

## Case Study 3: SCALE-UP Version of Statics (EM 201)

Scott Schiff (Civil Engineering)

Statics is one of the foundation courses to any mechanics-oriented curriculum. A poor understanding of the material covered in a statics course will have severe detrimental impact on a student's ability to master follow-up material in many other courses. At Clemson and at most other institutions, statics is taken after a student has completed one semester of mechanics-based physics. In truth, many of the topics covered in physics are repeated again in this statics course, but with greater depth and more emphasis on problems solving skills.

Historically at Clemson, and likely at other institutions, Statics was taken by all engineering majors given that it was considered to be a fundamental course in engineering. In the past decade, some of the non-mechanics based majors have either dropped this course as a requirement or placed it on a restricted elective list. More recently the Mechanical Engineering Department at Clemson has combined two traditional 3-hour courses: Statics and Dynamics into one 5-hour course covering both topics in an integrated fashion. The impact of these recent changes is that the majority of the students now taking Statics (EM 201) at Clemson are Civil Engineering majors and the multiple sections are generally taught by civil engineering faculty.

In the late 1990's, the College of Engineering at Clemson developed a laptop program to investigate how the use of laptop computers could improve the teaching/learning experience of engineering students. A cohort of students opted to participate in this program and purchase laptop. My first EM 201 teaching assignment was to develop a laptop section of EM 201 for a class size of 18 to 24 students. The first offering augmented traditional lectures with the use of laptops in the class by using simulation software and other education software packages related to statics.

At the end of the first semester, I reevaluated the course and decided that the use of simulation software was not very effective since students perceived the simulations as simply animations without mathematical basis. I also noticed that many of the students had difficulty understanding concepts because they had limited physical experiences with statics concepts and also had difficulty visualizing many of the concepts. The following semester I introduced several hands-on team activities, similar to experiments assigned in physics labs. While I thought these activities were effective, the commitment of in-class lecture time was too demanding and students were getting short-changed on the working of example problems and thus had difficulty working homework problems.

The next generation of the course was to move the hands-on activities to out-of-class assignments and use the class period to lecture, work example problems on the board and assigned in-class problems that would be worked by small teams of students. These small problems focused on the basic and direct application of the material covered in the lecture – providing an opportunity to apply the lecture material under supervision of the instructor and the opportunity for peer instruction.

Today, I teach the class by generally having a mini-lecture covering the theory of the topic followed by working one or two simple example problems. I then assigned an in-class team activity of similar difficulty to the examples that were worked in class. At first, I was quite surprised by how simple these activities needed to be so that students were able to complete the activities in a timely manner. While

working an activity, I along with my teaching assistants are monitoring the activity of the class, helping individual teams work through the activity and when needed halting the activity to highlight a common misconception. After giving the students a reasonable amount of time to complete the activity, I work another example problem that requires a deeper understanding of the material and one that is more representative of the assigned homework. I no longer have students conduct the low-technology experiments, since the majority of my students are civil engineering majors that are now required to take a physics lab associated with the prerequisite mechanics-based physics course.

I have found the use of team-oriented active learning to be a very positive experience for the students, teaching assistants and instructor. One of the common concerns expressed by my colleagues is that I must not be covering as much material since I am using class time to complete activities. My response is that I cover the same amount of material as other instructors. I do confess that I work fewer example problems. Students benefit more by solving a problem with immediate assistance if needed, then watching a problem being worked with little opportunity for real input into the solution process. In addition, I can quickly assess their understanding of the material and decide if additional lecture time is warranted or if it is reasonable to move onto new material.

Some of the keys to success in using active learning are: 1) Begin slowly by introducing some active learning modules into some of your current lectures and understanding what works well in this active learning environment, 2) Use a classroom that is conducive to active team learning and monitoring of their activity, 3) Have enough “sharp” teaching assistants to be able to quickly respond to students’ request for assistance, and 4) Continually assess the effectiveness of each mini-lecture and activity and be prepared to make changes in subsequent offerings of the course to improve the delivery of material.

Attached to this document are two assignment sheets for in-class activities. One of the activities was used when I had students doing low-technology experiments. The second activity is a current version of an in-class activity that is completed after a mini-lecture on how to add vector quantities.

### 3. Moment about a Point in 2-D Space

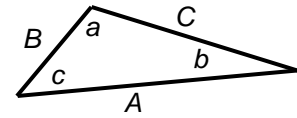
Objective: Observe and measure the moment about a point.

Materials: torque wrench, special flat bar, spring scale, protractor

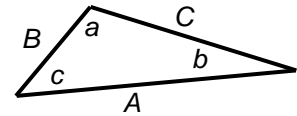
1. In your own words, define moment.
2. Moment about a point,  $M_o$  is equal to  $r \times F$ . The magnitude of this moment is equal to  $rF\sin\theta$  or  $Fd$ . Show the relationship between  $d$ ,  $r$ , and  $\theta$ .
3. Place the lever in a near horizontal position. If a force perpendicular to the lever is applied to the end of the lever, what is the moment arm about the socket of the torque wrench? Why?
4. If a force parallel to the lever is applied to the end of the lever, what is the moment arm about the socket of the torque wrench? Why?
5. Apply a 1-lb perpendicular force to the lever arm. From your *calculations*, what is the *theoretical* resulting moment?
6. From the *reading on the torque wrench*, what is the *measured* moment created by the 1-lb force?
7. Create a moment of 10 in-lbs. What is the required perpendicular force applied to the end of the lever?
8. If this same force were applied at the midpoint of the lever what would be the resulting moment?
9. What moment could be expected if the same force was directed along a direction not perpendicular to the torque wrench? Test this theory on the torque wrench.

### 4. Vectors

1. Assume you only know the length of sides  $B$  and  $C$  and the included angle  $a$ . What is the length of side  $A$  and interior angles  $b$  and  $c$ ?

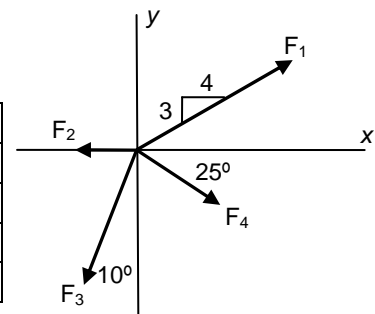


2. Assume you only know the length of side  $B$  and the interior angles  $a$  and  $b$ . What is the length of sides  $A$  and  $C$  and the interior angle  $c$ ?



3. Using the magnitudes given in the table below, calculate the x and y components for each force.

Force	Magnitude (N)	$F_x$ (N)	$F_y$ (N)
$F_1$	220		
$F_2$	70		
$F_3$	200		
$F_4$	120		



4. Write the force vectors  $F_1$  and  $F_4$  in terms of unit vectors.

*Personal Reflection of Activity: Can a rectangular component of a force ever exceed the magnitude of the force? Could the magnitude of a resultant force ever be smaller than the magnitude of any of the individual forces? Is it always possible to show the resultant force acting in the 1<sup>st</sup> or 2<sup>nd</sup> quadrant?*