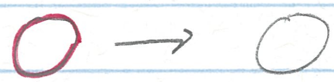
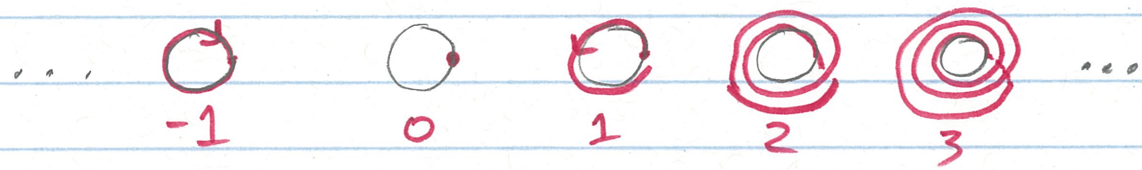
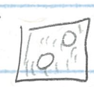
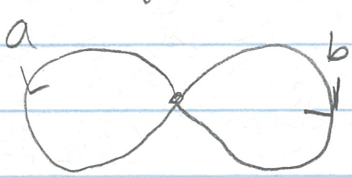
Incorrect Def $\pi_i(X)$ is the group of homotopy classes of maps $S^i \to X$

Ex $\pi_1(S^1) = \mathbb{Z}$ 



Group operation in π_1 is loop concatenation

Ex $\pi_1(\infty) = \pi_1($$) = \langle a, b \rangle$ is the free group on two generators (non-abelian)



Note $ab \neq ba$

Elements $ab^2a^{-1}b^{-3}$

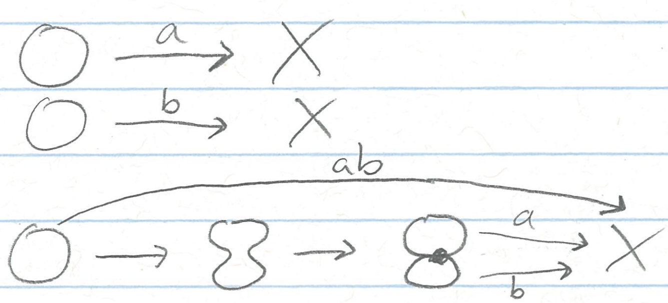
Note $ab^3a^{-2}a^2b = ab^3b = ab^4$

Multiplication $(aba^2) * (a^{-2}b^{-1}a^2)$

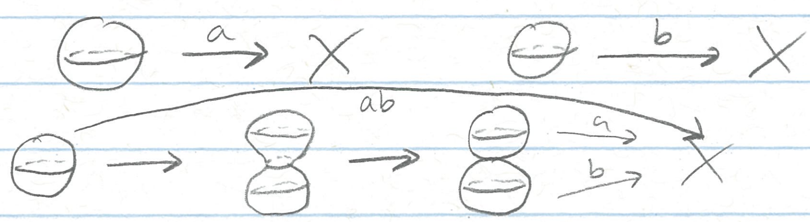
$= aba^2a^{-2}b^{-1}a^2 = abb^{-1}a^2 = a^3$

Ex What's group operation in π_i ?

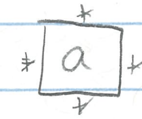
π_1

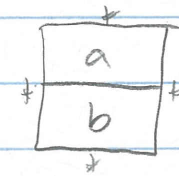


π_2



Why is π_i abelian for $i \geq 2$?

Data  $\xrightarrow{a} X$ is same as  $\longrightarrow X$

Data  $\xrightarrow{ab} X$ is same as  $\longrightarrow X$

Note