

$$\begin{array}{ccc}
F_C(U) = \mathrm{Hom}_C(V, U) & \xrightarrow{F_M(U)=f_*} & F_C(W) = \mathrm{Hom}_C(V, W) \\
\varphi(U) \downarrow & \circlearrowleft & \downarrow \varphi(W) \\
G_C(U) = U & \xrightarrow{G_M(f)=f(\textit{underlying})} & G_C(W) = W
\end{array}$$