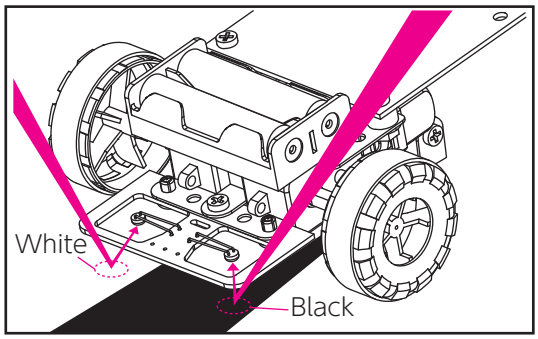
1 . Operate the robot in Line Tracing Mode

Use the included course sheet for line tracing experiments to verify that the tracing robot functions properly.

• How the optical sensors work

The optical sensors measure the intensity of light reflected from the paper course. Black areas reflect light of a different intensity to white areas. The robot can therefore use its optical sensors to determine where it is on the course.

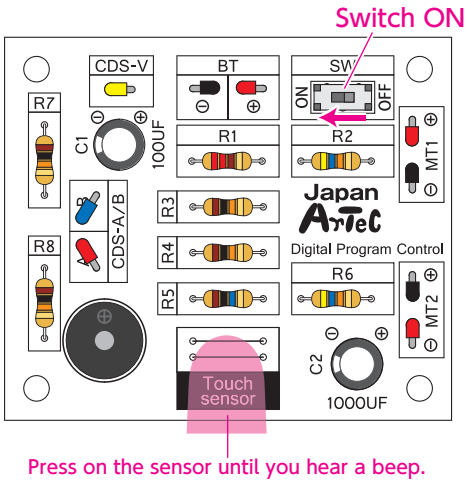


• How the tracing robot works

When the right-hand sensor detects black, the robot determines that the course leads to the right. It stops the right motor, allowing the left motor to turn the robot to the right. (The opposite occurs when the left-hand motor detects black.) When both sensors detect the black finish line, the robot determines that the course is about to end, and stops both motors.

• How to use Line Tracing Mode

Place the robot at the start position. Align the black course line with the center of the main body.
(Make sure the sensors are not directly over the black line.)
Rest one finger on the touch sensor and switch on the power.
You will hear a long beep when Line Tracing Mode activates.
(Keep your finger on the touch sensor until the beep stops.)
Lift your finger off the touch sensor. You will hear a short beep and the robot will start to move.
See if the robot is able to follow the line and stop at the right spot.



Troubleshooting

● **The robot does not move**

→ The robot may still be in Programming Mode. Switch off the power. Press on the sensor, then switch on the power again.

● **Line Tracing Mode does not start**

→ If your finger is dry, the sensor will not detect your touch. Moisten your finger with water.

● **The tracing robot does not follow the line**

→ The robot uses optical sensors to detect black course lines when in Line Tracing Mode. The robot's movement is easily affected by its surroundings. If the room is too bright, course line detection may be impaired. Close all curtains and operate under controlled lighting conditions. Make sure there are no shadows cast on the course. They could affect the operation of the sensors.

Check!

Finished the course. ☐

Optical sensors

Think about what kinds of things around you use optical sensors. Also consider how the optical sensors control those objects.

What kinds of things?	How do they use sensors?	What do they do?

Make your own tracing course

Use a black felt-tip pen to draw a course line 20 mm wide on a sheet of white paper. Try running the robot along the course.

If one of the sensors detects black, the tracing robot turns in the direction of that sensor. The robot is not able to react to sudden changes in direction or curves with a radius less than 100 mm. Remember these facts so that the robot does not leave the course.

Check!

Finished my course. ☐

2. Use the software to create a control program for the robot

● Installing the control software from the CD-ROM

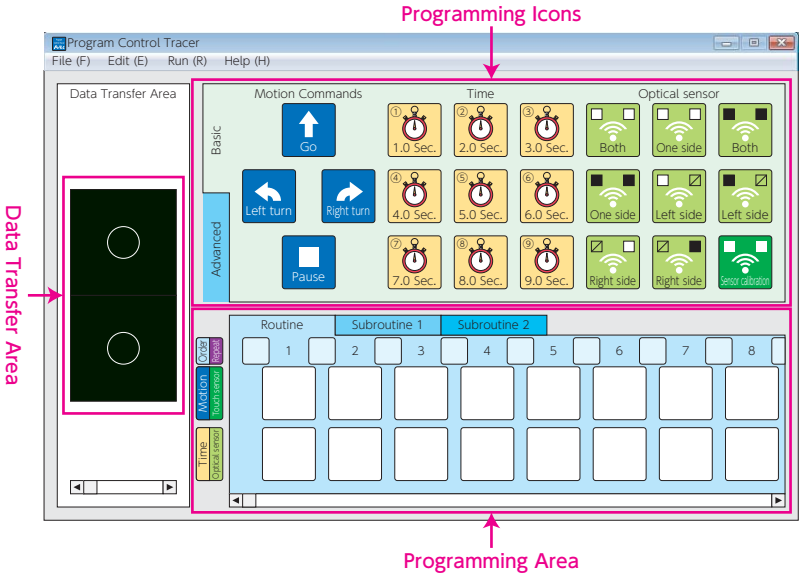
Insert the CD-ROM into your computer's CD/DVD drive. Access the CD/DVD drive from My Computer, then drag-and-drop the icon onto the desktop.

● Installing the control software from the Internet

Visit the Artec website (http://www.artec-kk.co.jp/en/pct) and download the control software to your desktop. Double-click the icon to launch the software.

Programming Screen

This is a screenshot of the programming screen.
Simply drag-and-drop icons into the programming area to create a routine for the robot. You can add 24 icons under the Routine tab and 8 icons under each of the Subroutine tabs.
When you have finished designing your program, simply send it to the robot via optical communication from the data transfer area. The robot will carry out the actions indicated on the icons in the order you place them.



Check!
Launched the control software successfully. ☐

Exiting the control software

Access the File menu and select <Exit> to quit the control software.

Check!
Exited the software successfully. ☐

Control Software Icons

Basic Icons

Motion Icons

- Go
- Right turn
- Left turn
- Pause

Time Icons

There are nine time setting icons. By default, time periods from 1.0 to 9.0 seconds are allocated to the icons. Double-click any icon, then set the time period from the pop-up menu. You can select time periods from 0.5 to 25.5 seconds, in 0.1 second increments.

Optical Sensor Icons

Place these icons to create routines that use the optical sensors. (For more information, refer to section 6, "Utilize the optical sensors" on page 7.) The sensors use the light intensity of the starting point as a reference value. Light intensity values the same or higher than the reference value are considered white; values below are considered black.

- Both: Until both sensors detect white color
- One side: Until one of the sensors detects black color
- Right side: Until the right sensor detects white color
- One side: Until one of the sensors detects white color
- Left side: Until the left sensor detects white color
- Right side: Until the right sensor detects black color
- Both: Until both sensors detect black color
- Left side: Until the left sensor detects black color

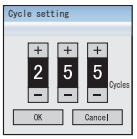
Advanced Icons

- Repeat start: Start repeating a part of a program from this point.
- 005 times repeat: Indicates when and where to stop repeating.
- 1 Subroutine: Insert a specific action sequence into your program.
- 2 Subroutine: Insert a specific action sequence into your program.
- Touch sensor: Pause the program. Use the touch sensor to resume operation.

● Configure icons

You can edit values for the time icons and repeat icons. Double-click an icon, then enter a new value in the settings window that appears. Click OK to apply the change.

Time setting
You can set times from 0.5-25.5 seconds. The minimum unit is 0.1 seconds.



Cycle setting
You can set 1-255 repeats. The minimum unit is 1.

Check!
Understood what the icons mean. ☐

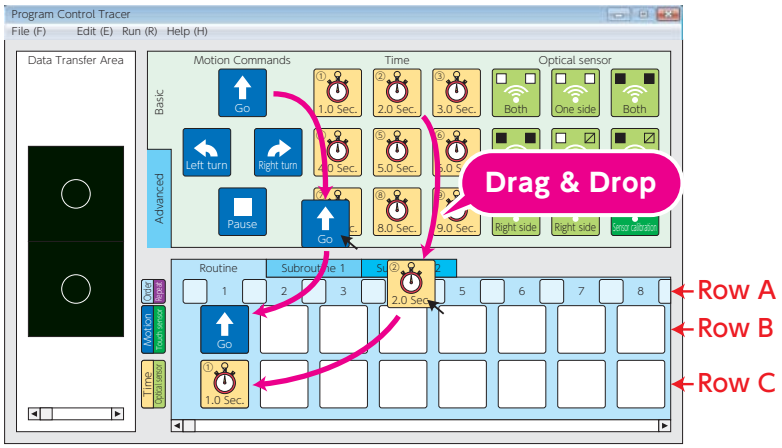
Date	Grade	Class	Student no.	NAME

3. Use the software to create a control program for the robot

How to use the control software

Creating control programs (routines)

Add repeat icons to Row A. Add motion, subroutine, and touch sensor icons to Row B. Add time icons and sensor icons to Row C.
Drag-and-drop icons into each row to create your program.
Now try it yourself! Add the Go icon to the first column of your routine.
Time icon ① will automatically be added underneath. To adjust the time setting, drag-and-drop a different time icon over ①.



Check!

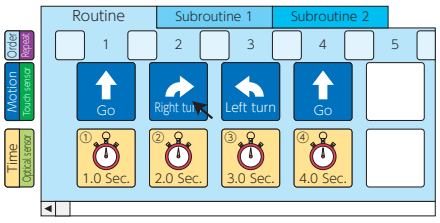
Added icons to the routine. ☐

Editing icons in your routine

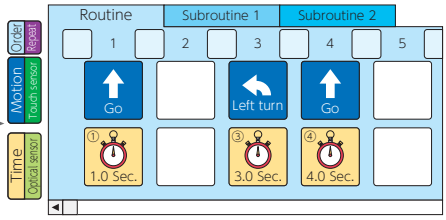
Right-click on the icon you want to change to bring up the Edit menu.

Edit menu

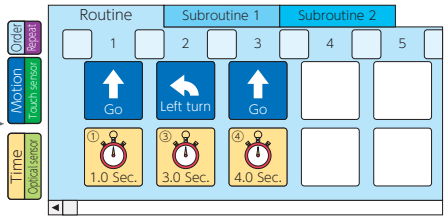
- Delete (X)
- Delete a column (Y)
- Add a column (Z)



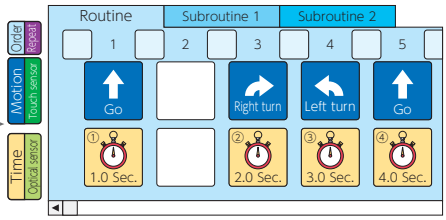
"Delete" removes an icon.



"Delete a column" removes a column, pulling the remaining columns to the left.



"Insert a column" puts a new column in between two existing ones.

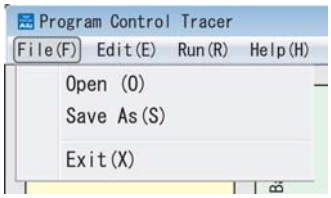


Check!

Edited icons in the routine. ☐

Useful Functions

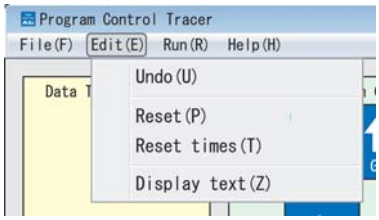
File → Open: Opens previously saved data.
File → Save As: Saves created program.



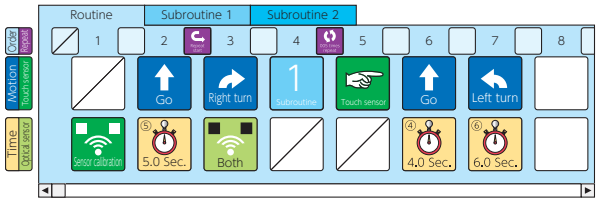
Edit → Reset: Delete all icons added to your program.

Edit → Reset times: Returns each time icon to its original setting.

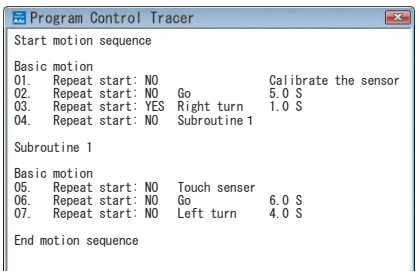
Edit → Display text: Shows a readable text version of the program you created.



●Example routine



● Text example



Check!

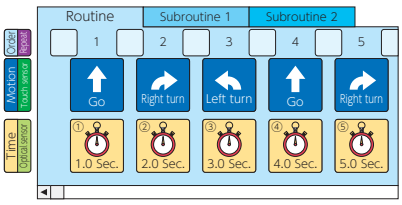
Understood useful functions. ☐

Transferring a control program to the Program Control Tracer

How to transfer a control program

Add icons to the routine. After creating your program, transfer it to the Program Control Tracer.

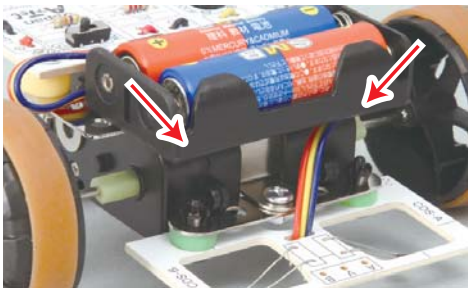
● Example routine



★ The Program Control Tracer transmits data to a computer via optical communication. Glossy monitors, inappropriate color depth settings, and glare from the sun or other lighting may adversely affect data transmission. Close all curtains to prevent light from entering the room and falling on the monitor. You may find it helpful to use cardboard or something similar to shade the optical sensor from external light while holding it to the monitor.
If the contrast is too high, refer to the monitor's documentation and change the setting. If problems occur with data transfer even after adjusting the operating environment and display settings, use the optical sensor protective cover provided in the instructions. For best results, attach the cover to the cardboard before use.

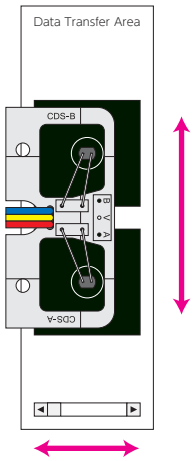
1. Remove the optical sensor from the Program Control Tracer.

Press down the rivet collar and remove the rivet from the back of the sensor board.



2. Hold the optical sensor to the data transfer area.

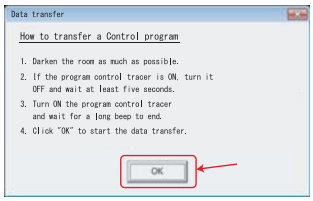
Position the sensors right above the white circles in the black squares. If the sensors and circles are not aligned, adjust the placement of the black squares using the bar at the bottom of the data transfer area.

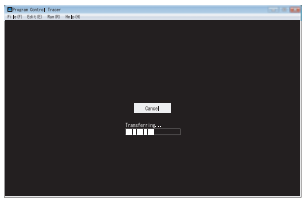


3. Access the Run menu, then click "Send control program".

4. The Data Transfer dialog box appears. Hold the optical sensor to the data transfer area, switch on the power, and wait for the long beep to end.

5. Click "OK" to start the data transfer.



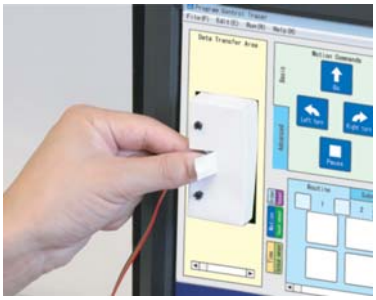


You will hear a short beep every time the Program Control Tracer receives data.

6. When data transfer is complete, you will hear a long beep before being returned to the programming screen.
   ★ There will be no beep if data transfer fails.
7. Reattach the optical sensor circuit board to the robot body.
8. To execute the control program, tap the touch sensor on the main circuit board with your finger.
9. To repeat the program, tap the touch sensor again.
10. When you turn the power off, the robot's program memory will be erased.

Problems during data transfer...

Prepare the included optical sensor protective cover.
Use the rivet collar to attach the protective cover to the sensor, as shown.



Check!

Transferred a control program to the robot. ☐

● Enjoy making many different kinds of control programs for your Program Control Tracer!

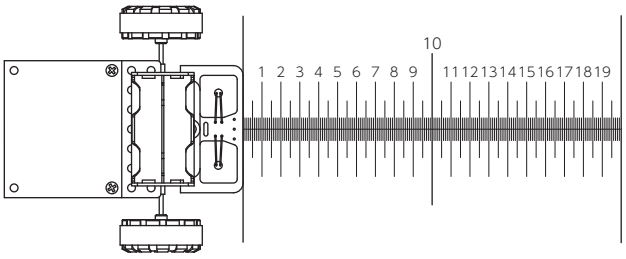
Date	Grade	Class	Student no.	NAME

4. Measure the movement of the Program Control Tracer

The robot's movement is controlled by two motorized gearboxes. The performance of individual gearboxes may vary. If the two gearboxes provide different performance, the robot may veer slightly as it travels straight. Performance is also affected by the state of the batteries. Use the gauges provided to periodically measure the robot's movements, and make necessary adjustments with the control software.

Forward movement

Use the gauge on page 11 for measurement. Create programs to test how long it takes the robot to move forward a certain distance and how far it can travel over a given time period. Record your results in the table on page 11.

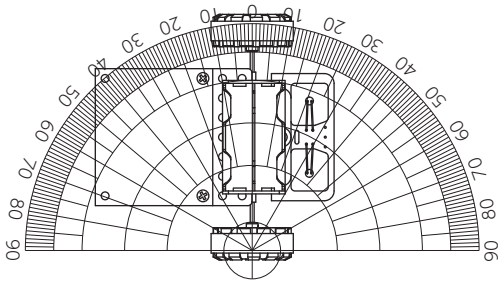


Check!

Gathered data about forward movement. ☐

Left and right movement

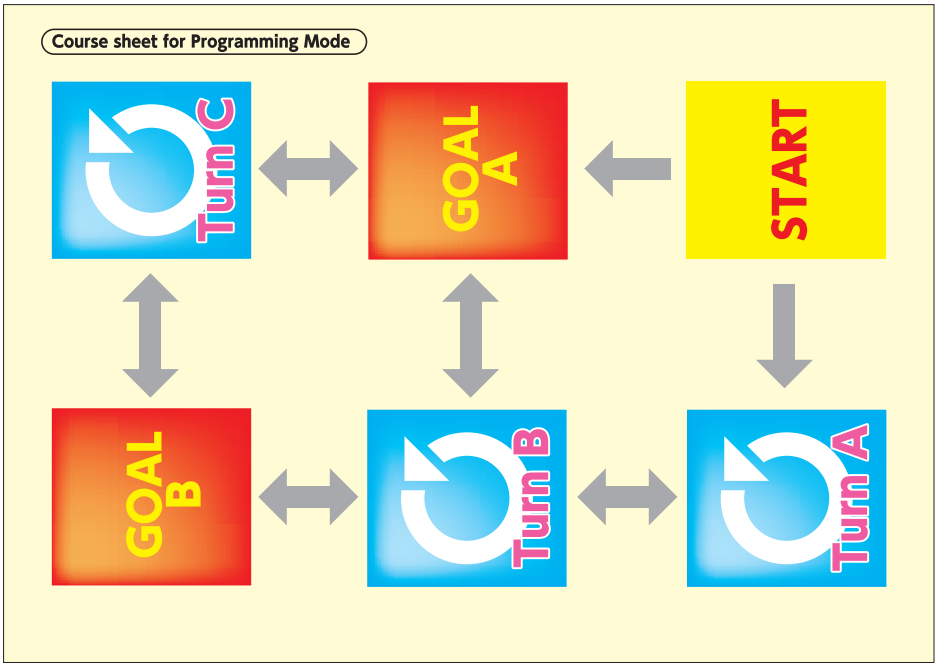
Use the gauge on page 12 for measurement. Create programs to test how long it takes the robot to change direction and how much it turns over a given time period. Record your results in the tables on page 12.



Check!

Gathered data on left and right turns. ☐

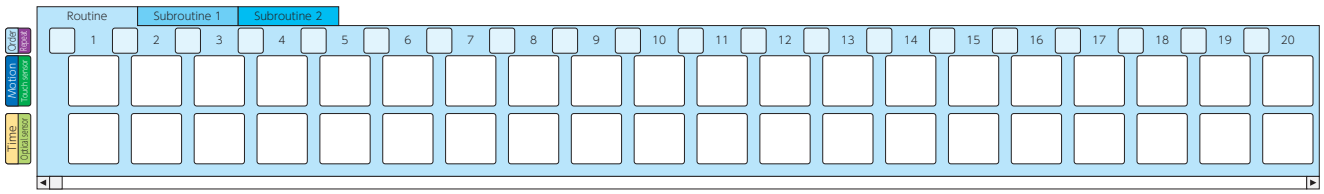
5. Complete an experiment course



How to use the course sheet

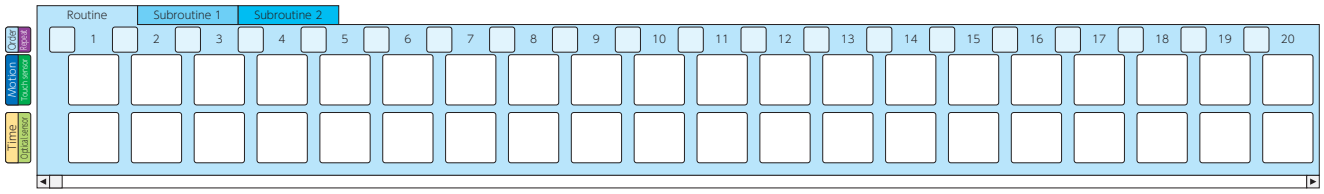
Place the Program Control Tracer on the START space, and create programs to make it reach the goal in various ways. Fill in each table to record what routines you used to clear the courses.

Course 1: Start → Goal A



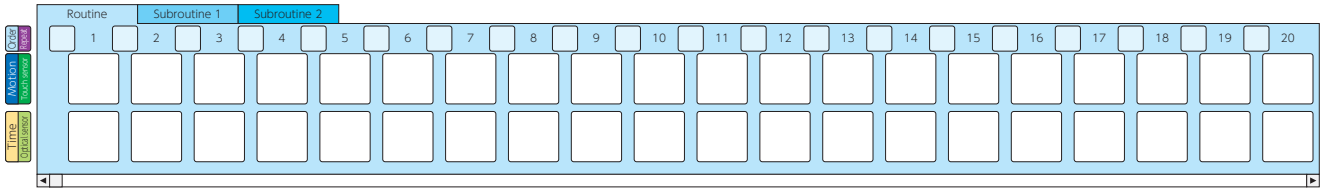
Check! Course 1 cleared. ☐

Course 2: Start → Turn A → Goal B



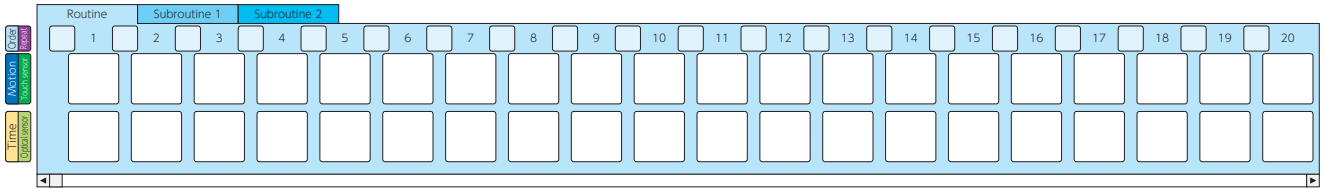
Check! Course 2 cleared. ☐

Course 3: Start → Turn C → Goal B



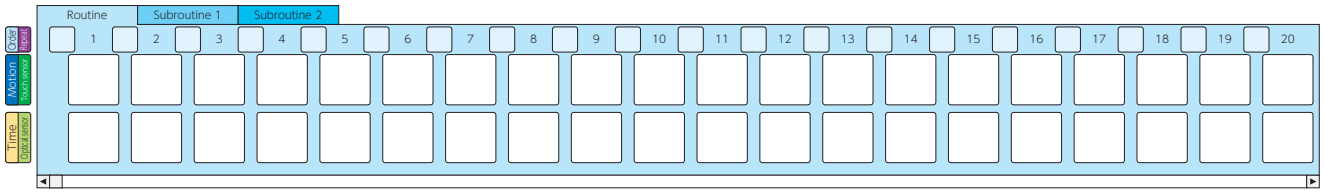
Check! Course 3 cleared. ☐

Course 4: Start → Turn A → Turn B → Goal B



Check! Course 4 cleared. ☐

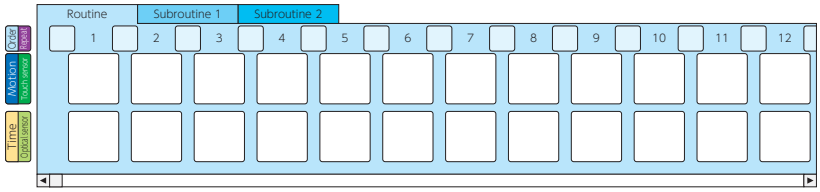
Course 5: Start → Turn A → Turn B → Goal A → Turn C → Goal B

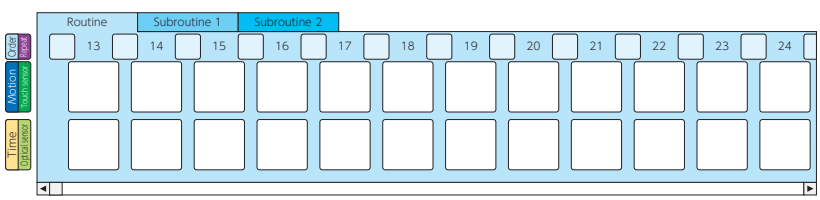


Check! Course 5 cleared. ☐

Course 6: My own course

Create your own course and try to clear it.
Start →





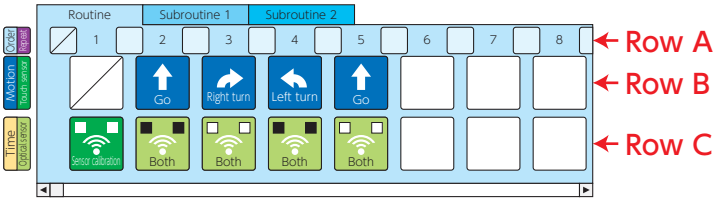
Check!
Course 6 cleared. ☐

Date	Grade	Class	Student no.	NAME

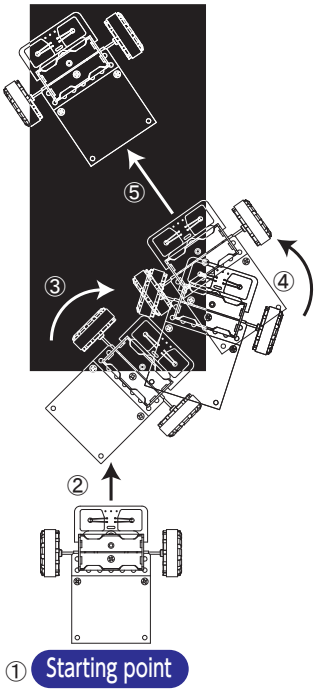
6 . Utilize the optical sensors

To create a program that uses the optical sensors, drag-and-drop the icon onto the first column in row C.

● Example routine



When the above program is executed, the sensors will calibrate by measuring the light intensity of the start point. They use this measurement as a reference value. Light intensity values the same or higher than the reference value are considered white; values below are considered black. The larger the difference between black and white, the easier it is for the sensor to detect the course line.



① The robot calibrates its sensors, then it proceeds to the next step in the program.

② The robot goes straight until both sensors detect black, then it proceeds to the next step.

③ The robot keeps turning right until both sensors detect white, then it proceeds to the next step.

④ The robot keeps turning left until both sensors detect black, then it proceeds to the next step.

⑤ The robot goes straight until it detects white, then the program ends.

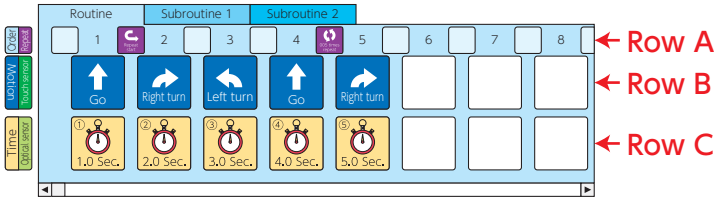
Check!
Understood how to program the optical sensors. ☐

7. Advanced Operations

How to use the repeat function

This function allows you to repeat a portion of your control program. Bracket the desired portion between icons on Row A. Place a Repeat icon at the beginning and a icon at the end of the portion to be repeated. For information about changing the number of repeat times, refer to the "Configure icons" section on page 2.

Example routine with repeat commands between the second and fifth columns



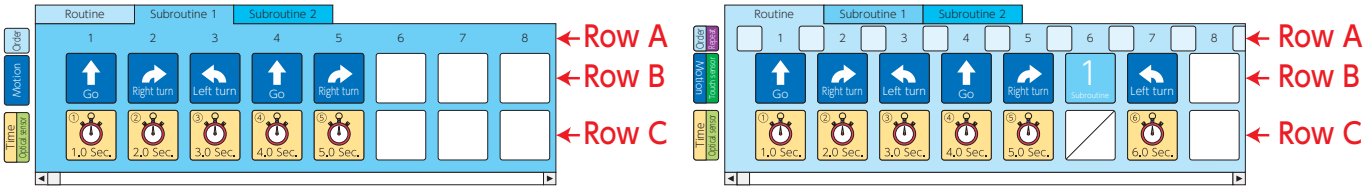
★ Include at least two commands when using the repeat function.

Check!
Understood how to use the repeat function. ☐

How to use subroutines

Subroutines are mini sequences that you can insert into your routine. Click the Subroutine tab to display the programming area. Add icons in the same manner as when creating routines. (The repeat, subroutine, and touch sensor icons are not available for subroutines.) When you finish placing icons on the Subroutine, go back to the Routine tab. Define where to execute the subroutine by placing the Subroutine 1 icon in Row B. (Create Subroutine 2 in the same manner.)

● Example subroutine

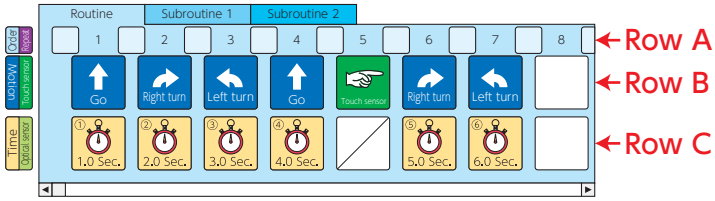


Check!
Understood how to use subroutines. ☐

How to use the Touch Sensor icon

The Touch Sensor icon pauses the current routine. Add the icon to Row B wherever you wish to use the touch sensor. Tap the touch sensor to resume the routine.

● Example routine



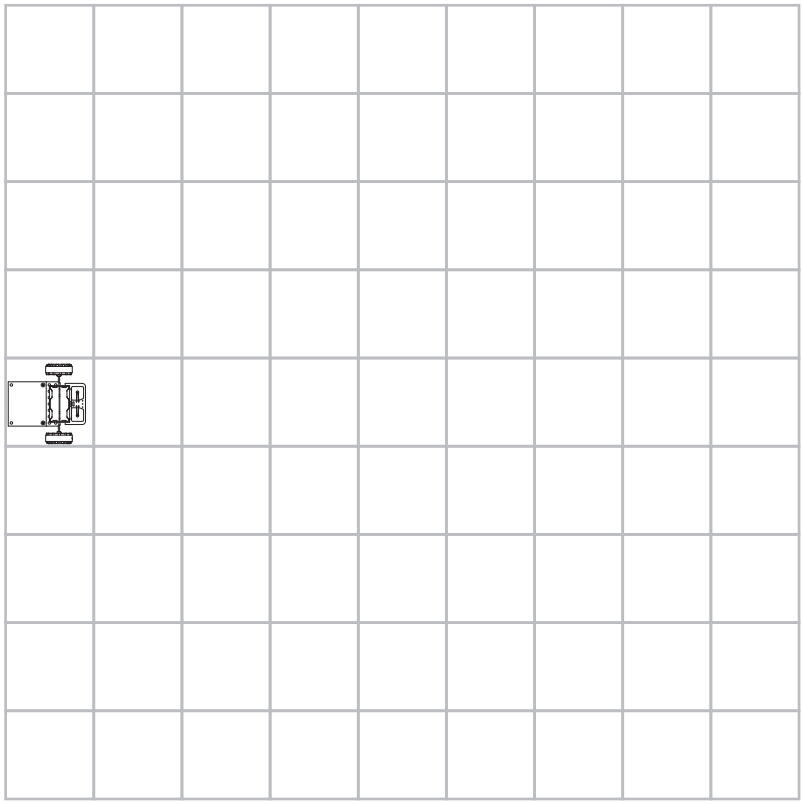
Check!

Understood how to use the touch sensor. ☐

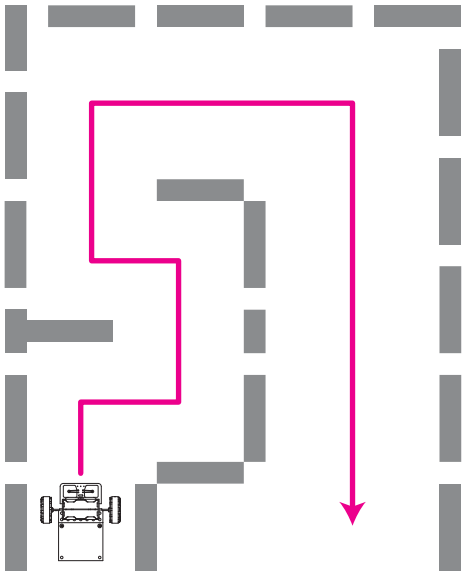
8. Make your own obstacle course!

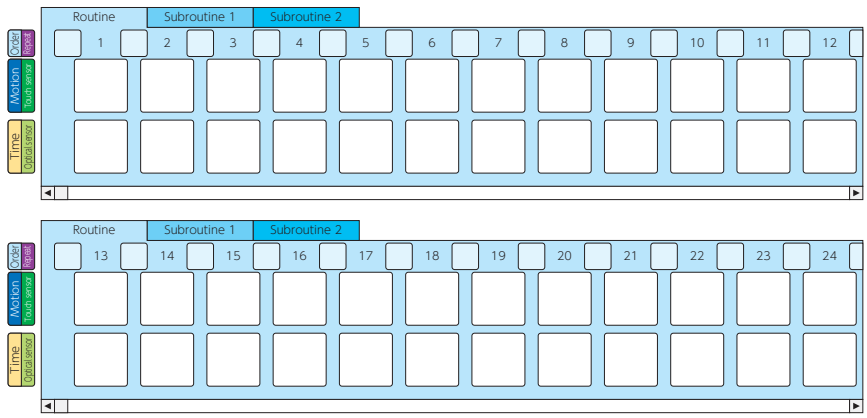
Maze Escape

Create your own maze!



Example course





Measure how long it takes the robot to escape from the maze.

sec.

Check!

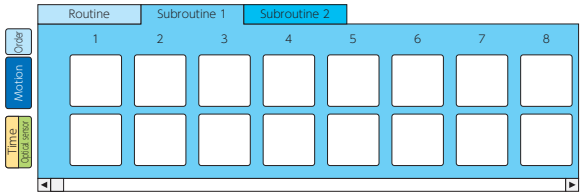
Maze cleared. ☐

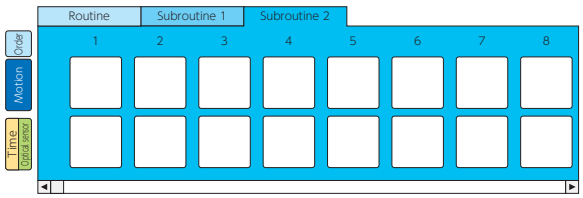
Date	Grade	Class	Student no.	NAME

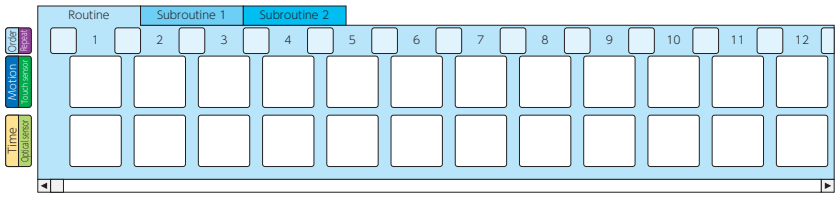
9. Free course

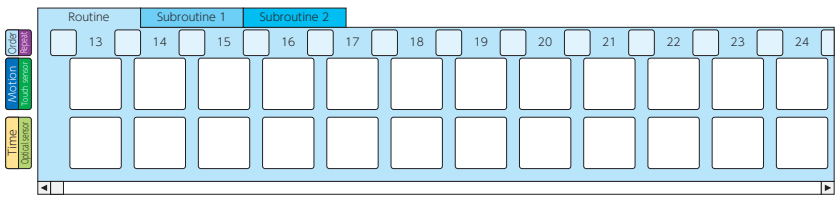
Create and clear your own course, utilizing everything you have learned about the Program Control Tracer's functions.

Design your course below.









Check!

Free course cleared. ☐

10. Review

● What have you learned about Line Tracing Mode?

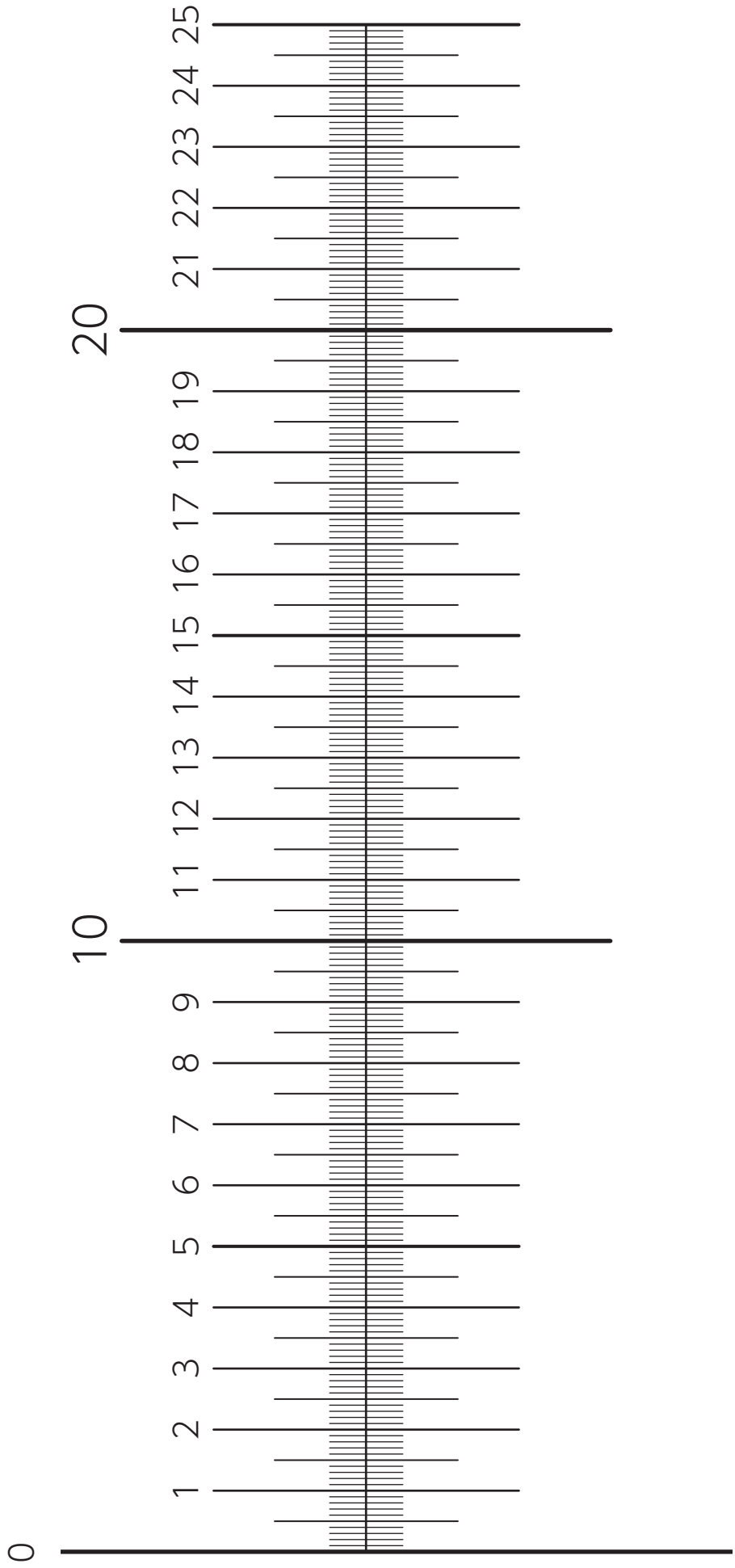
● Write about the movements of the robot and the programs that employ them.

● Think about the world around you. What kinds of things feature control systems, and what kinds of systems are they?

● Write down your overall impressions, based on your experiences controlling the robot.
What control techniques do you think would be useful to have?

Date	Grade	Class	Student no.	NAME

Measuring gauge for forward movement

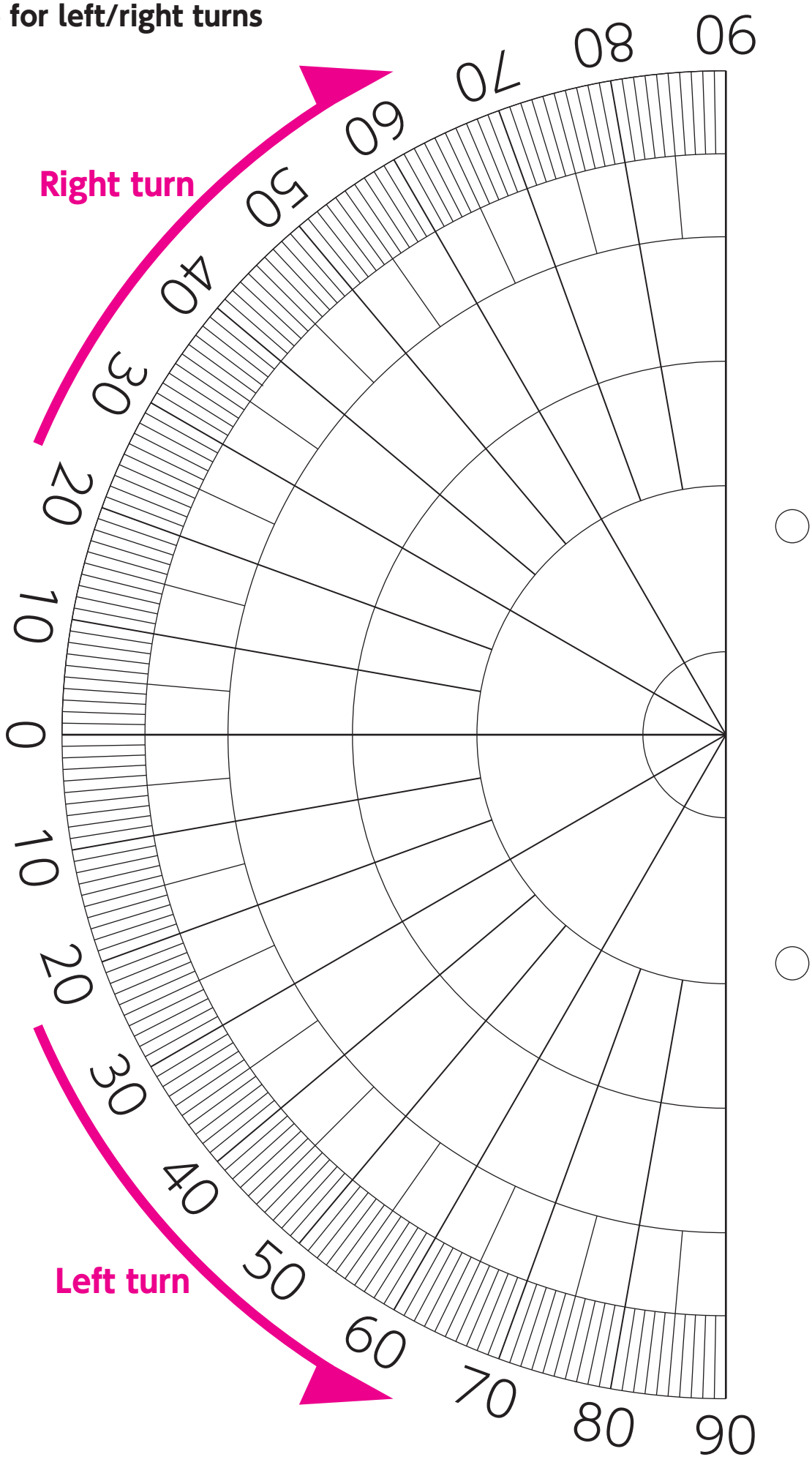


	Set time (sec.)	Travel distance (mm)
①		
②		
③		
④		
⑤		
⑥		
⑦		
⑧		
⑨		
⑩		
⑪		
⑫		
⑬		
⑭		
⑮		
⑯		
⑰		
⑱		
⑲		
⑳		

Measuring gauge for left/right turns

Right turn

	Set time (sec.)	Turning angle
①		
②		
③		
④		
⑤		
⑥		
⑦		
⑧		
⑨		



Left turn

	Set time (sec.)	Turning angle
①		
②		
③		
④		
⑤		
⑥		
⑦		
⑧		
⑨		

Date	Grade	Class	Student no.	NAME