

## **Cartesian Robot Experiment List:**

1. Comparative Study of XY Gantry Systems
2. Performance Evaluation of Hardware Components  
in an XY Plotter
3. Line Drawing Accuracy with Encoder Feedback
4. Drawing Shapes with an XY Plotter
5. Measuring Accuracy of Drawn Shapes with an XY  
Plotter
6. Study and Hands-On of Inkscape Software for G-  
code Generation
7. Drawing Alphabets with an XY Plotter
8. Writing Words with an XY Plotter
9. Drawing an Image with an XY Plotter

## **Experiment1: Study of XY Gantry Systems**

**Objective:** To conduct a comparative study of different XY gantry systems to evaluate their performance, accuracy, and capabilities.

### **Materials:**

- Multiple XY gantry systems from different manufacturers (at least two)
- Computer(s) with the respective control software for each XY gantry system
- Measuring tools (ruler or calipers)
- Test objects or targets for positioning and accuracy evaluation
- Paper or surface for drawing or marking positions
- Optional: Additional accessories or attachments specific to each XY gantry system

### **Procedure:**

1. Set up each XY gantry system according to the manufacturer's instructions. Ensure that they are properly calibrated and connected to their respective control software.
2. Familiarize yourself with the features and capabilities of each XY gantry system, including software functionality and available accessories.
3. Identify the specific aspects you want to evaluate and compare, such as positioning accuracy, speed, versatility, ease of use, or any other relevant performance metrics.
4. Develop a standardized set of tests or tasks that can be performed on each XY gantry system to assess the identified aspects.
5. Perform tests or tasks on each XY gantry system one at a time, following a predetermined sequence or random order.

6. Record the results for each test or task, including measurements, timings, observations, or any other relevant data.
7. Evaluate the performance of each XY gantry system based on the collected data and observations.
8. Analyze the results to identify strengths, weaknesses, similarities, and differences among the XY gantry systems.
9. Consider subjective factors such as user experience, software intuitiveness, or overall satisfaction when comparing the systems.
10. Summarize the findings and draw conclusions regarding the performance, accuracy, and capabilities of each XY gantry system.

### **Tips:**

- Prioritize a consistent and fair testing methodology across all XY gantry systems.
- Include a variety of test scenarios that cover different aspects of the systems' performance and capabilities.
- Pay attention to details such as software features, ease of setup, maintenance requirements, and any limitations or constraints.
- Conduct multiple trials for each test or task to ensure reliable and representative results.
- Consider involving multiple operators to gather diverse perspectives and feedback.

### **Safety Precautions:**

- Follow all safety guidelines provided by the manufacturers for each XY gantry system.
- Take caution when operating the systems, ensuring that hands and other body parts are clear of moving parts.

- Ensure a safe working environment, free from potential hazards or obstructions.
- Adhere to any specific safety recommendations or requirements stated by each XY gantry system manufacturer.

**Note:** This experiment requires access to multiple XY gantry systems, which may not be readily available. If access to multiple systems is not possible, you may consider conducting a comparative study based on existing research, user reviews, or specifications provided by manufacturers.

**Conclusion:**

## **Experiment 2: Performance Evaluation of Hardware Components in an XY Plotter**

**Objective:** To evaluate the performance of individual hardware components used in an XY plotter and assess their impact on the overall system performance.

### **Materials:**

- XY plotter
- Computer with the control software for the XY plotter
- Measuring tools (ruler or calipers)
- Test objects or targets for evaluating performance
- Paper or surface for drawing or marking positions

### **Procedure:**

1. Identify the hardware components of the XY plotter that you want to evaluate, such as motors, belts, pulleys, linear guides, or any other relevant components.
2. Set up the XY plotter according to the manufacturer's instructions. Ensure that it is properly calibrated and connected to the control software.
3. Familiarize yourself with the function and specifications of each hardware component being evaluated.
4. Select one hardware component to evaluate at a time.
5. Develop a specific test or task that highlights the performance of the chosen hardware component.
6. Perform the test or task, ensuring that all other hardware components and settings remain consistent throughout the experiment.

7. Record relevant measurements or observations related to the performance of the tested hardware component. This could include accuracy, speed, noise level, or any other relevant metrics.
8. Repeat steps 4-7 for each hardware component you wish to evaluate.
9. Analyze the data collected for each hardware component, comparing their individual performance and identifying any strengths or weaknesses.
10. Draw conclusions about the impact of each hardware component on the overall performance of the XY plotter.

### **Tips:**

- Ensure a standardized testing methodology for each hardware component to ensure fair and consistent comparisons.
- Consider evaluating multiple aspects of performance, such as precision, speed, noise level, or any other relevant criteria, depending on the hardware component being tested.
- Pay attention to details such as component specifications, material quality, and construction to understand their potential influence on performance.
- Conduct multiple trials for each test or task to ensure reliable and representative results.
- Document any observations or unexpected findings during the evaluation process.

### **Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter and working with its hardware components.
- Take caution when performing tests or tasks, ensuring that hands and other body parts are clear of moving parts.
- Ensure a safe working environment, free from potential hazards or obstructions.

- Adhere to any specific safety recommendations or requirements stated by the manufacturer for the hardware components being evaluated.

**Conclusion:**

### **Experiment 3: Line Drawing Accuracy with Encoder Feedback**

**Objective:** To measure the accuracy of line drawing on an XY plotter with encoder feedback by comparing user-provided length values with the actual measured length values.

#### **Materials:**

- XY plotter with encoder feedback
- Computer with XY plotter software
- Measuring tools (ruler or calipers)
- Paper or surface for drawing lines
- Pen or marker for line drawing

#### **Procedure:**

1. Set up the XY plotter according to the manufacturer's instructions. Ensure that the encoder feedback system is properly installed and calibrated.
2. Connect the XY plotter to a computer running the XY plotter software.
3. Open the software and configure the settings for line drawing mode.
4. Prepare a sheet of paper or a surface for drawing lines.
5. Set a specific line length value to be used as the target length for drawing the lines.
6. Provide the line length value to the software either in millimeters (mm) or in pulses (if applicable).
7. Instruct the XY plotter to draw a line with the user-provided length value.
8. Once the line drawing is complete, use a ruler or calipers to measure the actual length of the drawn line. Record this measurement.
9. Repeat steps 5-8 for multiple line lengths, covering a range of values.
10. Calculate the accuracy of line drawing by comparing the user-provided length values with the actual measured length values obtained from the encoder feedback.
11. Analyze the data to determine the average accuracy and any variations or trends in line drawing accuracy.

#### **Tips:**

- Ensure that the XY plotter is properly calibrated and the encoder feedback system is accurately measuring the line lengths.
- Use a consistent measurement technique and be precise in recording the provided length values and the measured lengths.
- Repeat the experiment multiple times for different line lengths to obtain reliable data for accuracy assessment.



- Consider testing line lengths at various positions on the drawing surface to identify any positional discrepancies in accuracy.
- Document any observed patterns or trends in the accuracy data, such as systematic errors or variations based on line length or position.

### **Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter.
- Keep hands and other body parts clear of the plotter's moving parts during operation.
- Be cautious when using tools such as rulers or calipers to avoid injury.
- Avoid placing obstacles or interfering with the movement of the XY plotter while drawing lines.
- Take care not to exceed the plotter's maximum load capacity to ensure safe and accurate operation.

### **Conclusion:**

## **Experiment 4: Drawing Shapes with an XY Plotter**

**Objective:** To evaluate the accuracy and precision of an XY plotter in drawing various shapes.

### **Materials:**

- XY plotter
- Computer with the control software for the XY plotter
- Paper or surface for drawing
- Measuring tools (ruler or calipers)

### **Shapes to be drawn:**

1. Square
2. Circle
3. Triangle
4. Rectangle
5. Custom shape (optional)

### **Procedure:**

1. Set up the XY plotter according to the manufacturer's instructions. Ensure that it is properly calibrated and connected to the control software.
2. Open the control software on the computer and configure it for shape drawing mode.
3. Prepare the drawing surface (paper or any other suitable material) on which the shapes will be drawn.
4. Begin with the square:

- a. Instruct the XY plotter to draw a square with a specified side length.
  - b. Observe and record the accuracy of the drawn square by measuring its side lengths using a ruler or calipers.
5. Move on to the circle:
  - a. Command the XY plotter to draw a circle with a specified radius or diameter.
  - b. Measure the radius or diameter of the drawn circle using a ruler or calipers and record the accuracy.
6. Proceed with the triangle:
  - a. Instruct the XY plotter to draw a triangle with specified side lengths or angles.
  - b. Measure the side lengths and angles of the drawn triangle and record the accuracy.
7. Continue with the rectangle:
  - a. Command the XY plotter to draw a rectangle with specified length and width.
  - b. Measure the length and width of the drawn rectangle using a ruler or calipers and record the accuracy.
8. Optionally, draw a custom shape of your choice:
  - a. Define the parameters of the custom shape, such as its coordinates or dimensions.
  - b. Instruct the XY plotter to draw the custom shape.
  - c. Evaluate the accuracy of the drawn custom shape by measuring relevant dimensions and recording the results.
9. Repeat the experiment multiple times for each shape to gather reliable data and assess the consistency of the XY plotter's performance.
10. Analyze the collected data to evaluate the accuracy and precision of the XY plotter in drawing the different shapes.

**Tips:**

- Ensure that the XY plotter is properly calibrated before conducting the experiment.
- Use a consistent method for measuring the drawn shapes, such as using a ruler or calipers, to maintain accuracy.
- Consider repeating the experiment with different sizes or variations of the shapes to assess the XY plotter's performance across different parameters.
- Take note of any observed deviations or variations in the drawn shapes and analyze their possible causes.

**Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter.
- Keep hands and other body parts clear of the plotter's moving parts during operation.
- Ensure a safe working environment, free from potential hazards or obstructions.

**Conclusion:**

## **Experiment 5: Measuring Accuracy of Drawn Shapes with an XY Plotter**

**Objective:** To measure the accuracy of shapes drawn by an XY plotter and compare them with their intended dimensions.

### **Materials:**

- XY plotter
- Computer with the control software for the XY plotter
- Measuring tools (ruler or calipers)
- Paper or surface for drawing
- Shapes to be drawn (e.g., square, circle, triangle, rectangle)

### **Procedure:**

1. Set up the XY plotter according to the manufacturer's instructions. Ensure that it is properly calibrated and connected to the control software.
2. Open the control software on the computer and configure it for shape drawing mode.
3. Prepare the drawing surface (paper or any other suitable material) on which the shapes will be drawn.
4. Select a shape to begin with, such as a square: a. Determine the intended dimensions of the square (e.g., side length). b. Instruct the XY plotter to draw the square based on the specified dimensions. c. Measure the drawn square using a ruler or calipers and record the measured dimensions. d. Calculate the deviation of the drawn square from the intended dimensions by comparing the measured dimensions with the intended dimensions.
5. Repeat steps 4b-4d for other shapes, such as a circle, triangle, and rectangle, following the same process of specifying the dimensions, drawing the shape, measuring it, and calculating the deviation.
6. For each shape, perform multiple iterations to gather reliable data and assess the consistency of the XY plotter's performance.
7. Analyze the collected data by calculating the average deviation and comparing it with the intended dimensions.
8. Repeat the experiment with different sizes or variations of the shapes to assess the XY plotter's performance across different parameters.
9. Optionally, compare the accuracy of the XY plotter for different shapes to identify any variations in performance.
10. Draw conclusions about the XY plotter's accuracy in drawing different shapes based on the measured deviations.

**Tips:**

- Ensure that the XY plotter is properly calibrated before conducting the experiment.
- Use a consistent method for measuring the drawn shapes, such as using a ruler or calipers, to maintain accuracy.
- Consider repeating the experiment multiple times to gather reliable data and assess the consistency of the XY plotter's accuracy.
- Take note of any observed deviations or variations in the drawn shapes and analyze their possible causes.
- Consider evaluating the accuracy of the XY plotter for different regions of the drawing surface to identify any positional discrepancies.

**Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter.
- Keep hands and other body parts clear of the plotter's moving parts during operation.
- Ensure a safe working environment, free from potential hazards or obstructions.

- **Conclusion:**

## **Experiment 6: Study and Hands-On of Inkscape Software for G-code Generation**

**Objective:** To gain familiarity with Inkscape software and its functionality for generating G-code for use with an XY plotter or CNC machine.

### **Materials:**

- Computer with Inkscape software installed
- XY plotter or CNC machine (optional)
- Paper or surface for drawing (optional)

### **Procedure:**

1. Install Inkscape on your computer following the software's installation instructions.
2. Familiarize yourself with the basic features and interface of Inkscape.
3. Learn about the functionalities of Inkscape that are relevant to generating G-code for an XY plotter or CNC machine.
4. Create a simple design or artwork using the drawing tools and features in Inkscape. This can be a basic shape, text, or any design of your choice.
5. Explore the G-code generation capabilities of Inkscape:
  - a. Install any required extensions or plugins for G-code generation in Inkscape (e.g., Gcodetools, J Tech Photonics Laser Tool, etc.) based on your specific use case.
  - b. Open your design or artwork in Inkscape.
  - c. Access the G-code generation functionality through the installed extensions or plugins.
  - d. Configure the settings as per your requirements, such as feed rate, laser power (if applicable), toolpath generation options, and other parameters.

- e. Generate the G-code from your design within Inkscape.
6. Save the generated G-code to a file for further use with an XY plotter or CNC machine.
7. Optionally, if you have access to an XY plotter or CNC machine:
  - a. Set up and connect your XY plotter or CNC machine to your computer, following the manufacturer's instructions.
  - b. Load the saved G-code file into the control software of your XY plotter or CNC machine.
  - c. Run the G-code file to observe the execution of your design on the XY plotter or CNC machine.
  - d. Evaluate the accuracy and quality of the output in comparison to your design.
8. Take notes of your experience, any challenges faced, and observations during the hands-on experimentation with Inkscape and G-code generation.
9. Reflect on the capabilities and limitations of Inkscape for G-code generation based on your experimentation.
10. Document any tips or best practices you discover while using Inkscape for G-code generation.

### **Tips:**

- Explore Inkscape's official documentation or online tutorials to learn more about its features and functionalities.
- Join online forums or communities related to Inkscape to seek guidance or share experiences with other users.
- Consider experimenting with different design elements, tool options, and parameters to explore the full potential of Inkscape for G-code generation.



**Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when using an XY plotter or CNC machine.
- Ensure a safe working environment, free from potential hazards or obstructions.
- Take appropriate safety measures, such as wearing protective gear, when operating the XY plotter or CNC machine.

**Conclusion:**

## **Experiment 7:** Drawing Alphabets with an XY Plotter

**Objective:** To evaluate the accuracy and precision of an XY plotter in drawing alphabets.

### **Materials:**

- XY plotter
- Computer with the control software for the XY plotter
- Paper or surface for drawing
- Alphabet templates or reference images

### **Procedure:**

1. Set up the XY plotter according to the manufacturer's instructions. Ensure that it is properly calibrated and connected to the control software.
2. Open the control software on the computer and configure it for drawing mode.
3. Prepare the drawing surface (paper or any other suitable material) on which the alphabets will be drawn.
4. Gather alphabet templates or reference images that will serve as a guide for drawing the alphabets.
5. Select an alphabet to begin with (e.g., letter "A"):
  - a. Display the template or reference image for the selected alphabet on the computer screen.
  - b. Instruct the XY plotter to draw the alphabet based on the template or reference image.
  - c. Observe and record the accuracy of the drawn alphabet by comparing it to the template or reference image.

6. Repeat steps 5a-5c for the remaining alphabets, ensuring to choose a variety of letter shapes and sizes.

7. Measure the dimensions of the drawn alphabets using a ruler or calipers to assess their precision.

8. Calculate the deviation of each drawn alphabet from its intended dimensions by comparing the measured dimensions with the dimensions of the template or reference image.

9. Analyze the collected data to evaluate the accuracy and precision of the XY plotter in drawing alphabets.

10. Consider repeating the experiment with different drawing settings (e.g., speed, pen pressure) to assess their impact on the accuracy and precision of the drawn alphabets.

### **Tips:**

- Ensure that the XY plotter is properly calibrated before conducting the experiment.
- Use a consistent method for measuring the dimensions of the drawn alphabets, such as using a ruler or calipers, to maintain accuracy.
- Consider repeating the experiment multiple times to gather reliable data and assess the consistency of the XY plotter's performance.
- Take note of any observed deviations or variations in the drawn alphabets and analyze their possible causes.
- Experiment with different sizes and styles of alphabets to assess the XY plotter's performance across different parameters.

### **Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter.

- Keep hands and other body parts clear of the plotter's moving parts during operation.
- Ensure a safe working environment, free from potential hazards or obstructions.

**Conclusion:**

## **Experiment 8:** Writing Words with an XY Plotter

**Objective:** To evaluate the accuracy and precision of an XY plotter in drawing words with small and capital alphabets, considering a maximum size of 7 for small alphabets and 5 for capital alphabets.

### **Materials:**

- XY plotter
- Computer with the control software for the XY plotter
- Paper or surface for drawing
- Word templates or reference images

### **Procedure:**

1. Set up the XY plotter according to the manufacturer's instructions. Ensure that it is properly calibrated and connected to the control software.
2. Open the control software on the computer and configure it for drawing mode.
3. Prepare the drawing surface (paper or any other suitable material) on which the words will be drawn.
4. Gather word templates or reference images that will serve as a guide for drawing the words.
5. Select a word to begin with:
  - a. Display the template or reference image for the selected word on the computer screen.
  - b. Ensure that the word consists of small or capital alphabets and does not exceed the maximum size (7 for small alphabets and 5 for capital alphabets).
  - c. Instruct the XY plotter to draw the word based on the template or reference image.

- d. Observe and record the accuracy of the drawn word by comparing it to the template or reference image.
6. Repeat steps 5a-5d for the remaining words, ensuring to choose a variety of word lengths and letter combinations.
7. Measure the dimensions of the drawn words using a ruler or calipers to assess their precision.
8. Calculate the deviation of each drawn word from its intended dimensions by comparing the measured dimensions with the dimensions of the template or reference image.
9. Analyze the collected data to evaluate the accuracy and precision of the XY plotter in drawing words.
10. Consider repeating the experiment with different drawing settings (e.g., speed, pen pressure) to assess their impact on the accuracy and precision of the drawn words.

### **Tips:**

- Ensure that the XY plotter is properly calibrated before conducting the experiment.
- Use a consistent method for measuring the dimensions of the drawn words, such as using a ruler or calipers, to maintain accuracy.
- Consider repeating the experiment multiple times to gather reliable data and assess the consistency of the XY plotter's performance.
- Take note of any observed deviations or variations in the drawn words and analyze their possible causes.
- Experiment with different word lengths, letter combinations, and font styles to assess the XY plotter's performance across different parameters.

**Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter.
- Keep hands and other body parts clear of the plotter's moving parts during operation.
- Ensure a safe working environment, free from potential hazards or obstructions.

## **Experiment 9:** Drawing an Image with an XY Plotter

**Objective:** To evaluate the accuracy and precision of an XY plotter in drawing an image.

### **Materials:**

- XY plotter
- Computer with the control software for the XY plotter
- Image editing software (e.g., GIMP, Photoshop)
- Image to be drawn
- Paper or surface for drawing

### **Procedure:**

1. Set up the XY plotter according to the manufacturer's instructions. Ensure that it is properly calibrated and connected to the control software.
2. Open the control software on the computer and configure it for drawing mode.
3. Prepare the drawing surface (paper or any other suitable material) on which the image will be drawn.
4. Select an image to be drawn:
  - a. Choose an image that is suitable for the capabilities of the XY plotter, considering its resolution and complexity.
  - b. If necessary, resize and optimize the image using image editing software to match the drawing area and reduce complexity.
5. Convert the image into a format compatible with the control software of the XY plotter:



a. If the control software supports importing image files directly, save the image in the appropriate format (e.g., SVG, DXF).

b. If the control software requires converting the image into G-code, use an appropriate software or extension (e.g., GcodeTools in Inkscape) to generate the G-code from the image.

6. Load the image file or the generated G-code into the control software of the XY plotter.

7. Instruct the XY plotter to draw the image on the prepared drawing surface based on the loaded file or G-code.

8. Observe and record the accuracy and precision of the drawn image by comparing it to the original image.

9. Measure specific features or dimensions of the drawn image using a ruler or calipers to assess its precision.

10. Calculate the deviation of the drawn image from the original image by comparing the measured features or dimensions.

11. Analyze the collected data to evaluate the accuracy and precision of the XY plotter in drawing the image.

12. Consider repeating the experiment with different images, varying complexity levels, and settings to assess the XY plotter's performance across different parameters.

### **Tips:**

- Ensure that the XY plotter is properly calibrated before conducting the experiment.
- Use a consistent method for measuring features or dimensions of the drawn image, such as using a ruler or calipers, to maintain accuracy.
- Consider adjusting the drawing settings (e.g., speed, pen pressure) to optimize the accuracy and precision of the drawn image.
- Take note of any observed deviations or variations in the drawn image and analyze their possible causes.

- Experiment with different image types and complexities to assess the XY plotter's performance across different scenarios.

### **Safety Precautions:**

- Follow all safety guidelines provided by the manufacturer when operating the XY plotter.
- Keep hands and other body parts clear of the plotter's moving parts during operation.
- Ensure a safe working environment, free from potential hazards or obstructions.

### **Conclusion:**