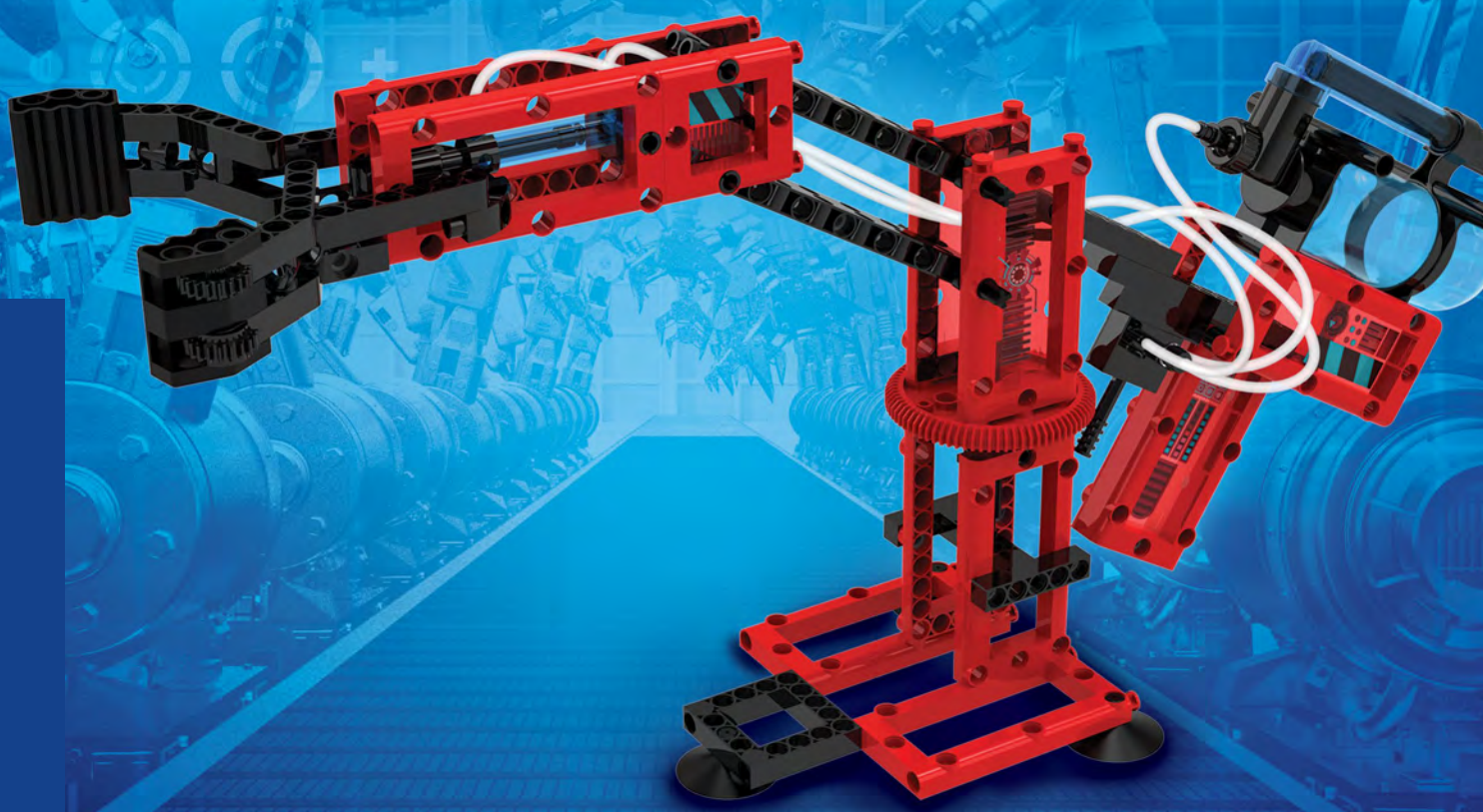
EXPERIMENT MANUAL

MECHANICAL ENGINEERING

ROBOTIC ARMS



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GOOD TO KNOW! If you are missing any parts, please contact Thames & Kosmos customer service.

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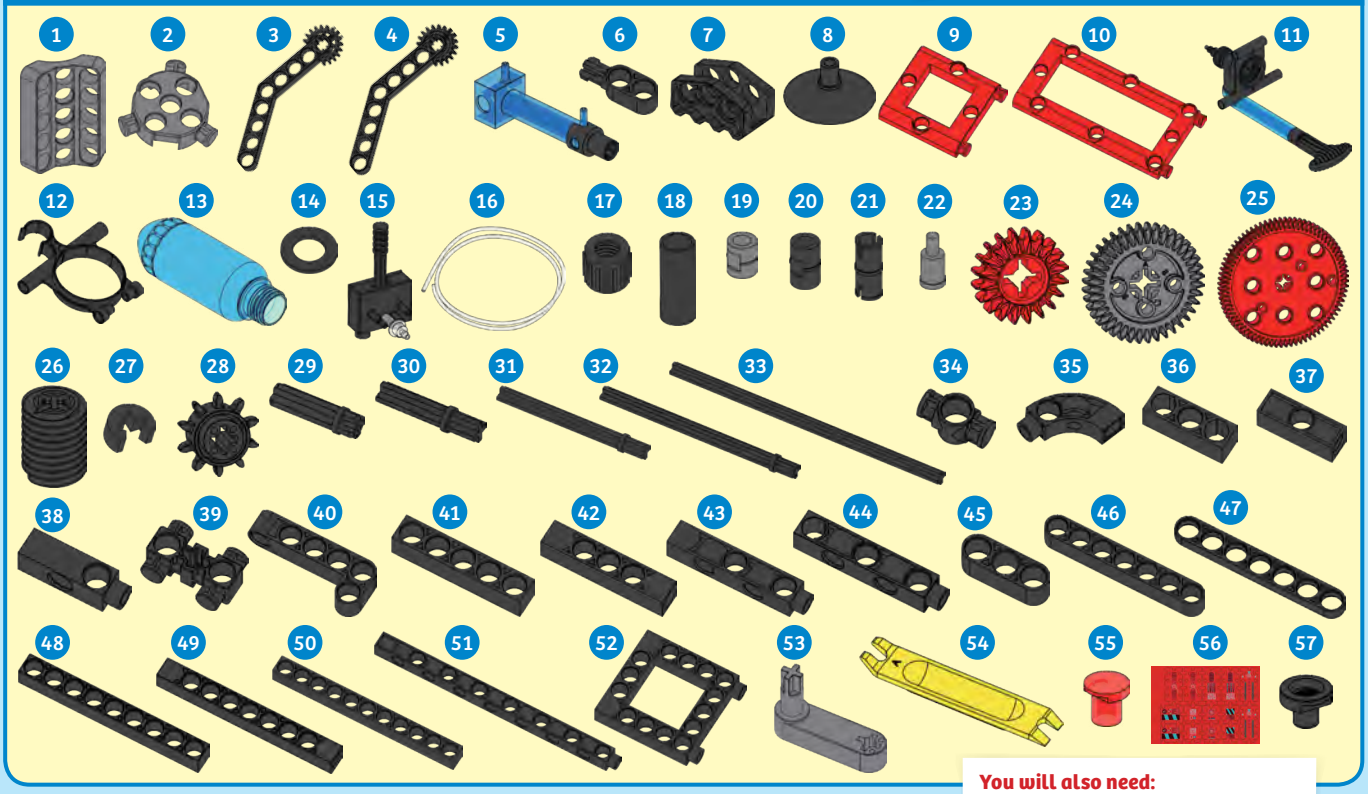
What's inside your experiment kit:



You will also need:
scissors, ruler or measuring tape

Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
○	1	120-degree 5-hole connector	3	7411-W10-A1S
○	2	3-way circular adapter	2	7411-W10-B1S
○	3	Crankshaft gear A	2	7411-W10-C1D
○	4	Crankshaft gear B	2	7411-W10-C2D
○	5	Pneumatic piston cylinder	1	7411-W85-A
○	6	Pneumatic piston handle	1	7411-W10-D3D
○	7	Gripper	4	7411-W10-G1D
○	8	Suction cup	3	R12-25
○	9	Rounded square frame,red	2	7411-W10-F1R
○	10	Rounded short frame, red	12	7411-W10-E1R
○	11	Pump	1	7389-W85-A1D
○	12	Air tank bracket	1	7389-W10-B2D
○	13	Air tank	1	7389-W11-A1B
○	14	O-ring	1	R12-05
○	15	Switch	1	1155-W85-I4DN
○	16	Tube, 1200 mm	1	1155-W85-120
○	17	Small (S) security nut	1	1156-W10-J1D
○	18	Tube, 20 mm	4	7400-W10-G2D
○	19	Short anchor pin, gray	25	7344-W10-C2S
○	20	Anchor pin, black	26	7061-W10-C1D
○	21	Joint pin	13	1156-W10-A1D
○	22	Shaft pin	2	7026-W10-J3S
○	23	Small gear, red	2	7026-W10-D2R
○	24	Medium gear, gray	2	7346-W10-C1S
○	25	Extra large gear, red	1	7328-W10-G2R
○	26	Worm gear	3	7344-W10-A1D
○	27	Axle lock	7	3620-W10-A1D
○	28	Small sprocket	1	3569-W10-D2D
○	29	Motor axle	3	7026-W10-L1D

✔	No.	Description	Qty.	Item No.
○	30	35-mm axle	1	7413-W10-O1D
○	31	70-mm axle	2	7061-W10-Q1D
○	32	100-mm axle	4	7413-W10-L2D
○	33	150-mm axle	2	7026-W10-P1D
○	34	1-hole connector	5	7430-W10-B1D
○	35	Curved rod	2	7061-W10-V1D
○	36	3-hole rod	1	7026-W10-Q2D
○	37	3-hole cross rod, black	4	7026-W10-X1D
○	38	3-hole dual rod, black	2	7061-W10-R1D
○	39	3-hole bolt rod, black	1	7406-W10-B1D
○	40	5-hole L rod	1	7406-W10-B2D
○	41	5-hole rod	4	7413-W10-K2D
○	42	5-hole cross rod	1	7413-W10-K3D
○	43	5-hole dual rod C, black	2	7026-W10-S3D
○	44	5-hole dual rod B, black	2	7026-W10-S2D
○	45	3-hole wide rounded rod	2	7404-W10-C1D
○	46	7-hole wide rounded rod	2	7404-W10-C2D
○	47	7-hole flat rounded rod	2	7404-W10-C3D
○	48	9-hole rod	2	7407-W10-C1D
○	49	9-hole cross rod	2	7407-W10-C2D
○	50	11-hole rod	3	7413-W10-P1D
○	51	15-hole dual rod	5	7413-W10-H1D
○	52	Square frame	1	7026-W10-T2D
○	53	Crank	2	7063-W10-B1S1
○	54	Anchor pin lever	1	7061-W10-B1Y
○	55	Long button pin	16	7061-W10-W2TR
○	56	Die-cut plastic sheet	1	K41#7411
○	57	Tube bolt cap	3	7409-W10-F2D

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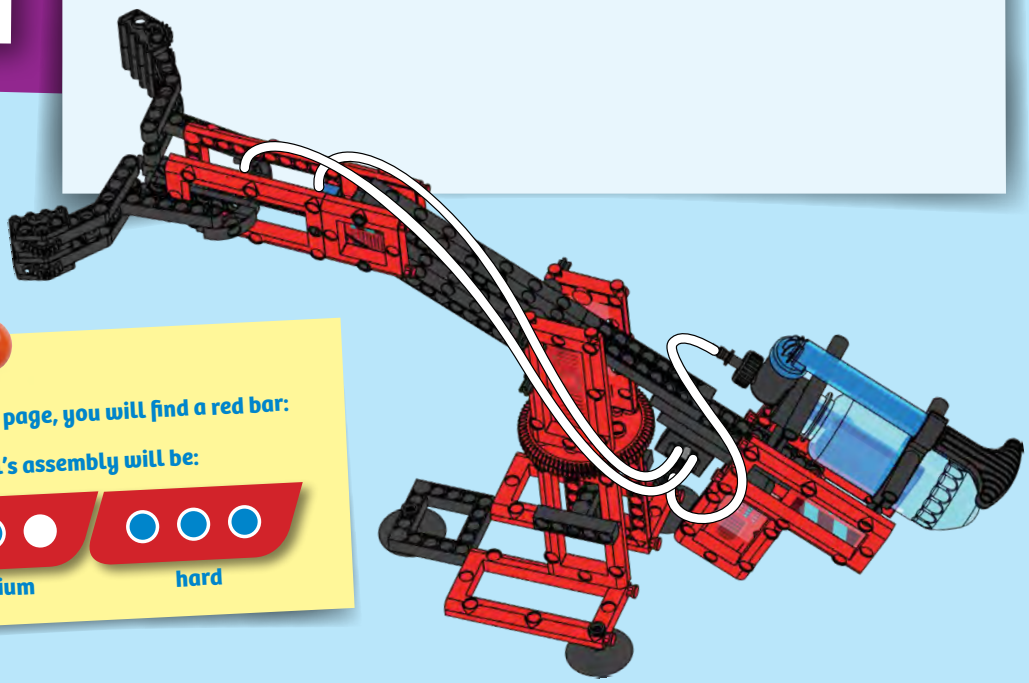
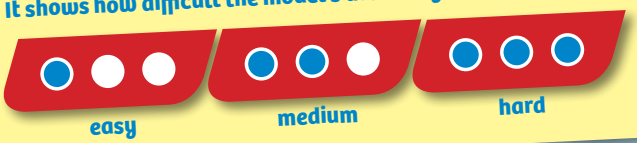


TIP!

At the top of each model assembly page, you will find a red bar:

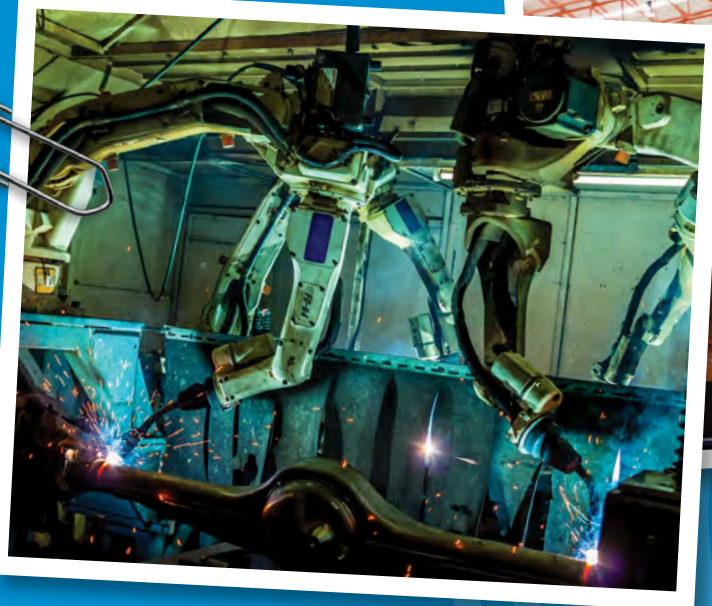
››› It shows how difficult the model's assembly will be:



What Is a Robotic Arm?

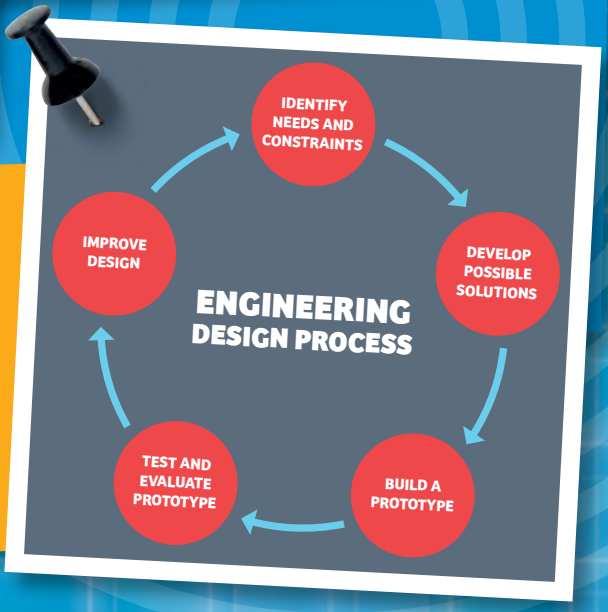
A robotic arm is a machine that may look and function somewhat like a human arm, but is able to perform tasks with greater strength, accuracy, and speed, or perform tasks that are too dangerous for a human. Robotic arms are one of the most common types of robots used in manufacturing.

A robotic arm is a combination of mechanical, electrical, and computer systems. This kit focuses on the mechanical portion of designing robotic arms, which is the expertise of mechanical engineers. Engineers apply physical laws and empirical knowledge to build complex systems. Empirical knowledge is simply information you learn by observing the results of experiments and observing occurrences in the world around you. Mechanical engineers focus on the design, construction, and operation of machines.



WHAT IS DESIGN?

Engineers often use the word "design" to describe what they do. Design is a sequence of steps that are used to take an idea from concept to functioning product or process. The engineering design process is iterative, meaning steps can be repeated multiple times and then improvements can be made each time, until the correct or optimal outcome is achieved.



PIVOTING ROBOTIC ARM

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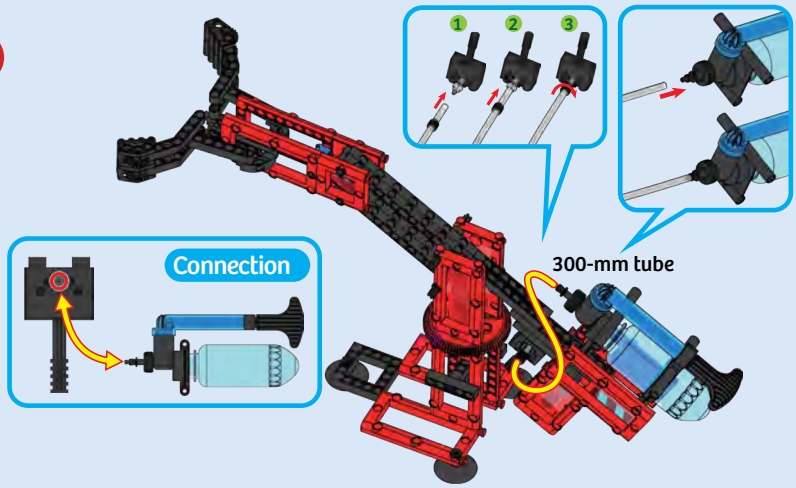

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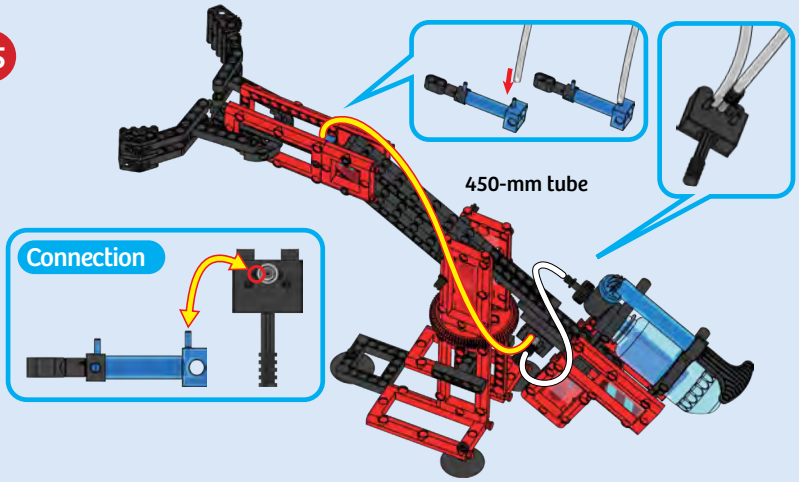

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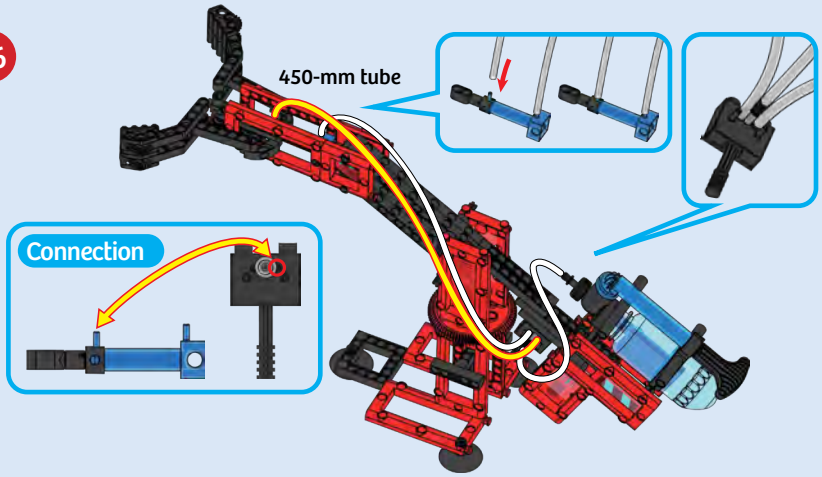

EXPERIMENT 1

Can you move it?

HERE'S HOW

Place a cylinder in front of the pivoting robotic arm. Use the robot arm to move the cylinder from one location to another using two different paths. What positions can the pivoting robotic arm not reach?

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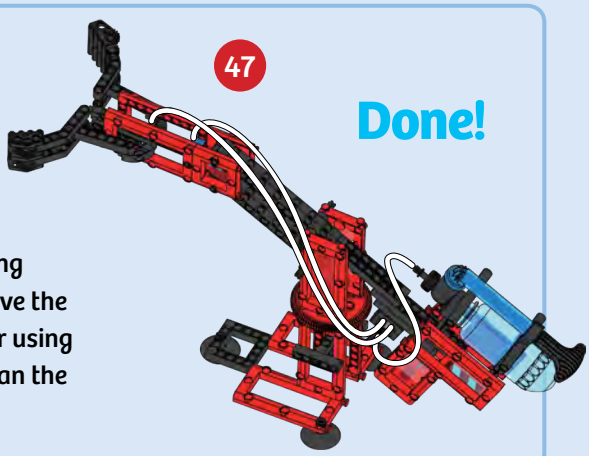
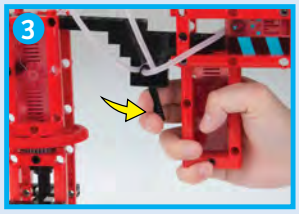


Done!

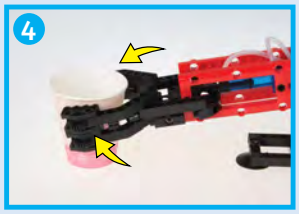
HOW TO USE

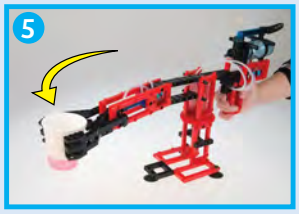
Put the switch lever in the center position.

Pump about 30 times to fill the air tank.

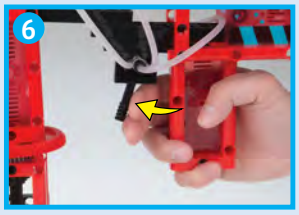


The gripper will close when you pull the switch lever.

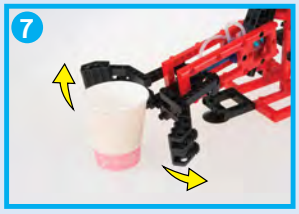




Rotate the handle to move the gripper.



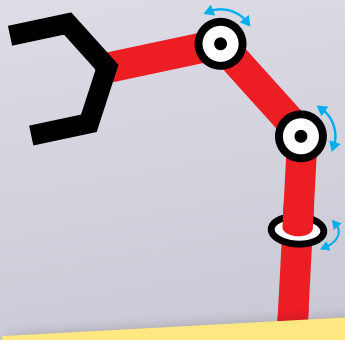
The gripper will open when you push the switch lever.



CHECK IT OUT

LINKS AND JOINTS

In engineering, it is often necessary to create simplified models of structures or systems in order to better understand their physical characteristics or behaviors. When simplifying a robotic arm to better understand it, the mechanical parts can be thought of as either links or joints. **Links** are the rigid structural elements of the robotic arm. In this kit, this includes the frames and rods. The **joints** are the pieces that allow for movement, such as the joint pins, axles, gears, and pistons in this kit. Joints allow a link to move by either rotation or translation (moving from one point in space to another).



Together, links and joints form what is called a **kinematic chain**. The word "kinematic" refers to how objects move. In a robotic arm, the links in the kinematic chain are constrained by their connection points to the other links — like how your elbow is constrained by the range of motion of your shoulder. To understand how a robotic arm can move as a whole, you can look about how each element in the kinematic chain can move.

Often the end of the robotic arm, called the **end effector,** is designed separately from the rest of the arm. It is designed to interact with objects in its environment, like a human hand, but for specialized tasks such as welding, gripping, spinning, applying materials, and so on.

MOVEMENT THROUGH SPACE

Unlike a human arm, a robotic arm can have a lot more freedom to move through space in different ways. The movement of a robotic arm can be described by the term **"degrees of freedom."** The position and orientation of an object in space can be given by three components of movement in the x, y, and z directions, and three components of rotation around those axes. For a single object in space, there are at most six degrees of freedom.

Each joint in a robotic arm has a certain number of degrees of freedom, which might be less than the maximum number of six. For example, not all of the pivoting robotic arm's joints can rotate 360 degrees.

The area defined by all of the positions in space that the end of the robotic arm can reach is known as the **workspace.** If the object that the robotic arm needs to pick up is not in the workspace, the robot cannot pick it up! The workspace depends on the degrees of freedom, limitations of the joints, lengths of the linkages, and the angles at which the object must be picked up.