11 – How to Effectively Read a Physics Textbook

The following is how I prepare for studying. It's like stretching at the gym or doing some quick cardio before intense exercise to loosen and prepare the mind.

1) First, read everything before chapter one and everything after the last chapter.

2) Before reading, isolate and rephrase all bold text in your own words.

3) Once you have collected all the bold words, collect all the formulae, equations, definitions, and theorems, and organize them.

4) At this point, once you are warmed up and have collected the data, take a break. Go for a walk, make dinner, relax. (Stay away from drugs and alcohol until you are 28 or, at the very least, have graduated.)

5) Now, after you take a break, come back and start at paragraph one from chapter one. Read paragraph one until you understand fully. Once you understand completely, then move to paragraph two and repeat.

6) Do step 5 with the same concept for the example problems. Make sure you can solve all the 'worked example' problems like an exam without referencing anything before you attend the lecture on the chapter. (If you want to make the course as easy as possible and get an A with minimal effort and maximum understanding.)

NOTE* All of this seems to take a long time, and it does for the first few chapters. Once you get the ball rolling, it becomes easy and fast, and you will learn 10x as much and work 10x less! I guarantee it!

Suppose you are two 2-weeks ahead of the semester before it starts. In that case, the long part of this process will have already been completed. You can begin the easy part of this learning process and spend more time on other classes or learning additional skills for the workforce. (Anything you do during your college education should be something that can be put on your resume.)

For Example-Questions: Attempt to solve it based on what you read before using their solution. If you cannot solve it based on what you read, then follow the provided solution. Repeat (not all at once) until you can solve the example question(s) without referencing the book, as if it were an exam question, timed and in a stressful environment.

Take your solution to office hours, ask the professor to grade the solution the same way they would an exam, to make sure you understand what the professor wants to see, for the purpose of maximizing points on exams!

The following data is from "Young, H. D., Freedman, R. A., & Ford, A. L. (2020). University Physics with Modern Physics (Most Editions). Pearson.

[1] First, read everything before chapter one and everything after the final chapter. Then, start at chapter one and extract the data methodically.

Chapter 1 Vocabulary: The following is a real example of how I took notes in college. These are the bold words from chapter 1 of the University Physics with Modern Physics textbook cited previously.

Theory is often misused in lieu of hypotheses when, in actuality, it means the subject is true, and in general, if experimentation furthers its truth, it may become law. E.g., the Theory of Relativity and the Law of Gravity.

A **theory** is an idea or set of ideas that explains how something works based on evidence and reasoning.

Range of validity refers to the conditions or limits within which a particular theory, formula, or law accurately applies.

A **model** is a simplified representation or description of a system or phenomenon used to explain, predict, or analyze its behavior.

A **particle** is a small object, often treated as having no size, used to represent matter or energy in physics.

Physical quantity refers to a measurable property of nature, like length, time, or mass, expressed with a value and a unit.

An **operational definition** explains a concept by describing the specific process or method used to measure or observe it.

A **unit** is a standard measurement used to express the size, amount, or quantity of something, like meters for length or seconds for time.

The **International System**, or **SI**, is a standardized system of measurement used worldwide, based on units like the meter, kilogram, and second.

Second: The base unit of time in the SI system is defined by the vibrations of cesium atoms.

Meter: The base unit of length in the SI system, defined as the distance light travels in a vacuum in 1/299,792,458 of a second.

Kilogram: The base unit of mass in the SI system, defined by the mass of a specific platinum-iridium cylinder or based on the Planck constant.

A **prefix** is a short word or symbol added to a unit to represent a specific multiple or fraction of that unit, like "kilo-" for 1,000 or "milli" for 0.001.

The **British System** is a traditional measurement system that uses units such as inches, pounds, and seconds, often called the **Imperial system**.

Dimensionally consistent means that all terms in an equation have the same units or dimensions, ensuring the equation is physically meaningful.

Uncertainty is the estimate of the possible error or variation in a measurement or calculation.

Error is the difference between a measured value and the true or accepted value of a quantity.

Accuracy refers to how close a measured value is to the true or accepted value.

Fractional error is the ratio of the error to the true value. In contrast, **percent error** expresses this ratio as a percentage.

Significant figures are the digits in a number that carry meaningful information about its precision, starting from the first non-zero digit.

Scientific Notation is a way of writing numbers as a product of a number between 1 and 10 and a power of 10, making very large or small numbers easier to handle.

Powers-of-10 Notation: Expresses numbers as 10^n, where n is an integer, to represent their scale or magnitude.

Scientific Notation: Represents numbers as a product of a number between 1 and 10 and a power of 10, providing both scale and significant figures 3.2×10^4.

Order-of-magnitude estimates approximate a value by its nearest power of 10, providing a simple sense of scale without precise details.

A **scalar quantity** has only magnitude (size) and no direction, such as mass, time, or temperature.

A **vector quantity** has both magnitude (size) and direction, such as velocity, force, or displacement.

Magnitude refers to the size or amount of a quantity, often expressed as a positive value regardless of direction.

Displacement: The straight-line change in position from the starting point to the endpoint, including direction.

Distance: The total length of the path traveled, regardless of direction.

Parallel vectors: Vectors that have the same direction or are aligned along the same line.

Perpendicular vectors: Vectors that meet at a 90-degree angle to each other.

Antiparallel vectors: Vectors that are aligned along the same line but point in opposite directions. Magnitude is irrelevant—that is, $\vec{A} = -\vec{B}$.

Vector sum: The total of two or more vectors added together, considering both magnitude and direction.

Resultant: The single vector that represents the combined effect of two or more vectors.

Components are the parts of a vector that represent its influence along specific directions, such as the x-axis and y-axis in a coordinate system.

A **unit vector** is a vector with a magnitude of 1, used to specify direction.

The **scalar product**, also known as the **dot product**, is a method for multiplying two vectors, yielding a scalar value that is calculated by multiplying their magnitudes and the cosine of the angle between them.

The **cross product**, or vector product, combines two vectors to produce a new vector perpendicular to both, with a magnitude based on their magnitudes and the sine of the angle between them.

The **right-hand rule** is a method for determining the direction of a cross product by aligning your right hand with the first vector, curling it toward the second, and noting the direction of your thumb.

A **right-handed system** is a coordinate system that uses the right-hand rule to define the orientations of its axes consistently.

[2] Extract formulae, definitions, and theorems:

SI Units

- Time
    - Seconds, s

- Distance
    - Meters, m
- Mass
    - Kilograms, kg

Vector,

$$\vec{\boldsymbol{A}} = \langle A_x, A_y \rangle = \langle A\cos\theta\,, A\sin\theta \rangle.$$

Length, norm, or magnitude, [do not confuse 'norm' with 'normal vector'—perpendicular]

$$|\vec{\boldsymbol{A}}| = A = \sqrt{A_x^2 + A_y^2}.$$

Angle,

$$\tan\theta = \frac{A_y}{A_x} \Rightarrow \theta = \arctan\frac{A_y}{A_x} = \tan^{-1}\left(\frac{A_y}{A_x}\right) \neq [\tan\theta]^{-1} = \frac{1}{\tan\theta}$$

$$f^{-1}(x) \neq [f(x)]^{-1} = \frac{1}{f(x)} \text{ [recripricol].}$$

Resultant Vector,

$$\vec{\boldsymbol{R}} = \vec{\boldsymbol{A}} + \vec{\boldsymbol{B}} = \langle A_x, A_y \rangle + \langle B_x, B_y \rangle = \langle A_x + B_x, A_y + B_y \rangle = \langle R_x + R_y \rangle,$$

$$|\vec{\boldsymbol{R}}| = R = \sqrt{R_x^2 + R_y^2} = \sqrt{(A_x + B_x + \cdots)^2 + \left(A_y + B_y + \cdots\right)^2}.$$

Alternate Notation, [unit vectors] *Notation can change between texts/subjects*

$$\langle A_x, A_y \rangle = \langle A_x, 0 \rangle + \langle 0, A_y \rangle = A_x\langle 1,0 \rangle + A_y\langle 0,1 \rangle = A_x\hat{\imath} + B_y\hat{\jmath} = A_x\mathbf{i} + B_y\mathbf{j}.$$

The Dot Product,

$$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = \langle A_x, A_y \rangle + \langle B_x, B_y \rangle = A_xB_x + A_yB_y,$$

$$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = |\vec{\boldsymbol{A}}||\vec{\boldsymbol{B}}|\cos\theta = AB\cos\theta,$$

$$|\langle A_x, A_y \rangle||\langle B_x, B_y \rangle|\cos\theta = \sqrt{A_x^2 + A_x^2}\sqrt{B_y^2 + B_y^2}\cos\theta.$$

Note* If the dot product is zero, the vectors are perpendicular —that is,

$$\vec{\boldsymbol{A}} \perp \vec{\boldsymbol{B}} \iff \vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = 0.$$

Note* Most arithmetic translates to 3D, E.g.,

$$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = \langle A_x, A_y, A_z \rangle + \langle B_x, B_y, B_z \rangle = A_x B_x + A_y B_y + A_z B_z.$$

The Cross Product,

$$\left|\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}\right| = \left|\vec{\boldsymbol{A}}\right|\left|\vec{\boldsymbol{B}}\right| \sin\theta,$$

$$\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} \text{ [this is } \textit{not} \text{ a determinant],}$$

Note* A determinant outputs a scalar, whereas the cross product results in a vector. The Notation and arithmetic may be similar, but they are not the same.

$$\begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = +\left[A_y B_z - A_z B_y\right]\hat{\imath} - [\dots]\hat{\jmath} + [\dots]\hat{k}$$

$$\begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = +[\dots]\hat{\imath} - [A_x B_z - A_z B_x]\hat{\jmath} + [\dots]\hat{k}$$

$$\begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = +[\dots]\hat{\imath} - [\dots]\hat{\jmath} + \left[A_x B_y - A_y B_x\right]\hat{k}$$

Thus,

$\vec{\boldsymbol{C}} = \vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}$

$$= \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = +\left[A_y B_z - A_z B_y\right]\hat{\imath} - [A_x B_z - A_z B_x]\hat{\jmath} + \left[A_x B_y - A_y B_x\right]\hat{k}$$

$$= +\left[A_y B_z - A_z B_y\right]\hat{\imath} - [A_x B_z - A_z B_x]\hat{\jmath} + \left[A_x B_y - A_y B_x\right]\hat{k}$$

$$= \left[A_y B_z - A_z B_y\right]\hat{\imath} + [A_z B_x - A_x B_z]\hat{\jmath} + \left[A_x B_y - A_y B_x\right]\hat{k}$$

$$= \left[A_y B_z - A_z B_y\right]\langle 1,0,0\rangle + [A_z B_x - A_x B_z]\langle 0,1,0\rangle + \left[A_x B_y - A_y B_x\right]\langle 0,0,1\rangle$$

$= \langle A_y B_z - A_z B_y, 0,0 \rangle + \langle 0, A_z B_x - A_x B_z, 0 \rangle + \langle 0,0, A_x B_y - A_y B_x \rangle$

$= \langle A_y B_z - A_z B_y, A_z B_x - A_x B_z, A_x B_y - A_y B_x \rangle$

$= \langle C_x, C_y, C_z \rangle$.

Note* When you take the 'cross product' of two vectors

i) The vector that results from the arithmetic is perpendicular to both original vectors—that is, $\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{C}} = \vec{\boldsymbol{B}} \cdot \vec{\boldsymbol{C}} = 0$.
ii) If the answer is the zero vector, often noted $\mathbf{0}$ or $\bar{0}$—that is, $\langle 0,0,0 \rangle$, then the two vectors, $\vec{A}$ and $\vec{B}$ are parallel to each other —that is, $\vec{\boldsymbol{A}} \parallel \vec{\boldsymbol{B}}$.

[3] Read! You must read!

I used to tutor physics. I learned that you cannot tutor physics if the student does not read the book, learn the vocabulary, and work on examples. I then found that if they do this, they don't need tutoring! (Tutoring is also construed as cheating without professor's permission.)

The previous steps are from Chapter 1 of the University Physics book. Any author or course will be nearly identical. I just happened to use the Young, H. D., Freedman, R. A., & Ford, A. L. (2020).

After collecting the necessary data, use the worked examples. Work them until you can administer yourself an exam and solve them all without referencing the book.

Steps 1, 2, and 3 must be done before the lecture on the topic. You will need to be informed and have prior knowledge of the subject before attending the lecture. How do you expect to engage with the class, the professor, and the material if you don't know anything about it?

[4] Interval learning.

Like exercise, it is very effective to teach yourself or learn in short intervals. Why? You are a blob of physical mass! It takes time to grow and make physical connections and new brain cells or current brain cells to store data…you are not a computer! You must develop and heal. What you eat is what your body uses to grow and function properly. Eat wisely!

[5/6] Recap: The above should be done before the semester starts. If you don't know which book you are using, use any book, as they all contain the same information, more or less. You should be two weeks ahead of the semester before it begins.

[PL] Students who do not take weekly practice exams generally have a grade average of 40-60% (based on my research, observation, and personal grades). Students who manage themselves effectively in a timed, stressful environment tend to score 95% or higher on exams. The homework is usually not worth much of the grade. So, don't waste all your time trying to get 100s on HW when the time could be used to gain test-taking skills to get 100s on the exams, which is the bulk of the grade!

Now, working on the example questions from the textbook, I scroll through the book and allow myself to see just the question. I try to solve the question using any information that came before it. I give it a shot. If I cannot get the same solution—not an answer, but a solution. Then, I follow the instructions. I then take a break, return later, and attempt to solve it again without reference.

Once I can complete all the example questions without reference, I take a day off and then come back to do all the example questions as if it were an exam.

Sample Exam from Chapter 1: (These questions are from the same textbook's Chapter 1.)

Chapter 1 Exam (practice)

Go through and type out each example from the whole chapter:

[Example 1] The world land speed record of 763.0 mph was set on October 15, 1997, by Andy Green in the jet-engine car Thrust SSC. Express this speed in meters per second.

…

[Example 10] You are writing an adventure novel in which the hero escapes with a billion dollars' worth of gold in his suitcase. Could anyone carry that much gold? Would it fit in a suitcase?

Before the lecture, make sure you can solve all the example questions and take notes on the questions you have for the professor. I know it seems like a lot of work. However, it is actually way less work once you get the groove of it. You will also understand everything better, get better grades, and I guarantee you will study less—once you get the hang of it!

Also, administer a similar practice exam to yourself, consisting of the questions the professor covers during lecture and the questions you are struggling with on homework. The questions that the majority of students answer incorrectly on homework are often the same ones that appear on exams. It is like a joke the professor plays on you.

What is likely to be on exams: questions solved during lecture, questions from worked examples in reading, and the questions students get wrong on homework.

For a non-physics textbook, the steps above are identical.

