VECTORS

Scalar product

The scalar product is used to find the angle between two vectors (or between two lines).

The formula for scalar product is
$$\mathbf{a} \cdot \mathbf{b} = ab\cos\theta \text{ (LEARN THIS!!)}$$
where a is the magnitude of $\mathbf{a}$, b is the magnitude of $\mathbf{b}$, and θ is the **angle** between vectors $\mathbf{a}$ and $\mathbf{b}$.

Note: The angle between two lines is the angle between their direction vectors.

The magnitude of a vector is its length. The magnitude of the vector $\begin{pmatrix} a \\ b \\ c \end{pmatrix}$ is $\sqrt{a^2 + b^2 + c^2}$.

The distance between 2 points A and B is $\left|\overline{AB}\right|$.

The vector equation of the line passing through the point (a, b, c) in the direction of the vector $l\mathbf{i} + m\mathbf{j} + n\mathbf{k}$ is: $\mathbf{r} = \begin{pmatrix} a \\ b \\ c \end{pmatrix} + t\begin{pmatrix} l \\ m \\ n \end{pmatrix}$

Note: t is a parameter and $\mathbf{r}$ is the position vector of a general point (x, y, z) on the line.

Lines are called *skew* if they do not intersect and if they are not parallel. So to prove that two lines are skew you prove they don't intersect.

Example:
Find the angle between the vectors
$3\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$ and $-4\mathbf{i} - \mathbf{j} + 3\mathbf{k}$.

Solution:
Step 1: Find the scalar product:
$$\begin{pmatrix} 3 \\ 2 \\ -2 \end{pmatrix} \cdot \begin{pmatrix} -4 \\ -1 \\ 3 \end{pmatrix} = -12 - 2 - 6 = -20$$

Step 2: Find the magnitude of each vector:
$$\left|\begin{pmatrix} 3 \\ 2 \\ -2 \end{pmatrix}\right| = \sqrt{9+4+4} = \sqrt{17}, \quad \left|\begin{pmatrix} -4 \\ -1 \\ 3 \end{pmatrix}\right| = \sqrt{16+1+9} = \sqrt{26}$$

Step 3: Use the formula for the scalar product:
$$\mathbf{a.b} = ab\cos\theta$$
$$-20 = \sqrt{17} \times \sqrt{26} \times \cos\theta$$
$$\cos\theta = \frac{-20}{\sqrt{17} \times \sqrt{26}} = -0.9513$$

So, $\theta = 162°$
There is also an acute angle between the lines. This is $180 - 162 = 18°$.

Example: a) Find the vector equation of line l_1 passing through the points A(1, -2, 6) and B(7, 1, -3).
b) A second line l_2 has equation
$$\mathbf{r} = (\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}) + s(4\mathbf{i} - 6\mathbf{j} + 2\mathbf{k}).$$
Show that line l_1 and l_2 are skew and find the angle between the lines.

Solution:
a) The direction of the line is
$$\overrightarrow{AB} = \mathbf{b} - \mathbf{a} = \begin{pmatrix} 7 \\ 1 \\ -2 \end{pmatrix} - \begin{pmatrix} 1 \\ -2 \\ 6 \end{pmatrix} = \begin{pmatrix} 6 \\ 3 \\ -8 \end{pmatrix}$$

The line passes through (1, -2, 6), so the equation is
$$\mathbf{r} = \begin{pmatrix} 1 \\ -2 \\ 6 \end{pmatrix} + t\begin{pmatrix} 6 \\ 3 \\ -8 \end{pmatrix}$$

b) To show lines are skew we show they can't intersect. We do this by writing the two vector equations equal to each other and attempting to solve the equations:
$$\begin{pmatrix} 1 \\ -2 \\ 6 \end{pmatrix} + t\begin{pmatrix} 6 \\ 3 \\ -8 \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} + s\begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}$$

NOTE: It is ESSENTIAL that the lines are written with different parameters.

We can form equations:
$$1 + 6t = 1 + 4s \rightarrow 6t - 4s = 0 \quad (1)$$
$$-2 + 3t = 2 - 6s \rightarrow 3t + 6s = 4 \quad (2)$$
$$6 - 8t = 3 + 2s \rightarrow 8t + 2s = 3 \quad (3)$$
Solving equations (1) and (2):
$$6t - 4s = 0 \quad (1)$$
$$6t + 12s = 8 \quad (2) \times 2$$
Subtract equations to remove t: $16s = 8$
So $s = 0.5$.
From equation (1), we then get $t = 1/3$.

To show they are skew lines, we must check that these values do not work in the 3rd equation:
$$8t + 2s = 8 \times \tfrac{1}{3} + 2 \times 0.5 \neq 3$$
Therefore the lines are skew.

We find the angle between the direction vectors:
$$\begin{pmatrix} 6 \\ 3 \\ -8 \end{pmatrix} \cdot \begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix} = 24 - 18 - 16 = -10$$
$$\left|\begin{pmatrix} 6 \\ 3 \\ -8 \end{pmatrix}\right| = \sqrt{36+9+64} = \sqrt{109} \text{ and } \left|\begin{pmatrix} 4 \\ -6 \\ 2 \end{pmatrix}\right| = \sqrt{56}$$

So $-10 = \sqrt{109} \times \sqrt{56} \times \cos\theta$
Therefore $\cos\theta = -0.12799 \Rightarrow \theta = 97.4°$
So the acute angle is $82.6°$.

Calculus And Vectors Appendiz

Gyula Béda,Imre Kozák,József Verhás

Calculus And Vectors Appendiz:

 Strength and Conditioning Gavin L. Moir,Moir,2015-02-27 Written for both the undergraduate graduate level student as well as practitioners in the field this text incorporates all programming aspects of strength and conditioning including training methods to develop muscular strength and power flexibility and the development of effective warm up regimens Performance analysis techniques in sport are introduced while the constraints led approach to motor skills acquisition is presented as a framework that can guide the development of practices for the strength and conditioning practitioner The biomechanical and motor skill acquisition concepts introduced in the text are then applied to fundamental movements including jumping landing and sprint running Key Features Provides a solid introduction to biomechanics pertinent to the study of human movements Discusses the performance analysis techniques in sport that can be used by the strength and conditioning practitioner to determine the physiological mechanical and technical demands of specific sports and also the assessment of the techniques used in the execution of sport specific skills Includes a critical review of the different approaches to motor skill acquisition Incorporates clear learning objectives and worked examples in each chapter that allow readers to apply the concepts to real life situations Discusses the application of the most recent research pertinent to concepts in each chapter Includes appendices to expand on some of the more complex mathematical techniques required to perform biomechanical analyses and useful resources to aid the student in locating and evaluating scientific evidence

 Classical Mechanics Matthew J. Benacquista,Joseph D. Romano,2018-02-27 This textbook provides an introduction to classical mechanics at a level intermediate between the typical undergraduate and advanced graduate level This text describes the background and tools for use in the fields of modern physics such as quantum mechanics astrophysics particle physics and relativity Students who have had basic undergraduate classical mechanics or who have a good understanding of the mathematical methods of physics will benefit from this book *Adhesion Measurement Methods* Robert Lacombe,2005-11-21 Adhesion Measurement Methods Theory and Practice provides practical information on the most important measurement techniques their unique advantages and disadvantages and the selection of the proper method for a given application It includes useful information and formulae on adhesion related matters such as driving force formulae for various m **An Elementary Treatise on Calculus** William Suddards Franklin,Barry MacNutt,Rollin Landis Charles,1913

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Popović,2000 Modern Introductory Electromagnetics relates physical principles to engineering practice with a number of application deriving mathematical tools from physical concepts when needed **Proceedings** ,1900 **Principles of Fluid Mechanics** Salamon Eskinazi,1968 *Global Differential Geometry: An Introduction for Control Engineers* B. F. Doolin,1982 **Electromagnetic Fields, Waves, and Numerical Methods** Zijad Haznadar,Željko Štih,2000 *Introduction to Continuum Mechanics for Engineers* Ray M. Bowen,1989-04-30 This textbook is intended to introduce engineering graduate students to the essentials of modern continuum mechanics The objective of an introductory course is to establish certain classical continuum models within a modern framework Engineering students need a firm understanding of classical models such as linear viscous fluids Navier Stokes theory and infinitesimal elasticity This understanding should include an appreciation for the status of the classical models as special cases of general nonlinear continuum models The relationship of the classical models to nonlinear models is essential in light of the increasing reliance by engineering designers and researchers on prepackaged computer codes These codes are based upon models which have a specific and limited range of validity Given the danger associated with the use of these computer codes in circumstances where the model is not valid engineers have a need for an in depth understanding of continuum mechanics and the continuum models which can be formu lated by use of continuum mechanics techniques Classical continuum models and others involve a utilization of the balance equations of continuum mechanics the second law of thermo dynamics and the principles of material frame indifference and material symmetry In addition they involve linearizations of various types In this text an effort is made to explain carefully how the governing principles linearizations and other approximations combine to yield classical con tinuum models A fundamental understanding of how these models evolve is most helpful when one attempts to study models which account for a wider array of physical phenomena Global Differential Geometry B. F. Doolin,1982 **Continuum Mechanics** Gyula Béda,Imre Kozák,József Verhás,1995 *Schaum's Outline of Mathematics for Physics Students* Robert Steiner,Philip Schmidt,2007-05-11 Confusing Textbooks Missed Lectures Tough Test Questions Fortunately for you there s Schaum s Outlines More than 40 million students have trusted Schaum s to help them succeed in the classroom and on exams Schaum s is the key to faster learning and higher grades in every subject Each Outline presents all the essential course information in an easy to follow topic by topic format You also get hundreds of examples solved problems and practice exercises to test your skills This Schaum s Outline gives you Practice problems with full explanations that reinforce knowledge Coverage of the most up to date developments in your course field In depth review of practices and applications Fully compatible with your classroom text Schaum s highlights all the important facts you need to know Use Schaum s to shorten your study time and get your best test scores Schaum s Outlines Problem Solved **Electrical Communication** ,1955

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