A. Let $X$ be path connected and $x, y \in X$. Suppose that $\pi_1(X, x)$ is commutative. Prove that, for any two paths $\alpha, \beta$ from $x$ to $y$, $\alpha_\# = \beta_\#$. (This is a medium-length exercise. It is half of Section 52 Exercise 3. You are invited, but not required, to do the other half.)

B. Section 52 Exercise 4. (This is a short exercise.)

C. Under the same hypotheses as Section 52 Exercise 4, let $i : A \hookrightarrow X$ be the inclusion. Prove that $i_*$ is injective. (This is a short exercise.)

If the preceding exercises B and C seem too easy — like maybe you're missing something — then apply that unsettled feeling to this question: If $x \in Y \subseteq X$ and $i : Y \hookrightarrow X$ is the inclusion, then is $i_*$ injective? (But I am not asking you to hand it in.)

D. Section 53 Exercise 4. (This is a medium-length-to-long exercise. My solution is a bit longer than most of my solutions are.)