Exercise 3.5 Commutation of covariant derivatives

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{a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,q,r,s,t,u,v,w#}::Indices(position=independent).

\nabla{#}::Derivative.

expr :=   \nabla_{d}{\nabla_{c}{A_{a} B_{b}}}
        - \nabla_{c}{\nabla_{d}{A_{a} B_{b}}}.  # cdb(ex-0305.100,expr)

product_rule (expr)                             # cdb(ex-0305.101,expr)
distribute   (expr)                             # cdb(ex-0305.102,expr)
product_rule (expr)                             # cdb(ex-0305.103,expr)
factor_out   (expr,$A_{a?},B_{b?}$)             # cdb(ex-0305.104,expr)
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$$\begin{aligned}
\nabla_d\left(\nabla_c\left(A_a B_b\right)\right)-\nabla_c\left(\nabla_d\left(A_a B_b\right)\right) &= \nabla_d\left(\nabla_c A_a B_b + A_a \nabla_c B_b\right) - \nabla_c\left(\nabla_d A_a B_b + A_a \nabla_d B_b\right) && \text{(ex-0305.101)}\\
&= \nabla_d\left(\nabla_c A_a B_b\right) + \nabla_d\left(A_a \nabla_c B_b\right) - \nabla_c\left(\nabla_d A_a B_b\right) - \nabla_c\left(A_a \nabla_d B_b\right) && \text{(ex-0305.102)}\\
&= \nabla_d\left(\nabla_c A_a\right) B_b + A_a \nabla_d\left(\nabla_c B_b\right) - \nabla_c\left(\nabla_d A_a\right) B_b - A_a \nabla_c\left(\nabla_d B_b\right) && \text{(ex-0305.103)}\\
&= B_b\left(\nabla_d\left(\nabla_c A_a\right) - \nabla_c\left(\nabla_d A_a\right)\right) + A_a\left(\nabla_d\left(\nabla_c B_b\right) - \nabla_c\left(\nabla_d B_b\right)\right) && \text{(ex-0305.104)}
\end{aligned}$$