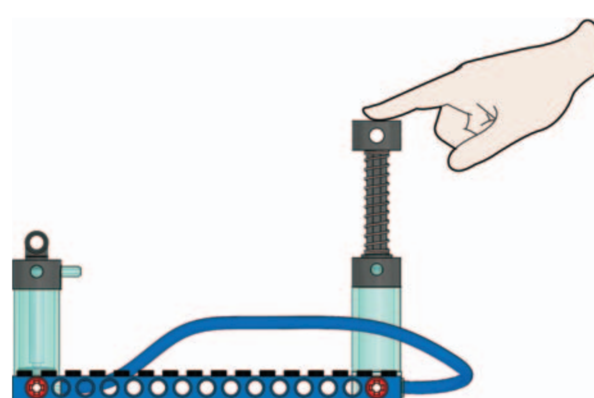
As you pull up on the piston rod, you draw air from the second cylinder and the tube into the first cylinder. The first cylinder's piston rod will remain extended after you let go of it. The vacuum created by force of the air flowing from the second to the first cylinder forces the second cylinder's piston up, thereby extending the second cylinder's piston rod.



2A

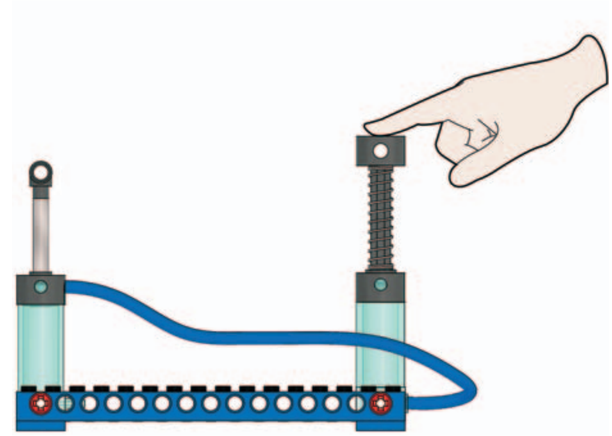
Build 2A book 5 to step 7

The pump forces the air into the tube and into the cylinder's bottom air port. This forces the piston up and the piston rod will extend almost completely.



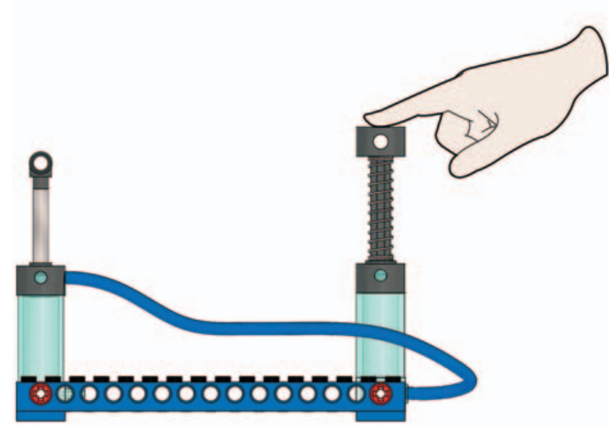
2B

The pump forces the air into the tube and into the cylinder's top air port. This forces the piston down and the piston rod will completely retract.



2C

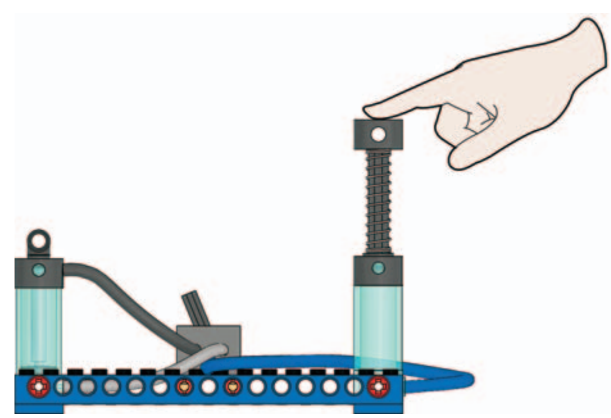
After one pump you will be able to completely extend the piston rod. After two pumps it becomes much harder. After 4 pumps it is very difficult to extend to piston rod. After 6 pumps the pump or tube will begin leaking air.



3A

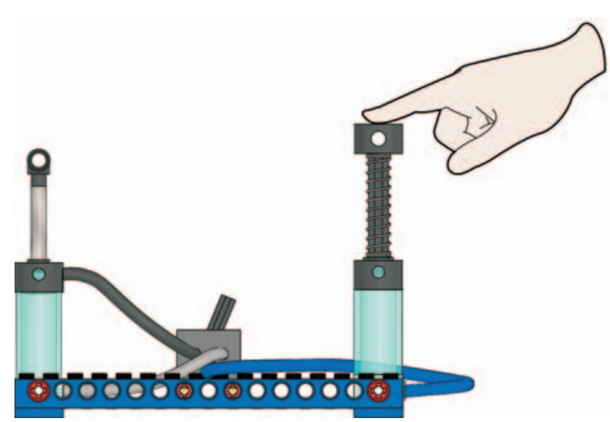
Build 3A book 5 to step 10

As you press down on the pump, the air will flow from the pump into the valve, which directs it in to the tube that leads to the cylinder's bottom air port. As the air enters the cylinder it forces the piston up, thereby extending the piston rod.



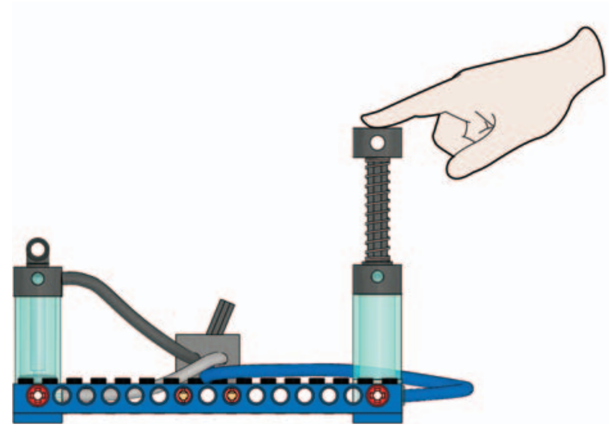
3B

As you press down on the pump, the air will flow from the pump into the valve, which directs it into the tube that leads to the cylinder's top air port. As the air enters the cylinder it forces the piston down, thereby retracting the piston rod.



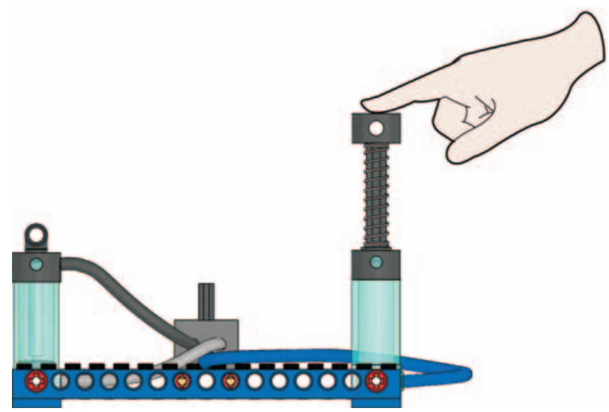
3C

As you press down on the pump, the air will flow from the pump into the valve, which directs it in to the tube that leads to the cylinder's top air port. As the air enters the cylinder it forces the piston down, but as the piston already is down, nothing happens. After about 7 pumps the pump or tube will begin leaking air.



3D

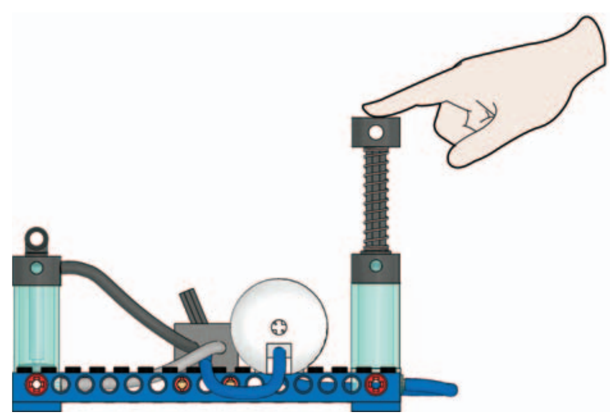
As you press down on the pump, the air will flow from the pump to the valve, where it is stopped. After about 2 pumps the pump or tube will begin leaking air.



4A

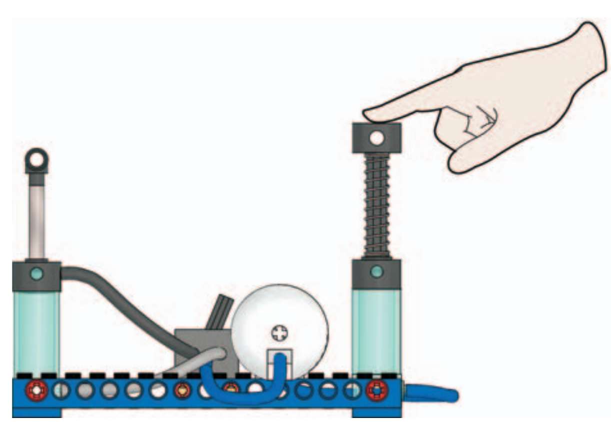
Build 4A book 5 to step 13

As you press down on the pump, the air will flow from the pump, through the air tank and into the valve, which directs it in to the tube that leads to the cylinder's bottom air port. As the air enters the cylinder it forces the piston up, thereby extending the piston rod. After 2 pumps the piston rod will be fully extended.



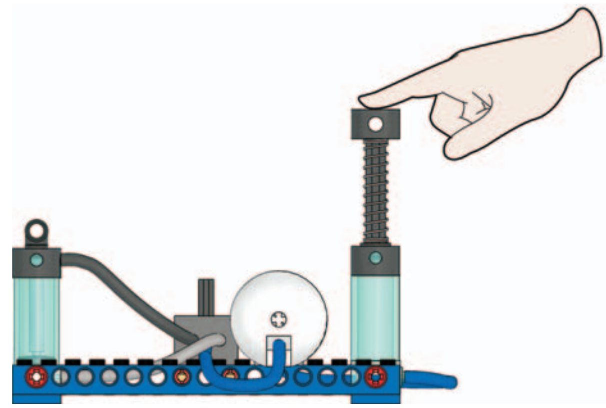
4B

As you press down on the pump, the air will flow from the pump, through the air tank and into the valve, which directs it in to the tube that leads to the cylinder's top air port. As the air enters the cylinder it forces the piston down, thereby retracting the piston rod. After 2 pumps the piston rod will be fully retracted.



4C

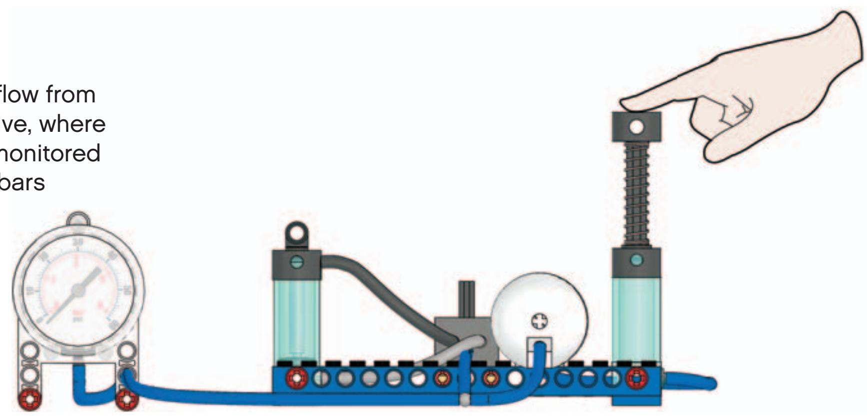
As you press down on the pump, the air will flow from the pump, through the air tank and to the valve, where it is stopped. After about 40 pumps the pump or tube will begin leaking air.



5A

Build 5A book 5 to step 17

As you press down on the pump, the air will flow from the pump, through the air tank and to the valve, where it is stopped. The pressure build up can be monitored on the manometer. At a pressure of about 3 bars the pump or tube will begin leaking air.



You can get 6 complete cylinder actions from 1 bar

You can get 11 complete cylinder actions from 2 bars

You can get 13 complete cylinder actions from 2.5 bars

Principle models activities

The principle models show you how pneumatics work in a simple and hands-on way. Use the building instructions to build the model, investigate what happens when you do as instructed and then explain why it happens. You can also use the words presented at the top of each page as you write your findings.

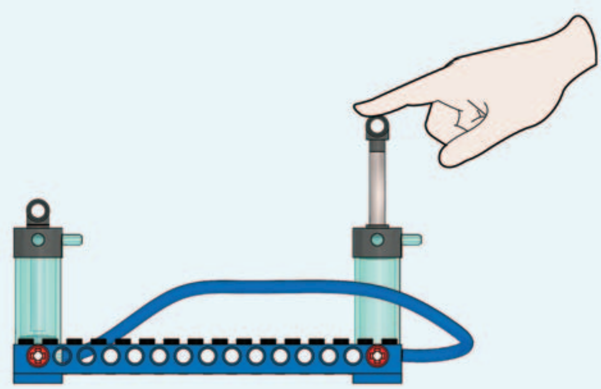
Next, make a minor change as shown in the illustration and you are ready for new learning.

There are five principle models and 14 steps. When you have completed these, you will be ready to make interesting pneumatic machines.

Air tank · Piston Rod · Manometer · Piston · Pump · Tube · Air port · Valve · Cylinder · Force

1A

Build 1A book 5 to step 5.
Press down on the piston rod.
Explain what happened and why.



When I push down on the piston rod...

____

____

____

____

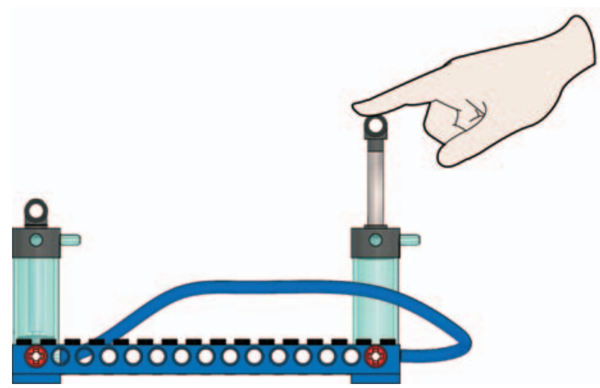
Tips and Tricks when working with the pneumatic elements!

- The easiest way to empty the air tank is to disconnect the tube going from the air tank to the valve.
- It is always a good idea to start with the valve in the off position. This allows you to control the air flow.

Air tank
Manometer
Piston Rod
Piston
Pump
Tube
Air port
Valve
Cylinder
Force

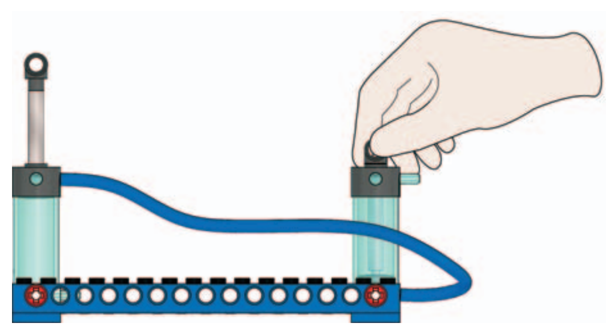
1A

Build 1A book 5 to step 5
Press down on the piston rod.
Explain what happened and why.



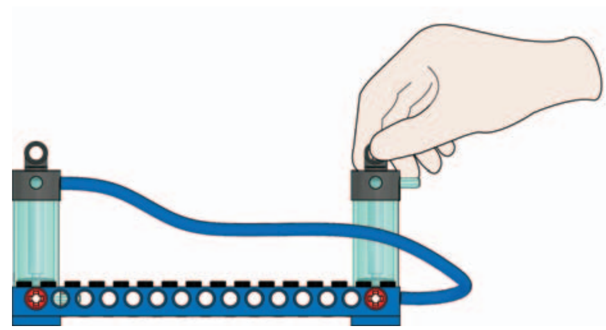
1B

Change the model as shown.
Pull up on the piston rod.
Explain what happened and why.



1C

Change the model as shown.
Pull up on the piston rod.
Explain what happened and why.



Air tank

Piston Rod

Manometer

Piston

Pump

Tube

Air port

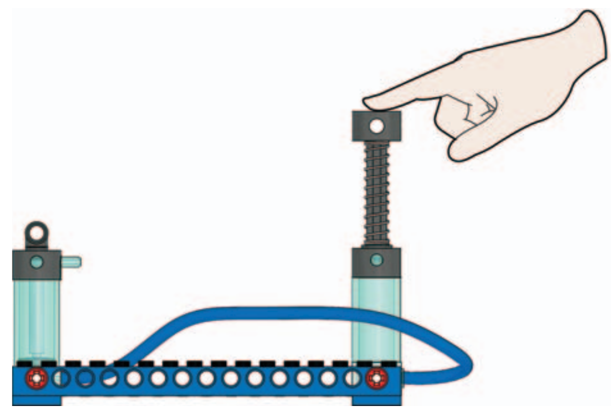
Valve

Cylinder

Force

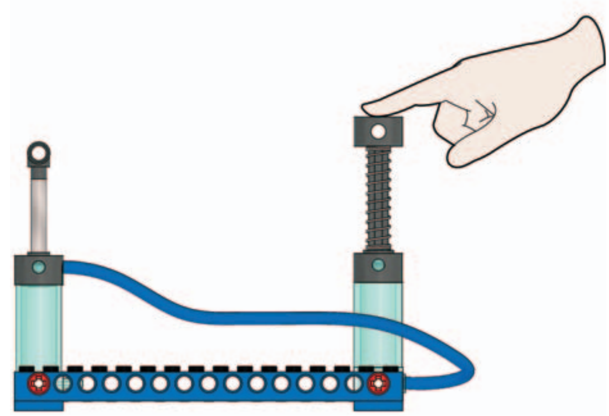
2A

Build 2A book 5 to step 7
Press down on the pump once.
Explain what happened and why.



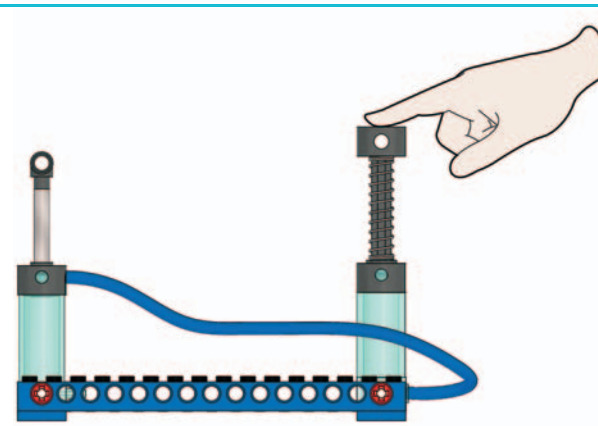
2B

Change the model as shown.
Press down on the pump once.
Explain what happened and why.



2C

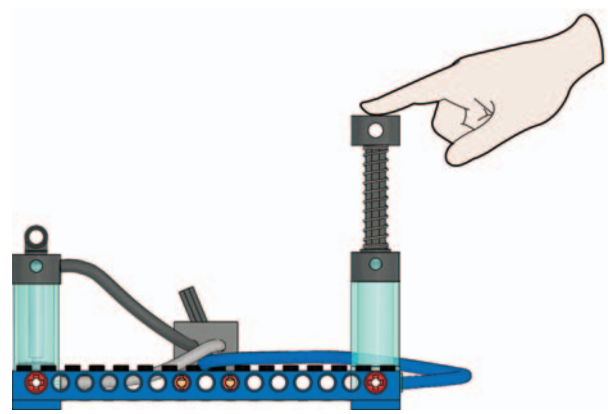
Keep pumping and after each pump
try pulling the cylinder piston rod up.
Explain what happened and why.



Air tank Piston Rod Manometer Piston Pump Tube Air port Valve Cylinder Force

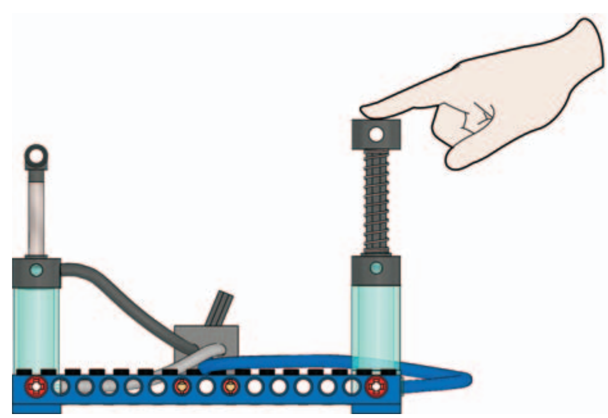
3A

Build 3A book 5 to step 10
Press down on the pump once.
Explain what happened and why.



3B

Change the model as shown.
Press down on the pump once.
Explain what happened and why.



Air tank

Piston Rod

Manometer

Tube

Air port

Piston

Pump

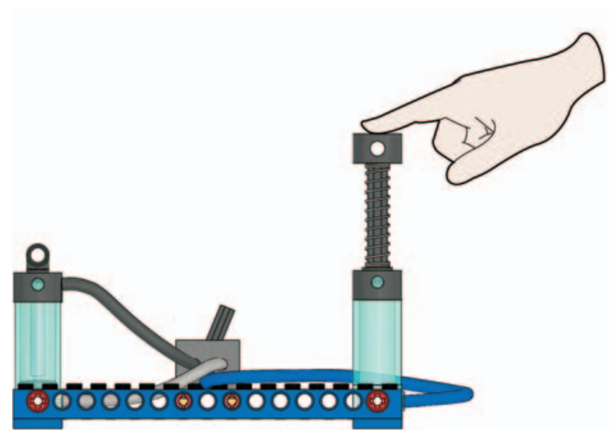
Valve

Cylinder

Force

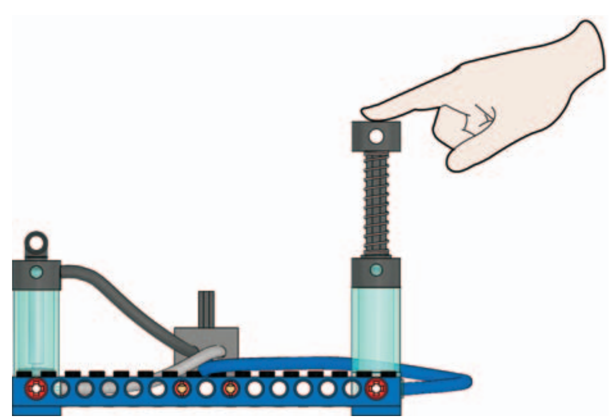
3C

Change the model as shown.
Press down on the pump once.
Explain what happened and why.



3D

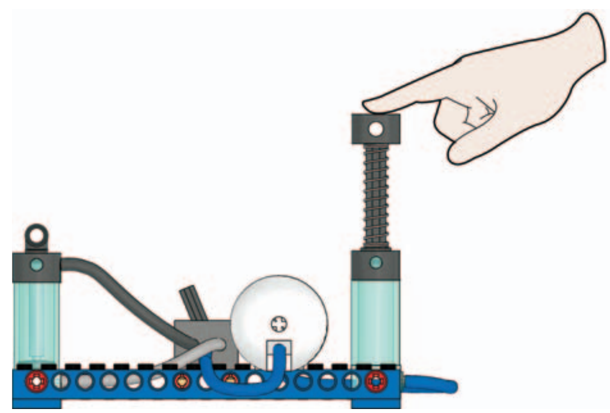
Change the model as shown.
Press down on the pump twice.
Explain what happened and why.



Air tank Piston Rod Manometer
Piston Pump
Valve Tube Air port
Cylinder Force

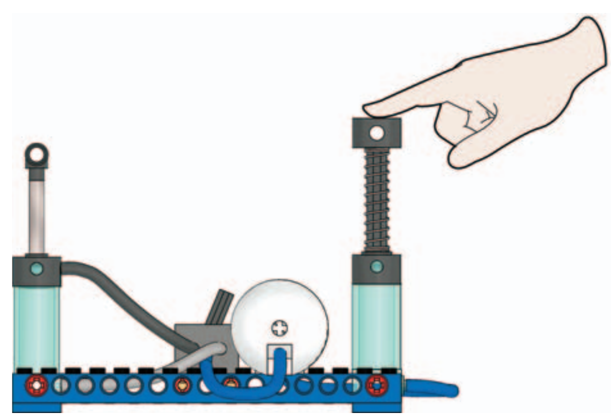
4A

Build 4A book 5 to step 13
Press down on the pump twice.
Explain what happened and why.



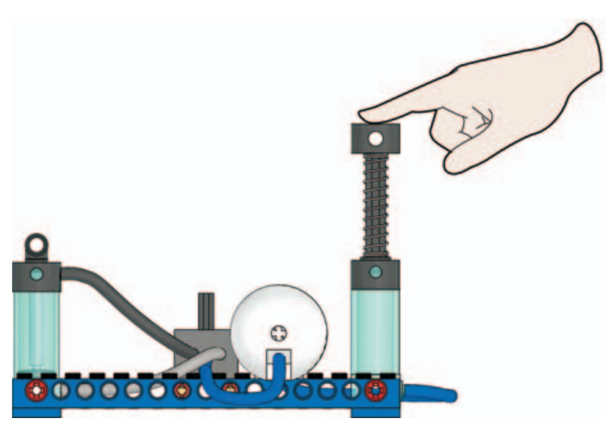
4B

Change the model as shown.
Press down on the pump twice.
Explain what happened and why.

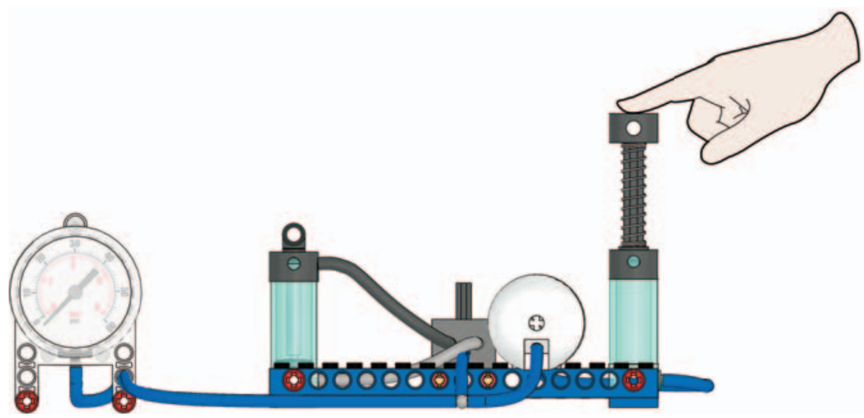


4C

Change the model as shown.
Press down on the pump twice.
Explain what happened and why.
How many pumps are needed to fill the tank completely?



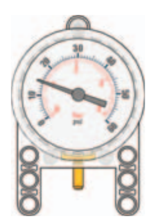
Air tank Manometer Piston Rod Piston Tube Air port Pump Valve Cylinder Force

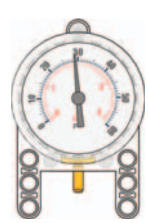


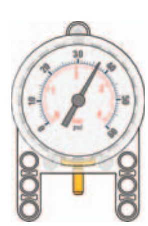
5A

Build 5A book 5 to step 17
Press down on the pump twice.
Explain what happened and why.
Then keep pumping.
What's the highest pressure you can obtain?

Test how many times can you extend and retract the piston rod when using 1 bar of pressure.
Then do the same test using 2 and 2.5 bars?







Scissor Lift

Science
- Area
- Behaviour of gases under pressure
- Forces

Design & Technology
- Assembling components
- Control of mechanisms
- Evaluating
- Using mechanisms – levers

Vocabulary
- Compression
- Cylinder
- Force
- Levers
- Manometer
- Pressure
- Pump
- Valve
- Weight

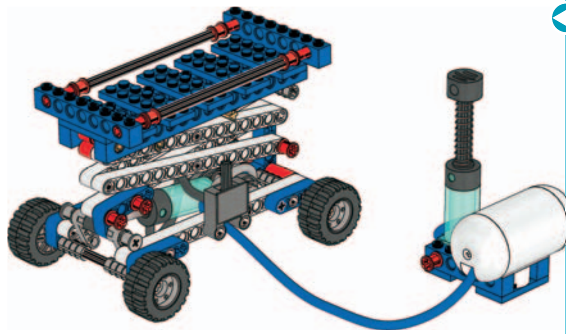
Connect

Scissor lifts are designed for easy and safe access to elevated positions and are often used where ladders are not an option. A scissor lift's work platform provides space for tools and movement, and can lift a heavy load.

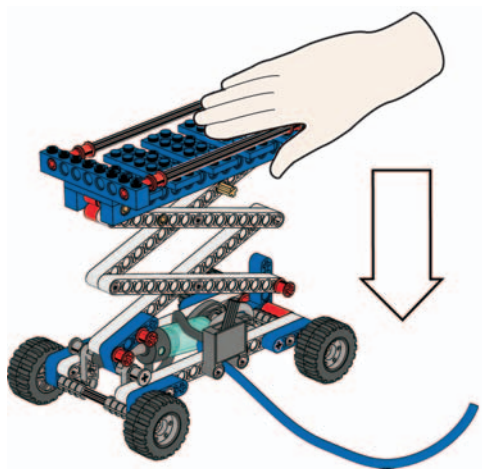
Build the Scissor Lift and investigate how its function is influenced by weight and height. Let's find out!

Construct

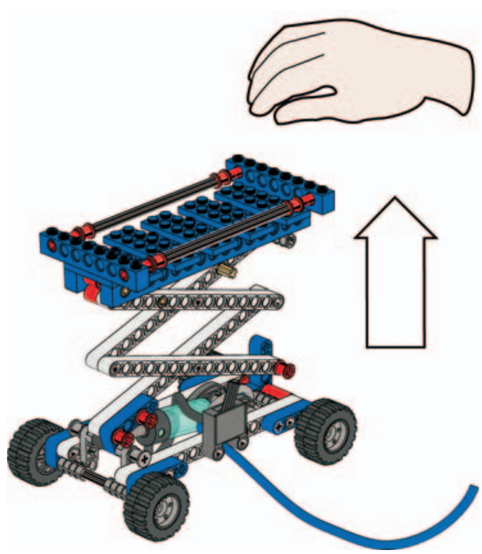
Build the Scissor Lift.
(All of book 1A and book 1B to page 11, step 15)



- Pump air into the system and make sure the Scissor Lift raises smoothly
- Press down on the platform of the raised Scissor Lift



- When you let go, the platform should bounce back up again. If not, check for air leaks
- Then lower the Scissor Lift and empty the air tank



Hint
The easiest way to empty the air tank is to disconnect the tube going from the air tank to the valve.

Contemplate

Going Up?

Find out what influence weight and height have on the number of pumps needed to raise the Scissor Lift to its maximum height.

First, predict how many pumps are needed to raise Scissor Lift A to its maximum height.
Record your predictions on the worksheet.

Then, test how many pumps are needed.
Record your findings on the worksheet.

Next, follow the same procedure for Scissor Lifts B, C and D.
Test several times to make sure your results are consistent.

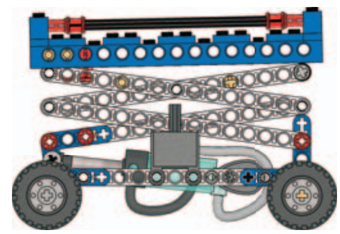
Scissor Lift A (page 11, step 15) needs about 12 pumps

Scissor Lift B (page 12, step 16) needs about 20 pumps

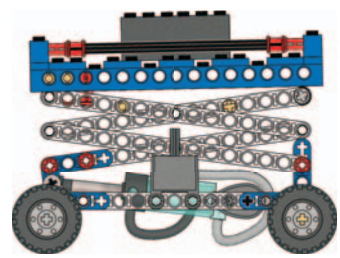
Scissor Lift C (page 17, step 21) needs about 17 pumps

Scissor Lift D (page 18, step 22) needs about 28 pumps

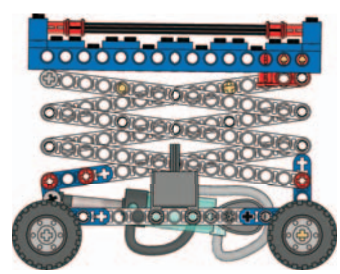
A



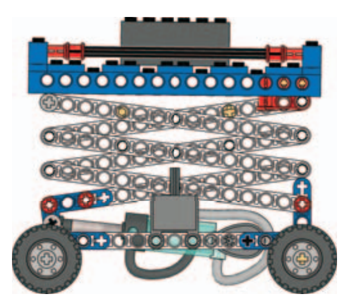
B



C



D



Have the students reflect on their investigations by asking questions such as:

- What did you predict would happen and why?
- How does the Scissor Lift work?
  It is a series of first class levers each squeezing the next one. The pivot points are the pegs in the centre of the beams.
- How did you make sure the tests were fair?
  Did you empty the air tank?

Continue

How much pressure is needed?

You know how many pumps are needed to raise the Scissor Lift to its maximum height. Now add the manometer and find out how much pressure is needed (page 20, step 24).

First, predict how much pressure is needed to raise Scissor Lift A to its maximum height. *Record your prediction on the worksheet.*

Then, test how much pressure is needed. *Record your findings on the worksheet.*

Next, follow the same procedure for Scissor Lifts B, C and D.
Test several times to make sure your results are consistent.

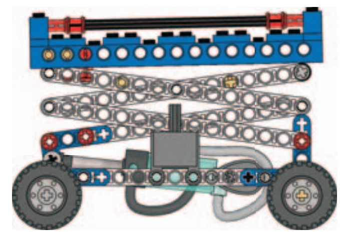
Scissor Lift A (page 11, step 15) needs a pressure of about 1.0 bar

Scissor Lift B (page 12, step 16) needs a pressure of about 1,5 bars

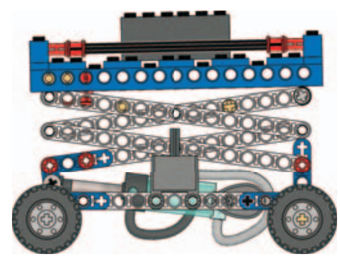
Scissor Lift C (page 17, step 21) needs a pressure of about 1,4 bars

Scissor Lift D (page 18, step 22) needs a pressure of about 2,1 bars

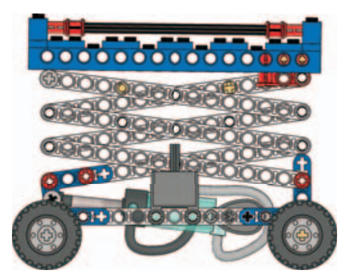
A



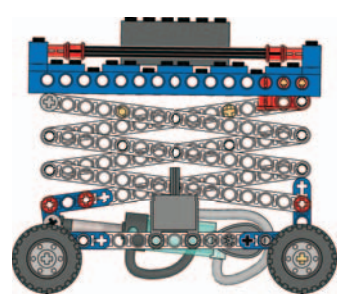
B



C



D



Optional: Further investigations

- Why does the pressure drop immediately after the Scissor Lift has reached its maximum height?
  When the cylinder piston extends the total area for compressed air has increased. The pressure adaptation the new total area results in a small pressure drop.

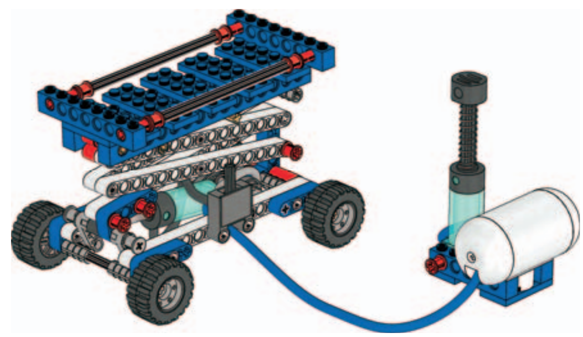
Scissor Lift

Name(s):

Build the Scissor Lift and investigate how its function is influenced by weight and height. Let's find out!

Build the Scissor Lift.

(All of book 1A and book 1B to page 11, step 15)



- Pump air into the system and make sure the Scissor Lift raises smoothly
- Press down on the platform of the raised Scissor Lift
- When you let go, the platform should bounce back up again. If not, check for air leaks
- Then lower the Scissor Lift and empty the air tank

Going Up?

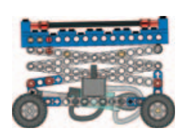
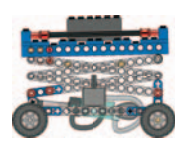
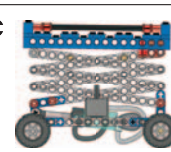
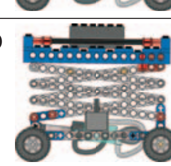
Find out what influence weight and height have on the number of pumps needed to raise the Scissor Lift to its maximum height.

First, predict how many pumps are needed to raise Scissor Lift A to its maximum height.

Then, test how many pumps are needed.

Next, follow the same procedure for Scissor Lifts B, C and D.

Test several times to make sure your results are consistent.

	My prediction	My findings
A 		
B 		
C 		
D 		

Explain your findings:

How much pressure is needed?

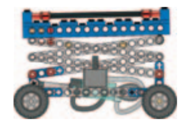
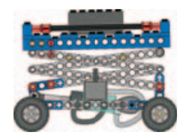
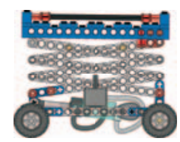
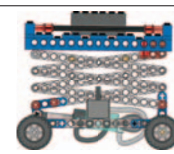
You know how many pumps are needed to raise the Scissor Lift to its maximum height. Now add the manometer and find out how much pressure is needed.

First, predict how much pressure is needed to raise Scissor Lift A to its maximum height.

Then, test how much pressure is needed.

Next, follow the same procedure for Scissor Lifts B, C and D.

Test several times to make sure your results are consistent.

	My prediction	My findings
A 		
B 		
C 		
D 		

Optional: My Amazing Pneumatic ____________ !

Invent a new and useful machine that uses the same mechanism as the Scissor Lift but does a different job. Sketch it and explain the three most important features.

Optional: Further Research

Describe some of the industries and jobs the Scissor Lift is used for and what some of its limitations might be.

Robot Hand

Science
- Behaviour of gases under pressure
- Forces
- Friction
- Measuring weight
- Scientific investigation

Design & Technology
- Assembling components
- Evaluating
- Testing before making improvements
- Using mechanisms – levers

Vocabulary
- Circumference
- Cylinder
- Force
- Grip
- Levers
- Manometer
- Mass
- Pressure
- Pump
- Valve
- Weight

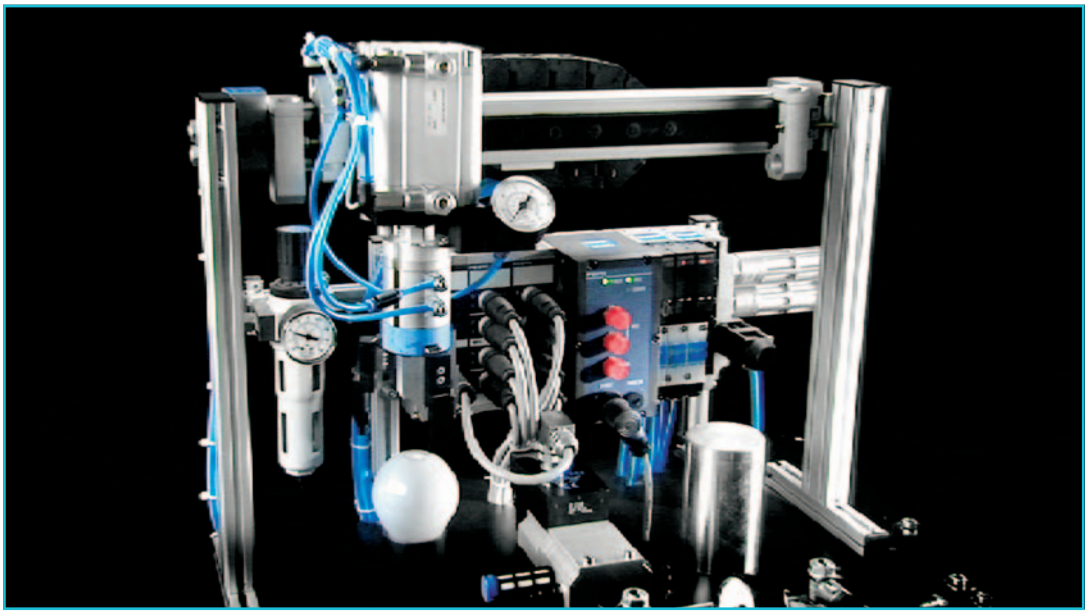
Other materials required
- A collection of small objects of different size and weight
- Plastic cup

Optional
- Modelling clay
- Rubber bands
- Weighing machine

Connect

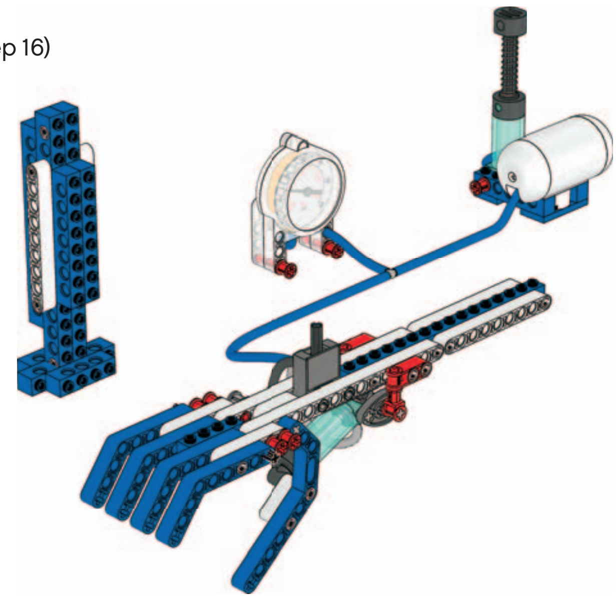
Industry and hospitals often need to handle and move objects that can be dangerous to touch by hand. Metal objects and fragile glass containers, for example, are often handled using pneumatic hands or grippers.

Build the Robot Hand and investigate what pressure is needed to hold different objects without dropping or crushing them.
Let's find out!

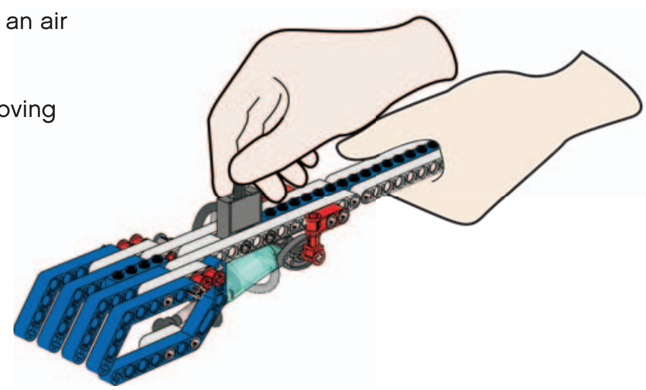


Construct

Build the Robot Hand and the carrier.
(All of book 2A and book 2B to page 10, step 16)



- Pump air into the system and use the manometer to detect whether there is an air leak
- Try the valve settings and check all moving parts to ensure that they move freely



- Then open the hand and empty the air tank

Hint
The easiest way to empty the air tank is to disconnect the tube going from the air tank to the valve.

Contemplate

How good a grip?

The Robot Hand can pick up the carrier from two different sides – the smooth white side and the studded blue side. Find out how much pressure the Robot Hand needs to pick up the carrier.

First, predict how much pressure the Robot Hand needs to lift carrier A.
Record your findings on the worksheet.

Then, test how much pressure is needed.
Record your findings on the worksheet.

Next, follow the same procedure for Robot Hands B, C and D.
Test several times to make sure your results are consistent.

Robot Hand A (page 10, step 16) needs a pressure of about 0.5 bar

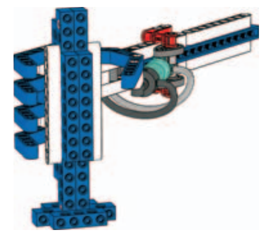
Robot Hand B (page 10, step 16) needs a pressure of about 0.4 bar

Robot Hand C (page 12, step 18) needs a pressure of about 1.2 bars

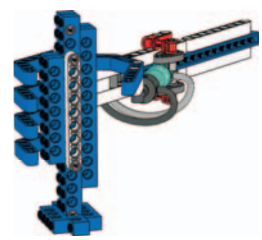
Robot Hand D (page 12, step 18) needs a pressure of about 1.0 bar

Does weight have an effect?
When carrying extra weight, the type of surface does matter. Extra friction and gripping points on the load mean less crushing pressure is needed. This is safer and more efficient.

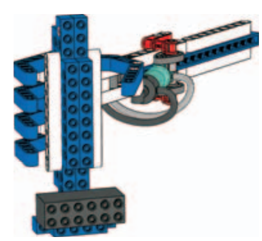
A



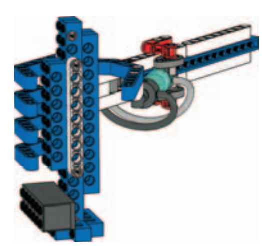
B



C



D



Have the students reflect on their investigations by asking questions such as:

- What did you predict would happen and why?
- How does the Robot Hand work and what type of lever system does it use?
  The gripping thumb is a third class lever. The pivot is at the wrist.
- What are the limitations of the Robot Hand's grip?
  The fingers and thumb are too slippery and do not have enough friction.
  The fingers do not bend in and grip like real fingers.

Continue

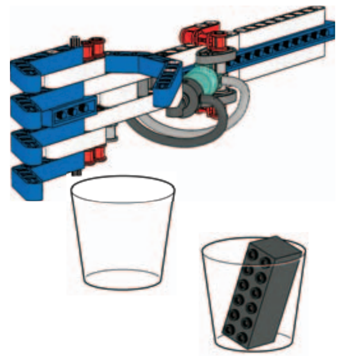
What else can the Robot Hand hold?

Prepare a fragile paper or plastic cup. Find a variety of different objects to put in the cup. Find out how much pressure is needed for the Robot Hand to pick up the cup.

First, predict how much pressure the Robot Hand needs to lift the different objects without damaging them.
Record your prediction on the worksheet.

Then, test how much pressure is needed.
Record your findings on the worksheet.

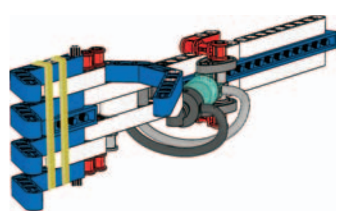
Test several times to make sure your results are consistent.



Hint
Make an egg-shaped object out of modelling clay. Marks on the clay's surface can be used to record damage caused by pressure.
But remember to wrap it in cling film to keep the elements clean.

Optional: Further investigations

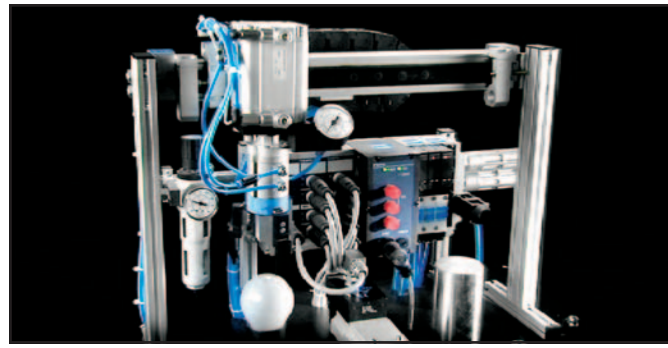
Need a better grip?
Experiment by adding different materials to the Robot Hand for a better and safer grip that also causes less damage.



Robot Hand

Name(s):

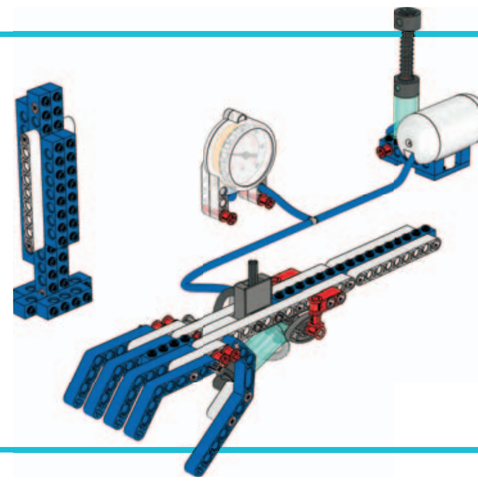
Build the Robot Hand and investigate what pressure is needed to hold different objects without dropping or crushing them. Let's find out!



Build the Robot Hand and the carrier.

(All of book 2A and book 2B to page 10, step 16)

- Pump air into the system and use the manometer to detect whether there is an air leak
- Try the valve settings and check all moving parts to ensure that they move freely
- Then open the hand and empty the air tank



How good a grip?

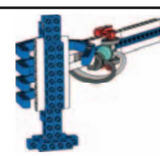
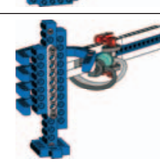
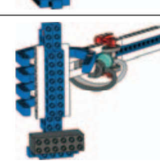
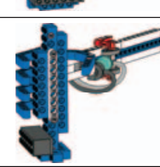
The Robot Hand can pick up the carrier from two different sides – the smooth white side and the studded blue side. Find out how much pressure the Robot Hand needs to pick up the carrier.

First, predict how much pressure the Robot Hand needs to lift carrier A.

Then, test how much pressure is needed.

Next, follow the same procedure for Robot Hands B, C and D.

Test several times to make sure your results are consistent.

	My prediction	My findings
A 		
B 		
C 		
D 		

Explain your findings:

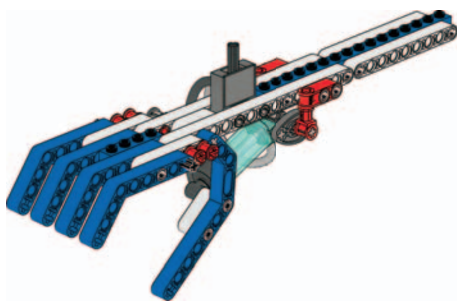
What else can the Robot Hand hold?

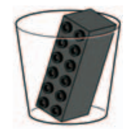
Prepare a fragile paper or plastic cup. Find a variety of different objects to put in the cup. Find out how much pressure is needed for the Robot Hand to pick up the cup.

First, predict how much pressure the Robot Hand needs to lift the different objects without damaging them.

Then, test how much pressure is needed.

Test several times to make sure your results are consistent.



Object	My prediction	My findings
A 		
B 		
C		
D		

Optional: My Amazing Pneumatic ______!

Invent a new and useful machine that uses the same mechanism as the Robot Hand but does a different job. Sketch it and explain the three most important features.

Optional: Further Research

Describe some of the industries and jobs the Robot Hand is used for and what some of its limitations might be.

Stamping Press

Science
- Area
- Behaviour of gases under pressure
- Forces
- Scientific investigation

Design & Technology
- Assembling components
- Control of mechanisms
- Evaluating
- Properties of materials
- Using mechanisms – levers

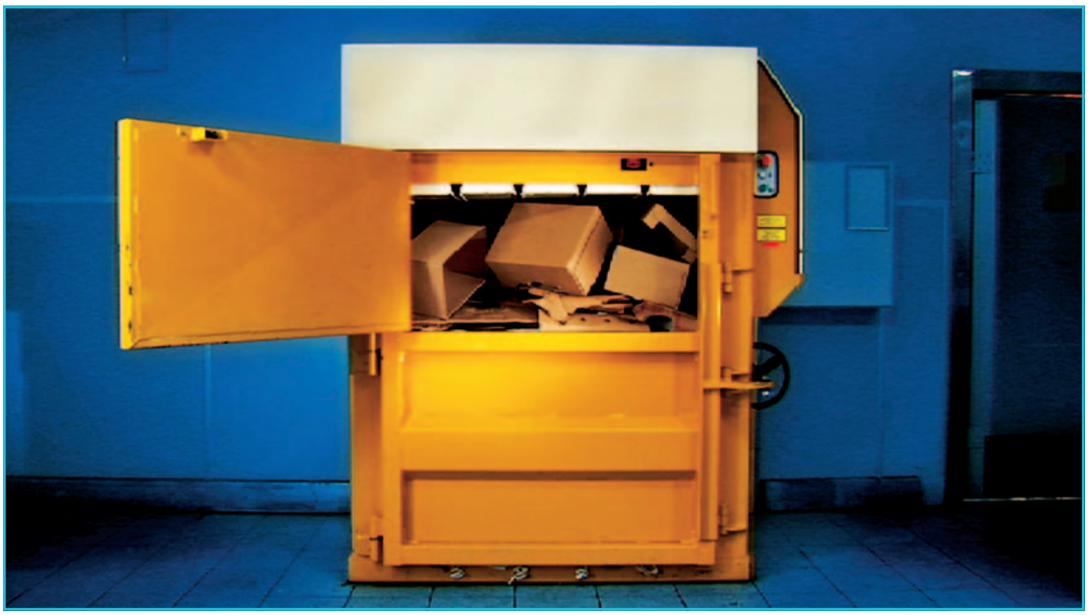
Vocabulary
- Area
- Cylinder
- Efficiency
- Force
- Levers
- Manometer
- Mass
- Pressure
- Pump
- Valve

Other materials required
- Aluminium foil or cling film
- Clay or small pieces polystyrene foam
- Graph paper
- Stopwatch or timer

Connect

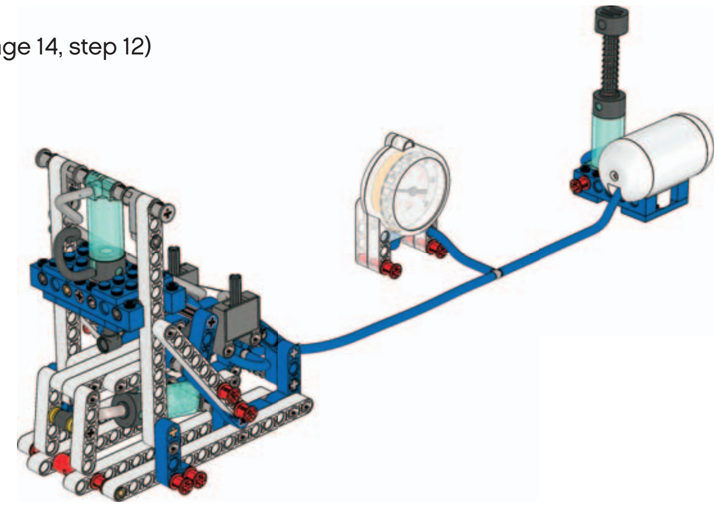
A stamping press stamps or presses a material into a new shape or size. To be as efficient as possible, the process needs to use the least amount of energy possible, yet work as fast as possible.

Build the Stamping Press and investigate how energy efficient it is.
Let's find out!

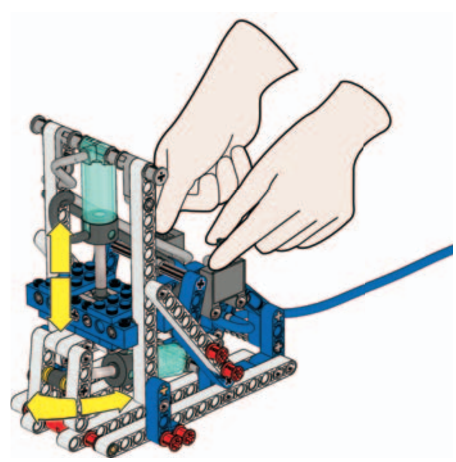


Construct

Build the Stamping Press.
(All of book 3A and book 3B to page 14, step 12)



- Pump air into the system and use the manometer to detect whether there is an air leak
- Try all valve settings and test if the Stamping Press can do all four possible strokes; press down, press up, ejector down, and ejector up. Make sure all moving parts move freely



- Then move the press up, the ejector forward and empty the air tank

Hint
The easiest way to empty the air tank is to disconnect the tube going from the air tank to the valve.

Contemplate

How energy efficient is your press?

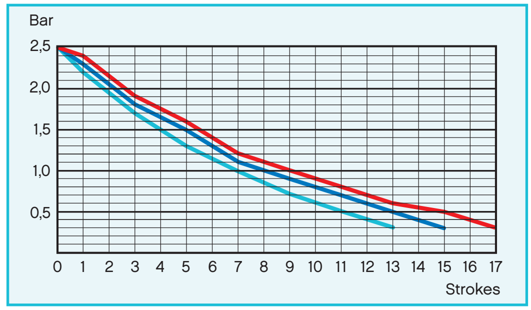
One complete work cycle is four 'strokes' in sequence; press down, press up, ejector down, and ejector up. Find out how repeated work cycles affect loss of pressure.

First, predict how repeated work cycles affect the loss of pressure when working with empty Stamping Press A.
Record your predictions on the graph paper as a dotted line starting at 2.5 bars and ending near zero bar. Remember it doesn't have to be a straight line.

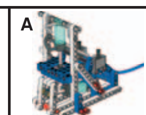
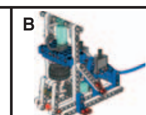
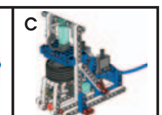
Then, test how Stamping Press A's repeated work cycles actually affect the loss of pressure.
Start with 2.5 bars of pressure.
Record your findings on the graph paper.

Next, follow the same procedure for Stamping Presses B and C.

Test several times to make sure your results are consistent.



Hint
For a more accurate graph, record your findings after each stroke.

	A 	B 	C 
1	2.2	2.3	2.3
3	1.7	1.8	1.9
5	1.3	1.5	1.6
7	1.0	1.1	1.2
9	0.7	0.9	1.0
11	0.5	0.7	0.8
13	0.3	0.5	0.6
15		0.3	0.5
17			0.3

Have the students reflect on their investigations by asking questions such as:

- What did you predict would happen and why?
- How does the Stamping Press work, and which type of lever is used?
  The stamper delivers a direct press and the ejector uses a complex second class lever.
- How many complete work cycles can you do when starting with 2.5 bars of pressure?
  About three complete work cycles.

Continue

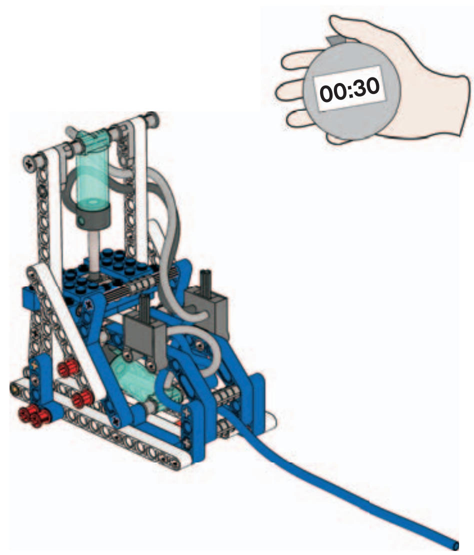
How good of a press operator are you?

The faster you can operate the empty Stamping Press, the more cost efficient it will be. Find out how many complete work cycles you can finish in 30 seconds.

First, predict how many complete work cycles you can finish in 30 seconds when using an empty Stamping Press.
Record your predictions on the worksheet.

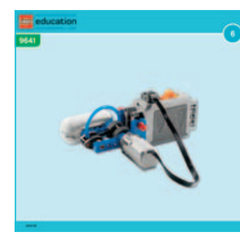
Then, test how many complete work cycles you actually finished.
Record your findings on the worksheet.

Next, try pressing different objects of your choice and compare the number of complete work cycles you are able to finish.



Hint
Before you start, it is a good idea to decide if you are starting with an empty or full air tank.

Hint
To help overcome the loss of pressure, you could build a compressor.



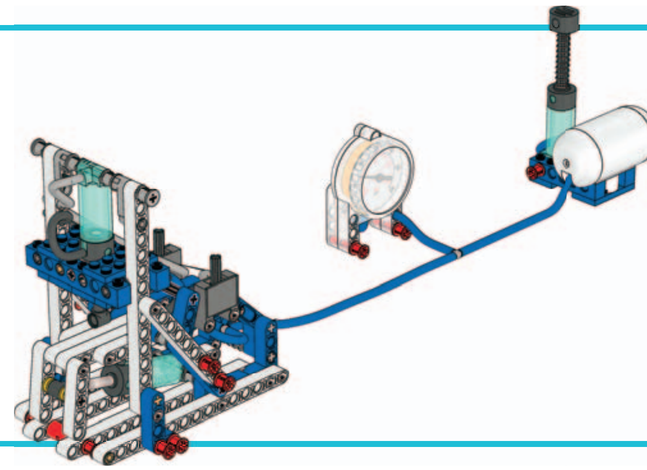
Stamping Press

Name(s):

Build the Stamping Press and investigate how energy efficient it is.
Let's find out!

Build the Stamping Press.

(All of book 3A and book 3B to page 14, step 12)



- Pump air into the system and use the manometer to detect whether there is an air leak
- Try all valve settings and test if the Stamping Press can do all four possible strokes; press down, press up, ejector down and ejector up. Make sure all moving parts move freely
- Then move the press up, the ejector forward and empty the air tank

How energy efficient is your press?

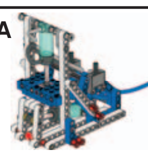
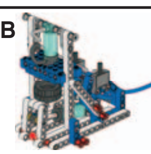
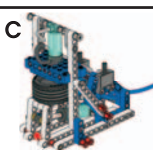
One complete work cycle is four 'strokes' in sequence; press down, press up, ejector down and ejector up. Find out how repeated work cycles affect loss of pressure.

First, predict how repeated work cycles affect the loss of pressure when working with empty Stamping Press A.

Then, test how Stamping Press A's repeated work cycles actually affect the loss of pressure.
Start with 2.5 bars of pressure.

Next, follow the same procedure for Stamping Presses B and C.

Test several times to make sure your results are consistent.
Record your result on graph paper.

	A 	B 	C 
1			
3			
5			
7			
9			
11			
13			
15			
17			

Explain your findings:

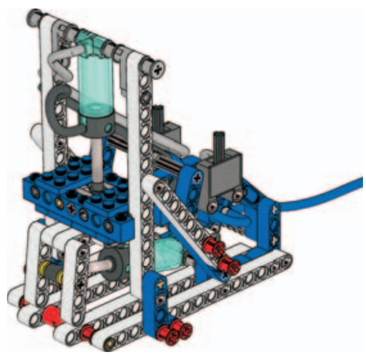
How good of a press operator are you?

The faster you can operate the empty Stamping Press, the more cost efficient it will be. Find out how many complete work cycles you can finish in 30 seconds.

First, predict how many complete work cycles you can finish in 30 seconds when using an empty Stamping Press.
Record your predictions on the worksheet.

Then, test how many complete work cycles you actually finished.
Record your findings on the worksheet.

Next, try pressing different objects of your own choice and compare the number of complete work cycles you are able to finish.



	My prediction	My findings
Test 1		
Test 2		
Test 3		

Optional: My Amazing Pneumatic ________________ !

Invent a new and useful machine that uses the same mechanisms as the Stamping Press but does a different job. Sketch it and explain the three most important features.

Optional: Further Research

Describe some of the industries and jobs the Stamping Press is used for and what some of its limitations might be.

Robot Arm

Science
- Area
- Behaviour of gases under pressure
- Friction
- Scientific investigation

Design & Technology
- Assembling components
- Control of mechanisms
- Evaluating
- Testing before making improvements
- Using mechanisms – levers

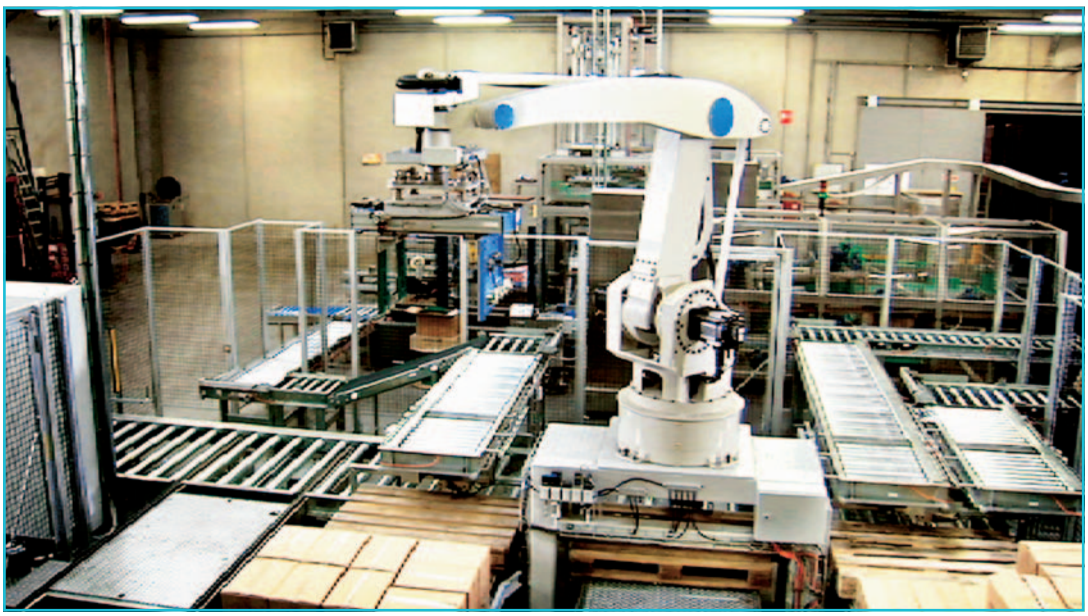
Vocabulary
- Area
- Cylinder
- Grip
- Levers
- Manometer
- Mass
- Pressure
- Pump
- Valve

Other materials required
- A collection of small objects of different size and weight
- Graph paper
- Several small pieces of crumpled up paper

Connect

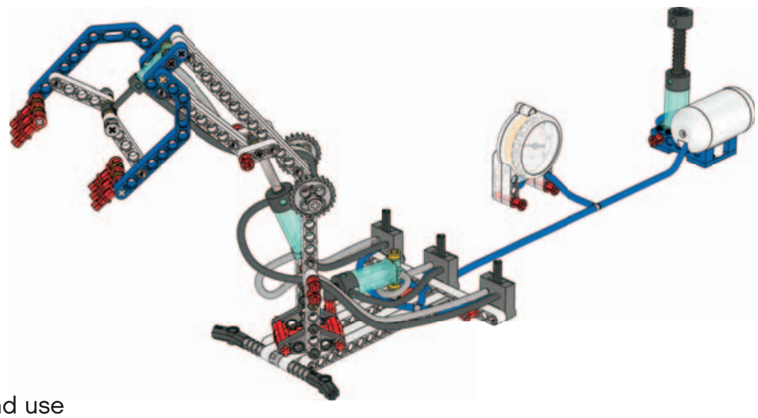
Robotic arms are used for jobs that involve picking up, moving and placing objects. Usually they do jobs which are difficult or repetitive, and need to be done quick and efficiently. To achieve maximum efficiency, the picking and placing sequence needs to be decided beforehand.

Build the Robot Arm and investigate how to make the most energy efficient sequence of strokes. Let's find out!

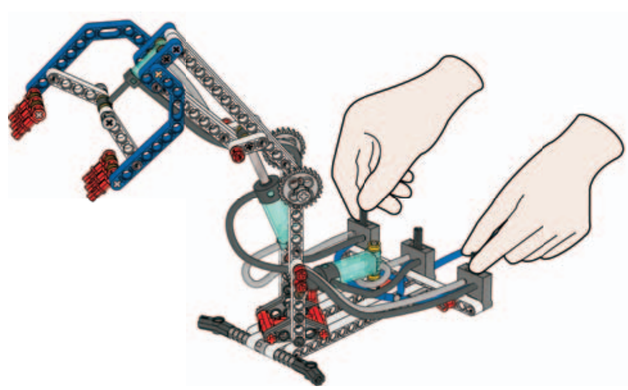


Construct

Build the Robot Arm.
(All of book 4A and book 4B to page 19, step 19)



- Pump air into the system and use the manometer to detect whether there is an air leak
- Try all valve settings and check all moving parts to ensure that they move freely



- Then turn the arm to its resting position: turned to the far right, arm up and grippers open, and empty the air tank

Hint
The easiest way to empty the air tank is to disconnect the tube going from the air tank to the valve.

Contemplate

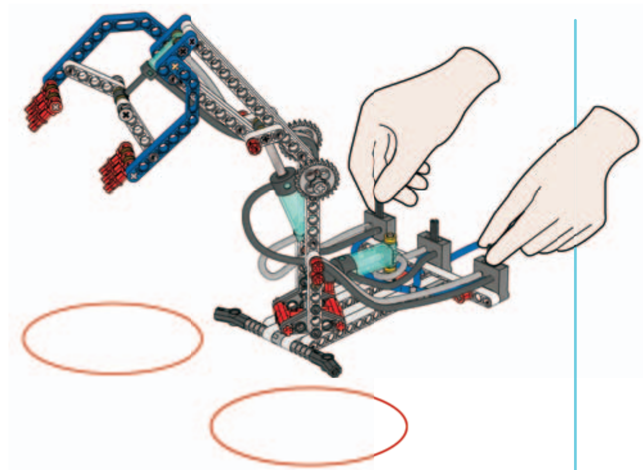
What is the most energy efficient sequence?

Find out which sequence is the most energy efficient for picking and placing objects.

First, predict which sequence of strokes is the most energy efficient at picking and placing a pellet of paper. Your sequence has to start in the resting position, use all six movements at least once and then return to the resting position.
Record your predictions on the worksheet.

Then, test your sequence of strokes and note the loss of pressure after each stroke.
Start with 2.5 bars of pressure.
Record your findings on the worksheet and graph paper.

Test several times to make sure your results are consistent.



Stroke	My sequence
A	Arm down
B	Grip close
C	Arm up
D	Arm turn left
E	Arm Down
F	Grip open
G	Arm up
H	Arm turn right

Have the students reflect on their investigations by asking questions such as:

- What did you predict would happen and why?
  It takes eight strokes to complete the work cycle and back to the resting position.
  If the object is dropped without lowering the arm it can be done in six strokes.
- How does the Robot Arm work?
  The gripper is a complex third class lever linkage. The arm lift is a third class lever too.
- Can you explain any features of the pressure graph?
  The small cylinder uses much less air resulting in less pressure loss than the big cylinders. See stroke B and F.

Continue

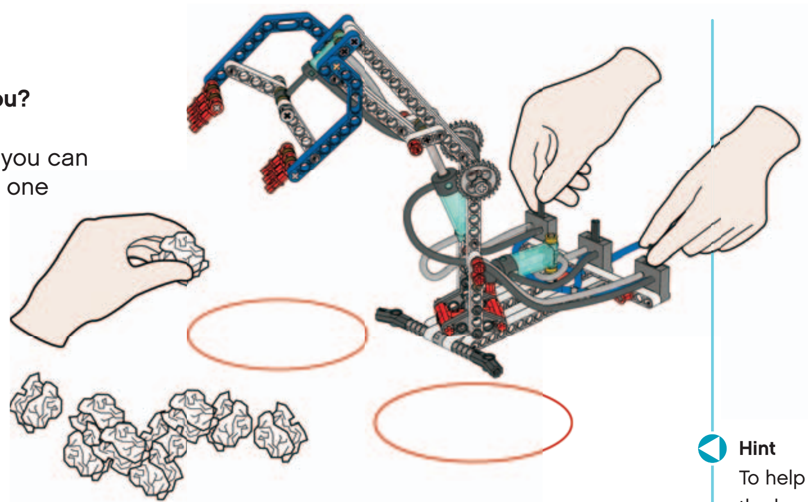
How good of a robot operator are you?

Find out how quickly and accurately you can pick and place pellets of paper from one circle to another

First, predict how many pellets you can accurately place within the circle in 30 seconds.
Record your predictions on the worksheet.

Then, test how many pellets you actually place accurately within the circle in 30 seconds.
Record your findings on the worksheet.

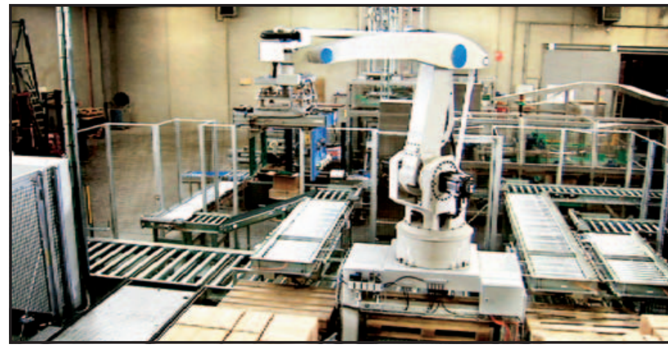
Repeat the test three times to see if your speed and accuracy improve.



Optional: How about new grippers?
Design and make your own grippers that will help you to pick and place different objects of your choice.

Hint
To help overcome the loss of pressure, you could build a compressor.

Robot Arm

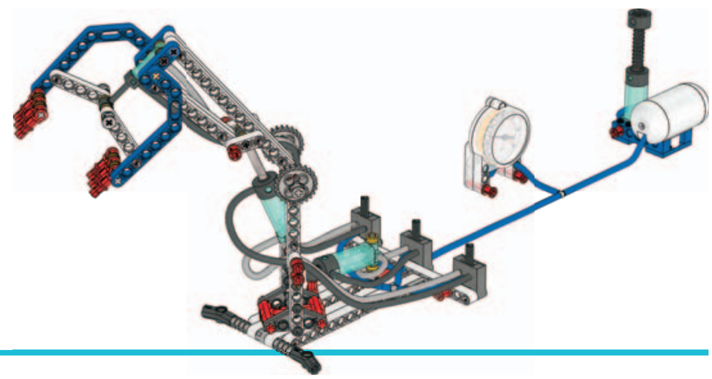


Name(s):

Build the Robot Arm and investigate how to make the most energy efficient sequence of strokes. Let's find out!

Build the Robot Arm.

(All of book 4A and book 4B to page 19, step 19)



- Pump air into the system and use the manometer to detect whether there is an air leak
- Try all valve settings and check all moving parts to ensure that they move freely
- Then turn the arm to its resting position: turned to the far right, arm up and grippers open, and empty the air tank

What is the most energy efficient sequence?

Find out which sequence is the most energy efficient for picking and placing objects.

First, predict which sequence of strokes is the most energy efficient at picking and placing a pellet of paper. Your sequence has to start in the resting position, use all six movements at least once and then return to the resting position.

Then, test your sequence of strokes and note the loss of pressure after each stroke.
Start with 2.5 bars of pressure.

Test several times to make sure your results are consistent.
Record your findings on graph paper.

Stroke	My sequence
A	
B	
C	
D	
E	
F	
G	
H	

Explain your findings:

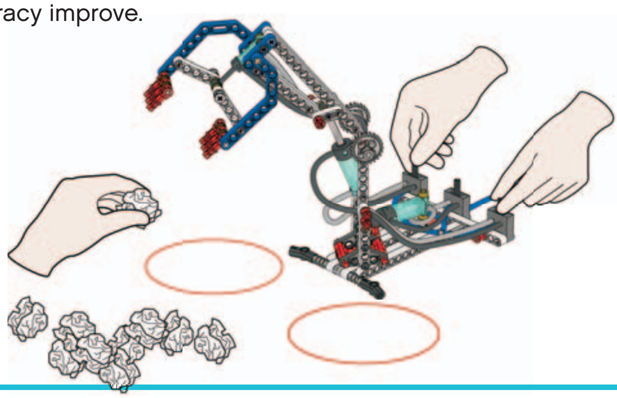
How good of a robot operator are you?

Find out how quickly and accurately you can pick and place pellets of paper from one circle to another circle.

First, predict how many pellets you can accurately place within the circle in 30 seconds.

Then, test how many pellets you can accurately place within the circle in 30 seconds.

Repeat the test three times to see if your speed and accuracy improve.



	My prediction	My findings
Test 1		
Test 2		
Test 3		

Optional: My Amazing Pneumatic ______ !

Invent a new and useful machine that uses the same mechanisms as the Robot Arm but does a different job. Sketch it and explain the three most important features.

Optional: Further Research

Describe some of the industries and jobs the Robot Arm can be used for and what some of its limitations might be.

Introduction to the designing and making activities

When is it best to use these?

They are ideal to use after you have worked on the principle and main activities, and you wish to find out how well your students can find and apply knowledge in designing and problem-solving. Each assignment is cross-referenced to the principle and main models. The students will creatively adapt their previous experiences with pneumatic concepts to solve the design task.

How to use them?

The assignment page is intended to be printed and handed out to your students. The page describing objectives, motivation, etc. are for you.


Dinosaur

How to customise the designing and making activities to fit your students.

For the less experienced designers or where you need more control over demands on materials, hand out the assignment and give them a specific design brief. A design brief can limit the range of possible solutions, and make it easier to compare the various ideas that students come up with. For experienced designers, just handing out and presenting them with the assignment section should be enough for them to start designing.


Dinosaur

Dinosaur

The assignment

A small film studio needs a dinosaur for a new film. Although they could can use computer-generated images for the dinosaur, the film studio has found that true-to-life, full size moving models of dinosaurs have greater appeal.
The dinosaur must be stationary, but parts of it must move as it acts out the scene.

Your task is to design and make a dinosaur model that has pneumatic movement and will work in a film scene.

Dinosaur

Objectives
Applying knowledge of:
- Animatronics
- Levers
- Product and services
- Pneumatics
- Applying principles of fair testing and product reliability

Other materials required
- Decorative materials

Motivation
- Instruct the students to look at the pictures of the dinosaur or search the Internet to learn more about the appearance, shape and form of dinosaurs from different periods.

Relating knowledge, skill and understanding to the task at hand
Instruct the students to…
- Ask yourself how you might create the dinosaur?
- Ask yourself which parts of your dinosaur will move and how you might achieve this movement?
- Ask yourself how you might decorate your dinosaur so that they look as real as possible?

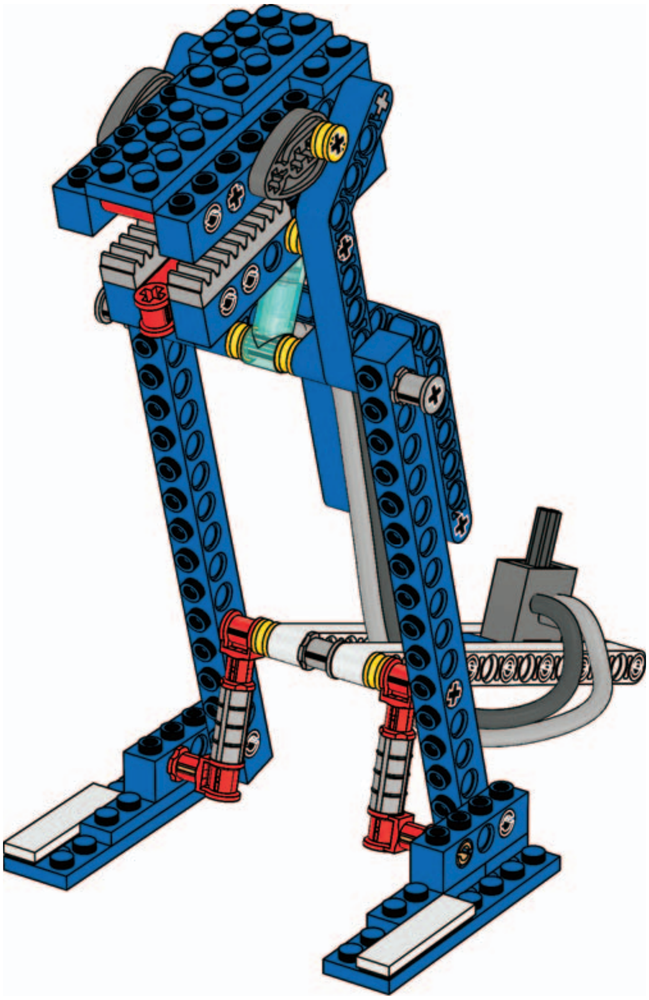
Encouraging reflection
Whilst the designing and making is in progress, encourage the students to discuss…
- If the movements of the dinosaurs make sense in terms of a film scene.

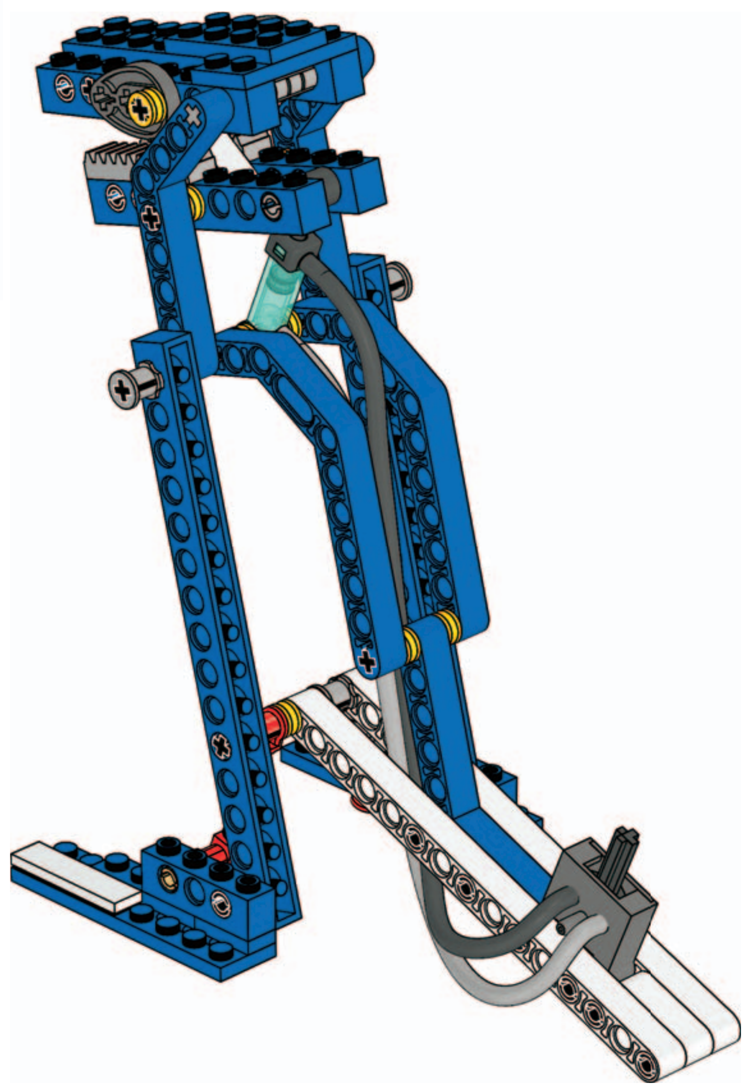
When the activity is finished, encourage the students to evaluate…
- How the various dinosaur parts work?
- How well does the dinosaur work and whether it is reliable or not?
- Is the dinosaur efficient? Test this with the manometer.
- How is the model decorated to look like a dinosaur?
- What your concept for the film scene looks like? Explain how this will appeal to a cinema audience.

Need help?
Look at:

Robot Arm

Principle models for levers





Scarecrow

The assignment

A local organic farmer has a lot of problems with birds eating his crops. He knows from experience that when he runs into his field waving his arms wildly and jumping up and down the birds fly away. Shouting at the birds without the movement, however, has little effect. He has tried using a conventional scarecrow, which does not move. Although it frightened the birds away in the beginning, they soon became used to it and it no longer makes any difference.

Your task is to design and make a pneumatic scarecrow model that moves in a way that will scare off the birds that are trying to eat the farmer's crops.

Scarecrow

Objectives
Applying knowledge of:
- Animatronics
- Levers
- Product and services
- Pneumatics
- Applying principles of fair testing and product reliability

Other materials required
- Decorative materials

Motivation
- Instruct the students to look at the picture of the scarecrow or search the Internet to learn about the appearance, shape and form of traditional and unconventional scarecrows.

Relating knowledge, skill and understanding to the task at hand
Instruct the students to…
- Ask yourself how you might create the scarecrow?
- Ask yourself which parts of the scarecrow will move and how you might achieve this movement?
- Ask yourself how you might decorate your scarecrow so that it looks as real as possible?

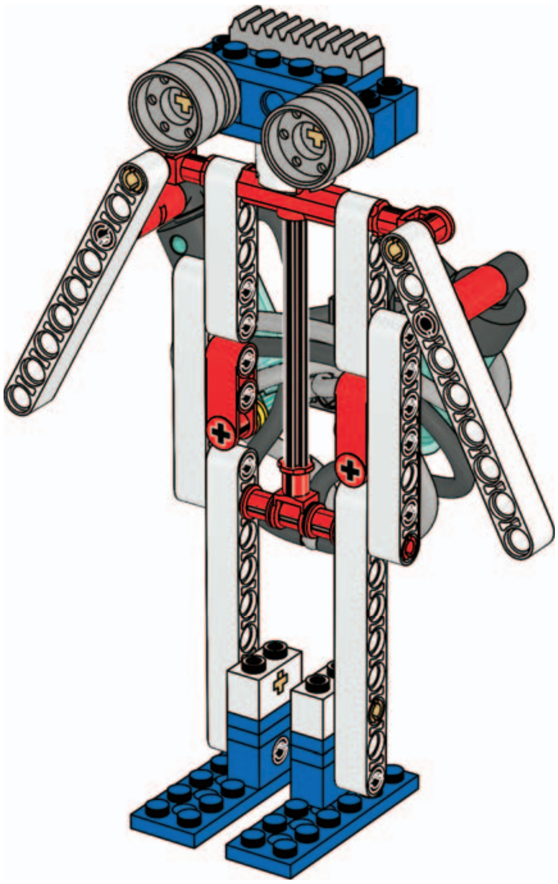
Encouraging reflection
Whilst the designing and making is in progress. encourage the students to discuss…
- If the movements of the scarecrow make sense in terms of scaring off birds

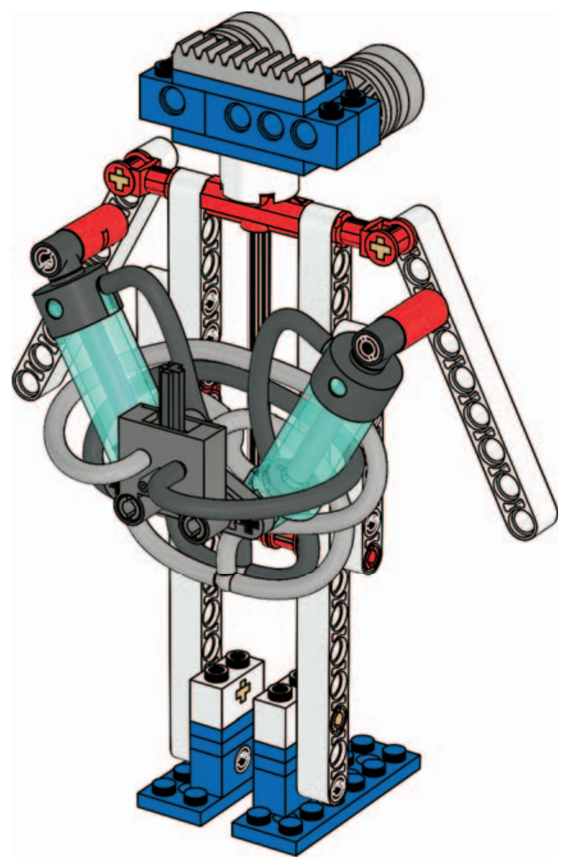
When the activity is finished, encourage the students to evaluate…
- How the various scarecrow parts work?
- How well does the scarecrow work and whether it is reliable or not?
- Is the Scarecrow efficient? Test this with the manometer.
- How is the model decorated to look like a scarecrow?

Need help?
Look at:

Robot Hand

Principle models
for levers





Glossary

A	**Air tank**	A storage tank, or reservoir, for compressed air.
B	**Balanced force**	An object under the influence of balanced forces is at rest or moves at a uniform velocity.
	Bar	A common metric unit used for pressure measurement. 1 bar equals 100,000 Pascals.
C	**Circumference**	The distance around a circle.
	Compressibility	The characteristic of substances, such as gases, that can be compressed so that they occupy less space to fit into smaller containers.
	Compressor	A mechanism used to compress air. A compressor could be motorized or operated manually.
	Cylinder	A rigid barrel with closed ends containing a piston and a piston rod. When compressed air enters the cylinder, it expands against the piston, producing force and creating movement.
	Cylinder Piston	See Piston.
E	**Efficiency**	A measure of how much of the force that goes into a machine comes out as useful work. Friction often wastes a lot of energy reducing the efficiency of a machine.
	Energy	The capacity to do work.
F	**Fair Testing**	Measuring the performance of a machine by comparing its performance under different conditions.
	Force	A push or a pull in a particular direction that can be applied to an object. The force created by a pneumatic cylinder is the product of the air pressure times the area of the piston.
	Friction	The resistance met when one surface is sliding over another, e.g. when an axle is turning in a hole or when you rub your hands together.
G	**Grip**	The grip between two surfaces depends on the amount of friction between them. Tyres grip dry road surfaces better than wet road surfaces.
K	**Kinetic energy**	The energy of an object that is related to its speed or movement. The faster it is travelling, the more kinetic energy it has.

L

Lever — A bar that pivots about a fixed point when an effort is applied to it.

Lever, first class — The pivot is between the effort and the load. A long effort arm and short load arm amplifies the force at the load arm. For instance prying the lid off a paint can. The Scissor Lift uses a first class lever.

Lever, second class — The load is between the effort and the pivot. This lever amplifies the force from the effort to make lifting the load easier; for instance a wheelbarrow.

Lever, third class — The effort is between the load and the pivot. This lever amplifies the speed and distance the load moves compared to the effort. The thumb of the Hand is a third class lever.

Linkages — A mechanical linkage carries movement and forces through a series of rods or beams connected by moving pivot points. The Scissor Lift contains many linkages.

M

Machine — A device that makes work either easier or faster to do. It usually contains mechanisms.

Manometer — A manometer is a pressure measuring instrument. The LEGO® manometer gives you a pressure reading in both bar and psi.

Mass — Mass is the quantity of matter in an object. Mass is often confused with weight.

Mechanism — A simple arrangement of components that transforms the size or direction of a force, and the speed of its output, such as a lever or two gears meshing.

P

Piston — A solid disk that moves inside a cylinder in response to changing pressure.

Piston rod — A rod connected to a piston and extending outside a cylinder. When the piston moves inside the cylinder, the piston rod also moves.

Pivot — The point around which something turns or rotates, such as the pivot of a lever. The pivot of a pair of scissors is the screw or rivet holding it together.

Pneumatic — Related to the use of compressed air.

Pneumatic circuit — The path of compressed air through a system of pneumatic components.

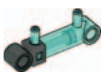
Potential energy — Stored energy. Compressed air has potential energy that can be used to do work when it expands against a piston in a cylinder.

Power — The rate at which a machine does work (work divided by time).

Pressure — The amount of force exerted on a unit area. Atmospheric pressure at sea level is approximately 15 pounds per square inch (psi) and we are so used to this that we don't notice it.
The scientific unit for pressure is the pascal (Pa) and 1 Pa is 1 newton per square metre. A newton is quite a small force and a square metre is a large area so the force per unit area of 1 Pa is tiny.
In fact it takes almost 7000 Pa to exert 1 psi and 100 000 Pa to exert atmospheric pressure.

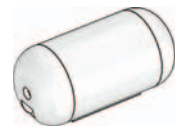
	Psi	Pounds force per square inch. Psi is common a unit used for pressure measurement. 1 psi equals 6894,76 Pascals
	Pump	A device that applies a force to a fluid, such as air or water, to create pressure or movement.
S	**Sequencing**	Setting up actions to happen in the right order and at the right time intervals.
T	**Tube**	Flexible, hollow cylindrical material used to transport a fluid, such as compressed air.
V	**Valve**	A device to accept compressed air and direct its flow through tubing to other compressed air components. A valve is controlled by a handle with several positions.
W	**Work**	The result of a force moving against a resistance through a distance. The act of compressing air is an example of doing work.

LEGO® Element Survey

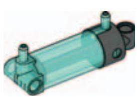


1x
Cylinder, small, transparent blue
4529337

1x
Pump, small, transparent blue
4529222

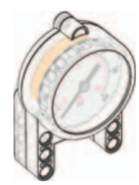


1x
Air tank, white
4529226



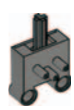
2x
Cylinder, large, transparent blue,
4529334

1x
Pump, large, transparent blue
4529341



1x
Manometer, transparent
4529230

5x
Tee, grey
4211508



3x
Valve, dark grey
4237158

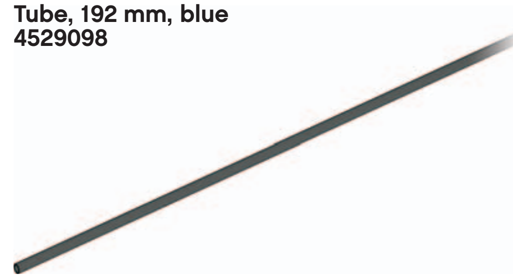
4x
Tube, 48 mm, blue
4529096

3x
Tube, 96 mm, blue
4529097

1x
Tube, 192 mm, blue
4529098

2x
Tube, 96 mm, black
4529099

1x
Tube, 192 mm, black
4529100



1x
Tube, 320 mm, black
4529102

2x
Tube, 96 mm, grey
4529103

1x
Tube, 192 mm, grey
4529104

1x
Tube, 320 mm, grey
4529105

The machines shown in the video sequences are kindly provided by:
Scissor Lift – Haulotte
Robot Hand – Aarhus Technical School
Stamping Press – Bramidan
Robot Arm – Sealing System A/S

UK source file, including curriculum objectives, has been developed in cooperation with David Barlex.
Localisation, translation & DTP: EICOM ApS, Denmark

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