Exoplanet research with Arduino

1. Experiment design.

Design an experiment that models the transit method used to detect exoplanets.
Use the following tools:

- Arduino
- Photo resistance
- convex lens
- 5W LED Bulb E27
- Cables, switches
- Laptop

Take a picture of the measurement layout and explain the measurement process and the role of each device.

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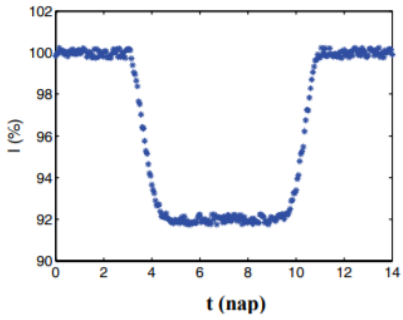
2. Transit method - solve one of the counting tasks! 😊

2.1.

Some of the exoplanets (i.e. planets outside our solar system) orbit their stars in such an orbit that, when viewed from Earth, they pass in front of the star. An exoplanet research method is the transit (photometric) method, which is based on measuring the light intensity of the star. The graph below shows a typical measurement curve showing a percentage reduction in the star's light intensity. *(Matura exam task, May 2011)*

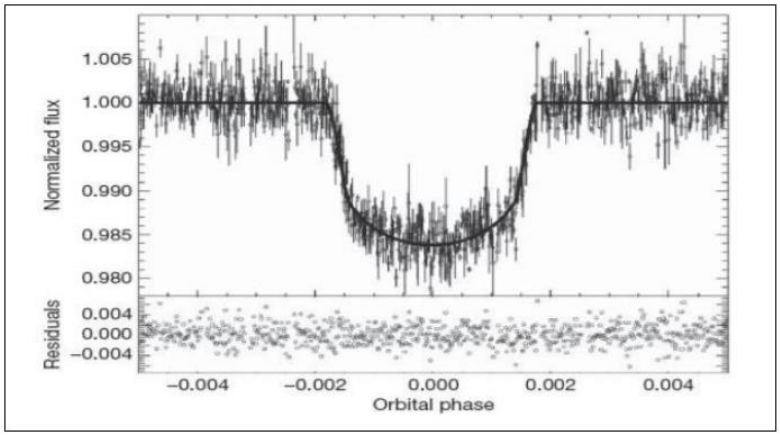


(a) Why does the light intensity of the star decrease?

b) How long did it take for the planet to pass in front of the star? Justify your answer.

b) What can we say about the ratio (ratio) of the diameter of the star and the planet orbiting it based on the curve?

2.2.
The image shows the light curve of the exoplanet CoRoT 9b. Determine the percentage of the decrease in brightness based on the figure. From the ratio of minimum to maximum intensity, determine the ratio of the diameter of the star to the planet.



Decrease in light intensity: ... .

Ratio of surfaces: ... .

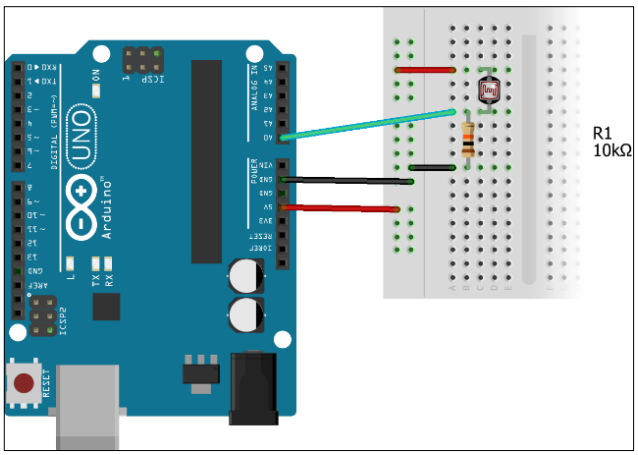
Ratio of diameters: ... .

3.1 Transit method introductory measurement task

Conduct an experiment that models the transit method used to research exoplanets.

Devices

- Arduino and laptop
- Photo resistance
- Convex lens
- 15W LED Bulb E27
- Cables + 100 ohm resistance
- Ruler
- Mobile phone



Description of the task

- Place the lamp at least 1 m from the lens.
- Place the photo resistance where the convex lens represents the light of the lamp in a circle with the smallest cross section.
- The intensity of light is measured using photo resistance.

Build the graphic switch. Put the black cable to the Arduino "Ground/GND" pin, the "red" end of the photo resistance to a permanent 5V pin, the other "green" end to the analog input/pin "A0".

To measure light intensity, program the photo resistance. Use the following code.

```
int bejovo = A0;

int szenzorAdat = 0;

void setup()
{

  Serial.begin(9600);
}

void loop()
{

  szenzorAdat = analogRead(bejovo);
  Serial.println(szenzorAdat);
  delay(100);

}
```

Q&A questions/tasks

Determine the degree of light intensity under normal conditions on the Arduino scale.

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Determine the light intensity of the light source on the Arduino scale.

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Move your phone at an even speed in front of the light source (d= ... cm diameter)! What do you experience? What percentage of the light intensity changes at this time?

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Represent the measurement data on graphs in Excel using the Data streamer.

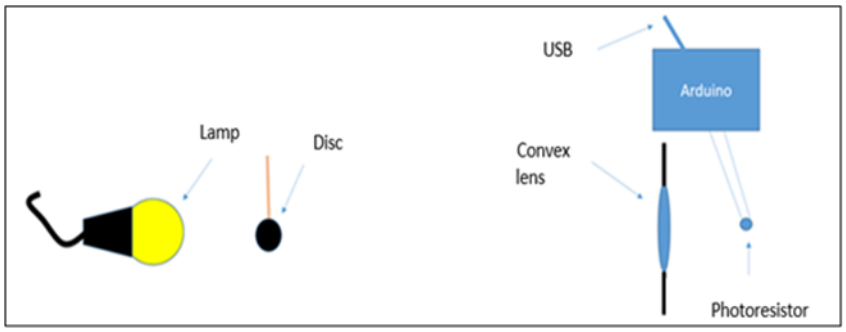
You can find help with data streamer on a separate page!

3.2 Transit method - star and planets

Model the transit method. Measure how long it takes for the planet to pass in front of its star. Determine the ratio of the diameter of the star to the planet. What is the period of the planet?

Devices

- Arduino and laptop
- Photo resistance + 100-ohm resistance
- 15W LED Bulb E27
- Cables
- Caps of different diameters
- Loop stick
- Convex lens



Description of the task

Build the experimental setup and the circuit used in the previous task. The lamp should be at least 1 m from the convex lens. In front of the LED bulb, move the caps of different diameters (glued to a loop stick) at an even speed of about 5 cm in front of the LED bulb, measure the light intensity and use the Excel Data streamer to graph the measurement data! Save each measurement result in a separate file (e.g. *measurement1. csv*).

Q&A questions/tasks

Draw the graph.

Interpret the graph in 3-5 sentences.

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Based on the graphs, determine the ratio of the diameter of the star to the planets. Justify your answer.

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<u>Bonus tasks</u>

Two planets of the same size (such as Venus and Earth) pass at different distances around their stars. In the model experiment, one planet (small cap) should pass 10 cm, the other 20 cm away from the star (lamp)!

Estimate how the light intensity of the lamp changes in the two cases.

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Measure the light intensity in the two cases and check your estimation based on the measured results and justify the deviations.

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Move the "planet" 10 cm from the "star" (diameter 6 cm), take it around the star in the 10 cm radius orbit at an even speed! It measured the intensity of light. Use the excel data streamer to represent the measured values, and then use the graph to determine the planet's orbital time. Justify your answer.

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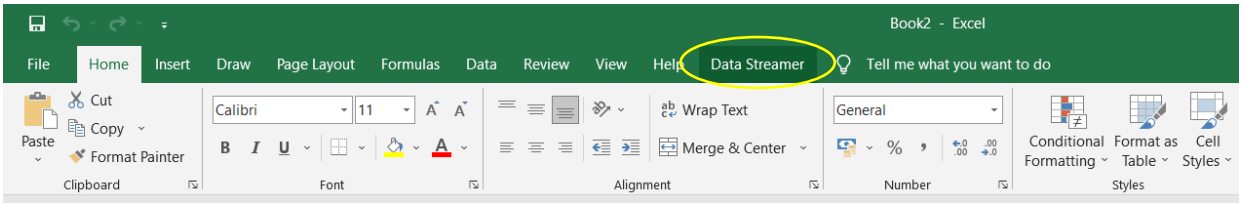
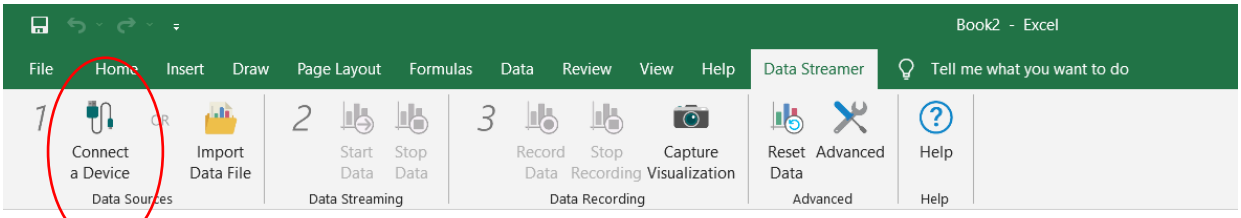
Data Streamer

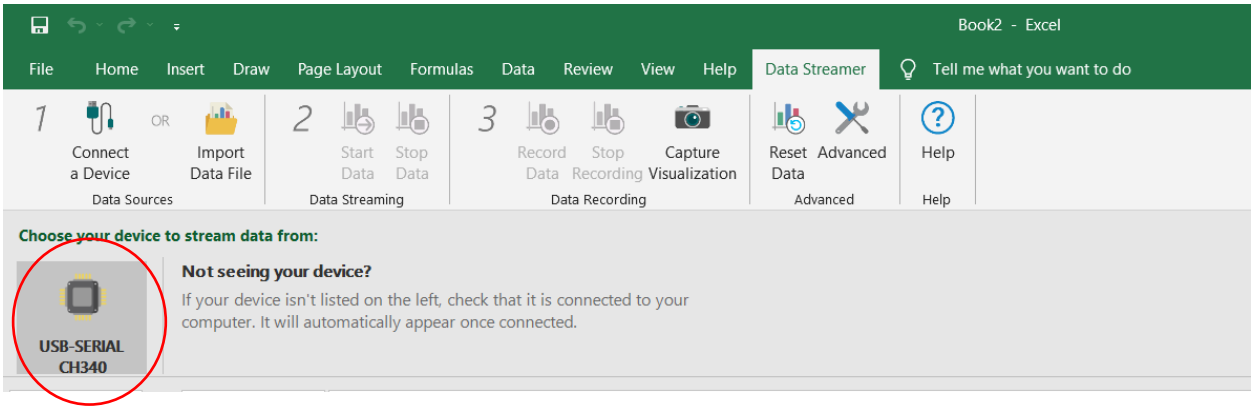
1. On the ribbon, click Data streamer.



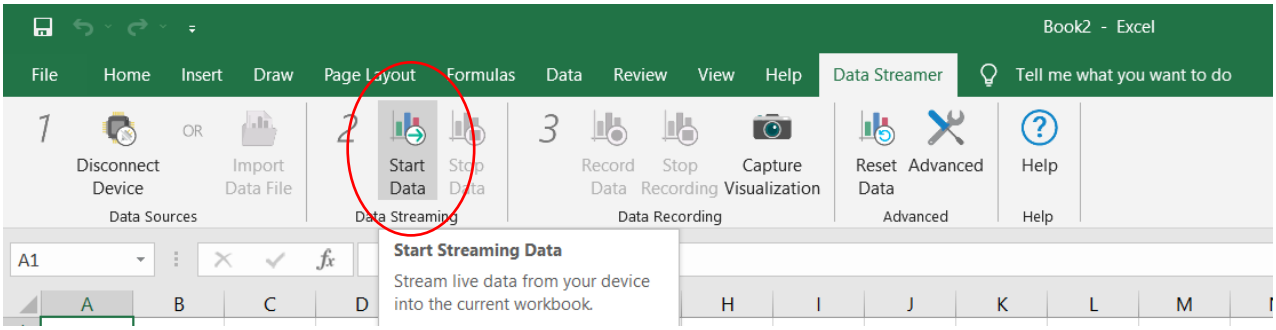
2. Then click connect *to device* .



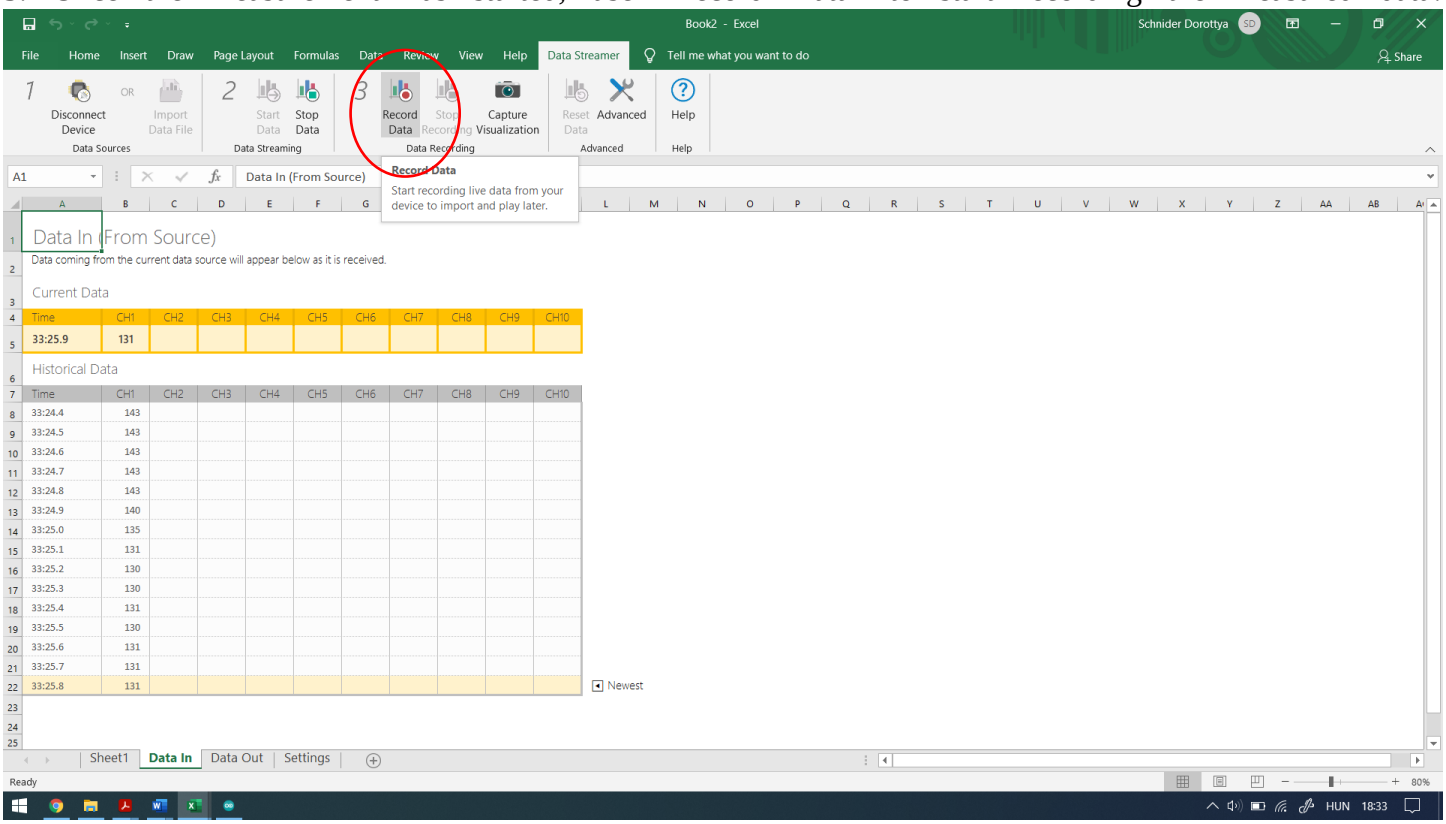
3. Click on the "USB SERIAL CH340" button:



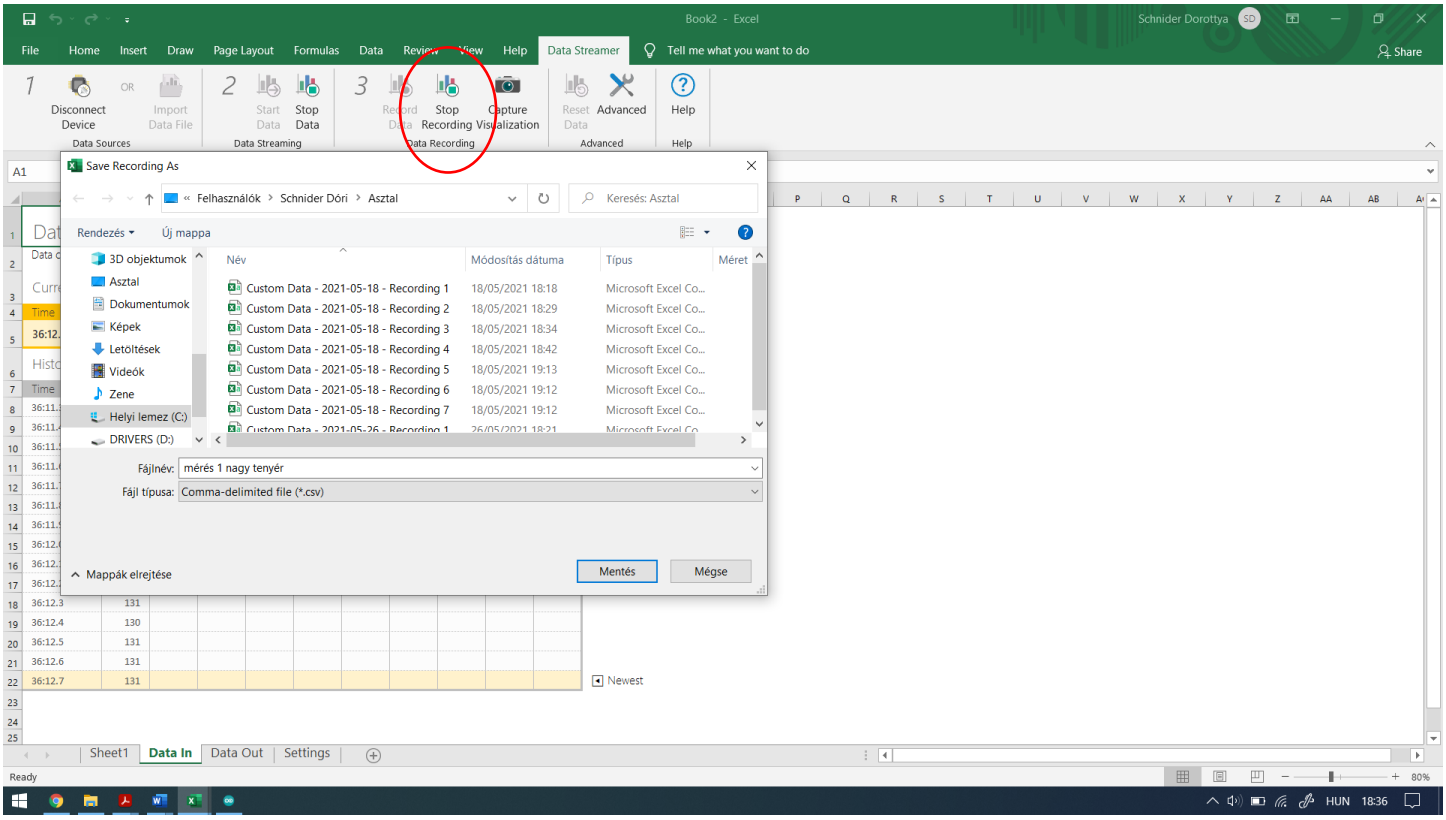
4. Start "live" data transfer with the "Start Data" button:



5. Once the measurement has started, use "Record Data" to start recording the measured data:



6. After the measurement is complete, stop storing the data with the "Stop recording" button, and then save the measurement in the form of the corresponding "file name.csv" :



7. Open the previously saved "file name.csv" document, and then plot the measurement data in a graph: