Welcome back to PHY 3305

Today's Lecture:

Uncertainty Principle

Werner Heisenberg
1901-1976

ANNOUNCEMENTS

- Reading Assignment for Thursday, October 6th:
  Chapter 5.1 - 5.4.
- Problem set 7 is due **Thursday, October 12th** at 12:30 pm.
- Regrade for problem set 6 is due **Thursday, October 12th** at 12:30 pm.
- Exam 2 is in class, Thursday, October 19th at 12:30 pm. It will directly cover chapters 3 and 4. This does not mean you can forget everything from the beginning of the course as the material builds.
- Dr. Cooley will be out of town October 15th - 18th. I will be here for the exam. I will be at UT Dallas on Friday, Oct 20th.

The Nobel Prize in Physics 2017

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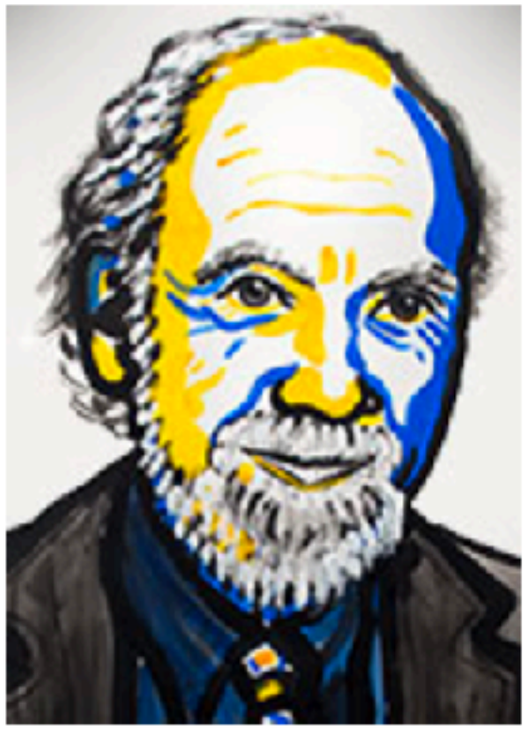
Rainer Weiss

Prize share: 1/2



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Barry C. Barish

Prize share: 1/4

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Kip S. Thorne

Prize share: 1/4

The Nobel Prize in Physics 2017 was divided, one half awarded to Rainer Weiss, the other half jointly to Barry C. Barish and Kip S. Thorne *"for decisive contributions to the LIGO detector and the observation of gravitational waves"*.

<http://www.nobelprize.org/nobel_prizes/physics/laureates/2017/>

PHDCOMICS.COM/TV

https://www.youtube.com/watch?v=4GbWfNHtHRg&feature=youtu.be

GRAVITATIONAL WAVES FROM COLLIDING BLACK HOLES

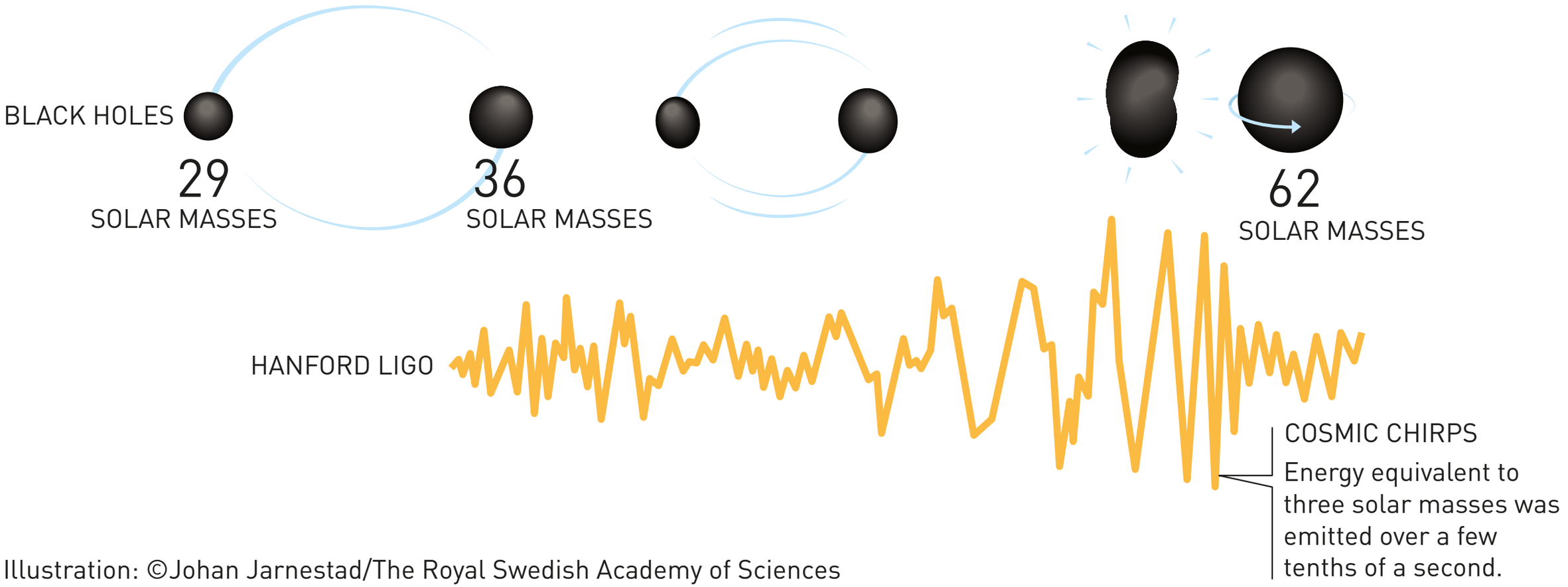


Illustration: ©Johan Jarnestad/The Royal Swedish Academy of Sciences

LIGO – A GIGANTIC INTERFEROMETER

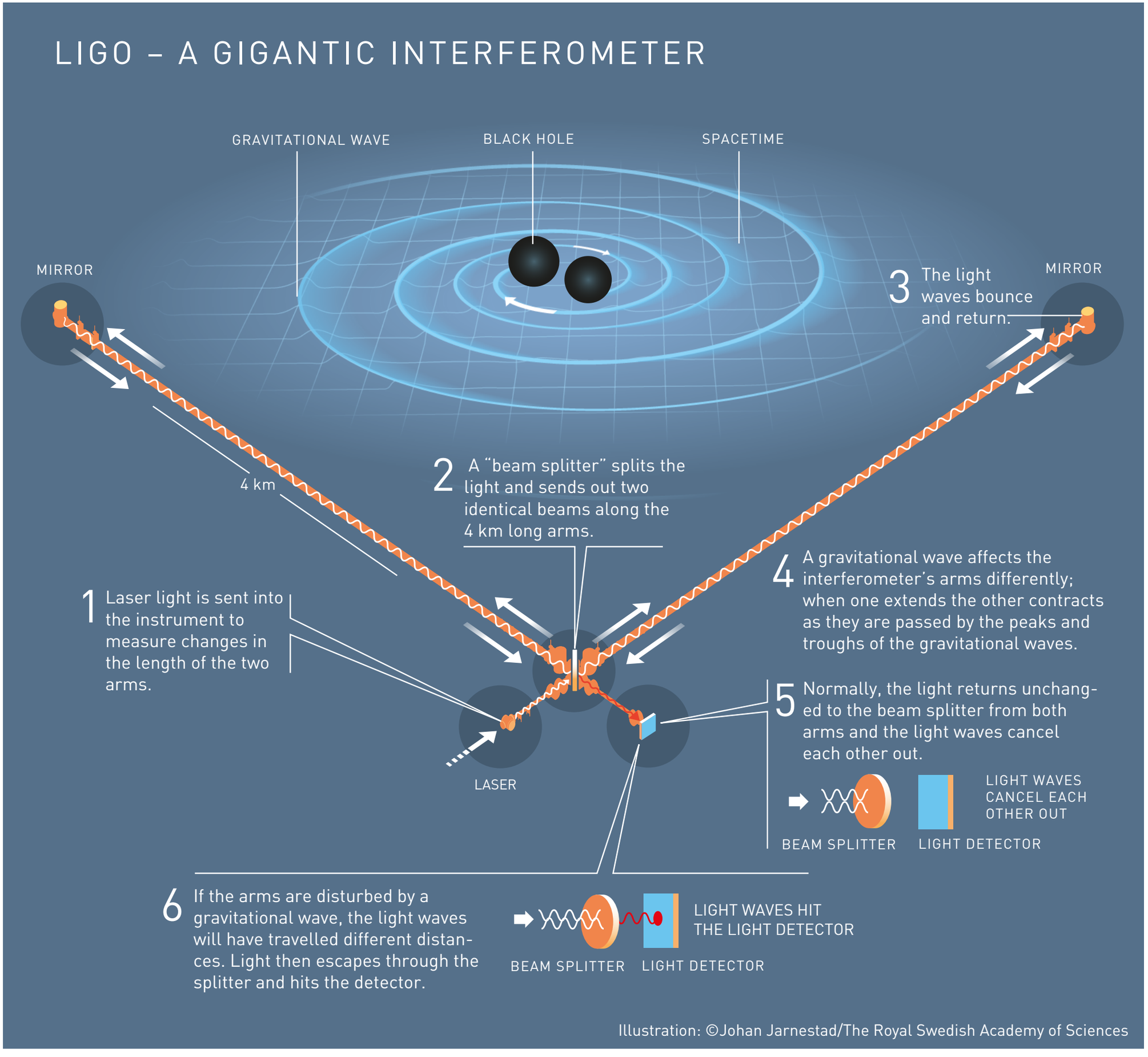
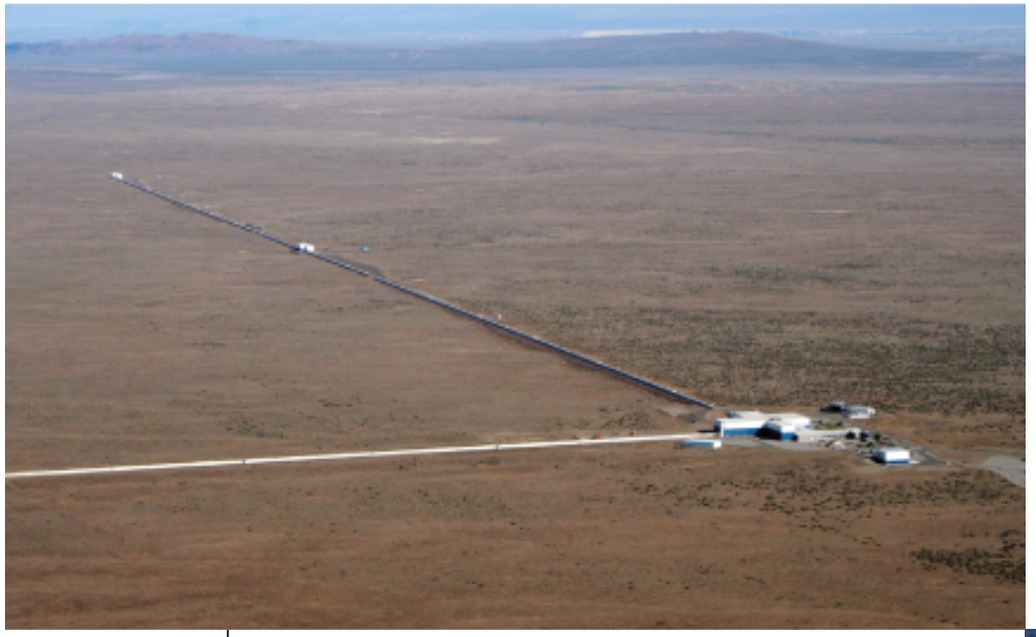


Illustration: ©Johan Jarnestad/The Royal Swedish Academy of Sciences



The Hanford facility is on the steppes of the northwest USA, outside Hanford.

The Livingston facility is in Livingston in the southern swampland of Louisiana.

Courtesy Caltech MIT/Ligo Laboratory

Courtesy Caltech MIT/Ligo Laboratory

FIG 4. LIGO consists of two gigantic identical interferometers. The gravitational wave first hit the interferometer in Livingston and then passed its twin in Hanford, just over 3,000 km away, 7 milliseconds later. The signals were almost identical, and were a good match with the predicted signal for a gravitational wave. Using the signals, an area in the southern skies could also be identified as the area the waves came from.

Illustration: ©Johan Jarnestad/The Royal Swedish Academy of Sciences

MODERN PHYSICS PRESENTATIONS

You will be expected to do the following:

1. Deliver a 15 minute presentation on the topic.
2. Adhere to the basic principles of good presentation design.
3. Answer questions from the audience on the subject.
4. Ask questions of your classmates on their subjects.

This week you will be asked to find good references for your presentations.

Give some examples of reliable (good) references.

peer reviewed journals (best)
textbooks
some websites
interview with an expert

Give some examples of not not reliable (bad) references.

some websites
interview with your friend (unless he/she is an expert)

What about wikipedia?

Use with caution case. Wikipedia is not a PRIMARY source. However, articles often do have primary sources as references.

PRIMARY REFERENCES

- You will be required to use at least 3 sources of good quality in your talk/project.

Reliable

Peer Reviewed Journal article (best).
Most Textbook
Interview with an expert.
Some websites.
Some videos/movies/ multimedia.

Unreliable

Some websites (Wikipedia,).
Your friend.
Some books.
Some articles.

Where should you go to find resources?

http://www.smu.edu/Libraries

http://scholar.google.com/

https://sites.smu.edu/cul/apps/or/dbTitleKeyword.aspx?KeywordSearch=IEEE+XPLORE

REVIEW QUESTION 1:

The probability that a particle is in a given small region of space is proportional to:

a) its energy

b) its momentum

c) the frequency of its wave function

d) the square of the average wavelength of its wave function

e) the square of the magnitude of its wave function

Last details:

There is a formal procedure for calculating Δx and Δp. The outcome of these calculations gives the wave packet with the smallest possible value of the product Δx Δp as h/4π. (section 4.7 of your book).

$$\Delta p_x \Delta x \geq \frac{\hbar}{2}$$

Nobel Prize: 1932

Heisenberg Uncertainty Principle:

Because of a particle's wave nature, it is theoretically impossible to know precisely both its position along an axis and its momentum component along that axis; Δx and Δp can not be zero simultaneously. There is a strict theoretical lower limit on their product.

EXAMPLE: HYDROGEN ATOM

The hydrogen atom is known to be about 0.1 nm in radius. That is the electron's orbit, whatever may be its shape, extends to about this far from the proton. Accordingly, the uncertainty in the electron's position is no larger than about 0.1 nm. What is the minimum theoretical uncertainty in its velocity?

Solution:

$$\Delta p_x \Delta x \geq \frac{\hbar}{2}$$

$$\Delta p_x \geq \frac{\hbar}{2\Delta x}$$

$$\Delta v_x = \frac{\Delta p_x}{m} \geq \frac{\hbar}{2m\Delta x} = \frac{1.055 \times 10^{-34} J \cdot s}{2(9.11 \times 10^{-31} kg)(0.1 \times 10^{-9} m)}$$

$$\Delta v_x = 5.8 \times 10^5 \frac{m}{s}$$

THE END
(FOR TODAY)