## 3a. [1 mark]

Show that $\cot 2\theta = \frac{1-\tan^2\theta}{2\tan\theta}$.

Method 1

LHS

$\Rightarrow \frac{\cos 2\theta}{\sin 2\theta}$

$\Rightarrow \frac{\cos^2\theta - \sin^2\theta}{2\sin\theta\cos\theta}$

$\Rightarrow \frac{\cos^2\theta(1-\tan^2\theta)}{2\sin\theta\cos\theta}$

$\Rightarrow \frac{1-\tan^2\theta}{2\frac{\sin\theta}{\cos\theta}}$

$\Rightarrow \frac{1-\tan^2\theta}{2\tan\theta}$  D

Method 2

$\frac{1-\tan^2\theta}{2\tan\theta}$

$\Rightarrow \frac{1-\frac{\sin^2\theta}{\cos^2\theta}}{\frac{2\sin\theta}{\cos\theta}}$

$\Rightarrow \frac{\frac{\cos^2\theta-\sin^2\theta}{\cos^2\theta}}{\frac{2\sin\theta}{\cos\theta}}$

$\Rightarrow \frac{\cos 2\theta}{2\sin\theta\cos\theta}$

$\Rightarrow \frac{\cos 2\theta}{\sin 2\theta}$

$\Rightarrow \cot 2\theta$ □

## 3b. [7 marks]

Verify that $x = \tan\theta$ and $x = -\cot\theta$ satisfy the equation $x^2 + (2\cot 2\theta)x - 1 = 0$.

If $x = \tan\theta$ and $x = -\cot\theta$ are the solutions then they must satisfy the equation.

Case $x = \tan\theta$

$(\tan\theta)^2 + (2\cot 2\theta)\tan\theta - 1$

$\tan^2\theta + 2\left(\frac{1-\tan^2\theta}{2\tan\theta}\right)\tan\theta - 1$

$\tan^2\theta + 1 - \tan^2\theta - 1$

$0$

Thus $\tan\theta$ is the solution of $x^2 + (2\cot 2\theta)x - 1$

Case $x = -\cot\theta$

$(-\cot\theta)^2 + (2\cot 2\theta)(-\cot\theta) - 1$

$\cot^2\theta - 2\left(\frac{1-\tan^2\theta}{2\tan\theta}\right)\frac{1}{\tan\theta} - 1$

$\cot^2\theta - (\cot^2\theta - 1) - 1$

$\cot^2\theta - \cot^2\theta + 1 - 1$

$0$

Thus $-\cot\theta$ is the solution of $x^2 + (2\cot 2\theta)x - 1$

## 3c. [5 marks]

Hence, or otherwise, show that the exact value of $\tan\frac{\pi}{12} = 2 - \sqrt{3}$.

Let $\theta = \frac{\pi}{12}$   ∴ by part (b)  $x^2 + \left(2\cot\left(2\left(\frac{\pi}{12}\right)\right)\right)x - 1 = 0$

$\Rightarrow x^2 + 2\cot(\pi/6)x - 1 = 0 \Rightarrow x^2 + \frac{2}{\tan(\pi/6)}x - 1 = 0$

$\Rightarrow x^2 + \frac{2}{\frac{1}{\sqrt{3}}}x - 1 = 0 \Rightarrow x^2 + 2\sqrt{3}x - 1 = 0$

$\Rightarrow \frac{-(2\sqrt{3}) \pm \sqrt{(2\sqrt{3})^2 - 4(1)(-1)}}{2\cdot 1} \Rightarrow \frac{-2\sqrt{3}\pm\sqrt{12+4}}{2}$

$\Rightarrow \frac{-2\sqrt{3}\pm 4}{2} \Rightarrow -\sqrt{3}\pm 2$

$\tan\left(\frac{\pi}{12}\right) = 2 - \sqrt{3}$  (we take the value since $0 < \frac{\pi}{12} < \frac{\pi}{2}$ tan is +ve)

$\Rightarrow \cot\left(\frac{\pi}{12}\right) = \frac{1}{2-\sqrt{3}}$

$\Rightarrow \cot\left(\frac{\pi}{12}\right) = 2+\sqrt{3}$

$-\cot\left(\frac{\pi}{12}\right) = -2-\sqrt{3}$

$\Rightarrow \cot\left(\frac{\pi}{12}\right) = 2+\sqrt{3}$

## 3d. [6 marks]

Using the results from parts (b) and (c) find the exact value of $\tan\frac{\pi}{24} - \cot\frac{\pi}{24}$.

Give your answer in the form $a + b\sqrt{3}$ where $a, b \in \mathbb{Z}$.

To evaluate $\tan\frac{\pi}{24}$ let's use the equation from part (b) & result from part (c) ie $\tan\theta = 2-\sqrt{3}$

∴ in eq (b) above $\theta = \frac{\pi}{24} \Rightarrow x^2 + 2\cot\left(2\left(\frac{\pi}{24}\right)\right)x - 1 = 0$

$\Rightarrow x^2 + 2\cot\left(\frac{\pi}{12}\right)x - 1 = 0$

$\Rightarrow x^2 + 2(2+\sqrt{3})x - 1 = 0$

$\Rightarrow x^2 + (4+2\sqrt{3})x - 1 = 0$

$\Rightarrow \frac{-(4+2\sqrt{3})\pm\sqrt{(4+2\sqrt{3})^2 - 4(1)(-1)}}{2(1)}$

∴ $\tan\left(\frac{\pi}{24}\right) = \frac{-4-2\sqrt{3}\pm\sqrt{16+16\sqrt{3}+12+4}}{2} = \frac{-4-2\sqrt{3}\pm\sqrt{32+16\sqrt{3}}}{2}$

$\tan\left(\frac{\pi}{24}\right) = \frac{-4-2\sqrt{3}\pm 4\sqrt{2+\sqrt{3}}}{2} = \frac{-4-2\sqrt{3}+4\sqrt{2+\sqrt{3}}}{2} \Rightarrow -2-\sqrt{3}+2\sqrt{2+\sqrt{3}}$

∴ $-\cot\left(\frac{\pi}{24}\right) = -2-\sqrt{3}-2\sqrt{2+\sqrt{3}} \Rightarrow \cot\left(\frac{\pi}{24}\right) = 2+\sqrt{3}+2\sqrt{2+\sqrt{3}}$

∴ $\tan\left(\frac{\pi}{24}\right) - \cot\left(\frac{\pi}{24}\right) = -2-\sqrt{3}+2\sqrt{2+\sqrt{3}} - 2-\sqrt{3}-2\sqrt{2+\sqrt{3}} = \boxed{-4-2\sqrt{3}}$

$\tan\left(\frac{\pi}{24}\right) - \cot\left(\frac{\pi}{24}\right)$

$= -7.464101615...$  ✗

$-4 - 2\sqrt{3}$  ✗

$= -7.464101615...$

Note: We find the value $\tan\theta$ and $-\cot\theta$. For values $\theta = \frac{\pi}{12}$ and $\theta = \frac{\pi}{24}$ we chose the true values of $\tan\theta$ & $-\cot\theta$ because the angles are...

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**Ib Math Hl Trigonometry Practice Problems:**

*Learning and Understanding* National Research Council,Division of Behavioral and Social Sciences and Education,Center for Education,Committee on Programs for Advanced Study of Mathematics and Science in American High Schools,2002-08-06 This book takes a fresh look at programs for advanced studies for high school students in the United States with a particular focus on the Advanced Placement and the International Baccalaureate programs and asks how advanced studies can be significantly improved in general It also examines two of the core issues surrounding these programs they can have a profound impact on other components of the education system and participation in the programs has become key to admission at selective institutions of higher education By looking at what could enhance the quality of high school advanced study programs as well as what precedes and comes after these programs this report provides teachers parents curriculum developers administrators college science and mathematics faculty and the educational research community with a detailed assessment that can be used to guide change within advanced study programs **STEM Education for High-Ability Learners** Bronwyn MacFarlane,2021-09-23 STEM Education for High Ability Learners Designing and Implementing Programming focuses on the rigorous articulation of quality STEM education programming to develop STEM talent among high ability and gifted learners The intent of this book is to provide a comprehensive resource for educators designing and implementing each of the supports within STEM education by providing a discussion of each critical component for inclusion in a planned coherent and high quality sequenced system This edited volume provides a cutting edge discussion of best practices for delivering STEM education by experts in the field The contributing authors provide a differentiated discussion and recommendations for the learning experiences of gifted students in STEM education programs **Introduction to Optimization with Matlab® Examples** Jose Maria Giron-Sierra,2026-01-01 The textbook provides a comprehensive yet practical look at optimization theory and applications with examples and MATLAB programs The author introduces concepts and methods with mathematical formulations followed by clear examples The programs provided in MATLAB inserted in text being also downloadable are useful for practicing the methods on the given examples and for visualization of results Topics covered include Linear Programming or Calculus of Variations Quadratic Programming Integer Programming etc After presenting basics the book goes on to introduce further methodological steps like Interior Point methods Evolutionary approaches Multi objective Optimization and Decision making including Portfolio management Games and the application to sparse representations also related to Machine Learning and image processing The reader can easily take initiative exploring other examples or cases of own interest by using modifying the programs The book is addressed to upper undergraduate and graduate students of engineering mathematics and other sciences computer studies economics and management Catalog of Copyright Entries. Third Series Library of Congress. Copyright Office,1961 Includes Part 1 Number 1 2 Books and Pamphlets Including Serials and Contributions to Periodicals January December IB Math Analysis & Approaches HL: 300

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