(1) Hatcher 1.3.24 (if you did not submit it last week)

(2) Hatcher 1.3.25

(3) Hatcher 1.3.26

(4) Hatcher 1.3.27

(5) Hatcher 1.3.31

(6) Hatcher 1.3.32

7). A covering space \( p : E \to X \) induces an action of \( \pi_1(X, x_0) \) on \( p^{-1}(x_0) \); hence if \( |p^{-1}(x_0)| = n \), there is a group homomorphism \( \pi_1(X, x_0) \to S_n \), the group of permutations of a set with \( n \) elements.

a) Find all group homomorphisms \( \mathbb{Z} \to S_n \) that are realized by connected covering spaces of \( X = S^1 \); do the same for all covering spaces (not necessarily connected ones).

b) Repeat problem a) for group homomorphisms \( \mathbb{Z} \times \mathbb{Z} \to S_n \) for \( X = S^1 \times S^1 \).