Test

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CURRENT ISSUES:
• Replacement issues
• ISSUES WITH NEGATIVES!!!!

QUESTION — should outside brackets have to be

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????

$$\partial_\mu A\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \tag{1}$$

$$\partial_\mu\Big(YA\partial_\nu h^{\mu\nu} + XA\partial^\mu h^\nu_\nu\Big) \tag{2}$$

Contract:

$$\partial_\mu A\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \tag{3}$$

1 Representation

Reading in and understanding equations (display initial equation)

Reading in signs between brackets

$$\Big(a\Big) + \Big(b\Big) \to \Big(a\Big) + \Big(b\Big) \tag{4}$$

$$\Big(a\Big) - \Big(b\Big) \to \Big(a\Big) - \Big(b\Big) \tag{5}$$

basic reading in signs inside brackets

$$b_\gamma - g_j \to \Big(b_\gamma - g_j\Big) \tag{6}$$

inside and outside brackets

$$A^\mu + \Big(A^\gamma - B^\zeta\Big) \to A^\mu + \Big(A^\gamma - B^\zeta\Big) \tag{7}$$

$$A^\mu - \Big(A^\gamma - B^\zeta\Big) \to A^\mu - \Big(A^\gamma - B^\zeta\Big) \tag{8}$$

with partial derivatives

$$\partial_\alpha\Big(a + \Big(b_\gamma - g\Big)\Big) \to \partial_\alpha\Big(a + \Big(b_\gamma - g\Big)\Big) \tag{9}$$

multiplied by a tensor

$$A^\mu + C^\epsilon\Big(A^\gamma - B^\zeta\Big) \to A^\mu + C^\epsilon\Big(A^\gamma - B^\zeta\Big) \tag{10}$$

complicated bracket nesting

$$\Big(\Big(a\Big) - \Big(b - \Big(c\Big)\Big)\Big) + \Big(\Big(a - d\Big) - b\Big) \to \Big(\Big(a\Big) - \Big(b - \Big(c\Big)\Big)\Big) + \Big(\Big(a - d\Big) - b\Big) \tag{11}$$

complicated bracket nesting and tensor indices

$$\left(\left(a\right) - \left(b - \left(c\right)\right)\right) + \left(\left(a^{\gamma} - d^{\gamma}\right) - b\right) \to \left(\left(a\right) - \left(b - \left(c\right)\right)\right) + \left(\left(a^{\gamma} - d^{\gamma}\right) - b\right) \tag{12}$$

complicated bracket nesting and tensor indices, multiplication, and partials

$$\partial_{\zeta}\left(G^{\gamma}\right)\partial^{\zeta}\Box\left(\left(A\right) - \left(B^{\kappa}_{\kappa} - \left(C\right)\right)\right) + \left(\left(A^{\gamma} - D^{\gamma}\right) - B^{\alpha\gamma}_{\alpha}\right) \\ \to \partial_{\zeta}\left(G^{\gamma}\right)\partial^{\zeta}\Box\left(\left(A\right) - \left(B^{\kappa}_{\kappa} - \left(C\right)\right)\right) + \left(\left(A^{\gamma} - D^{\gamma}\right) - B^{\alpha\gamma}_{\alpha}\right) \tag{13}$$

with equals sign

$$G^{\mu} = A^{\mu} + C^{\mu\epsilon}\left(A_{\epsilon} - B_{\epsilon}\right) \to G^{\mu} = A^{\mu} + C^{\mu\epsilon}\left(A_{\epsilon} - B_{\epsilon}\right) \tag{14}$$

with begin equation command

```
\begin{equation}
G^{\mu} = A^{\mu} + C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\)
\end{equation}
->
\begin{equation}
G^{\mu} = A^{\mu} + C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)
\end{equation}
```

with begin multline command (but short so it changes to equation)

```
\begin{multline}
G^{\mu} = A^{\mu} + C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\)
\end{multline}
->
\begin{equation}
G^{\mu} = A^{\mu} + C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)
\end{equation}
```

with begin multline command and long enough to stay multline

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\begin{multline}
G^{\mu} = A^{\mu} + C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\)  + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\)  + A^{\mu}
+\\ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+\\ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\) + A^{\mu}
+ C^{\mu \epsilon}\(A_{\epsilon} - B_{\epsilon}\)
\end{multline}
->
\begin{multline}
G^{\mu} = A^{\mu} + C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu} \\
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu} \\
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu} \\
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+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)+ A^{\mu}
+ C^{\mu \epsilon} \( A_{\epsilon} - B_{\epsilon} \)
\end{multline}
```

also print above to test what it looks like visually: output is

$$
\begin{multline}
G^{\mu} = A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} \\
+ C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} \\
+ C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} \\
+ C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) + A^{\mu} + C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) \quad (15)
\end{multline}
$$

each line could be longer before wrapping but I'm pretty happy with how it looks for now

with etas and deltas and fractions

$$7X\eta_{\mu\nu}\delta^{\gamma}_{\nu}\Box A^{\mu} + \frac{1}{3}\delta^{\gamma}_{\mu}C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) \rightarrow 7X\delta^{\gamma}_{\nu}\eta_{\mu\nu}\Box A^{\mu} + \frac{1}{3}\delta^{\gamma}_{\mu}C^{\mu\epsilon}\Big(A_{\epsilon} - B_{\epsilon}\Big) \quad (16)$$

multiple coefficients

$$\Big(XYZ\partial_{\nu}h^{\mu\nu} + 6bX\partial^{\mu}h^{\nu}_{\nu}\Big) \rightarrow \Big(XYZ\partial_{\nu}h^{\mu\nu} + 6bX\partial^{\mu}h^{\nu}_{\nu}\Big) \quad (17)$$

multiple coefficients in unusual order

$$\Big(XY\partial_{\nu}h^{\mu\nu}Z + b6X\partial^{\mu}h^{\nu}_{\nu}\Big) \rightarrow \Big(XYZ\partial_{\nu}h^{\mu\nu} + 6bX\partial^{\mu}h^{\nu}_{\nu}\Big) \quad (18)$$

breaks (is this good or no??)

$$A^{\alpha}\frac{1}{3}B_{\gamma} \rightarrow \text{ Equation: pop from empty list} \quad (19)$$

this one seems to work...

$$A^{\alpha}3B_{\gamma} \rightarrow 3A^{\alpha}B_{\gamma} \quad (20)$$

QUESTION: does multiplication always need brackets? If no, when does it need them? Why does the whole number work but the fraction breaks....

Please email jbrucero@uwo.ca for if you think this is a bug

*****things that shouldn't work
*** uneven brackets

$$\Big(A+B \rightarrow WORKING(thoughthemessagecouldbegreatlyimproved)''Equation : Pleaseemailjbrucero@uwo.caforifyouthinkth \quad (21)$$

*** uneven index brackets

$$A^{\{}\gamma \rightarrow Workinginthatitshoulderrorbutagaintheissuecouldprobablybecaughtearlierandabettermessagegiven)''Equation : string \quad (22)$$

$$A^{\gamma} + B^{\{} \rightarrow thisonereadstheequationfine - isthisanissue???\Big(A^{\gamma} + B\Big) \quad (23)$$

2 Multiply

2.1 FOIL out terms, distributing derivatives when necessary (recommended)

Basic case:

$$\Big(A\Big)\partial_{\mu}\Big(Y\partial_{\nu}h^{\mu\nu} + X\partial^{\mu}h^{\nu}_{\nu}\Big) \rightarrow \Big(YA\partial_{\nu}\partial_{\mu}h^{\mu\nu} + XA\partial^{\mu}\partial_{\mu}h^{\nu}_{\nu}\Big) \quad (24)$$

Also need to test adding summations, with and without partials, and subtracting summations, with and without partials

2.2 distribute partial derivatives

Basic case:

$$\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \to \Big(Y\partial_\nu\partial_\mu h^{\mu\nu} + X\partial^\mu\partial_\mu h^\nu_\nu\Big) \tag{25}$$

** number coefficients

$$\partial_\mu\Big(5\partial_\nu h^{\mu\nu} + 3\partial^\mu h^\nu_\nu\Big) \to \Big(5\partial_\nu\partial_\mu h^{\mu\nu} + 3\partial^\mu\partial_\mu h^\nu_\nu\Big) \tag{26}$$

** mixed coefficients

$$\partial_\mu\Big(5\partial_\nu h^{\mu\nu} + V\partial^\mu h^\nu_\nu\Big) \to \Big(5\partial_\nu\partial_\mu h^{\mu\nu} + V\partial^\mu\partial_\mu h^\nu_\nu\Big) \tag{27}$$

** product rule

$$\partial_\mu\Big(A^\gamma B^\zeta\Big) \to \Big(\partial_\mu A^\gamma B^\zeta + \partial_\mu B^\zeta A^\gamma\Big) \tag{28}$$

** three term product rule

$$\partial_\mu\Big(A^\gamma B^\zeta G^\alpha\Big) \to \Big(\partial_\mu A^\gamma B^\zeta G^\alpha + \partial_\mu B^\zeta G^\alpha A^\gamma + \partial_\mu G^\alpha B^\zeta A^\gamma\Big) \tag{29}$$

*** Distribute through multiple terms

$$\partial_\mu\Big(A^\gamma B^\zeta\Big)\partial_\alpha\Big(A_\gamma\Big) + \partial_\alpha\Big(G_{\mu\zeta}\Big) \to \Big(\partial_\mu A^\gamma B^\zeta + \partial_\mu B^\zeta A^\gamma\Big)\Big(\partial_\alpha A_\gamma\Big) + \Big(\partial_\alpha G_{\mu\zeta}\Big) \tag{30}$$

** multiple partials product rule

$$\partial_\alpha\partial_\gamma\Big(A^\alpha B^\gamma\Big) \to \Big(\partial_\alpha\partial_\gamma A^\alpha B^\gamma + \partial_\gamma B^\gamma\partial_\alpha A^\alpha + \partial_\alpha\partial_\gamma B^\gamma A^\alpha + \partial_\gamma A^\alpha\partial_\alpha B^\gamma\Big) \tag{31}$$

** product rule with squares

$$\Box\Big(A^\alpha B_\alpha\Big) \to \Big(\Box A^\alpha B_\alpha + \partial^\tau B_\alpha\partial_\tau A^\alpha + \Box B_\alpha A^\alpha + \partial^\tau A^\alpha\partial_\tau B_\alpha\Big) \tag{32}$$

******** also check with equals signssssss
It appears that numbers are working but symbolic coefficients are not
** non-tensor terms
** only partial terms

ALSO test product rule with multiple tensors!!!!

QUESTION: why num co, symco, AND tensorCos?? What happens with multiple coefficients???

2.3 FOIL out terms without distributing derivatives

Basic case:

$$\Big(A\Big)\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \to \Big(YA\partial_\nu h^{\mu\nu} + XA\partial^\mu h^\nu_\nu\Big) \tag{33}$$

Alternate cases:
*** constants that can move through the derivatives

$$\partial_\mu A\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \to \partial_\mu\Big(YA\partial_\nu h^{\mu\nu} + XA\partial^\mu h^\nu_\nu\Big) \tag{34}$$

$$A\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \to \partial_\mu\Big(YA\partial_\nu h^{\mu\nu} + XA\partial^\mu h^\nu_\nu\Big) \tag{35}$$

$$4\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^\nu_\nu\Big) \to \partial_\mu\Big(4Y\partial_\nu h^{\mu\nu} + 4X\partial^\mu h^\nu_\nu\Big) \tag{36}$$

*** multiple terms

$$\Big(A+5B+CD\Big)\partial_\mu\Big(Y\partial_\nu h^{\mu\nu}+X\partial^\mu h^\nu_\nu\Big) \to \partial_\mu\Big(YA\partial_\nu h^{\mu\nu}+5YB\partial_\nu h^{\mu\nu}+YCD\partial_\nu h^{\mu\nu}+XA\partial^\mu h^\nu_\nu+5XB\partial^\mu h^\nu_\nu+XCD\partial^\mu h^\nu_\nu\Big) \tag{37}$$

*** etas and deltas

$$\delta^{\gamma}_{\zeta}\eta^{\nu\alpha}\partial_\mu\Big(Y\partial_\nu h^{\mu\zeta} + X\partial^\mu h^{\zeta}_{\nu}\Big) \rightarrow \partial_\mu\Big(Y\delta^{\gamma}_{\zeta}\eta^{\nu\alpha}\partial_\nu h^{\mu\zeta} + X\delta^{\gamma}_{\zeta}\eta^{\nu\alpha}\partial^\mu h^{\zeta}_{\nu}\Big) \tag{38}$$

*** sum of mixed constants

$$\Big(A\eta^{\gamma\epsilon} + A5B + 56\delta^{\phi}_{\xi}\Big)\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) \rightarrow \partial_\mu\Big(YA\eta^{\gamma\epsilon}\partial_\nu h^{\mu\nu} + 5YAB\partial_\nu h^{\mu\nu} + 56Y\delta^{\phi}_{\xi}\partial_\nu h^{\mu\nu} + XA\eta^{\gamma\epsilon}\partial^\mu h^{\nu}_{\nu} + 5XAB\partial^\mu h^{\nu}_{\nu} + 56X\delta^{\phi}_{\xi}\partial^\mu h^{\nu}_{\nu}\Big) \tag{39}$$

TODO: decide on how partials behave then implement test cases for them
Question: do all nodes have summation objects or do some have multgroup objects?? – they appear to all be summation objects
*** derivative is attached to a multgroup and doesn't need to be distributed

$$\partial_\gamma A^\gamma\Big(Y\partial_\mu\partial_\nu h^{\mu\nu} + X\partial_\mu\partial^\mu h^{\nu}_{\nu}\Big) \rightarrow \Big(Y\partial_\gamma A^\gamma\partial_\mu\partial_\nu h^{\mu\nu} + X\partial_\gamma A^\gamma\partial_\mu\partial^\mu h^{\nu}_{\nu}\Big) \tag{40}$$

** with added term at the end

$$\partial_\mu A^\epsilon\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) + B^\epsilon \rightarrow \Big(Y\partial_\mu A^\epsilon\partial_\nu h^{\mu\nu} + X\partial_\mu A^\epsilon\partial^\mu h^{\nu}_{\nu} + B^\epsilon\Big) \tag{41}$$

***with subtracted term at the end

$$\partial_\mu A^\epsilon\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) - B^\epsilon \rightarrow \Big(Y\partial_\mu A^\epsilon\partial_\nu h^{\mu\nu} + X\partial_\mu A^\epsilon\partial^\mu h^{\nu}_{\nu} - B^\epsilon\Big) \tag{42}$$

*** test FOIL ability ** 2 terms

$$\Big(A^\epsilon + B^\gamma\Big)\Big(\partial_\mu X^\mu + M^{\nu\zeta}_{\gamma}\Big) \rightarrow \Big(A^\epsilon\partial_\mu X^\mu + A^\epsilon M^{\nu\zeta}_{\gamma} + B^\gamma\partial_\mu X^\mu + B^\gamma M^{\nu\zeta}_{\gamma}\Big) \tag{43}$$

** 3 terms

$$H\Big(A^\epsilon+B^\gamma\Big)\Big(\partial_\mu X^\mu+M^{\nu\zeta}_{\gamma}\Big)\Big(X+Y\Big) \rightarrow \Big(HXA^\epsilon\partial_\mu X^\mu+HYA^\epsilon\partial_\mu X^\mu+HXA^\epsilon M^{\nu\zeta}_{\gamma}+HYA^\epsilon M^{\nu\zeta}_{\gamma}+HXB^\gamma\partial_\mu X^\mu+HYB^\gamma\partial_\mu X^\mu+HX \tag{44}$$

TODO figure out the part with switching and write test cases for it
ALSO etas and deltas
** multgroup also has constant factor

$$B\partial_\gamma A^\gamma\Big(Y\partial_\mu\partial_\nu h^{\mu\nu} + X\partial_\mu\partial^\mu h^{\nu}_{\nu}\Big) \rightarrow \Big(BY\partial_\gamma A^\gamma\partial_\mu\partial_\nu h^{\mu\nu} + BX\partial_\gamma A^\gamma\partial_\mu\partial^\mu h^{\nu}_{\nu}\Big) \tag{45}$$

**** Shouldn't be distributed

$$A^\zeta\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) \rightarrow A^\zeta\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) \tag{46}$$

$$\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) + T^\gamma\Big(A_\gamma + B_\gamma\Big) \rightarrow \partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) + \Big(T^\gamma A_\gamma + T^\gamma B_\gamma\Big) \tag{47}$$

*** with added term at the end

$$A^\epsilon\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) + B^\epsilon \rightarrow A^\epsilon\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) + B^\epsilon \tag{48}$$

*** with subtracted term at the end

$$A^\epsilon\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) - B^\epsilon \rightarrow A^\epsilon\partial_\mu\Big(Y\partial_\nu h^{\mu\nu} + X\partial^\mu h^{\nu}_{\nu}\Big) - B^\epsilon \tag{49}$$

Is this sensical or non-sensical???

$$\Big(\partial_{alpha}\Big)\Big(A^\gamma B_\gamma\Big) - > LEADSTO\partial_{alpha}\Big(A^\gamma B_\gamma\Big) \tag{50}$$

What about...

$$\Big(\partial_\alpha\Big)\partial^\alpha\Big(A^\gamma B_\gamma\Big) - > LEADSTO\partial_\alpha\partial^\alpha\Big(A^\gamma B_\gamma\Big) \tag{51}$$

Also need to test adding summations, with and without partials, and subtracting summations, with and without partials

3 Contract

3.1 contract etas and deltas

$$\delta^{\gamma}_{\beta}\eta^{\nu\alpha}\partial_{\mu}h^{\mu}_{\alpha}\partial_{\nu}h^{\beta}_{\gamma} \rightarrow \partial_{\mu}h^{\mu\nu}\partial_{\nu}h^{\gamma}_{\gamma} \tag{52}$$

3.2 contract only deltas

Basic case:

$$\delta^{\nu}_{\alpha}\partial_{\mu}h^{\mu}_{\alpha}\partial_{\nu}h^{\gamma}_{\gamma} \rightarrow \partial_{\mu}h^{\mu}_{\alpha}\partial_{\alpha}h^{\gamma}_{\gamma} \tag{53}$$

3.3 contract only etas

Basic case:

$$\eta^{\nu\alpha}\partial_{\mu}h^{\mu}_{\alpha}\partial_{\nu}h^{\gamma}_{\gamma} \rightarrow \partial_{\mu}h^{\mu\nu}\partial_{\nu}h^{\gamma}_{\gamma} \tag{54}$$

Alternative cases:

4 Factor

4.1 factor out GCF

Basic case:

$$\Big(3Y\partial_{\nu}h^{\mu\nu} + Y\partial^{\mu}h^{\nu}_{\nu}\Big) \rightarrow Y\Big(3\partial_{\nu}h^{\mu\nu} + \partial^{\mu}h^{\nu}_{\nu}\Big) \tag{55}$$

Alternative cases:

$$\Big(X\partial_{\nu}h^{\mu\nu} + Y\partial_{\nu}h^{\mu\nu}\Big) \rightarrow \partial_{\nu}h^{\mu\nu}\Big(X + Y\Big) \tag{56}$$

*** sum

$$\Big(XA^{\alpha}_{\alpha} + YA^{\alpha}_{\alpha}\Big) \rightarrow A^{\alpha}_{\alpha}\Big(X + Y\Big) \tag{57}$$

*** no outer brackets...

$$XA^{\alpha}_{\alpha} + YA^{\alpha}_{\alpha} \rightarrow A^{\alpha}_{\alpha}\Big(X + Y\Big) \tag{58}$$

$$\Big(X\partial_{\gamma}h^{\mu\gamma} + Y\partial_{\nu}h^{\mu\nu}\Big) \rightarrow \partial_{\gamma}h^{\mu\gamma}\Big(X + Y\Big) \tag{59}$$

$$\Big(X\partial_{\gamma}h^{\mu\gamma}A^{\alpha}_{\alpha} + Y\partial_{\nu}h^{\mu\nu}\Big) \rightarrow \partial_{\gamma}h^{\mu\gamma}\Big(XA^{\alpha}_{\alpha} + Y\Big) \tag{60}$$

$$\Big(X\partial_{\gamma}h^{\mu\gamma} + Yh^{\gamma\nu}\Big) \rightarrow \Big(X\partial_{\gamma}h^{\mu\gamma} + Yh^{\gamma\nu}\Big) \tag{61}$$

$$\Big(\frac{1}{2}\partial_{\gamma}h^{\mu\gamma} + \frac{1}{4}h^{\gamma\nu}\Big) \rightarrow \frac{1}{4}\Big(2\partial_{\gamma}h^{\mu\gamma} + h^{\gamma\nu}\Big) \tag{62}$$

*** factor of 1 (implied)

$$\Big(X\partial_{\nu}h^{\mu\nu} + \partial_{\nu}h^{\mu\nu}\Big) \rightarrow \partial_{\nu}h^{\mu\nu}\Big(X + 1\Big) \tag{63}$$

4.2 factor out user specified term

*** smaller numerical

$$\Big(\frac{1}{2}\partial_{\gamma}h^{\mu\gamma} + \frac{1}{4}h^{\gamma\nu}\Big), \frac{1}{8} \rightarrow \frac{1}{8}\Big(4\partial_{\gamma}h^{\mu\gamma} + 2h^{\gamma\nu}\Big) \tag{64}$$

*** bigger numerical

$$\Big(\frac{1}{2}\partial_{\gamma}h^{\mu\gamma} + \frac{1}{4}h^{\gamma\nu}\Big), 8 \rightarrow 8\Big(\frac{1}{16}\partial_{\gamma}h^{\mu\gamma} + \frac{1}{32}h^{\gamma\nu}\Big) \tag{65}$$

*** smaller tensor

$$\Big(X\partial_\gamma h^{\mu\gamma}A^\gamma + Y\partial_\nu h^{\mu\nu}A^\gamma\Big), A^\gamma \to A^\gamma\Big(X\partial_\gamma h^{\mu\gamma} + Y\partial_\nu h^{\mu\nu}\Big) \tag{66}$$

*** not included tensor

$$X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}, A^{alpha} \to \Big(X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}\Big) \tag{67}$$

*** different index

(***decide if this should be the expected behaviour (tensor logic question))

$$\Big(X\partial_\gamma h^{\mu\gamma}A^\gamma + Y\partial_\nu h^{\mu\nu}A^\gamma\Big), A^\alpha \to \Big(X\partial_\gamma h^{\mu\gamma}A^\gamma + Y\partial_\nu h^{\mu\nu}A^\gamma\Big) \tag{68}$$

*** make sure it's recognizing not to factor out tensors under partials

$$\Big(X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}A^\gamma\Big), \partial_\nu h^{\mu\nu} \to \partial_\nu h^{\mu\nu}\Big(YA^\gamma\Big) + \Big(X\partial_\mu\partial_\nu h^{\mu\nu}\Big) \tag{69}$$

*** what about if there's a different index with the same sum pattern, and what about coefficient of 1

$$\Big(XA^\alpha_\alpha + A^\alpha_\alpha\Big), A^\beta_\beta \to A^\beta_\beta\Big(X+1\Big) \tag{70}$$

— variation, no brackets...

$$XA^\alpha_\alpha + A^\alpha_\alpha, A^\beta_\beta \to A^\beta_\beta\Big(X+1\Big) \tag{71}$$

5 Replace

5.1 replace indices

Basic case:

*** single replacement

$$4X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}A^\gamma, \Big(\mu \to \alpha\Big) \to \Big(4X\partial_\alpha\partial_\nu h^{\alpha\nu} + Y\partial_\nu h^{\alpha\nu}A^\gamma\Big) \tag{72}$$

*** list replacement

$$4X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}A^\gamma, \Big(\mu,\nu,\gamma \to \alpha,\beta,\xi\Big) \to \Big(4X\partial_\alpha\partial_\beta h^{\alpha\beta} + Y\partial_\beta h^{\alpha\beta}A^\xi\Big) \tag{73}$$

*** replace index that doesn't exist

$$4X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}A^\gamma, \Big(\mu,\nu,\xi \to \alpha,\beta,\chi\Big) \to \Big(4X\partial_\alpha\partial_\beta h^{\alpha\beta} + Y\partial_\beta h^{\alpha\beta}A^\gamma\Big) \tag{74}$$

*** what if it's not there but it's one of the replacement indices

$$4X\partial_\mu\partial_\nu h^{\mu\nu} + Y\partial_\nu h^{\mu\nu}A^\gamma, \Big(\mu,\nu,\alpha \to \alpha,\beta,\xi\Big) \to \Big(4X\partial_\alpha\partial_\beta h^{\alpha\beta} + Y\partial_\beta h^{\alpha\beta}A^\gamma\Big) \tag{75}$$

*** long number of indices (mismatched list lengths)

5.2 replace terms

5.2.1 direct replacement, tensor $\to$ tensor

- replacing a tensor on its own
  Starting with the equation

$$A^{\alpha\gamma} + A^\gamma + C \tag{76}$$

  replacing A^γ with B^γ

$$\Big(A^{\alpha\gamma} + B^\gamma + C\Big) \tag{77}$$

- replacing a tensor that is multiplied by other elements

  Starting with the equation

$$4X\partial_\mu\partial_\nu h^{\mu\nu}B^{\alpha\gamma} + Y\partial_\nu h^{\alpha\nu}A^\gamma \tag{78}$$

  replacing A^γ with B^γ

$$\left(4X\partial_\mu\partial_\nu h^{\mu\nu}B^{\alpha\gamma} + Y\partial_\nu h^{\alpha\nu}B^\gamma\right) \tag{79}$$

- replacing a tensor that has partial derivatives

  - Replace with just a tensor

    Starting with the equation

$$\partial_\mu\partial_\nu h^{\mu\nu} + \frac{3}{4}Y \tag{80}$$

    replacing $\partial_\mu\partial_\nu h^{\mu\nu}$ with B_γ^γ

$$\left(B_\gamma^\gamma + \frac{3}{4}Y\right) \tag{81}$$

  - Replace with a partial and tensor

    Starting with the equation

$$\partial_\mu\partial_\nu h^{\mu\nu} + \frac{3}{4}Y \tag{82}$$

    replacing $\partial_\mu\partial_\nu h^{\mu\nu}$ with $\partial_\gamma B^\gamma$

$$\left(\partial_\gamma B^\gamma + \frac{3}{4}Y\right) \tag{83}$$

  - Includes a term that shouldn't be replaced

    Starting with the equation

$$\left(\partial_\mu\partial_\nu h^{\mu\nu}\right)\left(\partial_\xi\partial_\beta h^{\chi\beta}\right) \tag{84}$$

    replacing $\partial_\mu\partial_\nu h^{\mu\nu}$ with $\partial_\gamma B^\gamma$

$$\left(\partial_\gamma B^\gamma\right)\left(\partial_\xi\partial_\beta h^{\chi\beta}\right) \tag{85}$$

- replacing a tensor and some of its partial derivatives

  - can replace either derivative

    Starting with the equation

$$\partial_\mu\partial_\nu h^{\mu\nu} + \frac{3}{4}Y \tag{86}$$

    replacing $\partial_\nu h^{\mu\nu}$ with B^μ

  - must replace the derivative with the sum

    Starting with the equation

$$\partial_\gamma\partial_\nu h^{\mu\nu} + \frac{3}{4}Y \tag{87}$$

    replacing $\partial_\nu h^{\mu\nu}$ with B^μ

$$\left(\partial_\gamma B^\mu + \frac{3}{4}Y\right) \tag{88}$$

- must replace the derivative without the sum

  Starting with the equation

$$\partial_\gamma \partial_\nu h^{\mu\nu} + \frac{3}{4}Y \tag{89}$$

  replacing $\partial_\gamma h^{\mu\nu}$ with $B^{\mu\nu}_\gamma$

$$\left(\partial_\nu B^{\mu\nu}_\gamma + \frac{3}{4}Y\right) \tag{90}$$

- replacing a number of derivatives

  Starting with the equation

$$\partial_\gamma \partial_\nu \partial^\epsilon h^{\mu\nu} + \frac{3}{4}Y \tag{91}$$

  replacing $\partial_\nu \partial^\epsilon h^{\mu\nu}$ with $B^{\mu\epsilon}$

- including square

  Starting with the equation

$$\partial_\gamma \partial_\nu \partial^\epsilon \Box h^{\mu\nu} + \frac{3}{4}Y \tag{92}$$

  replacing $\Box h^{\mu\nu}$ with $B^{\mu\nu}$

- replacing a tensor that has partial derivatives and is multiplied by other elements
  Starting with the equation

$$A^\zeta \partial_\mu \partial_\nu h^{\mu\nu} \Box M_\zeta \tag{93}$$

  replacing $\partial_\mu \partial_\nu h^{\mu\nu}$ with B^μ_μ

$$A^\zeta \Box M_\zeta B^\mu_\mu \tag{94}$$

- replacing a tensor and some of its partial derivatives when it is multiplied by other elements

  - can replace either derivative

    Starting with the equation

$$A^\zeta \partial_\mu \partial_\nu h^{\mu\nu} \Box M_\zeta \tag{95}$$

    replacing $\partial_\nu h^{\mu\nu}$ with B^μ

  - must replace the derivative with the sum

    Starting with the equation

$$A^\zeta \partial_\gamma \partial_\nu h^{\mu\nu} \Box M_\zeta \tag{96}$$

    replacing $\partial_\nu h^{\mu\nu}$ with B^μ

$$A^\zeta \Box M_\zeta \partial_\gamma B^\mu \tag{97}$$

  - must replace the derivative without the sum

    Starting with the equation

$$A^\zeta \partial_\gamma \partial_\nu h^{\mu\nu} \Box M_\zeta \tag{98}$$

    replacing $\partial_\gamma h^{\mu\nu}$ with $B^{\mu\nu}_\gamma$

$$A^\zeta \Box M_\zeta \partial_\nu B^{\mu\nu}_\gamma \tag{99}$$

- replacing a tensor in a multgroup with derivatives
  Starting with the equation

$$\partial_\mu \partial^\gamma \left(A^\zeta \partial_\gamma \partial_\nu h^{\mu\nu} \Box M_\zeta\right) \tag{100}$$

  replacing $h^{\mu\nu}$ with $B^{\mu\nu}$

$$\partial_\mu \partial^\gamma \left(A^\zeta \Box M_\zeta \partial_\gamma \partial_\nu B^{\mu\nu}\right) \tag{101}$$

5.2.2 direct replacement, tensor → sum

- replacing just a tensor

  Starting with the equation

$$A^{\alpha\gamma} + A^{\gamma} + C \tag{102}$$

  replacing A^{γ} with $B^{\gamma} + 8fG^{\gamma}$

$$\left(A^{\alpha\gamma} + C\right) + \left(B^{\gamma} + 8fG^{\gamma}\right) \tag{103}$$

- replacing a tensor that is multiplied by other elements

  Starting with the equation

$$4X\partial_{\mu}\partial_{\nu}h^{\mu\nu}B^{\alpha\gamma} + Y\partial_{\nu}h^{\alpha\nu}A^{\gamma} \tag{104}$$

  replacing A^{γ} with $B^{\gamma} + 8fG^{\gamma}$

```
\begin{equation}
\(4 X B^{\alpha \gamm} \partial_{\mu} \partial_{\nu} h^{\mu \nu} a^{} \)+Y \partial_{\nu} h^{\alpha \n
\end{equation}
```

- replacing a tensor that has partial derivatives

  Starting with the equation

$$\partial_{\mu}\partial_{\nu}h^{\mu\nu} + \frac{3}{4}Y \tag{105}$$

  replacing $\partial_{\mu}\partial_{\nu}h^{\mu\nu}$ with $\partial_{\gamma}B^{\gamma} + 5 + G^{\mu}_{\mu}$

$$\left(\frac{3}{4}Y\right) + \left(\partial_{\gamma}B^{\gamma} + 5 + G^{\mu}_{\mu}\right) \tag{106}$$

- replacing a tensor and some of its partial derivatives

  Starting with the equation

$$\partial_{\mu}\partial_{\nu}h^{\mu\nu} + \frac{3}{4}Y \tag{107}$$

  replacing $\partial_{\mu}\partial_{\nu}h^{\mu\nu}$ with $B^{\gamma}_{\gamma} + \frac{5}{4}V$

$$\left(\frac{3}{4}Y\right) + \left(B^{\gamma}_{\gamma} + \frac{5}{4}V\right) \tag{108}$$

- replacing a tensor that has partial derivatives and is multiplied by other elements

  Starting with the equation

$$A^{\zeta}\partial_{\mu}\partial_{\nu}h^{\mu\nu}\Box M_{\zeta} \tag{109}$$

  replacing $\partial_{\mu}\partial_{\nu}h^{\mu\nu}$ with $B^{\mu}_{\mu} + 16\Box B$

$$A^{\zeta}\Box M_{\zeta}\left(B^{\mu}_{\mu} + 16\Box B\right) \tag{110}$$

- replacing a tensor and some of its partial derivatives when it is multiplied by other elements

  Starting with the equation

$$A^{\zeta}\partial_{\gamma}\partial_{\nu}h^{\mu\nu}\Box M_{\zeta} \tag{111}$$

  replacing $\partial_{\nu}h^{\mu\nu}$ with $B^{\mu} + C^{\mu}$

$$A^{\zeta}\Box M_{\zeta}\partial_{\gamma}\left(B^{\mu} + C^{\mu}\right) \tag{112}$$

- replacing a tensor in a multgroup with derivatives
  Starting with the equation

$$\partial_\mu \partial^\gamma \Big(A^\zeta \partial_\gamma \partial_\nu h^{\mu\nu} \Box M_\zeta \Big) \tag{113}$$

  replacing $h^{\mu\nu}$ with $B^{\mu\nu} + C^{\mu\nu}$

$$\partial_\mu \partial^\gamma \Big(\Big) + A^\zeta \Box M_\zeta \partial_\gamma \partial_\nu \Big(B^{\mu\nu} + C^{\mu\nu} \Big) \tag{114}$$

a *** more complicated replacement term

$$4X \partial_\mu \partial_\nu h^{\mu\nu} B^{\alpha\gamma} + Y \partial_\nu h^{\alpha\nu} A^\gamma, \qquad \partial_\nu h^{\alpha\nu} \to \partial_\zeta V^{\alpha\zeta} \tag{115}$$

$$4X \partial_\mu \partial_\nu h^{\mu\nu} + Y \partial_\nu h^{\mu\nu} A^\gamma, \qquad \partial_\nu h^{\mu\nu} \to V^\mu \tag{116}$$

— ***probably one of the most complicated algorithms, need to look over in detail then finish cases***

6 Sort

6.1 combine like terms differing only by a numerical factor

Basic case:

$$3A^\gamma + \frac{5}{7} A^\gamma \to \Big(\frac{26}{7} A^\gamma \Big) \tag{117}$$

*** fraction simplification

$$3A^\gamma + \frac{4}{2} A^\gamma \to \Big(5A^\gamma \Big) \tag{118}$$

*** coefficient of 1 (implied)

$$A^\gamma + A^\gamma \to \Big(2A^\gamma \Big) \tag{119}$$

*** more complicated term

$$3\partial_\gamma A^\gamma + \frac{5}{7} \partial_\beta A^\beta \to \Big(\frac{26}{7} \partial_\gamma A^\gamma \Big) \tag{120}$$

$$3\partial_\gamma \partial^\mu A^\gamma_{\nu\mu} + 7\partial_\beta \partial^\zeta A^\beta_{\nu\zeta} \to \Big(10\partial_\gamma \partial^\mu A^\gamma_{\nu\mu} \Big) \tag{121}$$

*** not all terms combine

$$3\partial_\gamma A^\gamma + 4A^\chi + \frac{5}{7} \partial_\beta A^\beta \to \Big(\frac{26}{7} \partial_\gamma A^\gamma + 4A^\chi \Big) \tag{122}$$

*** things that shouldn't combine

*** different tensors

$$3A^\gamma + \frac{5}{7} B^\gamma \to \Big(3A^\gamma + \frac{5}{7} B^\gamma \Big) \tag{123}$$

*** not differing only by numerical factor

$$3XA^\gamma + 7A^\gamma \to \Big(3XA^\gamma + 7A^\gamma \Big) \tag{124}$$

***different free indices

$$A^\beta + A^\alpha \to \Big(A^\beta + A^\alpha \Big) \tag{125}$$

***different number of partials

$$3\partial_\gamma A^\gamma_\nu + 7\partial_\beta \partial^\zeta A^\beta_{\nu\zeta} \to \Big(3\partial_\gamma A^\gamma_\nu + 7\partial_\beta \partial^\zeta A^\beta_{\nu\zeta} \Big) \tag{126}$$

*** different position of free index

$$3\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7\partial_{\beta}\partial^{\zeta}A^{\beta}_{\zeta\nu}\rightarrow\Big(3\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7\partial_{\beta}\partial^{\zeta}A^{\beta}_{\zeta\nu}\Big) \tag{127}$$

***(Unless A is a symmetric tensor, in which case):

$$3\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7\partial_{\beta}\partial^{\zeta}A^{\beta}_{\zeta\nu}\rightarrow\Big(10\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}\Big) \tag{128}$$

6.2 combine like terms differing by any (numerical or symbolic) coefficient

*** basic case

$$3XA^{\gamma}+7A^{\gamma}\rightarrow\Big(\Big(3X+7\Big)A^{\gamma}\Big) \tag{129}$$

*** more complicated term

$$3B\partial_{\gamma}A^{\gamma}+\frac{5}{7}V\partial_{\beta}A^{\beta}\rightarrow\Big(\Big(3B+\frac{5}{7}V\Big)\partial_{\gamma}A^{\gamma}\Big) \tag{130}$$

$$3B\partial_{\gamma}A^{\gamma}+\frac{5}{7}B\partial_{\beta}A^{\beta}\rightarrow\Big(\frac{26}{7}B\partial_{\gamma}A^{\gamma}\Big) \tag{131}$$

$$3M\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7X\partial_{\beta}\partial^{\zeta}A^{\beta}_{\nu\zeta}\rightarrow\Big(\Big(3M+7X\Big)\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}\Big) \tag{132}$$

*** not all terms combine

$$3V\partial_{\gamma}A^{\gamma}+4ZA^{\chi}+\frac{5}{7}N\partial_{\beta}A^{\beta}\rightarrow\Big(\Big(3V+\frac{5}{7}N\Big)\partial_{\gamma}A^{\gamma}+4ZA^{\chi}\Big) \tag{133}$$

***shouldn't combine

$$3B\partial_{\gamma}A^{\gamma}+\frac{5}{7}V^{\alpha}_{\alpha}\partial_{\beta}A^{\beta}\rightarrow(IthinkthisiswhatIwantbutshoulddoublecheck/seeifanimprovementcombinethesetoo\rightarrow wouldthisbehe \tag{134}$$

*** different tensors

$$3CA^{\gamma}+\frac{5}{7}DB^{\gamma}\rightarrow\Big(3CA^{\gamma}+\frac{5}{7}DB^{\gamma}\Big) \tag{135}$$

***different free indices

$$XA^{\beta}+A^{\alpha}\rightarrow\Big(XA^{\beta}+A^{\alpha}\Big) \tag{136}$$

***different number of partials

$$3\partial_{\gamma}A^{\gamma}_{\nu}+7M\partial_{\beta}\partial^{\zeta}A^{\beta}_{\nu\zeta}\rightarrow\Big(3\partial_{\gamma}A^{\gamma}_{\nu}+7M\partial_{\beta}\partial^{\zeta}A^{\beta}_{\nu\zeta}\Big) \tag{137}$$

*** different position of free index

$$3V\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7L\partial_{\beta}\partial^{\zeta}A^{\beta}_{\zeta\nu}\rightarrow\Big(3V\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7L\partial_{\beta}\partial^{\zeta}A^{\beta}_{\zeta\nu}\Big) \tag{138}$$

***(Unless A is a symmetric tensor, in which case):

$$3V\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}+7L\partial_{\beta}\partial^{\zeta}A^{\beta}_{\zeta\nu}\rightarrow\Big(\Big(3V+7L\Big)\partial_{\gamma}\partial^{\mu}A^{\gamma}_{\nu\mu}\Big) \tag{139}$$

6.3 sort the tensors in each term by number of derivatives (least to greatest)

$$\partial_{\gamma}\Box G^{\nu\gamma}\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\Box\Box\partial_{\chi}X^{\kappa\zeta}_{\nu}\partial_{\mu}T^{\mu}\rightarrow\partial_{\mu}T^{\mu}\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\partial_{\gamma}\Box G^{\nu\gamma}\partial_{\chi}\Box\Box X^{\kappa\zeta}_{\nu} \tag{140}$$

***What about with coefficients

$$4A\partial_{\gamma}\Box G^{\nu\gamma}\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\Box\Box\partial_{\chi}X^{\kappa\zeta}_{\nu}\partial_{\mu}T^{\mu}\rightarrow WORKING4A\partial_{\mu}T^{\mu}\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\partial_{\gamma}\Box G^{\nu\gamma}\partial_{\chi}\Box\Box X^{\kappa\zeta}_{\nu} \tag{141}$$

***What about multiple terms and coefficients

$$4A\partial_{\gamma}\Box G^{\nu\gamma}\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}+\frac{7}{8}C\Box\Box\partial_{\chi}X^{\kappa\zeta}_{\nu}\partial_{\mu}T^{\mu}\rightarrow\Big(4A\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\partial_{\gamma}\Box G^{\nu\gamma}+\frac{7}{8}C\partial_{\mu}T^{\mu}\partial_{\chi}\Box\Box X^{\kappa\zeta}_{\nu}\Big) \tag{142}$$

***And with brackets

$$\Big(4A\partial_{\gamma}\Box G^{\nu\gamma}\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\Big)\Big(\frac{7}{8}C\Box\Box\partial_{\chi}X^{\kappa\zeta}_{\nu}\partial_{\mu}T^{\mu}\Big)\rightarrow\Big(4A\partial_{\beta}\partial^{\xi}M^{\beta}_{\xi}\partial_{\gamma}\Box G^{\nu\gamma}\Big)\Big(\frac{7}{8}C\partial_{\mu}T^{\mu}\partial_{\chi}\Box\Box X^{\kappa\zeta}_{\nu}\Big) \tag{143}$$

6.4 sort terms by number of derivatives (least to greatest)

$$\partial_\gamma \partial_\kappa A^\gamma + \partial^\chi B_\chi + C \to \Big(C + \partial^\chi B_\chi + \partial_\gamma \partial_\kappa A^\gamma \Big) \tag{144}$$

***with brackets

$$\Big(\partial_\gamma \partial_\kappa A^\gamma + \partial^\chi B_\chi + C \Big) \to \Big(C + \partial^\chi B_\chi + \partial_\gamma \partial_\kappa A^\gamma \Big) \tag{145}$$

***with coefficients

$$\Big(9\partial^\chi B_\chi + \frac{1}{2} T \partial_\gamma \partial_\kappa A^\gamma + MC \Big) \to \Big(MC + 9\partial^\chi B_\chi + \frac{1}{2} T \partial_\gamma \partial_\kappa A^\gamma \Big) \tag{146}$$

*** with multiplied terms

$$\Big(\partial_\gamma \partial_\kappa A^\gamma + \partial_\omega G \Big) \Big(\partial^\chi B_\chi + C \Big) \to \Big(\partial_\omega G + \partial_\gamma \partial_\kappa A^\gamma \Big) \Big(C + \partial^\chi B_\chi \Big) \tag{147}$$

** with multiple tensors per term (I think it goes by either least or greatest...)

$$\Big(\partial_\gamma \partial_\kappa \Box A^\gamma \partial_\omega G + \Box \partial^\chi B_\chi + \Box X_\xi + \Box VC \Big) \to \Big(\Box X_\xi + \Box VC + \partial^\chi \Box B_\chi + \partial_\gamma \partial_\kappa \Box A^\gamma \partial_\omega G \Big) \tag{148}$$

(must sort by total)

$$\partial_\xi H \partial_\omega G \partial^\xi M + \Box A \to \Big(\Box A + \partial_\xi H \partial_\omega G \partial^\xi M \Big) \tag{149}$$

*** interesting thing with brackets - should look into at some point
-¿ At the very least it should be a warning and not make it look like it worked...

*** same idea but with summation -¿ INTERESTING BRACKET STUFF - is it important??

$$(X A^\alpha_\alpha + Y A^\alpha_\alpha) \to NOTWORKING (X + Y) A^\alpha_\alpha A^\alpha_\alpha \tag{150}$$

— variations on above:

$$(X \partial_\mu A^\alpha_\alpha + Y \partial_\mu A^\alpha_\alpha) \to sameissue (X + Y) \partial_\mu A^\alpha_\alpha \partial_\mu A^\alpha_\alpha \tag{151}$$

$$(X \partial_\alpha A^\alpha + Y \partial_\alpha A^\alpha) \to ISSUE (X + Y) \partial_\alpha A^\alpha \partial_\alpha A^\alpha \tag{152}$$

$$(X \partial_\alpha h^\alpha + Y \partial_\alpha h^\alpha) \to (X + Y) \partial_\alpha h^\alpha \partial_\alpha h^\alpha \tag{153}$$

$$(X \partial_\alpha h^{\alpha\beta} + Y \partial_\alpha h^{\alpha\beta}) \to (X + Y) \partial_\alpha h^{\alpha\beta} \partial_\alpha h^{\alpha\beta} \tag{154}$$