

Solutions to *Algebraic Topology**

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August 1, 2008

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1 The Fundamental Group

1.1 Basic Constructions

3. **Exercise.** For a path-connected space X , show that $\pi_1(X)$ is Abelian if and only if all basepoint-change homomorphisms β_h depend only on the endpoints of the path h .

Solution. Suppose that for any two paths g and h from x_0 to x_1 , the isomorphisms $\pi_1(X, x_0) \rightarrow \pi_1(X, x_1)$ given by $f \mapsto g^{-1}fg$ and $f \mapsto h^{-1}fh$ are the same. Now choose $f, f' \in \pi_1(X, x_0)$. We wish to show that $f'f = ff'$. Note that f' is homotopy equivalent to a composition gh^{-1} , where g and h are paths from x_0 to x_1 , for the following reason. We can pick any point y on the path f' and let p be a path from y to x_1 . Then the path from x_0 to y along f' composed with p is the desired g , and p^{-1} composed with the path from y to x_0 along f' is the desired

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