Energy transformation worksheet answer

You get to the course and sit perched on the edge of the chair, open notebook to a clean page and freshly sharpened pencil in hand. You follow every word the teacher says. Well, maybe the area a few times in the middle, but who doesn't? Plus, copy everything and you can review it later. That weekend, you diligently read the manual. Maybe skip a few parts because it's a busy week, but you definitely study the chapter summary and read all the examples. You do problems with your homework, even three days early. When you're stuck, you go to office hours and ask yours for help until you show it done. Before the exam, study your published notes and theme solutions. Try the practice exam, and it looks like the pieces are finally falling into place. You can solve most of the problems and remember most of the formulas and derivatives! Finally you take the final, referring to the single sheet allowed of notes you have prepared at length the night before. You have almost every question right, or at least partial credit, and take home a well-deserved A.Three months later, you can hardly remember what the class was all about. What's going on? Why did you forget so much? Are you the only one? Should you have memorized more and worked even harder? The answer is no. A student who memorizes the entire physics curriculum is no more physicist than one who memorizes the dictionary is a writer. Studying physics is about building skills, especially modeling new situations and solving difficult problems. The results in the manual are only the raw material. You're a builder. Don't spend all your time collecting more materials. Collect a few, then build things. Here. Cathedral and StonesWhile delivering the famous set of student in the year in 20 lectures on physics, Richard Feynman held several special review sessions. In the first of these, he discussed the issue of trying to memorize all the physics that you have learned:I will not do to memorize formulas, and tell you, I know all the formulas; All I have to do is figure out to put them in trouble! Now, you might succeed with this for a while, and the more you work on memorizing formulas, the more you'll go forward with this method – but it doesn't work in the end. You might say, I'm not going to believe it, because I've always been successful: that's how I always did; I'll always do it that way. You're not always going to do it this way: you're going to fail - not this year, not next year, but finally, when you get your job, or something like that - you're going to lose along the line somewhere, because physics is an extremely broad thing: there are millions of formulas! It is impossible to remember all the formulas - it is And the great thing you ignore, the powerful machine you don't use, is this: suppose 1 - 19 is a map of all physics formulas, all relationships in physics. (It should have more than two dimensions, but let's assume it's so.) Now, suppose something happened to your mind, that somehow all the material in a region was erased, and there was a little place of missing goo there. Nature's relationships are so beautiful that it is possible, by logic, to triangulate from what is known to what is in the hole. (See Fig. 1-20.) And you can recreate the things you've forgotten perpetually - if you don't forget too much, and if you know enough. In other words, there comes a time - which you haven't yet gotten to do, where you'll know so many things that as you forget them, you can reconstruct them from the pieces you still remember. Therefore, it is of prime importance that you know to triangulate - that is, to know to figure something out of what you already know. It's absolutely necessary. You might say, Ah, I don't care; I'm a good memorator! Actually, I took a memory course! It's still not working! Because the true utility of physicists - both to discover new laws of nature, and to develop new things in industry, and so on - is not to talk about what is already known, but to do something new - and so they triangulate from the known things: they do a triangulation that no one has ever done before. (See Fig. 1-21.) To learn to do this, you need to forget how to memorize formulas and try to learn to understand the interrelationships of nature. It's a lot more difficult at first, but it's the only way to succeed. Feynman's advice is a common theme in the learning process. Beginners want to memorize the details, while experts want to communicate a gestalt. Foreign language students talk about how many words they have memorized, but teachers see this as the most banal component of fluency. Beginner musicians try to get the right grades and rhythms, while experts want to find their own interpretation of the play's aesthetics. Mathematics students want to memorize theorems while mathematicians look for a way to think instead. History students see lists of data and facts, while teachers see personality, context, and narrative. In each case, the beginner is too overwhelmed by the details to see the whole. They look at a cathedral and they see a pile of 100,000 stones. A particularly clear description of the difference between the minds of experts and beginners comes from George Miller's 1956 study Magic Number Seven, Plus or Minus Two. Miller presented chessboards to both senior chess players and beginners. He discovered that the masters could memorize an entire board in just five seconds, while the novices were hopeless, getting only a few pieces. However, this was only true when were memorizing positions from real chess games. When Miller instead scattered scattered random pieces, he found the advantage of the disappeared masters. They, like beginners, could remember only a small part of what they had seen. The reason is that master level chess players have choked chess information. They no longer have to remember where each pawn is; they can instead remember where the weak point in the structure lies. Once I know that, the rest is inevitable and easy to rebuild. I played chess in high school without getting to a high level. At a tournament, I met a master who told me about every square on the chessboard was meaningful to him. Whereas when writing down my move, I would have to count the rows and columns to figure out where I put my knight (A-B-C, 1-2-3-4, knight to C4) he would know instantly because the target square felt like C4, with all the knowledge of the accompanying chess about the control of the center or the protection of the king that a knight on C4 implies. To see the same principle working in you right now, memorize the following. You have two seconds: 酱, 后冻Easy, right? Well, it would be if you were literate in Chinese. Then you'd know it's the big peak, first the peanut butter, then the jelly. You can remember the English phrase equivalent no problem, but I probably don't remember Chinese characters at all (unless you know Chinese, of course). This is because you automatically process English at an extreme level. Your brain turns the different loops, lines and spaces displayed on the screen into letters, then words, then a familiar maxim tied to sandwiches, all without any effort. Just this highest-level abstraction you remember. Using it, you could reproduce the detail of the expression first peanut butter, then jelly quite accurately, but you would probably forget something like if I capitalized the first letter or if the font had serifs. Remembering an equally long list of randomly chosen English words would be harder, a random list of harder letters yet, and seemingly random Chinese characters almost impossible without much effort. At every step, we are increasingly losing the ability to abstract raw data with our cognitively installed firmware, and this makes it harder and harder to extract meaning. That's why you have such a hard time memorizing equations and derivatives from physics classes. They're not significant to you yet. It doesn't fit into a sweeping frame that you built. So, after you get back to the final, they all start to slide away. Don't worry about it. These details will become more memorable with time. In beginning tutoring students, I used to be surprised at how bad their memories were. I work a problem in basic physics over the course of 20 minutes. Next time we met, I'd ask them about as a review. Personally, I could remember what the problem was, what was the answer, the answer, to solve it, and even details, would be the minor mistakes the student made along the way and similar problems that I compared it to last week. Often, I found that the student remembered none of this – not even what the problem was asking! What happened was, while I thought about how this problem fit into their understanding of physics and wondering what their mistakes told me about which concepts they were still shaky on, were underlined by what the thirty-degree sinus is and the difference between centrifugal and centripetal. Imagine an athlete trying to play football, but just yesterday they learned about things they would be running and kicking. They would be so distracted by making sure they moved their legs in the right order that they would have no concept of making a feint, the less things would be how the movement pattern of their midfielder was opening a hole in the opponent's defense. The result is that the player is doing badly and the coach gets frustrated. Much of the technical education works this way. You're trying to understand the mechanics of the continuum when Newton's Laws are still not cemented in your mind, or quantum mechanics when you still don't understand linear algebra. Inevitably, you will have to learn topics several times - the first time to struggle with the details, the second to see through what is going on beyond. Once you start to see the big picture, you'll find the details become meaningful and you'll manipulate and remember them more easily. Randall Knight's Five Easy Lessons describes the research on expert vs novice problem solving. Both groups received the same physics problems and were asked to recount their thoughts aloud in the stream of consciousness as they solved them (or failed to do so). Knight cites the following summary from Reif and Heller (1982)The observations of Larkin and Reif and ours indicate that experts quickly redescribthe problems presented to them, often use qualitative arguments to plan solutions before mathematically developing them and to make many decisions by first exploring their consequences. Moreover, the basic knowledge of such experts appears to be well structured hierarchically. Instead, beginner students usually encounter difficulties because they fail to describe problems adequately. They usually do little prior planning or qualitative description. Instead of doing through successive refinements, they try to assemble solutions by stringing the various mathematical formulas in their repertoire. In addition, their underlying knowledge consists largely of a connected collection of such formulas. Experts see the cathedral first, then the stones. Novices desperately grab every in view and hope that one of them is worth at least partial credit. In another experiment, subjects were given a lot of physics problems and to invent categories for problems, then put the problems in whatever category they belonged to. Knight writes: Experts sort problems into relatively few categories, would be Problems that can be solved by using Newton's second law or Problems that can be solved using energy conservation. Novices, on the other hand, make a much larger number of categories, would be tilted plane problems and pulley problems and collision problems. That is, novices first see the surface characteristics of a problem, not the underlying physical principles. Aha! FeelingIt is clear that your work as a student is to slowly build the mental structures that experts have. As you do that, the details will be easier. Eventually, many details will become effortless. But you're getting there? In the Mathoverflow question I've linked about memorator theorems, Timothy Gowers wrote, as far as possible, you should turn into the kind of person who shouldnot remember the theorem in question. To get to this stage, the best way I know is simply to try to prove your theorem. If you've tried this hard enough and you're stuck, then take a quick look at the evidence -- enough to find out what the idea is that I'm missing. That should give you an Aha! feeling that it will make the step much easier to remember in the future than if you had just read it passively. Feynman addressed the same questionThe problem of inferring new things from the old, and solving problems, is really very difficult to teach, and I don't really know how to do it. I don't know how to tell you something that will turn you from a person who can't analyze new situations or solve problems, to a person who can. In the case of mathematics, I can transform you from someone who can't differentiate from someone who can, giving you all the rules. But in the case of physics, I can't turn you from someone who can't into someone who can, so I don't know what to do. Because I intuitively understand what's going on physically, it's hard for me to communicate: I can only do it by showing you examples. Therefore, the rest of this lecture, as well as the next, will consist in making a lot of small examples - of applications, of phenomena in the physical world or in the industrial world, of applications of physics in different places - to show you what you already know will allow you to understand or analyze what is happening. Only from the examples will you be able to catch on. This sounds horribly ineffective to me. Feynman and Gowers have achieved the highest level of achievement in their fields, and both are renowned as superb communicators. Despite this, neither has any better advice than doing it a lot and ultimately the expertise will just kind of happen. Mathematicians and physicists talk about the qualities of mathematics and physical physics They are essential to pass the most basic level, but it seems that no one knows where they come from. Circular reasoningThere are certainly attempts to be more systematic than Feynman or Gowers, but before we get to that, let's do a case study. I remember that, as a year-round student, I knew that the formula for accelerating a ball orbiting in a circle was [math]a = v^2/r[/math]. I wanted to know why, so I drew a movie: imagined a small starting on the right side of the circle, heading up where the blue speed vector [mathematics] v_1 [/mathematics] is drawn. The ball moves around the circle, goes counterclockwise over the top and then goes down on the left side, where the red speed [mathematics] v_2 [/math] is. The speed of the ball has changed, which means it's accelerated. Acceleration is [math]a = \frac{\Delta v}{\Delta t}[/math][math]\Delta v[/math] is clear [math]2v[/math], and [math]\Delta t[/math] is the time it takes to bypass the circle, which is [math]\frac{\text{distance}}{\text{speed}}= \frac{\pi r}{v}[/math]. Therefore, the acceleration is [math]a = \frac{2v}{\pi r/v} = \frac{2 v^2}{\pi r} \approx 0.64 \frac{v^2}{r}[/math]This is not quite correct. The answer should be [math]v^2/r[/math]. Somehow there is an additional factor of [mathematics]2/\pi[/math] floating around. If you already understand the calculation, this is a silly and obvious mistake. But for me it took a while - weeks, I think - until I realized that I had found the average acceleration, but the formula I was trying to get was instant acceleration. The way I got out of this mental ditch was to think about where the ball went a quarter of the way around, like this:Then the same approach offers [math] a = \frac{\Delta v}{\Delta t} = \frac{2\sqrt{2}v^2}{\pi r} \approx 0.90 \frac{v^2}{r}[/math], which is closer to the correct value. If you try to get it when the ball goes 1/8 way around, you get [math]a = \frac{4 \sqrt{2 - \sqrt{2}}v^2}{\pi r} \approx 0.97 \frac{v^2}{r}[/math] and you get the idea that what you need to do is take the limit as the ball goes an infinitesimal fraction of the road around. (By the way, if I'd been smart, maybe I'd have discovered the Viète formula that way, or something like that. I only admitted that now because I remembered meeting Viete's formula. So memory certainly has its place in allowing you to make connections. It's just not as central as beginners usually think.) You're doing that thing with the infinitesimal fraction of the road? Well, if the ball travels an angle [mathematics] \ theta [/ math] around the circle, we can draw before and after speeds asand[math] \Delta v = 2 \sin (\theta/2) v[/math]which in [math]\theta \to 0[/math] becomes[math] \Delta v = \the ta v[/math] and [math] a = \frac{\Delta v}{\Delta t} = \frac{\theta v}{\theta r/v} = \frac{v^2}{r}[/math]But all all took a long time to come together in my mind, assembling gradually, but in discrete pieces with each small epiphany. So I went through it now, I can see that there are many concepts involved, and in fact, if you're a start student it's likely that the argument isn't clear because I skipped some steps. The main idea in this argument is calculus - we are looking at an infinitesimal displacement of the ball. To understand the whole argument, though, we need, also, to make a fair amount of geometry, develop the idea of speed vectors sliding around in space, so that they come at the same point, introduce the concept of an arbitrary angle of rotation [mathematics]\theta [/ mathematics], find the time needed to rotate with this angle for a certain [mathematics] r [/mathematics] and [math]v [/mathematics], use the low-angle approximation of the function itself, and maybe a couple other things Do not see. It's a lot of mental exercise. No wonder that all this work for you is both harder and more effective than reading it in the book. Just reading it, you'll skip it or fail to appreciate how much drifting goes. The next time you try to understand something, you want those previously mastered ideas about geometry and computing already there in your mind, ready to be called. They won't be if you let a book do all the work. Today, I can solve this problem in other ways. For example, I could write down the rectangular coordinates and differentiate, describe the movement in the complex plane as [math]r e^{i\omega t}[/math] and differentiate this, or turn into a rotating frame of reference, and note the centrifugal force on the stationary ball, and conclude that it needs to accelerate in an inertia frame. A cute one is to write down the position and speed of the vectors of intuition, and notice that going from position to speed you rotate 90 degrees and multiply the length of [mathematics]v/r [/ math]. To go from speed to acceleration is mathematically identical, so rotating another 90 degrees and multiplying with [math]v /r [/ math] again we get the answer. I can argue from the dimensional analysis that the only way to achieve something with acceleration units is [math]v^2/r[/math], or heuristic underlining that if you increase speed, speed vectors become higher, but we also go from one to another in less time, so that acceleration should scale with [mathematics]v^2 [/math], etc. I also see aspects of the problem that I did not then, would be that this is not really a matter of physics. There are no physical laws involved. It would become a matter of physics if we included the fact that the ball spins because of gravitational forces and used Newton's gravitational law, for example, but, that's the way it is, this problem just a little math. So, yes, I can easily memorize this result and provide a drift for it. I can do that for most of the curriculum of undergraduate physics, including pendulum and Doppler Doppler you mentioned, and I think I could, or at least beat the average class, on the final end in any physics course at my university without additional training. But I can do that because I've built a general understanding of physics, not because I remember huge lists of equations and techniques. to Chuk ItI can do these things now because of years of accumulated experience. Somehow, my mind has built pieces to think about elementary physics just like chess players do for chess. I taught courses, I worked on advanced issues, I listened to people, I talked to people, I meditated, I wrote about physics on the internet, etc. It's a mixture of activities and approaches, and there's no way for me to tease from my own experience what was most important for the learning process. Fortunately, people from different fields have made contributions to understanding how we create the cognitive machine of expertise. Here is a list of quick hits. George Pólya's How to Solve It examines the problem-solving process as a series of steps, and suggests the student to ask specific questions, would, Is it clear that there is enough information to solve the problem? Scott H Young, Cal Newport, and many others give specific advice on study skills: take notes, let diagram the connections between ideas, test your knowledge, match what you're learning into the larger scheme of things, etc. When you need to memorize things, spaced rehearsal software as Anki takes an algorithmic, research-supported approach to help you remember facts with minimal time and effort.K. Anders Ericsson tried to find the key factors that make some forms of practice better than others – things would be getting feedback as you go and having clear goals. He refined them in the concept of deliberate practice. He also thinks there is no shortcut. Even if you practice effectively, it usually takes about 10,000 hours of hard work to reach the highest levels in complex fields, such as physics or music. Chunking and attributing meaning are ways your mind can do with overloading the information of minitiae that inevitably pop-up in any field. Another approach, though, is to try to expand your mind's ability to handle these minutiae. If you can push your magic number from seven to ten, you'll be able to remember and understand more of your physical work because it takes a little longer to fill the cognitive buffer. Dual N-Back exercises are the most popular method of working on this. Nootropic drugs can also provide benefits for some people. Fruit with low hanging first, though. If you don't Sleeping 8-9 hours a day, getting a few hours of exercise a week, and eating healthy food for most meals, you're probably giving up some of the power of your mind potentially already. (There are individual variations, however.) Howard Gardner is a champion of the idea of different types of learning. When working in electric fields, for example, Gardner might advise to study Maxwell's equations, draw vector fields and intuit their loops, stand up and use the body, pointing his arms around to indicate electric field vectors, write or talk about what you study, learn with a friend or guardian, or maybe even create musical mnemonics to help you study , depending on where your personal strengths are located. Of course, all students should build the facility with drawing sketches, drawing functions, handling equations, dynamic visualization, and writing and talking about the material. Psychologist Carol Dweck's research studies the effect of your attitude towards learning how much you learn, finding, for example, that children praised for their hard work are likely to continue and learn more when they are offered difficult problems, while children praised for their intelligence are more likely to give up. Productivity guru David Allen helps people organize their lives and defeat procrastination with specific techniques, would be dividing complicated tasks into small, specific next actions and deciding when to do them, then organizing them into a planner system. Mihály Csíkszentmihályi believes that people operate best in a state of flux, where they are so focused on the task that they consider enjoyable and captivating to the point where they are innately motivated to continue. He points out, for example, that the task must be the correct level of difficulty - not too hard and not too easy - to find the state of the stream. (Some people believe that this state does not jibe with deliberate practice; others argue that it is possible to achieve both simultaneously.) Taken together, this produces enough practical tips to chew on months or years. To summarize, when you're learning something new: Try to figure it out for yourselfIf you get stuck, take a look at your manual to get the main ideaTeach the idea of someone elseOnce you've learned something, repeat the entire reasoning behind it for you, work through every detailAsk yourself Pólya's questions when you're stuckUse Young Techniques and Newport to map your class ideas and correlate them with your previous knowledgeMake Anki punta and reviewing them a few minutes a day to keep what you've learnedMake sure the study sessions include all the principles of deliberate practice, especially feedback, challenge, and attentionBuild a picture of yourself as someone motivated by learning and proud to have worked hard and effectively rather than as someone proud to be smart or reputable. Find a system which allows you to manage all the details of life smoothly and efficiently. Search for the status of the stream, observe when you enter it, and position yourself to find the stream more and more often. Works on different topics, reviewing both They will eventually all form together in your mind, and you are likely to have to take at least two passes to any topic before you understand it well. Take care of your physical health. This list does not include reading each page of the manual or solving each problem at the end of the chapter. These things are not necessarily bad, but they can easily become rote. Building the material for you while diving into reference materials for clues is likely to be more effective and engaging once you have learned to do it. It's a slow, difficult process. It can be frustrating, sitting there and shaking your brain and feeling incredibly stupid because you don't understand something you know you should have down. And strangely, once you figure it out, it will probably seem completely obvious! That's your reward. Once the thing is obvious, you've done it and you can move on. (Although you still need to review with spaced repetition.) This is the opposite of the usual pattern of sitting in lectures and feeling that you understand everything quite clearly, just to find everything evaporated the next day, or the final acing just to find your knowledge is all gone the next month. I think that sums up practical knowledge and advice about learning. Memorizing equations and derivatives is difficult and ineffective because they are just the details. You can only take care of a few details before your mind is flooded. To cope, train to the point where you automatically process equations and physical reasoning. This will free up the conscious effort to get into the big picture and see what the topic is all about. It's just gets in the way, You Seehow, I've developed a one this is calculation instinct, so if I see the problem about speeding up in circular motion, or any other problem about change rates, I know it's about a limit of some kind. Where is this instinct in my brain? What shape does it take? is it called at the right time? George Lakoff believes that almost everything we understand is through metaphor. Any kind of abstract concept is understood by linking it to concrete concepts that we have previously understood. For example, if the math comes from, Lakoff and co-author Rafael Nuñez argue that we think of the mathematical concept of a set as some kind of box or container with things stacked in it. We think about sets using our intuition about boxes, then later go back and support our conclusions with technical details. Learning to think about sets, then, is learning to think about the metaphor of the box and translating it back and forth into the formal language of axioms and theorems. This seems to match the introspective reports of many mathematicians, who that they build intuitive or visual models of their mathematics when they find results, then add in the delte and epsilons to may be the reason why we so often see students starting out asking things like, but what is the electron, really? If they were told she was just a little girl, it would work, because it's a very easy metaphor. But instead, they are told that it is not a particle, not a wave, not spinning, even if it has spin, etc. In fact, they are told to reject all previous concepts entirely! This is something That Lakoff thinks is simply impossible. No wonder students are bobbing into an ocean of bubbles of confused thinking with nothing but mixed metaphors to understand until the last straw evaporates across the board. Linguists like Steven Pinker believe that the language we use tells us our minds work. Physicists certainly have a specialized lexicon, and the ability to use it correctly correlates quite well with the general physical intuition in my experience. In his review of Pinker's The Stuff of Thought, Douglas Hofstadter summarizes:Pinker shows, for example, the subtle features of English verbs revealing the hidden operations of the human mind. Consider such contrasting sentences as Farmer loaded hay in cart and Farmer loaded haystack wagon. In this pair, the load verb has two different types of objects: the things that move and where it goes. In the first sentence, the destination is also the subject of a preposition; secondly, things are the subject of another. Pinker sees these alternations as representing a microclass of verbs acting in this way, such as spray (water spray on roses versus rose spray with water). Where does this observation take him? To the idea that we sometimes frame events in terms of movement in the physical space (moving hay; moving water) and sometimes in terms of movement in the state space (car becoming full; roses becoming wet). Moreover, there are verbs that refuse such alternations: for example, pour. We can say I poured water into the glass, but I didn't pour the glass of water. What explains this curious difference between load and pour? Pinker claims that casting only allows a liquid to move under the influence of gravity, while loading is movement caused by the human agent. Pour and load thus belong to different microclasses, and these microclasses reveal how we interpret events. [W]e have discovered a new layer of concepts that the mind uses to organize a banal experience: concepts about substance, space, time and strength, Writes Pinker. Philosophers [S]ome consider [these concepts] to be the very scaffolding that organizes mental life... But I came across these big categories of cognition... trying to make sense of a small phenomenon in the acquisition of language. If it is correct, then in order to think about physics how an expert does, we should learn to how the experts do it. If we try to solve the problems of physics using the words pregnancy and pour, pour, carry a bunch of distracting anthropocentric luggage. If we don't recognize that, we will be stuck, saying that the problem doesn't make sense, when in fact our linguistically instilled expectations are wrong. To combat this, it can be as useful to get the facility with the language of physics as with its equations. Five easy lessons provide a clear example of such difficulties: the force case study. So I type this, my laptop is sitting on a desk that exerts an upward force on it. Few early students think this is really a force, even after they've been browbeaten in drawing arrows for normal strength on exam charts. The problem is in the way we use force: The thief forced the door to open. Your apology seemed forced. ... the force of the explosion... ... the force of justice... I'm forced to take physics, even if I'll never use it. Literally or figuratively, we think of force as involving not only movement, but intent or purpose, and also control. The force is for people pushing on things, or maybe for cars and projectiles. These things use energy and will remain in peace if left alone. What about the office under my laptop? He's sitting there, completely passive. could it be the exercise of a force when they don't even get tired? Needing some kind of rationalization for why the laptop doesn't fall, beginners say it's not that the office exerts a force on the laptop, the office just offers something for the laptop to sit on. Or if something falls on the desk, the office didn't exert a force to stop it. He just got in my way, that's all. Why doesn't the teacher understand this obvious difference? An office that exerts a force? Hai... Five easy lessons describe how students just overcome this difficulty after seeing a class demonstration where, using a laser pointer and a mirror put on top of the desk, the teacher demonstrates how, when a heavy slag block is put on the desk, the surface responds by bending its natural shape , exercising force on the cinder block as a compressed arc would be. You may need to find many such views before you can reconcile your colloquial use of words with their use in physics. But this could also be dangerous, because although finding a way to make physics listen to your idea of what a word means works decently in this case, in other cases it's your expectations for the word that should change. (Relativity, with words like contraction, slowing down, etc. is a good example.) Mythology Joseph Campbell believes that we understand the world first through story. Perhaps we understand the derivatives, the experimental evidence, and the logic behind the physical conclusions as a kind of and it is in building this story that our cognitive pieces are formed. Mind Neural Gap JunctionsYou are the model of neural activity in your brain. When a part of you Building a new memory, installing a new habit, or building a tool to address a class of problems, that change must be reflected somewhere in your brain. Lesswrong user kalla724 describes this process in Attention Control is critical for changing/increasing/modifying motivationThe first thing to keep in mind is the plasticity of cortical maps. Essentially, certain functional areas of our brain can expand or shrink based on how often (and how intensely) they are used. A small amount of this growth is physical, as the new axons grow, expanding white matter; mostly happens by repurposing any less used circuits in the vicinity of the active area. For example, the sense of vision is processed by our visual cortex, which transforms the signals in our eyes into lines, shapes, colors and movement. In blind people, however, this part of the brain is invaded by other senses and begins to process sensations such as touch and hearing, so that they become significantly more sensitive than in visually impaired people. Similarly, in deaf people, the auditory cortex (a part of the brain that processes sounds) becomes adapted to process visual information and gather linguistic cues through vision. But, they warn, these neural changes occur primarily in those parts of our mind to which we pay conscious attention: A man sits in his living room in front of a chessboard. Classical music plays in the background. The man is focused, thinking about his next move, his chess strategy and the future possibilities of the game. His neural networks are optimizing, making him a better chess player. A man sits in the living room in front of a chessboard. Classical music plays in the background. The man is focused, thinking about the music he hears, listening to the chords and anticipating the sounds that will follow. Its neural networks are optimizing, making it better at understanding music and hearing subtleties in a song. A man sits in the living room in front of a chessboard. Classical music plays in the background. The man is focused, gravel his teeth as another flash of pain comes from the bad back. Its neural networks are optimizing, making the pain more intense, easier to feel, harder to ignore. You need to pay attention not only to physics, but to the right parts of physics - the parts most related to intuition. James Nearing gave his advice on how to do this in Mathematical Tools for PhysicistsHow do you learn intuition? When you've finished a problem and the answer agrees with the back of the book or with friends or even a teacher, you're not done. The way to gain an intuitive understanding of mathematics and physics is to analyze your good. Does that make sense? There are almost always several parameters that get into the problem, so what happens to the solution when you push these parameters to their limits? Their? a problem of mechanics, what if one mass is much larger than another? Is your solution doing the right thing? In electromagnetism, if you make a few parameters equal to each other, it reduces everything to a simple, special case? When you do an integral surface should the answer be positive or negative and not your answer agree? When you address these questions to every problem you solve, you do more things. First, you'll find your own mistakes before someone else does. Secondly, you gain an intuition about equations and the world they describe should behave. Third, it makes all efforts later easier, because you will then have some clue about what equations work the way they do it. Is it going to take longer? Certainly. It will however be some of the most valuable extra time you can spend. Is it just the students in my classes, or is it a widespread phenomenon that no one is willing to sketch a graph? (\Holding your teeth is the cliché that comes to mind.) You may never have been taught that there are some basic methods that work, so look at section 1.8. And keep referring to that. This is one of those basic tools that is much more important than you've ever been told. It's amazing how many problems get simpler after you've sketched a graph. Also, until you've sketched out some graphics of functions you just don't know how to behave. (To see tips on graphs, along with a detailed step-by-step example, see his book, free online) Brown Big SpidersOne of the difficulties with pieces is that they are mostly subconscious. We may eventually know of their existence, so did the chess master who told me that he knew it felt every square of the chess board, but their precise nature and the process of creating them are almost immune to introspection. The study methods we talked about above are empirically useful in creating pieces, so we have guidelines for how to make new pieces in general, but we usually don't know which ones we are creating. Lesswrong user Yvain comments on the essay being a teacherI used to teach English as a second language. It was a journey of the mind. I remember one of my students saying something like I saw a big brown spider. I said no, it should be the big brown spider. He asked me why. Not only did I not know the rule involved, but I also never imagined that anyone would say it in any other way until that point. Such experiences have been quite a lot of daily appearances. In other words, the best cognitive process we have - language - develops largely without our awareness. (In this story, I met a surprising number of people who actually don't know about the adjective order in English, but most of them either learned English as a second language or studied it in psychology or linguistics course.) This makes it incredibly difficult for physics teachers or writers to communicate with beginners. It is inevitable that beginners will say that a particular lecturer or book simply does not explain it clearly enough, or must give more examples. Meanwhile, the lecturer has no idea why what they said was not already perfectly clear and believes that the example was completely explicit. Neither side can articulate the problem, the student because he cannot see the incorrect assumption that they make, the teacher because he does not realize that they have already made such an assumption. For example, once I was proctoring a test in a physics class for biology majors. A question on the test described a particular situation with light going through a prism and asked, What is the sign of phase change? A student came to ask for clarification, and it wasn't until they asked their question three times that I finally got. They thought they should find the sign as in an indicator, or marker. It would be a kind of observable behavior that would indicate that there had been a change of phase, and that it was a sign of phase change. Until then, I was just able to think of the sign as positive or negative meaning – did the wave get advanced or retarded? If you want to learn a language with all those rules you don't even know about, you have to immerse yourself. Endless exercises and exercises from a book won't be enough, as millions of Americans a decade of high school straining to remember, Dondé esta el baño? can attest. You need to read, speak, see and hear that language around you before you need to. To learn physics, then read, speak and hear it all around. Participate in the colloquium. Read the papers. Solve problems. Read books. Talk to teachers and TA, and expose yourself to all the thinking patterns that are the native language of the field. As you learn, you'll build the right pieces to think about physics without realizing what they are. But there is part of this problem, which is that when you don't do physics, you can build the wrong pieces. I can get in your way, and again you don't realize it. In Drawing on the Right Side of the Brain, Betty Edwards discusses an exercise she gave her art students: One day, on impulse, I asked students to copy a Picasso drawing upside down. That little experiment, more than anything else I tried, showed that something very different happens during the drawing act. To my surprise, and to the surprise of the students, the finished drawings were so well made that I asked the class, is it that you can shoot upside down when you can't draw on the right side up? The students replied: Upside down, we didn't know what we were drawing. When we see a recognised image, unconscious consciousness immediately reaches work, interpreting, sharing meaning and, Distortion. Learning to shoot, according to Edwards, involves circumventing harmful pieces as much as building useful ones. So it's with physics. The ideas about force, animation and intent discussed in the laptop-and-desk example seem to illustrate only this issue. Five easy lessons list many of the known misconceptions that students have somehow learned in every subject of introductory physics - for example, that the electric current gets used up as it goes around a circuit. But I think it's likely that there are many more such patterns of obstructive thinking that we don't know yet exist. These could be more general notions about things, would be cause and effect, what nature wants to achieve, etc. I feel DumbEducators are perpetually frustrated by what seems to be an outrageous model. They explain something clear. All students claim to understand perfectly and can even solve quantitative problems. However, when you ask students to answer basic conceptual questions, they get it all wrong. is this possible? In this YouTube video, Veritasium explores what happens when you explain something clear:Amazing, the clearer the explanation, the less students learn. People have a wide range of cognitive biases. In general, these different biases work so we continue to believe whatever we thought to begin with, unless there's a very good reason not to. Someone offering a clear, authoritative physics course does not register in your mind as a good reason to check your beliefs, so you happily listen and rave about what a great lecture was, all while maintaining the wrong ideas. However, with the right stimulus you can get your brain to throw old, wrong ideas. Entering such a state is a prerequisite for true learning, and fortunately we can detect ourselves. We call it confusion. Confusion is a message from your emotional mind (the part that tells your analytical mind what decisions to start justifying). Say, hey, something about our beliefs is very wrong, and this is actually important. Be careful and figure it out. A great lecturer, instead of being clear, will confuse students with asking them to predict in advance what a demonstration will show, then they do, and the opposite actually takes place. Or they will ask students to solve questions that sound simple, but students actually can't figure it out. Only after the confusion sets in, the teacher will reveal the trick. You want to overcome your prejudices, throw away your wrong beliefs and learn physics at the Feynman level - the level at which you create knowledge as you move forward. Even many specialists don't fully get there, instead growing to increasingly sophisticated levels of rehashing the same arguments memorized in a way that can carry them quite and trick most people. The only way to avoid this is to spend many, many hours completely confused. Have you ever missed an argument, just to think about the perfect line two days later when it stopped a traffic light? This shows how your mind will continue to work on heavy issues in the background. Finally comes up with a great answer, but only if you first prime it with what to chew on. This works for physics issues as well as for smart comebacks once you find good problems to struggle with. I conjuncture that engaging this subconscious system requires a strong emotional connection to the problem, would be the frustration or embarrassment of being amazed into an argument or the confusion of being stamped by a difficult problem. Confusion is essential, but often unpleasant. When you feel repeatedly frustrated or upset by confusion, your unconscious mind learns to shy away from hard thinking. You've developed a ugh field. This could happen for different reasons. A common one occurs in people who judge themselves by their intellect. Confusion for such people is a harsh reminder of how limited they are; It's a challenge to their identity. Whether for this reason or another, it is common for students and academics to fall into models of procrastination and impostor syndrome when sailing the maze of confusion that come with their chosen path. I don't have the answer for that. I've heard many people tell their stories, but I have yet to figure out my own. Sometimes the confusion feels terrible, and my story in physics is a jerky one, complicated because of the way I handled it. But every once in a while a problem is so good that none of this matters. When I find one of these problems, it hijacks my mind like Cordyceps in a bullet ant, masturbates me back to a fresh piece of scratch paper again and again, sometimes for days. If you get to this state over and over, you'll know Feynman meant by, what I can't create I don't understand confused. Solve problems. Repeat. The universe is waiting for you. ReferencesIn the order of appearance in this answerFeynman's Sfent on physics: Richard P. Feynman, Michael A. Gottlieb, Ralph Leighton: 9780465027972: Amazon.com: Bookssoft Question - MemorizeTheorems - MathOverflowMagic Names Seven, Plus or Minus Two (wikipedia)Magic Number Seven (original paper)Google Translate (Chinese phrase)Knight, Randall. Five Easy Lessons pp 37Reif and Heller, 1982 Viste's formulaHow To Solve It: A New Aspect of Mathematical Method (Amazon)How To Solve It (summary)How to Solve It (Wikipedia)Learn Faster with the Feynman Technique (Scott Young. His page is to start to get spammy.) 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Does it feel analogous to having mastery of another language as in programming or linguistics? Satvik Beri's response to understanding mathematical geniuses extremely harsh mathematical concepts so quickly? Qiaochu Yuan's answer to Why is it almost impossible to learn a mathematical concept on Wikipedia? They are very difficult to follow, especially if one does not have a solid background in the subject. Christopher VanLang's response to what should I do if my doctor counselor and my lab colleagues think I'm stupid? What Richard Feynman meant when he said: What can't I create, I don't understand? Debo Olaosebikan's response to What are some words, phrases, or phrases that physicists frequently use in ordinary conversations? Is Paul King's response to significant arbitrariness? transforms the human mind into things like art into emotion and experience? What are some English language rules that native speakers don't know, but still follow? User response to What is an effective way to overcome procrastination? Next ReadingI feel a little sleazy writing this answer, because when I mentioned, for example, Carol Dweck does research on the psychology of mentalities or K. Anders Ericsson studying deliberate practice, in fact there are thousands of people working in these areas. The ones I have mentioned are simply the most public people or those I have met since I haven't even read the original research in most of these cases, relying on summaries instead. The answer is also preliminary and There's still a lot of research to be done, and I'm no expert on what's out there. However, here is a guide to some additional resources that have informed this response. For an overview of the psychology of learning, I like the audio course of Monica Papasuphi we learn from the Teaching Company. It covers many intelligent experiments designed to help you build a model of what's going on in your mind as you learn. Bret Victor explores software solutions for visualizing the connection between the physical world, mathematical representation and mental models. Check outThe Carder of AbstractionExplorable ExplanationsI think it is useful to build an innate impression of your mind that it does not perceive the world directly, but as its own concoction, interpretation adapted from the data of meaning. Oliver Sacks's books are great at making this clear by illustrating what happens to people for whom some of the processing machines break down. The LessWrong sequences were, for me, a powerful introduction to the cirks of human thought, preliminary steps toward working best with the firmware that I've taken, and what it means to seek the truth. Selected bibliographyThese are some physics books that have helped me so far. I am not choosing them for clear exposure or expertise in a particular topic, but for the way I think they have helped me understand how to think about physics in general. Blandford and Thorne, Classical Physics Epstein Apps, Thinking PhysicsFeynman, Lectures on Physics------------ Character of Physical Law------------ QED: The Strange Theory of Light and Matter------------ Tips on PhysicsGeroch, General Relativity from A to BLevi, Mathematical MechanicLewin, Walter Classical Mechanics, Electricity and Magnetism (video lectures with demonstrations on MIT OpenCourseWare)Mahajan, Street-Fighting MathematicsMorin, Introduction to Classical MechanicsNearing, Mathematical Tools for PhysicsPurcell , Electricity and Magnetism---------- , Back of the Envelope ProblemsSchey, Div, Grad, Curl, and All ThatThomas and Raine, Physics at a DegreeThompson, Thinking Like a PhysicalWeisskopf, The Search for Simplicity (articles in Am. J. Physics)ImagesFeynman's Tips on Physics, Feynman, Gottlieb, LeightonArchitectural detail-cut stonefile:NotreDameI.jpg Let's take the CFA L1 exam as an example:There are 240 three-choice questions (33% probability of a correct answer for each question). Assuming a pass score of 70%, we need to get at least 240* 70% = 168 correct answers to succeed. If we choose all Cs (in the case of a 3-choice MCQ) we can expect a score of 33%* 240 = 80, but we are sure to fail (assuming of Ace, Bs and Cs are distributed equally), while if we choose at random, our expected score should also be 80, but our range of results will go from 0 to 240, , we should go for this option. For each chosen number of correct answers we have a binomial distribution with an average of np = 240 * 33% = 80 and a standard deviation of [np(1-p)]^0.5 = 7.3. Therefore, the minimum threshold of 168 is about 12 σ away from average, which means the chances of succeeding by randomly choosing As, Bs or Cs are infinitesimal. a) The probability of 168 correct answers, regardless of the order of 240 questions is 240! * (1/168!) * [1/(240-168)!] * (33%^168) * [(1-33%)^(240-168)]. We also need to consider 169 correct answers, 170, 171... up to 240, and the sum of all these amounts.b) We can also use the Excel BINOMDIST function and calculate 1 - BINOMDIST(167, 240, 1/3, TRUE) to find the cumulative probability from 168 to 240 correct responses. We find a very small figure of the order E-15 (which happens to be negative, should be positive, probably Excel can not handle such a small figure). This is the probability of succeeding in passing the CFA L1 exam by randomly choosing between As, Bs or Cs.As a conclusion, we have a choice between choosing all Cs (0% success rate) and randomly picking between As, Bs and Cs (infinitesimal success rate, but infinitely better than 0%). The smart choice is second, and the real smart choice is to study for the exam. You can represent yourself. Each form is different by state or county, but generally an answer is simply a written document that presents a summary of your story to the court. The answer is not your defense, just a written notice to the court that you intend to challenge the process. Empty forms are available at the court clerk's office and are pretty much self explanatoryThere is a waiting space for a lawyer's signature. You should sign your name on space and write the words Pro se after your signature. This lets the court know that you are as your own lawyer. Quora allows users to delete their account if they choose to do so. Deleting your Quora account means that the following content will be removed from public view: your profile, including photos and biography, responses, comments, blog posts, votes, approvals, and messages. The questions you have asked will remain because questions about Quora are owned by the community, but will not be publicly associated with your name. Deleting your account is not reversible after the process is complete. Alternatives to deletion include:DisableEd change Quoraprivacy settingsDelete individual parts of content, such as replies, comments, or postsIf you are sure you want to delete your account, visit your account privacy settings and choose Delete Account. After account will be deactivated immediately and the deletion process will begin. If you sign in within the next 14 days, your account will be reactivated and the deletion will be canceled. After the expiry of the 14-day grace period and after the expiry of the Content and profile will be permanently deleted and personal data associated with your account will be removed from Quora's databases. Keep in mind that your content may have been republished or shared by others outside Quora. Deleting your account here does not remove any links or data hosted by others. If you have any further questions about deleting your account, contact us using our contact form. Q: Can torsion generators produce 25KW and more of the vacuum without violating the energy conservation law? They can't. There is no such thing as free energy or vacuum energy. Anyone who had even a raw lab model of any such device would simply use to power their lab for free, saving enough money to build a larger model that they would use to generate free selling energy, which they would use to fill their bank accounts until they controlled the whole world. Anyone who wants to attract investors in their free energy device is a con artist or an idiot. They're too stupid to know they're fooling themselves, or they're asking for money now because they know that energy will never materialize. And it won't be like that. Because you can't. Because FIZICA. Good question, at least for me. I made some attempts to port the concepts of statistical mechanics to Economics, using wealth as preserved quantity instead of energy. I immediately ran into protests from economists about wealth creation, and it was like trying to reason with a creationist. However, they have a point: our notion of wealth conservation is really based on a zero-sum model that is at least partially manufactured in order to bilking the rubies. But there is also a deep-rooted zero-sum instinct that goes back long before our big brains grew. See Dogonomics.Anyanyway, at least in individual financial transactions there is a deep-rooted sense of fair exchange, where each participant wants to exchange a valuable commodity for another of about equal (or higher if possible) value. This is usually true even in barter economics (though probably less in agalmics), so if we use a broad definition of wealth we can please just get on with it, huh? Sheesh! In a classic capitalist model, I believe that wealth conservation is a valid law, if it is approximate. In this case, if each individual possesses a certain amount of wealth, and if transactions involving the exchange of wealth occurred approximately randomly, you would expect to be able to define Economic Entropy as the log of the number of different wealth modes could be within a system (some collection of natural persons), and then define the economic temperature as the inverse rate of change in entropy with the net wealth of that system. The temperature would be measured in $$. In a socialist system (like an idealized Cuba) idealized) holds everything equally, so there is no entropy, no matter how much wealth is added or low; when such a system is put in economic contact with a capitalist system (which exists mainly to maximize its entropy), wealth will flow from first to second, despite the fact that there is much less wealth for it to lose. See Poor Cuba.Another thing Statistical economics would predict is that the distribution of individual wealth in a capitalist system would look like a Boltzmann distribution: an exponential degradation as a function of net worth, with the highest number of people close to zero Wealth and a small queue of people with enormous Wealth.In fact, the distribution of net personal wealth in the U.S. differs from a Boltzmann distribution only close to the end of zero (because of what little social assistance is still provided to the poor) and at the very top end (due to the fact that the transactions of these people are much less random than anyone else). After you might expect, this means that the tail extends to even more enormous wealth than luck can possibly explain. So I guess it's not so bad an analogy, despite the panicked reactions of economists to any suggestion that transactions are not all governed by rational agents. The idea of relativistic physics is that each inertia frame will experience the same physics. This means that if you travel in a frame that does not accelerate, there should be no difference between any two measurements within your own framework and any two measurements by someone else in a different frame. If we only consider an inertia framework, so that the event you are considering is viewed entirely from that framework, then we will find that energy is conserved. However, if you change frames, or momentum between one frame from reference to another, so that the frames have different speeds, you will find that the energy is not conserved. If you think about it, it makes sense. So what's preserved? Well, for that you need 4-impulse, which is a tensor that includes the energy and impulse of the system. This tensor is invariant under Lorentz turns, and is therefore preserved when you change frames. I hope that helped. If you want to learn more, search for the Wikipedia article. Mathematics is actually quite simple at a basic level, and gaining intuition is, in my opinion, simply a matter of putting time to understand phenomena. Phenomena.