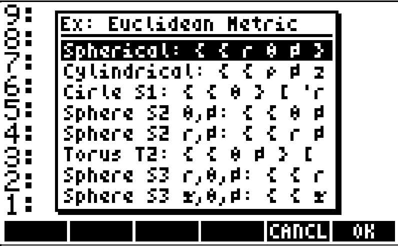
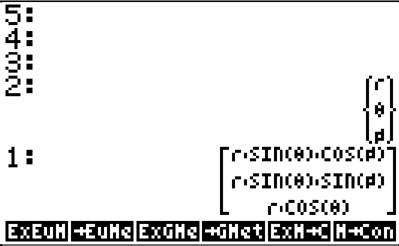
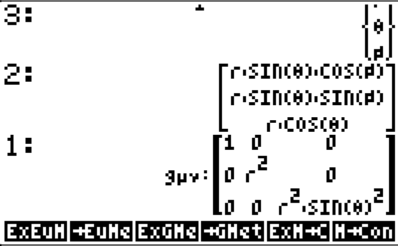
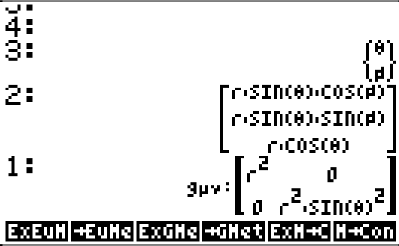
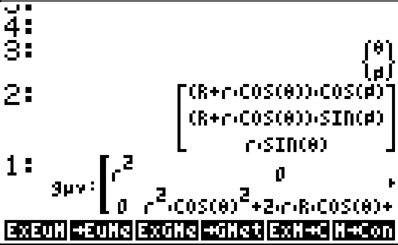
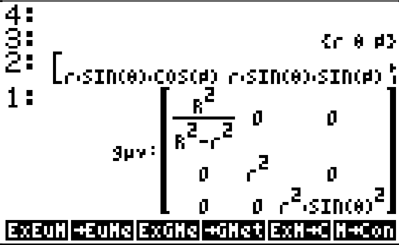
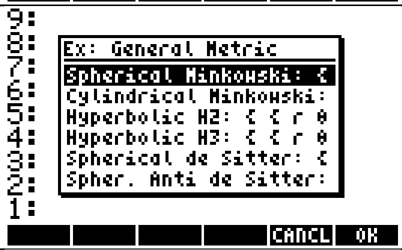
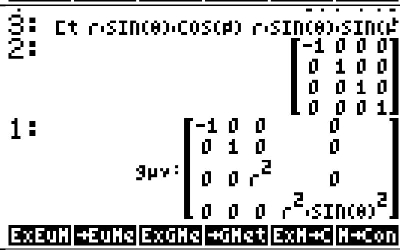
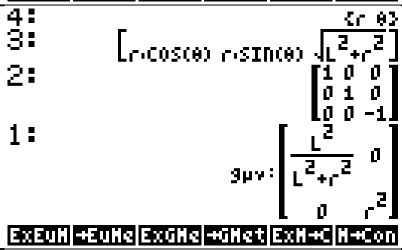
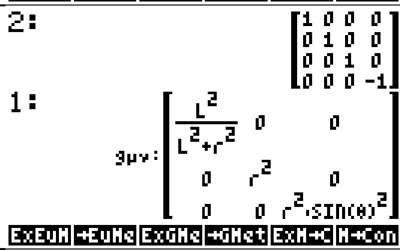
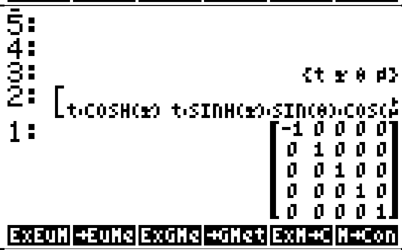
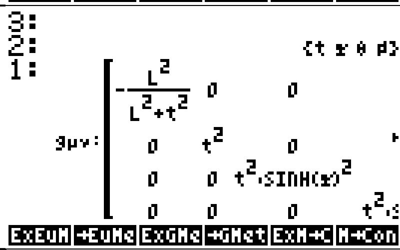
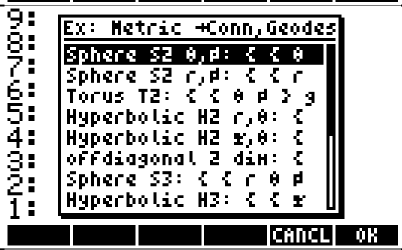
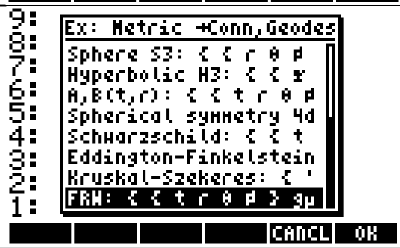
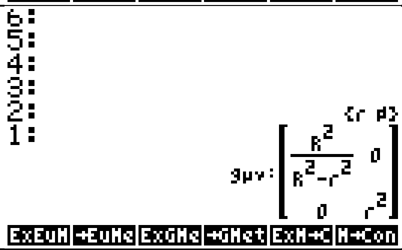
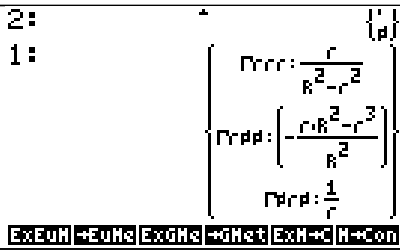
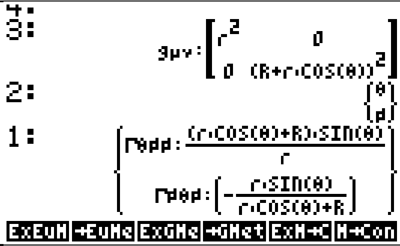
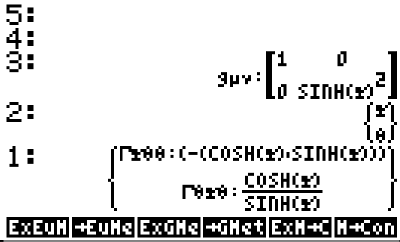
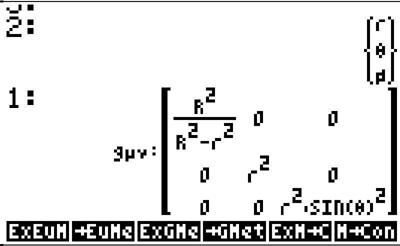
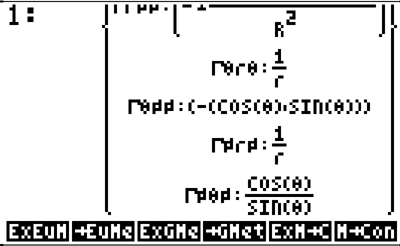
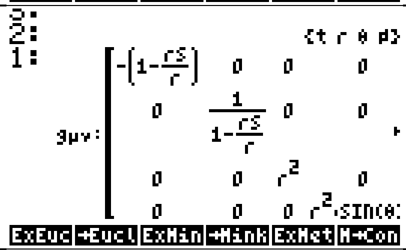
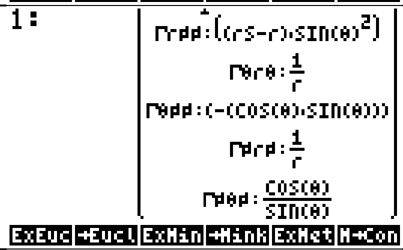
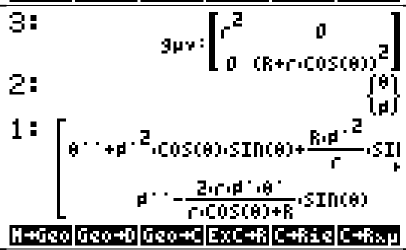
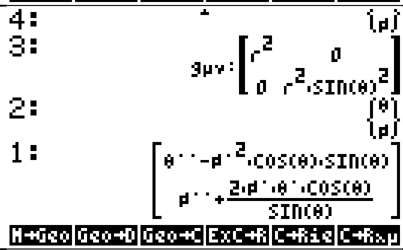
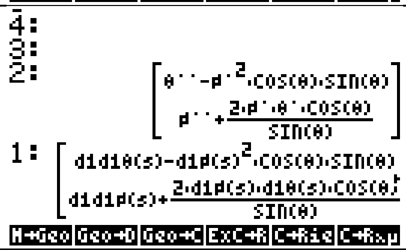
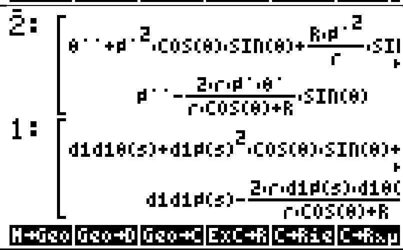
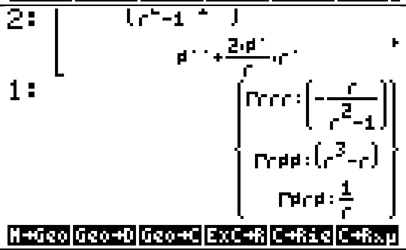
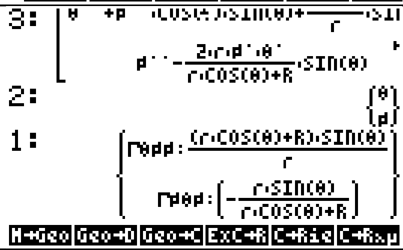
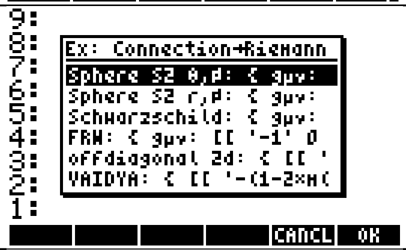
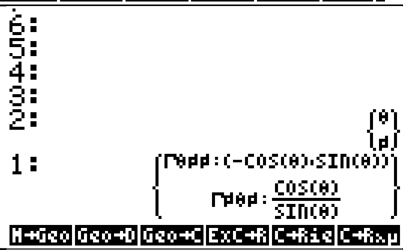
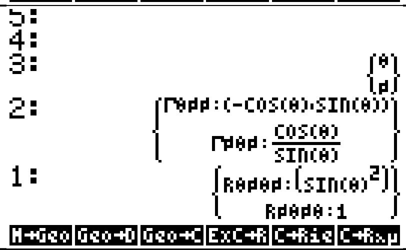
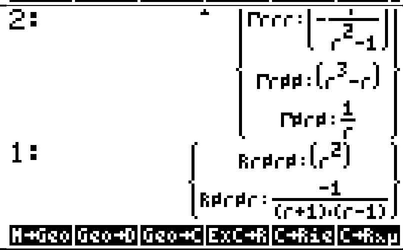
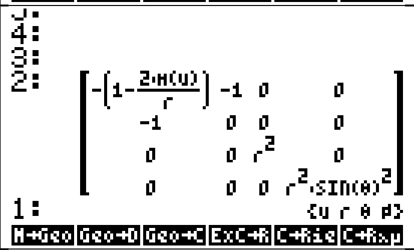
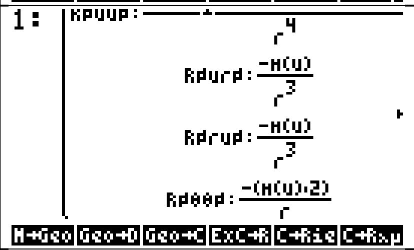
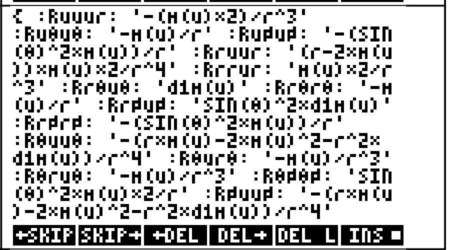
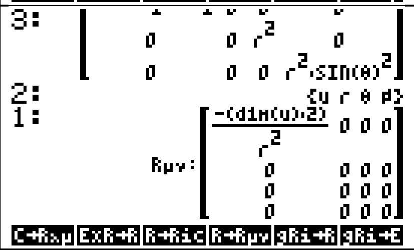
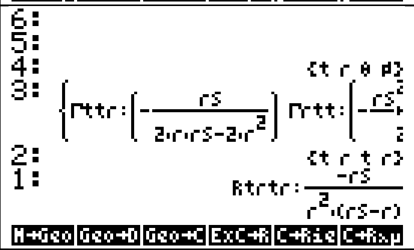
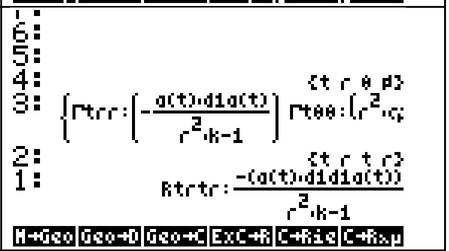
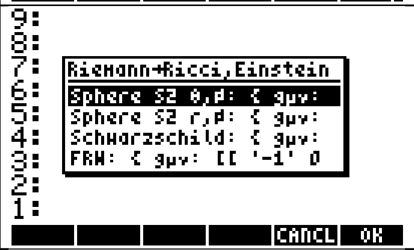
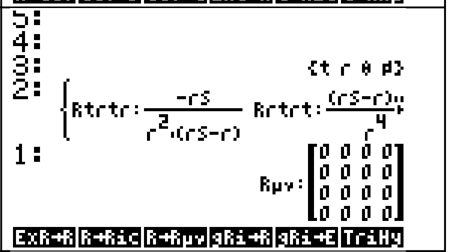
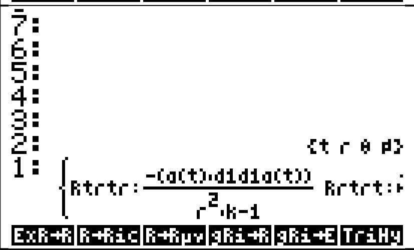
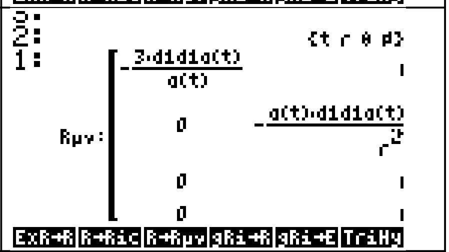
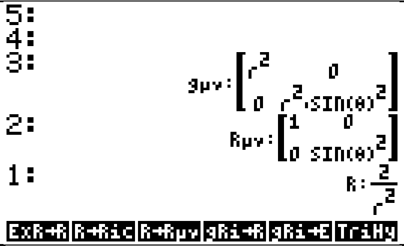
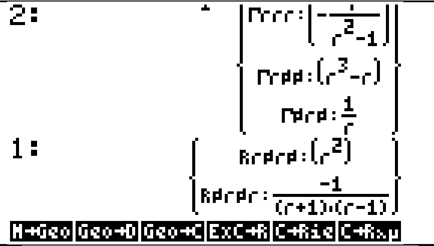
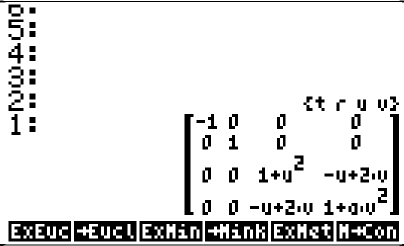
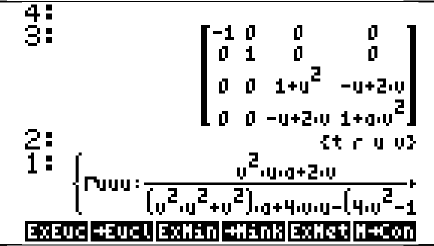
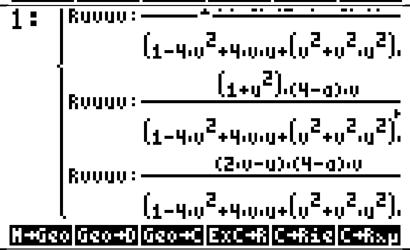
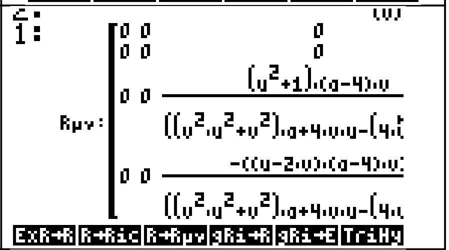
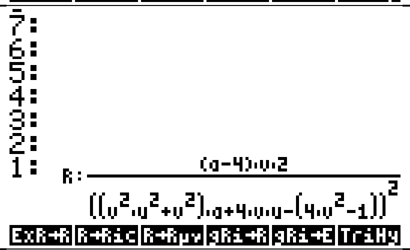
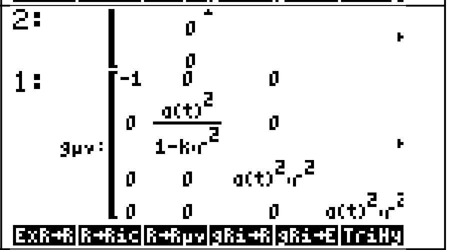
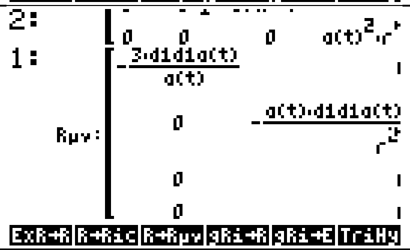
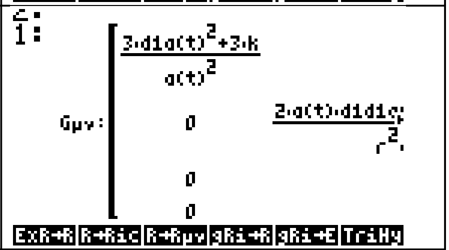
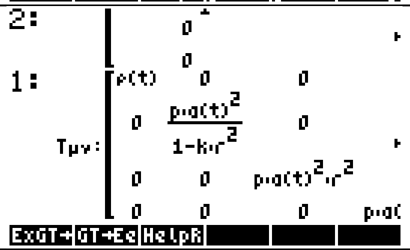
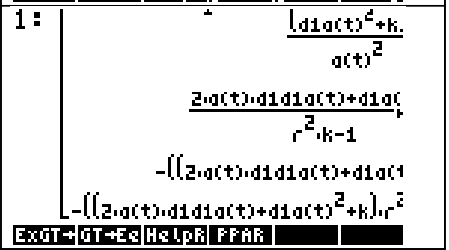
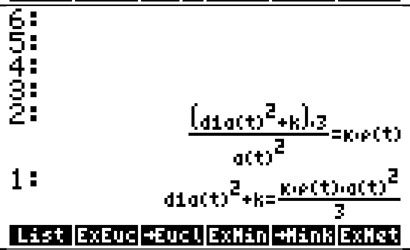
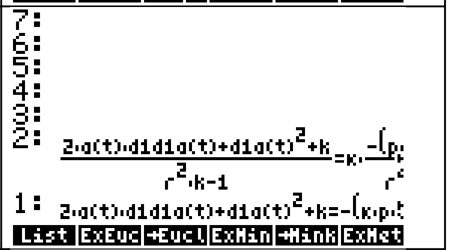
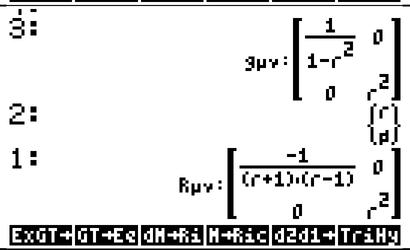
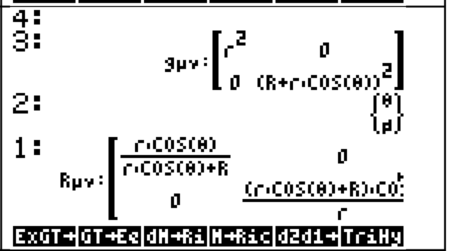
RIEMANN

ExEuMetr: examples for →EuclM, Euclidean metric [OK] gives example		
→EuMetr: Euclidean metric of coordinates or manifold, ex: spher. coordinates (10s/0.5s) (HP50/Emulator on notebook) sphere S2 θ φ (4.5s/0.2)		
→EuMetr: torus T2 (7.5s/0.2s) sphere S3(14s/0.5s)		
ExGMetr: examples for →GMetr, general metric spherical Minkowski (11s/0.5s)		
→GMetr: ex. hyperbolic H2 (5s/0.1s) hyperbolic H3 (14s/0.6s)		
→GMetr: spherical de Sitter (74s/3.5s)		
ExMetric: examples coordinates, metric		
M→Conn: metric to connection, (nonvanishing Christoffel symbols, note that Γλνμ=Γλμν is not shown and Γλμν:=$\Gamma^{\lambda}{}_{\mu\nu}$) sphere S2 r φ (22s/0.6s)		

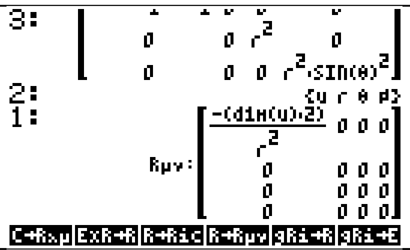
M→Conn: torus T2 (12s/0.6s) M→Conn: hyperbolic H2 (12s/0.4s)		
M→Conn: sphere S3 (60s/1.3s)		
M→Conn: Schwarzschild (150s/3s)		
M→Geodes: metric to geodesic ex: torus (23s/0.5s) ex. sphere S2 (12s/0.4s)		
Geo→DEQ: geodesic to differential equation sphere S2 (1s/0s) torus T2 (1.3s,0s)		
Geo→Conn: geodesic to connection ex: sphere S2 (2.3s/0s) ex: torus T2 (5s/0s)		
ExC→R: examples for connection to Riemann tensor [OK] gives example		
C→Riemann: calculates components $R^{\mu}{}_{\nu\mu\nu}$, ($\mu\neq\nu$) of Riemanntensor for diagonal metric ex: S2 θ φ (4s/0s) ex S2 r φ (4s/0s)		

C→Riemann: Schwarzschild connection (48s/1s)		
C→Riemann: FRW connection (74s/2s)		
C→Riemann: connection to Riemann tensor for offdiagonal metric. Ex: Vaidya metric		
C→Riemann: connection to Riemann tensor for offdiagonal metric. Ex: Vaidya metric (300s/7s)		
R→Ricci: Riemann to Ricci tensor, ex: Vaidya metric (30s/0.7s) gRi→R: metric and Ricci to Ricciscalar		
C→$R_{\lambda\mu\nu\rho}$: calculate one component $R^{\lambda}{}_{\mu\nu\rho}$ of the Riemann tensor Schwarzschild (5s/0s) FRW (7s/0s) FriedmannRobertsonWalker		
ExR→RE: examples for Riemann to Ricci, Einstein tensor R→Ricci: Riemann to Ricci Ex: Schwarzschild (15s/0.4s)		
R→Ricci: Ex: FRW(19s/0.5s)		

gRi→R: metric and Ricci tensor to Ricci scalar ex: sphere S2 (1s/0s)		
M→Conn: offdiagonal Minkowski (120s/2.6s)		
C→Riemann: offdiagonal Minkowski (70s/0.5s) R→Ricci: (29s/0.6s)		
MRi→R: metric and Ricci tensor to Ricci scalar (32s/0.6s). For a=4 R=0. FLRW metric		
FLRW Ricci tensor gRi→E: metric and Ricci tensor to Einstein tensor Ex: FRW (43s/1s)		
ExGT→Eeq: example Einstein G and energy mom. tensor T to Einstein equations ex: FRW GT→Eeq (6s/0s)		
1. equation (before and after simplifying) 2. equation (3. and 4. eq are identical)		
M→Ricci: diagonal metric to Ricci tensor ex: sphere S2 (26s/0.6s) ex: torus T2 (40s/1s)		

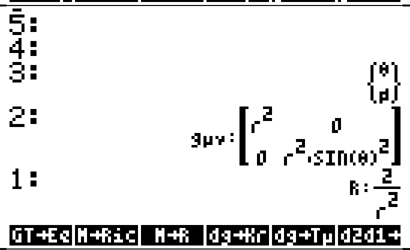
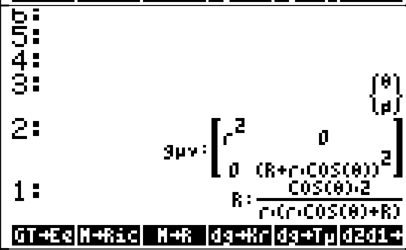
M→Ricci: (off-) diagonal metric to Ricci tensor
ex: Vaidya metric
(emulator:10,5s)

d2d1→d1d2:



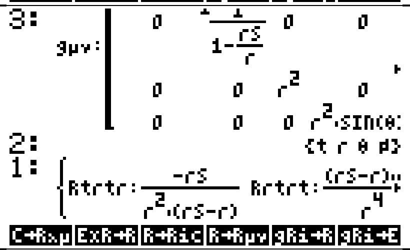

M→R: metric to Ricci scalar,
ex: sphere S2
(21s/0.5s)

ex: torus (42s/1s)

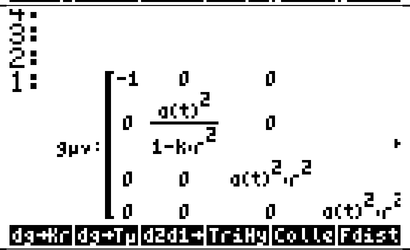
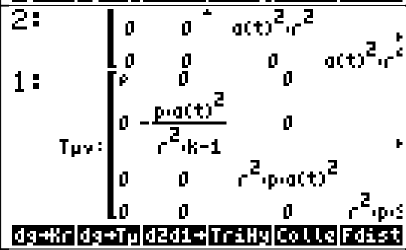
dM→Kret: diagonal metric to Kretschmann scalar K= $R_{\lambda\mu\nu\rho}R^{\lambda\mu\nu\rho}$ ex: Schwarzschild
(42s/0.5s)

ex: torus (42s/1s)



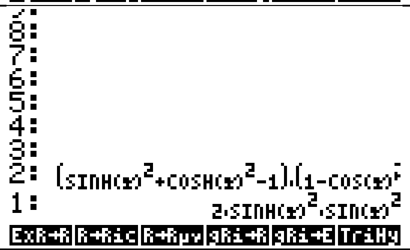
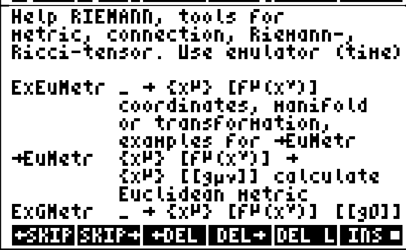

dM→Tμν: diagonal metric to energy momentum tensor comoving coordinates
(1.6s/0s)

ex: torus (42s/1s)

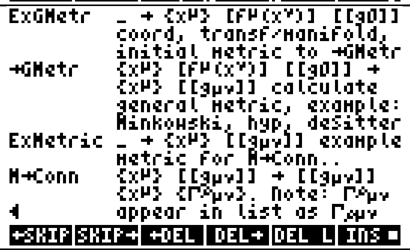



TriHyp: simplify terms with SINH,COSH,SIN,COS
(2.6s/0s)

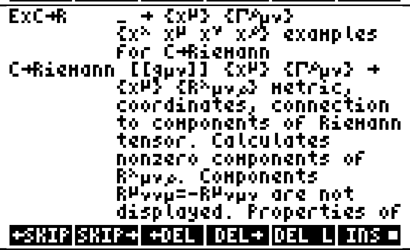
HelpRIEMANN: help to programs

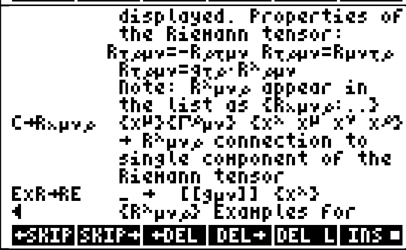



HelpRIEMANN: help to programs

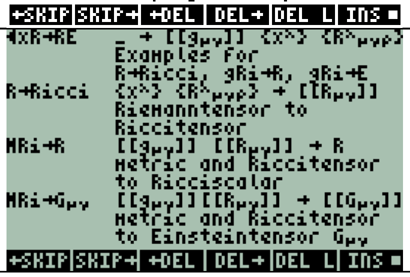


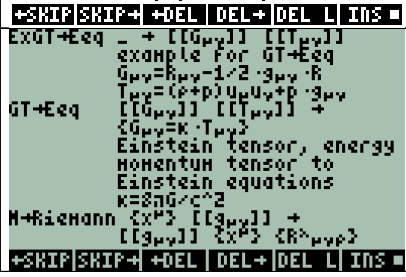
HelpRIEMANN: help to programs





HelpRIEMANN: help to programs





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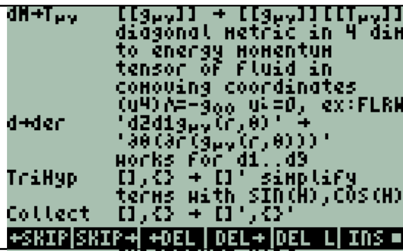
<td>
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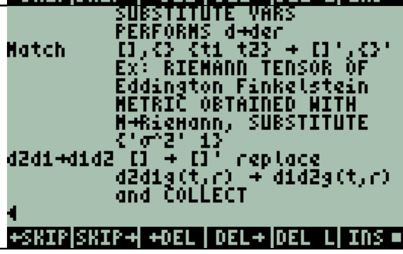
<td>
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The software RIEMANN provides tools for calculating metric, connection, geodesic equations, Riemann and Ricci tensor and Einstein equations step by step. The programs run rather fast on the HP50 emulator on a computer or tablet. The software requires the MPC font for correct display of tensor indices.

Some important books on the subject are:

A. Zee, Einstein Gravity in a Nutshell
L. Ryder, Introduction to General Relativity
M. Nakahara, Geometry, Topology and Physics