

1 Equalizers and Coequalizers

1.1 Equalizers

Proposition 1. In any category, if $e : E \rightarrow A$ is an equalizer of some pair of arrows, then e is monic.

Proof. Consider the diagram

$$\begin{array}{ccccc} E & \xrightarrow{e} & A & \begin{array}{c} \xrightarrow{f} \\ \xrightarrow{g} \end{array} & B \\ \uparrow x & & \nearrow z & & \\ Z & & & & \end{array}$$

in which we assume e is the equalizer of f and g . Supposing $ex = ey$, we want to show $x = y$. Put $z = ex = ey$. Then $fz = fex = gex = gz$, so there is a unique $u : Z \rightarrow E$ such that $eu = z$. So from $ex = z$ follows that $x = u = y$. \square

In SETS, the equalizer would just be the set $x \in A | f(x) = g(x)$.

Suppose $f, g : R^2 \rightarrow R$ where $f(x, y) = x^2 + y^2$ and $g = 1$. We take the equalizer, say in TOP, which is the subspace $S = (x, y) \in R^2 | x^2 + y^2 = 1 \rightarrow R^2$ which is the unit circle in the plane!

Awodey: In abelian groups though, using the fact that

$$f(x) = g(x)$$

iff

$$(f - g)(x) = 0$$

we know that the equalizer of f and g is the same as that of the homomorphism $(f - g)$ and the zero homomorphism $0 : A \rightarrow B$, so it suffices to consider equalizers of the special form $A(h, 0) \rightarrow A$ for arbitrary homomorphisms $h : A \rightarrow B$. This subgroup of A is the *kernel*.

Cook: In abelian groups: $G \xrightarrow[f]{Hom\phi} H$

$$E = \{g \in G | \phi(g) = f(g)\} = \{g \in G | \phi(g) = 1_{+1}\}$$

Is the kernel of a homomorphism by definition, also equalizers don't have to exist.

1.2 Coequalizers

$$\begin{array}{ccc} A & \rightrightarrows & B \xrightarrow{c} Q \\ & \searrow z & \downarrow u \\ & & Z \end{array}$$

This is the weakest equivalence relation that forces $f(a)$ relates $g(a) \forall a \in A$