SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ONTARIO

Sault College

COURSE OUTLINE

COURSE TITLE: *APPLIED MECHANICS – STATICS*

CODE NO. : *MCH 110*   **SEMESTER:** *TWO*

PROGRAM: *Mechanical Techniques – Industrial Maintenance*

AUTHORS: *GEOFFREY DISANO*

DATE: *January 2004*   **PREVIOUS OUTLINE DATED:**

APPROVED:

_____   _____
                    DEAN   **DATE**

TOTAL CREDITS: *4*

PREREQUISITE(S):

LENGTH OF COURSE: *4 hours per week*

I. COURSE DESCRIPTION:

The intention of this course is to introduce the student to a number of fundamental concepts of 'statics' which should prove useful to the mechanical technician student. The fundamental concepts are very important as they form the basis for other subsequent courses in mechanical technology.

Every effort will be made not to dwell on the theory of these concepts but to instead stress practical applications through the extensive use of problem solving and the presentation of the solutions in a style consistent with standard engineering practice.

II. LEARNING OUTCOMES AND ELEMENTS OF THE PERFORMANCE:

Upon successful completion of this course, the student will demonstrate the ability to:

1. ***Using the theorems, laws and functions of both right-angle and non right-angle trigonometry, and an understanding of basic algebra and geometry, solve 'force vector' problems.***
    Potential Elements of the Performance:

    - Write both a verbal and a mathematical statement of the basic principle known as the *Pythagorean theorem*.
    - Illustrate with a sketch of a right-angled triangle the accepted method of labeling both the sides and the angles of this triangle.
    - Recall the six trigonometric functions and apply these to simple *right-angled triangle* problems to solve for the lengths of unknown sides or the magnitude of unknown angles.
    - Recall both the *sine law* and the *cosine law* and apply these to the solution of triangles which are non-right-angled. Show that for a right-angled triangle the *cosine law* reduces to the *Pythagorean theorem*.
    - Recall the relationships that exist by way of conversion factors between the *S.I. metric* and the *Imperial system of units* for quantities such as length, mass, weight and force. Convert between systems of units using the *method of multiplying by ratios equal to one*.
    - Recall the two main concepts of *dimensional analysis* that an algebraic relationship involving quanties must satisfy.
    - Recall the basic rules of geometry involving: intersecting straight lines, *supplementary* angles, *complementary* angles, the relationships between angles when a straight line intersects two parallel lines, interior angles of a triangle, similar triangles and the equations for the circumference and the area of a circle.

2. ***Determine the 'resultants' and the 'equilibrants' of systems of forces both by adding the vector quantities and by adding the vector components.***

    Potential Elements of the Performance:

    - Define what is meant by a *scalar quantity* and list at least a dozen examples of *scalar quantities*.
    - Define what is meant by a *vector quantity* and list seven examples of *vector quantities.*
    - List the various types of forces along with their characteristics and the commonly used units for forces both in the S.I. metric and the Imperial system of units.
    - Describe what is meant by the *resultant* of a system of forces.
    - Describe what is meant by the *equilibrant* of a system of forces.
    - Using the method known as the *parallelogram method*, determine the *resultant* of two vector quantities using both a graphical and a mathematical approach.
    - Using the method known as the *string polygon method*, determine the *resultant* of two or more vector quantities using a graphical approach.
    - Given a vector quantity superimposed onto an x-, y-coordinate plane, resolve the vector into its two *orthogonal components*, namely its *x-component* and its *y-component*.
    - Determine the *resultant* of two or more vector quantities by the analytical method known as the *method of components.*

3. ***Determine the 'moment' of a force about a given point of rotation.***

    Potential Elements of the Performance:

    - Define what is meant by the '*moment*' or '*torque*' of a force about a given point of rotation.
    - Write the equation for determining the *moment* or *torque* of a force about a given point of rotation.
    - Calculate the *moment* of a force by:
      (a) multiplying the total force by its perpendicular distance to the point of rotation; &.
      (b) multiplying each of the force's components by their respective perpendicular distances to the point of rotation.
    - Determine the *resultant moment* for a system *of moments.*

- Name the three factors that together constitute what is known as a '*couple*'.
- Calculate the *moment* of a given *couple*.
- Replace a given *couple* with an equivalent *couple* at a different location.
- Analyze the effects of *couples* on a body.

4. ***Apply the "Three Conditions of Equilibrium" to determine unknown forces in various force systems.***

   Potential Elements of the Performance:

   - Write the 3 equations that represent the three requirements that must be met for a body to be in a state of '*static equilibrium*'.
   - Explain what is meant by a '*free body diagram*'.
   - List the assumptions or conventions that one must employ when drawing *free body diagrams* and replacing supports with equivalent supporting forces.
   - Construct a *free body diagram* for parts or the whole of given mechanisms or structures.
   - Differentiate between '*externally applied loads*' and '*internal reactions*'.
   - Apply the *three conditions of equilibrium* to *free body diagrams* and determine the reactions.
   - Describe what is meant by a '*two force member*' and explain the implications for a *free body diagram* involving such members.
   - Apply the principles of equilibrium to the solution of problems involving static systems of pulleys.
   - Describe what is meant by and solve problems involving '*coplanar concurrent force systems*'.
   - Explain the difference between what is known as a '*concentrated load*' and a '*distributed load*'.
   - Describe what is meant by and solve problems involving '*coplanar parallel force systems*' including both *uniform* and *non-uniform beam loading*.
   - Describe what is meant by and solve problems involving '*coplanar non-concurrent force systems*'.

5. ***Use the 'method of joints', the 'method of sections' and the 'method of members' to solve for the internal forces in structures such as 'trusses' and 'frames'.***

   Potential Elements of the Performance:

   - Recognize the difference between the forces of '*tension*' and '*compression*' in structural members such as *struts* and *ties*.
   - Differentiate between the structures known as '*trusses*' and those known as '*frames*'.
   - Identify '*members that carry no load*' in *trusses* and *frames.* Appreciate the importance of identifying such members in the solution of internal forces in structural members such as *trusses* and *frames*.
   - Describe what is meant by a '*two-force member*' and list the implications that this type of member has on the solution of forces in members of *trusses* and *frames*.
   - Describe what is meant by and list the assumptions that apply to, what is known as a '*pin connection*' in a *truss* or a *frame*.
   - Using the method known as the '*Method of Joints*', determine the loads in individual members of *coplanar pin-connected trusses* and frames being certain to identify whether the members are in *tension* or *compression*.
   - Using the method known as the '*Method of Sections*' determine the forces in <u>selected</u> members of a *truss* being certain to identify whether the members are in *tension* or *compression*. This will require the drawing of a *free body diagram* of a '*partial truss*' that is part of the entire truss.
   - Describe what is meant by a '*three-force member*' and identify clearly the difference between this type of member and the previously used '*two-force member*'.
   - Using the method known as the '*Method of Members*' determine the forces in members of various mechanisms being certain to identify whether the members are in *tension* or *compression*.

6. ***Determine forces and reactions in the members of three-dimensional structures.***
   Potential Elements of the Performance:
   - Explain what is meant by '*isometric sketching*' and use *isometric sketching* to aid in visualizing forces acting on mechanisms in three dimensions.

- Construct *isometric free body diagrams* of the whole or parts of three dimensional mechanisms.
- Apply the six basic equations of three dimensional equilibrium, $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma F_z = 0$, $\Sigma M_x = 0$, $\Sigma M_y = 0$, $\Sigma M_z = 0$, to the three-dimensional systems of: (a) Parallel forces,
  (b) Concurrent forces, &
  (c) Nonconcurrent forces.

7. ***Apply the laws of friction for dry surfaces to flat surfaces to determine if motion is impending and whether tipping or sliding will occur.***

   Potential Elements of the Performance:
   - Write the characteristics that pertain to the force known as the '*friction force*'.
   - Sketch the graph of the *friction force* versus the *applied force* when a force is applied to a block, initially at rest, on a horizontal, flat surface. The *applied force* starts at zero and increases gradually up to and beyond the point where the block begins to slide.
   - Indicate clearly the two distinct regions of the graph drawn above, namely, the '*static region*' and the '*kinetic region*'.
   - Explain what is meant by the '*coefficient of friction*'.
   - Write the equation for the '*coefficient of static friction*'.
   - Write the equation for the '*coefficient of kinetic friction*'.
   - Explain what is meant by the '*angle of friction*'.
   - Write the equation for the '*angle of friction*' in terms of the '*maximum force of static friction*' and the '*normal reaction force*' between the object and the surface upon which it rests.
   - Solve a variety of problems involving friction. These problems will include those that require the student to determine whether motion is impending or not. Also, solve those problems that require the student to determine whether tipping or sliding will occur.

8. ***Apply the concepts of 'centroids' and 'centre of gravity' to the solution of problems in two and three dimensions.***

   Potential Elements of the Performance:
   - Explain what is meant by the term '*centroid*'' of a figure.
   - Explain what is meant by the term '*centre of gravity*' of an object.
   - Describe, using an example, a situation where the *centroid* and the *centre of gravity* of an object coincide. Be certain to list the two conditions that must be met for this to be true.

- Describe, using an example, a situation where the *centroid* and the *centre of gravity* of an object do not coincide.
- Locate the *centroids* of simple areas such as squares, rectangles, triangles, circles, semicircles and quarter circles.
- Calculate the *centroids* of composite areas by breaking the composite area into a number of simple areas and using the *moments* about both the x- and y-axes.

III.   TOPICS:

1.   *Introduction*
        Mathematics of Mechanics
        Conversions of Units

2.   *Vector Analysis*
        Vector and Scalar Quantities
        Forces, Resultants and Equilibrants of force systems

3.   *Moments and Couples*

4.   *Equilibrium of Forces in Two Dimensions*
        The Three Conditions of Equilibrium

5.   *Structures and Members*
        Force Analysis of Structures using the 'Method of Joints', the 'Method of Sections' and the 'Method of Members'.

6.   *Structures and Mechanisms in Three Dimensions*

7.   *The Laws of Friction*
        Coefficients of Static and Kinetic Friction
        Impending Motion
        Sliding versus Tipping Motion

8.   *Centroids and Centres of Gravity in Two and Three Dimesions*

IV.   REQUIRED RESOURCES/TEXTS/MATERIALS:
Keith M. Walker,   APPLIED MECHANICS FOR ENGINEERING TECHNOLOGY, Seventh edition. **Prentice-Hall Publishers.   Toronto. 2000. ISBN: 0-13-093375-9**

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V.   EVALUATION PROCESS/GRADING SYSTEM:
Your final grade in MCH110 will be determined on the basis of *three tests* to be administered during the semester plus a number of **unannounced quizzes** and **attendance**. The marks for the **unannounced *quizzes*** and **attendance** will total 10%.   Each *test* will examine your knowledge of a number of topics and will be administered within one week of completing those topics. The topics covered in each of the three *tests* are as follows:

Test #1 ----- Topic Number I
Topic Number II
Topic Number III

Test #2 ----- Topic Number IV
Topic Number V
Topic Number VI

Test #3 ---- Topic Number VII
Topic Number VIII

The three *tests* are of equal weight. (i.e. **Each of the three tests is worth 30% of your final grade.**) As a result, ***provided you have received a passing grade on each of the unit tests**, your final grade will simply be the total of your three test results and your unannounced quiz results and attendance*. In order to obtain your letter grade the percentage-letter grade equivalents shown on page 9 will be used.
If your final average is below 50%, **_or_** if you have received a failing grade in one or more of the unit tests, whether you receive an 'X' (*Incomplete*) or an 'F' (*Fail*) grade is entirely at the teacher's discretion. The decision will be based upon *your final average* (e.g. 32% **would** result in an F grade while 48% **might** result in an X grade); *your attendance* during the semester; *your attitude* while in the classroom; *your perceived level of effort* during the semester; etc..
In any case, should you find yourself with an X grade at the end of the semester, in order to upgrade your mark to a passing grade you will be required to write a "make-up" **examination *covering the entire course content***. *Should you receive a passing grade on the make-up exam (50% or higher) your X grade will be upgraded.* The best you can do after having received an X grade as a result of a failing average is a C! If you were required to write the make-up examination as a result of having failed one test you may substitute the exam result for this test result.
Prior to administering any test you will be notified a full week in advance. Should you, for any reason (*within reason of course*), not be able to be in attendance on a day for which the test has been scheduled it is ***your responsibility*** to notify the teacher **prior** to the test! *If your reasons are acceptable*, a date will be set during which you may write a *substitute* test or the one you have missed.

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The following semester grades will be assigned to students in postsecondary courses:

Grade	Definition	Grade Point Equivalent
A+	90 – 100%	4.00
A	80 – 89%	
B	70 - 79%	3.00
C	60 - 69%	2.00
D	50 – 59%	1.00
F (Fail)	49% and below	0.00

CR (Credit)	Credit for diploma requirements has been awarded.
S	Satisfactory achievement in field /clinical placement or non-graded subject area.
U	Unsatisfactory achievement in field/clinical placement or non-graded subject area.
X	A temporary grade limited to situations with extenuating circumstances giving a student additional time to complete the requirements for a course.
NR	Grade not reported to Registrar's office.
W	Student has withdrawn from the course without academic penalty.

VI.   SPECIAL NOTES:

Special Needs:
If you are a student with special needs (e.g. physical limitations, visual impairments, hearing impairments, or learning disabilities), you are encouraged to discuss required accommodations with your professor and/or the Special Needs office. Visit Room E1101 or call Extension 493 so that support services can be arranged for you.

Retention of Course Outlines:
It is the responsibility of the student to retain all course outlines for possible future use in acquiring advanced standing at other postsecondary institutions.

Plagiarism:
Students should refer to the definition of "academic dishonesty" in *Student Rights and Responsibilities*. Students who engage in "academic

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dishonesty" will receive an automatic failure for that submission and/or such other penalty, up to and including expulsion from the course/program, as may be decided by the professor/dean. In order to protect students from inadvertent plagiarism, to protect the copyright of the material referenced, and to credit the author of the material, it is the policy of the department to employ a documentation format for referencing source material.

Course Outline Amendments:
The professor reserves the right to change the information contained in this course outline depending on the needs of the learner and the availability of resources.

Substitute course information is available in the Registrar's office.

<include any other special notes appropriate to your course>

VII.   PRIOR LEARNING ASSESSMENT:

Students who wish to apply for advanced credit in the course should consult the professor. Credit for prior learning will be given upon successful completion of a challenge exam or portfolio.

VIII.   DIRECT CREDIT TRANSFERS:

Students who wish to apply for direct credit transfer (advanced standing) should obtain a direct credit transfer form from the Dean's secretary. Students will be required to provide a transcript and course outline related to the course in question.