**Exercise 13.** Let  $f: G \to H$  be a group homomorphism.

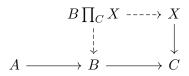
1. Let S be a subgroup of H. Find the pullback of

$$\begin{array}{c} S \\ & \downarrow \\ \text{inclusion} \\ G \xrightarrow{f} H \end{array}$$

2. Let N be a normal subgroup of G. Find the pushout of

**Exercise 14.** Let  $(X, \leq)$  be any poset, and F a Set-valued presheaf on X. Construct explicitly the limit and colimit of F. (In particular both limit and colimit exist.)

**Exercise 15.** In any category  $\mathcal{C}$  we are given the solid part of the following diagram.



Assume

- the pullback  $B \prod_C X$  exists in  $\mathcal{C}$ , as indicated by the dashed arrows in the diagram above, and
- the pullback  $A \prod_B (B \prod_C X)$  of the resulting left hand side of the diagram exists.

Show that the iterated pullback  $A \prod_{B} (B \prod_{C} X)$  is the pullback of the large square



given by composing the two lower arrows.

**Exercise 16.** In a preadditive category  $\mathcal{C}$ , assume two objects C and D have a biproduct  $C \oplus D$  as in the definition of additive categories.

Show that  $C \oplus D$  is both the product and the coproduct of C and D.