

Proposición 8.6 (*Identidad de polarización*)

- i. Sea (V, \langle, \rangle) un \mathbb{R} -espacio vectorial con producto interno. Entonces para cada $v, w \in V$ vale:
 $\langle v, w \rangle = \frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2.$
- ii. Sea (V, \langle, \rangle) un \mathbb{C} -espacio vectorial con producto interno. Entonces para cada $v, w \in V$ vale:
 $\langle v, w \rangle = \frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2 + \frac{i}{4} \|v + iw\|^2 - \frac{i}{4} \|v - iw\|^2.$

Proof. i. Calculemos $\|v + w\|^2$ y $\|v - w\|^2$:

- $\|v + w\|^2 = \langle v + w, v + w \rangle = \langle v, v \rangle + \langle v, w \rangle + \overline{\langle w, v \rangle} + \langle w, w \rangle =$
 $= \langle v, v \rangle + 2 \langle v, w \rangle + \langle w, w \rangle = \|v\|^2 + 2 \langle v, w \rangle + \|w\|^2.$
- $\|v - w\|^2 = \langle v - w, v - w \rangle = \langle v, v \rangle - \langle v, w \rangle - \overline{\langle w, v \rangle} + \langle w, w \rangle =$
 $= \langle v, v \rangle - 2 \langle v, w \rangle + \langle w, w \rangle = \|v\|^2 - 2 \langle v, w \rangle + \|w\|^2.$

$$\Rightarrow \frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2 = \frac{1}{4} (\|v + w\|^2 + \|v - w\|^2) =$$

$$\frac{1}{4} (\|v\|^2 + 2 \langle v, w \rangle + \|w\|^2 - \|v\|^2 + 2 \langle v, w \rangle - \|w\|^2) = \frac{1}{4} (4 \langle v, w \rangle) = \langle v, w \rangle$$

- ii. En forma análoga a lo hecho en i, usando el hecho de que:

$$\frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2 = \mathbf{Re} \langle v, w \rangle.$$

Ahora, $\|v + iw\|^2 = \langle v + iw, v + iw \rangle = \langle v, v \rangle + \langle v, iw \rangle + \overline{\langle iw, v \rangle} + \langle w, w \rangle =$
 $\|v\|^2 + 2 \mathbf{Re} \langle v, iw \rangle + \|w\|^2 = \|v\|^2 + 2 \mathbf{Im} \langle v, w \rangle + \|w\|^2$ y, similarmente,
 $\|v - iw\|^2 = \|v\|^2 - 2 \mathbf{Im} \langle v, w \rangle + \|w\|^2.$

$$\Rightarrow \frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2 + \frac{i}{4} \|v + iw\|^2 - \frac{i}{4} \|v - iw\|^2 = \mathbf{Re} \langle v, w \rangle + \mathbf{Im} \langle v, w \rangle = \langle v, w \rangle.$$

$$\Rightarrow \frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2 + \frac{i}{4} \|v + iw\|^2 - \frac{i}{4} \|v - iw\|^2 = \langle v, w \rangle.$$

$$\Rightarrow \frac{1}{4} \|v + w\|^2 - \frac{1}{4} \|v - w\|^2 + \frac{i}{4} \|v + iw\|^2 - \frac{i}{4} \|v - iw\|^2 = \langle v, w \rangle.$$

Ejercicio 8. Sea V un espacio vectorial. Demuestra que la suma de dos productos internos sobre V es un producto interno sobre V .

Sol. Sea \langle, \rangle_1 y \langle, \rangle_2 dos productos internos sobre V .

Definimos $\langle, \rangle = \langle, \rangle_1 + \langle, \rangle_2$. Veremos que \langle, \rangle satisface las condiciones de producto interno.

Sea $v, w, x \in V$ y sea $\alpha \in \mathbb{R}$.

- a) $\langle v, v \rangle = \langle v, v \rangle_1 + \langle v, v \rangle_2 \geq 0$ ya que \langle, \rangle_1 y \langle, \rangle_2 son productos internos sobre V .
 $\langle v, v \rangle = 0$ si y sólo si $\langle v, v \rangle_1 = 0$ y $\langle v, v \rangle_2 = 0$.
 $\langle v, v \rangle_1 = 0$ si y sólo si $v = 0$ y $\langle v, v \rangle_2 = 0$ si y sólo si $v = 0$.
 $\langle v, v \rangle = 0$ si y sólo si $v = 0$.

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