

Theorem 6.3 (Mayer–Vietoris). *If X_1, X_2 are subspaces of X with $X = X_1 \cup X_2$, then there is an exact sequence*

$$\cdots \longrightarrow H_n(X_1 \cap X_2) \xrightarrow{(i_{1*}, i_{2*})} H_n(X_1) \oplus H_n(X_2) \xrightarrow{g_* - j_*} H_n(X) \xrightarrow{D} H_{n-1}(X_1 \cap X_2) \longrightarrow \cdots,$$



with i_1, i_2, g, j inclusions and $D = dh_*^{-1}q_*$, where h, q are inclusions and d is the connecting homomorphism of the pair $(X_1, X_1 \cap X_2)$.

PROOF. The following diagram of pairs of spaces commutes when all maps are inclusions:

$$\begin{array}{ccccc} (X_1 \cap X_2, \emptyset) & \xrightarrow{i_1} & (X_1, \emptyset) & \xrightarrow{p} & (X_1, X_1 \cap X_2) \\ \downarrow i_2 & & \downarrow g & & \downarrow h \\ (X_2, \emptyset) & \xrightarrow{j} & (X, \emptyset) & \xrightarrow{q} & (X, X_2). \end{array}$$

By Theorem 5.9, there is a commutative diagram with exact rows:

$$\begin{array}{ccccccccccc} \cdots & \longrightarrow & H_n(X_1 \cap X_2) & \xrightarrow{i_{1*}} & H_n(X_1) & \xrightarrow{p_*} & H_n(X_1, X_1 \cap X_2) & \xrightarrow{d} & H_{n-1}(X_1 \cap X_2) & \longrightarrow & \cdots \\ & & \downarrow i_{2*} & & \downarrow g_* & & \downarrow h_* & & \downarrow i_{1*} & & \\ \cdots & \longrightarrow & H_n(X_2) & \xrightarrow{j_*} & H_n(X) & \xrightarrow{q_*} & H_n(X, X_2) & \xrightarrow{d} & H_{n-1}(X_2) & \longrightarrow & \cdots \end{array}$$

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