

Description of VLMS

There are five modules in VLMS dedicated to the topics covered in the Statics course. The title of each module along with a sample of topics covered within it are shown in Table 1 below.

Table 1. Description of Statics modules and samples of corresponding topics

Module	Sample of Topics
<i>1. Concurrent Force Systems</i>	Trigonometry; Analytic geometry; Vectors; Force resultant; Newton's laws; Free-body diagram and equilibrium of particles under 2- or 3-dimensional loading condition
<i>2. Non-Concurrent Force Systems</i>	Distributed forces; Moments about a point and axis; Rigid supports; Free-body diagram and equilibrium of rigid bodies under 2- or 3-dimensional loading condition
<i>3. Trusses, Frames, and Machines</i>	Analysis of plane trusses, frames and machines
<i>4. Friction</i>	Static and kinetic friction; Single- and multi-body contact problems
<i>5. Geometric Properties of Shapes</i>	Centroid; Center of gravity; Area and mass moments of inertia; Radius of gyration

VLMS is designed to be learner-centered with a presentation style that demystifies the concepts many students find difficult to understand and to learn. It contains elements that highlight the relevance of course material to students in all engineering disciplines but more so to those in aerospace, biological, civil, and mechanical engineering. Its various features are designed to support almost all learning styles.

Among students who take Statics, some start with a weak foundation of prerequisite topics in trigonometry, calculus, and physics. Consequently, they tend to quickly fall behind their peers and do poorly in the course. In response to this problem, several sections in Module 1 are devoted entirely to the discussion of mathematics essential in developing the student's ability to work various problems discussed in the Statics course.

Each module has a main page similar to that shown in Fig. 1 with the corresponding table of contents shown in the left frame. The user can select any item on that list and see the corresponding content appear in the right frame.

- *Frequently-Asked Questions*

In all modules, the first item that appears in the left frame is a question. This is done to immediately engage the student in thinking about the topics he/she is about to study. This question is then followed by a list of other frequently asked questions and answers. Depending on the nature of a question, the answer is given either in textual form or in combination with figures and equations. The collection of questions—asked by former students—are used to form the initial list with continuous updates and expansion over time.

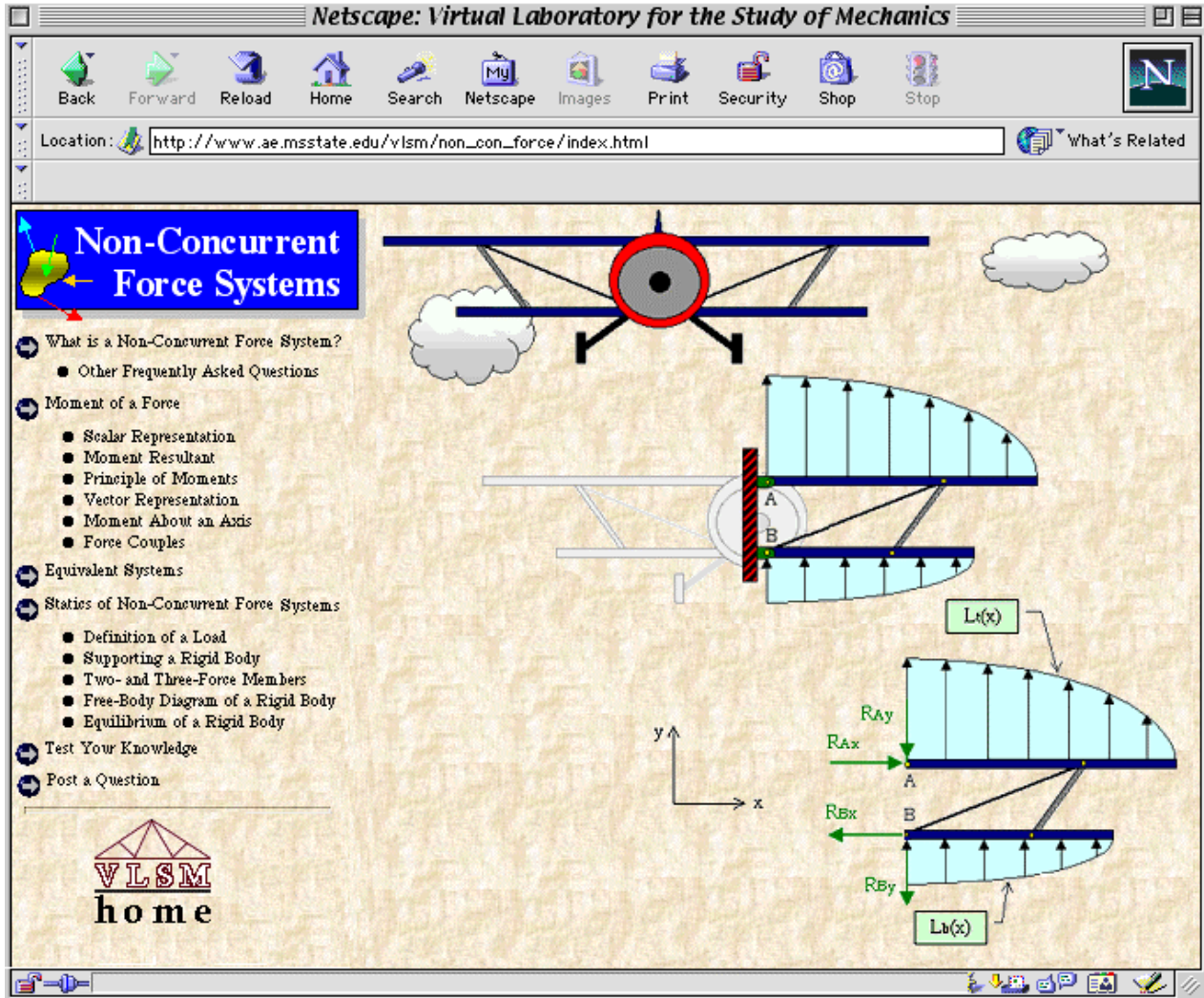


Fig. 1 View of the main page of the Non-Concurrent Force Systems module

- *Tutorial Discussions*

These discussions elaborate on specific topics in each module. They use a blend of text, figures, mathematical expressions, and in some cases interactive models and demonstrations. The interactive models are developed using the Macromedia's Flash/Shockwave software. They are designed to provide a vivid depiction of concepts that students find difficult to visualize and understand from still photos/drawings or textual descriptions found in most textbooks. The visual, and interactive features make the tutorial discussions particularly attractive to sensing, visual, and active learners. Figure 2 shows the tutorial discussion about the rigid supports. By clicking on a particular support, a new window appears. By clicking on the animate button, the general motion allowed by the support is animated and the free-body diagram of the connected member with reaction forces and possibly moments are drawn. There are a total of 20 animation or interactive models in the Statics modules of VLSM.

Netscape: Virtual Laboratory for the Study of Mechanics

Back Forward Reload Home Search Netscape Images Print Security Shop Stop

Location: http://www.ae.msstate.edu/vlsm/non_con_force/index.html What's Related

Non-Concurrent Force Systems

- What is a Non-Concurrent Force System?
 - Other Frequently Asked Questions
- Moment of a Force
 - Scalar Representation
 - Moment Resultant
 - Principle of Moments
 - Vector Representation
 - Moment About an Axis
 - Force Couples
- Equivalent Systems
- Statics of Non-Concurrent Force Systems
 - Definition of a Load
 - Supporting a Rigid Body
 - Two- and Three-Force Members
 - Free-Body Diagram of a Rigid Body
 - Equilibrium of a Rigid Body
- Test Your Knowledge
- Post a Question


VLASM
home

Statics of Non-Concurrent Force Systems

[Definition of a Load](#) | [Free-Body Diagram of a Rigid Body](#)

Supporting a Rigid Body: A rigid body is usually supported at one or more locations. These supports help keep the body in a stationary position. At a support location, the body exerts a load (action) on to the support and the support exerts an equal and opposite load (reaction) on the body.

As a general rule, **Movement Prevented = Reaction Created**
Click on the desired support type to see the animation and learn more...

				
Cable	Weightless Link	Smooth Contact	Pinned Collar	Fixed Collar
				
Rocker	Roller	Roller in Slot	Smooth Pin	Fixed Support

Rocker

A rocker is similar to a roller in terms of the support it provides to the rigid body. The reaction force acting on the body is perpendicular to the surface of contact.

Click to Animate



Fig. 2 Discussion of the rigid supports in the Non-Concurrent Force Systems module

- “Textbook-Style” Example Problems

These example problems demonstrate the analysis process and the application of solution techniques in a methodical and step-by-step fashion. However, unlike most textbooks, these examples describe all the intermediate steps and provide more explanations for various steps in the solution process, as shown in Fig. 3.

Statics of Non-Concurrent Force Systems
2-Dimensional Loading System: For a body under a two-dimensional loading system, the equations of equilibrium can be expressed in scalar form as

Example 7: For the beam and loading shown, determine the tension in the cable and the support reactions at A. Neglect the size of the pulley at C.

Solution: We begin the analysis by first drawing the free-body diagram of the beam. We remove the support A to reveal the reaction forces at that point. We also cut the cable at B and D to reveal the tension force in the cable.

Note that the cable is wrapped around a frictionless pulley, therefore, the tension in the cable is constant at every point along its length as indicated in the free-body diagram. We proceed by writing the equations of equilibrium and solving for the unknown forces. The distance between points C and D is $\sqrt{17}$ ft. Summing moments about point A gives

$$+\curvearrowright \sum M_A = 0 \Rightarrow T(8) - 400(12) + T\left(\frac{6}{\sqrt{17}}\right)17 - 800 = 0$$

The horizontal component of tension at D passes through point A, hence, it does not appear in the moment equation. Solving the above equation for T gives

$$T = 321.3 \text{ lb}$$

Having found the tension in the cable, we can now find the reaction forces at A by using the two force equilibrium equations.

$$+\rightarrow \sum F_x = 0 \Rightarrow R_{Ax} - \frac{9}{\sqrt{17}}T = 0 \Rightarrow R_{Ax} = 267.3 \text{ lb}$$

$$+\uparrow \sum F_y = 0 \Rightarrow R_{Ay} + T - 400 + \frac{6}{\sqrt{17}}T = 0 \Rightarrow R_{Ay} = -99.5 \text{ lb}$$

The negative sign in front of R_{Ay} indicates that it is directed in the opposite direction to that shown in the FBD.

Fig. 3 An example problem in the Non-Concurrent Force Systems module

While helpful to all, these examples are more appealing to sensing, visual, verbal, sequential, and reflective learners. The Statics modules of VLISM contain 43 such example problems.

- LiveMath Example Problems

These example problems differ from those in the previous group as they were developed using the Theorist Interactive's symbolic mathematical software LiveMath®. Although initially the solution is based on the data specified in the problem statement, LiveMath makes it possible for the user to alter the data directly from the browser window and immediately witness the changes reflected in every step of the solution as well as in the accompanying 3-dimensional graph, as shown in Fig. 4.

The screenshot shows a Netscape browser window titled "Virtual Laboratory for the Study of Mechanics". The address bar shows the URL "http://www.ae.msstate.edu/vlism/forcesys/". The page content is titled "Statics of Concurrent Force Systems" and "Example 8 (LiveMath)".

Example 8: A particle is under the action of three concurrent forces. The magnitudes and direction angles of two forces are known. Determine the magnitude and direction angles of the third force so that the particle is in equilibrium.

The diagram shows a 3D coordinate system with x, y, and z axes. Three forces are shown: F_a (red), F_b (green), and F_c (orange). The direction angles are labeled as θ_{ax} , θ_{ay} , θ_{bx} , and θ_{bz} .

Data: You can highlight and change any one of the following data and see the effect on the solution. Be careful not to delete the degree symbol when changing the value of an angle as that would cause an error in the solution.

$F_a = 500$ $\theta_{ax} = 65^\circ$ $\theta_{ay} = 30^\circ$
 $F_b = 650$ $\theta_{by} = 150^\circ$ $\theta_{bz} = 65^\circ$

Solution:

We begin by finding the x,y,z components of the known forces:

- Force F_a :** (Double click on the 'Q' symbol to see the content)
- Force F_b :** (Double click on the 'Q' symbol to see the content)

Equilibrium of forces requires the sum of all the forces to be zero. This means that the individual components must add up to zero as well.

$$\begin{aligned} F_{ax} + F_{bx} + F_{cx} &= 0 & \Delta F_{cx} &= 0 - (F_{ax} + F_{bx}) & \Delta F_{cx} &= -384.99 \\ F_{ay} + F_{by} + F_{cy} &= 0 & \Delta F_{cy} &= 0 - (F_{ay} + F_{by}) & \Delta F_{cy} &= 129.9 \\ F_{az} + F_{bz} + F_{cz} &= 0 & \Delta F_{cz} &= 0 - (F_{az} + F_{bz}) & \Delta F_{cz} &= -408.3 \end{aligned}$$

The magnitude of F_c is found as:

$$F_c = \sqrt{F_{cx}^2 + F_{cy}^2 + F_{cz}^2} \quad \Delta F_c = 576.02$$

The direction angles of F_c are:

The graph of the 3 forces acting on the particle is shown below. Force F_c is in orange.

The 3D graph shows the forces F_a , F_b , and F_c acting on a particle at the origin of a 3D coordinate system. The axes are labeled x, y, and z. The forces are represented by vectors originating from the origin. Force F_c is highlighted in orange.

The ability to change the data allows students to solve multiple problems based on a single LiveMath example. Students can, therefore, experiment with various "what if" scenarios. The ability to interact with the graph (e.g., rotate and zoom) enhances the visualization and understanding of the problem and its solution. These example problems are especially helpful to active, visual, and sensing learners. The Statics modules of VLISM contain 22 LiveMath example problems.

Fig. 4 A LiveMath example problem in the Concurrent Force Systems module

- *Test-Your-Knowledge Exercises*

In each test-your-knowledge exercise, as shown in Fig. 5, the student is asked to solve a particular problem and to input one or more numerical answers. When an answer is correct (within a specified margin of accuracy), the system responds with a positive message. More importantly, when an answer is wrong, the system responds with a hint as well as a link to the discussion that deals with topics related to that problem.

Trusses, Frames and Machines

Test Your Knowledge!

This section contains a collection of exercises for which you have to provide the answers.

Stability Assessment

Exercise 5

For the truss structure and loading shown, determine

- the support reactions,
- the internal forces in the six numbered members using the *Method of Joints*.

Also identify whether a member is in tension or compression.

$R_{1-x} = 4200 \text{ N}$ $R_{1-y} = \text{ } \text{ N}$ $R_{8-y} = \text{ } \text{ N}$

$F_{\text{①}} = \text{ } \text{ N}$ $F_{\text{②}} = \text{ } \text{ N}$ $F_{\text{③}} = \text{ } \text{ N}$

$F_{\text{④}} = \text{ } \text{ N}$ $F_{\text{⑤}} = \text{ } \text{ N}$ $F_{\text{⑥}} = \text{ } \text{ N}$

First Attempt

Sorry! Your answer for R_{1-x} is incorrect. Notice that there are two applied forces in the positive x direction, and there is no reaction at joint 8 in the x direction.

Second Attempt

Sorry! Your answer for R_{1-x} is incorrect. Check your equilibrium equation for forces in the x direction. There should be two 7000 N forces in that equation. Would you like to review the section on equilibrium? [Yes](#)

Third Attempt

Sorry! Your answer for R_{1-x} is incorrect. Here is how R_{1-x} is [calculated](#).

Fig. 5 A test-your-knowledge exercise in the Trusses, Frames, and Machines module

In each exercise, the student is given multiple opportunities to input an answer but will receive hints for up to three attempts. Each hint provides more helpful suggestions than the previous one with the final hint also containing a link to the solution. The hints in each exercise are based on a predetermined set of responses and do not involve artificial intelligence. The intent of these exercises is not to assign grades but to encourage students to improve their skills and competency in analysis of various problems and in application of solution techniques taught in the Statics course. As such, they are helpful to all learning styles. The Statics modules of VLISM contain 21 test-your-knowledge exercises.

- *Design and Analysis Tools*

In order to help stimulate higher-order thinking, as in synthesis and evaluation, we have developed two Java-based software tools for rapid development of alternative design models with accompanying analysis solutions. Figure 6 shows the Shape Design and Analysis Tool (S-DAT) in the Geometric Properties of Shapes module.

Analysis Results:

Total Area:	S = 126.0
Centroid:	Xc = 4.0
	Yc = 10.79
Centroidal Moments of Inertia:	Ixc = 5160.21
	Iyc = 2592.0
Product of Inertia:	Ixcyc = 225.0
Polar moment of inertia:	J = 7752.21
Radii of gyration:	pxc = 6.4
	pyc = 4.54
Polar radius of gyration:	pzc = 7.84
Principal moments of inertia:	Imax = 5179.78
	Imin = 2572.44
Orientation of principal axes:	Amax = -4.97 (deg)
	Amin = 85.03 (deg)

Shape: @1--Rectangle Added Successfully. x: 10

Warning: Applet Window

Fig. 6 Demonstration of S-DAT Java applet

With the help of S-DAT, students are able to generate a drawing model of any two-dimensional shape that can be formed using the available templates shown in Fig. 6. S-DAT would then analyze the model and provide numerical values for geometric properties such as centroid and area moments of inertia. S-DAT also allows the student to modify the model and to see the effects on the calculated geometric properties. One important feature that sets these tools apart from those previously developed is that they do not simply provide the final answers, but rather demonstrate a step-by-step solution sequence consistent with the methods and techniques taught in the course. Although helpful to all, these tools are of particular interest to sensing, visual, and global learners.

Although not as sophisticated as S-DAT, there is also a truss design and analysis tool (T-DAT) in the Trusses, Frames, and Machines module. In that case, students can choose any of the built-in truss models and go through the step-by-step solution sequence for solving for support reactions as well as for finding the member forces using the method of joints.

- Post a Question

If a student encounters a problem while using VLISM or thinks of a question to ask his/her instructor, he/she can send an e-mail to his/her instructor using the built-in message window in VLISM. This feature is set up to include the list of all instructors who are teaching Statics in a particular semester or summer session. Of these questions, those that could benefit other students are reformatted and added to the list of frequently-asked questions mentioned previously.

Effectiveness Assessment

The criteria we have established for evaluating the quality of VLISM and its effectiveness on student learning are outlined in Table 2 below.

Table 2. Criteria for evaluating the quality and effectiveness of VLISM

Constituency	Criteria
Students	<ul style="list-style-type: none"> • Views on VLISM's content presentation, clarity, and user friendliness. • Preference in using VLISM in addition to / instead of the textbook. • Interest in the course as a result of using VLISM. • Knowledge and comprehension of concepts in Statics. • Skills in analyzing problems and applying solution techniques.
Educators	<ul style="list-style-type: none"> • Views on VLISM's content and pedagogical style. • Use of VLISM as a preferred tool for in-class concept demonstrations and example problem discussions. • Willingness to experiment with instructional technology as a result of having access to VLISM.

VLSM Related Publications

- Rais-Rohani, M. “On Development, Application and Effectiveness of a Computer Based Tutorial in Engineering Mechanics (Statics),” Proceedings of the 2001 ASEE Annual Conference and Exposition, Albuquerque, NM, June 24-27, 2001.
- Rais-Rohani, M., “On Effectiveness of an Online Tutorial to Enhance Statics Instruction,” *Computers in Education Journal*, Vol. XI, No. 2, 2001, pp. 38-43.
- Rais-Rohani, M., “VLSM: An Online Tutorial for Solid Mechanics,” *Computers in Education Journal*, Vol. XI, No. 1, 2001, pp. 38-44.
- Rais-Rohani, M. and Brown, D., “Development of a Virtual Laboratory for the Study of Mechanics,” Proceedings of the ASEE Annual Conference and Exposition, St. Louis, MO, June 18-21, 2000.

Request to VLSM User Community

In an effort to improve the effectiveness of VLSM both as an asynchronous tutorial and a teaching tool, we solicit feedback from all who have used VLSM in any fashion. Please e-mail your comments and suggestions to Dr. Masoud Rais-Rohani (masoud@ae.msstate.edu).