

Name: _____

Gravitational Wave Astrophysics: **Searching for Gravitational Waves**

In this activity, we will learn about how gravitational waves are extracted from LIGO's data. We have gravitational wave templates that are printed on transparency sheets, and various streams of data that are printed on regular paper.

1) Referring to one of the templates, describe the general shape of the waves emitted from two black holes (i.e. how do the amplitude and frequency change before and after the black holes collide?).

Amplitude and frequency increase until the black holes merge. After the black holes merge, the amplitude dies off and eventually goes to zero.

Even though LIGO is sensitive to changes in distance as small as 10^{-18} metres, its data is still quite noisy! LIGO detects gravitational waves by matching templates to its data – if we can find a matching template, then the data could have a signal.

2) Using the gravitational-wave templates, determine if the four data sets given contain a gravitational wave signal by matching the data with the template. Fill in the table:

Data	Is there a signal?	Template
A	No	N/A
B	Yes	1
C	Yes	3
D	Yes	4

3) Using only the templates, how do you think the gravitational waves change (think about the amplitude, time before collision)...

... when you increase the **total mass** of the black holes?

With increasing total mass, increases amplitude, increases time before collision

... between black holes that are **spinning** vs. **non-spinning**?

Spinning vs. non-spinning: less time before collision, same amplitude

4) Why is it important for gravitational-wave detection to have templates for different binary black holes?

Different binary black holes emit different-looking gravitational waves. In order to detect gravitational waves from our data, we need many different templates.