

MAT 67 Homework 1

Hardy Jones

999397426

Professor Bandyopadhyay

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1. Let a , b , c and d be fixed real numbers and consider the following system of linear equations in two real variables x_1 and x_2

$$ax_1 + bx_2 = 0$$

$$cx_1 + dx_2 = 0$$

Note that $x_1 = x_2 = 0$ is a solution of the above equations for any choice of a , b , c , and d .

Prove that if $ad - bc \neq 0$, then $x_1 = x_2 = 0$ is the only solution.

Proof. Assume $ad - bc \neq 0$

$$ax_1 + bx_2 = 0$$

$$cx_1 + dx_2 = 0 \tag{1}$$

Let's multiply the first equation by d and the second equation by b .

$$adx_1 + bdx_2 = 0$$

$$bcx_1 + bdx_2 = 0$$

Now let's subtract the second equation from the first.

$$adx_1 - bcx_1 = (ad - bc)x_1 = 0$$

We assumed that $ad - bc \neq 0$ so we can divide through by $ad - bc$.

$$x_1 = 0$$

Now we need x_2 . Let's go back to the system in (1).

$$ax_1 + bx_2 = 0$$

$$cx_1 + dx_2 = 0 \tag{1}$$

Now let's multiply the first equation by c and the second by a .

$$acx_1 + bcx_2 = 0$$

$$acx_1 + adx_2 = 0$$

Now let's subtract the first equation from the second.

$$adx_2 - bcx_2 = (ad - bc)x_2 = 0$$

Again, we assumed that $ad - bc \neq 0$ so we divide by $ad - bc$.

$$x_2 = 0$$

So $x_1 = x_2 = 0$. Thus if $ad - bc \neq 0$, then $x_1 = x_2 = 0$.

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2. Let $z, \omega \in \mathbb{C}$.

Prove:

$$|z - \omega|^2 + |z + \omega|^2 = 2(|z|^2 + |\omega|^2)$$

Proof. Given $z, \omega \in \mathbb{C}$,

$$\exists a, b, c, d \in \mathbb{R} : a + ib = z, c + id = \omega$$

$$\begin{aligned} |z - \omega|^2 + |z + \omega|^2 &= |(a + ib) - (c + id)|^2 + |(a + ib) + (c + id)|^2 \\ &= |(a - c) + i(b - d)|^2 + |(a + c) + i(b + d)|^2 \\ &= \sqrt{(a - c)^2 + (b - d)^2}^2 + \sqrt{(a + c)^2 + (b + d)^2}^2 \\ &= (a - c)^2 + (b - d)^2 + (a + c)^2 + (b + d)^2 \\ &= (a^2 - 2ac + c^2) + (b^2 - 2bd + d^2) + (a^2 + 2ac + c^2) + (b^2 + 2bd + d^2) \\ &= a^2 + a^2 + b^2 + b^2 + c^2 + c^2 + d^2 + d^2 + \cancel{2ac} - \cancel{2ac} + \cancel{2bd} - \cancel{2bd} \\ &= 2a^2 + 2b^2 + 2c^2 + 2d^2 \\ &= 2(a^2 + b^2 + c^2 + d^2) \\ &= 2(\sqrt{a^2 + b^2}^2 + \sqrt{c^2 + d^2}^2) \\ &= 2(|a + ib|^2 + |c + id|^2) \\ &= 2(|z|^2 + |\omega|^2) \end{aligned}$$

So $|z - \omega|^2 + |z + \omega|^2 = 2(|z|^2 + |\omega|^2)$.

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