Applied Physics in STEM

Exploring guided inquiry-based learning

"Facilitating Experiential & STEM Learning Opportunities"

Organized and Hosted by Hua Quan Village and Sino-Exchange

Presented at HuaQuan Village

By: Scott A. Campbell

September 22nd-24th

STEM 教育中的应用物理学

探索探究式学习

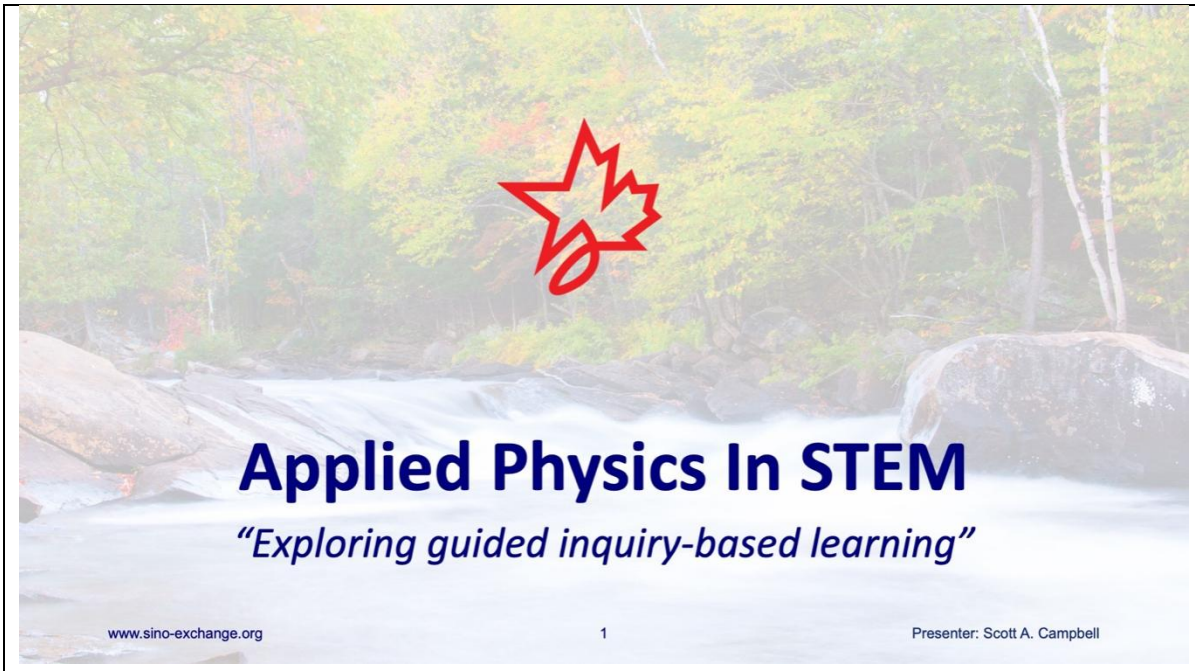
主办促进体验式和 STEM 学习机会

由华泉艺文休闲度假村、中外合作交流

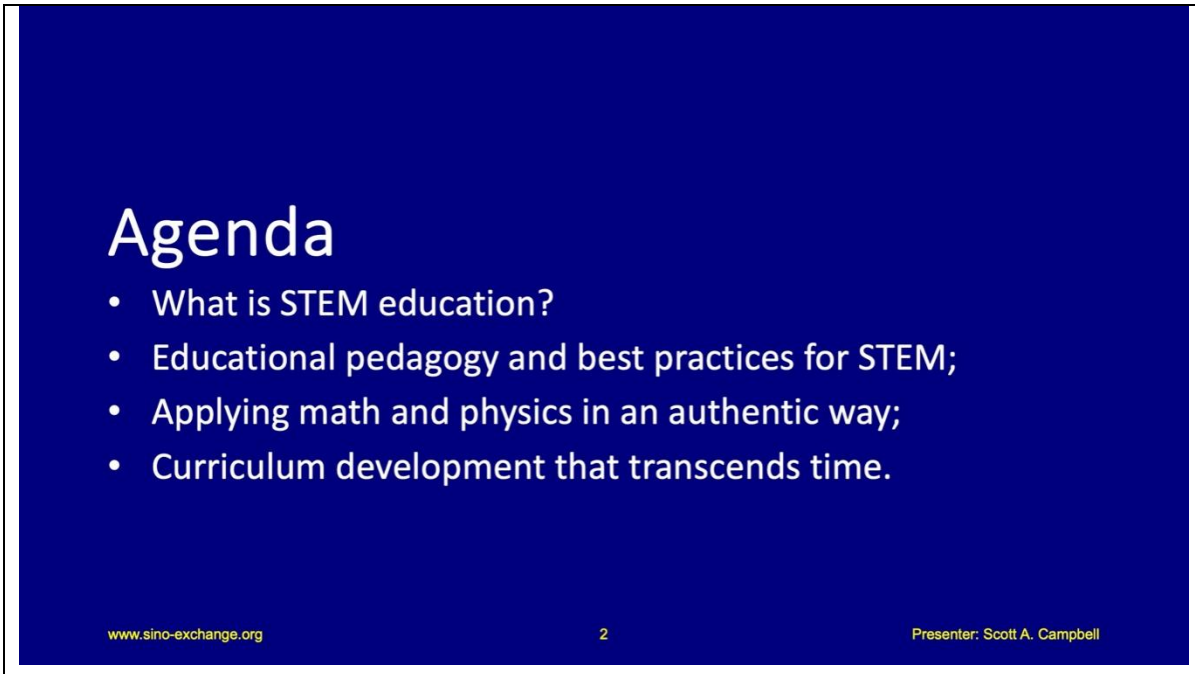
在华泉艺文休闲度假村举办

作者：胡屹龙

9 月 22 日-九月 24 日

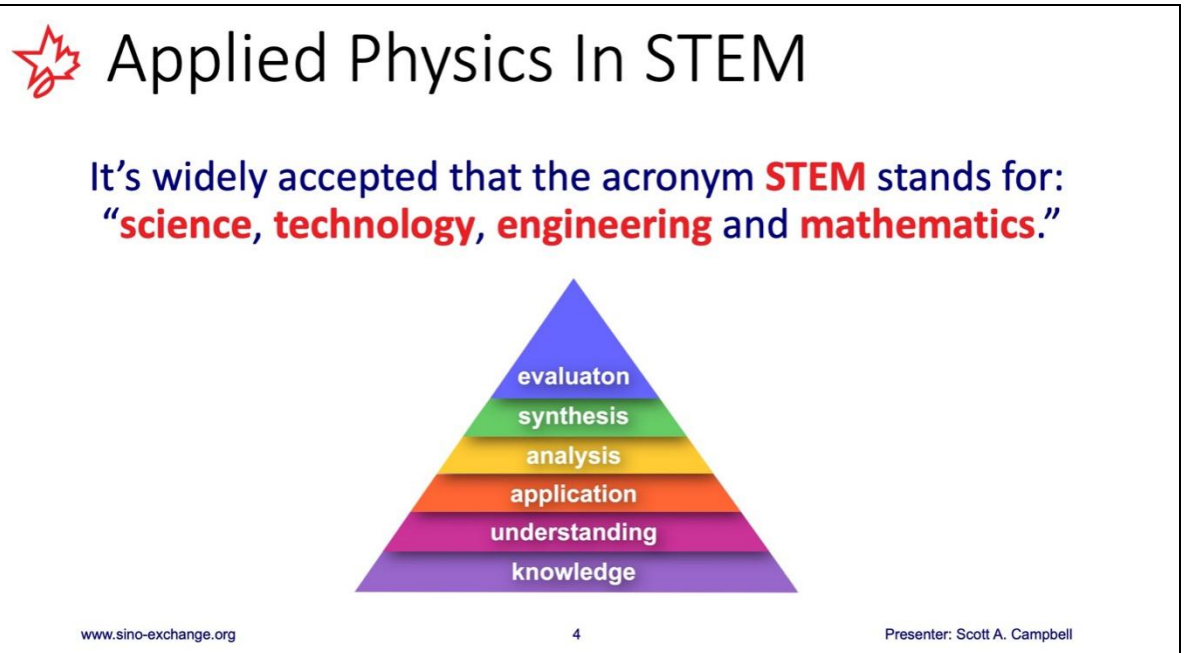


Gooday, and thank you all for attending this presentation of: "Applied Physics In STEM", where we will explore the real-world applications of math and science by using a process of ***guided inquiry-based learning***.	大家好，我很感谢大家参加"STEM 教育中的应用物理"的演讲，我们将通过引导探究性学习的过程来探索数学和科学在现实世界中的应用。



In today's presentation we will explore 4 big ideas: • This will include a brief review or exploration of the true nature of STEM education. • Some recondensation's for best practices for STEM, and these practices will be modeled throughout this presentation. • An in-depth exploration of how we can apply math and physics in an authentic way. • And we will conclude with the idea of developing curriculums that withstand the test of time.	在今天的演讲中，我们将探讨 4 个重要的概念: • 这将包括对 STEM 教育本质的简要回顾或探索。 • 对 STEM 教育的最佳实践进行了一些总结，这些实践将在整个演讲中进行建模。 • 深入探索我们如何以真实的方式应用数学和物理。 • 最后，我们将提出开发经得起时间考验的课程的想法。

So, let's start with BIG IDEA #1 - What is STEM education?	那么，让我们从大的想法#1 开始——什么是 STEM 教育?



It's widely accepted that **STEM** stands for: "**science**, **technology**, **engineering** and **mathematics**." It seems that everybody knows what STEM is, but there's still a lot of confusion and uncertainty surrounding STEM and all its derivatives. So let me delve into this a bit more.	人们普遍认为 STEM 代表"科学、技术、工程和数学"。似乎每个人都知道什么是 STEM ....但是围绕着 STEM 及其衍生产品有很多困惑和不确定性。让我们再深入研究一下。
Now I think most people are aware of Blooms taxonomy, but for those of you who don't – Blooms taxonomy is a classification of the different levels of thinking or cognition -- where knowledge is at the bottom, and as we develop our understandings, we can start applying what we know and eventually start synthesising and evaluating the results of our own thought process. And I think this is an important thing for us to stop and think about. **Everybody seems to have knowledge of what STEM is, but very few people understand the true nature of STEM education**, but we as educators we	现在我想大多数人都知道布鲁姆的分类法，但对于那些不知道的人来说，布鲁姆的分类法是对思维或认知的不同层次的分类——知识处于最底层，当我们发展我们的理解时，我们可以开始应用我们所知道的，最终开始综合和评估我们自己思维过程的结果。我认为这是一个值得我们停下来思考的重要问题。似乎每个人都知道什么是 STEM，但很少有人理解 STEM 教育的真正本质，但我们作为教育者，我们知道知识和理解之间有很大的区别。现在，由于围绕 STEM 教育的混乱，多年来对该框架提出了许多批评!

know that there is a **big difference between knowledge and understanding**. Now because of the confusion surrounding STEM education there has been numerous criticisms made of the framework over the years!	

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There is a lot of confusion surrounding STEM education as there no common perception or language of what STEM is anymore due to the development of a number of STEM derivatives such as:

- STEM
- STEAM
- STEMS
- STEMMA
- eSTEM + eSTEAM
- STREAM (adds "reading" or "research" and "arts")
- STEMM founded by Dr. Steve Meyer, & Rev. Jon Gerdts

"countries with high English proficiency are more innovative as they have access to a wider breadth of current research material from the global community" (Tran, 2015).

Tran, M., 2015. *Countries with High English Proficiency Are More Innovative.* [Online]
Available at: https://hbr.org/2015/11/countries-with-high-english-proficiency-are-more-innovative Page 1 of 6 [Accessed 5 2020].

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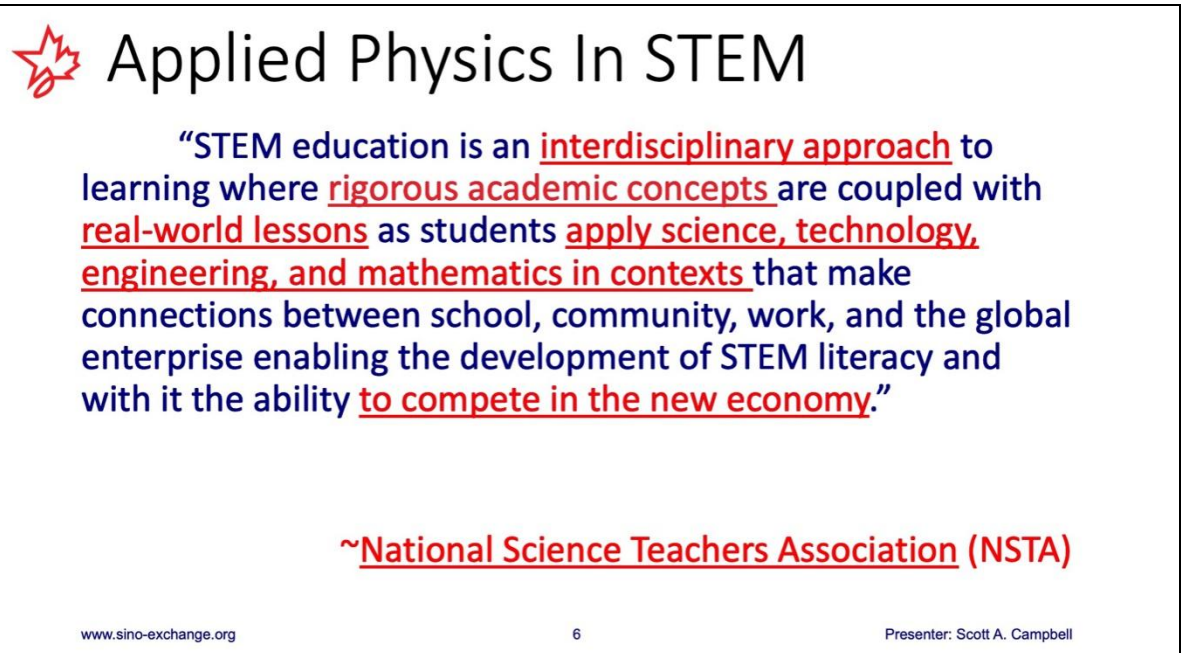
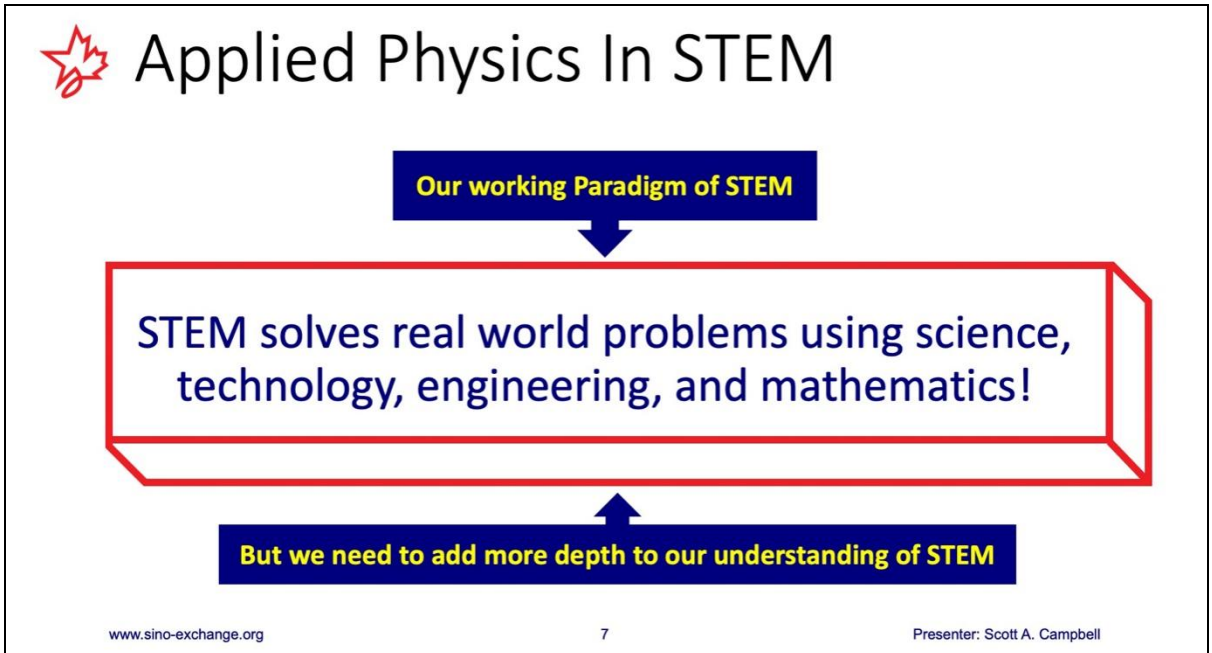
Now while these criticisms are valid. They only identified a problem **without understanding what caused the problem in the first place**, and these criticisms resulted in a numberer of STEM derivatives which have only created more confusion for educators and administrators alike!	虽然这些批评是正确的。他们只是发现了一个问题，而没有首先了解导致问题的原因，这些批评导致了许多 STEM 的相关衍生品，这只会给教育者和管理者带来更多的困惑!
So, let's look at some of these acronyms. • We have STEM. • And we also have STEAM which adds creativity through the arts. • But we also have STEMS which recognizes the importance Social Sciences by adding the S at the end of the acronym. • STEMMA which adds Managerial Arts and was first proposed by Harvard University. • Next, we have eSTEAM which recognizes the importance of developing English literacy development. And this idea of including an ESL curriculum into the	那么，让我们来看看这些缩写词。 • 我们有 STEM。 • 我们也有 STEAM，通过艺术增加创造力。 • 但是我们也有 stem，通过在首字母缩略词的末尾添加 S 来认识到社会科学的重要性。 • STEMMA 增加了管理艺术，最早由哈佛大学提出。 • 其次，我们有 eSTEAM，认识到发展英语读写能力的重要性。将 ESL 课程纳入 STEM 框架的想法对非英语国家来说很重要，这样学生就可以获得更广泛的研究材料，这将帮助他们变得更有创新精神。

STEM framework is important for none-English speaking countries so that students can access a wider range of research materials which will help them become more innovative. • And this leads us to another derivate know as STREAM with adds reading or research. • And finally, we have STEMM with a double M which was created by Dr. Steve Meyer and Revant Jon Gerdts who add the values of Christin Missionary to the mandate of STEM education. This idea also ties in with the recommendations that the World Economic Forum had made, but from a slightly religious standpoint, and it also corresponds to the Chinese interpretation of STEM + [sù zhì jiào yù], or moral education.	• 这就引出了另一个衍生词 STREAM，即附加阅读或研究的 STREAM。 • 最后，我们有一个双 M 的 STEM，它是由 Steve Meyer 博士和 Revant Jon Gerdts 创建的，他们将基督教传教士的价值观添加到 STEM 教育的任务中。这个想法也与世界经济论坛提出的建议有关，但从略带宗教色彩的角度来看，它也符合中国对 STEM + (sù zhì jiào yù素质教育)或道德教育的解释。



So, this definition of STEM education upholds the original ideology that Judith Ramaley had for STEM when she introduced the concept back in 2001. Let's take a moment to read through this definition together…	所以，这个 STEM 教育的定义坚持了朱迪思·拉马利在 2001 年提出 STEM 概念时对 STEM 的原始意识形态。 让我们花点时间一起读一下这个定义……
"STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy." WOW!	"STEM 教育是一种跨学科的学习方法，学生在学校、社区、工作和全球企业之间建立联系的背景下应用科学、技术、工程和数学，将严谨的学术概念与现实世界的课程相结合，从而提高 STEM 素养，并以此提高在新经济中竞争的能力。" 哇! 这个定义太啰嗦了!

This definition is very verbose! So, I am going to highlight a few key words here: • interdisciplinary approach • rigorous academic concepts • real-world lessons • apply science, technology, engineering, and mathematics in contexts. • to compete in the new economy As we can see by this last statement, STEM is linked to economic goals! To help students compete in the new global economy! therefore, we can't really forget about this connection because it's really the main driving force for STEM education at the government level. But let's try simplifying this definition before moving on.	所以，我要在这里强调几个关键词: • 跨学科方法 • 严谨的学术理念 • 现实世界的教训 • 应用科学，技术，工程和数学在上下文中 • 在新经济中竞争 从最后这句话中我们可以看出，STEM 与经济目标有关!帮助学生在新的全球经济中竞争!因此，我们不能真的忘记这种联系，因为它确实是政府层面 STEM 教育的主要推动力。 但在继续之前，让我们试着简化这个定义。



STEM solves real world problems using science, technology, engineering, and mathematics! This is the simplest definition that I can make to define STEM. However, this perception of STEM education, which I represented by a red box is incredibly limited. Therefore, we need to add more depth to our working paradigm. So let's expand the boundaries of our understandings.	STEM 利用科学、技术、工程和数学解决现实世界的问题! 这是我能给 STEM 下的最简单的定义。然而，我用红框表示的这种对 STEM 教育的看法是非常有限的。因此，我们需要为我们的工作范式增加更多的深度。 所以让我们扩大我们理解的界限。

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STEM solves real world problems using science, technology, engineering, and mathematics!

If our aim is to solve real-world problems, then:

- We must explore authentic problems;
- By developing authentic solutions;
- We must adopt a cross-curricular approach;
- While address legitimate **NEEDS** in society;
- And should **lead innovation** through **creative problem solving**.

***NOTE:** (although skills are often learnt in STEM, the focus of STEM education is not to develop skills for a general labour market).*

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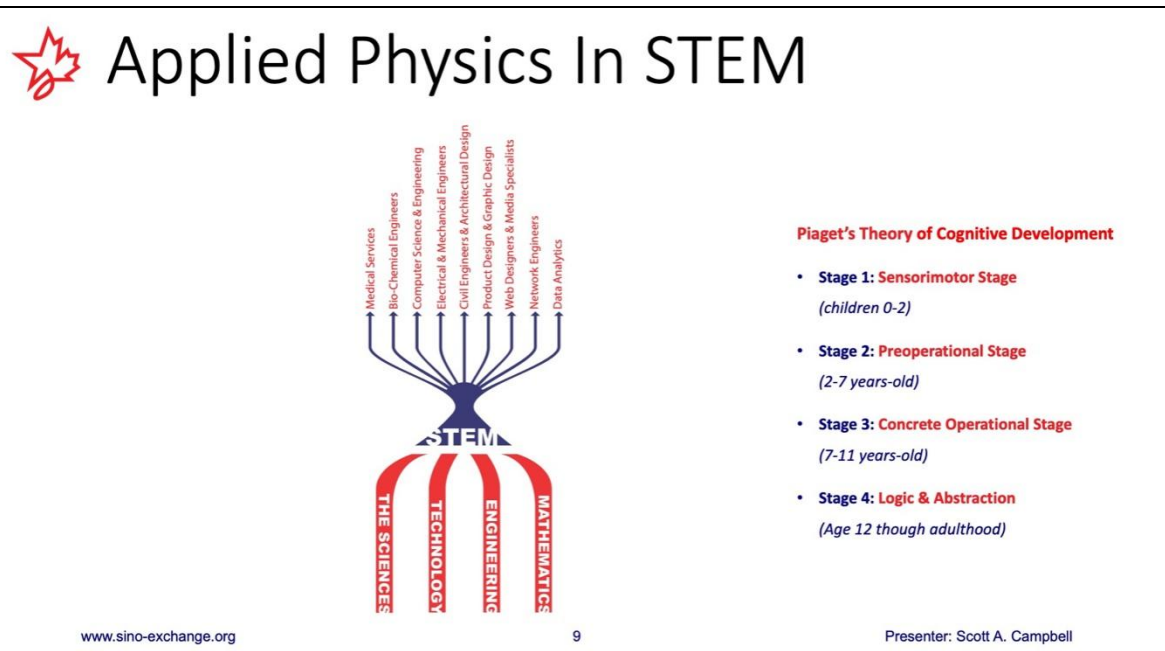
So, if our aim is to solve real world problems then: • Then the problems that we explore should be authentic. • By extension, the solutions to that problem should also be authentic. • And finally, the approach should also be cross-curricular. • But professionals in the fields of STEM are also addressing real world needs in our society. • And these industry professionals are leading innovation through creative problem solving.	所以，如果我们的目标是解决现实世界的问题，那么: •那么我们探索的问题应该是真实的。 •推而广之，该问题的解决方案也应该是可信的。 •最后，这种方法也应该是跨学科的。 •但 STEM 领域的专业人士也在解决我们社会的现实需求。 •这些行业专业人士通过创造性地解决问题来引领创新。
We now have a definition that is much simpler to understand, and it still upholds the ideology of the original definition that we look at a moment ago. However, there is still one last point that I should emphasize! Although students will often learn numerus skills in STEM, the focus of STEM education is not to develop job skills for a general	我们现在有了一个更容易理解的定义，它仍然支持我们刚才看到的原始定义的意识形态。然而，还有最后一点我应该强调!虽然学生通常会在 STEM 中学习许多技能，但 STEM 教育的重点不是培养一般劳动力市场的工作技能。

labour market.	



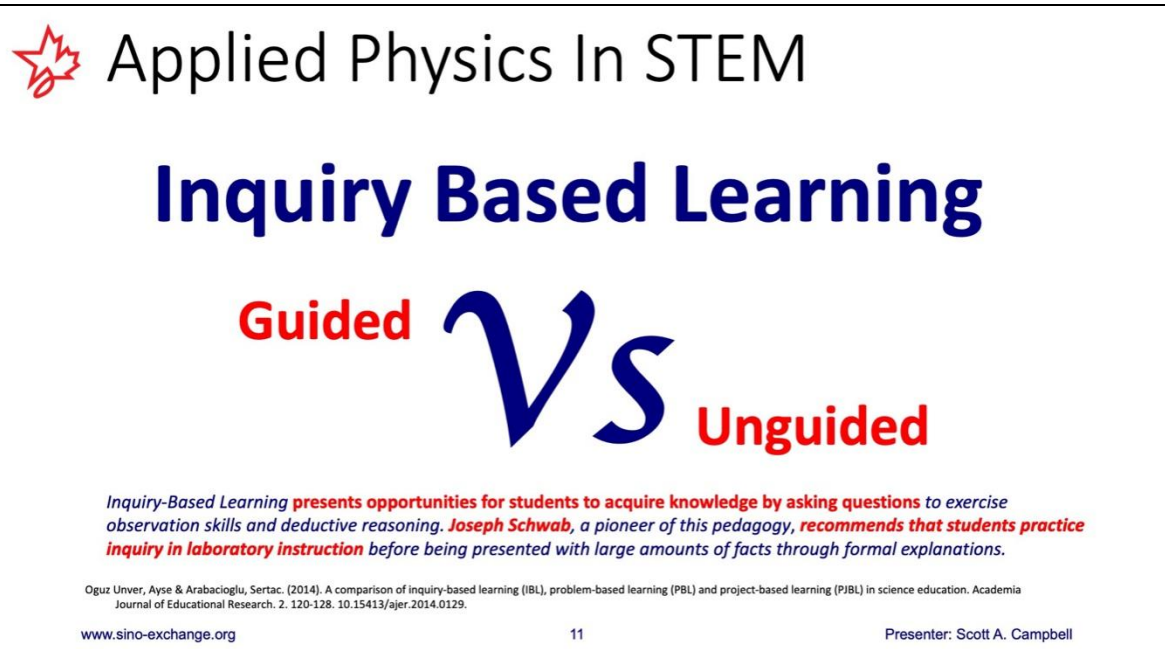
I would like to share this graphic to show you how all these different concepts are interconnected. • From the various subjects that STEM is comprised of. • The critical industry sectors that STEM is related to. • The educational theory that intersects with STEM education. • And the various stages of cognitive development. As you can see the core subjects Science and Mathematics act as columns supporting everything, and these core subjects are supplemented by inter-disciplinary subject areas. As such, STEM acts as merging point for the core subjects as we apply rigorous academic concepts in real-world lessons that will help students prepare for the new economy. However, there are so many critical sectors that are represented by STEM.	我想分享这张图，向你们展示这些不同的概念是如何相互联系的。 • 从 STEM 所包含的各个学科中。 • 与 STEM 相关的关键行业部门。 • 与 STEM 教育交叉的教育理论。 • 认知发展的各个阶段。 正如你所看到的，核心科目科学和数学作为支撑一切的栏目，这些核心科目由跨学科学科领域补充。因此，STEM 作为核心科目的融合点，我们将严格的学术概念应用于现实世界的课程，帮助学生为新经济做好准备。然而，有很多关键领域都有 STEM 的代表。 因此，在我们看到核心科目的合并之后，我们也看到 STEM 分支出许多专业，这些专业都属于 STEM 的保护伞。这就形成了一个沙漏形状，当我们学习多个科目时，把它们放在一起，然后当我们在

Therefore, after we see the merging of the core subjects, we also see STEM branch out into numerous specializations that all fall under the STEM umbrella. This creates an hourglass shape as we take multiple subjects, bring them all together, and then spread out again as we go on to specialize in a specific field of study later in life.	以后的生活中专攻某个特定的研究领域时，再把它们分散开来。 这让我想到了布鲁姆分类学。
And that brings me to **Blooms Taxonym**. As you can see, we always start with knowledge, and as we learn the basics, we start to understand abstract concepts.	正如你所看到的，我们总是从知识开始，当我们学习基础知识时，我们开始理解抽象的概念。
These concepts could include how to solve an equation, or how molecular bonds work… and these are all important concepts to understand if we are going to start applying theories in real-world lesson in a STEM program.	这些概念可能包括如何解方程，或者分子键是如何工作的，如果我们要开始在 STEM 项目的实际课程中应用理论，这些都是需要理解的重要概念。
AS you can see that the core subjects really need to proceed STEM, because we cannot apply math and science before first understanding the basics. Then in STEM we can start applying what we have learnt in context to solve real-world problems and go on to analyze the results, and finally, later in life industry professionals are required to synthesis seemingly unrelated concepts to solve complex problems in the real-world -- and of course they will need to evaluate the effectiveness of those solutions as well.	正如你所看到的，核心科目确实需要继续 STEM，因为在我们首先了解基础知识之前，我们无法应用数学和科学。然后，在 STEM 中，我们可以开始将我们所学到的知识应用于解决现实世界的问题，并继续分析结果，最后，在以后的生活中，行业专业人士需要综合看似无关的概念来解决现实世界中的复杂问题——当然，他们也需要评估这些解决方案的有效性。 接下来，我们可以看看我们将在 STEM 中获得最大的影响。由于批判性思维、数学和科学是 STEM 教育中至关重要的技能，你会发现 STEM 在初中和高中阶段的教学将产生最大的影响。这个概念也与皮亚杰的认知发展理论相吻合皮亚杰的认知发展理论指出，"逻辑和抽象"从 12

Next, we can look at where we are going to get the greatest impact in STEM. Since critical thinking, math, and science are crucial skill sets in STEM education, you will find that STEM will have the greatest impact when it is taught at middle and high-school levels. And this notion also corresponds well with what we know of **Piaget Theory of Cognitive Develop** which indicates that "**logic and abstraction**" only starts at age 12 and continues through adulthood.	岁开始，一直持续到成年。

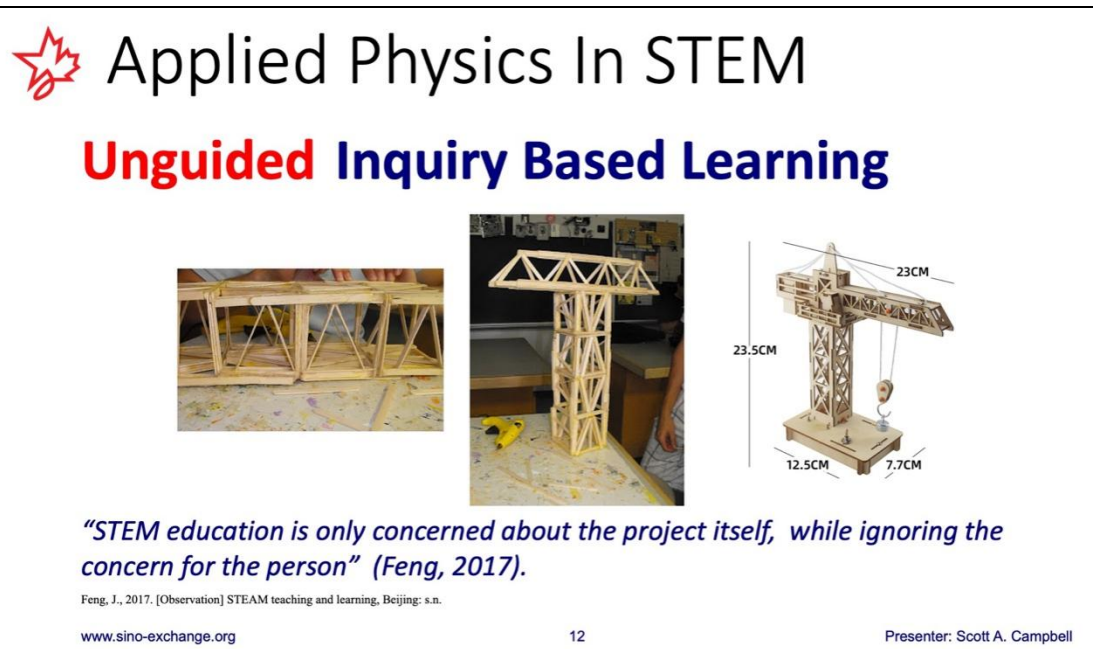
I should state that STEM education is so much more than just doing a project or making something, which that is something that is easy to forget in the excitement of doing a hands-on project or program of study.	我应该说，STEM 教育不仅仅是做一个项目或做一些东西，这是在做一个实践项目或学习计划的兴奋中很容易忘记的事情。
And that brings us to BIG IDEA #2, where I would like to briefly talk about best practices for STEM education. Because STEM is all about the authentic application of rigorous Math and Science skills which are generally applied through engineering and technological practices that are designed to solve real-world problems, and that was the primary focus of STEM when it was introduced by the National Science Foundation in 2001 -- To develop critical thinking skills in the core maths and sciences to prepare students for a highly competitive and sophisticated global economy. However, many STEM programs and projects have been losing sight of those	这就把我们带到了大创意#2，我想简要谈谈 STEM 教育的最佳实践。因为 STEM 是关于严谨的数学和科学技能的真实应用，这些技能通常通过旨在解决现实世界问题的工程和技术实践来应用，这是 STEM 的主要重点，当它在 2001 年被美国国家科学基金会引入时——培养核心数学和科学的批判性思维技能，为学生应对竞争激烈和复杂的全球经济做好准备。然而，近年来，许多 STEM 项目已经忽视了这些目标，如果我们想让我们的 STEM 课程为我们的学生进入他们将要进入的世界做好充分的准备，这是我们需要解决的问题。

objectives in recent years, and that is something that we need to address if we want our STEM curriculums to adequacy prepare our student for the world that they are going to be entering.	



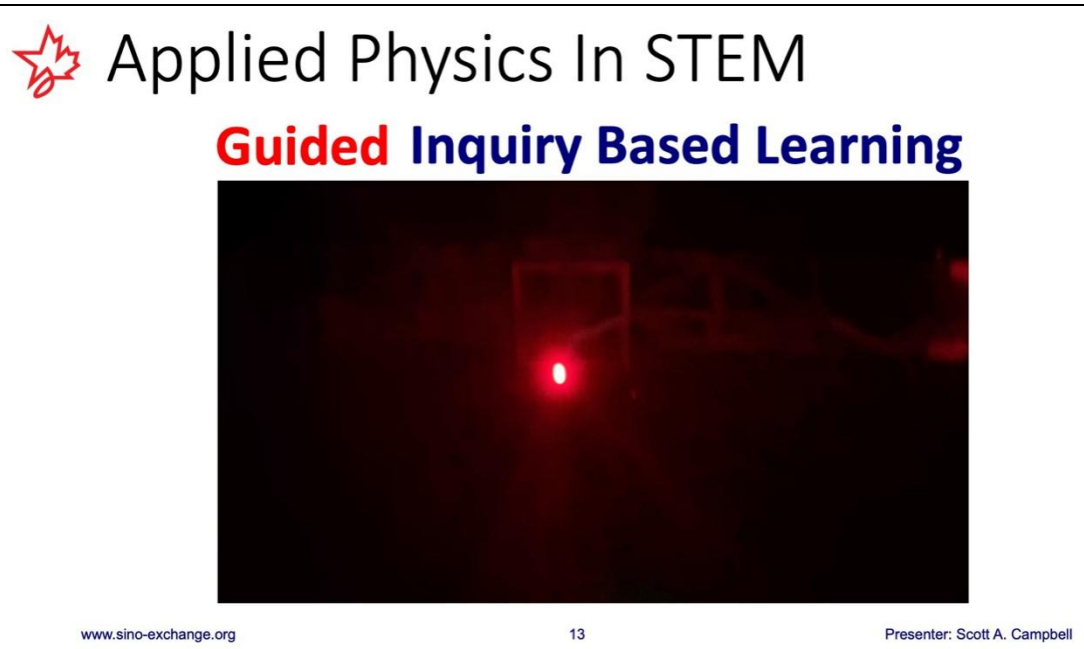
The first thing that I want to talk about is ***Inquiry Based Learning***. Now Inquiry Based Learning has its proponents. however, there are also lots of teachers out there that are strongly opposed to this philosophy as well. But I think biggest issue comes down to the differences between ***guided*** or ***unguided inquiry-based learning***. That is…. are we as teachers creating authentic learning opportunities for our students that will challenge them to ask questions, while also giving them the support and guidance they need to excel! Or are we leaving them to their own devices and hopping for the best? I would argue that the opposition that some teachers have towards ***Inquiry Based Learning*** is directed towards “unguided” practices.	首先我想说的是基于探究的学习。现在基于探究的学习有它的支持者。然而，也有很多老师强烈反对这种哲学。 但我认为最大的问题是指导性和非指导性探究式学习之间的差异。 这是……作为老师，我们是否为学生创造了真正的学习机会，挑战他们提出问题，同时也给予他们所需的支持和指导，让他们出类拔萃! 还是让他们自生自弃，等待最好的结果? 我认为，一些教师对研究性学习的反对是针对“无指导”的实践。 现在，约瑟夫·施瓦布建议学生在实验室教学中练习探究，因为它为学生提供了通过提问获得知识的机会。因此，基于

Now Joseph Schwab recommends that students practice inquiry in laboratory instruction as it presents opportunities for students to acquire knowledge by asking questions. Therefore, ***Inquiry Based Learning*** isn't about letting students do whatever they want and seeing what they come up with, it's about helping our students discover new things by asking questions in a structed settings such as a lab. However, we are not disseminating information through formal explanations but guiding our students through process of practical inquiry.	探究的学习不是让学生做他们想做的事情，看看他们想出了什么，而是通过在实验室这样的结构化环境中提出问题来帮助学生发现新事物。然而，我们不是通过正式的解释来传播信息，而是通过实践探究的过程来引导学生。

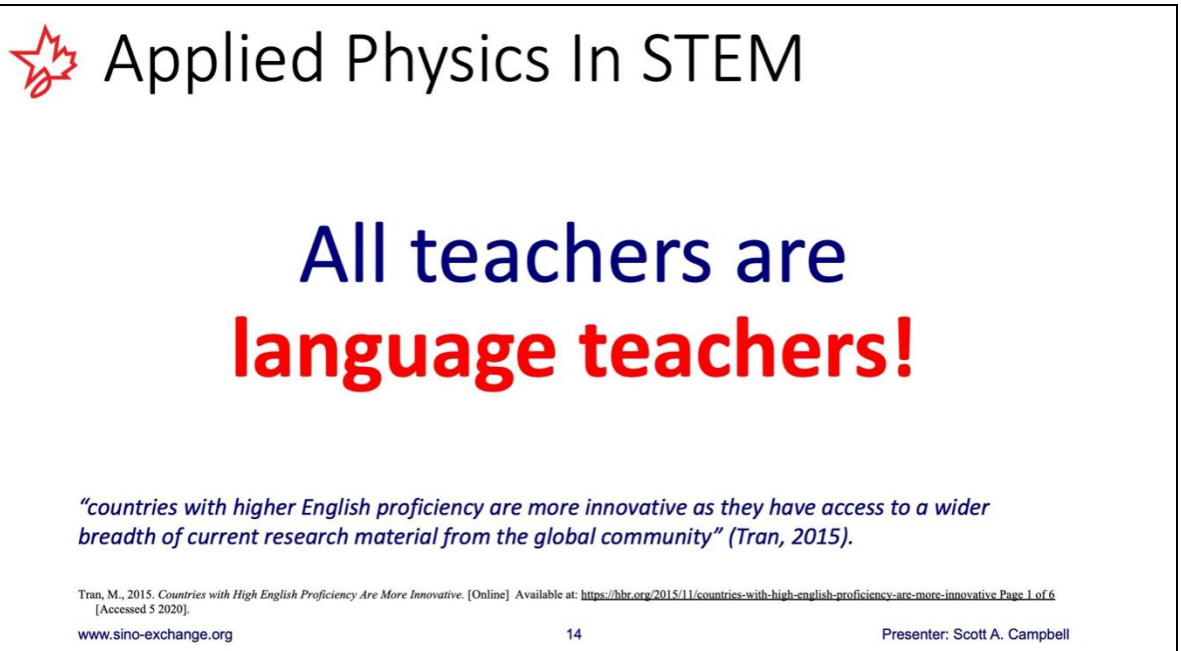


When we fail to provide structure, support, and guidance to our students. Our students will typically apply what they already know, or what they are currently capable of doing. As a result, they will seldomly go beyond a rudimentary understanding of the concepts that are related to what they are exploring. This is in-part because they won't even know what questions to ask unless we point them in the right direction. Therefore, ***Unguided Inquiry Based Learning*** tends to produce projects like this!	当我们不能给学生提供结构、支持和指导时。我们的学生通常会应用他们已经知道的，或者他们目前有能力做的事情。因此，他们很少会超越对与他们正在探索的内容相关的概念的基本理解。这在一定程度上是因为除非我们给他们指明正确的方向，否则他们甚至不知道该问什么问题。因此，无指导的基于探究的学习倾向于产生这样的项目！
Here we can see that the students have used popsicle sticks to create an object that resembles the general structure of a crane. However, very few scientific principles have been explored in this example. Alternately the students may use DIY kits, and while there is nothing wrong with the quality of these products, the students don't really learn much from these resources because they focus on the act of building rather	在这里，我们可以看到学生们用冰棒棍创造了一个类似起重机一般结构的物体。然而，在这个例子中几乎没有探索到科学原理。学生们也可以使用 DIY 工具，虽然这些产品的质量没有问题，但学生们并没有从这些资源中学到太多东西，因为他们关注的是建造的行为，而不是对严谨的学术概念的探索。这些资源给 STEM 教育带来了坏名声。例如，冯批评 STEM 说"STEM 教育只关心项目本身"。

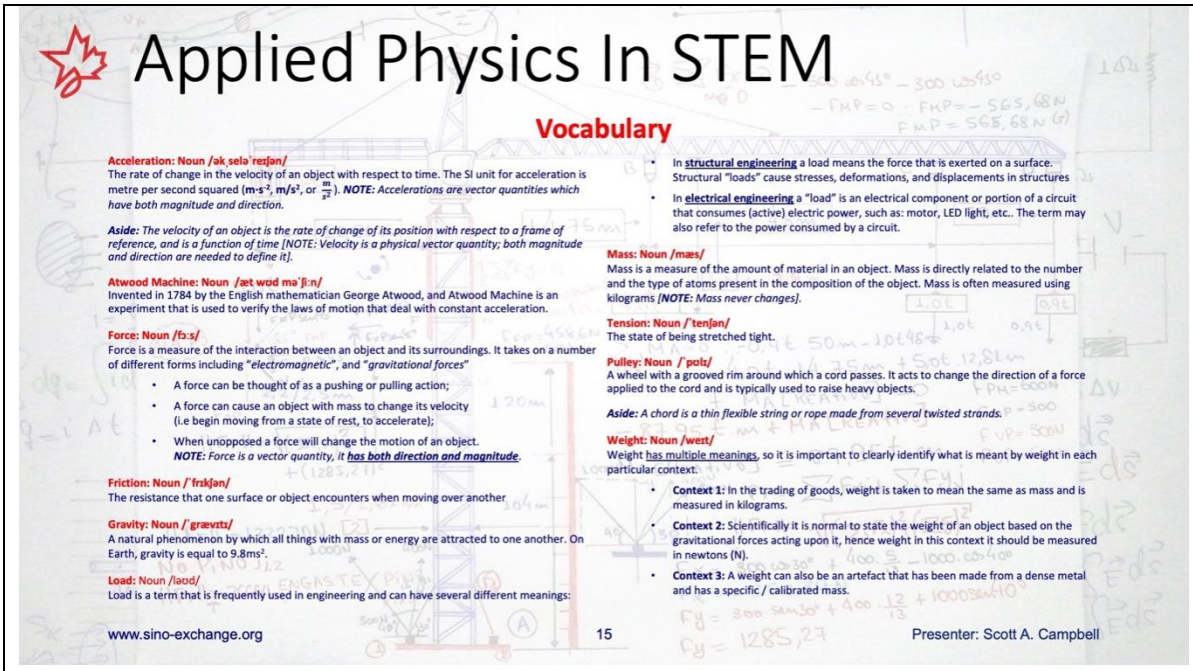
than the exploration of rigorous academic concepts. And these kinds of resources have been giving STEM education a bad reputation. For instance, Feng criticizes STEM saying that "*STEM education is only concerned about the project itself*". Therefore, in summary, neither of these examples had the students explore scientific concepts beyond the rudimentary function or shape of a crane, and that negates the value of doing the project in the first place.	因此，总而言之，这些例子都没有让学生探索超出起重机基本功能或形状的科学概念，这首先否定了做这个项目的价值。



Now in this example you can see what this project would look like using a "**Guided Inquiry Based Learning"** methodology**.**	现在在这个例子中，你可以看到这个项目是如何使用"引导探究式学习"方法的。
Now you can see by this example that the students have conducted a much deeper exploration, and the quality of their project is infinity better. While the video does an excellent job of showing the final project, we didn't get to see what happened behind the scenes!	现在从这个例子中你可以看到，学生们进行了更深入的探索，他们的项目质量也大大提高了。虽然视频很好地展示了最终的项目，但我们没有看到幕后发生了什么!
Therefore, for the remainder of this presentation, I will be using this project to model how math and physics can be applied in authentic way.	因此，在这次演讲的剩余时间里，我将使用这个项目来模拟数学和物理如何以真实的方式应用。

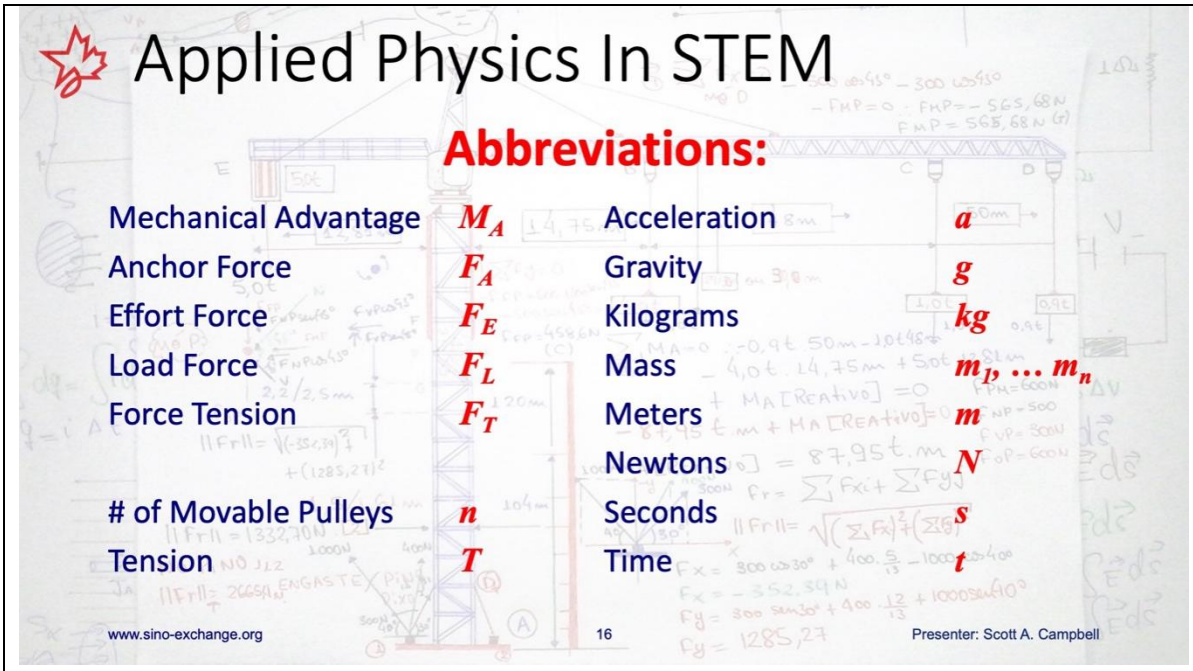


But before moving on I also want to emphasis this point: **All teachers are language teachers!** We can't just push off aspects of literacy development just because we are teaching STEM. We have our part in helping students develop "Cognitive Academic Language Proficiency Skills" to help prepare them for the new economy. As Tran indicates, "*countries with higher English proficiency are more innovative as they have access to a wider breadth of current research material from the global community*". Therefore, it is imperative that we help our students… especially if we are teaching STEM in an international setting, so that we help develop the literacy skills that our students will need to excel.	但在继续之前，我还想强调这一点: **所有的老师都是语言老师!** 我们不能仅仅因为教 STEM 就把读写能力的发展推到一边。我们的职责是帮助学生培养"认知学术语言能力"，帮助他们为新经济做好准备。 正如 Tran 所指出的那样，"英语水平较高的国家更具创新性，因为他们可以从国际社会获得更广泛的当前研究材料"。因此，我们必须帮助我们的学生，特别是如果我们在国际环境中教授 STEM，这样我们就可以帮助培养学生的识字技能，这将是我们超越学生所需要的。



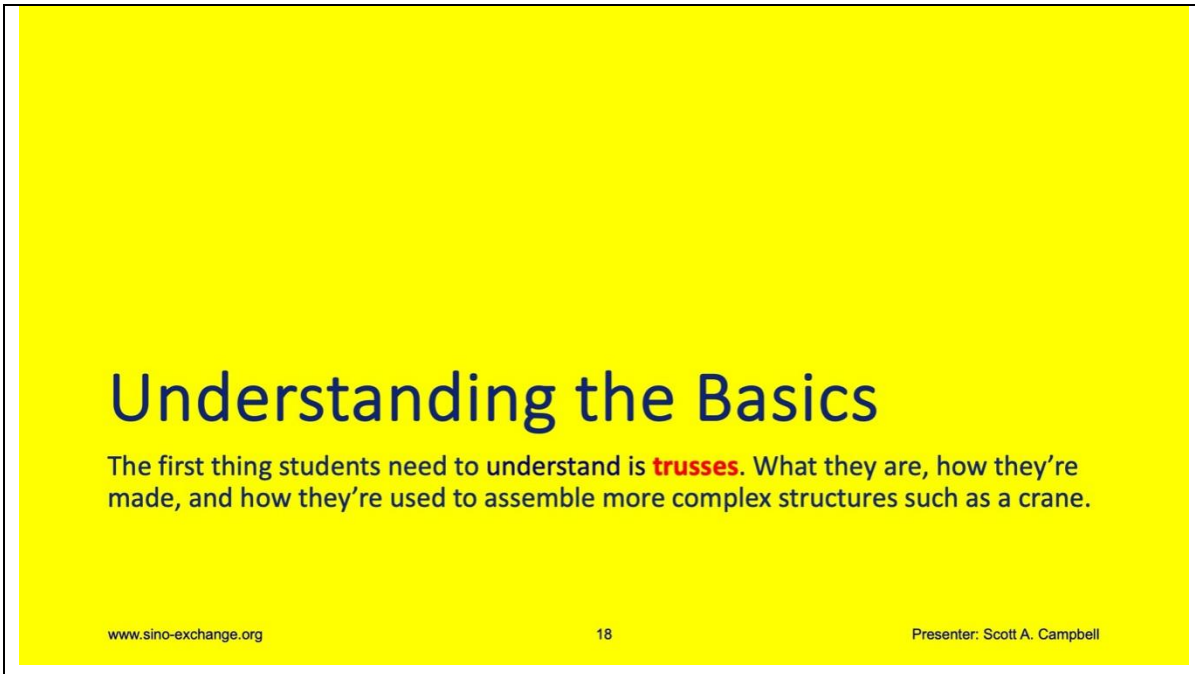
And to do this we need to make an effort to reinforce and teach vocabulary skills.	要做到这一点，我们需要努力加强和教授词汇技能。
For instance, these are all the vocabulary words that I will using while modeling this extended project. Now it's important for me to explain and model how to use these words properly; However, I always go a step further by providing my students with the IPA pronunciation guides for each word. This extra resource really helps our ESL students as it provides them with a support mechanism to sound out the word properly on their own. Therefore, the use of IPA empowers them to become autonomous self-directed learners.	例如，这些都是我将在建模这个扩展项目时使用的词汇。现在对我来说，重要的是解释和示范如何正确使用这些词;然而，我总是更进一步，为我的学生提供每个单词的国际音标发音指南。这个额外的资源确实帮助了我们的 ESL 学生，因为它为他们提供了一个支持机制，让他们自己正确地发单词的音。因此，IPA 的使用使他们能够成为自主自主的学习者。
But I will also try to reduce how many words I use. For example, I avoid using unnecessary synonyms, and this helps me to use select key words more often, which helps the students learn though repetition.	但我也会尽量减少我使用的单词。例如，我避免使用不必要的同义词，这有助于我更频繁地使用精选关键词，这有助于学生在重复中学习。此外，这也将有助于减少 ESL 学生之间的困惑。

Moreover, this will also help reduce confusion amongst ESL students. And finally, I always highlight keywords in my lessons to help draw my student's attention to important vocabulary words.	最后，我总是在我的课程中突出关键词，以帮助我的学生注意重要的词汇。

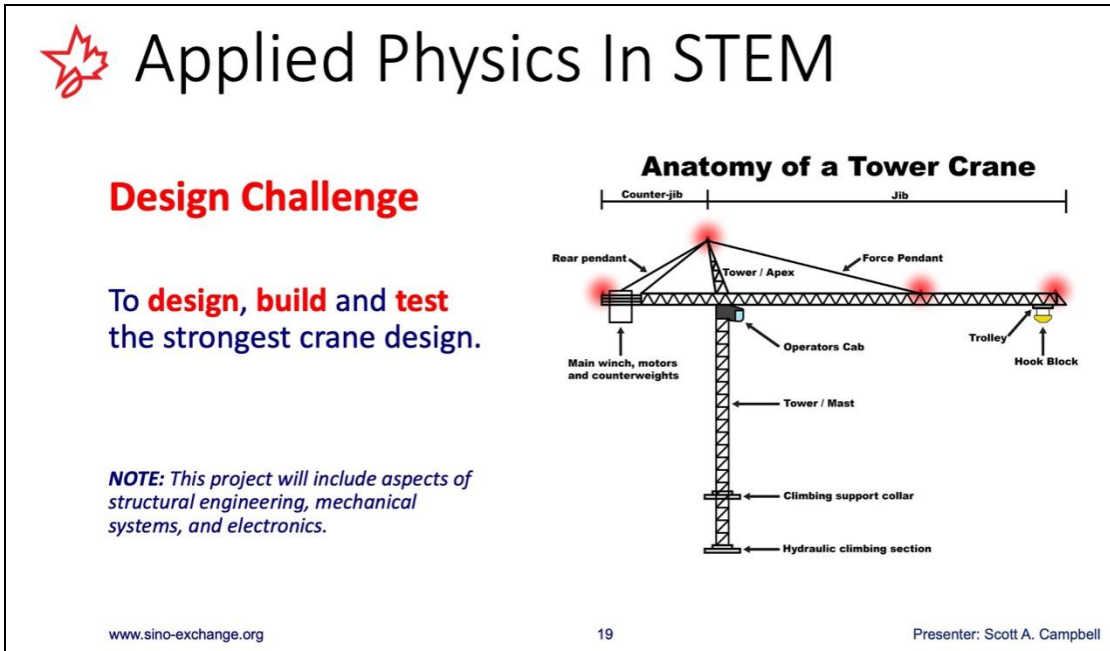


Moreover, it is also important to be very clear with any abbreviations that you use. And to be consistent in how you use them. For example, pre-made diagrams can be labeled very differently depending on their source, and these discrepancies can be very confusing for your ESL students. Therefore, it is best to ensure consistency throughout your lessons. As such, I will be using these exact abbreviations in today's presentation.	此外，非常清楚您使用的任何缩写也很重要。 并且在使用它们的方式上保持一致。 例如，预先制作的图表可以根据其来源进行非常不同的标记，这些差异可能会让您的 ESL 学生感到非常困惑。因此，最好在整个课程中确保一致性。因此，我将在今天的演讲中使用这些确切的缩写。

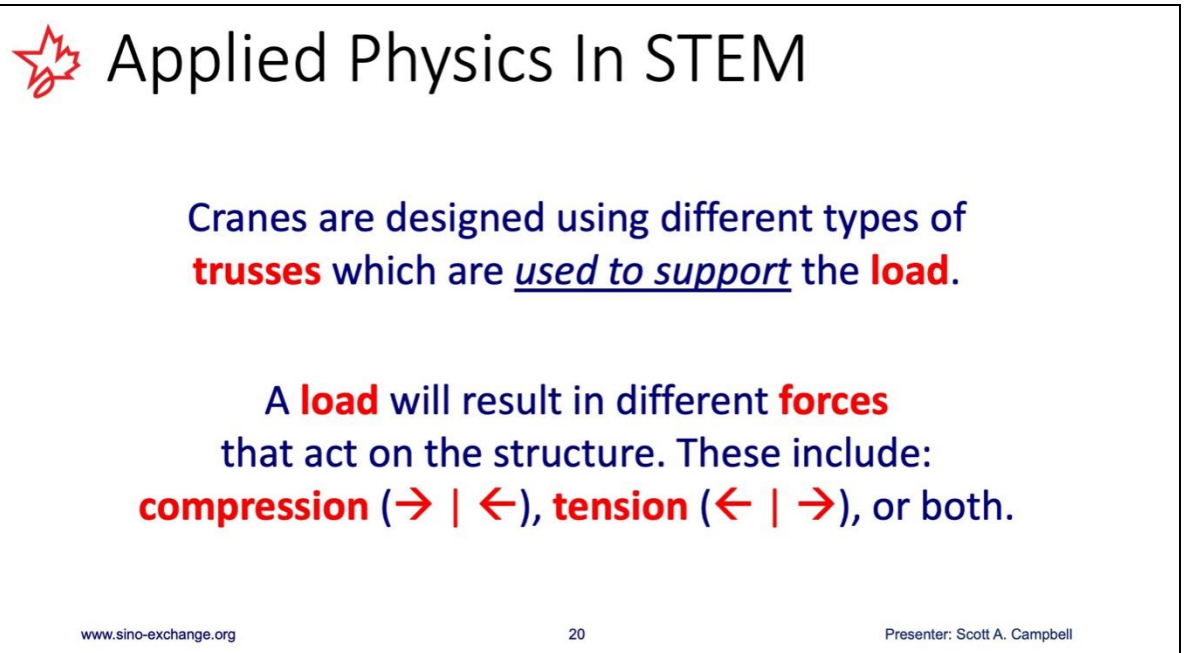
In the following section we will look at how we can apply math and physics in an authentic way within the context of STEM education, and to do this I will be modeling a single project, which is the development and testing of a tower crane.	在下一节中，我们将看看如何在 STEM 教育的背景下以真实的方式应用数学和物理，为了做到这一点，我将对一个项目进行建模，这是塔式起重机的开发和测试。
Now I have already showed you examples of what the end-product of both **guided** and **unguided inquiry-based learning** will look like. However, we haven't seen what we can do as teachers to guide and support our students which is important if we want to encourage an authentic process of inquiry that will promote the development of rigorous academic concepts.	现在我已经向你们展示了引导和非引导的基于探究的学习的最终产品是什么样子的例子。然而，我们还没有看到我们作为教师可以做些什么来指导和支持我们的学生，如果我们想鼓励一个真正的探究过程，这将促进严谨的学术概念的发展，这是很重要的。



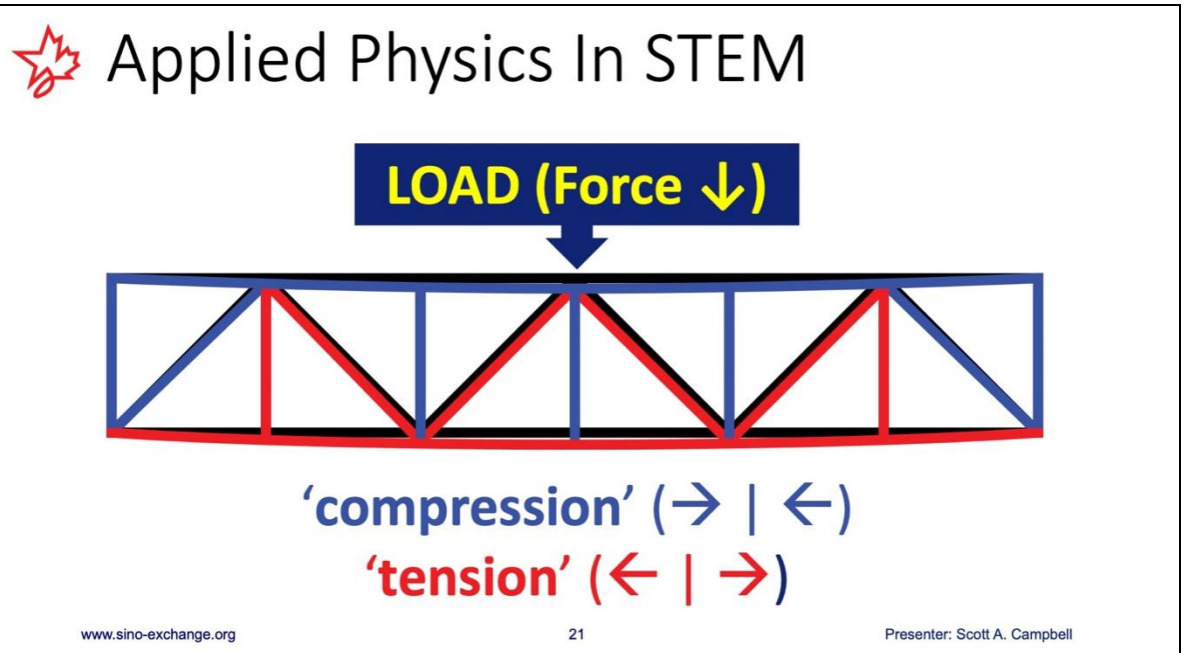
So, the first thing we need to do when understanding a crane is to learn the basics. Essentially, we want to activate prior knowledge, draw on dormmate observations of the real-world, or potentially introduce new concepts for the first time. At this stage we will be introducing students to the idea of trusses. What they are, how they're made, and how they're used to create more complex structures. And this is a transferable concept that gets used in bridges, buildings, and even spacecrafts.	所以，当我们了解起重机时，我们需要做的第一件事就是学习基础知识。从本质上讲，我们想要激活先验知识，利用室友对现实世界的观察，或者可能第一次引入新概念。在这个阶段，我们将向学生介绍桁架的概念。它们是什么，它们是如何制成的，以及它们如何被用来创造更复杂的结构。这是一个可转移的概念，可以用于桥梁，建筑物，甚至航天器。
I should say that projects within STEM are only a means to an end. Things shouldn't really be about the project itself but should be about the core concepts that the project introduces. These concepts should really be big transferable ideas that will transcend the project, but more importantly will focus on ideas and understandings that will transcend the test of time!	我应该说，STEM 教育中的项目只是达到目的的一种手段。事情不应该是关于项目本身，而应该是关于项目引入的核心概念。这些概念应该是超越项目的可转移的想法，但更重要的是，这些想法和理解将超越时间的考验!



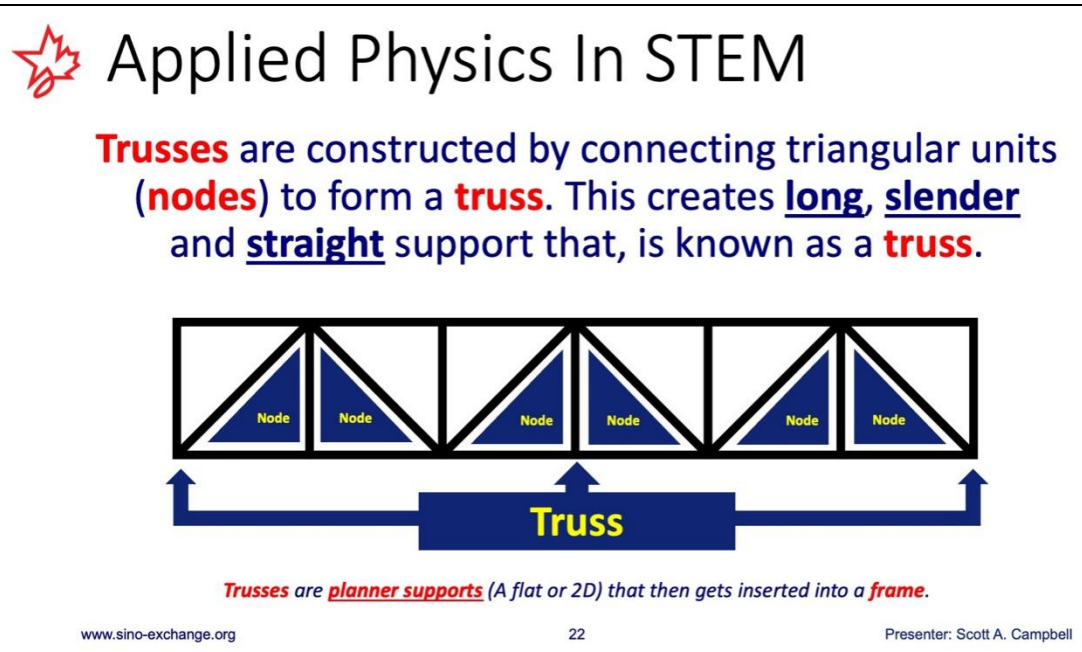
This is the challenge that I would give the students: To design, build, and test the strongest crane possible. This one project is going to cover aspects of structural engineering, mechanical systems, and electronics. Therefore, there are a lot of things that a project like this can cover, if we help guide our students through a process of ***guided inquiry-based learning,*** and this will give them an authentic learning opportunity to explore the application of math and science in context.	这是我给学生们的挑战: 设计，建造，并测试最坚固的起重机。 这个项目将涵盖结构工程、机械系统和电子学的各个方面。因此，像这样的一个项目可以涵盖很多东西，如果我们帮助引导我们的学生通过一个引导探究性学习的过程，这将给他们一个真正的学习机会去探索数学和科学在环境中的应用。



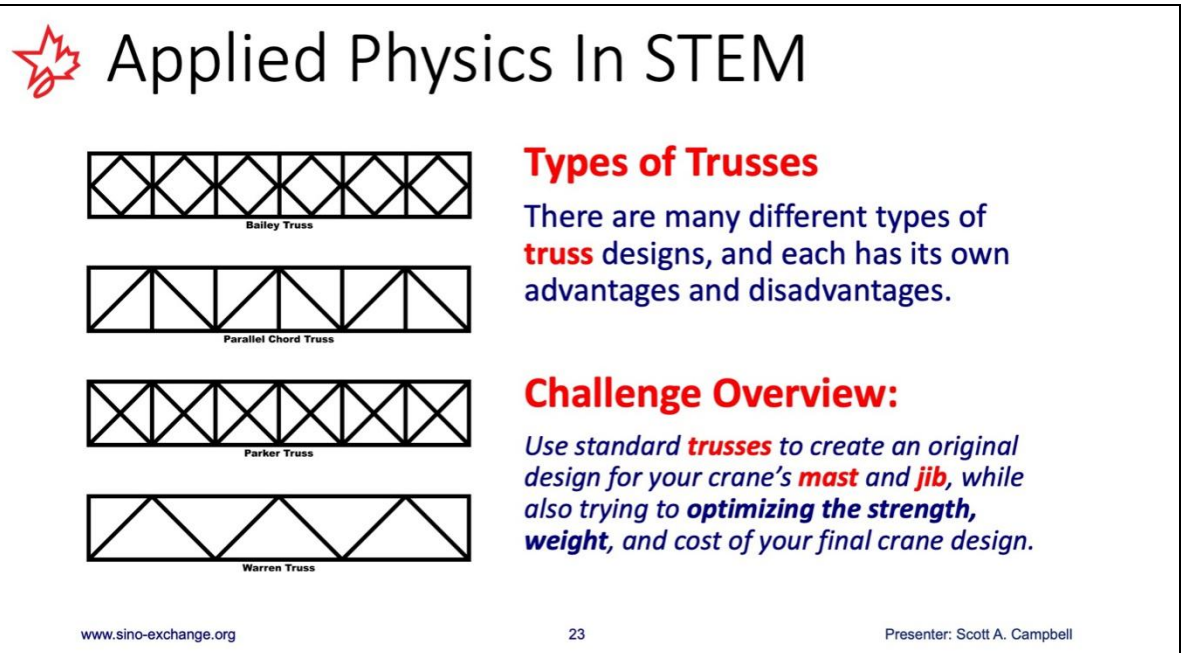
Now cranes are designed using trusses which support the load, and these loads will result in different forces that act upon the structure of the crane. As an aside, you can see how I have highlighted the key words, and how I have also added visuals such as symbols to help my ESL students identify the big ideas.	现在的起重机都是用桁架来支撑荷载的，这些荷载会对起重机的结构产生不同的力。 顺便说一句，你可以看到我是如何突出关键词的，以及我是如何添加视觉效果的，比如符号，来帮助我的 ESL 学生识别重要的思想。



Moving on. If we look at our standard truss and apply a load to the middle of that structure, we can see how the different forces which are exerted by that load disfigures the structure. And different parts of the structure will experience different types of forces as parts of the structure are compressed, while others are being ripped apart by forces of tension.	在移动。如果我们看一下标准桁架，在结构的中间施加一个载荷，我们可以看到不同的力是如何使结构变形的。当结构的一部分被压缩时，结构的不同部分将经历不同类型的力，而其他部分则被张力撕裂。

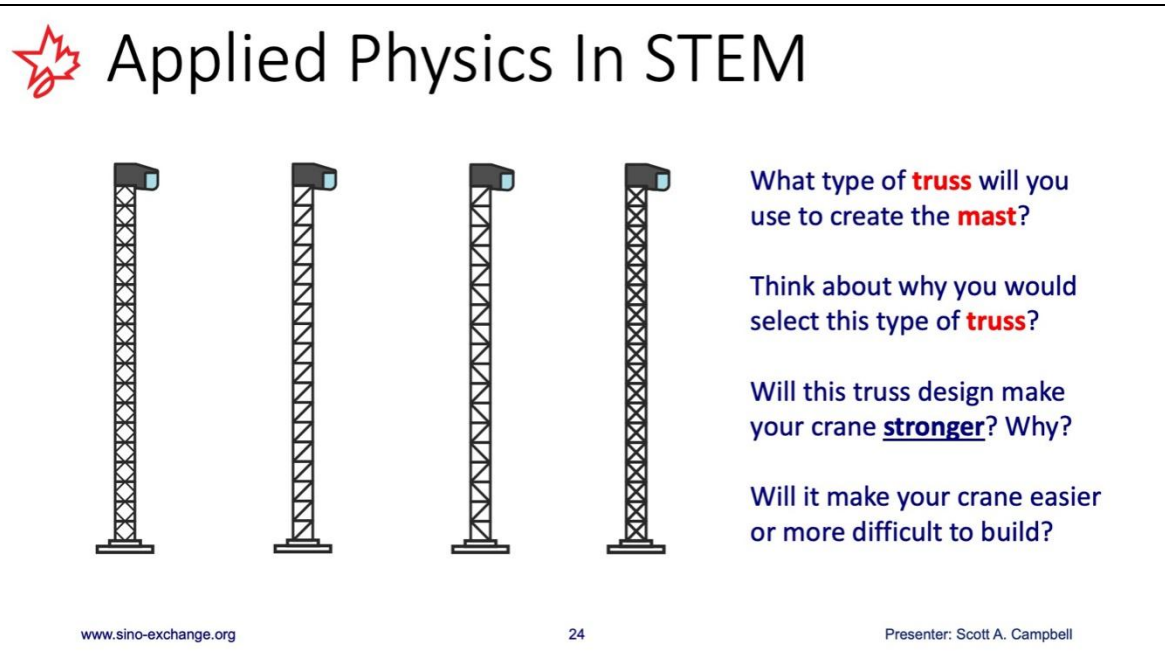


Now trusses are constructed using triangular units which are known as nodes. This creates a long planner support that is known as a truss, and these planner supports are then used to create a 3-dimensional frame.	桁架是由三角形单元构成的，这些单元被称为节点。这创建了一个长规划支撑，被称为桁架，然后这些规划支撑被用来创建一个三维框架。

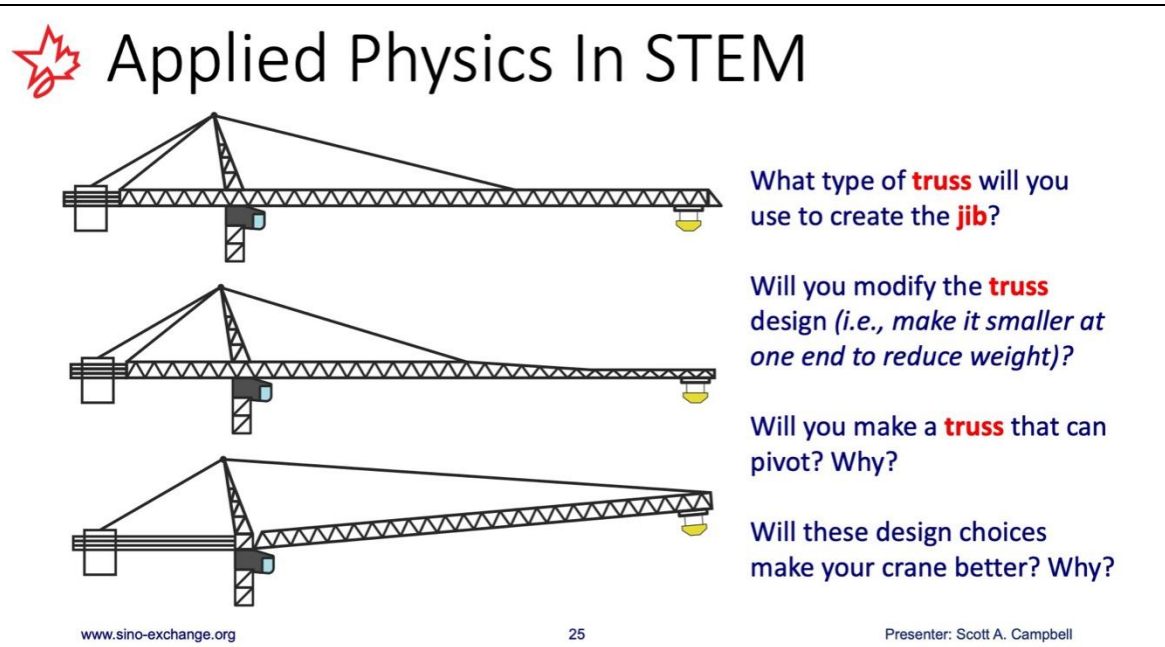


Now there are lots of different types of trusses such as: The Baily, parallel chord, Parker, and the Warren truss design just to name a few, and this is where the student's inquiry really comes into play. As we have created a scenario for authentic **inquiry-based learning** where we are guiding our students to explore new concepts. Therefore, the student's challenge is to design the best crane possible using standard trusses. However, they will need to ask themselves which truss will produce the best results and why? For instance, the bailey truss is incredibly strong. however, it's very heavy so the crane is going to have to support extra weight, and it's also very difficult to assemble a Bailey truss as well. Therefore, we have various tradeoffs which our students will need to evaluate and consider.	现在有很多不同类型的桁架，如:贝利，平行和弦，帕克和沃伦桁架设计只是举几个例子，这是学生的探究真正发挥作用的地方。因为我们已经为真正的探究性学习创造了一个场景，我们正在引导学生探索新概念。因此，学生面临的挑战是使用标准桁架设计最好的起重机。然而，他们需要问自己哪种桁架会产生最好的结果，为什么? 例如，贝利桁架非常坚固。然而，它非常重，所以起重机必须支撑额外的重量，而且组装贝利桁架也非常困难。因此，我们有各种各样的权衡，我们的学生需要评估和考虑。 因此，你的学生需要考虑哪种设计是最强的，最轻的，最便宜的。然后，他们还需要考虑如何平衡这些因素，以达到理想的强度重量比，同时保持低成本，

Therefore, your students will need to think about which design is going to be the strongest, the lightest, and the cheapest. Then they will also need to think about how they balance these factors to achieve the ideal strength to weight ratio while keeping costs down, which is essentially the big idea behind a feasibility study which the students would learn about in an economics class.	这本质上是可行性研究背后的大思想，学生将在经济学课上学习。

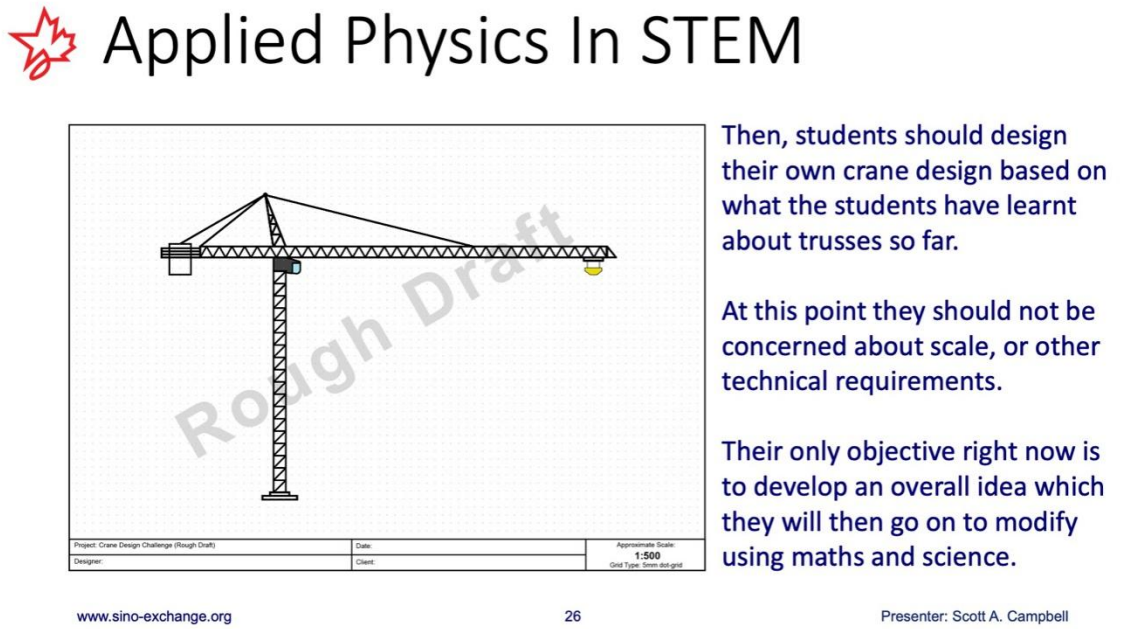


Therefore, as the students are designing their cranes, they will want to think about: • What type of truss they will use to create the mast. • Why they would select this kind of truss. • Will this truss make their crane stronger? • And are they capable of building and testing their own design.	因此，当学生们在设计他们的起重机时，他们会想: •他们将使用什么类型的桁架来创建桅杆。 •他们为什么会选择这种桁架。 •这个桁架会使他们的起重机更坚固吗? •他们是否有能力构建和测试自己的设计?

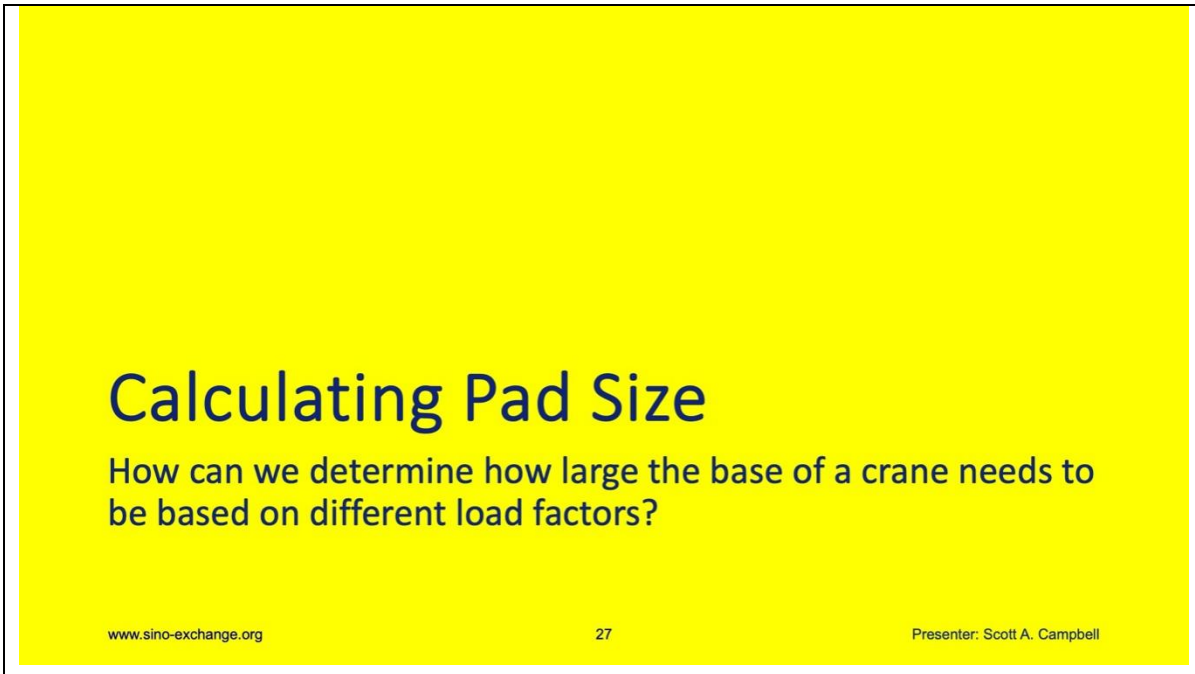


Students also need to think about how they will design the jib as well and will they modify the truss design here. For instance, they may decide to taper the jib at one end to reduce the weight, or they may add a pivot point. Because a lot of cranes do have a pivoting point. Regardless of the choices the students choose to explore. They will need to ask themselves the following questions: • Will this make my crane better or worse. • Is this design within my ability to make. Now this pivoting truss idea is really cool; however, it's going to be too difficult for your students to attempt. But here we have this idea of providing the necessary information to your students so they can make informed decisions. To help guide their process of inquiry, and differentiation is inherently built into this methodology as students will take on suitable challenges for	学生们还需要考虑如何设计臂。他们会修改这里的桁架设计吗? 例如，他们可能会决定在一端锥形臂以减轻重量。或者加一个枢轴点。因为很多起重机都有一个枢轴点。不管选择是什么，学生都选择去探索。他们需要问自己以下问题: • 这会让我的起重机变好还是变坏? • 这个设计在我的能力范围内吗? 这个旋转桁架的想法真的很酷;然而，这对你的学生来说太难了。但在这里，我们的想法是为你的学生提供必要的信息，这样他们就可以做出明智的决定。 帮助指导他们的调查过程。这种方法本身就具有差异性，因为学生们会为自己承担合适的挑战。

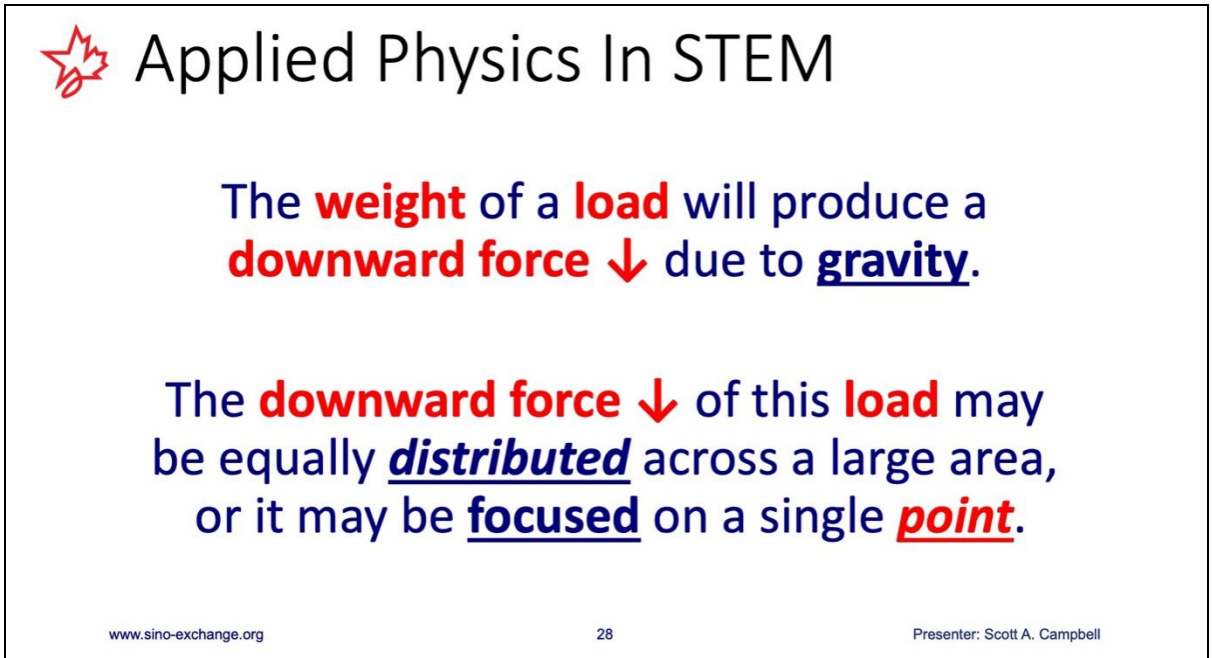
themselves.	



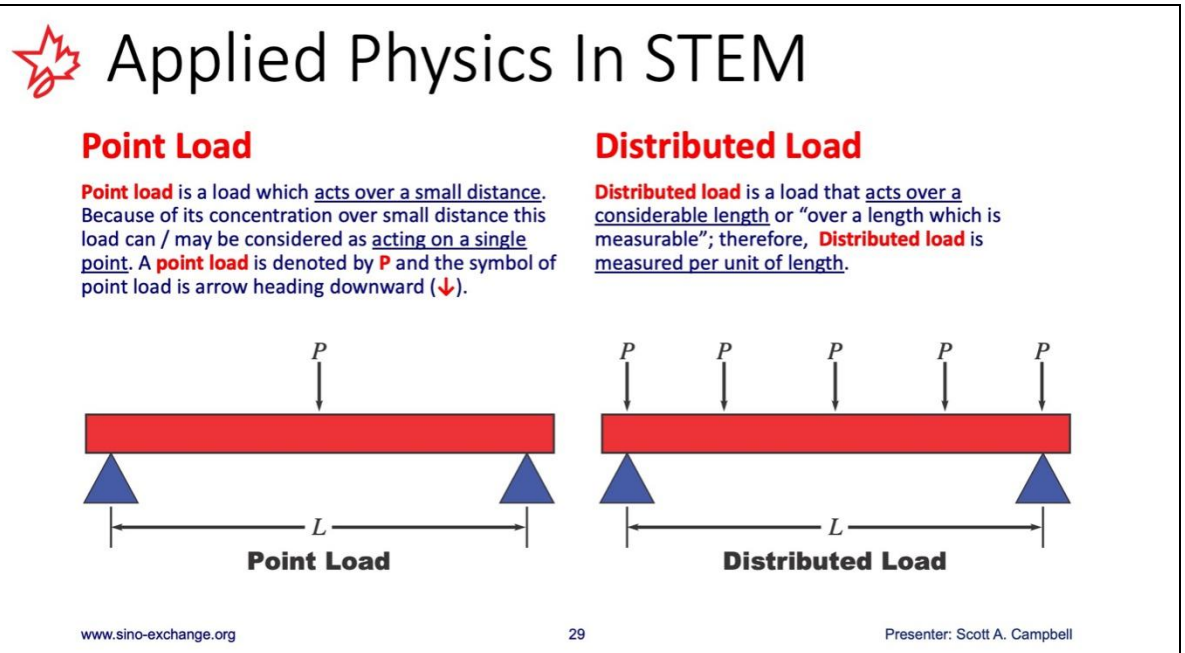
So, the first thing that students will need to do is design their own crane. Now at this point they shouldn't be concerned about things like scale or other technical requirements. Because we are going to modify these designs latter on	所以，学生们需要做的第一件事就是设计自己的起重机。在这一点上，他们不应该担心规模或其他技术要求。因为我们稍后会修改这些设计
Essentially, what we are going to do is continually throw our students curve balls as we guide them through a process of ***inquiry-based learning***	从本质上讲，我们要做的就是不断地向学生扔曲线球，引导他们完成以探究为基础的学习过程
As such, every time the students think that they are done the project we are going to say, ***"hey did you think about this yet?"***, and that's going to force them to go back and modify their designs, and this is exactly what engineers required to do when working on large projects in the real-world.	因此，每当学生们认为他们已经完成了这个项目时，我们就会说，"嘿，你想过这个了吗?"，这将迫使他们回头修改自己的设计，而这正是工程师在现实世界中从事大型项目时所需要做的。



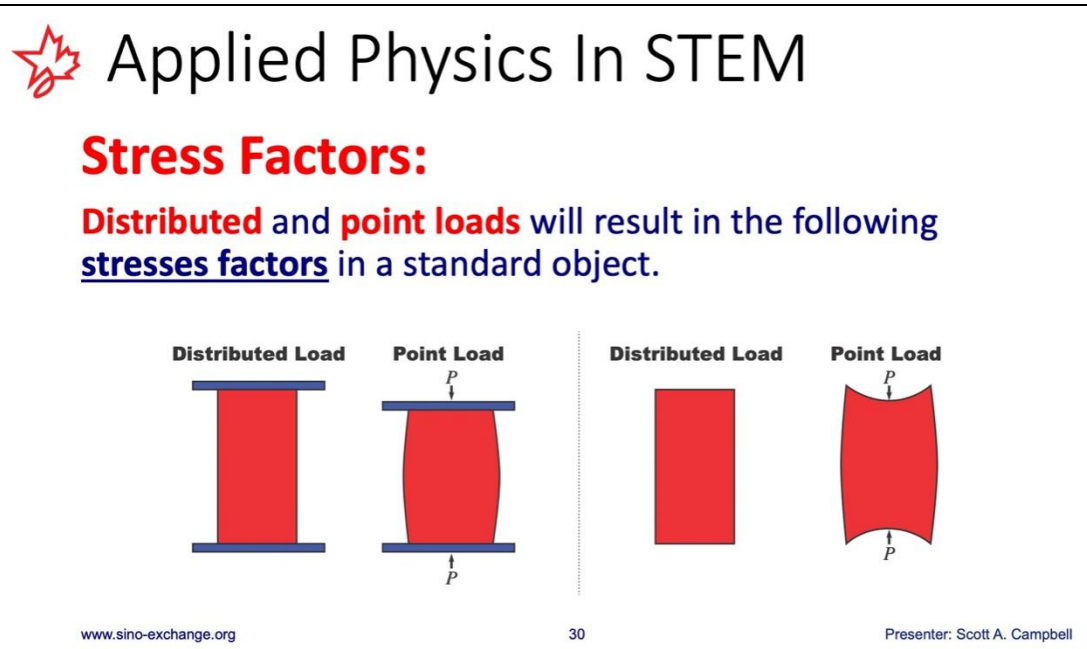
At this point students will have a rough draft, and this really is just focusing on the overall design, and what type of trusses they are planning on using. However, we haven't focused on other any of the other requirements and that brings us to ***"Pad Sizes"***. This is where we will determine how large the base of the crane needs to be for it to be stable, and this will require us to consider different variables and how they interact with one another.	在这一点上，学生将有一个粗略的草案，这真的只是专注于整体设计，什么类型的桁架，他们计划使用。然而，我们还没有关注其他任何其他需求，这就把我们带到了"Pad 尺寸"。 这就是我们要确定起重机的底座需要多大才能稳定的地方，这就需要我们考虑不同的变量以及它们之间的相互作用。



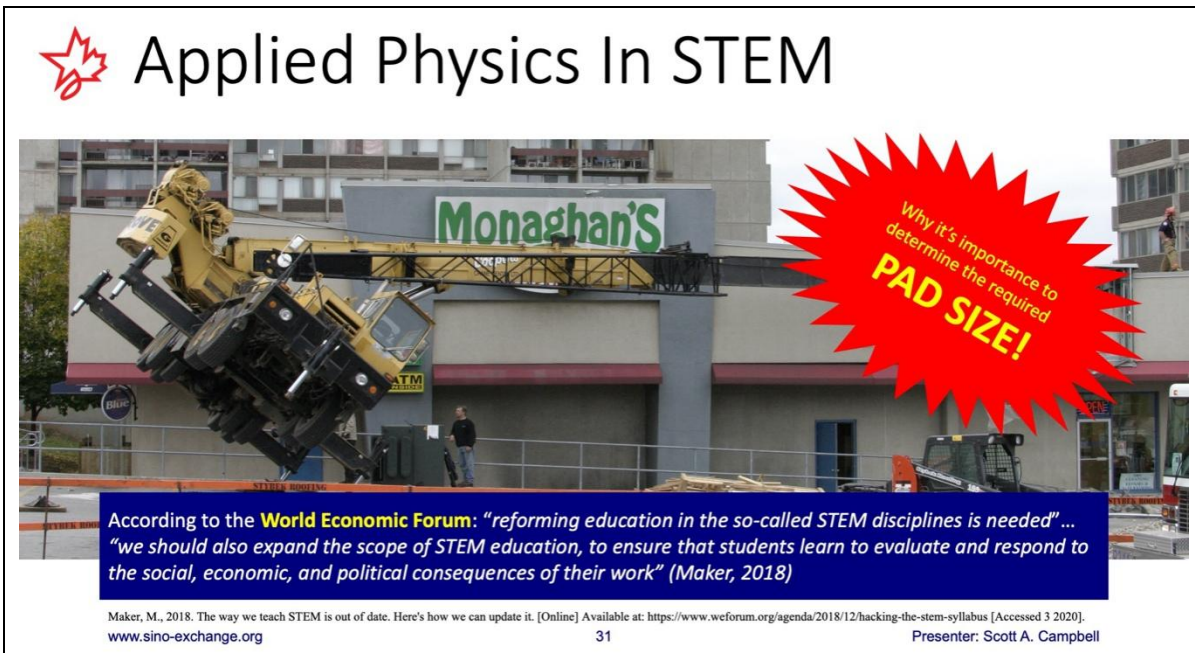
The load will produce a downward force which can either be distributed across a large area or focused on a singular point.	载荷将产生一个向下的力，这个力可以分布在一个很大的区域上，也可以集中在一个奇异点上。



And this brings us to the idea of "**Point Load**", and "**Distributed Loads**". As we can see a "**Point Load**" acts upon a single point, whereas a "**distributed load**" applies that same amount of force over a greater area.	这就引出了"点负荷"和"分布式负荷"的概念。正如我们所看到的，"点载荷"作用于单个点，而"分布载荷"在更大的区域上施加相同的力。

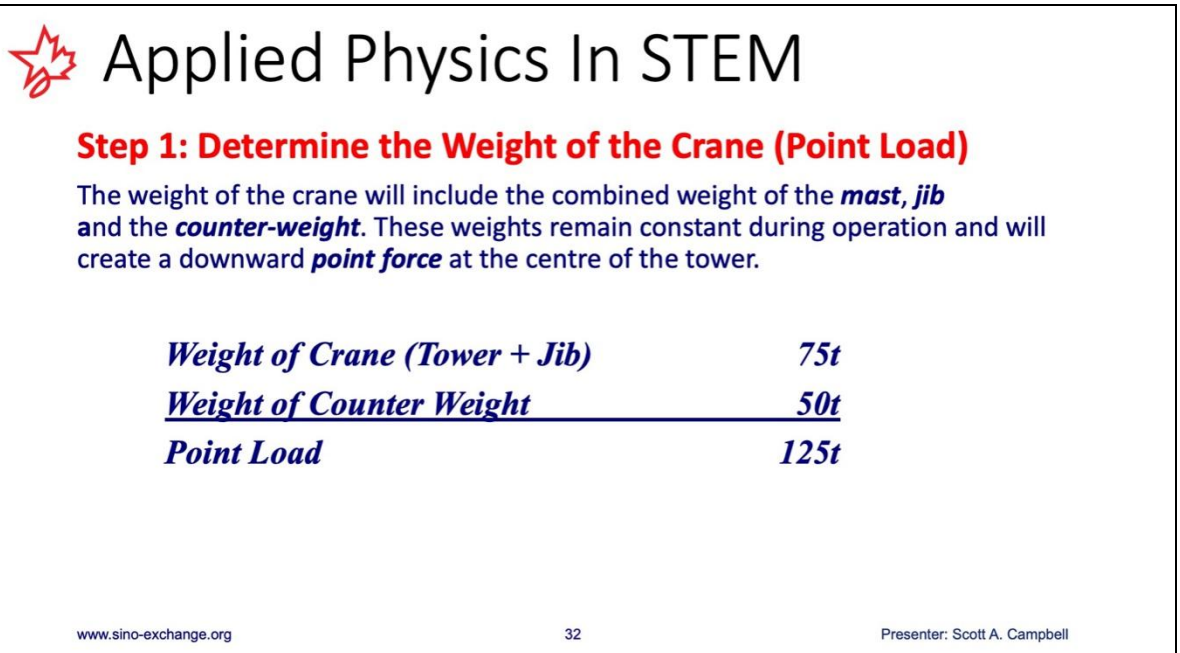


And this results in different "**stress factors**" in a standard object.	这就导致了一个标准物体中不同的"压力因素"。
As we can the distributed load applies the force equally across the entire object which reduces stress. However, the "**point load**" focuses that force on a singular point which creates a lot of pressure, or stress on the object, and this results in the deformation of the object.	正如我们所知，分布载荷在整个物体上均匀地施加力，从而减少了应力。然而，"点载荷"将力集中在一个奇异点上，这会对物体产生很大的压力或应力，从而导致物体变形。
Moreover, as we can see in the second diagram without the pads, the "**point load**" compresses the mid-point which causes the sides of the object to flex outwards to relive the stress, and eventually this could result in catastrophic failure as the support collapses due to structural stress.	此外，正如我们在没有衬垫的第二张图中所看到的那样，"点载荷"压缩了中点，导致物体的侧面向外弯曲以释放压力，最终这可能导致灾难性的失败，因为支撑由于结构应力而坍塌。

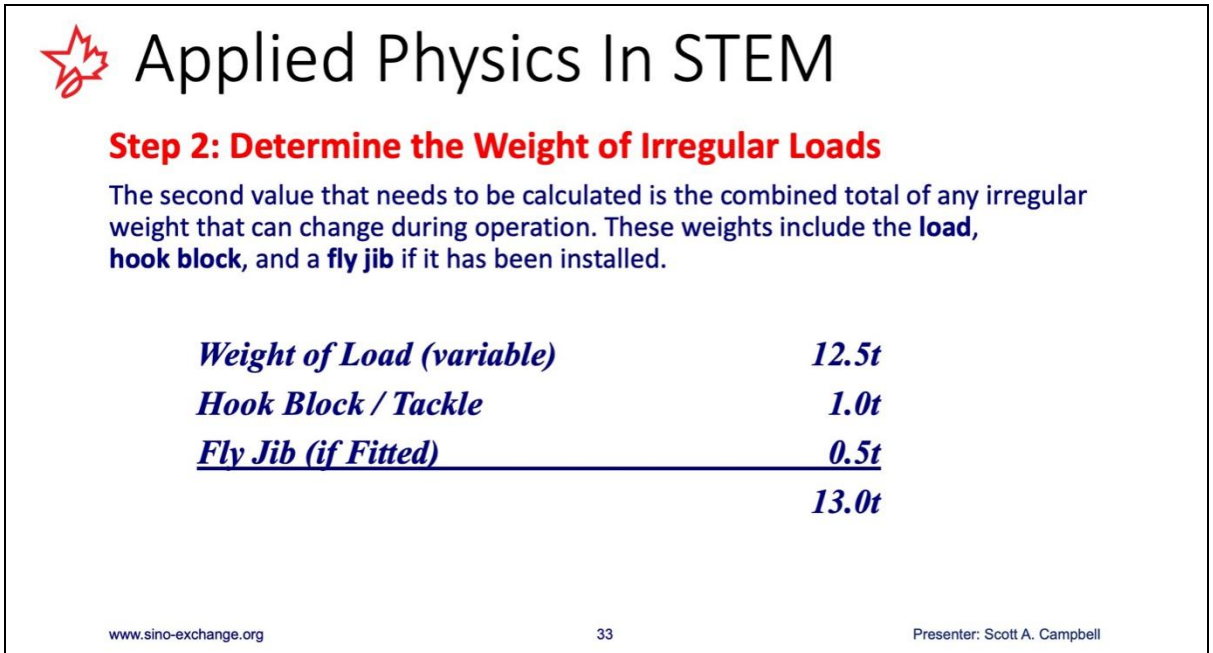


Now you might ask "Why is this important?"	现在你可能会问:"为什么这很重要?"
So, this is a picture that I took while I was still working as a photojournalist, and this one photo really illustrates the need for understanding math and physics in this kind of project.	这是我在做摄影记者的时候拍的一张照片，这张照片确实说明了在这类项目中理解数学和物理的必要性。
Here we have a crane where the operator ***DID NOT*** properly calculate the safe operational limits of the crane, and this resulted in the crane toppling over and causing a significant amount of damage.	这里我们有一个起重机，操作员没有正确计算起重机的安全操作限制，这导致起重机翻倒，造成了大量的损坏。
Luckily nobody was injured. however, things could have been much worse.	幸运的是没有人受伤。然而，事情本来可能会更糟。
And this brings me to a comment made by the world Economic Forum about STEM education indicating that:	这让我想到了世界经济论坛关于 STEM 教育的评论，它表明:
	"我们还应该扩大 STEM 教育的范围，以确保学生学会评估和应对他们工作的社

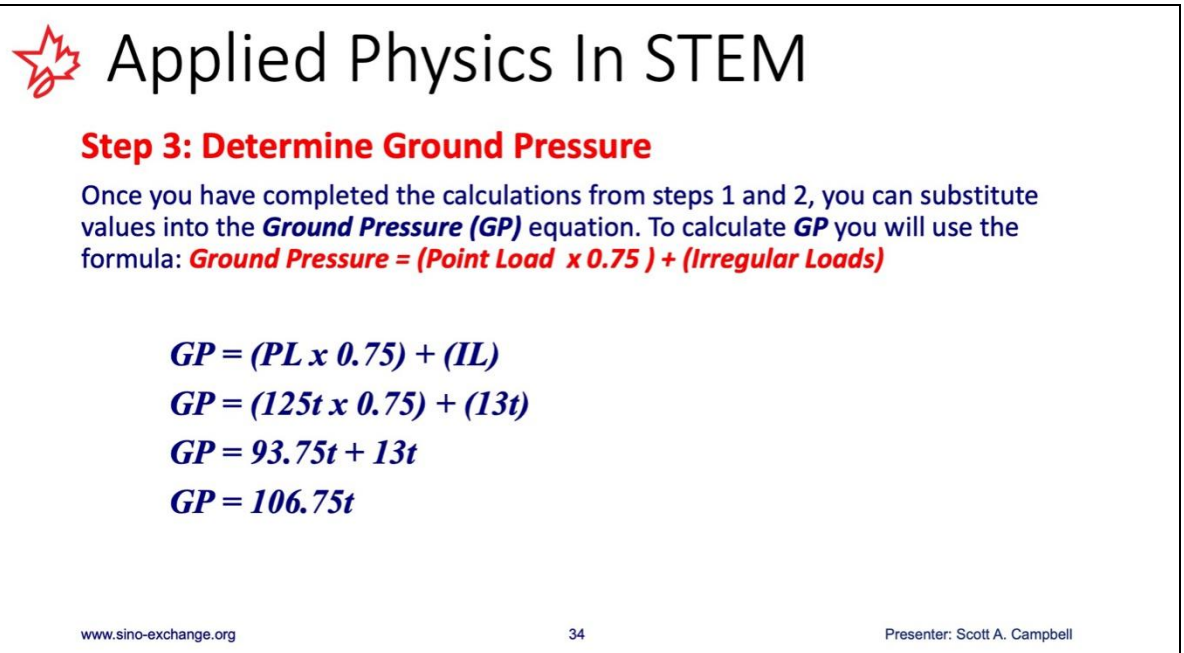
"We should also expand the scope of STEM education, to ensure that students learn to evaluate and respond to the social, economic, and political consequences of their work."	会、经济和政治后果。"
Therefore, we should also look at the impacts of what we do and why we do it!	因此，我们也应该看看我们所做的事情的影响，以及我们为什么要这样做!
And if we look at this example, we can see that these businesses are forced to close which has an adverse effect on their employees but also to their customers as well. We also have the structural damage to these buildings, and the time and money that it will take to repair these damages.	如果我们看一下这个例子，我们可以看到这些企业被迫关闭，这对他们的员工和客户都有不利影响。我们也有这些建筑物的结构损坏，以及修复这些损坏所需要的时间和金钱。
As such, there are huge social and economic impacts here, and that's part of what we should be looking at in STEM education.	因此，这里有巨大的社会和经济影响，这是我们在 STEM 教育中应该关注的一部分。
And that brings us to why it's important to calculate "**pad size**". Furthermore, you probably never even though about this issue until I gave you this example, and this really illustrates the difference between "**guided**", and "**unguided inquiry-based learning**".	这就引出了计算"pad 尺寸"的重要性。此外，在我给你举这个例子之前，你可能从来没有想过这个问题，这个例子确实说明了"引导"和"非引导的探究式学习"之间的区别。



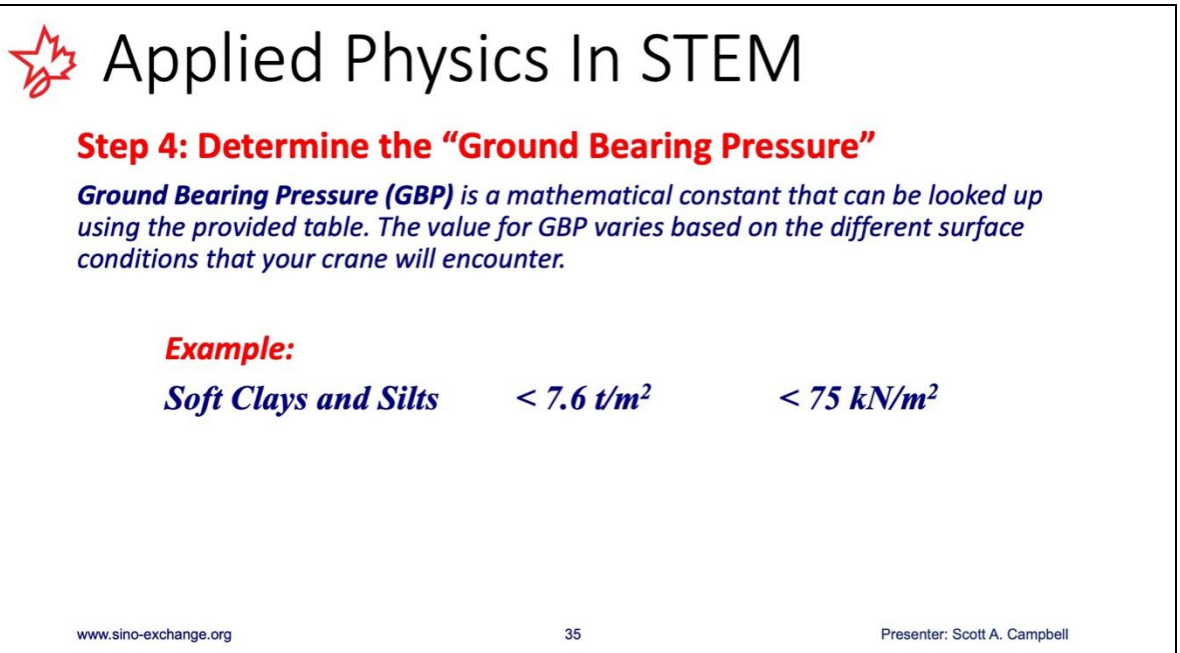
The first thing we need to do is to determine the "**Point Load**" that is exerted by the crane. To do this we will add up the weight of the crane's: tower, jib, and counterweight. Therefore, in this standard crane example we have a total mass of 125 tons.	我们需要做的第一件事是确定起重机施加的"点载荷"。要做到这一点，我们将起重机的重量加起来:塔架、臂架和配重。因此，在这个标准起重机的例子中，我们的总质量是 125 吨。



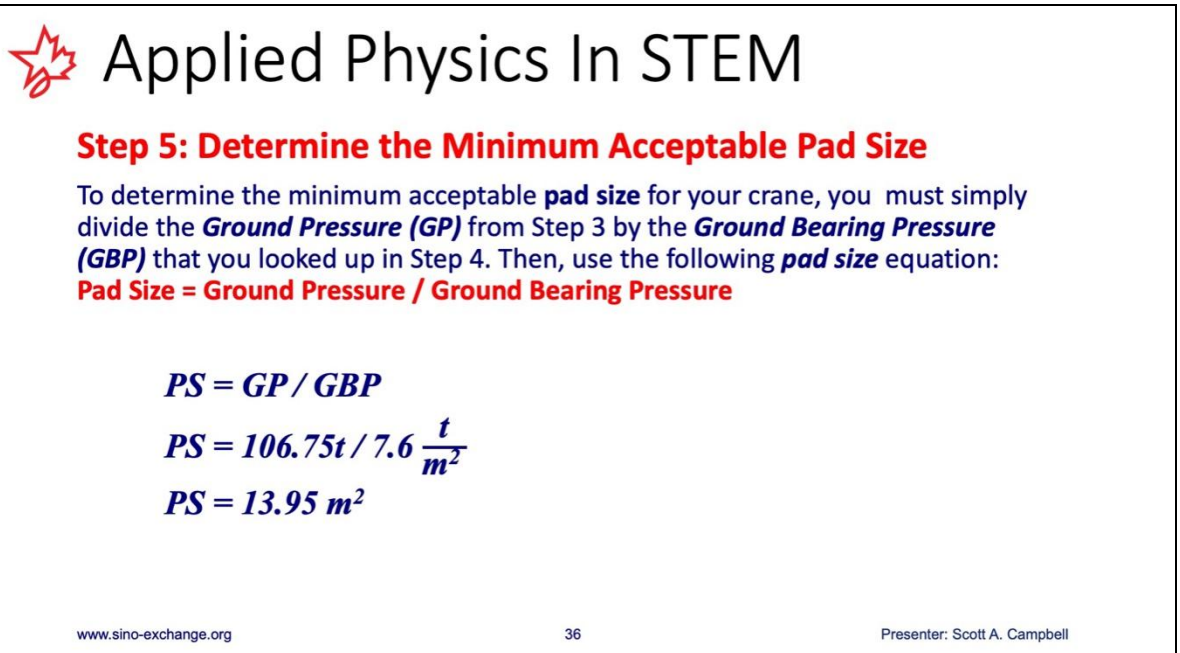
Next, we need to determine any ***"Irregular Loads"***. In this example we have ***"Irregular Load"*** that accounts for an additional 13 tons.	接下来，我们需要确定任何"不规则负载"。在这个例子中，我们有"不规则装载"，占额外的 13 吨。



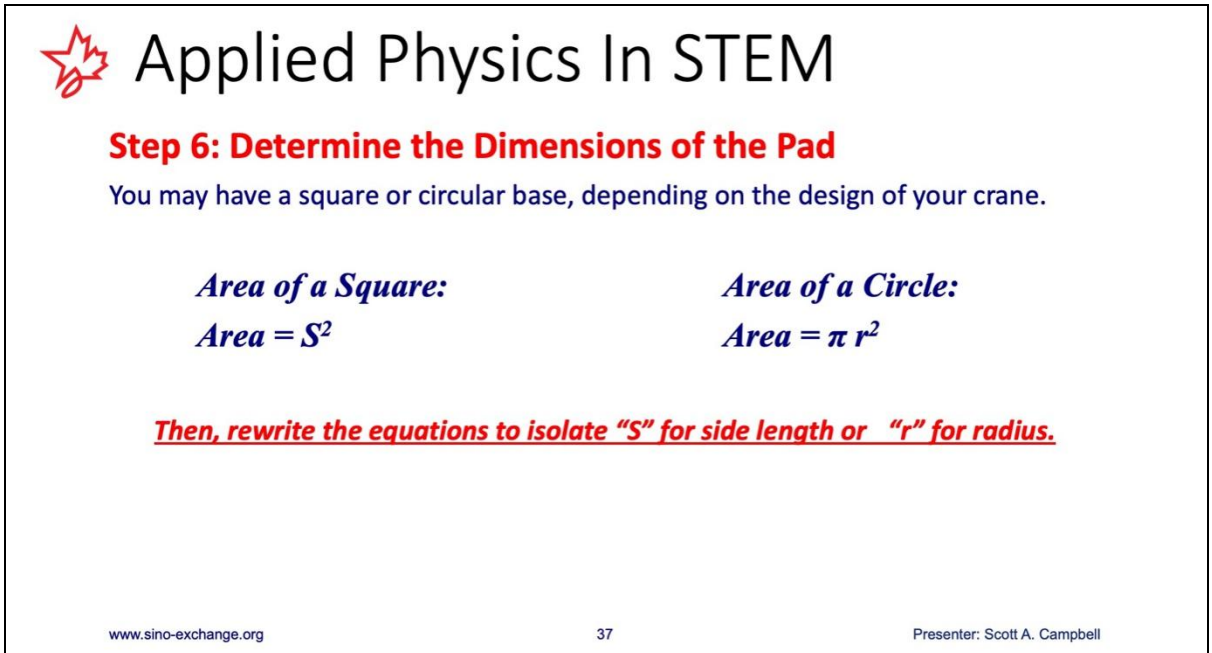
With our "**Point Load"** and "**Irregular Load**" known, we are now able to determine the amount of pressure that will be exerted by the crane on ground beneath it. We use the equation "**Point Load**" multiplied by a "**constant of 0.75**" plus the "**Irregular Load**" and in our working example, we get a "**Ground Pressure**" of approximately 107 tons.	已知"点载荷"和"不规则载荷"后，我们现在可以确定起重机将对其下方地面施加的压力量。我们使用"点荷载"乘以"0.75 常数"加上"不规则荷载"的公式，在我们的工作示例中，我们得到大约 107 吨的"地压力"。



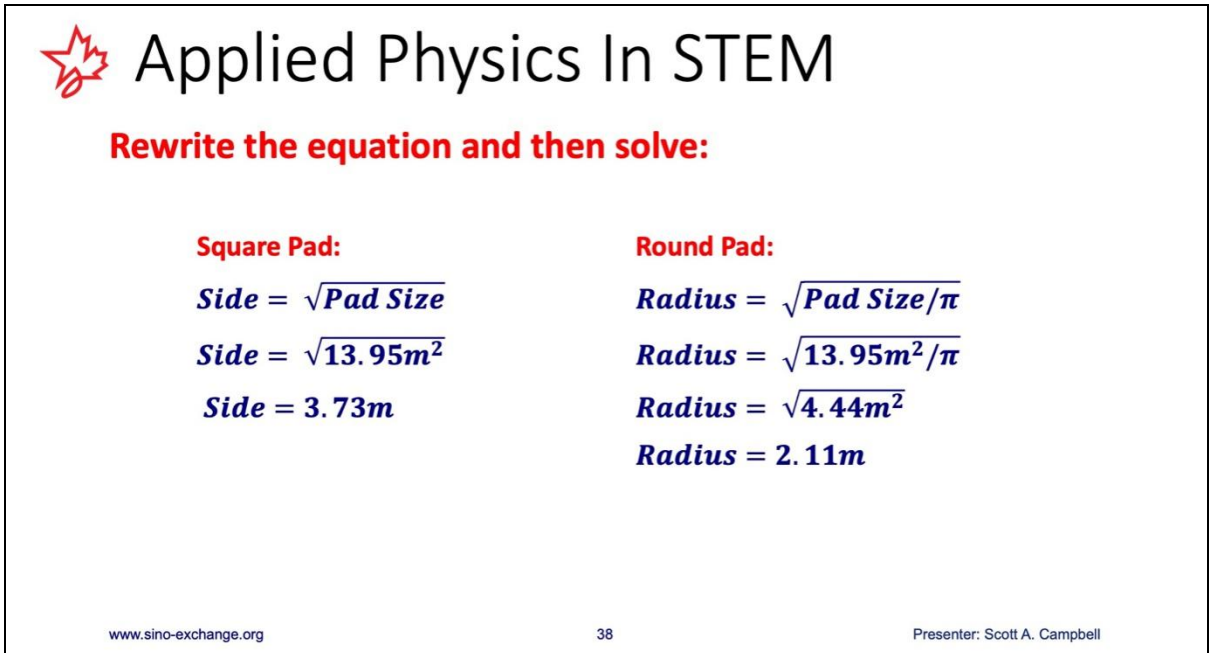
After that we need to determine the ***"Ground Bearing Pressure"***. Now these values are based on constants that are provided in a standard lookup table. However, in this example I am going to use the value for "**Soft Clays**' which is equal to 75 Kilonewtons per square meter.	之后我们需要确定"地面承重压力"。现在，这些值基于标准查找表中提供的常量。然而，在这个例子中，我将使用"软粘土"的值，它等于每平方米 75 千牛顿。



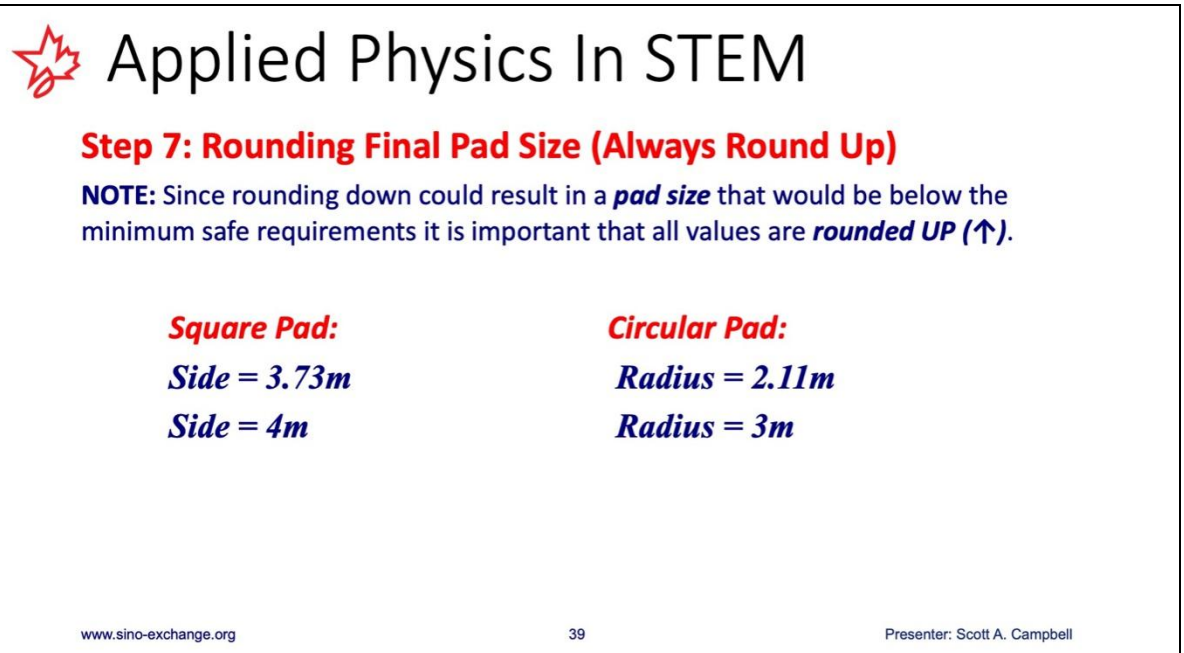
To determine our minimum "**pad size**" we then divide the "**Ground Pressure**" by the "**Ground Bearing Pressure**". Once we substitute our values into this equation. Therefore, we are left with a minimum acceptable "**pad size**" of approximately 14 square meters.	为了确定最小的"垫块尺寸"，我们将"地面压力"除以"地面承重压力"。一旦我们把值代入方程。因此，我们剩下的最小可接受的"垫大小"约为 14 平方米。



Now we will need to determine the dimensions of our pad and the method that we use will be slightly different depending on whether we plan on using either a square or circular pad.	现在我们需要确定垫的尺寸，我们使用的方法将略有不同，这取决于我们是打算使用方形垫还是圆形垫。



So at this point we simply rewrite the equation and substitute the known values.	此时我们只需重写方程并代入已知值。



And finally, standard operating procedures dictates that we round all values up for good measure.	最后，标准操作程序要求我们将所有值四舍五入。

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Step 8: Determine the Outrigger Point Load

The final step is to determine the ***Outrigger Point Load (OPL)*** for the final design of the crane. The ***OPL*** value takes into consideration the weight of the crane, the ***load***, ***pad size***, and the stability of ground that the crane has been placed on. The equation is: **Outrigger Point Load = Ground Pressure / Final Pad Size.**

$$OPL = GP / FPS$$
$$OPL = 106.75t / (4m \times 4m)$$
$$OPL = 106.75t / 16m^2$$
$$OPL = 6.67t/m^2$$

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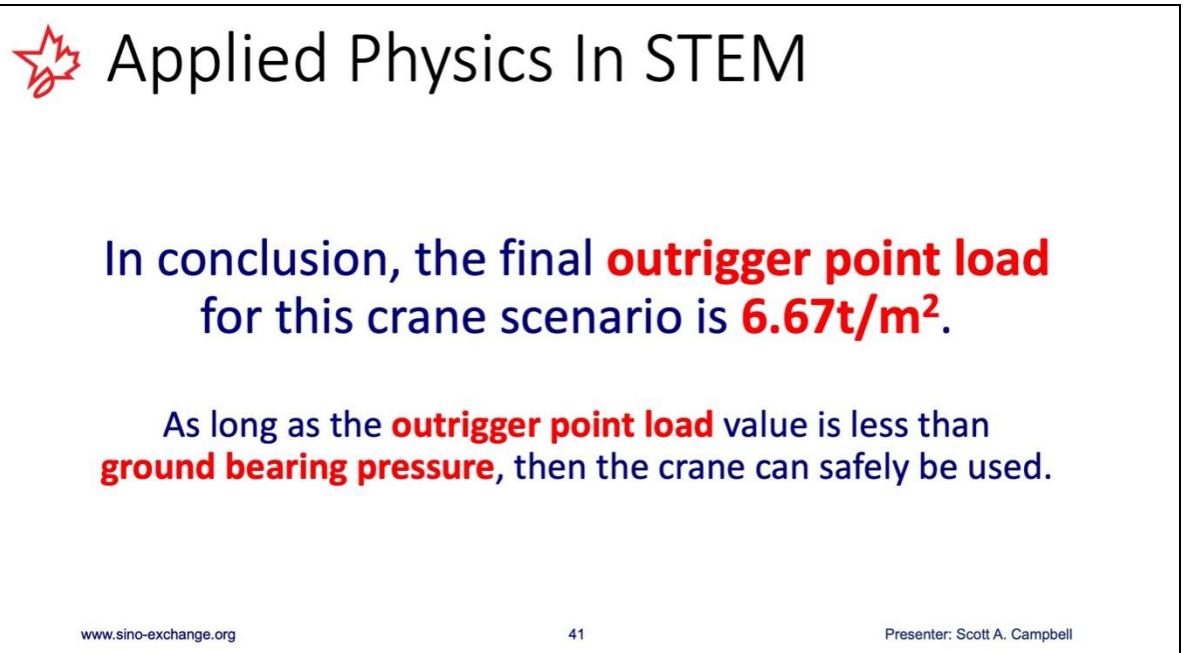
After that we determine the "**Outrigger Point Load**" which is determined by taking our "**Ground Pressure**" and dividing that by our "**Final Pad Size**", which is then compared to the "**Ground Bearing Pressure**" in a final safety check.	之后，我们确定"支腿点载荷"，这是通过我们的"地面压力"和除以我们的"最终垫块尺寸"来确定的，然后在最后的安全检查中将其与"地面承重压力"进行比较。



Therefore, provided that the "**Outrigger Point Load**" is less than the "**Ground Bearing Pressure**" the crane can be operated safely.	因此，只要"支腿点荷载"小于"地面承重压力"，起重机即可安全运行。
And all of this comes back to the recommendations that were made by Joseph Schwab, which indicated that students should acquire knowledge by asking questions…. exercise observation skills and deductive reasoning and practice inquiry though laboratory instruction. While also addressing concerns that Feng had when indicating that "STEM education is only concerned about the project itself", Whilst directing students towards evaluating and responding to the social and economic consequences of their work as indicated by the World Economic Forum, and this isn't something that would've been naturally intuitive if we left students to their own devices.	所有这些都回到了约瑟夫·施瓦布提出的建议，他指出学生应该通过提问来获取知识....通过实验室教学，锻炼观察能力和演绎推理能力，练习探究。同时也解决了冯教授在指出"STEM 教育只关注项目本身"时的担忧，同时引导学生评估和回应他们工作的社会和经济后果，正如世界经济论坛所指出的那样，如果我们让学生自己动手，这就不是自然而然的直觉了。 因此，在这一点上，我们应该能够看到引导探究性学习的好处，重要的是要记住，这种方法与我们通常在学术科目中看到的预先加载的教育方法有很大不同。在指导性的探究式学习中，我们使用所谓的"及时方法"。这是我们在最相关

Therefore, we should be able to see the benefits that **guided inquiry-based learning** at this point, and it's important to remember that this approach differs greatly from the **front-loading approach to education** that we typically see in academic subjects. With **guided inquiry-based learning** we use what's called a "***just in time approach***". Which is where we introduce and model theory when its most relevant, and this will help guide and shape the nature of the student's inquiry by encouraging them to ask the right type questions.	的时候引入和建模理论的地方，这将通过鼓励学生提出正确类型的问题来帮助指导和塑造学生探究的性质。

Applied Physics In STEM

Extension Activity:

1. Calculate the **pad size (PS)** that would be needed if:
   a) The crane has a ***point load (PL)*** of 125t, an ***irregular load (IL)*** of 50t, and the crane will be installed on ***dense gravel***.
   b) The crane has a ***point load (PL)*** of 125t , an ***irregular load (IL)*** of 50t, and the crane will be installed on ***soft clay or silts***.
   c) Then determine the ***outrigger point load (OPL)*** for both scenarios.

2. Determine the necessary ***pad size (PS)*** for your crane.
   a) Can you operate your crane under a wide variety of scenarios? Why?
      i. What is the required **pad size (PS)** that is needed for your crane to operate under all situations? ***NOTE:*** *This will be the the largest pad size that you calculated which will allow the crane to be used on unstable ground.*
      ii. What would the necessary ***pad size*** be for your model (scale is 1:500)?
   b) What you could do if the ***pad size*** in your proposed crane design is not large enough. What modifications could make your crane safer?

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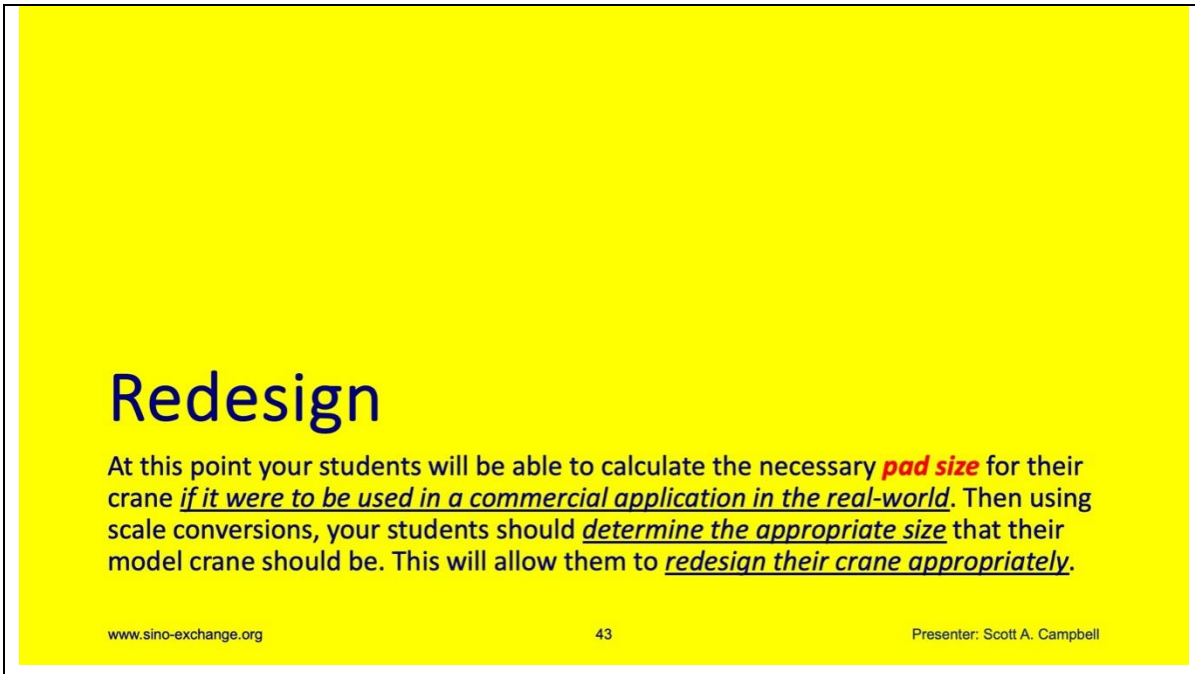
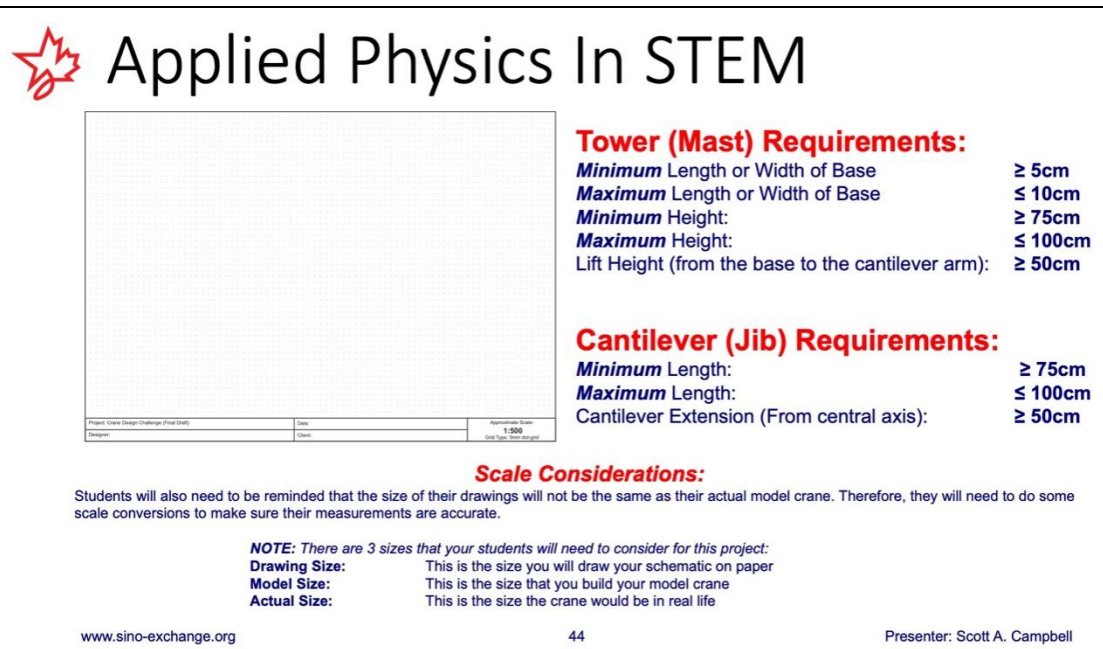
So now that we have introduced some new concepts, and properly modeled the application of this theory we can now give the students an extension activity such as: Asking them to calculate the pad size for their crane if it was would to be placed on either gravel or clay. Then with this information in hand the students will be able to evaluate their own crane designs. And all of this was to help guide the students towards asking themselves the following question: ***"Do I have a viable crane design?"*** ***"Is my crane design meeting all of the necessary safety requirements?"*** ***"And if not, what can I do to improve the design of my crane?"***	现在我们已经介绍了一些新的概念，并正确地模拟了这一理论的应用，我们现在可以给学生一个扩展活动，如:让他们计算他们的起重机的垫大小，如果它将被放置在砾石或粘土上。有了这些信息，学生们就可以评估自己的起重机设计了。 所有这些都是为了引导学生们问自己以下问题: "我有一个可行的起重机设计吗?" "我的起重机设计是否满足所有必要的安全要求?" "如果不是，我该怎么做才能改进我的起重机设计?" 这是我们作为 STEM 老师的工作……

And this is our job as a STEM teacher… To help guide our students through a process of inquiry, so that they will develop a deeper understanding of how math and science is used to solve real-world problems.	帮助引导我们的学生通过探究的过程，使他们对如何使用数学和科学来解决现实世界的问题有更深的理解。



At this point our student's will have a generic crane design, and we have also introduced them to a number of equations that place math into a real-world context. Now we are going to have the students apply that math so that they can effectively redesign their crane.	在这一点上，我们的学生将有一个通用的起重机设计，我们也向他们介绍了一些方程式，将数学应用到现实世界中。现在我们要让学生们运用这些数学知识，这样他们就能有效地重新设计他们的起重机。
To do this, they will need to determine the acceptable "***pad size***" for a crane that would be used in the real-world, and then use those calculations to determine the optimal size and portions of their model crane which needs to be built at scale.	为了做到这一点，他们需要确定在现实世界中使用的起重机的可接受的"衬垫尺寸"，然后使用这些计算来确定需要按比例建造的模型起重机的最佳尺寸和部分。



At this point I would give the students a new design template, and a number of reequipments for their project which will really help to keep the students on track.

And these guidelines are helpful to give your students because you'll always have students that will make computational errors. Therefore, by providing these requirements upfront students can quickly self-assess their work and catch their own errors early in the process. Now the students are also going to have to keep 3 different scales in mind when working on their project:

- **The actual size of a real crane which will be at a scale of 1:1**
- **The size of their prototype, or model, which will be at a scale of 1:100**
- **And the size of their drawing, or schematic, which will be at a scale of 1:500**

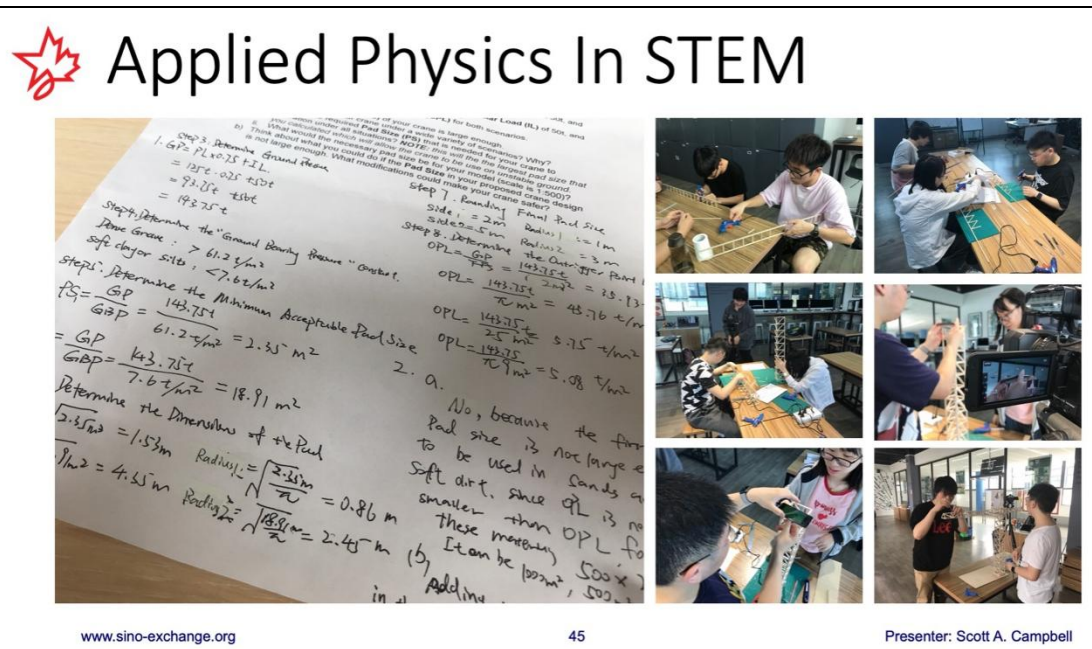
在这一点上，我会给学生一个新的设计模板，并为他们的项目重新配置一些设备，这将有助于保持学生的轨道。

这些指导方针对你的学生很有帮助，因为你总是会有学生犯计算错误。因此，通过预先提供这些要求，学生可以快速地自我评估他们的工作，并在过程的早期发现自己的错误。现在，学生们在做项目时还必须记住三种不同的尺度:

- 一个真正的起重机的实际尺寸，将按 1:1 的比例
- 原型或模型的大小，比例为 1:100
- 以及他们的图纸或原理图的大小，比例为 1:500

我还要提一下，这些不是标准的工程尺度。相反，我选择的尺度对我的学生来说非常简单，这将帮助他们专注于大的想法，而不是被琐碎的细节所束缚，这些细节最好留待以后再讨论。

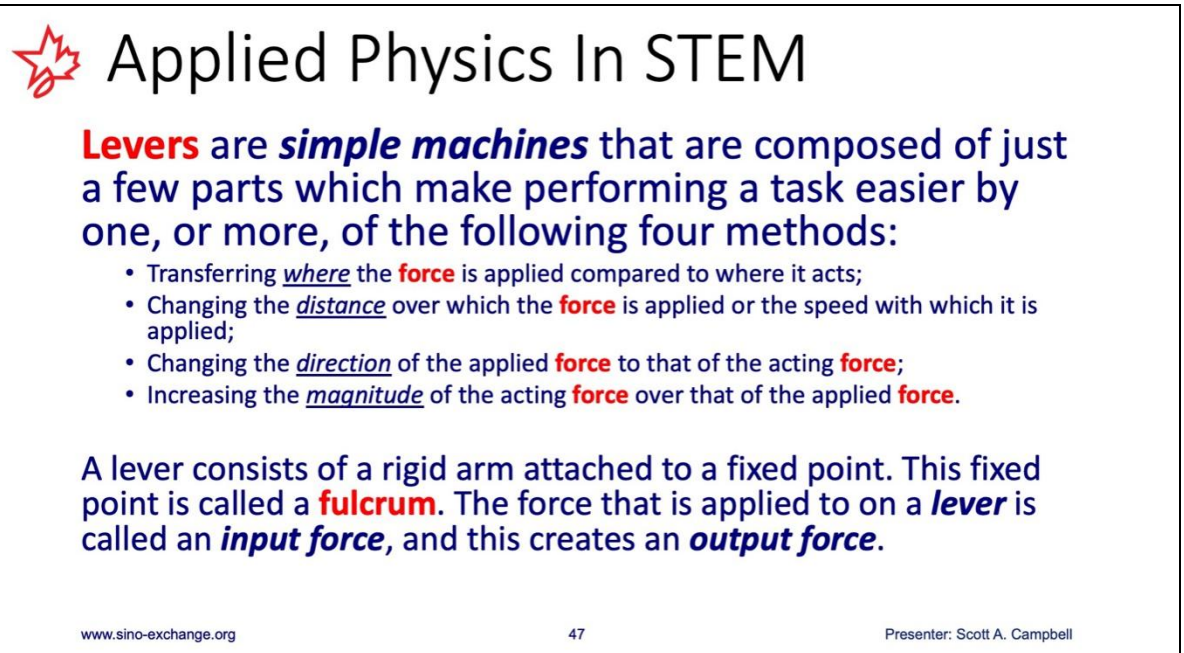
I should also mention that these are not standard engineering scales. Instead, I have selected scales that will greatly simply math for my students, and this will help them focus on big ideas and not get tied up with trivial details which are better left for another time.	



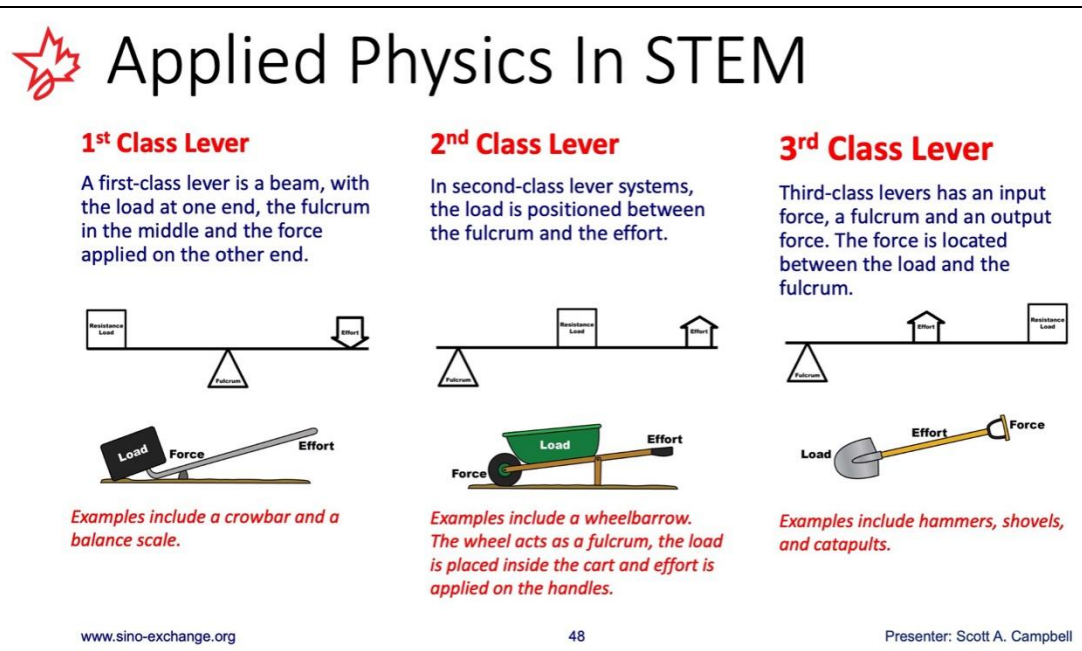
At this point the students should be able to determine the ***pad size*** of a real crane and then use that information to ascertain the ideal measurements to use for their model crane.	在这一点上，学生应该能够确定垫大小的一个真正的起重机然后利用这些信息来确定模型起重机的理想尺寸。
Let's assume that we found the optimal ***pad size*** was 6x6 meters, we can then use that information to effectively redesign the schematic for our model crane.	让我们假设我们找到了最佳的衬垫尺寸是 6x6 米，然后我们可以使用这些信息来有效地重新设计模型起重机的原理图。
For example, with a scale of 1:100, the base of our crane would be 6 cm wide based on the previous calculations. Moreover, with 6cm dimension for our nodes, we can connect 16 nodes to create a mast that is 96cm tall, and all these dimensions are within the specified project requirements.	例如，在 1:100 的比例下，根据前面的计算，我们的起重机的底部将是 6 厘米宽。此外，我们的节点尺寸为 6cm，我们可以连接 16 个节点来创建一个 96cm 高的桅杆，所有这些尺寸都在指定的项目要求范围内。
As you can see, the real-world application of math is really the most important aspect	正如你所看到的，数学在现实世界中的应用是这个项目目前最重要的方面。然后在所有计算完成后，制作出新的设计

of the project at this point. Then with all the calculations completed, and a new design schematic made. Students can then move on to building the crane as you can see in these project exemplars.	方案。然后，学生们可以继续建造起重机，正如你在这些项目范例中看到的那样。

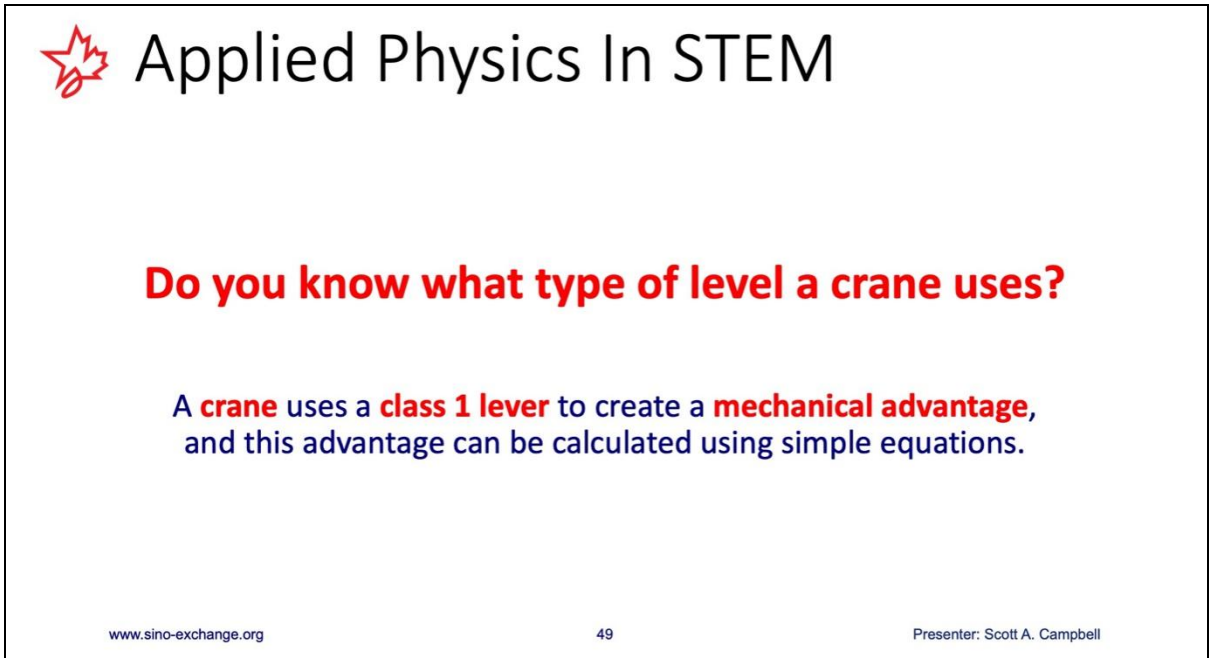
So once your students have finished building their crane, they will likely think that they're done the project, which was the case with the **unguided inquiry-based learning** mythology. However, the reality of the fact is that you students have just started this project.	因此，一旦你的学生完成了他们的起重机，他们可能会认为他们已经完成了这个项目，这就是无指导的探究式学习神话的情况。然而，现实情况是，你们这些学生才刚刚开始这个项目。
As a cranes main purpose is to create a mechanical advantage, and it does this though the combination of several simple machines such as levers, and pullies.	作为起重机的主要目的是创造一个机械优势，它通过几个简单的机器，如杠杆和滑轮的组合来实现这一点。
Therefore, we still need to determine how calculate the mechanical advantage of these systems. Moreover, we still need to design and build a pully system for our crane.	因此，我们仍然需要确定如何计算这些系统的机械优势。此外，我们还需要为我们的起重机设计和建造一个滑轮系统。



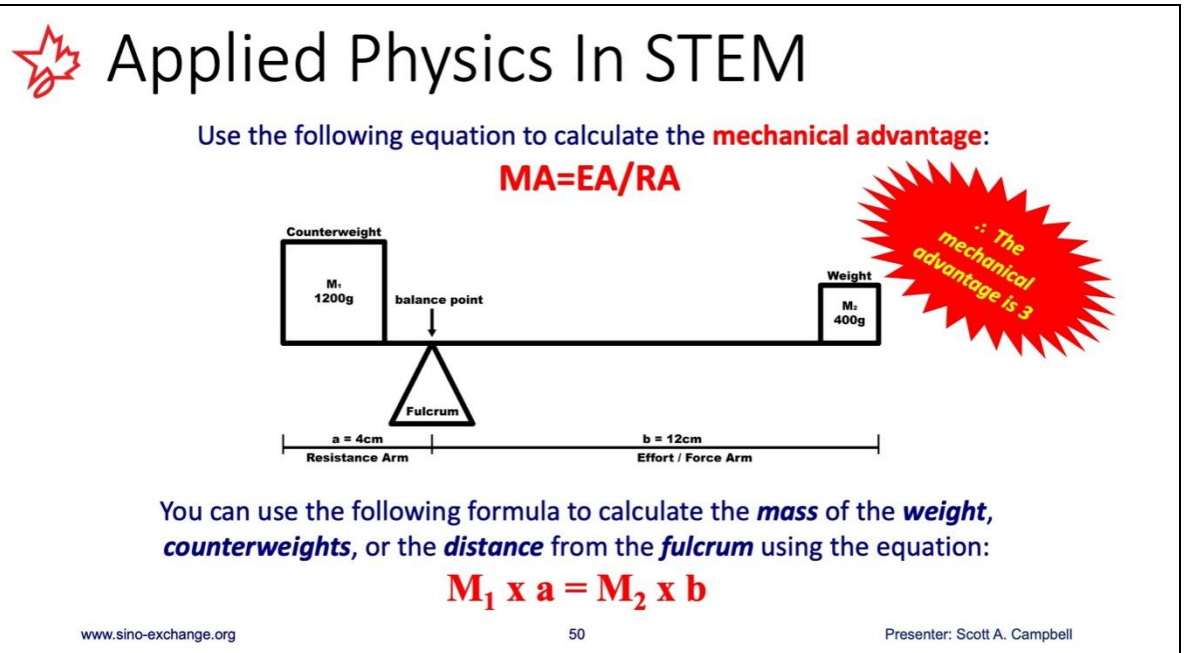
Again, we need to think about how we strategically introduce topics to help guide and shape the nature of our student's inquiry. As such, the next idea we need out students to think about is how levers are used to create a mechanical advantage. • A lever can change where a force is applies. • Change the distance or speed that a force is applied. • Change the direction of the applied force. • Or can increase the magnitude of the force. Furthermore, the relationship between the ***fulcrum***, the ***input force***, and ***output force*** are important concepts for students to understand.	再一次，我们需要思考如何策略性地引入话题，以帮助引导和塑造学生探究的本质。因此，我们需要学生思考的下一个想法是，杠杆是如何被用来创造机械优势的。 • 杠杆可以改变施加力的位置。 • 改变施加力的距离或速度。 • 改变作用力的方向。 • 或者可以增加力的大小。 此外，支点、输入力和输出力之间的关系是学生需要理解的重要概念。



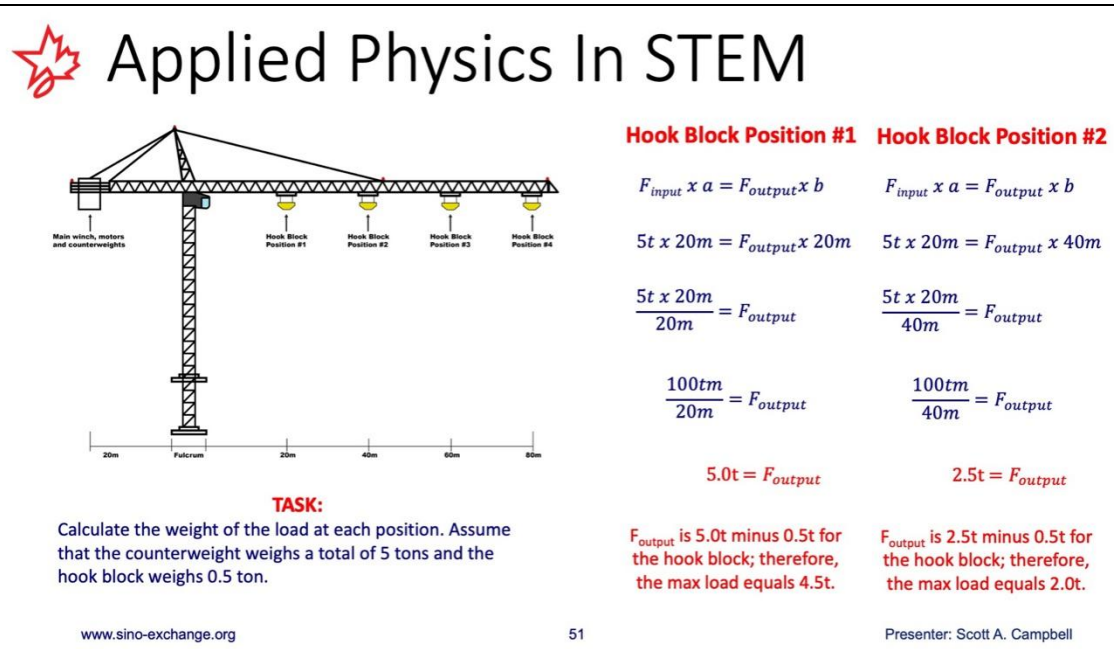
Now there are 3 different classes of levers. And they each work in a different way. An example of a first-class lever would include a crowbar. Whereas an example of a class 2 lever would include a wheelbarrow. And finally, a shovel is a great example of a 3rd class lever. Now I have gone through this incredibly fast. However, my intention is not to teach you these concepts, but to provide you with a quick overview of what an authentic application of theory would look like.	现在有三种不同的杠杆。它们都以不同的方式起作用。一级杠杆的一个例子是撬棍。然而，第 2 类杠杆的一个例子将包括独轮车。最后，铲子是第三类杠杆的一个很好的例子。 现在我已经非常快地完成了这个过程。然而，我的目的不是教你这些概念，而是为你提供一个快速的概述，一个真正的理论应用应该是什么样子的。



So before moving on, do you know what type of level a crane uses? A crane uses a "***class 1 lever***".	所以在继续之前，你知道起重机使用什么类型的水平吗? 起重机使用"一级杠杆"。

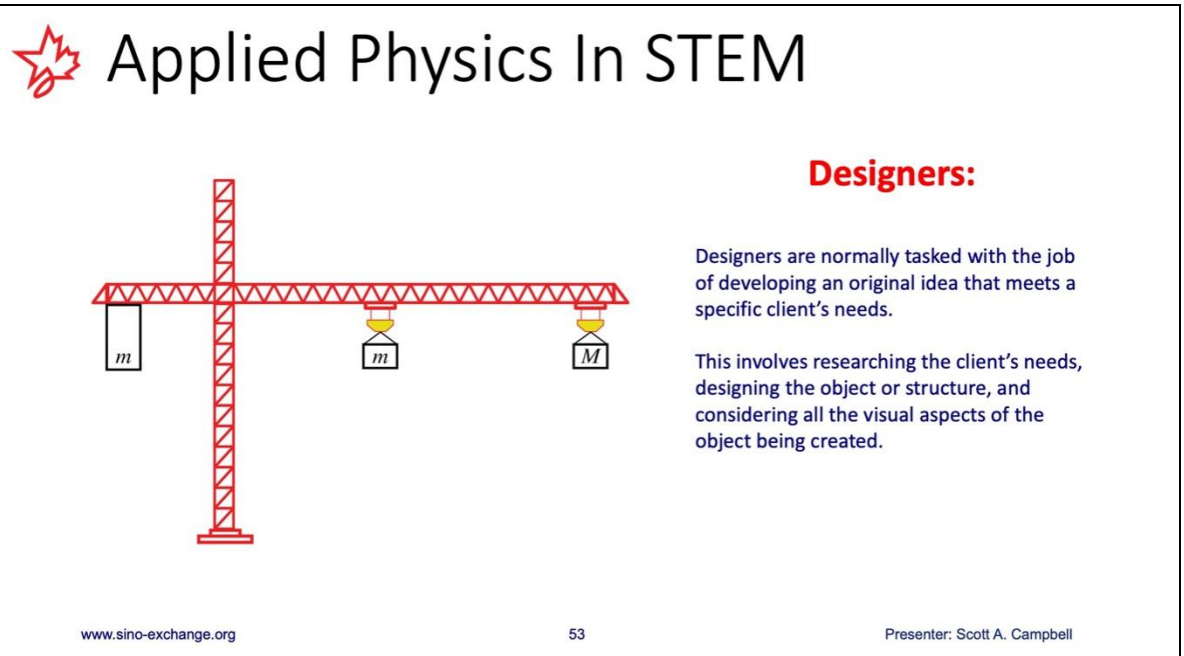


Now we can use the following equation to determine the mechanical advantage of this system. In this example we take the 12cm distance of the ***Effort Arm*** and divide that by the 4cm distance of the ***resistance arm,*** and this will give us a ***mechanical advantage*** of 3. As a result, this small 400-gram weight is able to counterbalance a weight 3 times its size. However, a slightly more sophisticated version of this formula is needed for our calculations.	现在我们可以用下面的方程来确定这个系统的机械优势。 在这个例子中，我们用力臂的 12cm 的距离除以阻力臂的 4cm 的距离，这就得到了机械优势 3。因此，这个 400 克的小重量能够平衡 3 倍于它的重量。然而，我们的计算需要这个公式稍微复杂一点的版本。

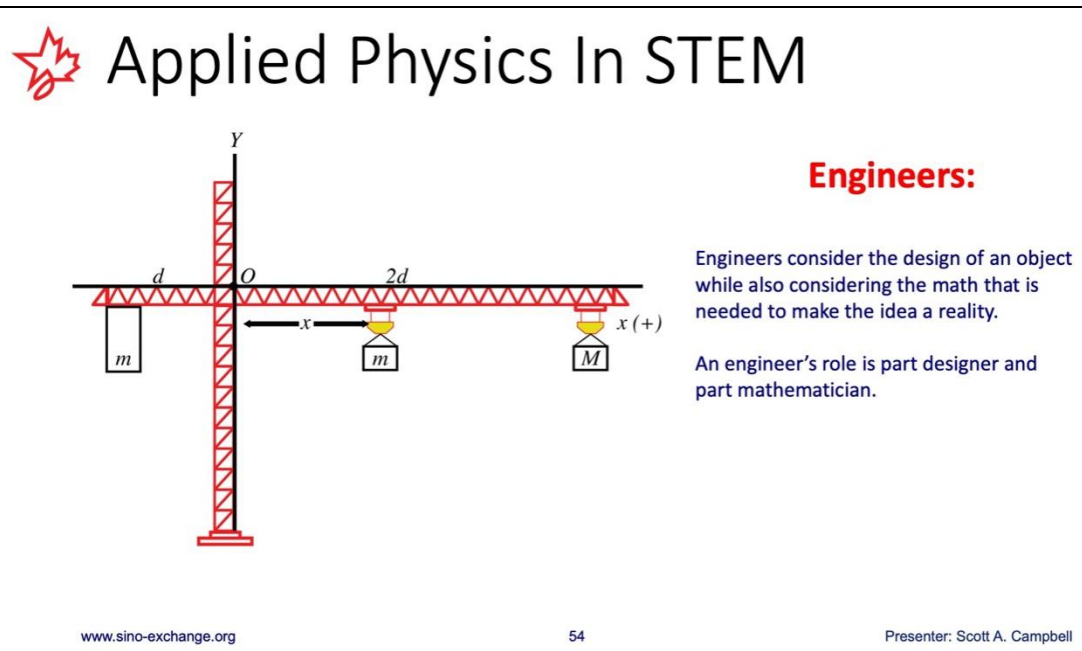


Using the equation "**M_1 x a = M_2 x b**" we are able to calculate the maximum safe load that can be lifted by a crane at any point along its jib. The first thing we do is plug in our known values. Then we isolate our unknown variable. Find the product of the numerator, and then simply which will leave us with a max load of 5 tons at position 1. However, the hock block is equal to 0.5 tons. Therefore, the actual maximum weight of the load is equal to 4.5 tons at position 1. Then we would repeat the process for the remaining positions and as we can see, the maximum weight at position 2 is only 2.0 tons.	利用"M_1 x a = M_2 x b"的公式，我们能够计算出起重机在其臂上任意点可以提升的最大安全载荷。我们要做的第一件事就是代入已知值。然后我们分离未知变量。求出分子的乘积，然后简单地得到在位置 1 的最大载荷是 5 吨。然而，飞节块等于 0.5 吨。因此，在位置 1 处，负载的实际最大重量等于 4.5 吨。然后我们将对剩下的位置重复这个过程，正如我们所看到的，位置 2 的最大重量只有 2.0 吨。

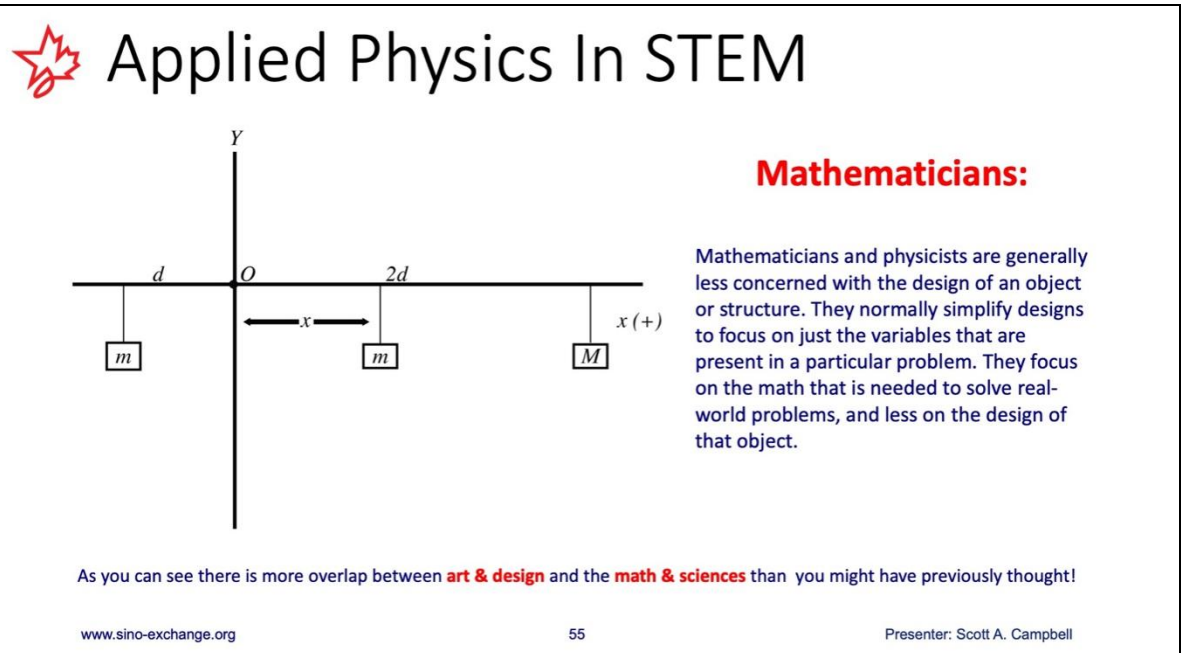
So far, the math in the examples that I have shown have not been overly complex. However, the concepts that these ideas and equations represent are.	到目前为止，我所展示的例子中的数学并没有过于复杂。然而，这些思想和方程所代表的概念是。
For instance, many of these equations have taken from a 68-page UK Ministry of Health and Safety guidebook for safety auditors. And it would be highly unlikely for our students to take the time to do this on their own. However, by modeling and guiding our students the process of **inquiry-based learning** becomes far more holistic as our student's exploration becomes far more rigorous than it would've been otherwise.	例如，这些方程式中的许多都摘自英国卫生与安全部(Ministry of Health and Safety)为安全审计员编写的 68 页指南。我们的学生不太可能自己花时间去做这件事。然而，通过建模和指导我们的学生探究性学习的过程变得更加全面，因为我们的学生的探索变得更加严格。
And that brings me to another big idea which is making connections between various subject disciplines, and then taking the application of the rigorous academic concepts and theories even further.	这让我想到了另一个重要的想法，那就是在不同学科之间建立联系，然后进一步应用严谨的学术概念和理论。



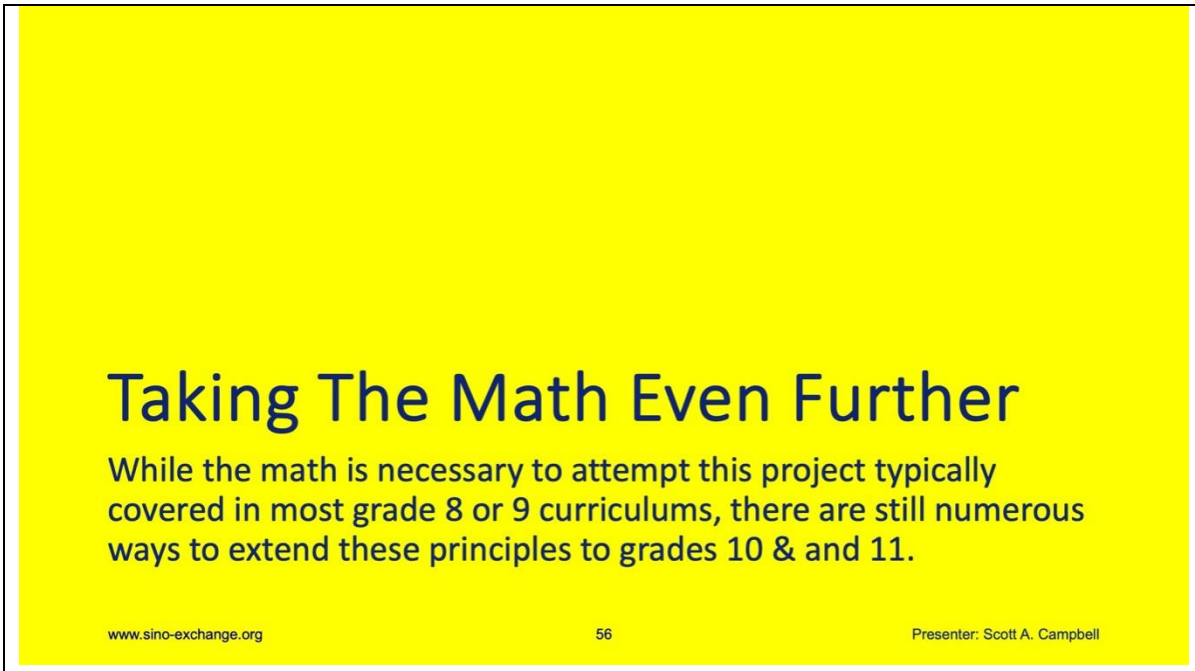
To illustrate this idea, I have made a series of graphics to show you.	为了说明这个想法，我做了一系列的图表给你看。
To start, a designer is primarily concerned with researching their clients' needs and creating a design.	首先，设计师主要关注的是研究客户的需求并创造设计。



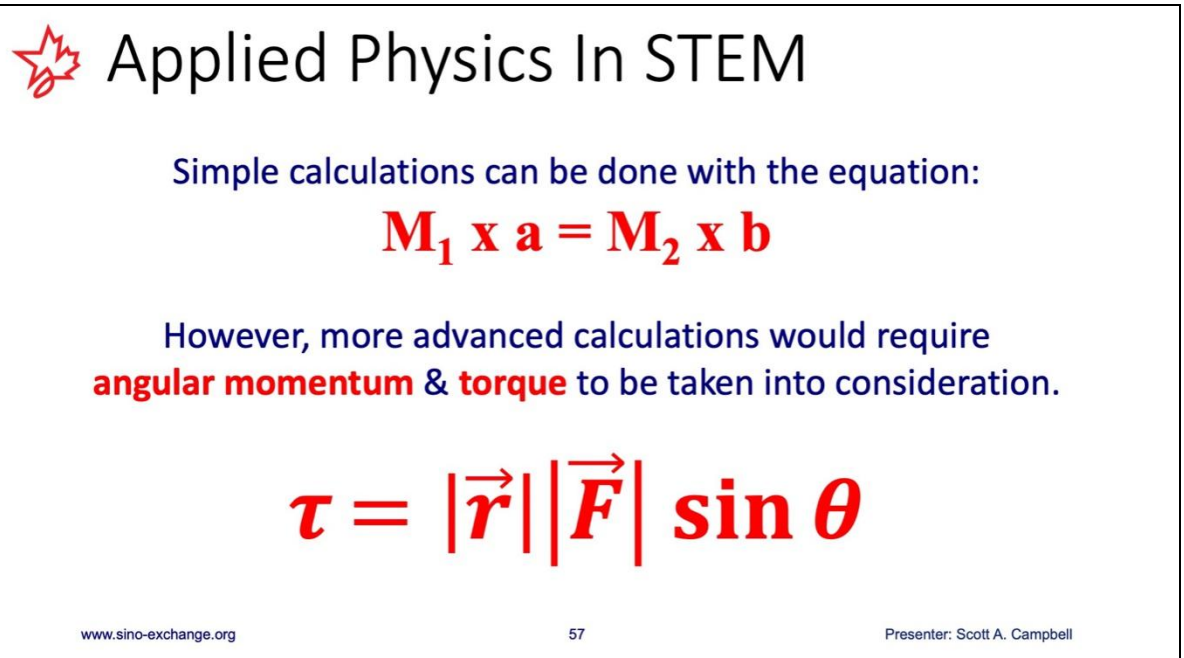
However, the engineer is more concerned the math that's needed to make the design a reality!	然而，工程师更关心的是使设计成为现实所需的数学问题!



And finally, the mathematician… Now they don't really care about the design. They only really care about representing the world though numbers and variables. To simplify to world to orderly equations that can be solved, and although this final representation looks incredibly different from the first diagram it still represents the same problem.	最后，数学家……现在他们并不真正关心设计。 他们只关心用数字和变量来表示世界。 为了简化到可以求解的有序方程，尽管最终的表示看起来与第一张图有很大的不同，但它仍然代表着同样的问题。



Therefore, I want to use this time to illustrate how we can take the math even further. Now the method that I showed earlier would be suitable if you were to do this project in an intermediate grade level. Therefore, I am going to model how we can place what the students would be learning in a senior physics class into a suitable context.	因此，我想利用这段时间来说明我们如何进一步利用数学。 如果你要在中级水平上做这个项目，我之前展示的方法会很合适。因此，我将模拟我们如何将学生将在高级物理课上学习的内容放入合适的环境中。



While the equitation "**M_1 x a = M_2 x b**" would reinforce what students would have learnt in an intermediate science program. The equation for angular moment and torque would allow us to solve the same problem using concepts form a senior level physics curriculum.	而等式"M_1 x a = M_2 x b"则会强化学生在中级科学课程中所学到的知识。角矩和扭矩的方程可以让我们用高级物理课程的概念来解决同样的问题。

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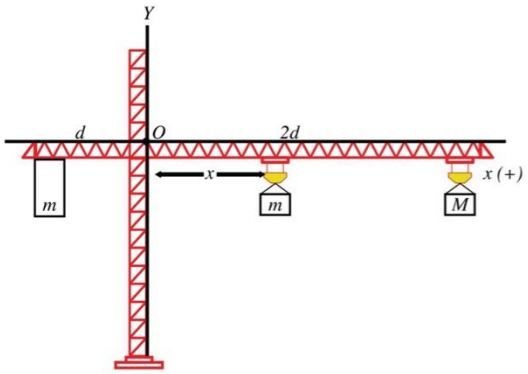
Sample Engineering Question:



The figure to the left shows a crane (for simplicity we will neglect its mass) whose arms have lengths d and $2d$ respectively. A mass m is fixed to the left and another was m can move horizontally along the arms of the crane. Another mass M is attached to the end of the right arm. The system is in static equilibrium. Determine:

a) the distance x with respect to the origin O to which the moving mass must be situated if the mass $M = m/4$
b) The value of m that is the moving mass m: the origin of coordinates.
c) The maximum value of m that the crane can hold.

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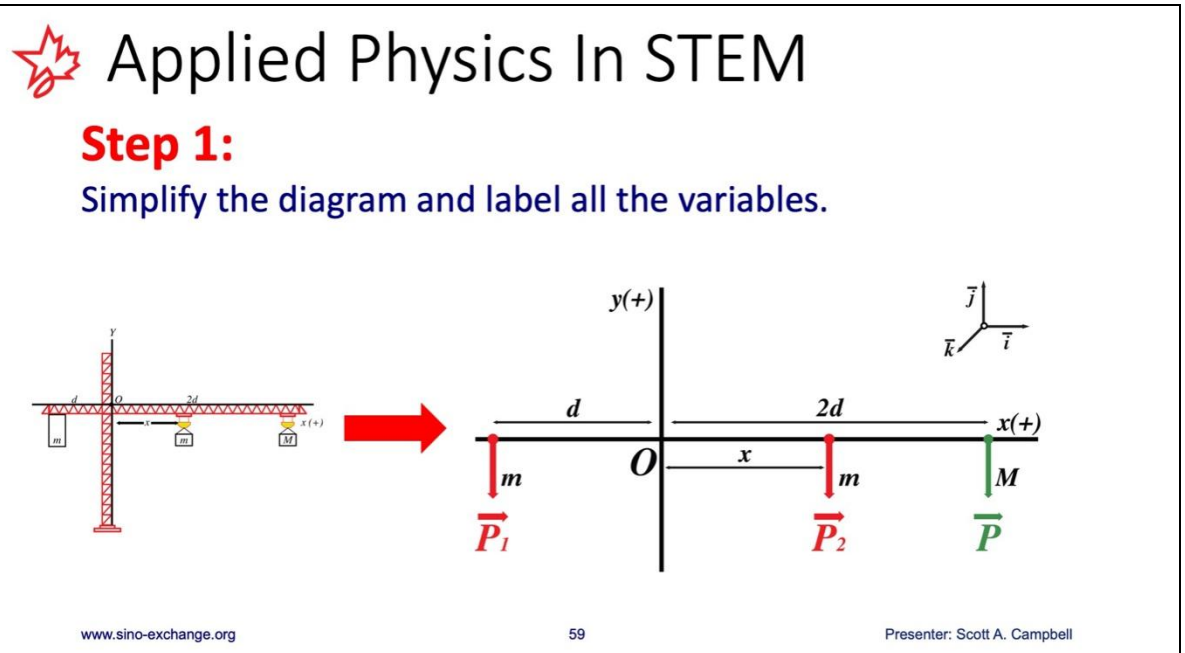
Here is a question that I have taken directly from a physics textbook.	这里有一个问题，我直接从一本物理教科书上抄下来的。
And we can see how this question relates to our crane project.	我们可以看到这个问题和我们的起重机项目有什么关系。
Now this is not the actual diagram that was shown in the textbook. I actually made a few modifications to the diagram to place the theory into a suitable context.	这不是课本上展示的图表。实际上，我对图表做了一些修改，以便将理论置于合适的上下文中。
So now that we understand what we are trying to do. Let's look at the steps necessary to solve this problem.	现在我们知道我们要做什么了。让我们看一下解决这个问题的必要步骤。



The first thing we need to do is to simplify the diagram if it hasn't been done already.	我们要做的第一件事是简化这个图，如果还没有这样做的话。
This is actually what the diagram looked like in the textbook example.	这就是课本上的例子。
A purely mathematical representation of the problem with no context, and if you look closely enough, you will notice that the information in these two diagrams is identical.	一个没有上下文的问题的纯数学表示，如果你看得足够仔细，你会注意到这两个图中的信息是相同的。

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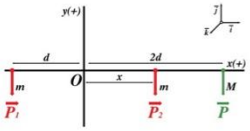
Step 2:

Write the equation for this problem.



$$\vec{\tau}P_1 + \vec{\tau}P_2 + \vec{\tau}P = 0$$

***Note:** This system does not rotate, so we can assume that there is a condition of **static equilibrium**; therefore, the equation of rotation must be equal to:*

$$\sum \vec{\tau}_{ext} = 0$$

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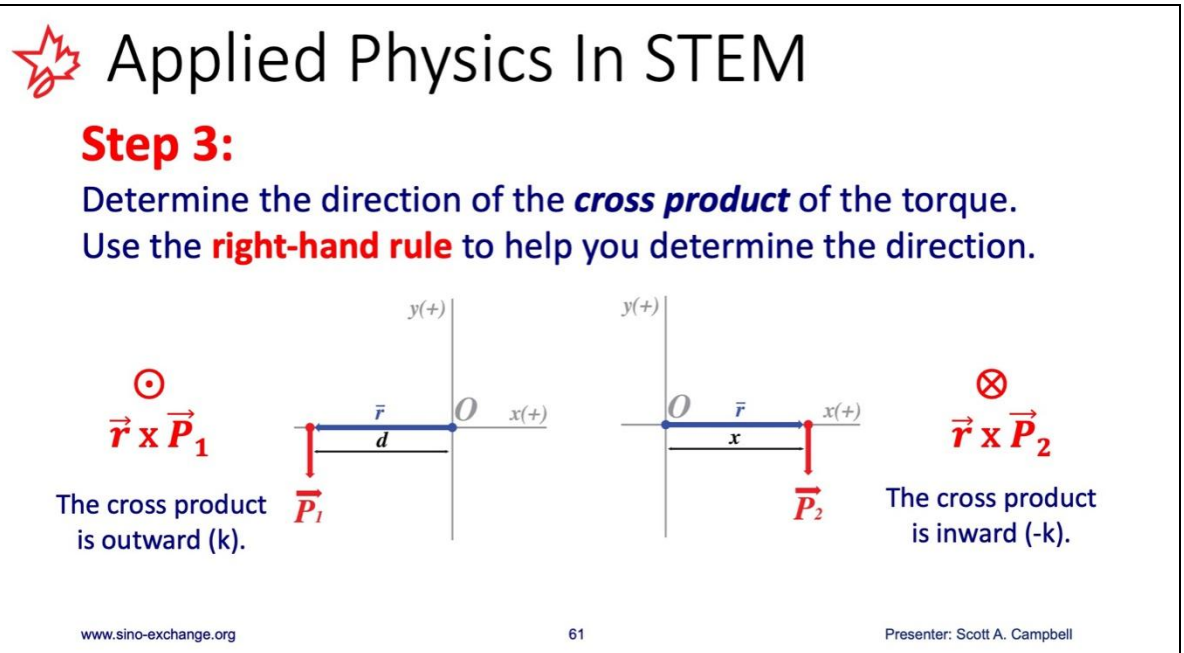
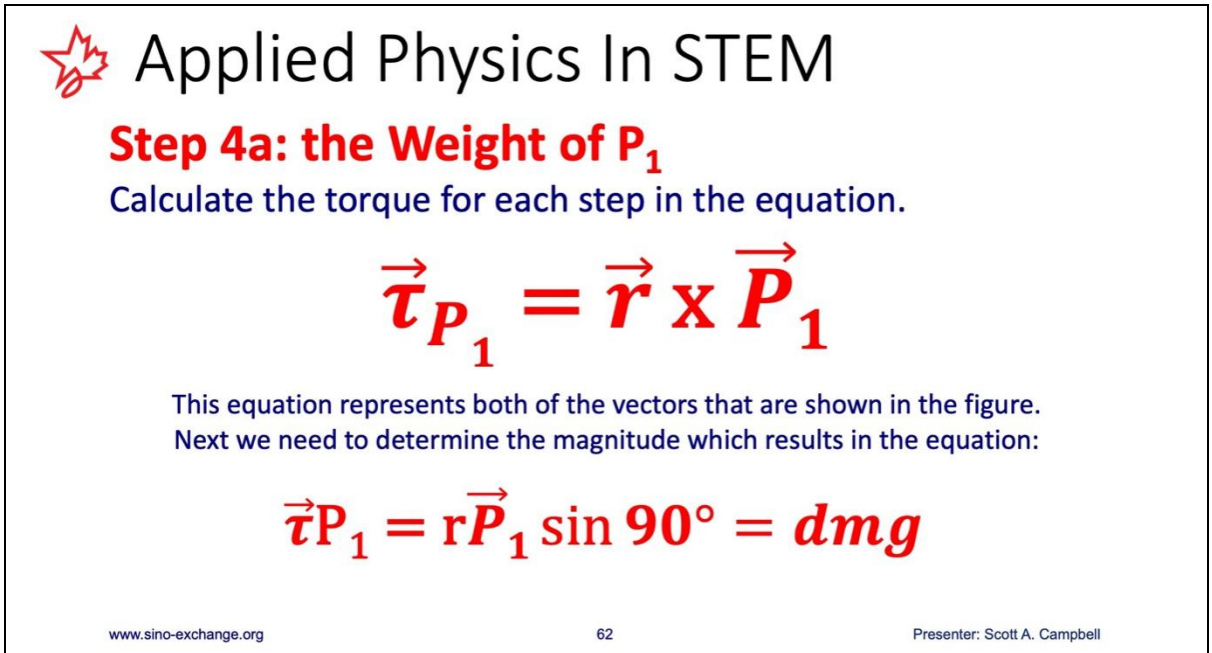
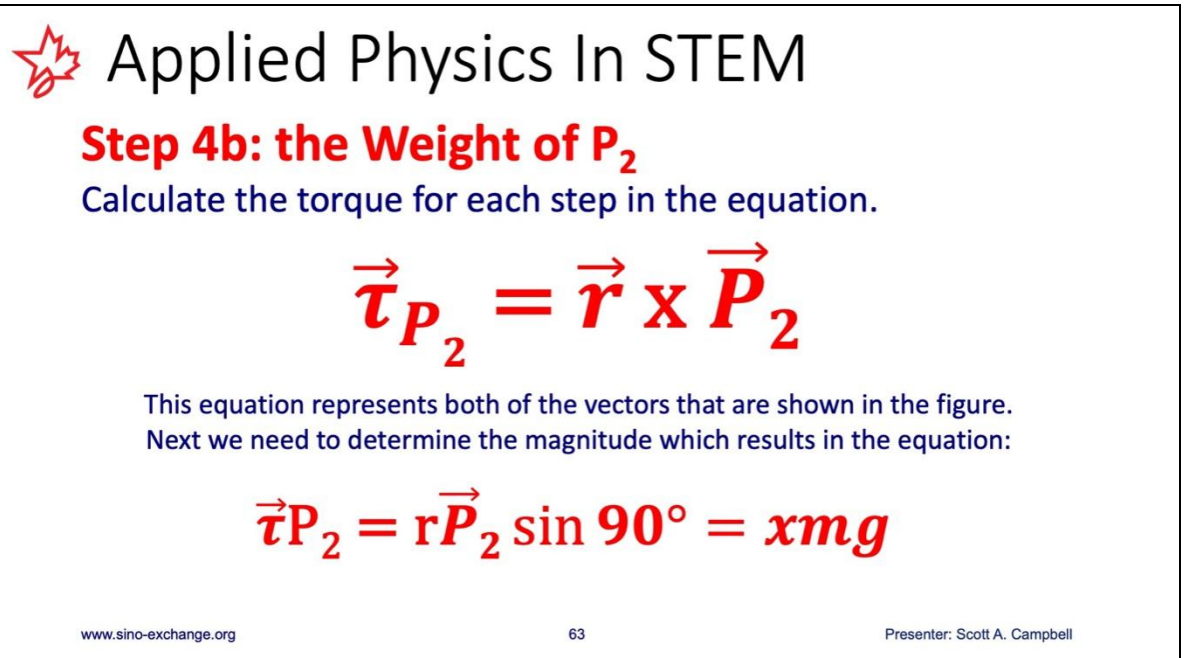
The next thing we need to do is to write the equation that represents this system and because we can assume that this system is in a state of static equilibrium, the summation of the cross products must be equal to 0. That is how we arrived at this equation.	接下来我们要做的是写出表示这个系统的方程因为我们可以假设这个系统处于静力平衡状态，叉乘的和一定等于 0。这就是我们得到这个方程的方法。



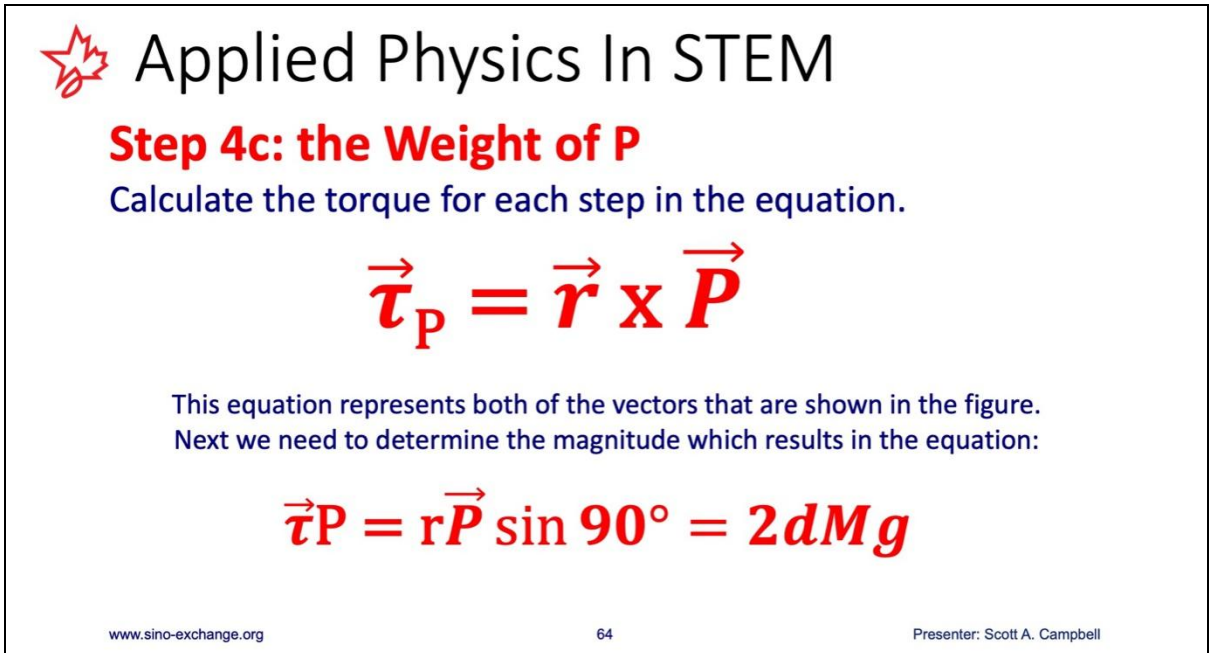
Next, we will need to determine the cross products, and if you teach physics, you might be aware of the "**right-hand rule**", but essentially P1 will have an outward cross product. Whereas P2 will have an inward cross product, and these are notated using the symbols and the variable notations that are shown on the screen.	接下来，我们需要确定外积，如果你教物理，你可能知道"右手法则"，但本质上 P1 有一个向外的外积。而 P2 会有一个向内的叉乘，这些是用符号和屏幕上显示的变量符号来表示的。



At this point we will need to determine the torque that each variable in the system will produce. So if we work our way through this process, we can simply "**P1**" to "**dmg**", and what that essentially means is that **"d"** indicates the position of the mass "**m**" along the jib, and that is multiplied by "**g**" which is the force of gravity.	此时，我们需要确定系统中每个变量将产生的扭矩。 所以如果我们通过这个过程，我们可以简单地从 P1 到 dmg，这本质上意味着 d 表示质量 m 沿着 jib 的位置，它乘以重力 g。



And we'll do the same for P2 which gives us the solution of xmg.	我们对 P2 做同样的处理，得到 xmg 的解。



And finally, we'll do the same for P which will give us 2dMg.	最后，我们对 P 做同样的处理，得到 2dMg。

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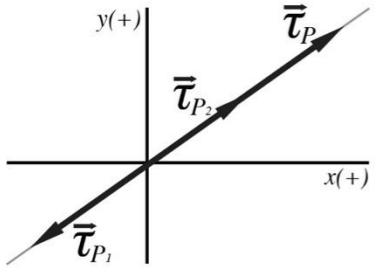
Step 5:

Represent the torques of all the weights in three dimensions.
An accurate scale is optional for this diagram.



The projection of the equation of the rotation on the z axis is then:

$$z = \vec{\tau}P_1 - \vec{\tau}P_2 - \vec{\tau}P = 0$$

And after replacing the variables with the magnitudes, we will be able to obtain the follow equation:

$$dmg - xmg - 2dMg = 0$$

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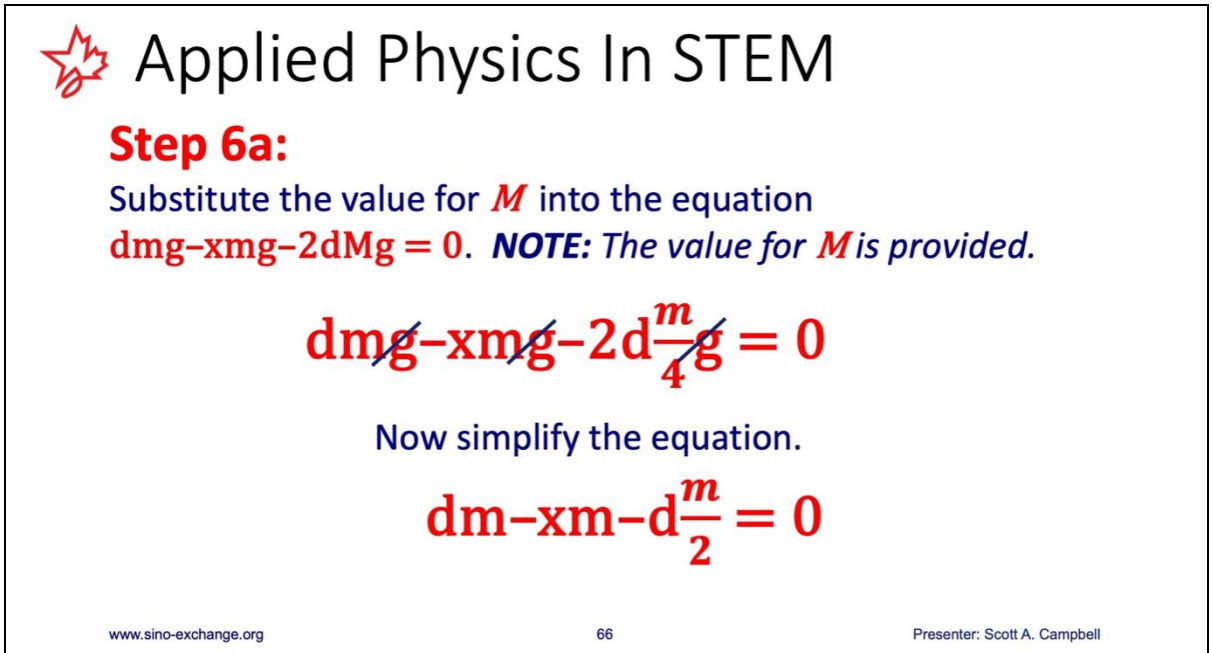
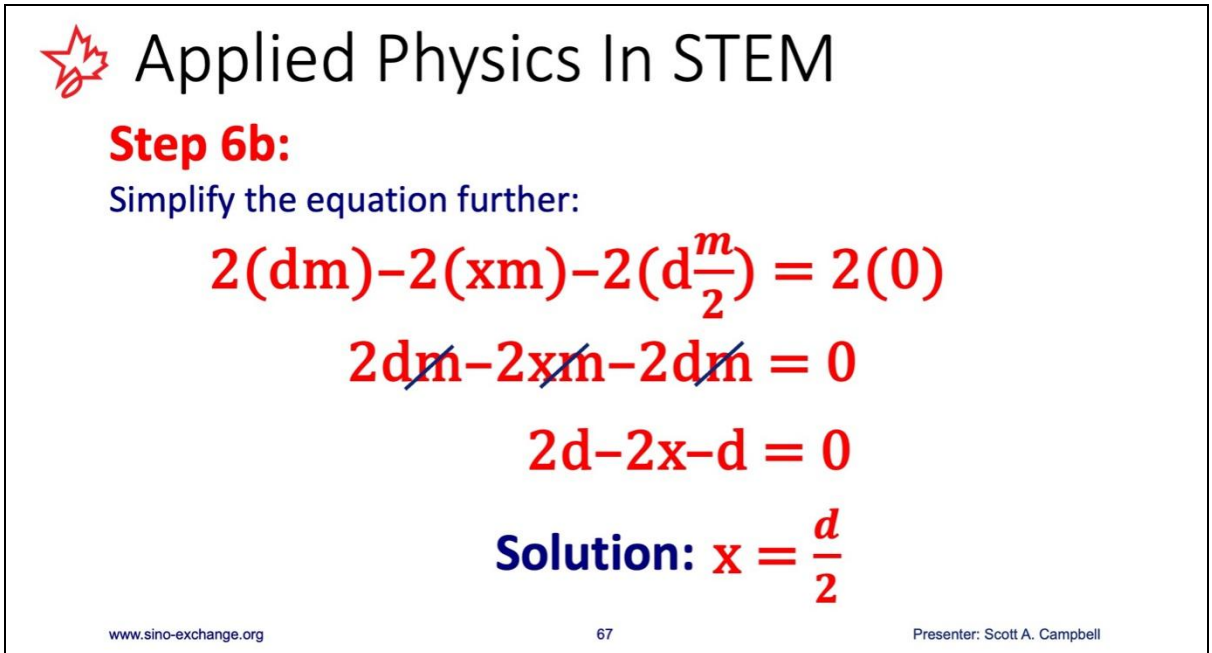
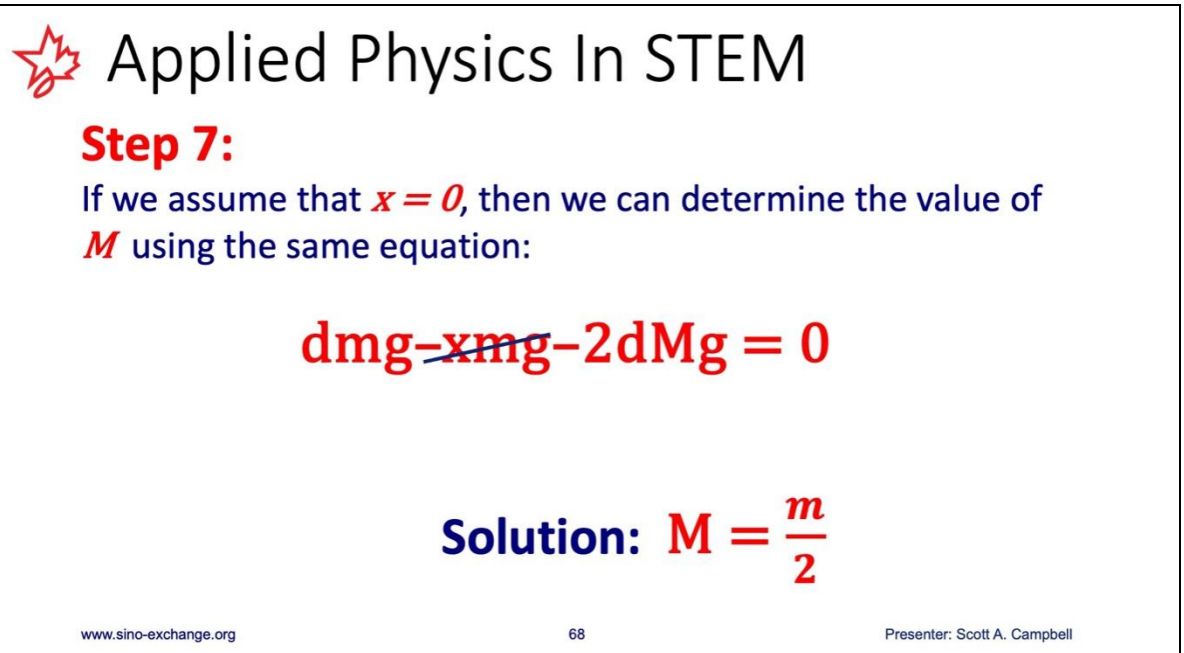
Next, we will plot all the weights in 3 dimensions which will give us a graph that should look like this.	接下来，我们将在三维空间中绘制所有的权重，这将得到一个像这样的图。
Based on the graph we should be able to see that the net force will equal 0. Therefore, we can substitute the values we derived in step 4 into this equation, and that will give us the equation "**dmg–xmg–2dMg = 0**".	根据这张图，我们应该可以看到合力等于 0。因此，我们可以将在第 4 步中得到的值代入这个方程，得到"dmg-xmg-2dMg = 0"。



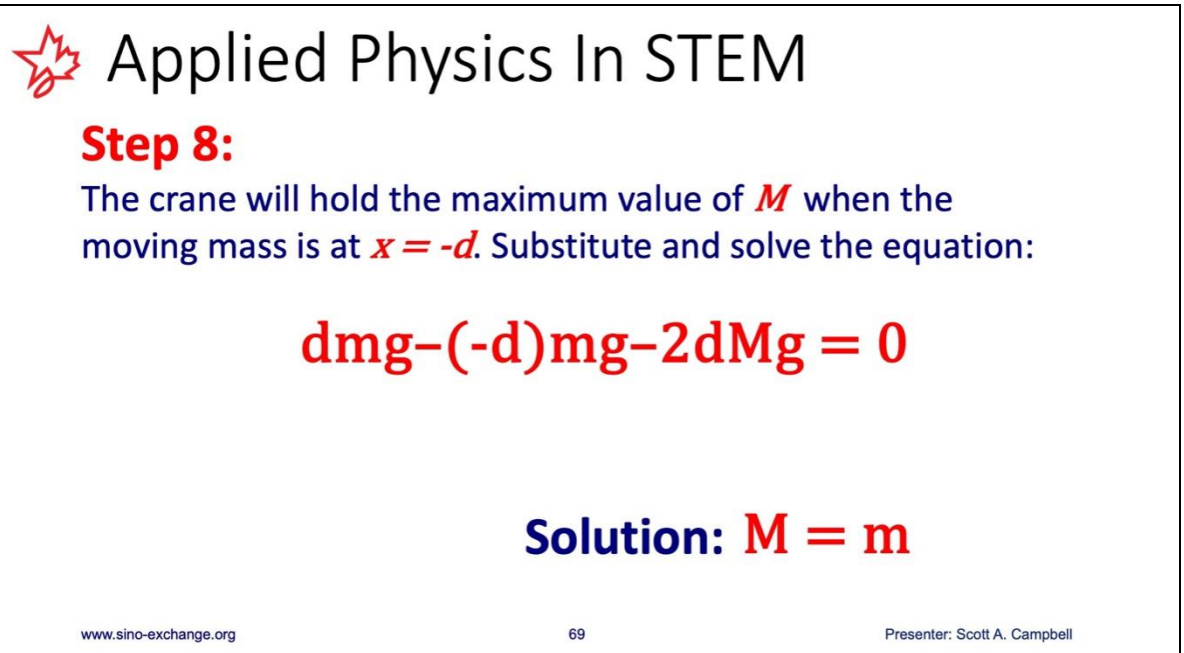
Then we can substitute the value that was given for M in the original problem.	然后我们可以代入原问题中给出的 M 的值。
Since the force of gravity is common to all the variables; therefore, we can divide all of the variables by g to cancel it out which leaves us with the following simplified equation.	因为重力对所有变量都是共有的;因此，我们可以把所有的变量都除以 g 来消掉，这样我们就得到了下面的简化方程。



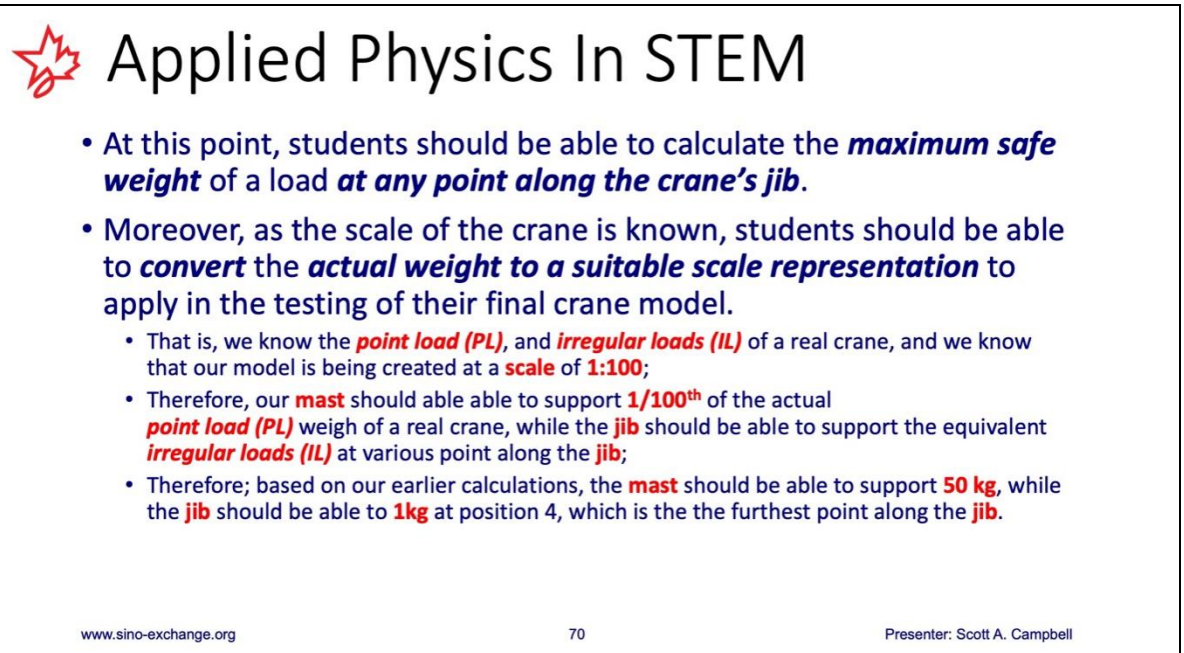
We will then need to simplify the equation even further, and this will give us a final value for **"x"**.	然后我们需要进一步简化方程，这样就能得到 x 的最终值。



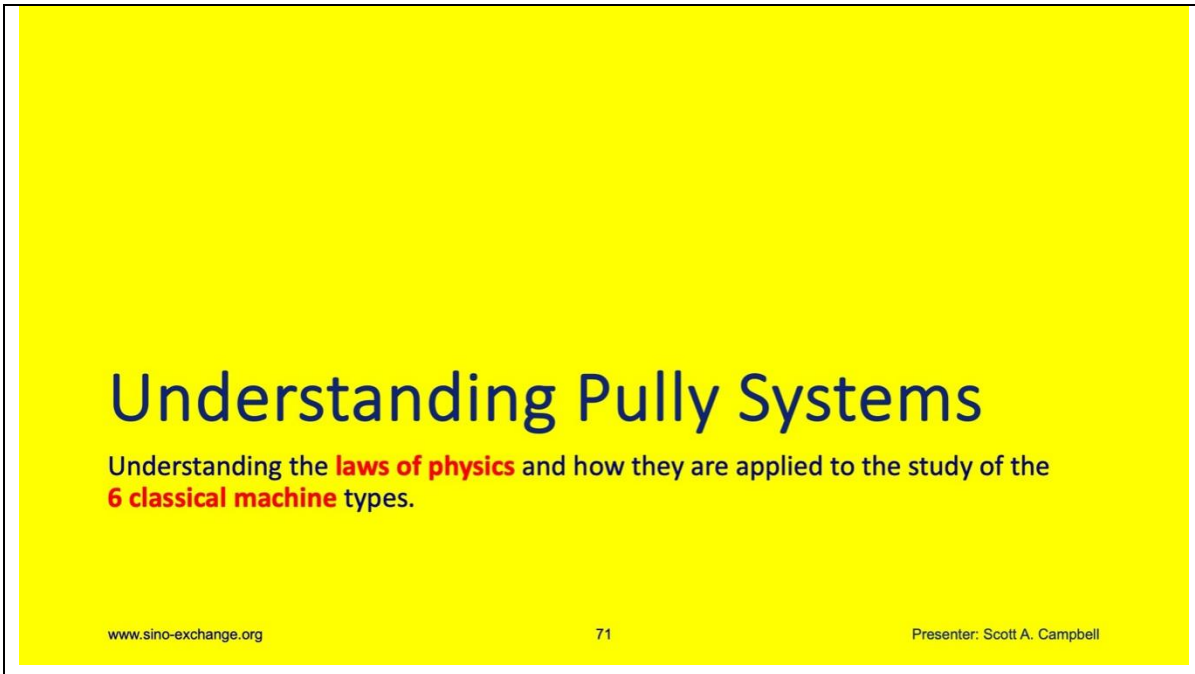
Next, if we assume that x is equal to 0 we can simplify and find a value for M.	接下来，如果我们假设 x 等于 0 我们可以化简并求出 M 的值。



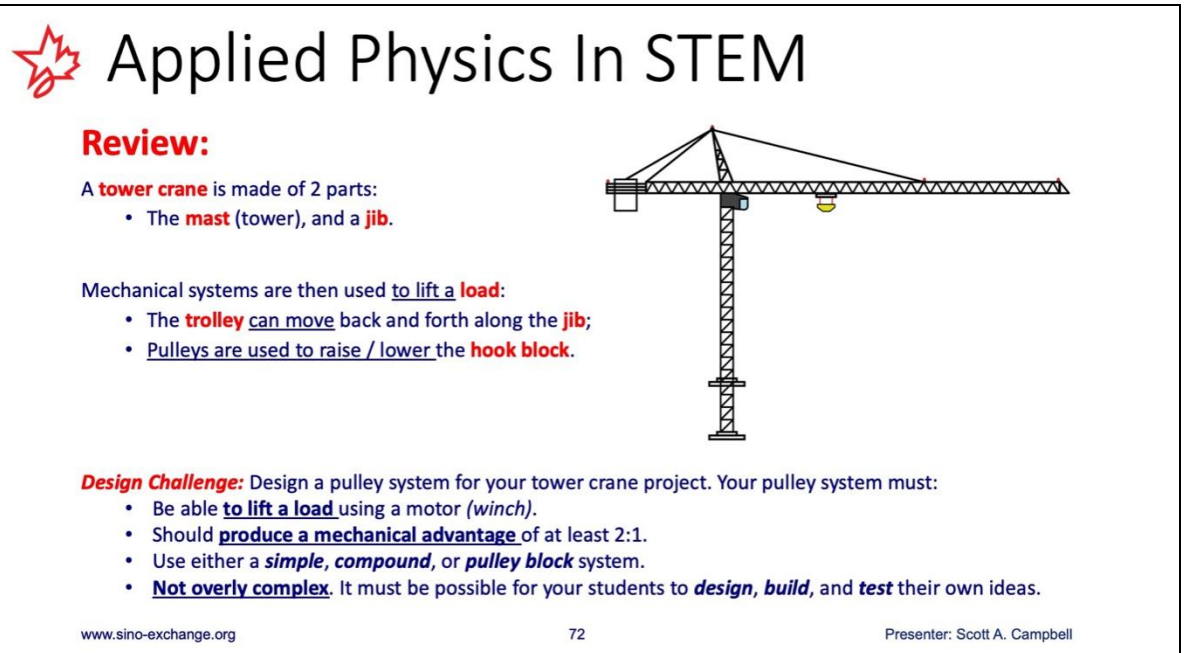
And finally, we substitute all our values we will find that large M is equal to small m when the moving mass is equal to negative d. At this point most people's heads are probably spinning, but this example was really meant to demonstrate how abstract concepts can be given new meaning through the authentic application of theory in in STEM education.	最后，我们代入所有的值我们会发现当运动质量等于- d 时，大 M 等于小 M。 在这一点上，大多数人可能会头晕目眩，但这个例子实际上是为了展示抽象概念如何通过在 STEM 教育中的真实应用来赋予新的含义。



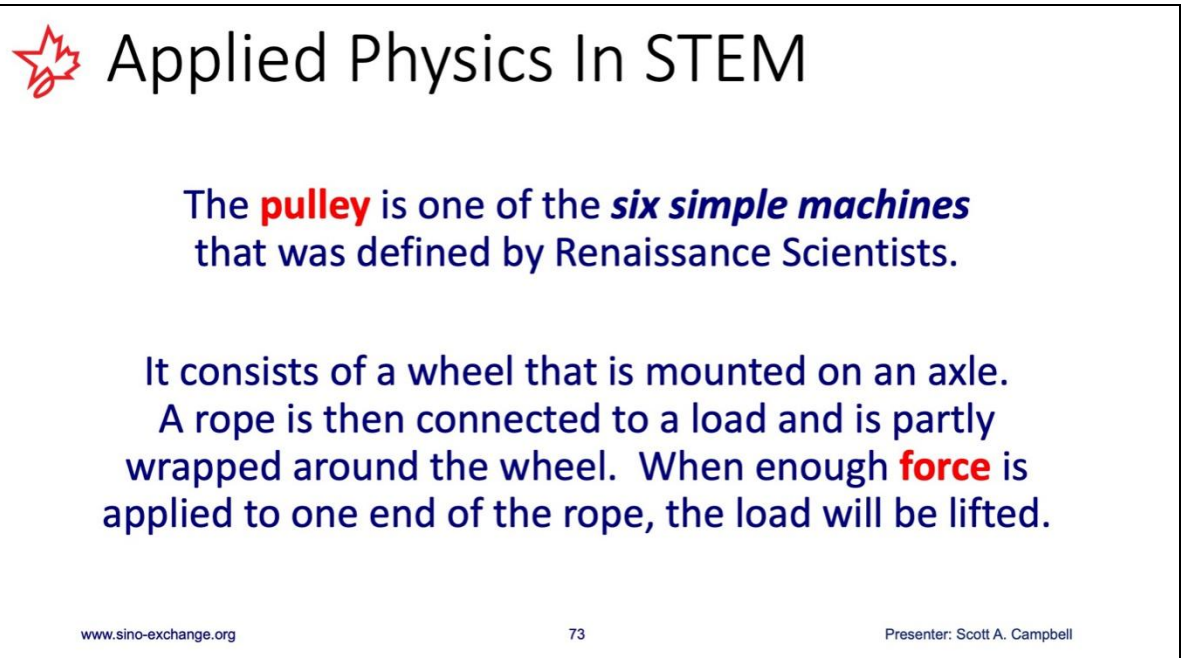
Therefore, at this point our students should be able to: • Calculate the maximum safe weight. • Covert measurements between actual size and the model size of our cranes for testing. • Which implies that students can calculate the ***point load*** and *irregular loads* of a real crane. • And then use that information to determine how much weight our model crane should be able to support. Based on this information we should be able to conclude that the mast of our model crane should be able to support 50KG. While the jib should be able to support 1kg is the furthest point, and this will give us suitable parameters for testing and evaluating our model crane.	因此，在这一点上，我们的学生应该能够: • 计算最大安全重量。 • 用于测试的实际尺寸和模型尺寸之间的隐蔽测量。 • 这意味着学生可以计算一个真正的起重机的点荷载和不规则荷载。 • 然后使用这些信息来确定我们的模型起重机应该能够支撑多少重量。 根据这些信息，我们应该能够得出结论，我们的模型起重机的桅杆应该能够支撑 50KG 的重量。而吊臂应该能够支撑 1 公斤是最远的点，这将为我们提供合适的参数来测试和评估我们的模型起重机。



At this point students will have a completed the overall structure of their cranes.	至此，学生将有一个完整的起重机的整体结构。
At this stage the students will need to design a pulley system. Moreover, this system needs to be able to create a noticeable mechanical advantage and this is because a typical 5-volt DC motor will not be able to handle a vertical lift for a 500g load on its own. Moreover, at our current working scale our ideal target weight is 1KG for the pully system to be able to lift. Therefore, we are not finished with the laws of physics just yet!	在这个阶段，学生需要设计一个滑轮系统。此外，该系统需要能够创造一个明显的机械优势，这是因为一个典型的 5 伏直流电机将无法处理一个垂直提升的 500g 负载。此外，在我们目前的工作规模下，我们理想的目标重量是 1 公斤，以使滑轮系统能够提升。因此，我们还没有完全了解物理定律!



So far we've covered a lot of information. So let's do a quick review. • A crane is made of 2 parts, the mast, and a jib. • And mechanical systems are used to raise or lower the load a using a pulley system. Therefore, the next thing your students need to do is design a pulley system for their cranes, and this will require them to retrofit their original designs. Which will present them with a series of unique design challenges to overcome.	到目前为止，我们已经了解了很多信息。让我们快速回顾一下。 • 起重机由两部分组成，桅杆和臂架。 • 机械系统使用滑轮系统来提高或降低负载。 因此，你的学生需要做的下一件事是为他们的起重机设计一个滑轮系统，这需要他们对原来的设计进行改造。这将给他们带来一系列需要克服的独特设计挑战。



Now a pulley is one of 6 classical machines and consist of a rope that is partly wrapped around a wheel to lift a load.	滑轮是六种经典机械中的一种，它由一根绳子组成，绳子部分缠绕在轮子上以提升负载。

Applied Physics In STEM

Newton's 3 Laws of Motion:

1. An object will remain at rest or in uniform motion in a straight line unless acted upon by an external force
2. When a net force acts on an object, it will cause the object to accelerate. This Law may be written as: **force = mass x acceleration** or: $F = m * a$
3. For every action, there is an equal and opposite reaction.

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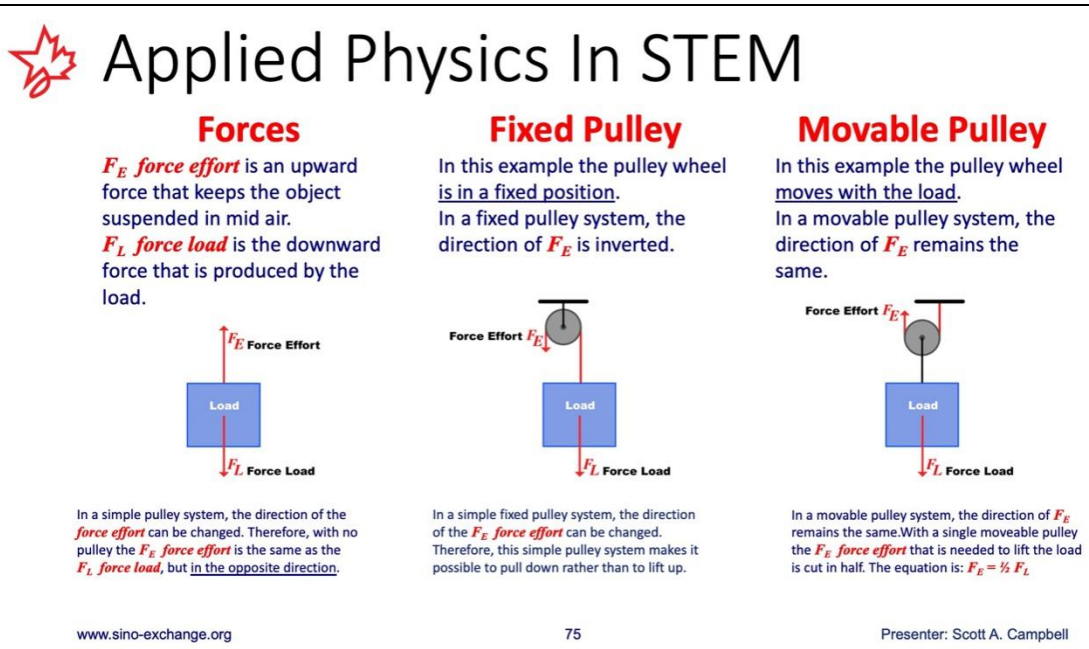
And this brings me to Newton's 3 laws of motion. • First, an object will remain at rest unless acted upon. • An applied force will cause an object to accelerate. • And finally, for every action, there is an equal and opposite reaction. However, we're interested in Newtown's second law ***"force = mass x acceleration"***.	这让我想到了牛顿三大运动定律。 • 首先，一个物体将保持静止，除非受到作用。 • 施加的力会使物体加速。 • 最后，对于每一个作用力，都有一个大小相等，方向相反的反作用力。 然而，我们感兴趣的是牛顿第二定律"力=质量 x 加速度"。

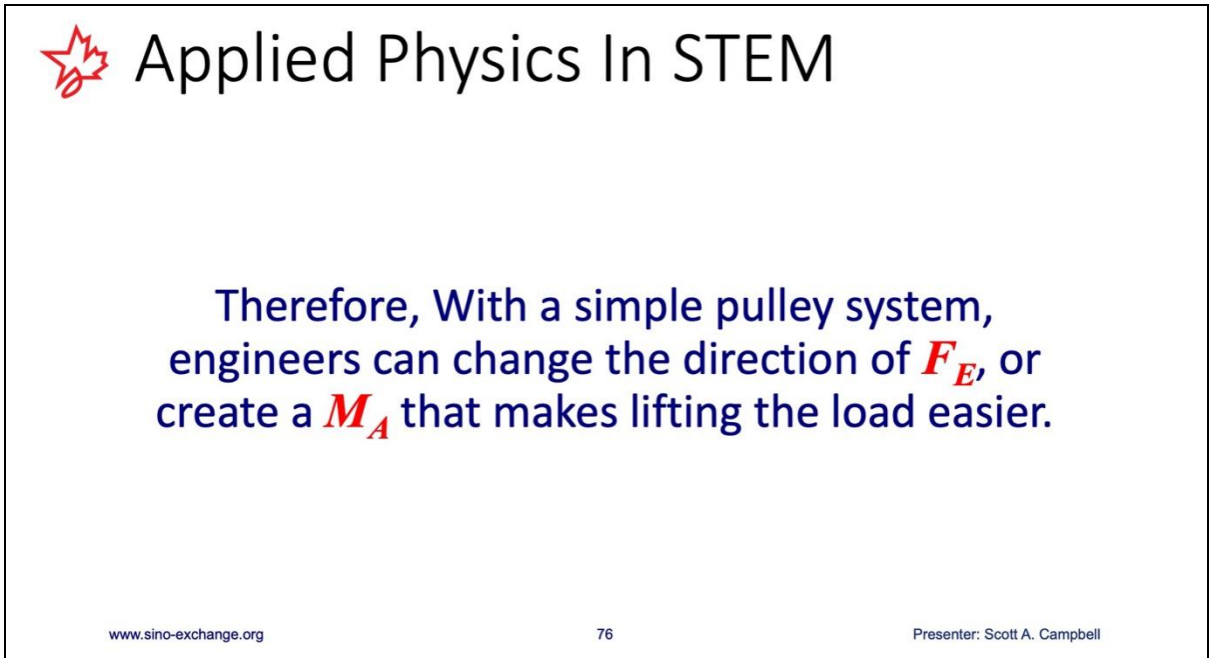


Without a pulley an object will experience 2 different forces. These are:

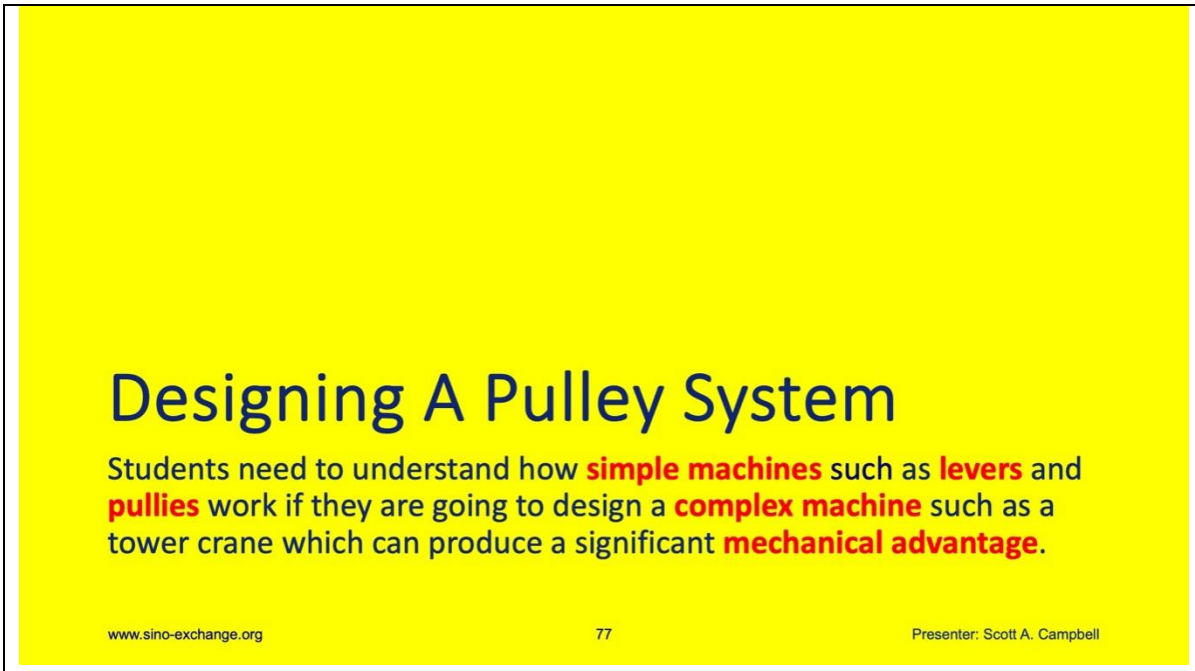
- The ***Effort*** that is needed to lift the object, and the **Force Load** which is the force created as a result of gravity.
- However, with a single **Fixed Pully** we can change the direction of the **Force Effort** which makes it possible for us to pull down on a rope to lift an object.
- And with a **Movable Pully** we can cut the amount of effort needed to life and object in half.

没有滑轮，物体会受到两种不同的力。这些都是:

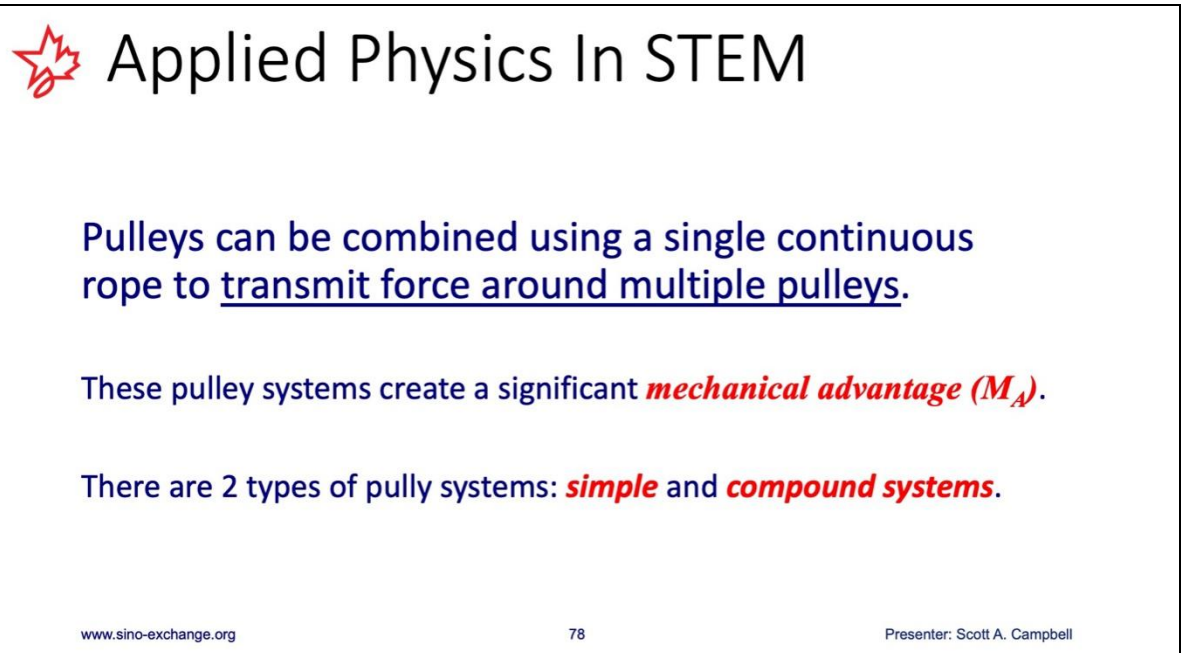
- 抬起物体所需的力，以及由于重力而产生的力。
- 然而，使用一个固定滑轮，我们可以改变力的方向，这使得我们可以拉绳子来提升物体。
- 使用可移动滑轮，我们可以将生命和物体所需的工作量减少一半。



Therefore, with a simple pulley system, engineers can change the direction of the applied **force**, or they can create a **Mechanical Advantage** that would make lifting the load easier.	因此，使用简单的滑轮系统，工程师可以改变施加力的方向，或者他们可以创造一个机械优势，使提升负载更容易。

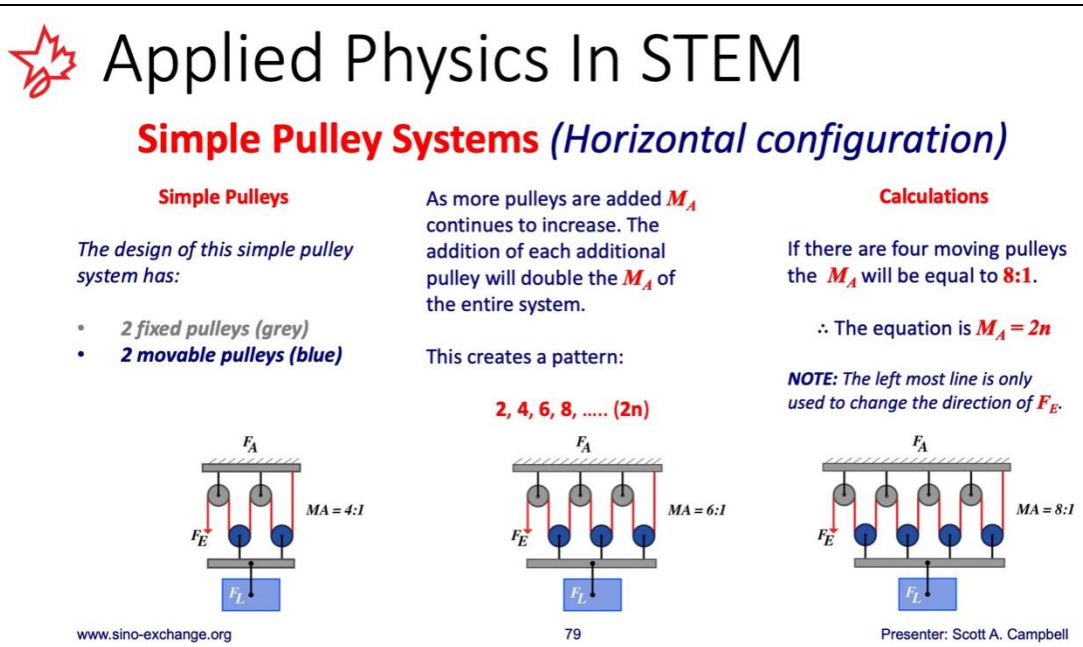


And that brings us to designing a pulley system. The combination of multiple simple machines such as pullies and levers create a complex machine. And that's our goal…. To guide the students through the process of creating a complex machine which is capable of producing a mechanical advantage.	这就引出了我们设计一个滑轮系统。多个简单机械如滑轮和杠杆的组合创造了一个复杂的机器。这就是我们的目标…. 引导学生完成制造能够产生机械优势的复杂机器的过程。



So now that we understand **Force Effort** and **Force Load**, students will need to understand the differences between **simple** and **compound pulley systems** so that they can start asking themselves the following types of questions:	现在我们了解了力，力，力和载荷，学生们需要了解简单滑轮系统和复合滑轮系统之间的区别，这样他们就可以开始问自己以下问题:
"How much mechanical advantage must my pully system produce to life the desired load?"	"我的滑轮系统必须产生多大的机械优势才能使所期望的负载生效?"
"What type of pulley system will produce the best results?"	"什么样的滑轮系统能产生最好的效果?"
"How can I go about retrofitting my crane to accommodate the addition of this new pulley system?"	"我该如何改造我的起重机以适应这个新的滑轮系统?"
"And do I need to modify my ideas to make	"我需要修改我的想法来让我的设计奏效吗?"
	这种类型的理论应用是由这一系列的问

my design work?" And this type of application of theory is a created by this line of questioning, which has been created as a direct result of the ***guided inquiry-based learning*** process.	题所创造的，这是由指导性的基于探究的学习过程直接产生的结果。

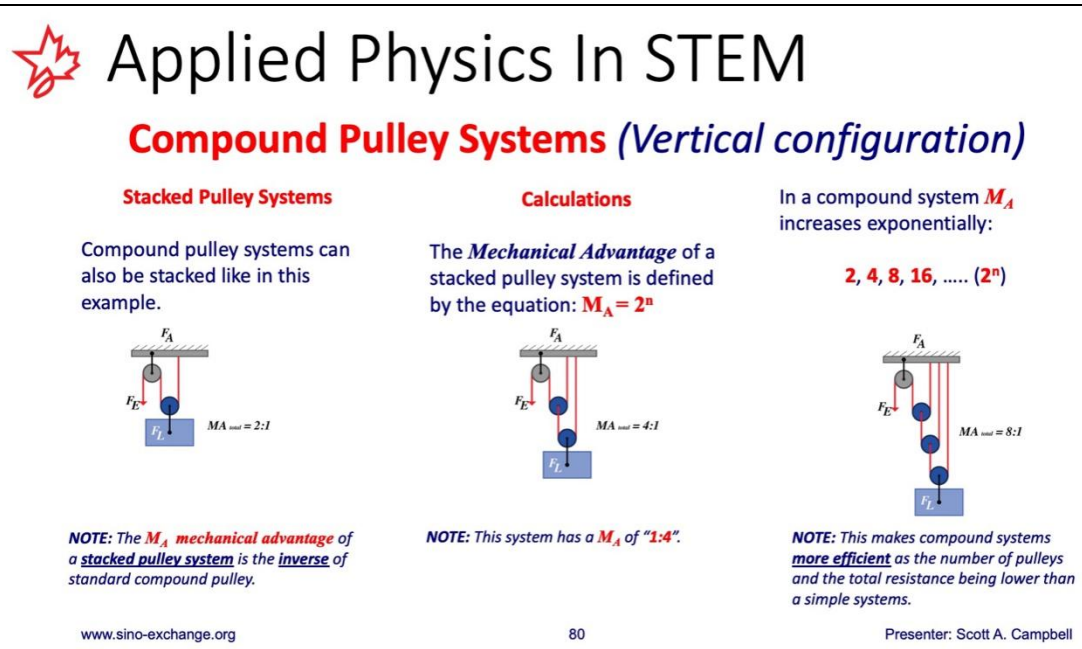


Now the first type of pulley systems that students might want to explore for their crane is a "***Simple Pulley System***".

- With a simple pulley system **2 fixed** and **2 movable pullies** are used to create a "**Mechanical Advantage**" of 4 to 1.
- And an additional pully will increase the "**Mechanical Advantage**" to a ratio of 6 to 1.
- And this pattern will continue which gives us the formula **"MA=2n"**, where n is the number of movable pullies in the system.

现在，学生们想要探索的第一种滑轮系统是"简单滑轮系统"。

- 使用简单的滑轮系统，使用 2 个固定滑轮和 2 个活动滑轮来创造 4 比 1 的"机械优势"。
- 一个额外的滑轮将把"机械优势"提高到 6 比 1。
- 这种模式将继续下去，得出公式"MA=2n"，其中 n 是系统中可移动滑轮的数量。



The second type of pulley systems is a "***Compound Pulley System***".

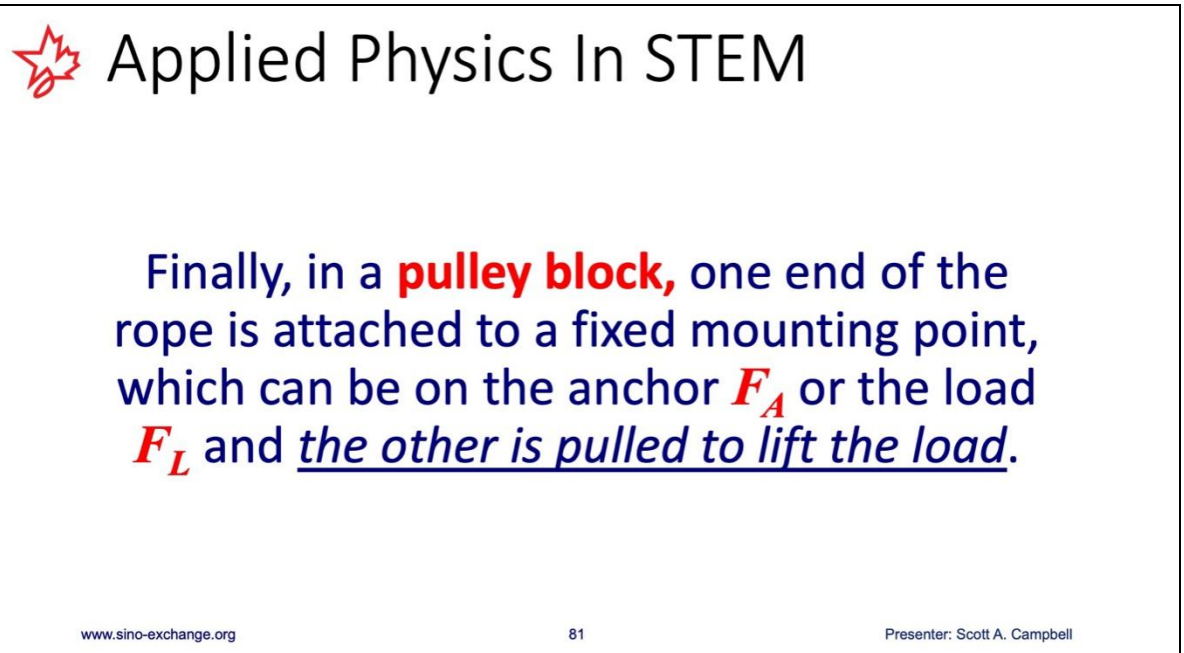
- Pullies are stacked in a vertical configuration in a "***Compound Pulley System***". It may not be particularly evident from the first example. However, the benefits of stacking pullies will become increasingly more evident in the following 2 examples.
- In this example there are only 2 movable pullies. However, we're able to create a "**Mechanical Advantage**" of 4 to 1.
- And in this finally, example we have created a "**Mechanical Advantage**" of 8 to 1.

Therefore, the resulting pattern is represented by an exponential equation where 2 is raised to the power of n.

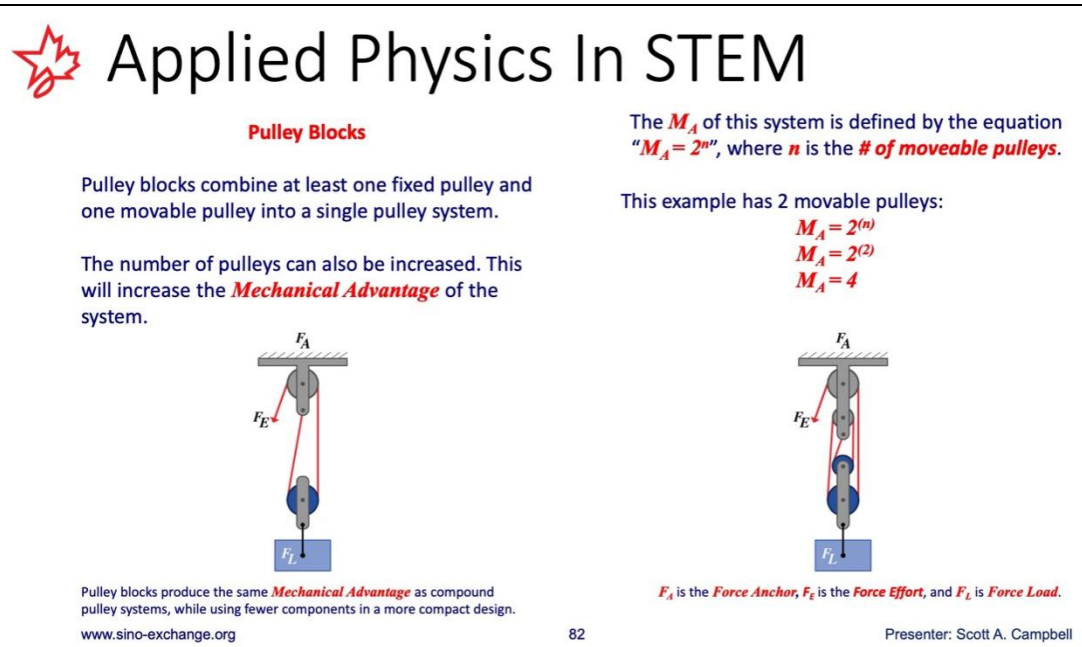
第二种滑轮系统是"复合滑轮系统"。

- 滑轮在"复合滑轮系统"中以垂直配置堆叠。从第一个例子来看，这可能不是特别明显。然而，在以下两个例子中，堆叠滑轮的好处将变得越来越明显。
- 在这个例子中，只有 2 个可移动滑轮。然而，我们能够创造 4 比 1 的"机械优势"。
- 在最后一个例子中，我们创造了 8:1 的"机械优势"。

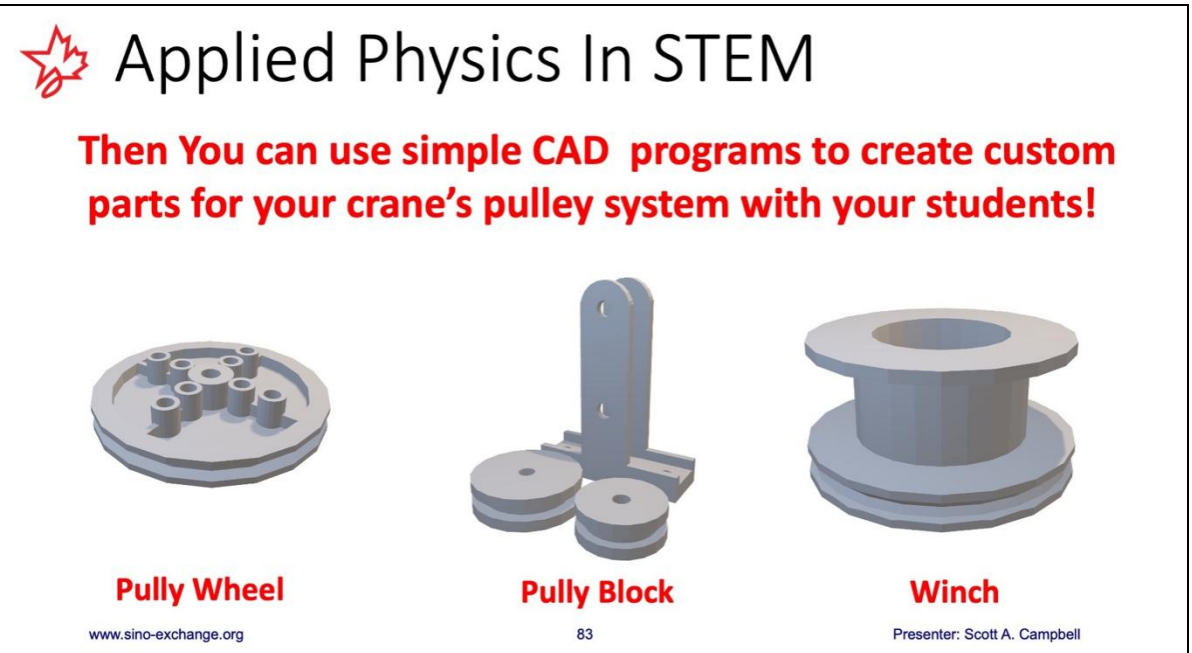
因此，结果模式由指数方程表示，其中 2 被提高到 n 的次方。



And finally, **compound pully systems** can be simplified by creating what's known as a **pulley block**, and you see examples of **pulley blocks** being use all the type at the gym as most weight machines utilize this design to improve efficacy and reliability.	最后，复合滑轮系统可以通过创建滑轮组来简化，你可以看到滑轮组在健身房被使用的例子，因为大多数重量机器都利用这种设计来提高效率和可靠性。

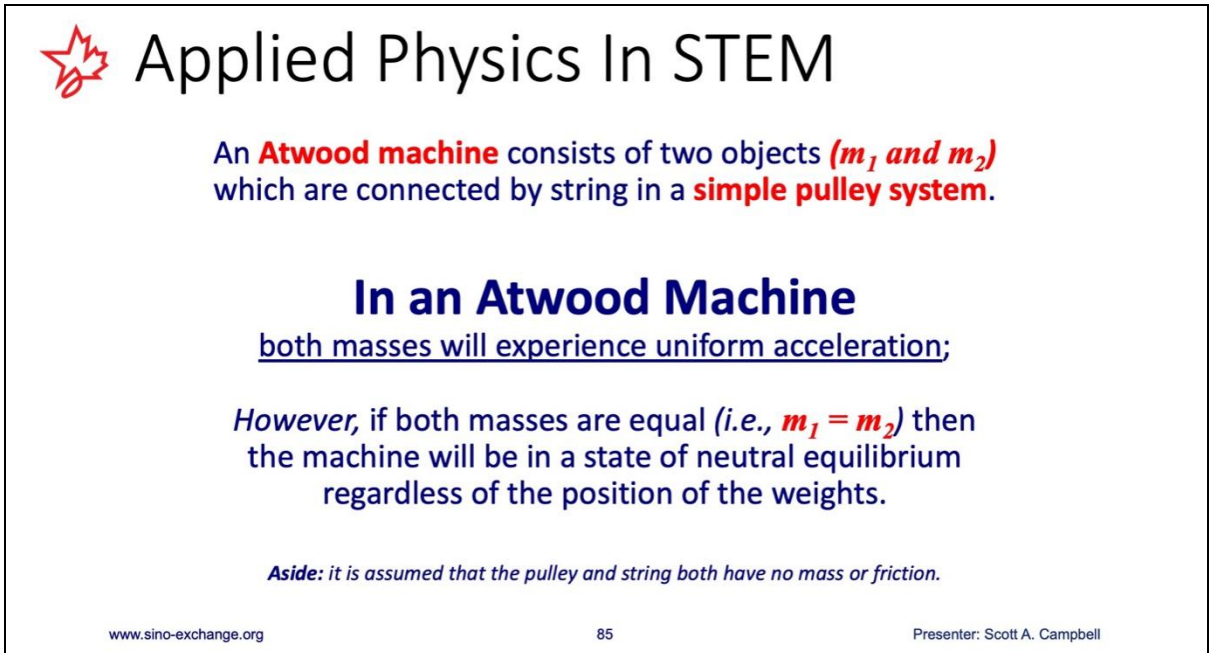


So here you can see how multiple pullies can be assembled to create a compact **pulley block**. And again, as this is representative of a **compound pulley system,** the pattern is exponential. Therefore, we use the equation **MA equals 2 to the power of n**, where n is the number of movable pullies in the system.	所以在这里你可以看到多个滑轮是如何组装成一个紧凑的滑轮组的。再一次，因为这是一个复合滑轮系统的代表，模式是指数型的。因此，我们使用方程 MA = 2 的 n 次方，其中 n 是系统中活动滑轮的数量。



So, with all this theory at the student's disposal, it is now time for them to start designing a pulley system for their crane, and this would be a good time for them to incorporate technology in an authentic way. For instance, in these examples the students used Computer Aided Design software to create parts that could be manufactured using a 3D printer. They then used these parts to create the pulley system for their crane, and you might have noticed some of these parts from the video that I showed at the start of this presentation.	有了这些理论知识，学生们就可以开始为他们的起重机设计滑轮系统了。这将是他们以一种真实的方式整合技术的好时机。 例如，在这些例子中，学生们使用计算机辅助设计软件来创建可以使用 3D 打印机制造的部件。然后他们用这些部件制造了起重机的滑轮系统，你们可能已经注意到了我在演讲开始时放的视频中的一些部件。

While understanding how to create a mechanical advantage using either simple or compound pulley systems is critical to this project, you may also want to take science a little bit further. This will allow you to continue to place scientific theories into a real-world context for your students, and in doing so you will continue to explore rigorous academic concepts that will help prepare your students for the real-word.	虽然了解如何使用简单或复合滑轮系统创造机械优势对这个项目至关重要，但你可能还想把科学带得更远一点。这将允许你继续把科学理论放在现实世界的背景下，这样你将继续探索严谨的学术概念，这将帮助你的学生为现实世界做准备。

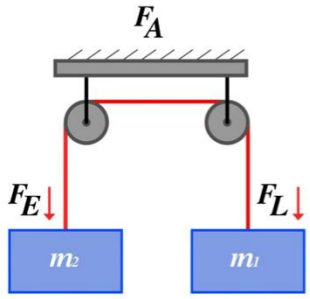


We often use an **Atwood Machine** when teaching about forces in science. In this simple contraption 2 masses are used.	在教授科学中的力时，我们经常使用阿特伍德机。在这个简单的装置中使用了 2 个质量。

Applied Physics In STEM

Calculating Force Effort

(How much force is needed to lift an object)



If m_1 and m_2 ***are equal,*** then the **downward force ↓** that each weight produces will also be ***the same***.

This means that this system is in a state of static **equilibrium**; therefore, both weights will not move.

$$F_E = F_L \therefore A \text{ must equal } 0$$

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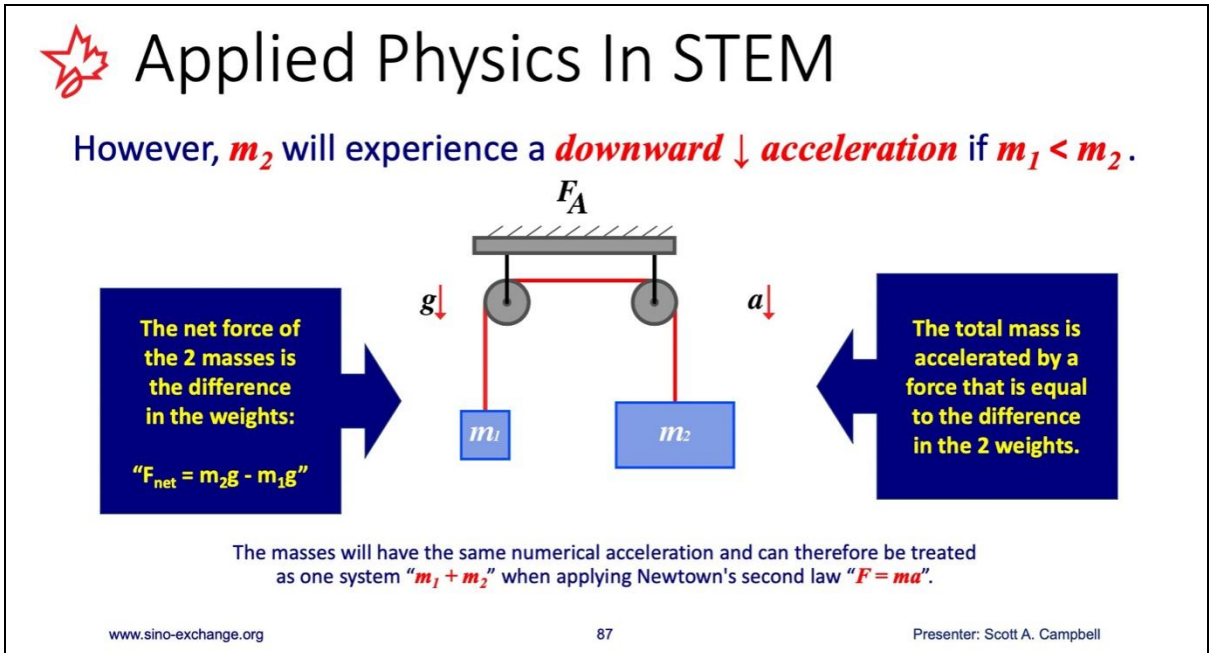
In this example, both masses are equal. Therefore, the system will be in a **state of neutral equilibrium.**	在这个例子中，两个质量是相等的。因此，系统将处于中性平衡状态。

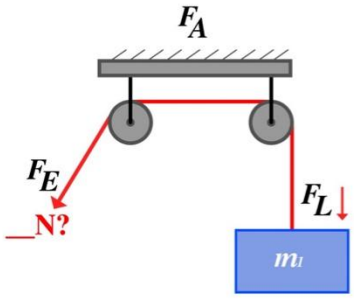


However, if the two masses are not equal, then both objects will experience an acceleration in opposite directions. In this example the total mass is accelerated by a force that is equal to the difference in the 2 masses. Therefore, the net force of the 2 masses is the difference between the two weights. However, the 2 masses will have the same numerical acceleration and can therefore be treated as one system when applying **Newtown's second law**, and that brings us back to the equation ***"Force = mass times acceleration".***	然而，如果两个质量不相等，那么两个物体将在相反的方向上经历加速度。 在这个例子中，总质量被一个力加速，这个力等于两个质量的差。因此，两个质量的合力是两个重量之差。然而，这两个质量将具有相同的数值加速度，因此在应用牛顿第二定律时可以被视为一个系统，这将我们带回到"力=质量乘以加速度"的方程。

Applied Physics In STEM

Calculating Force Effort

(How much force is needed to lift an object)



What if the weight m_2 is removed?

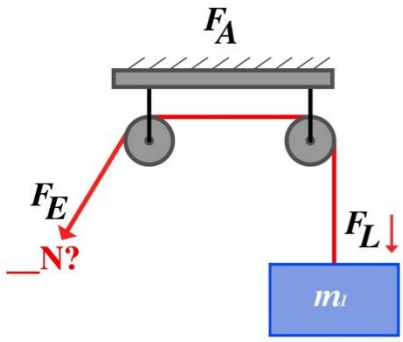
How much force is needed to lift m_1 if there is no counterweight?

You will need the follow equation to calculate F_E:

$$F = m*a$$

So, what would happen if we removed the second mass altogether?	那么，如果我们把第二个质量全部去掉会发生什么?
How much force will be needed to lift the first mass?	举起第一个物体需要多大的力?
In-order to do preform this calculation we will use the equation ***"Force = mass times acceleration".***	为了完成这个计算，我们将使用"力=质量乘以加速度"的公式。

Applied Physics In STEM



Assume that m_1 has a mass of $7.5kg$, and the force of gravity is $9.8m/s^2$.

$$F = 7.5kg\ x\ 9.8m/s^2$$

$$F = 73.5kg \cdot m/s^2$$

NOTE: *In this example the acceleration of the object would be the same as the force of gravity since there is no counterweight.*

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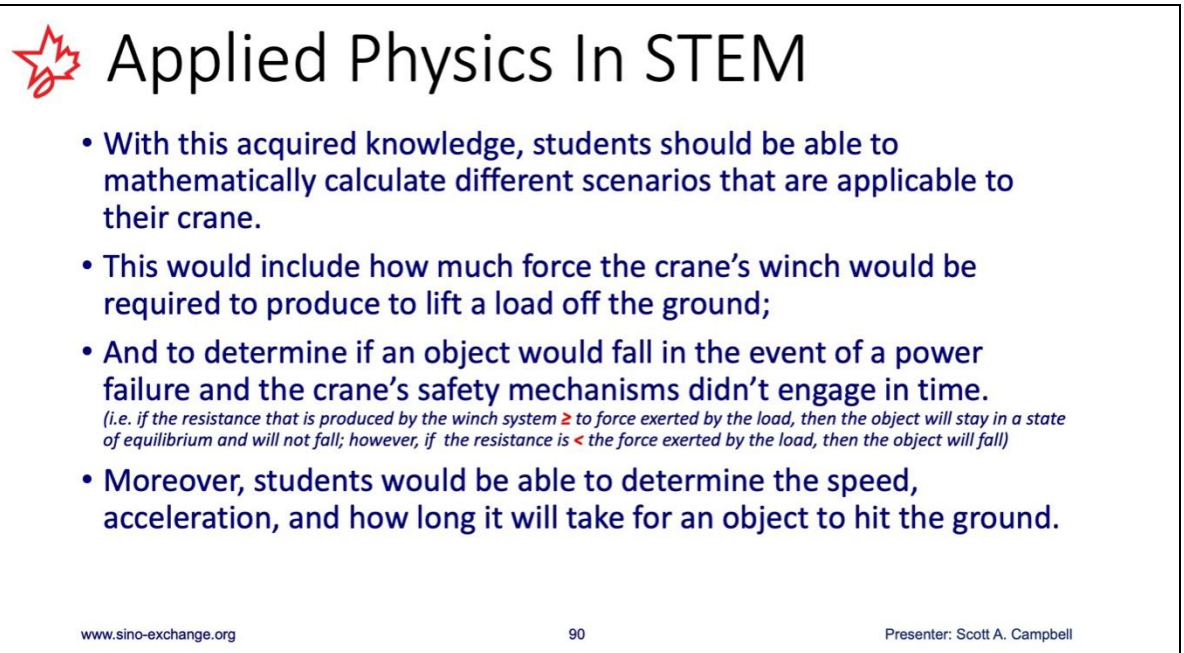
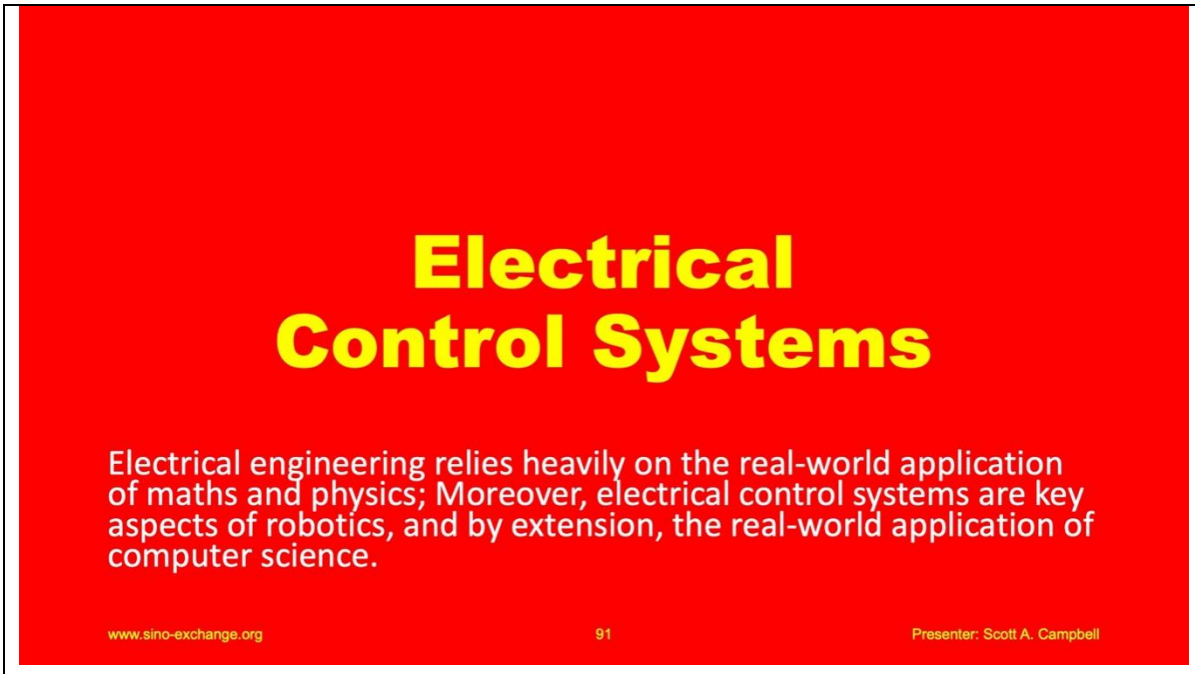
Let's Assume that m_1 has a mass of 7.5kg, and the force of gravity is 9.8m/s^2. We will substitute our known values into our equations, and then we will solve the system. This gives us the necessary force that is required to lift the object.	假设 m_1 的质量为 7.5kg，重力为 9.8m/s2。我们把已知值代入方程，然后解出方程组。这就给出了举起物体所需的力。

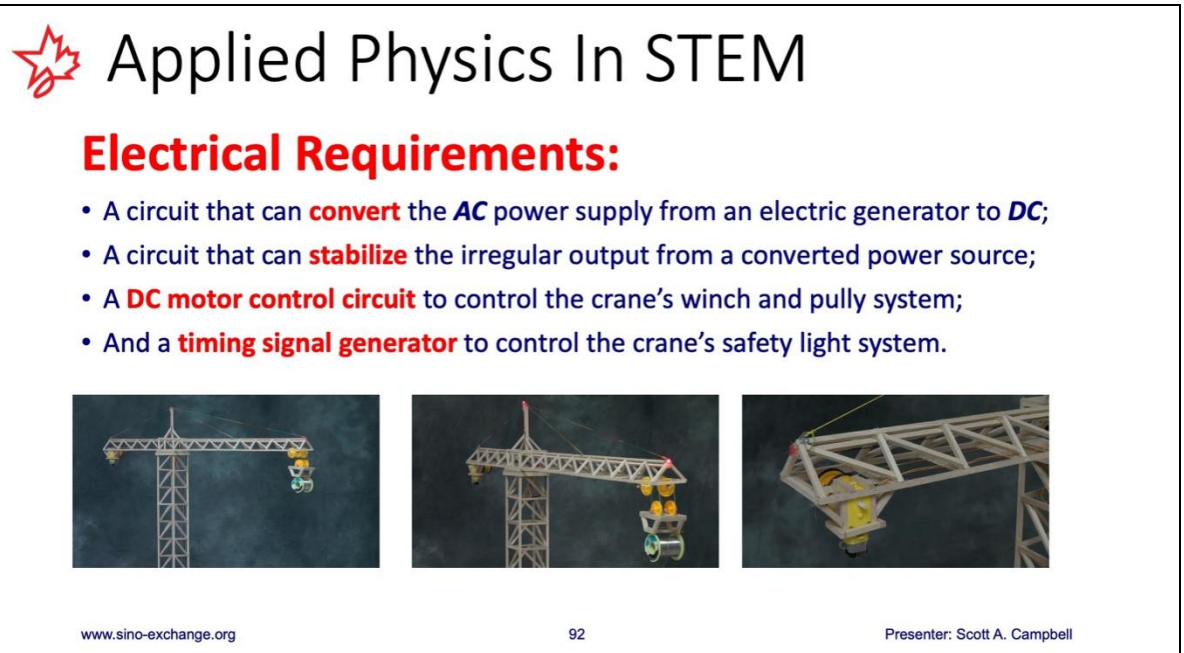


Therefore, at this point students should be able to complete the following calculations: • Apply different theories to make calculations relevant to the design of their cranes. • Including how much force the winch and pulley system must exert to lift a load off the ground. • Moreover, students could also explore some of the worst-case scenarios pertaining to safety and risk management, and this would satisfy the mandates from the World Economic Forum which indicated that STEM education should: Ensure that students learn to evaluate and respond to the social and economic impacts to their work. • And they can do this by applying the theories that we have covered so far! For instance, they could calculate how much time workers would have to reach a minimum safe distance in the event of	因此，在这一点上，学生应该能够完成以下计算: • 运用不同的理论进行与起重机设计相关的计算。 • 包括绞车和滑轮系统必须施加多大的力来将负载抬离地面。 • 此外，学生还可以探索一些与安全和风险管理有关的最坏情况，这将满足世界经济论坛的要求，该要求表明 STEM 教育应该:确保学生学会评估和应对对其工作的社会和经济影响。 • 他们可以通过应用我们目前所涵盖的理论来做到这一点!例如，他们可以计算出在灾难性系统故障的情况下，工人需要多少时间才能到达最小安全距离。

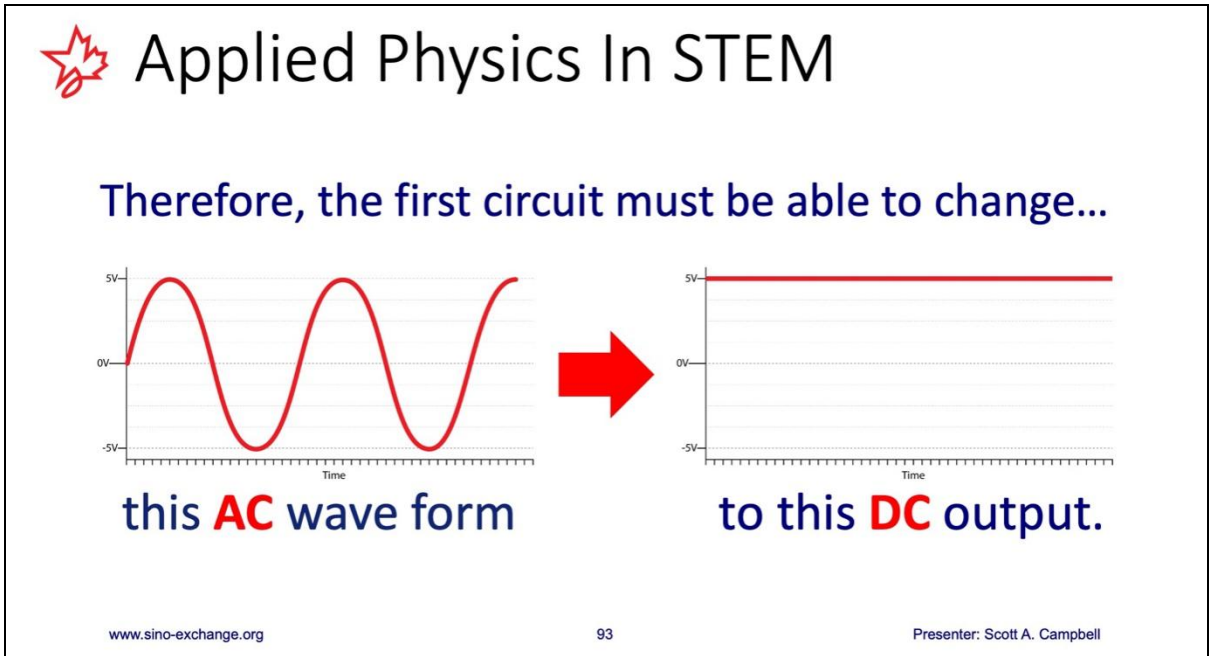
a cataphoric system failure.	



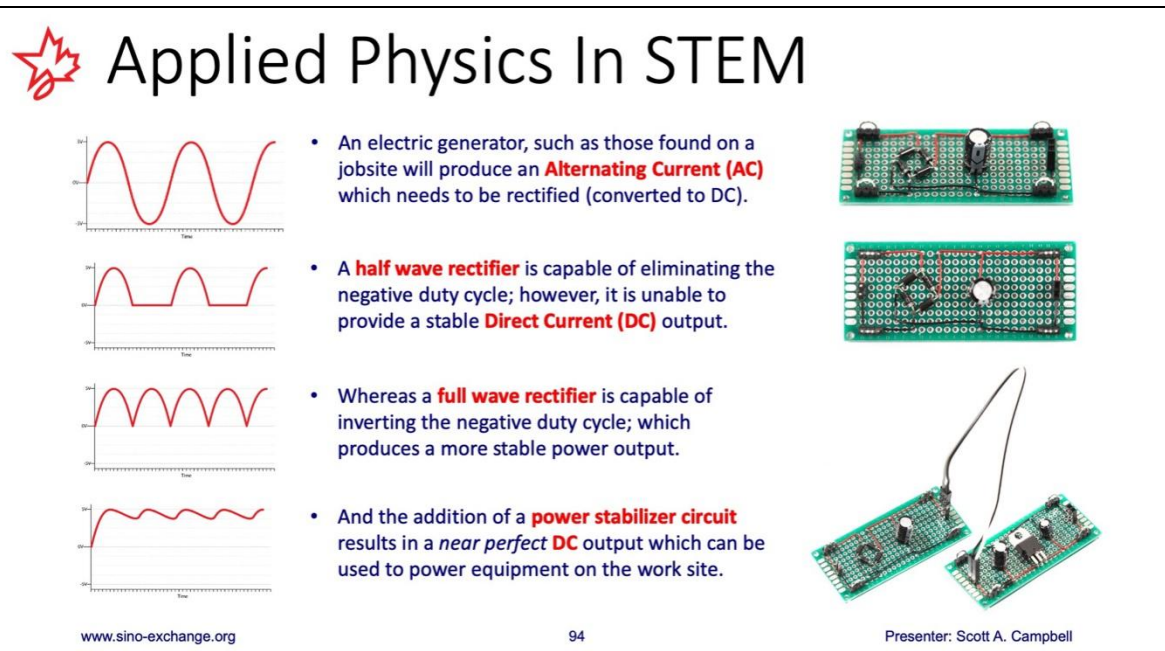
We have covered a lot in this one project already. However, we have only covered the math and science behind the development of a crane, and we haven't even looked at the engineering practices that would be necessary to design and build the electrical control systems for our crane. Moreover, these concepts are highly transferable as they lay the foundation for mechanical and robotic systems alike. So, the importance of this last component cannot be understated, and that will be our last major topic of the day. Looking at the application of the electromagnetism components of most physics curriculums to design, build, and test various electrical control systems that can be used to solve a variety of real-world problems that must be addressed to complete our current project.	我们已经在这个项目中涵盖了很多内容。然而，我们只涉及了起重机开发背后的数学和科学，我们甚至没有看到设计和建造起重机电气控制系统所必需的工程实践。 此外，这些概念是高度可转移的，因为它们为机械和机器人系统奠定了基础。所以，最后一个要素的重要性不容低估，这将是我们今天的最后一个主要话题。查看大多数物理课程中电磁组件的应用，以设计、构建和测试各种电气控制系统，这些系统可用于解决各种现实世界的问题，这些问题必须解决才能完成我们当前的项目。



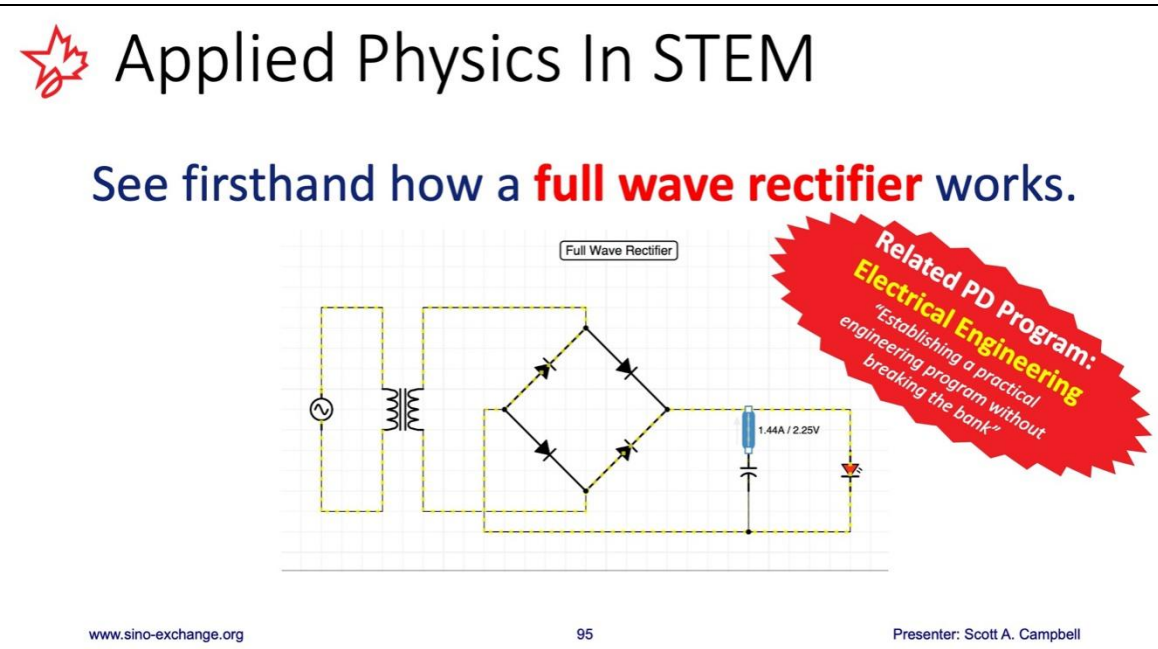
In order for our students to create a compressive control system they will need to: • Create a circuit that can **convert** the power from an electric generator. • And then make a circuit that can **stabilize** the irregular output from a generator. • So that we use a **DC motor control circuit** to control the crane's winch. • And a **timing signal generator** to control the crane's safety light system. It's a pretty comprehensive list, but you can see in this example what all of it will look like once everything is all said and done.	为了让我们的学生创建一个压缩控制系统，他们需要: • 创建一个电路，可以转换来自发电机的电力。 • 然后制作一个电路，可以稳定发电机的不规则输出。 • 采用直流电机控制电路对起重机绞车进行控制。 • 还有一个定时信号发生器来控制起重机的安全灯系统。 这是一个非常全面的列表，但是你可以在这个例子中看到，一旦所有的事情都说完了，所有的事情都完成了。



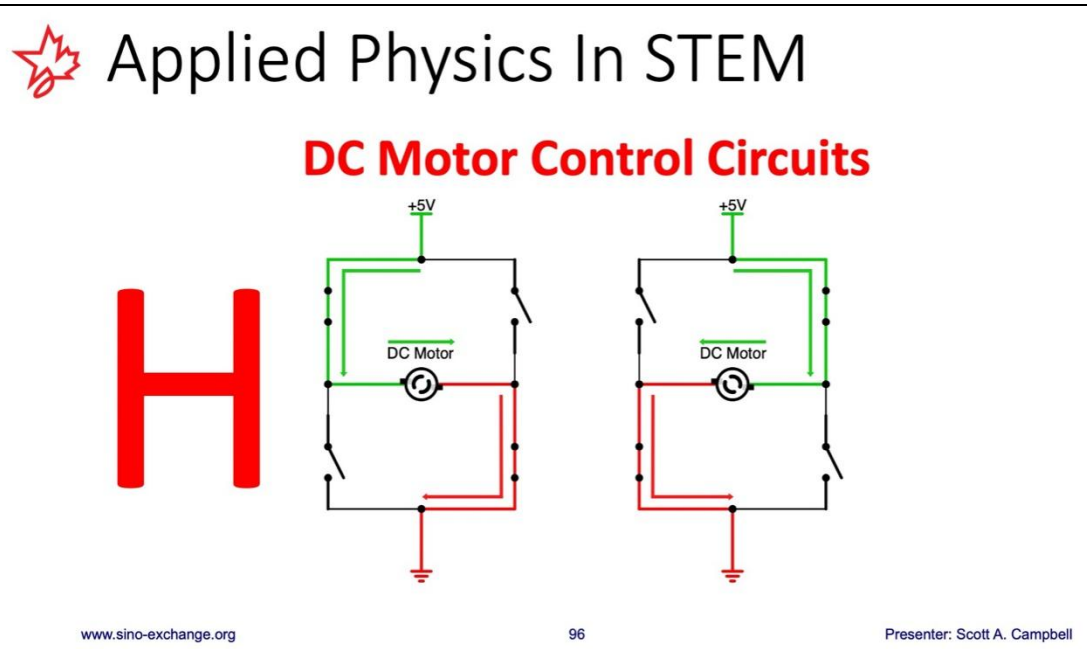
Therefore, the first circuit needs to change an ***Alternating Current*** from an electric generator to a ***Direct Current*** which can be used to power our crane's motor and winch system.	因此，第一个电路需要将发电机产生的交流电转换成直流电，从而为起重机的马达和绞车系统提供动力。



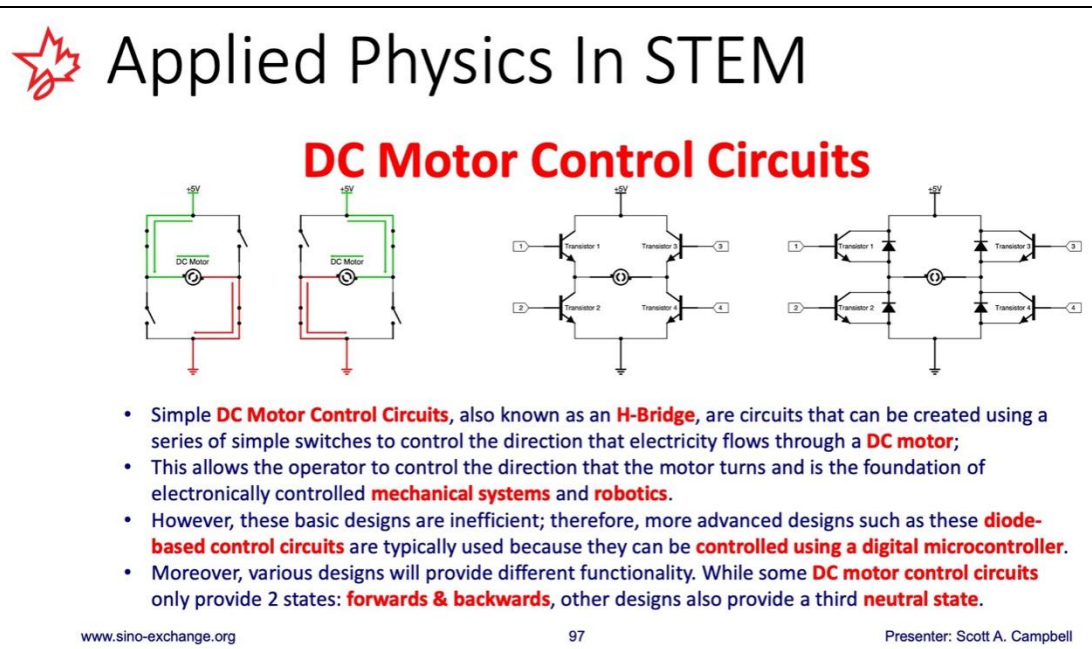
Now I am not going to spend a lot of time explaining how or why this circuit works, but for reference, this concept is covered in depth in the electromagnetism unit of the iGCSE physics curriculum. • We can use a half wave rectifier to eliminate the negative duty cycle. • However, this doesn't provide us with a stable output. • Therefore, we can use a full wave rectifier to invert the negative duty cycle. • However, a power stabilizer is still needed to provide us with a suitable power output. • And this is what a full wave rectifier and a 5-volt power stabilizer would look like in practice.	现在我不打算花很多时间解释这个电路是如何工作的，或者为什么工作，但是作为参考，这个概念在 iGCSE 物理课程的电磁学单元中有深入的介绍。 • 我们可以使用半波整流器来消除负占空比。 • 然而，这并不能为我们提供稳定的输出。 • 因此，我们可以使用全波整流器来反转负占空比。 • 然而，仍然需要一个功率稳定器来为我们提供合适的功率输出。 • 这是一个全波整流器和一个 5 伏电源稳定器在实践中的样子。



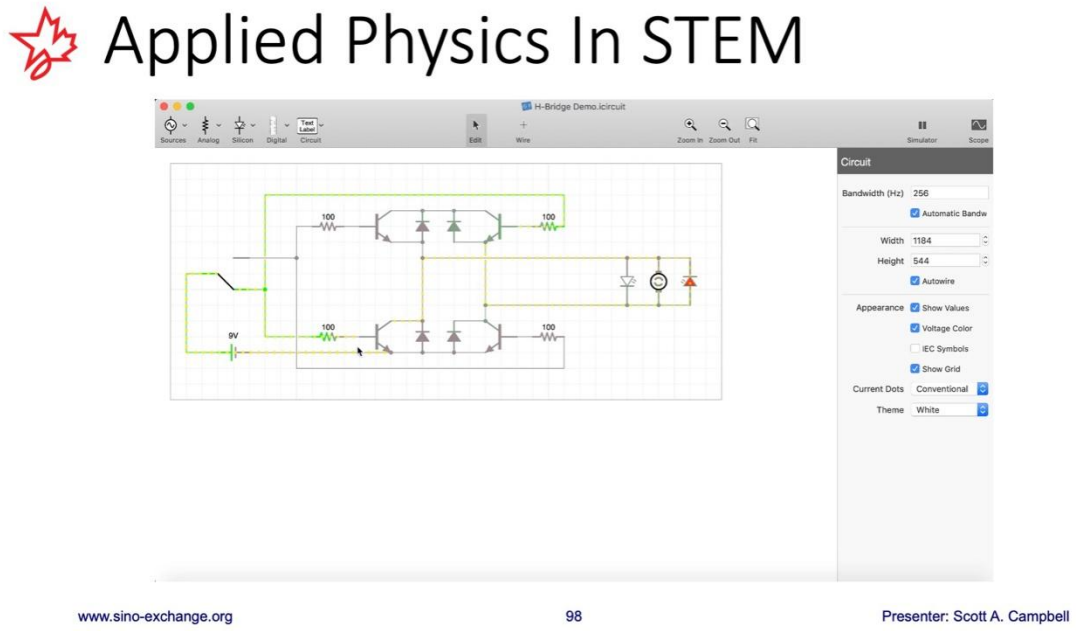
Now if you are not sure how a full wave rectifier works, don't worry, because we are going to watch a simulation of this circuit together.	现在，如果你不确定全波整流器是如何工作的，不要担心，因为我们将一起观看这个电路的模拟。
So right now, you can see the flow of electrons flowing through the circuit, and we can see the values entering and exiting the capacitor changing rapidly. This is because the capacitor is charging and discharging as the potential difference in circuit changes. Therefore, when the power cycle is high the capacitor will start charging and storing power, and when the power cycle is low the capacitor will the start discharging that power to the rest of the circuit.	现在，你可以看到电子在电路中流动，我们可以看到进入和离开电容器的值迅速变化。这是因为电容器随着电路中电位差的变化而充电和放电。因此，当功率周期高时，电容器将开始充电并存储功率，当功率周期低时，电容器将开始将该功率放电到电路的其余部分。
Now if you are interested in learning more about these ideas, then you may be interested in watching this related webinar that we have posted online.	现在，如果你有兴趣了解更多关于这些想法，那么你可能有兴趣观看我们在网上发布的相关网络研讨会。



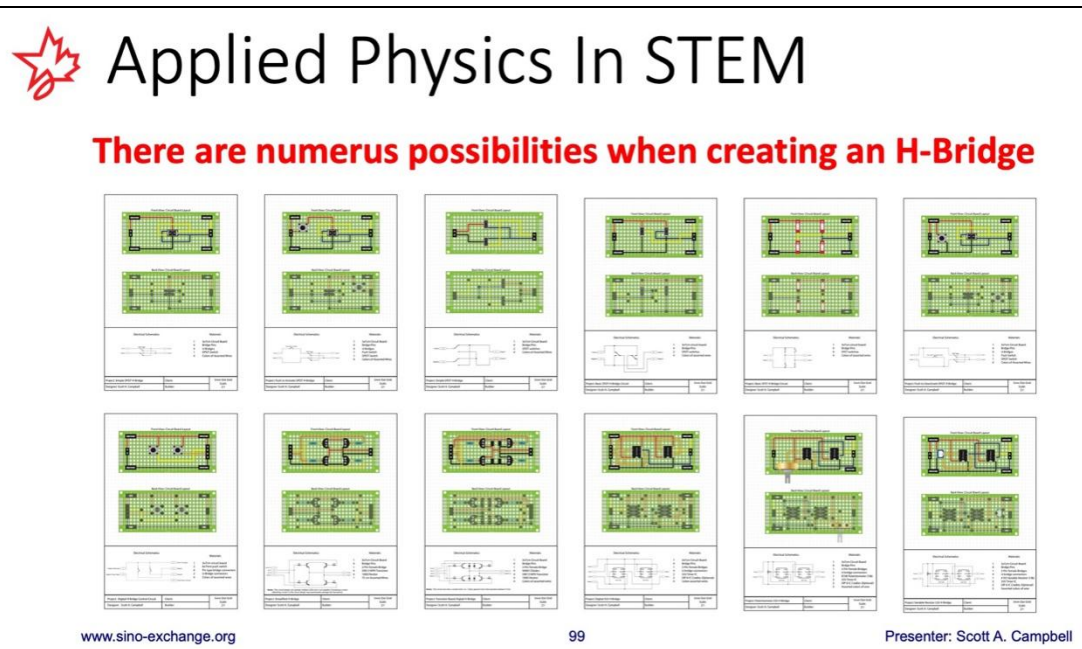
Next, we need to create a **DC motor control circuit**. Now the simplest design uses a series of switches to control the direction in-which electrons flow through a DC motor, and this allows us to control which direction the motor will turn. This creates a circuit that looks like a "***capital H***". Therefore, these circuits are commonly referred to as an "***H-Bridge***".	接下来，我们需要创建直流电机控制电路。现在最简单的设计是使用一系列开关来控制电子流过直流电动机的方向，这样我们就可以控制电机的转动方向。 这就形成了一个看起来像"大写 H"的电路。因此，这些电路通常被称为"h 桥"。



Now there are numerous H-bridge designs, and these designs range significantly in their sophistication.	现在有许多 h 桥设计，这些设计的复杂程度差别很大。
For instance, basic **H-Bridge** designs can be created using simple switches, and these rudimentary designs allow an operator to change the direction a motor turns. However, more advanced designs such as the **diode-based H-bridge** designs which are shown to the right can be controlled by a digital microcontroller. Moreover, various H-Bridge designs will provide different levels of functionality. While some DC control circuits only provide 2 states (i.e., forwards & backwards), other circuit designs will also provide a neutral state.	例如，基本的 h 桥设计可以使用简单的开关来创建，这些基本的设计允许操作员改变电机的旋转方向。然而，更先进的设计，如基于二极管的 h 桥设计，如图所示，可以由数字微控制器控制。此外，各种 H-Bridge 设计将提供不同级别的功能。虽然一些直流控制电路只提供两种状态(即向前和向后)，但其他电路设计也将提供中性状态。



Here is a short animation that shows how a diode-based H-bridge operates. You can see how the flow of electron changes direction in the circuit when the toggle switch is changed, and you can even have your students create these kinds of computer simulations for themselves using inexpensive CAD programs. For instance, this simulation has been created using **iCircuit.** However, you could also use **circuitlab.com** as to do this kind of activity as well.	这是一个简短的动画，展示了一个基于二极管的 h 桥是如何工作的。你可以看到当拨动开关改变时，电子在电路中的流动是如何改变方向的，你甚至可以让你的学生用便宜的 CAD 程序为自己创建这些类型的计算机模拟。 例如，这个模拟是用 icircuit 创建的。然而，你也可以使用 circuitlab.com 来做这种活动。



And there are so many different ways that you can design an ***H-Bridge***, and each design method will have its own advantages and disadvantages. Therefore, I like to do is have every student in a group build their own ***H-Bridge.*** Afterwards they will do a comparative analysis of all their circuits and select the best design for their cranes. Moreover, each student can select a design that is suitably challenging for themselves which means that differentiation is inherently built into this kind of activity. Furthermore, we are still requiring all our students to engage with the same learning outcomes, and that is what we really want to see from our differentiation methods.	设计 h 桥有很多不同的方法，每种设计方法都有自己的优点和缺点。因此，我喜欢做的是让每一个学生在一个小组中建立自己的 h 桥。然后，他们将对所有电路进行比较分析，并为他们的起重机选择最佳设计。 此外，每个学生都可以选择适合自己的具有挑战性的设计，这意味着这种活动固有的差异化。此外，我们仍然要求所有的学生参与相同的学习成果，这是我们真正希望从我们的差异化方法中看到的。

Applied Physics In STEM

Developing A Safety Light Control System

Real cranes will have complex electrical circuits that include microcontrollers, surge protectors, and relays circuits to control large high-powered lighting systems; however, a scaled down version of the control circuit can be created using a 555 timer. In "**Mode 1 - Astable**" the 555 timer can create an **oscillating square wave pulse.** This configuration is very useful when creating a wide variety of digital circuits, but more importantly it can provide a consistent output that can control the rate that safety lights on a crane will flash. Since ***the pulse rate of the circuit can be calculated in advance*** an electoral engineer can create a very ***specific interval*** for the flashing of the lights. That is how long the lights are **ON (Time High)** and **OFF (Time Low)**.

Parameter	Formula	Unit
T1 (Time High)	0.693 x (R1 + R2) X C1	Seconds (s)
T2 (Time Low)	0.693 x R2 x C1	Seconds (s)
T (Timer Period)	0.693 x (R1 + 2 x R2) x C1	Seconds (s)
F (Frequency)	1.44 / (R1 + 2 x R2) x C1	Hetz (Hz)
DC (Duty Cycle)	(T1 / T) x 100%	Percentage (%)

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And finally, the last circuit that is need is a **Timing Signal Generator** which is a circuit that will be used to control the safety light system in our model crane.

最后，我们需要的最后一个电路是时序信号发生器这个电路将用于控制我们模型起重机的安全灯系统。

Now one of the best ways to build this circuit is to use a 555 timer. Designed in 1971 by Hans Camenzind, the 555 timer is one of the most versatile and widely used integrated circuits ever made with over 1 billion units being sold annually as of 2017.

现在构建这个电路的最好方法之一是使用 555 定时器。由 Hans Camenzind 于 1971 年设计的 555 定时器是有史以来最通用和最广泛使用的集成电路之一，截至 2017 年，每年销售超过 10 亿部。

Now the 555 timer can be used in in 4 configurations. However, "Mode 1 Astable" is suitable for our needs as it will create a regular pulse that will cause our LED lights to flash. Furthermore, numerous formulas are used to calculate the necessary variables.

现在 555 定时器可以在 4 种配置中使用。然而，"模式 1 稳定"是适合我们的需要，因为它会产生一个规则的脉冲，将导致我们的 LED 灯闪烁。此外，还使用了许多公式来计算必要的变量。

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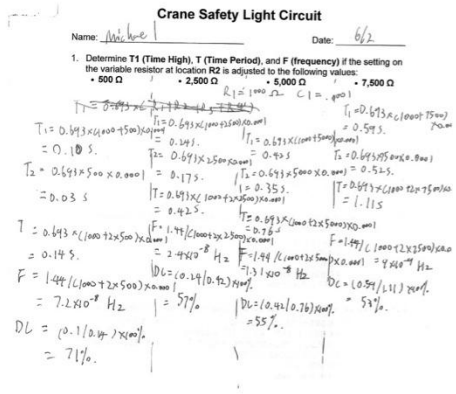
Timing Signal Generators (TSG)


Crane Safety Light Circuit

Name: Michael　Date: 6/2

1. Determine T1 (Time High), T (Time Period), and F (frequency) if the setting on the variable resistor at location R2 is adjusted to the following values:
   • 500 Ω　• 2,500 Ω　• 5,000 Ω　• 7,500 Ω

This simple 555 timer circuit can be used to produce a square wave in which the **T1 (High Time)** and the **T2 (Low Time)** can be calculated. This method of determining specific values ahead of time is used by electrical engineers to control the rate that an LED will blink.

This graph shows what is happening in this simple 555 timer circuit. In very simple terms the **capacitor (C1)** is constantly charging and discharging. This causes **Pin 6 (the trigger)** to be tripped. This then turns **PIN 3 (the output) ON** and then **OFF** again. This process of turning **Pin 3 ON and OFF** will happen as long as power is supplied to the circuit. This ***causes the LED light to blink***.

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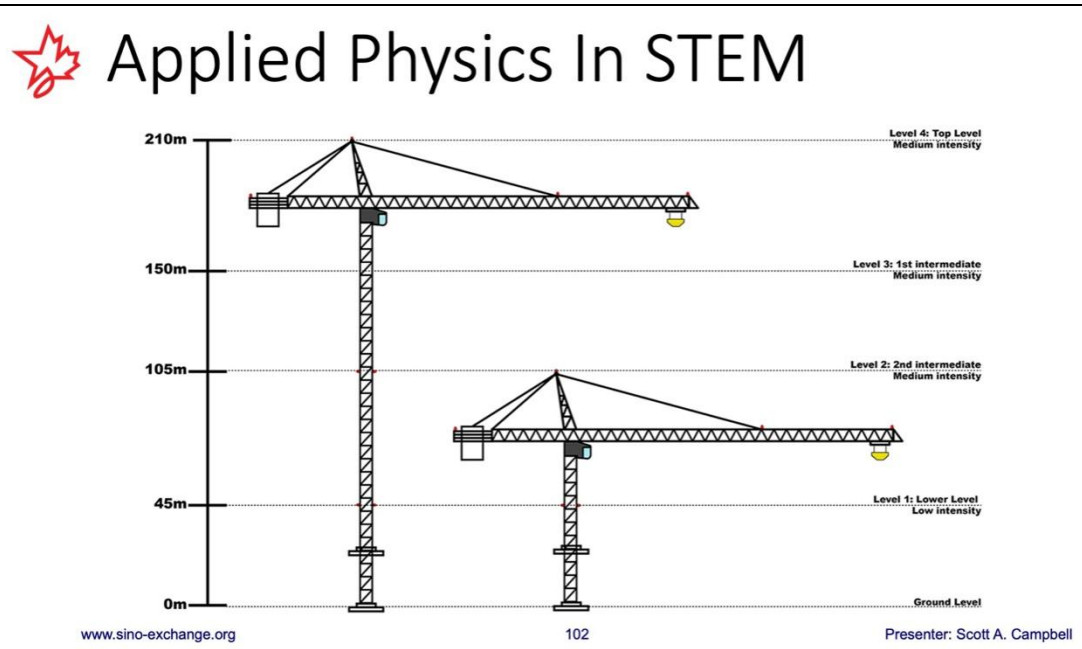
Here we can see what this circuit would look like, and there are a lot of things happening in this circuit as illustrate by this graph. But the concepts are not too hard to grasp if we properly model the theory before asking our students to apply it.	这里我们可以看到这个回路是什么样的，在这个回路中发生了很多事情正如这张图所示。但是，如果我们在要求学生应用理论之前对其进行适当的建模，这些概念就不会太难掌握。
So here you can see the calculations that the students used determine what components they needed to build their circuit, and these choices would have a direct effect on rate in-which their safety lights would flash.	在这里你可以看到学生们用计算来决定他们需要什么组件来构建他们的电路，这些选择将直接影响他们的安全灯闪烁的速度。



Moreover, there are standard regulations about the placement of safety lights that the students should take into consideration as well.	此外，还有关于安全灯的放置的标准规定，学生也应该考虑。

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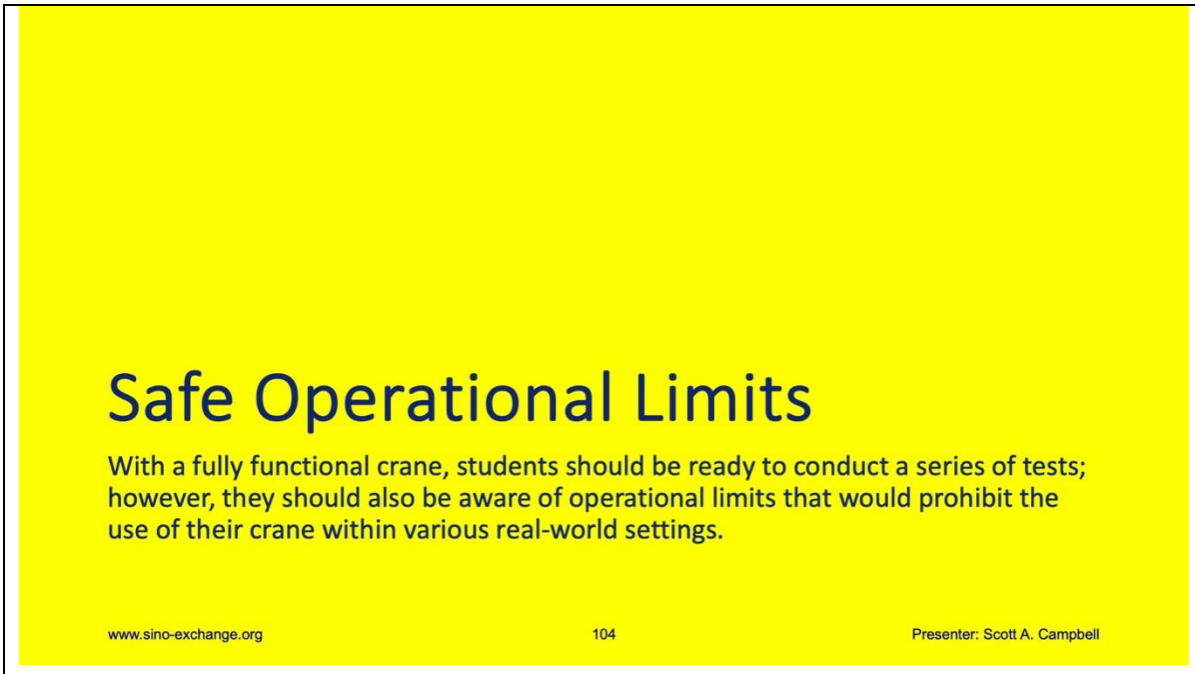
- At this point students should have a strong **working knowledge** of how control systems work, and how ***different systems interconnect***;
- This would include how a **full wave rectifier works**, the purpose of a **power stabilizer**, the advantages of different **DC motor control** circuits, and the use of a **timing signal generator (TSG)**.
- Moreover, students should have built and tested these circuits and have installed them as part of their final crane design.
- Additional tasks such as ***running cables through*** the **mast** and **jib** should have also been completed so that the ***lights*** and ***mechanical winch*** can be properly utilized at this point as well.

At this point we would have guided students though a compressive process of **guided inquiry-based learning**, and in this process, they would have developed:

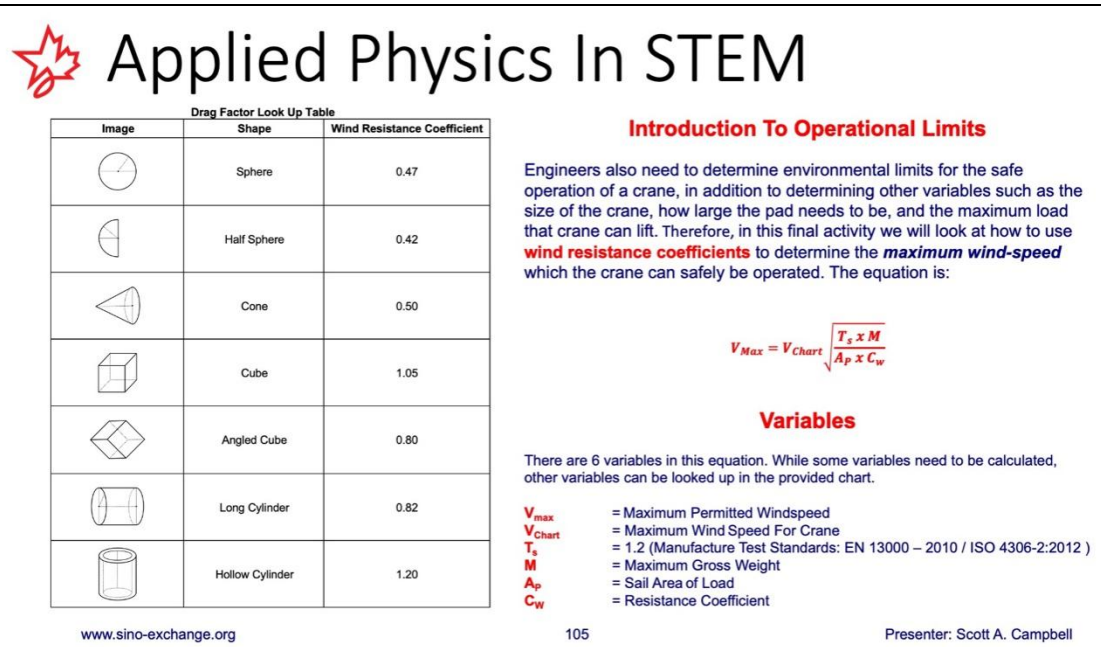
- A working knowledge of a number of different control systems and how these systems interconnect with one another.
- These systems would include: a full wave rectifier, power stabilizer circuits, DC motor control circuits, and a timing signal generator.
- Moreover, students should have built and tested all these circuits.
- And completed all the additional tasks necessary to install and make use of these circuits.

在这一点上，我们将引导学生通过引导探究性学习的压缩过程，在这个过程中，他们将发展:

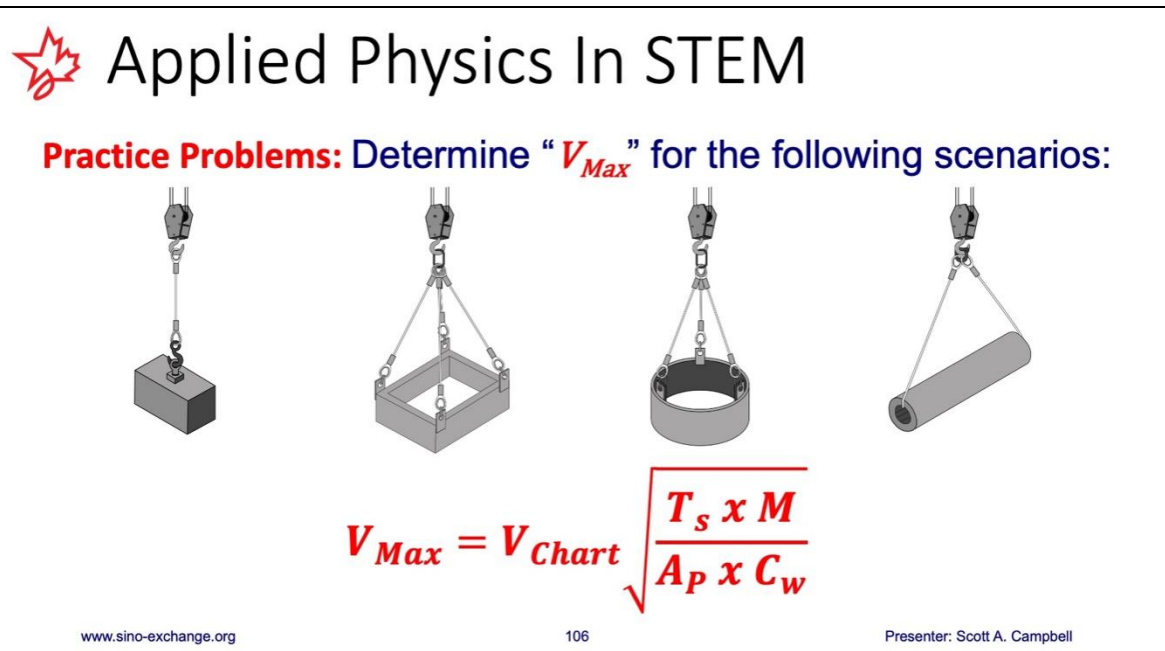
- 了解许多不同的控制系统以及这些系统如何相互连接。
- 这些系统将包括:全波整流器，功率稳定电路，直流电机控制电路和定时信号发生器。
- 此外，学生应该建立和测试所有这些电路。
- 并完成了安装和使用这些电路所需的所有额外任务。



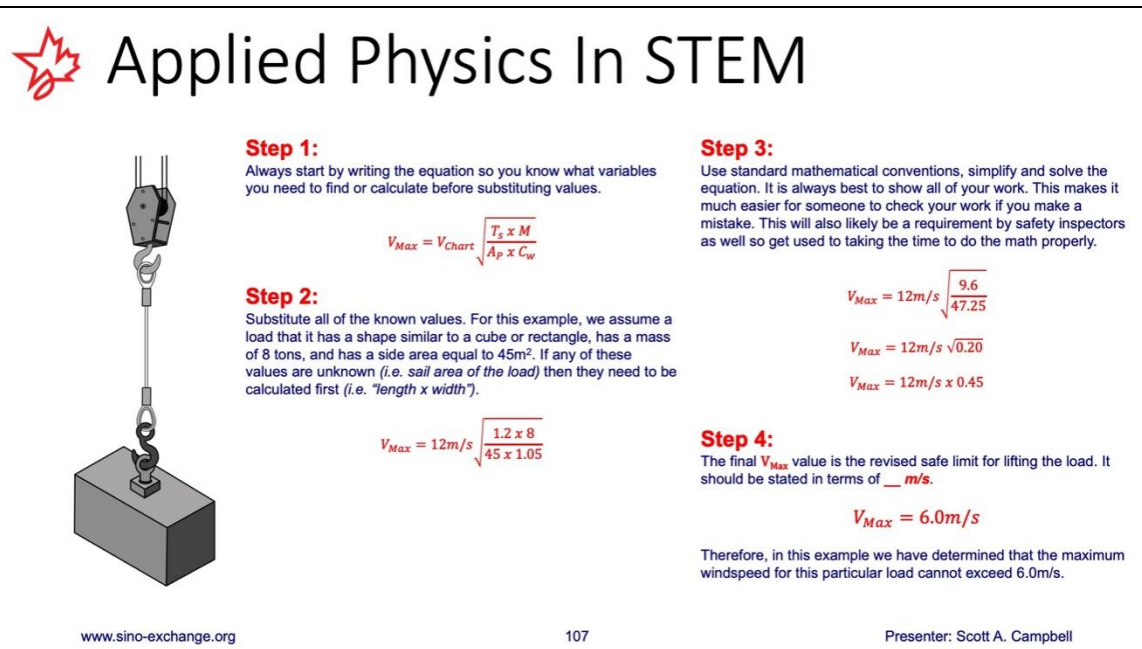
At this point your students should have a fully functional crane design. Therefore, they should be ready to start conducting a series of tests, and these tests should help them to evaluate the effectiveness of their crane designs. however, they should be aware of operational limits that would prohibit the use of their crane in a real-world setting. Therefore, there are still more teachable opportunities left in this project.	在这一点上，你的学生应该有一个功能齐全的起重机设计。因此，他们应该准备开始进行一系列的测试，这些测试应该帮助他们评估他们的起重机设计的有效性。然而，他们应该意识到操作限制，将禁止使用他们的起重机在现实世界的设置。因此，这个项目还有更多的可教的机会。



This formula will take environmental factors such as wind-speed and its effect on a load into consideration. Using standard wind resistance coefficients, an operator can determine at what point will it no longer be safe for the crane to be operated.	该公式将考虑风速等环境因素及其对荷载的影响。使用标准风阻系数，操作人员可以确定在什么情况下操作起重机不再安全。

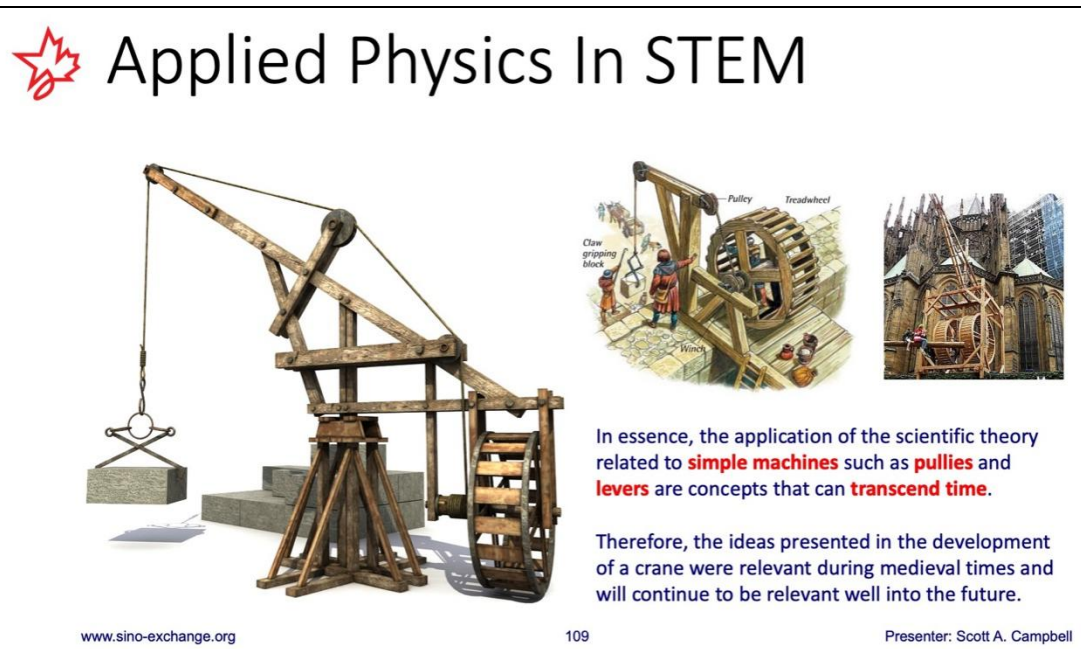


The first thing an operator will need to do is to evaluate the shape of the object that is going to be lifted. From there they will need to properly sling the load.	操作者需要做的第一件事是计算将要被举起的物体的形状。从那里，他们需要适当地吊起货物。
Now there are government regulations as to the number of slings, the minimum and maximum angles of the slings, and how the slings are attached to the load. Moreover, there are additional formulas to calculate the tension of each sling and these values are then compared against the tensile strength of cable.	现在政府对吊索的数量，吊索的最小和最大角度，以及吊索如何附着在荷载上都有规定。此外，还有额外的公式来计算每个吊索的张力，然后将这些值与电缆的抗拉强度进行比较。
However, I am going to skip over sling loads and go straight into window coefficients.	然而，我将跳过吊索载荷直接进入窗口系数。



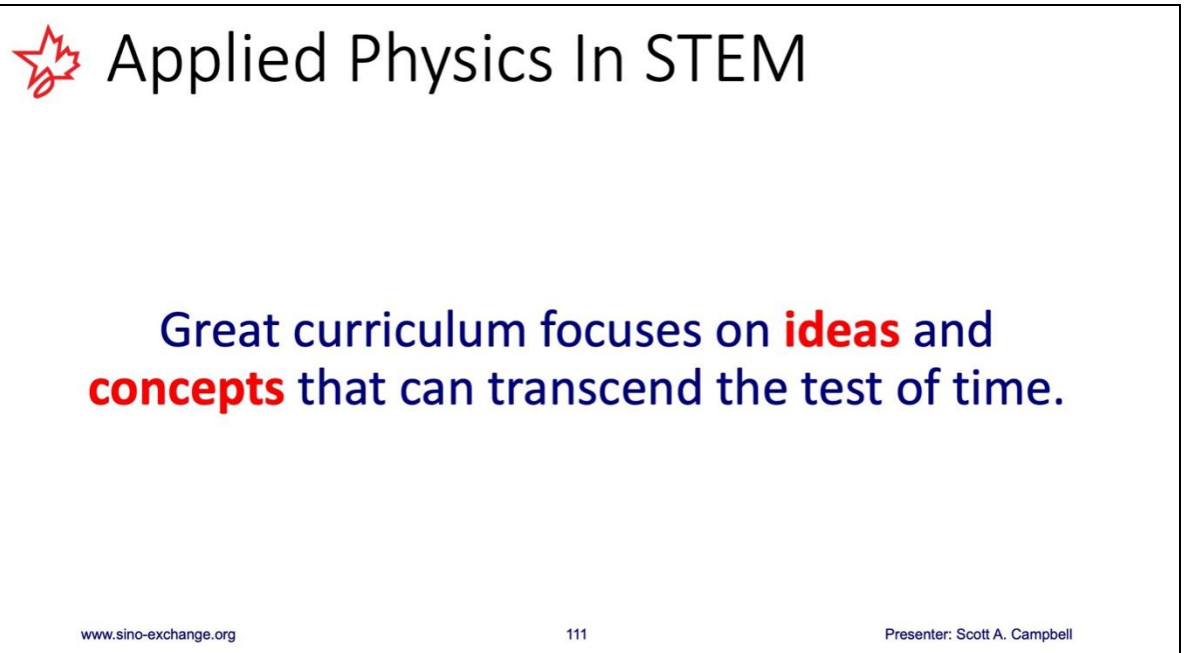
In our first example we have a relatively simple shape. We can start with the wind coefficient for a cube.	在第一个例子中，我们有一个相对简单的形状。我们可以从立方体的风系数开始。
Now the first step is to write the full equation and determine what our variables are. Next, we will substitute all the values into the equation. Then solve the equation, and we should always show every step in the process for good measure. And finally, state your final answer with the appropriate units.	现在第一步是写出完整的方程并确定变量是什么。接下来，我们将把所有的值代入方程。然后解这个方程，我们应该把这个过程中的每一步都展示出来。最后，用适当的单位陈述你的最终答案。
In this example the maximum wind speed was equal to 6 meters per second.	在这个例子中，最大风速等于每秒 6 米。

And that brings us to BIG IDEA #4, which is looking at developing a curriculum that can transcend the test of time.	这就引出了第 4 大理念，即开发一种能够超越时间考验的课程。



Cranes are not a new invention by any stretch of the imaginations. From the Roman Coliseums to medieval castles, levers, pullies, and complex machines like the crane have always been at the heart of innovation. Moreover, Renaissance scientist really advanced our understanding of these simple machines, and even to this day recreations of these ancient devices remain an academic curiosity for researchers. As you can see by this medieval crane in Prague outside of an old cathedral.	不管怎么想，起重机都不是什么新发明。从罗马竞技场到中世纪的城堡，杠杆、滑轮和像起重机这样的复杂机器一直是创新的核心。 此外，文艺复兴时期的科学家确实提高了我们对这些简单机器的理解，即使到今天，这些古老设备的娱乐仍然是研究人员的学术好奇心。正如你在布拉格一座古老大教堂外看到的这台中世纪起重机。

But fast forward to modern day and we can see the importance that cranes have to our society, and it might be evident that the use of the crane is actually more important today than it was a thousand years ago. Yet the underlying principals remain the same.	但快进到现代，我们可以看到起重机对我们社会的重要性，而且很明显，起重机的使用在今天实际上比一千年前更重要。然而，基本原则是一样的。
Therefore, I could easily go back in time 30 years and teach this same project and it would be completely relevant, and doable for that matter. As this project wasn't defined by the use of technology. Moreover, I can say with confidence that this project would be equally as relevant in 30 years from now as it is today, and in all honesty this project will continue to be relevant until such a point as we can refine the laws of physics with a breakthrough discovery that would be considered science fiction by today's standards.	因此，我可以很容易地回到 30 年前，教授同样的项目，这将是完全相关的，而且是可行的。因为这个项目不是由技术的使用来定义的。此外，我可以自信地说，从现在起的 30 年里，这个项目将和今天一样具有相关性，而且说实话，这个项目将继续具有相关性，直到我们可以用一个突破性的发现来完善物理定律，以今天的标准来看，这将被视为科幻小说。



Therefore, in summary, great curriculum focuses on ideas and concepts that can transcend the test of time and should not be driven by new technologies or fads.	因此，总而言之，优秀的课程关注的是能够超越时间考验的思想和概念，而不应该被新技术或时尚所驱动。
Yes, STEM will make use of technology. However, the use of technology must support the desired learning outcomes in an authentic way! We should not let the use of technology become the driving force in the development of our curriculum. Otherwise, we will likely make short sighted decision that will lead to unsustainable educational model.	是的，STEM 教育将利用技术。 然而，技术的使用必须以一种真实的方式支持期望的学习成果!我们不应该让技术的使用成为我们课程发展的动力。否则，我们可能会做出短视的决定，导致不可持续的教育模式。

So that brings us to the end of this presentation. In closing I would like to thank all of you for attending this presentation of Applied Physics In STEM. Moreover, I hope that you found this presentation informative, and I encourage you to consider attending our future in-service programs in the near future.	今天的演讲到此结束。 最后，我想感谢大家参加这次"STEM 教育中的应用物理"的演讲。此外，我希望这次演讲能给你带来信息，我鼓励你考虑在不久的将来参加我们未来的在职项目。