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## Question: Using the properties of an inner product, prove that

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Using the properties of an inner product, prove that the Pythagorean Theorem holds for any “induced norm”. Specifically, show that if  $\|x\| = \sqrt{\langle x, x \rangle}$ , then for any  $x, y$  satisfying  $\langle x, y \rangle = 0$ ,  $\|x + y\|^2 = \|x\|^2 + \|y\|^2$ .

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## Expert Answer



Anonymous Chegg expert  
answered this

$$\begin{aligned} \text{Sol: } \langle x, y \rangle &= 0 \text{ and } \|x\| = \sqrt{\langle x, x \rangle} \rightarrow \text{Given} \\ \text{Consider, } \|x+y\|^2 &= \langle x+y, x+y \rangle \\ &= \langle x, x \rangle + \langle x, y \rangle + \langle y, x \rangle + \langle y, y \rangle \\ &= \|x\|^2 + 0 + 0 + \|y\|^2 \\ &= \|x\|^2 + \|y\|^2 \quad (\text{LP}) \end{aligned}$$

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Using the properties of an inner product, prove that the Cauchy-Schwarz inequality holds for any “induced norm”. =  $\langle x, y \rangle$ . (a) Specifically, show that if  $\|x\|_2 = \sqrt{\langle x, x \rangle}$ , then for any  $x, y$  we have  $|\langle x, y \rangle| \leq \|x\|_2 \|y\|_2$ . (Hint: Consider writing  $x$  as a linear combination of  $y$  and the vector  $z = x - \langle x, y \rangle \frac{y}{\|y\|_2^2}$ . What is  $\langle z, y \rangle$ ? What can we infer from the previous problem?) (b...

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