

Trigonometry *Without* Right Angles

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This article describes how trigonometric functions can be defined for non-right-angled triangles. In particular, the ratios *csin*, *ccos*, and *ctan*, corresponding to the sine, cosine, and tangent ratios, are defined for triangles containing a $\pi/3$ angle. Some of the implications are discussed, including the graphs of these functions and the small-angle approximations.

How important are right angles for trigonometry? The standard trigonometric functions are defined as the ratios of sides within right-angled triangles, but is this essential? On a square lattice it makes sense to draw right-angled triangles and label the sides 'opposite', 'adjacent', and 'hypotenuse', but what about on an *icosahedric* grid?

We will label the sides of a triangle containing a $\frac{\pi}{3}$ angle as 'adjacent' and 'opposite' to a given angle (θ in figure 1) and call the side opposite the $\frac{\pi}{3}$ angle the 'hypotenuse'. Then we can define 'equilateral' trigonometric functions *csin*, *ccos*, and *ctan* by analogy with the *sin*, *cos*, and *tan* functions.

We can express the e-trigonometric functions in terms of the ordinary trigonometric functions by using the sine rule and the cosine rule on the $\frac{\pi}{3}$ triangle. Using *o* for opposite, *a* for adjacent, and *h* for 'hypotenuse' in the $\frac{\pi}{3}$ triangle we have, from the sine rule, that

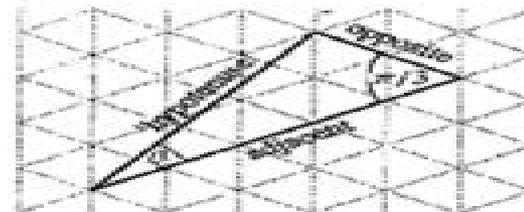
$$\frac{o}{\sin \theta} = \frac{h}{\sin(\frac{\pi}{3})} = \frac{a}{\sin(\pi - \frac{\pi}{3} - \theta)} \quad (1)$$

(a)



$$\begin{aligned} \sin \theta &= \frac{\text{opposite}}{\text{hypotenuse}} \\ \cos \theta &= \frac{\text{adjacent}}{\text{hypotenuse}} \\ \tan \theta &= \frac{\text{opposite}}{\text{adjacent}} \end{aligned}$$

(b)



$$\begin{aligned} \text{csin } \theta &= \frac{\text{opposite}}{\text{hypotenuse}} \\ \text{ccos } \theta &= \frac{\text{adjacent}}{\text{hypotenuse}} \\ \text{ctan } \theta &= \frac{\text{opposite}}{\text{adjacent}} \end{aligned}$$

Figure 1 (a) Trigonometry in a right-angled triangle; (b) e-trigonometry in a $\frac{\pi}{3}$ triangle.

Without Right Angles

James Manford Kerr



Without Right Angles:

Geometry without Axioms .. or, the first book of Euclid's Elements ... (By T. P. Thompson.) Fifth edition, with numerous alterations and additions, 1834 Passing the UKCAT and BMAT Rosalie Hutton, Glenn Hutton, Felicity Taylor, 2015-03-18 The most comprehensive guide available for the UKCAT and BMAT If you re an aspiring doctor or dentist this book is all you need to face the admissions tests with confidence and get in to medical or dental school whichever universities you re applying to Offering support for both the UKCAT and BMAT with hints and tips on how to pass the tests worked examples and guidance on technique this is your guide to success Inside you ll find Over 650 practice questions for the UKCAT and BMAT 2 full practice tests for focused revision Practice questions and guidance notes for the Situational Judgement section Guidance on applications and interviews including the personal statement Test taking strategies so you can practice and pass This text is your tool for extensive revision and question practice for the UKCAT and BMAT The practice tests replicate the format of the actual tests so you can tackle them under timed conditions and be fully prepared for the real thing A Round Indiana John T. Hanou, 2020-09-15 Rounds barns are architectural phenomena that have graced rural America for over a century Today the few that survive stand as symbols of another generation s innovation and ingenuity To understand the importance of these buildings is to begin to understand the story of farming in America A Round Indiana Round Barns in the Hoosier State Second Edition documents the 265 round barns identified in the history of Indiana This book contains more than 300 modern and historical photographs alongside nearly 40 line drawings and plans Author and award winning photographer John T Hanou combed through often forgotten documents to tell the fascinating story of the farmers builders and architects who championed the innovative construction techniques This second edition of A Round Indiana provides updated information on an additional 39 round barns discovered in Indiana s history Of the 265 total round barns found at one time on the plains of Indiana only 72 remain standing A Round Indiana is a tribute to the state s endangered buildings and a work to be treasured by those interested in the history of Indiana architecture and agriculture

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