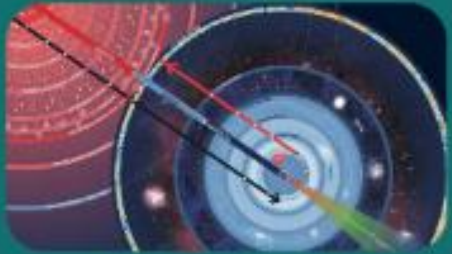
Zasoby, scenariusze i możliwości dla nauczycieli od LIGO

IV Kongres Nauczycieli Fizyki

Aleksander Kołodziej

Publicacions →

Resources →



Images →

LIGO

Laser Interferometer
Gravitational-Wave Observatory
Supported by the U.S. National Science Foundation
Operated by Caltech and MIT

LIGO-India Breaks Ground on New Observatory

News Release • April 23, 2026

New gravitational-wave observatory will become the fifth in the world and is poised to advance research in astrophysics, multi-messenger astronomy,

Virtual Field Trips

LIGO is offering virtual field trips!

*****NOTE:** Due to staffing constraints, we have availability through **November 1, 2026**. For events after that date, please email outreach@ligo-la.caltech.edu ***

Teachers of 4th grade and above have the option to book a virtual tour of the LIGO Livingston Observatory, choose from two inquiry-based activities lasting 15-20 minutes

LIGO

Laser Interferometer
Gravitational-Wave Observatory
Supported by the U.S. National Science Foundation
Operated by Caltech and MIT

LIGO-India Breaks Ground on New Observatory

News Release • April 23, 2026

New gravitational-wave observatory will become the fifth in the world and is poised to advance research in astrophysics, multi-messenger astronomy, fundamental physics, and more.

Educational Resources

Whether you're a K-12 educator, a parent, or an interested student, you should browse our education web pages. There's something fun and educational here for everyone.

- **Classroom Activities** - All sorts of activities you can bring to your classroom that concentrate on LIGO, or concepts related to LIGO (such as, waves)
- **Teacher Professional Development** - Visit this page to learn about the teacher professional development programs offered through each of our two observatories
- **Field Trips** - Want to take a school field trip to LIGO? Click on this link to book a field trip to one of our two observatories
- **Bring LIGO to You** - If you can't bring your class to LIGO, then we may be able to bring a LIGO educator to you. Click here to learn more
- **GW Alerts on Your Phone** - Get notified of new gravitational wave candidate detections!
- **Ask a LIGO-ite** - Do you have a question that's not answered anywhere else on our site? Click here to ask a question of a real LIGO scientist!
- **Recommended Reading and Video** - Some of our favorite resources related to the science behind LIGO
    - **Science Summaries**: available in many languages, these are condensed and simplified versions of a selection of LIGO's published papers
- **Try This at Home** - Here are some LIGO related activities you can try at home!

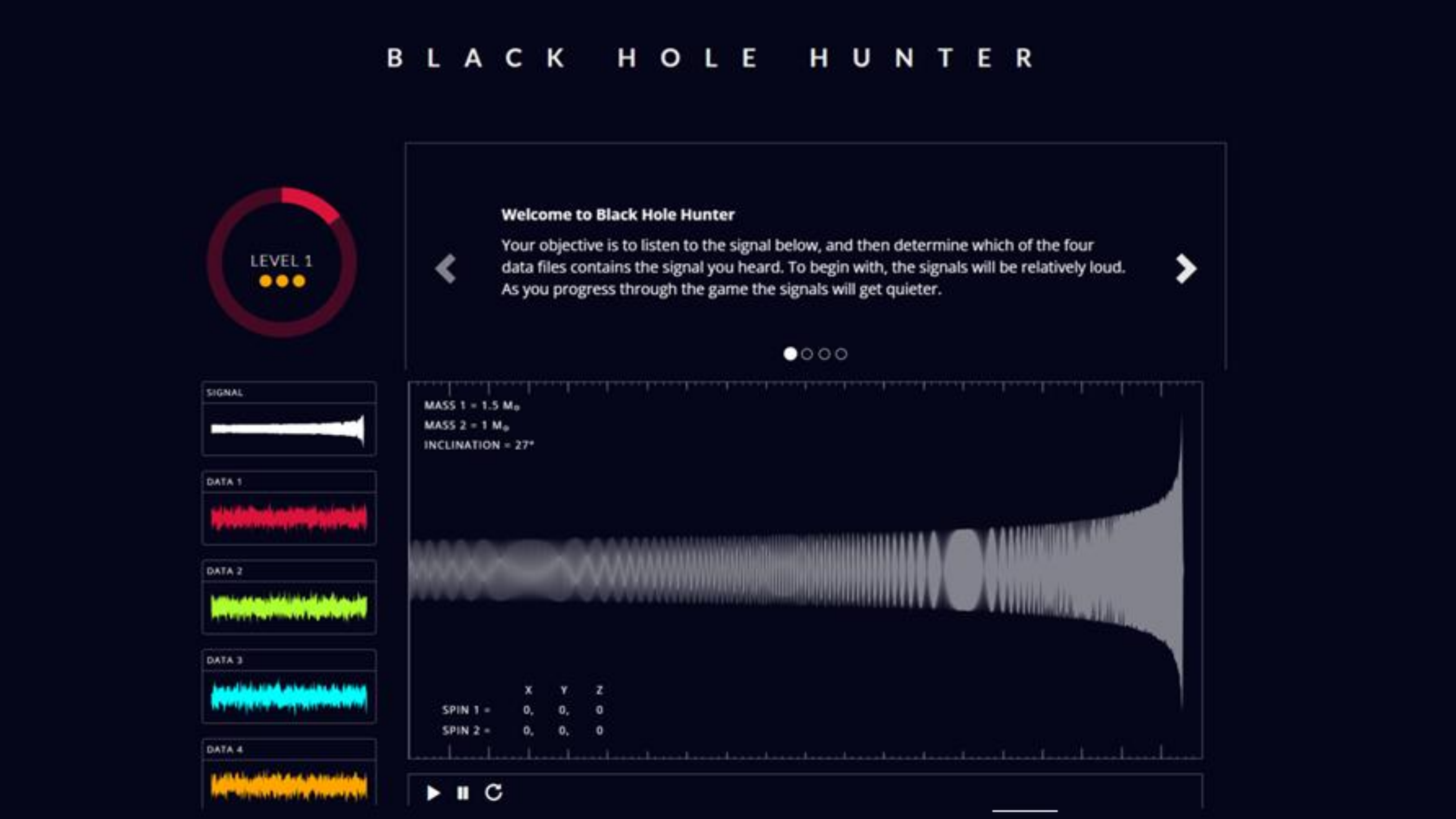
Classroom Activities

This page's resources are intended as tools for teachers and educators to implement to engage their students in hands-on STEM activities. If you'd rather have a LIGO educator come to your classroom to lead an activity, please check out our **"Bring LIGO to You"** page.

Direct Observation of Gravitational Waves: LIGO Educator's Guide: This Educator's Guide provides a brief introduction to LIGO and to gravitational waves, along with two simple demonstration activities that you can do in your classroom to engage your students in understanding LIGO's discoveries.

To view lessons by gradeband, select the gradeband pages linked here: **K-5 Lessons**, **6-8 Lessons**, **9-12 Lessons**.

LIGO Lesson Plans	Lesson Title	Topic	Recommended Grades
	**Black Hole Hunter** https://blackholehunter.org/	Astronomy	4th - 12th


BLACK HOLE HUNTER
LEVEL 1
Welcome to Black Hole Hunter
Your objective is to listen to the signal below, and then determine which of the four data files contains the signal you heard. To begin with, the signals will be relatively loud. As you progress through the game the signals will get quieter.
SIGNAL
DATA 1
DATA 2
DATA 3
DATA 4
MASS 1 = 1.5 M☉
MASS 2 = 1 M☉
INCLINATION = 27°
X Y Z
SPIN 1 = 0, 0, 0
SPIN 2 = 0, 0, 0

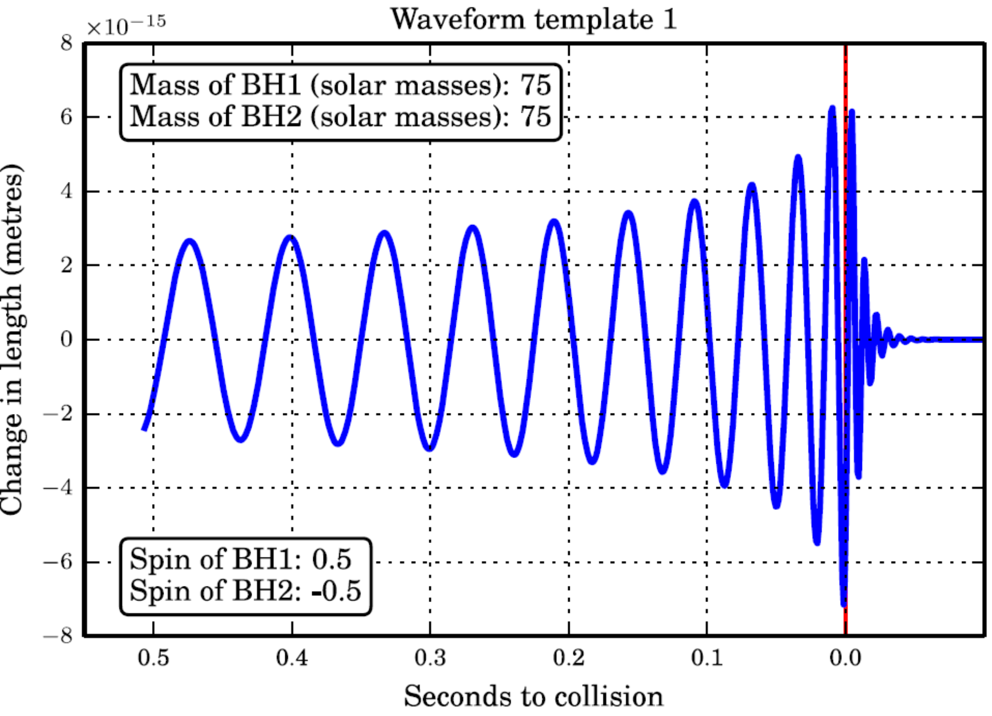
Classroom Activities

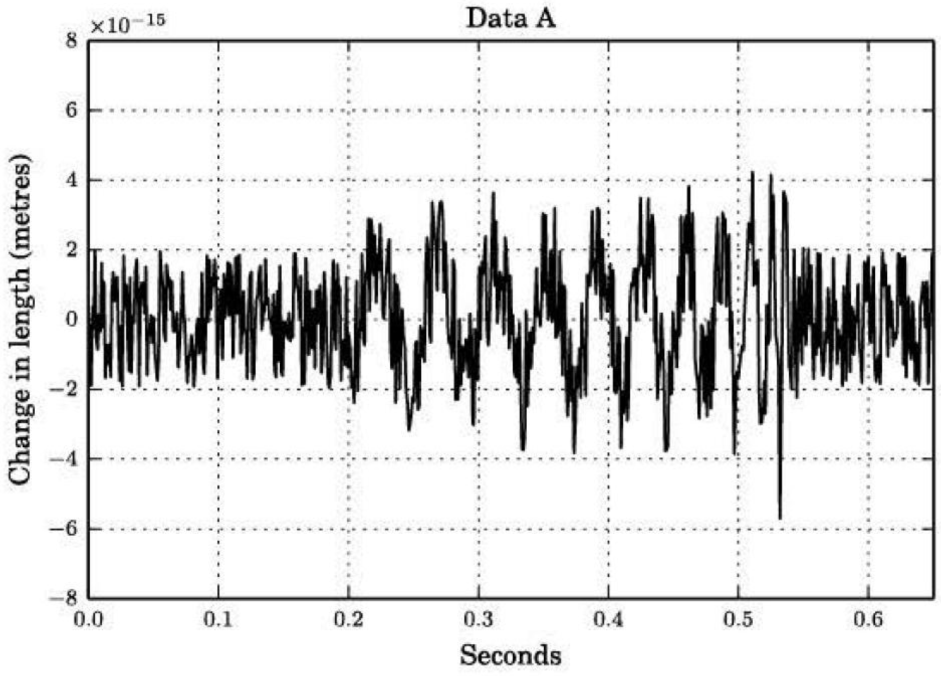
This page's resources are intended as tools for teachers and educators to implement to engage their students in hands-on STEM activities. If you'd rather have a LIGO educator come to your classroom to lead an activity, please check out our **"Bring LIGO to You"** page.

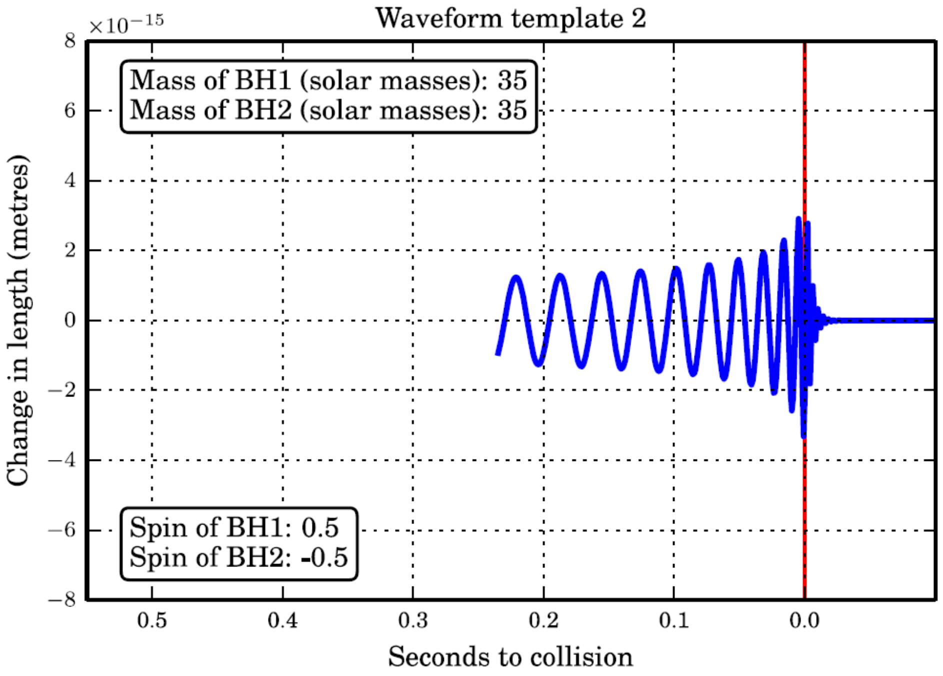
Direct Observation of Gravitational Waves: LIGO Educator's Guide: This Educator's Guide provides a brief introduction to LIGO and to gravitational waves, along with two simple demonstration activities that you can do in your classroom to engage your students in understanding LIGO's discoveries.

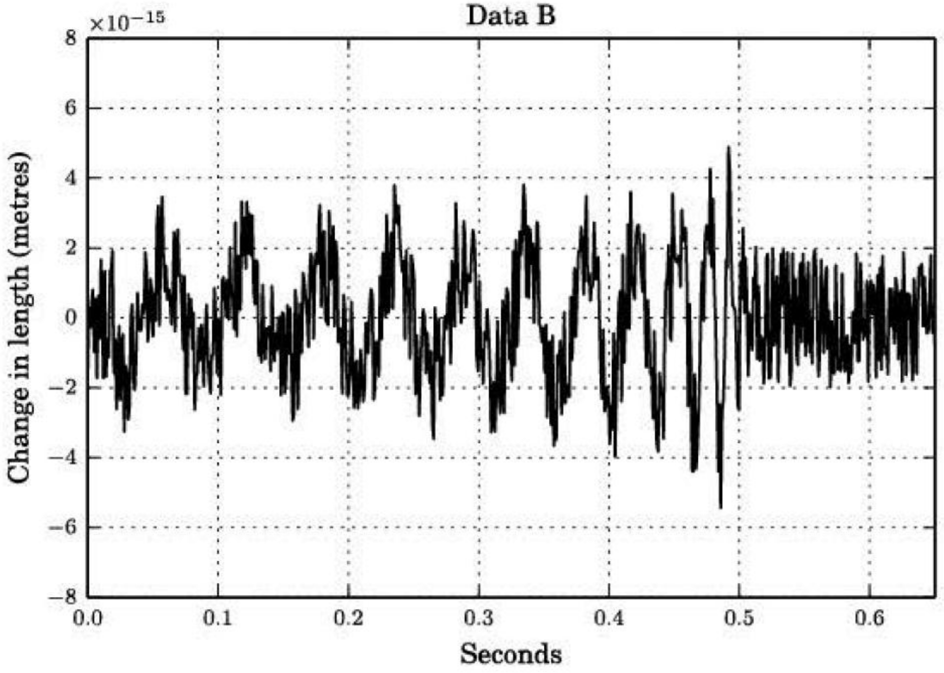
To view lessons by gradeband, select the gradeband pages linked here: **K-5 Lessons**, **6-8 Lessons**, **9-12 Lessons**.

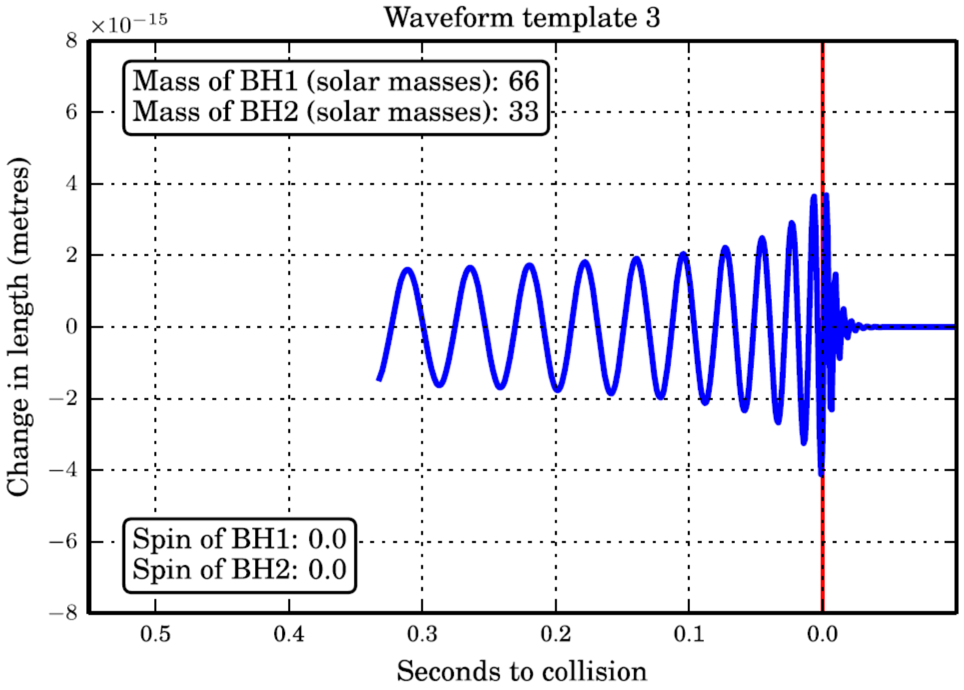
LIGO Lesson Plans	Lesson Title	Topic	Recommended Grades
	**Gravitational Wave Template Matching**	Waves	9th - 12th

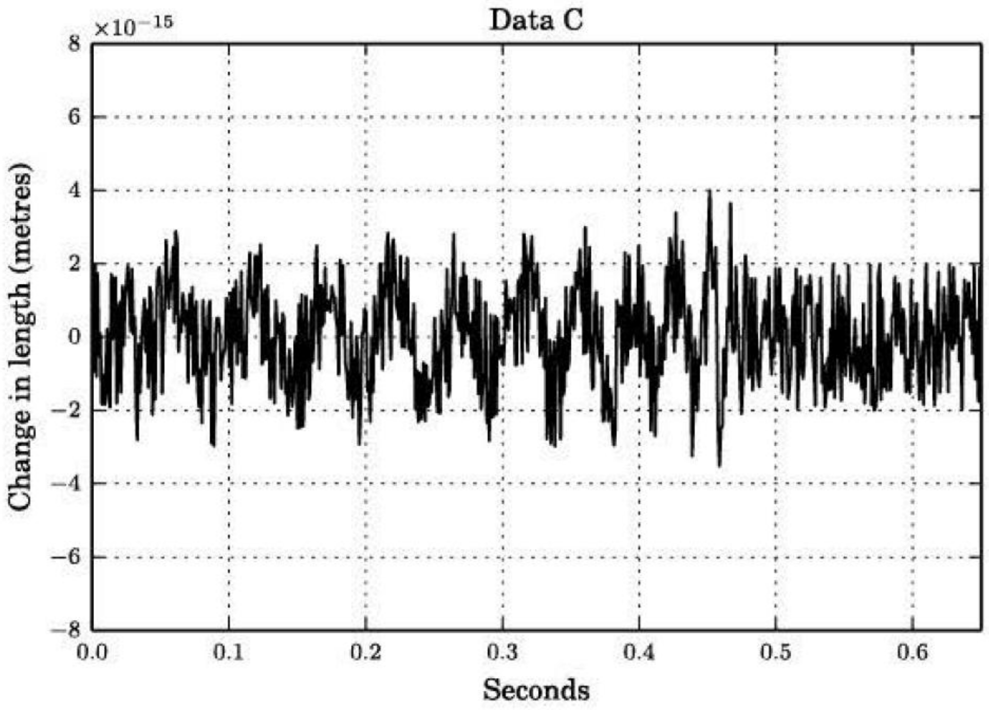

Waveform template 1
×10^−15
Mass of BH1 (solar masses): 75
Mass of BH2 (solar masses): 75
Spin of BH1: 0.5
Spin of BH2: -0.5
Change in length (metres)
Seconds to collision
8
6
4
2
0
−2
−4
−6
−8
0.5
0.4
0.3
0.2
0.1
0.0

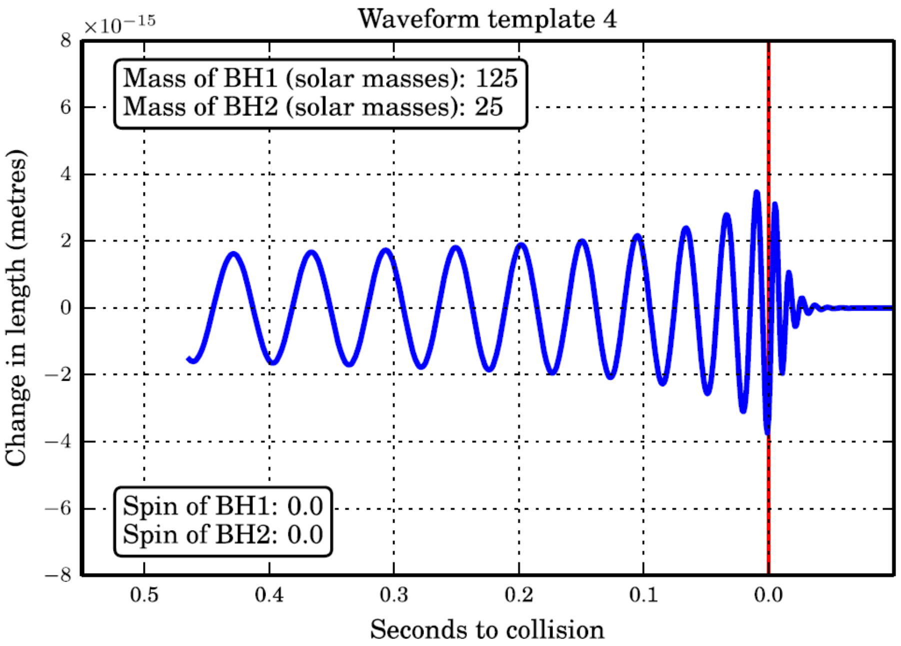

Data A
×10^−15
Change in length (metres)
Seconds
8
6
4
2
0
−2
−4
−6
−8
0.0
0.1
0.2
0.3
0.4
0.5
0.6

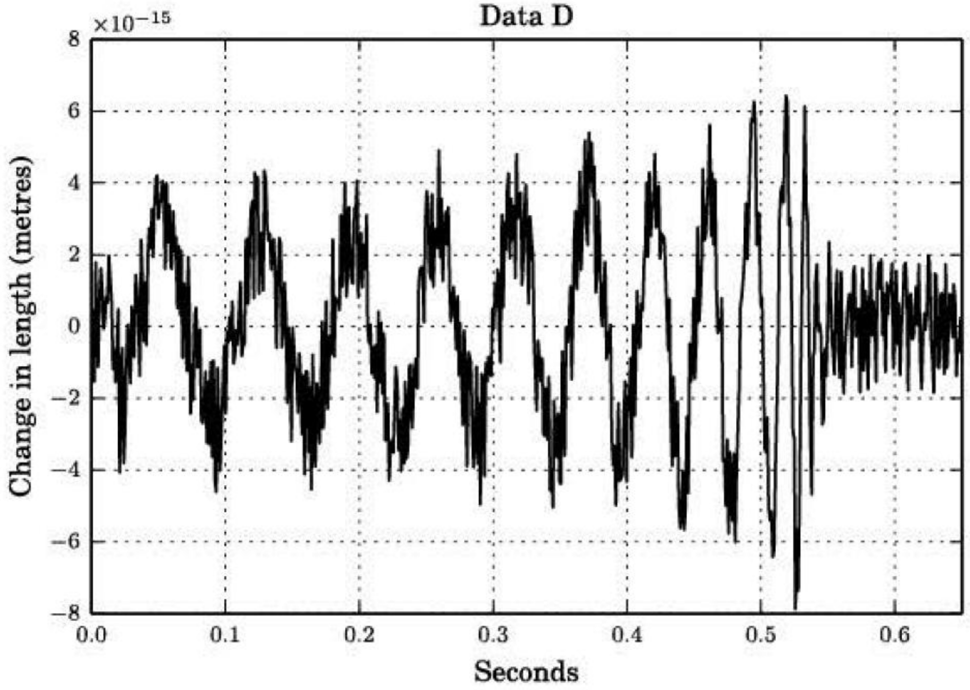

Waveform template 2
×10^−15
Mass of BH1 (solar masses): 35
Mass of BH2 (solar masses): 35
Spin of BH1: 0.5
Spin of BH2: -0.5
Change in length (metres)
Seconds to collision
8
6
4
2
0
−2
−4
−6
−8
0.5
0.4
0.3
0.2
0.1
0.0


Data B
×10^−15
Change in length (metres)
Seconds
8
6
4
2
0
−2
−4
−6
−8
0.0
0.1
0.2
0.3
0.4
0.5
0.6


Waveform template 3
Mass of BH1 (solar masses): 66
Mass of BH2 (solar masses): 33
Spin of BH1: 0.0
Spin of BH2: 0.0
Change in length (metres)
$\times 10^{-15}$
Seconds to collision


Data C
Change in length (metres)
$\times 10^{-15}$
Seconds


Waveform template 4
Mass of BH1 (solar masses): 125
Mass of BH2 (solar masses): 25
Spin of BH1: 0.0
Spin of BH2: 0.0
Change in length (metres)
$\times 10^{-15}$
Seconds to collision


Data D
Change in length (metres)
$\times 10^{-15}$
Seconds

TIPS:

- Make sure the Template is right side up, you should be able to read "Waveform" at the top of the template.
- DO NOT line up the axis, instead **shift** the signal template left and right along the data graphs to find where it might fit best.
- DO NOT just line up the highest amplitude, look for the match of the shape of the wave.
- Some data graphs **may not** contain any real gravitational wave signals.

Match the Data to the GW Signal Templates		
Data	Is there a signal?	Template Number
A		
B		
C		
D		

Analysis:

1. Did you always agree with your classmates as you chose what you thought were the best matches? Can you see how scientists could disagree with each other as they try to match models to signals in their data?

   Answers may vary, but scientists use many sets of eyes to confirm detection, as well as computer programs to help rule out false positive detections.

3. Compare the gravitational wave signals from Template 1 and Template 2.
    a. How are the two signals different? (Be specific, use words like frequency to describe these differences.)
       Waveform 2 has a larger frequency, and smaller amplitude.
    b. What do you think is the reason for difference in the signals?

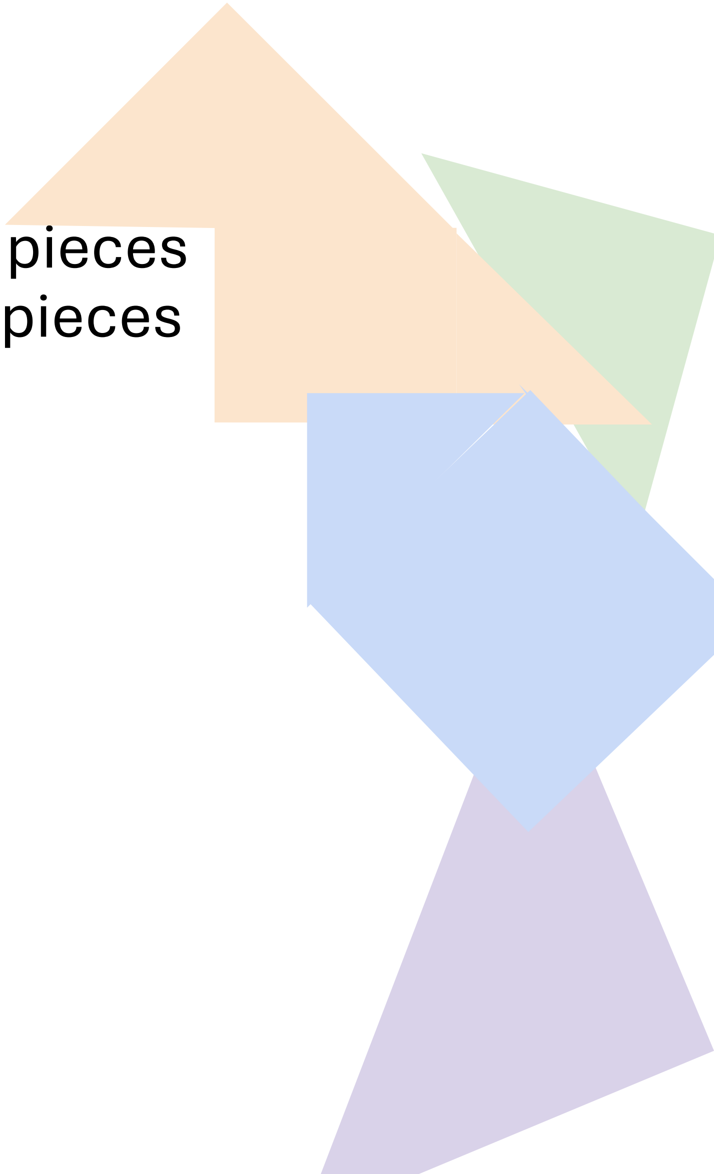
       You can also see on the templates that waveform 2 has black holes of much smaller mass.
4. Compare the gravitational wave signals from Template 3 and Template 5. These compare how spin affects the Gravitational waves of black holes.
    a. How are the two signals different? How are they similar? (Be specific.)
       Waveform 3 has a higher frequency, different spins.
       They have the same amplitude, and mass.

Rearrange the pieces to make a square. Do not:

- Overlap pieces
- Alter the shape of the pieces
- Change the size of the pieces

Nature of Science

- You will be divided into 8 breakout rooms
- You will be given 5 minutes to complete the activity
- Each group will receive a slide that they can edit which has 4 pieces
- Each piece represents a piece of data. We need to put those pieces together in a coherent “theory”, a square.
- Rules:
  - You cannot distort (reshape or resize) pieces
  - You cannot overlap pieces
  - You must use all the pieces



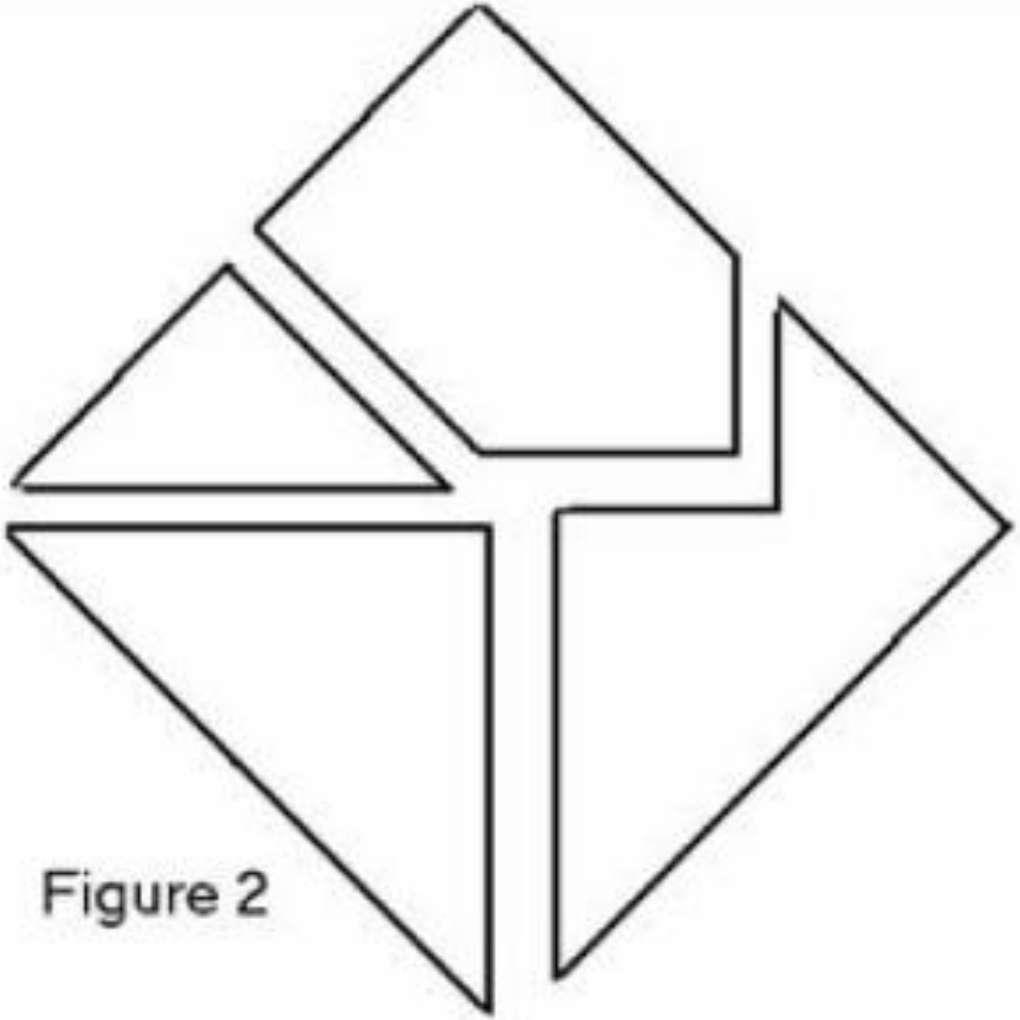


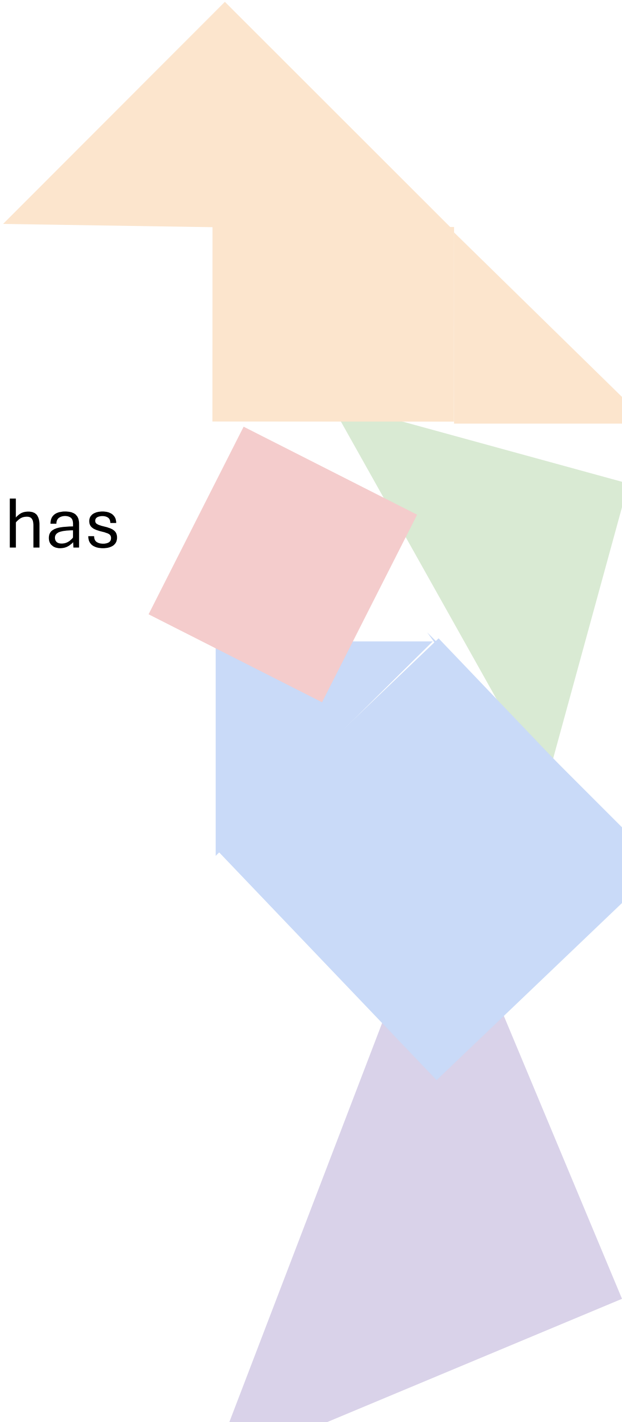
Figure 2

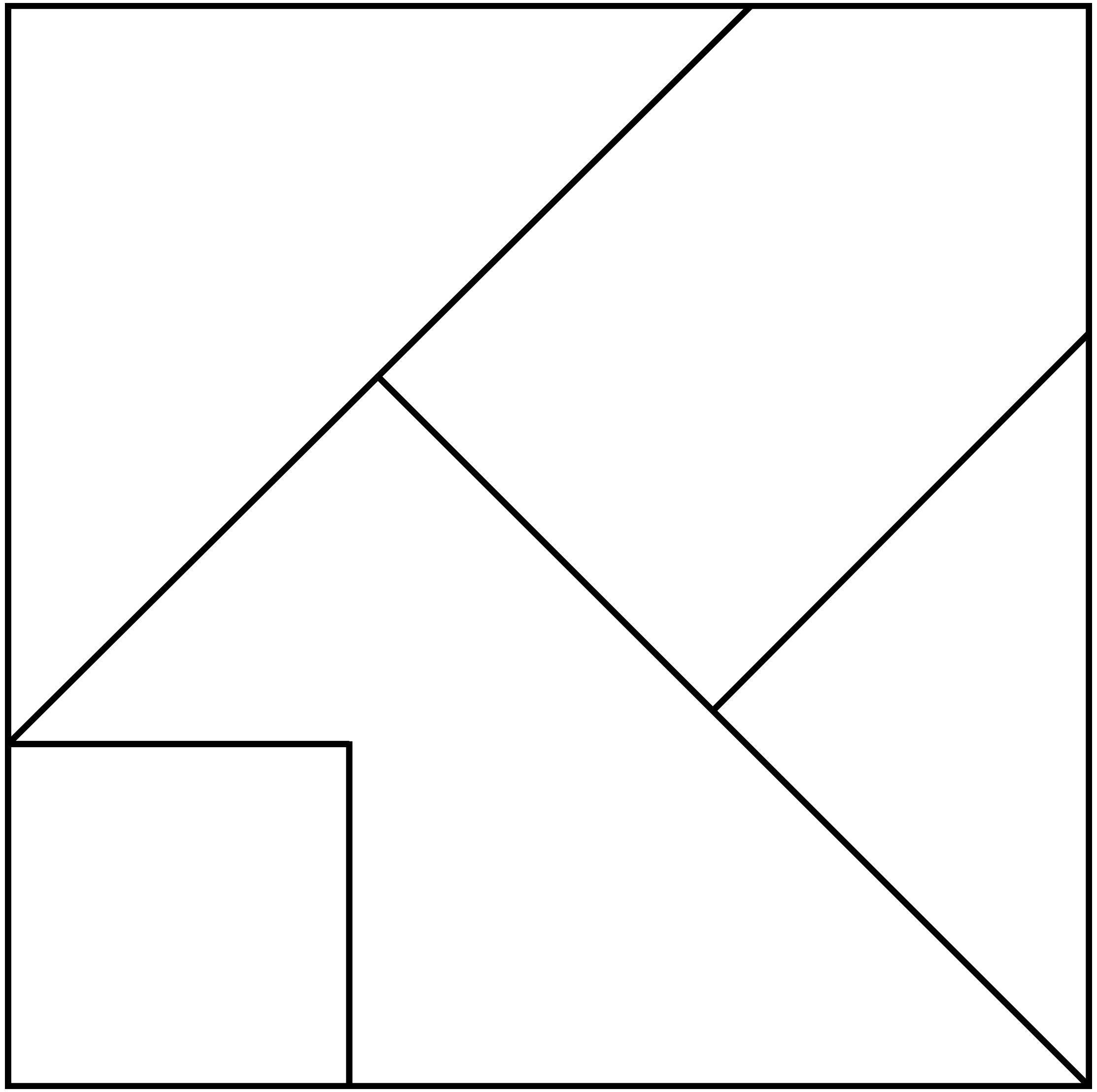
Rearrange the pieces to make a square. Do not:

- Overlap pieces
- Alter the shape of the pieces
- Change the size of the pieces

Nature of Science

- You will be divided into 8 breakout rooms
- You will be given 10 minutes to complete the activity
- Each group will receive a slide that they can edit which has 5 pieces
- Each piece represents a piece of data. We need to put those pieces together in a coherent “theory”, a square.
- Rules:
  - You cannot distort (reshape or resize) pieces
  - You cannot overlap pieces
  - You must use all the pieces



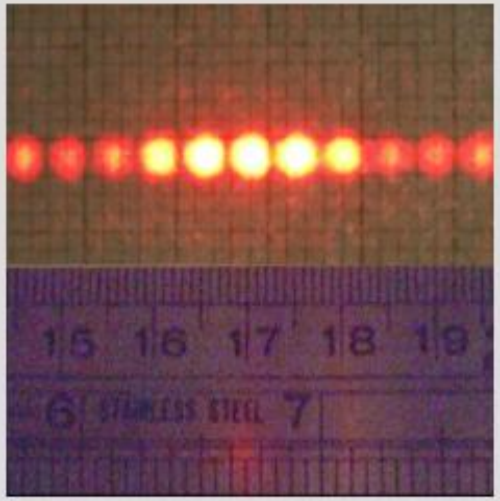


Classroom Activities

This page's resources are intended as tools for teachers and educators to implement to engage their students in hands-on STEM activities. If you'd rather have a LIGO educator come to your classroom to lead an activity, please check out our **"Bring LIGO to You"** page.

Direct Observation of Gravitational Waves: LIGO Educator's Guide: This Educator's Guide provides a brief introduction to LIGO and to gravitational waves, along with two simple demonstration activities that you can do in your classroom to engage your students in understanding LIGO's discoveries.

To view lessons by gradeband, select the gradeband pages linked here: **K-5 Lessons**, **6-8 Lessons**, **9-12 Lessons**.

LIGO Lesson Plans	Lesson Title	Topic	Recommended Grades
	**Width of a Hair** **Laser Diffraction**	Light, Waves, Interferrence	9th - 12th

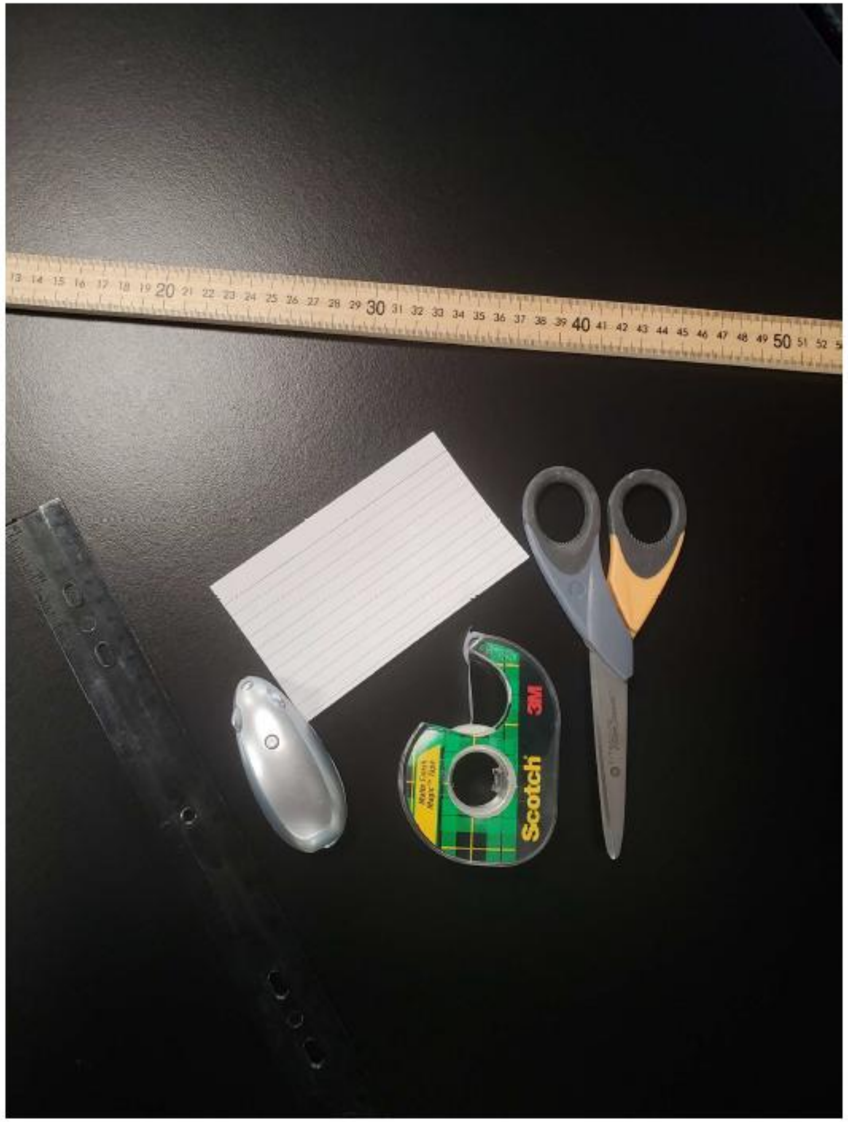
Objective:

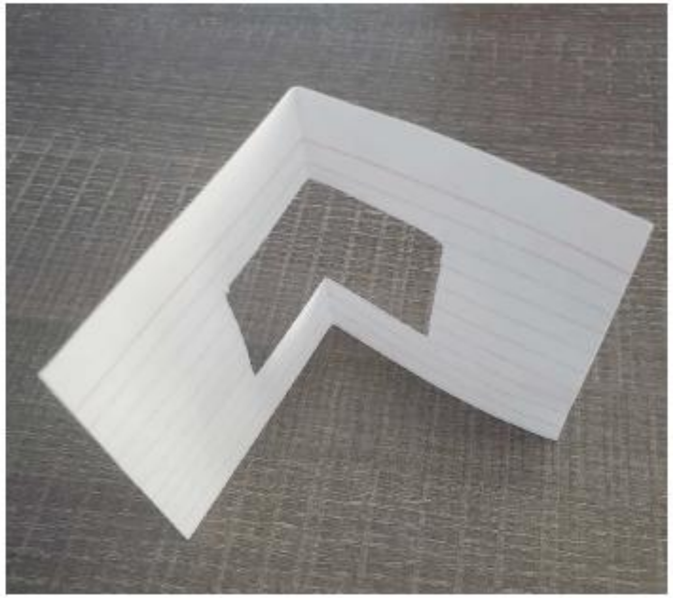
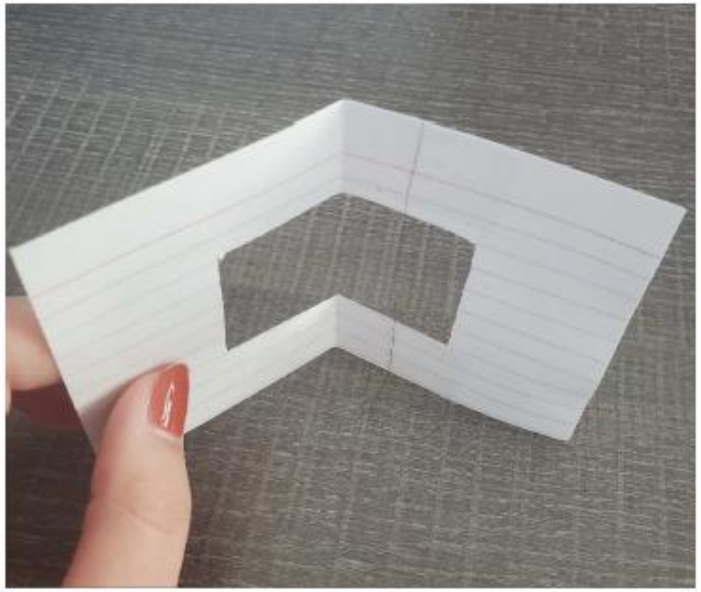
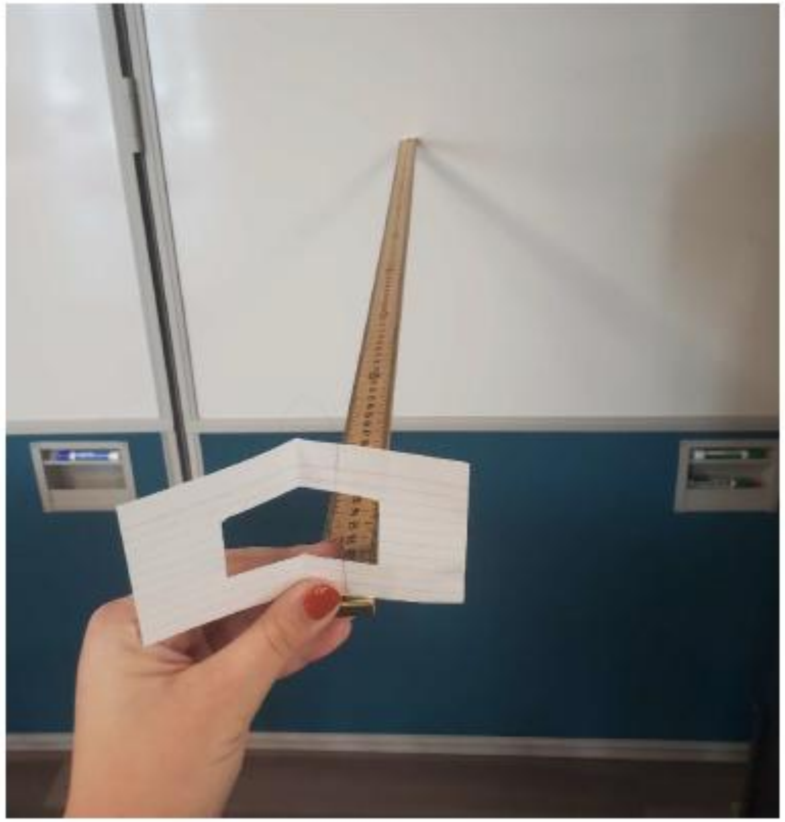
- Students will be able to calculate the diameter of a human hair using the properties of light diffraction.

Safety Considerations: Students will need to work with laser pointers in approximately the 650nm wavelength range. Students should be instructed never to point a laser pointer into a person's face or eyes, which may lead to injury.

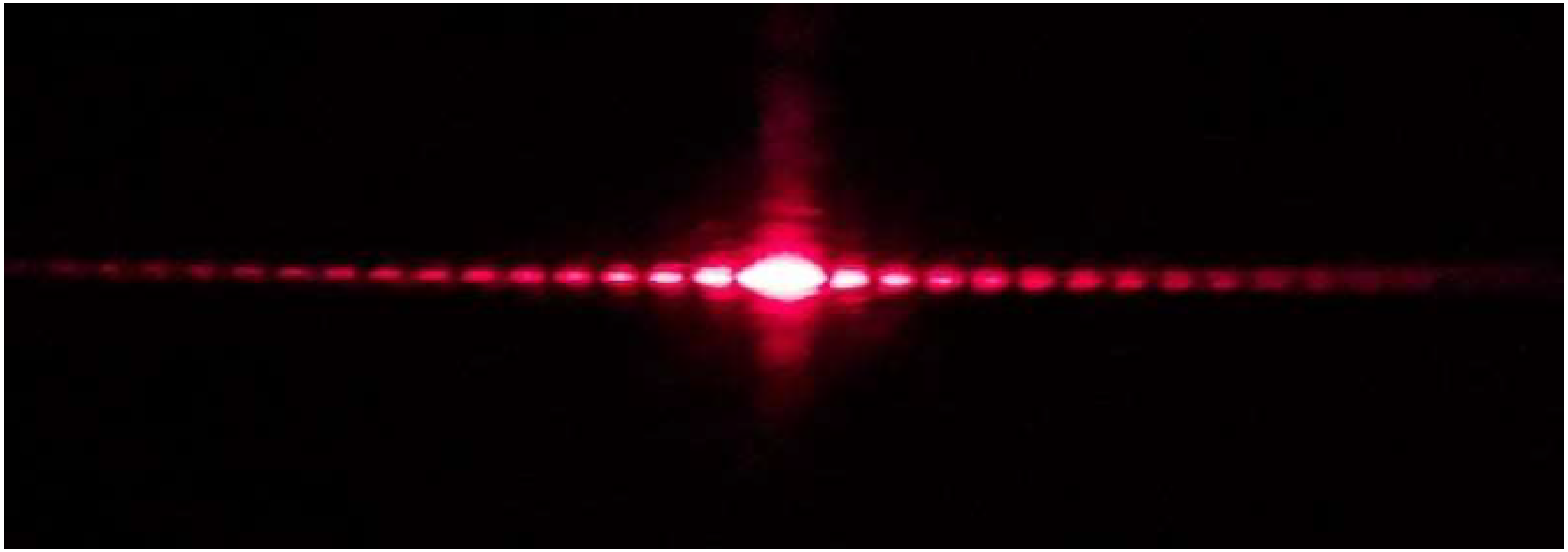
Materials:

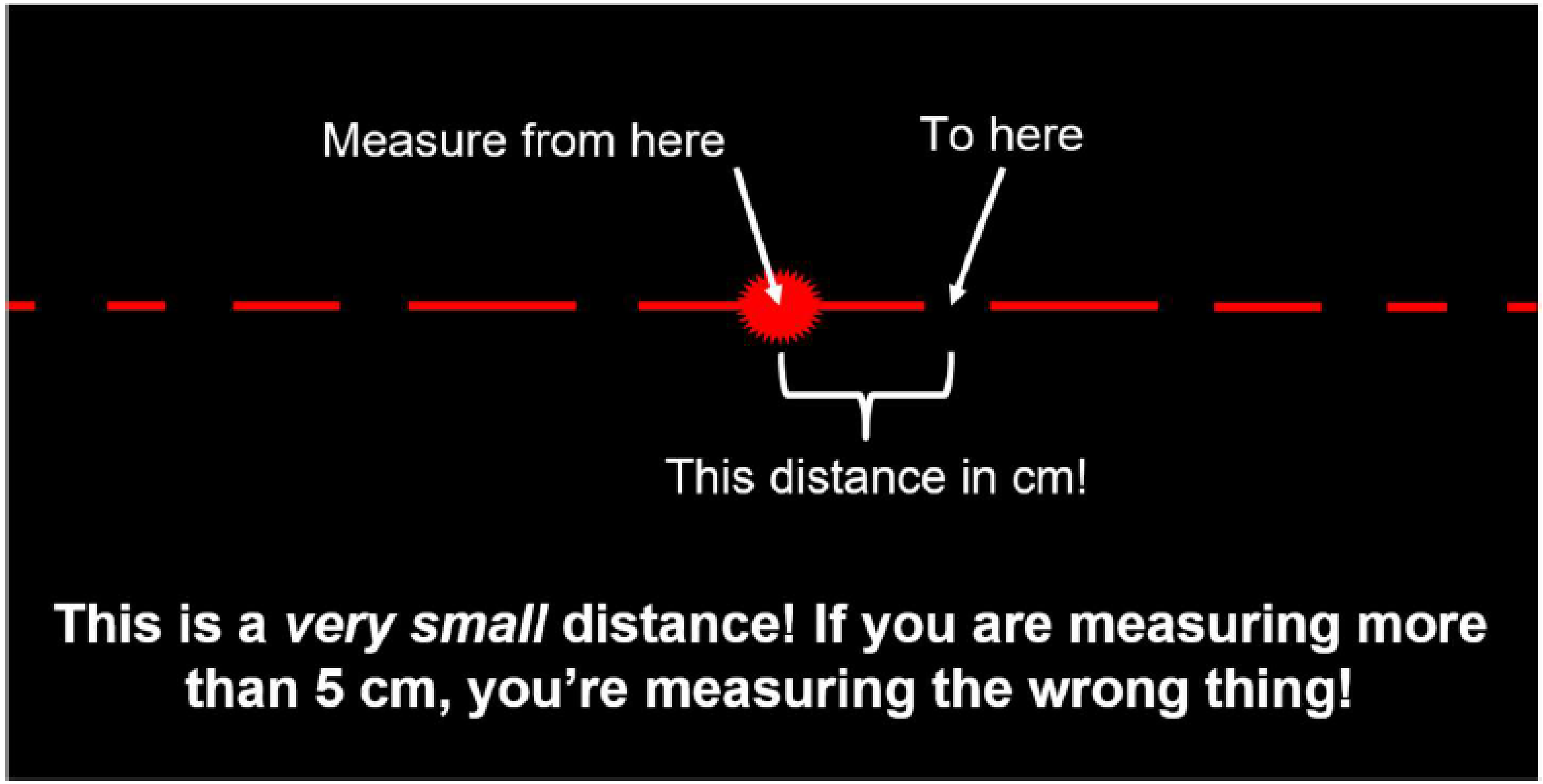
- 1 meter stick
- 1 pair of scissors
- 1 ruler
- 1 roll of Scotch tape
- 1 index card or similarly stiff paper
- 1 ~650nm laser pointer (cat toy laser pointer pictured below)
- 1 human hair




- v




Measure from here
To here
This distance in cm!
This is a *very small* distance! If you are measuring more than 5 cm, you're measuring the wrong thing!

7. The following equation may be used to calculate the width of the hair in nanometers.

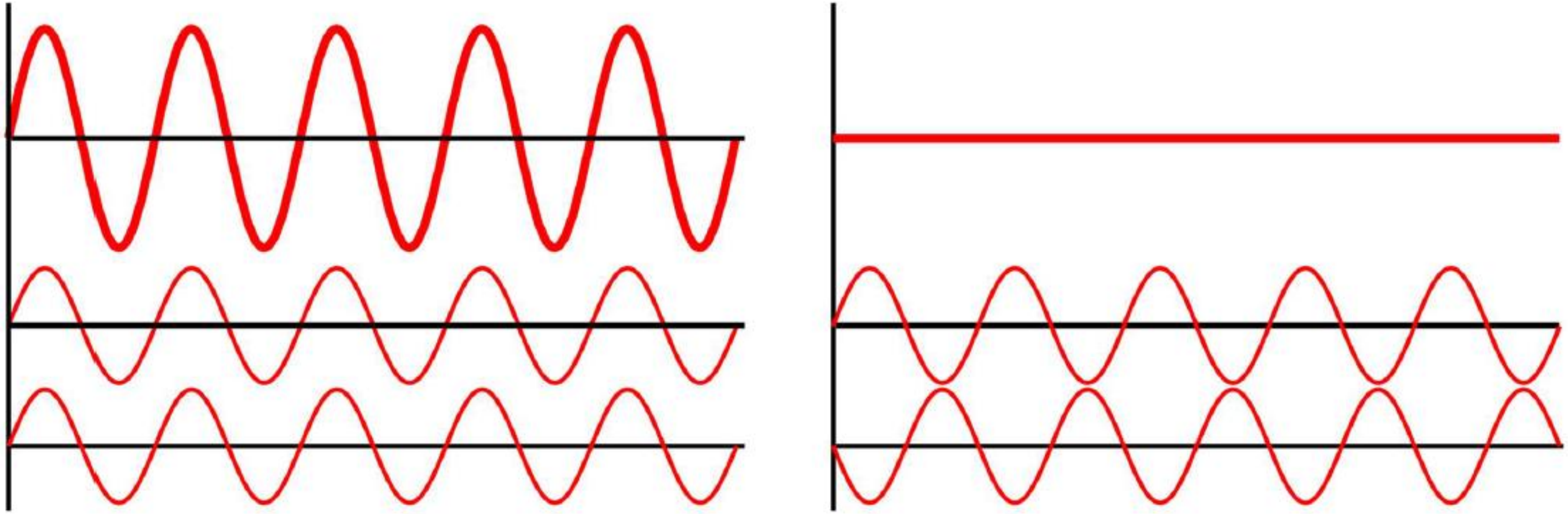
$$d = \frac{\lambda D}{y}$$

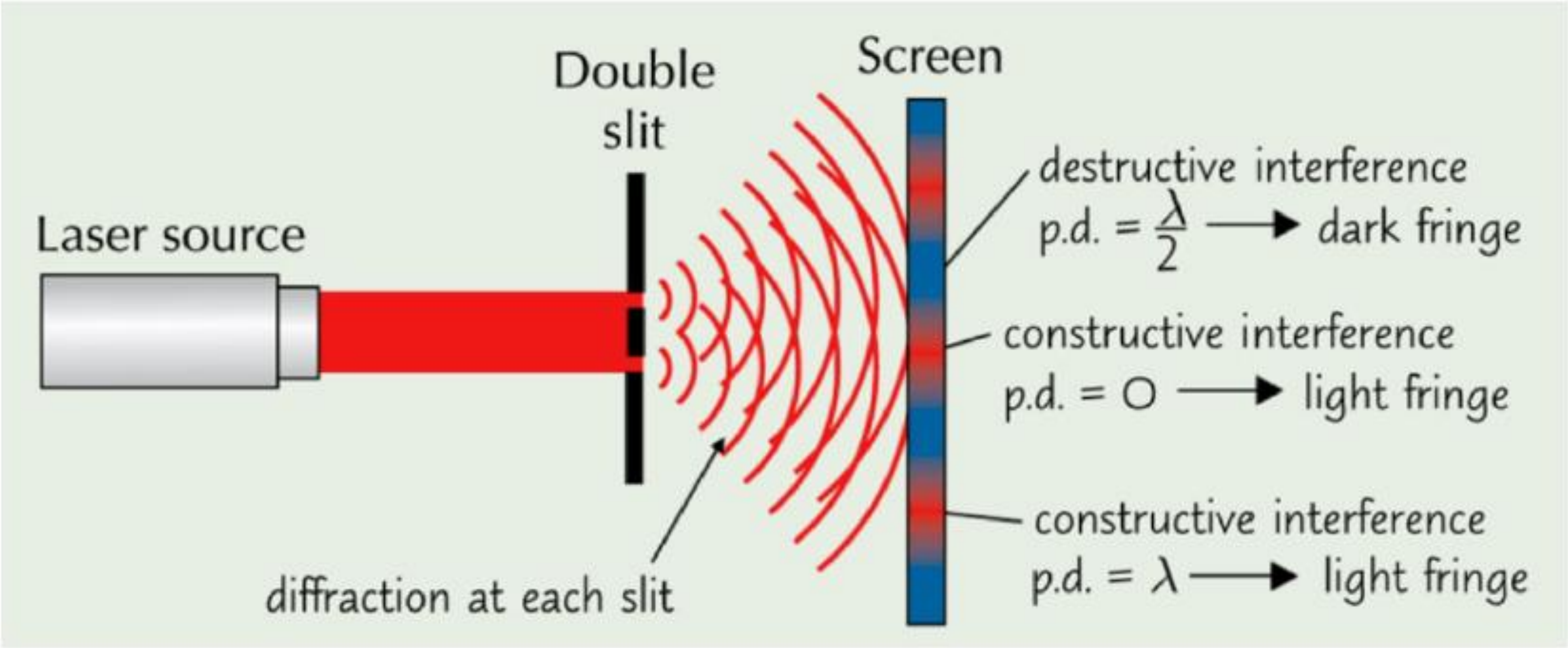
$$d \text{ in } nm = \frac{(650\ nm)\ (100\ cm)}{y \text{ in } cm}$$

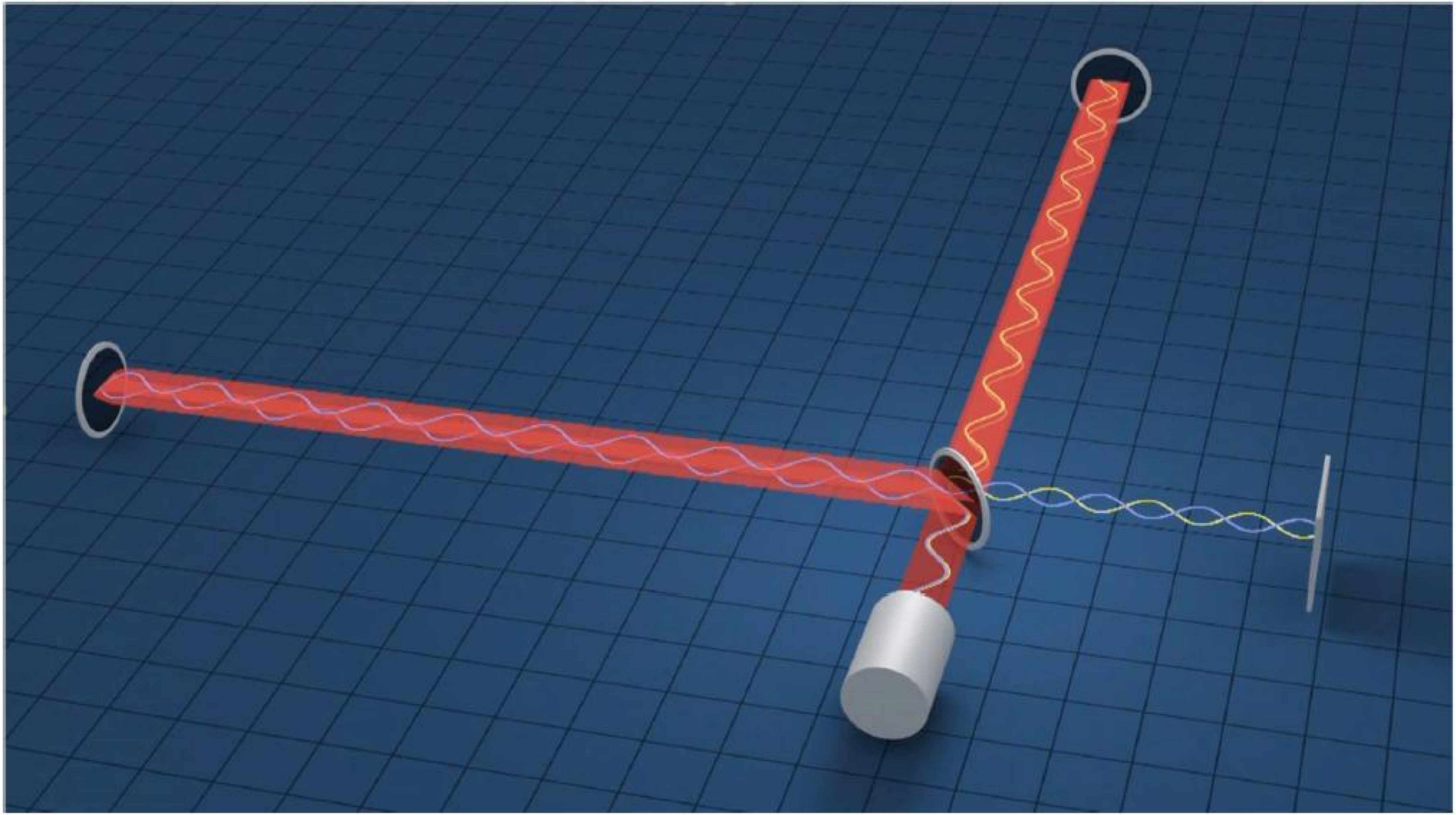
Where d = the diameter of your hair in nanometers
$\lambda = 650\ nm$, the wavelength of the laser
D = 100 cm, the distance from the hair to the wall
y = the distance measured from one maximum to the next minimum in centimeters

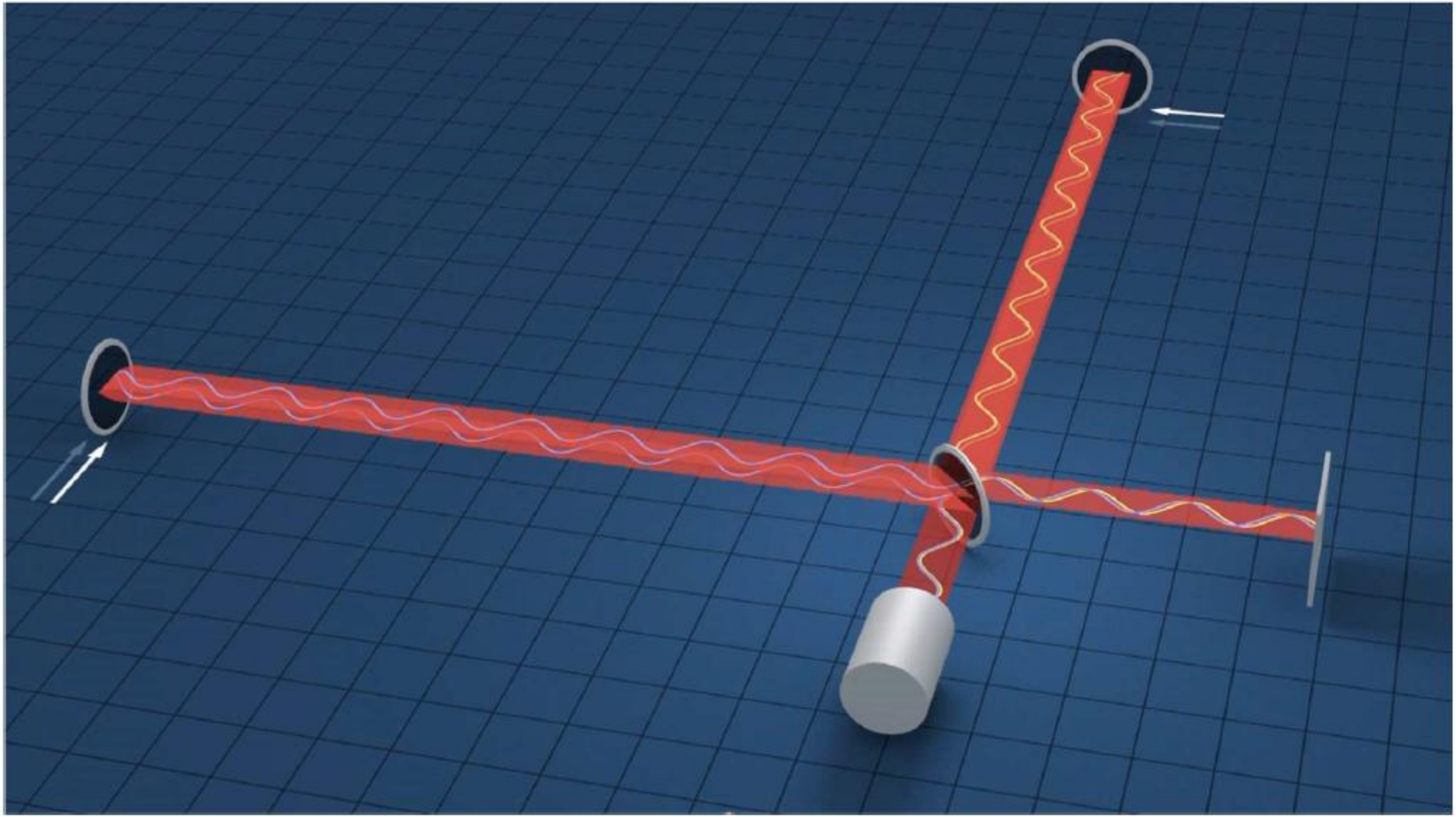
Width of a Hair

8. Have student groups run the calculation, then call out their answers. You might share with students that the average width of a hair is between *17,000 – 180,000 nm*. Students can then determine scientifically if their hair is particularly fine or thick.

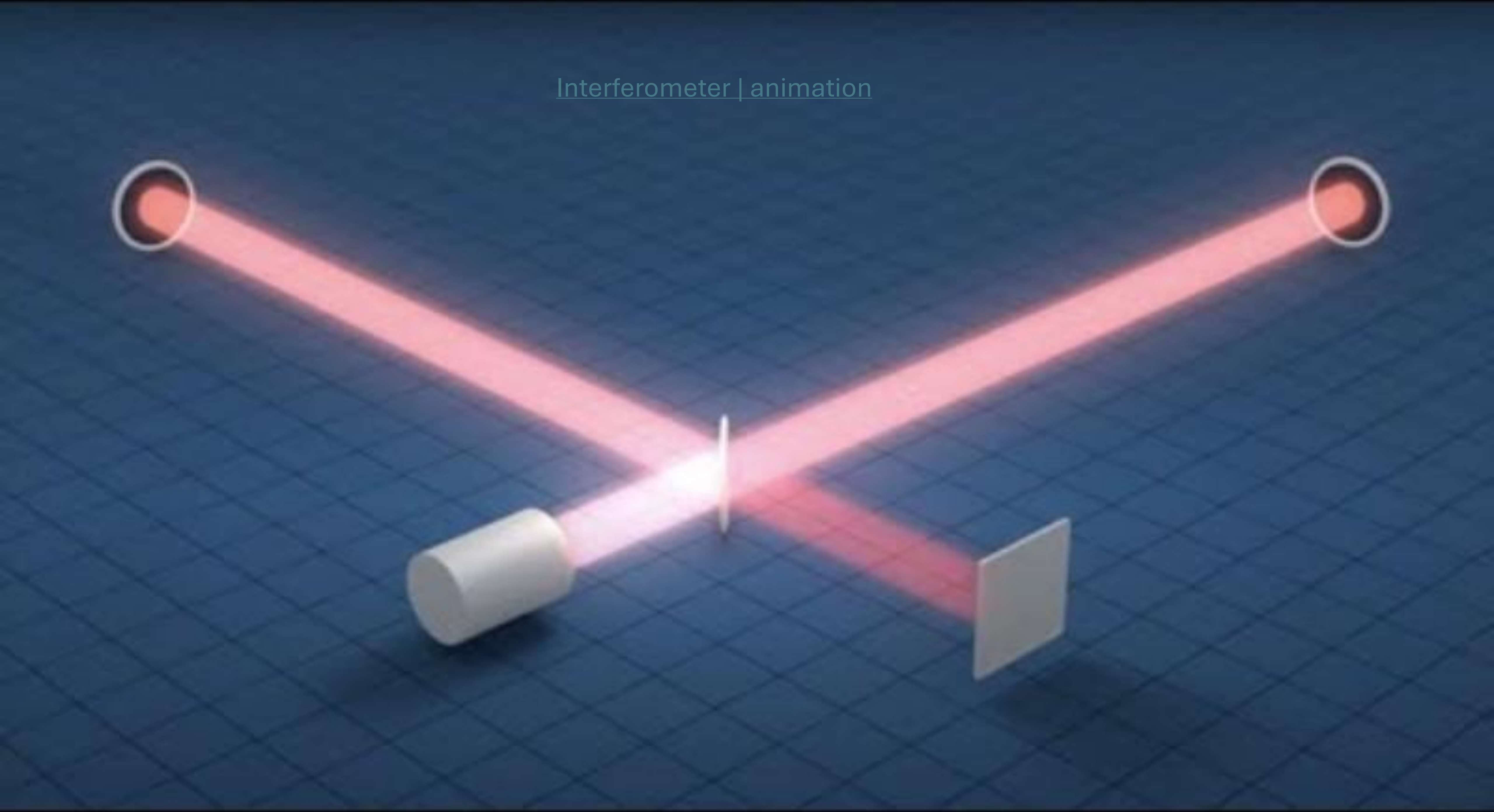



Double slit
Screen
Laser source
destructive interference
p.d. = $\frac{\lambda}{2}$ → dark fringe
constructive interference
p.d. = 0 → light fringe
constructive interference
p.d. = λ → light fringe
diffraction at each slit





Interferometer | animation

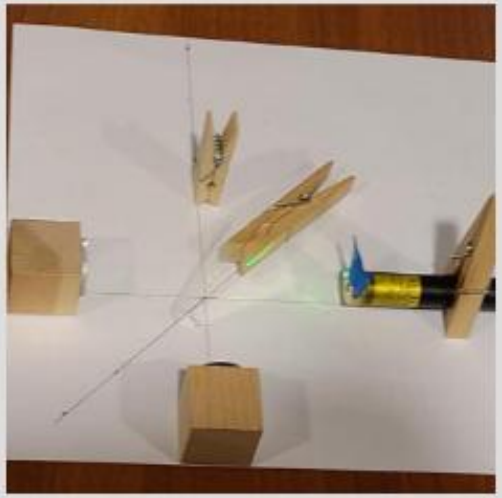


Classroom Activities

This page's resources are intended as tools for teachers and educators to implement to engage their students in hands-on STEM activities. If you'd rather have a LIGO educator come to your classroom to lead an activity, please check out our **"Bring LIGO to You"** page.

Direct Observation of Gravitational Waves: LIGO Educator's Guide: This Educator's Guide provides a brief introduction to LIGO and to gravitational waves, along with two simple demonstration activities that you can do in your classroom to engage your students in understanding LIGO's discoveries.

To view lessons by gradeband, select the gradeband pages linked here: **K-5 Lessons**, **6-8 Lessons**, **9-12 Lessons**.

LIGO Lesson Plans	Lesson Title	Topic	Recommended Grades
	**Build Your Own Interferometer**	Light, Waves, Interferrence	10th - 12th

Try This at Home

Check out these leisure-time U.S. National Science Foundation Laser Interferometer Gravitational-wave Observatory (NSF LIGO) activities that you can try alone or with friends. Build an interferometer, play a game, operate a virtual interferometer, or search for gravitational waves with your own computer!

Interactive Activities, Games, and Ways to Help LIGO:

- **Gravity Spy** Help NSF LIGO scientists search for gravitational waves by finding different kinds of "glitches" found in real LIGO data. By identifying glitches, you will help train LIGO's computers to find gravitational wave signals more efficiently! Get started today! (Brought to you by Zooniverse.)
- **Build an interferometer** **(Method A -- Glue; Method B -- Magnets)**
- **Black Hole Hunter** Brought to you by Cardiff University
- **Black Hole Master** Brought to you by Laser Labs, the makers of the Detection Alert iPhone and Android Apps
- **Space-Time Quest** Brought to you by Laser Labs, the makers of the Detection Alert iPhone and Android Apps
- **Einstein@Home** Use your computer's idle time to search for gravitational waves.

Free Educational Resources for Teachers

Perimeter Institute's free digital resources are designed to help teachers explain a range of important physics and science topics. Each compilation includes a set of lesson plans, hands-on activities and demos, modifiable worksheets, background information for teachers, and original PI videos.

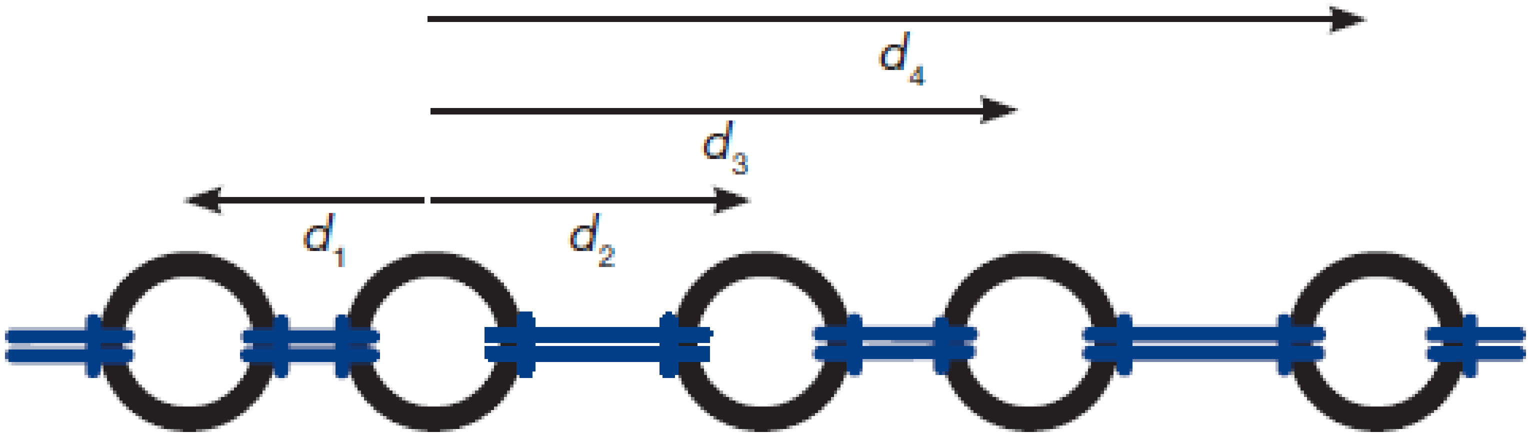
Learn More

The Expanding Universe

The Expanding Universe

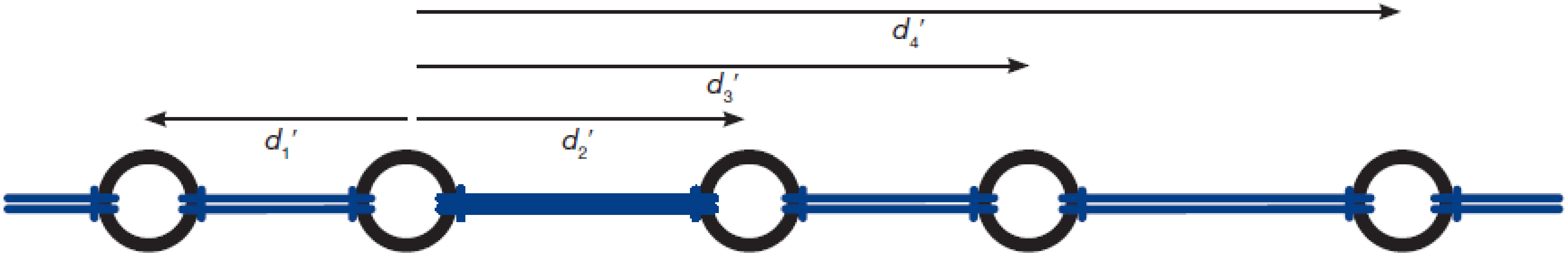
Activity 3
The Expansion of Space

4. Choose your group's home galaxy from your chain, and record in Table 1. Measure the distance from your to the other galaxies in your chain. Record your measurements in column 1 of Table 1.



Measure the distances (d_1, d_2, d_3, d_4 etc.) from your home galaxy to all the other galaxies.

5. Now the universe needs to expand. A group member is positioned at each end of the galaxy chain, then they each pull their washers such that the universe doubles in size (from end to end). A third group member repeats Step 4 and measures the new distances to the galactic neighbours. Record your measurements in column 2 of Table 1.



Measure the stretched distances (d_1', d_2', d_3', d_4' etc.) from your home galaxy to all the other galaxies.

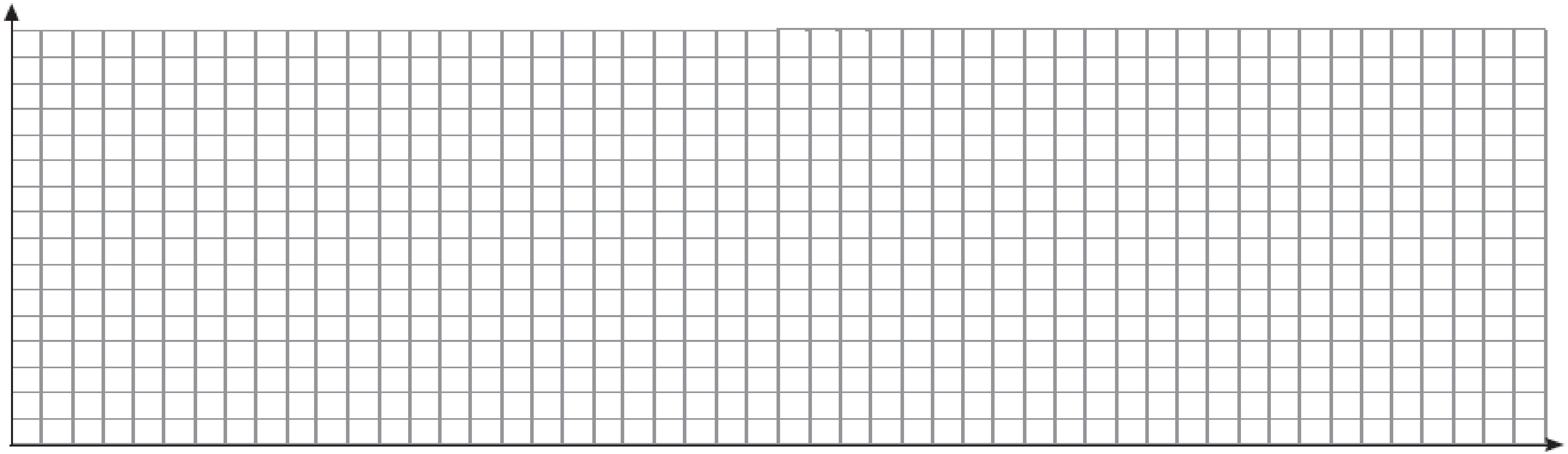
Part 2: Plotting and Comparison

6. Complete column 3 of Table 1 by calculating the increase in distance between the two measurements in columns 1 and 2.

Table 1 Galaxy Distance Measurements

Home Galaxy Number: ____	Column 1: Original Distances (unit)	Column 2: New Distances (unit)	Column 3: Increase in Distances (unit)
Galaxy ________			
Galaxy ________			
Galaxy ________			
Galaxy ________			
Galaxy ________			
Galaxy ________			
Galaxy ________			
Galaxy ________			
Galaxy ________			

7. Graph the data from Table 1, with the original distance (column 1) on the horizontal axis and the increase in distance (column 3) on the vertical axis. Be sure to label both axes and include your chosen measurement units.



8. Draw a line of best fit, and calculate the slope. Be sure to include all units.

Inquiry

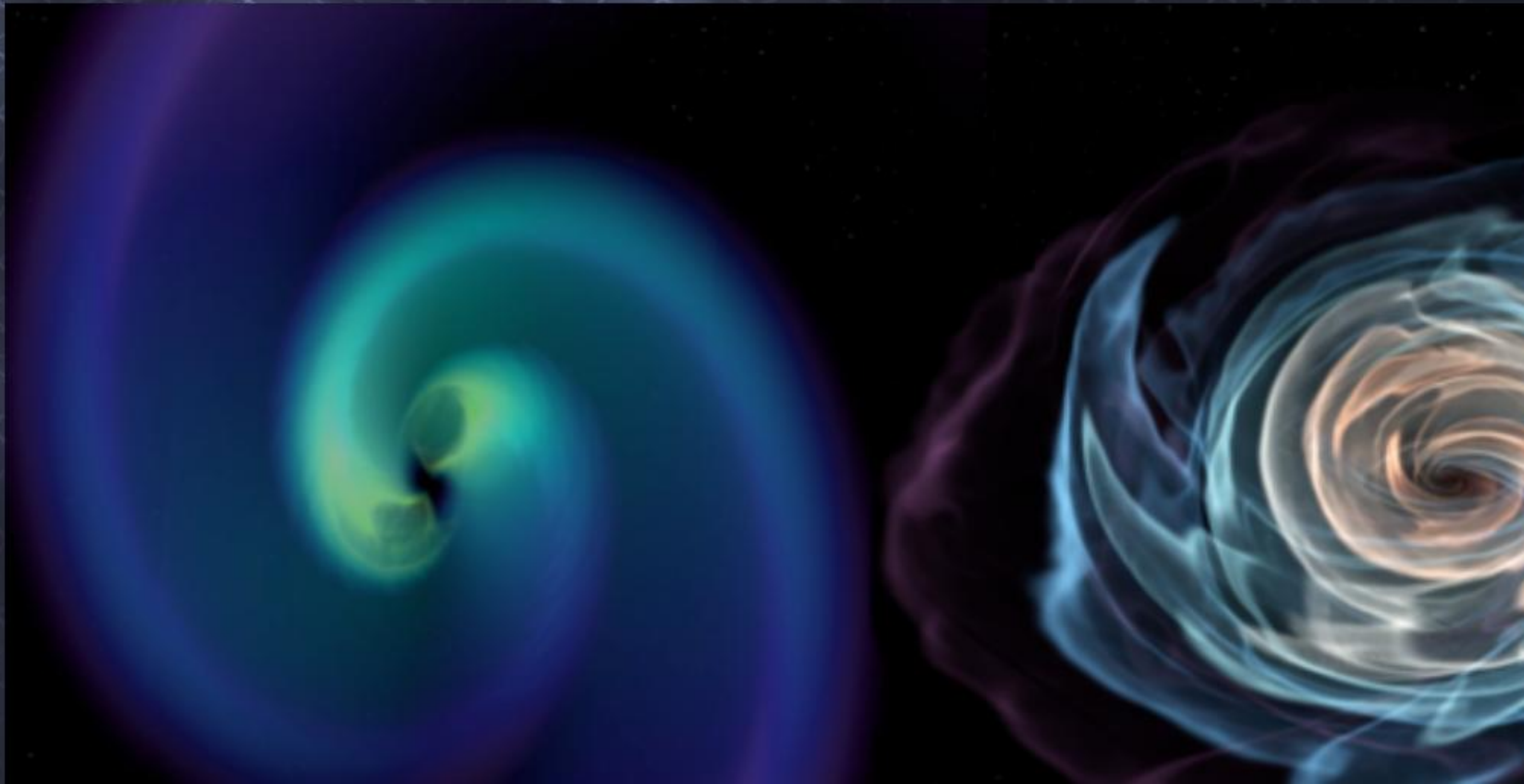
(Answer on a separate piece of paper.)

1. Compare your slope with that of your classmates. What do you notice? What effect does your choice of home galaxy have on the slope?
2. Describe how the positions of the distant galaxies changed compared to the positions of the nearby galaxies. How does your slope reflect this?
3. How would the chain look if the slope value were higher? Lower? How would you describe the universe if the slope were higher? Lower?
4. Comment on the difference in measurement units used. Is one system better than another?
5. If the universe is expanding, why don't the sizes of the galaxies expand as well?

LIGO

Laser Interferometer
Gravitational-Wave Observatory
Supported by the U.S. National Science Foundation
Operated by Caltech and MIT

International Physics & Astronomy Educator Program
Elementary Teacher Waves Workshop
Field Trips
LHO Internships
Bringing LIGO to You



International Physics & Astronomy Educator Program

Applications for the 2026 LIGO International Physics and Astronomy (IPA) program are now closed. Please check back when applications for the 2027 IPA program open in November 2026.

PERIMETER INSTITUTE

Group photo of 2019's IPA participants at LIGO Hanford Observatory. Attendees hailed from 11 countries.

Teachers work in teams playing the role of student while learning new hands-on activities to be applied in their classrooms around the world.

Szkolenie w LIGO na Youtube

juddy PRODUCTIONS