```
In[1]:= ClearAll["Global`*"]
coordinateList = {r, ϕ};

(* Loop over k *)
Do[
 Print["
------------ k = ", k, " ------------"];

 (* Define gμν *)
 g = ( 1/(1-k r^2/L^2)   0
          0             r^2 );

 (* Initialize Γ^μ_νρ as rank 3 tensor *)
 tmp[a_, b_, c_] := 0;
 Γ = Array[tmp, {2, 2, 2}];

 (* Loop over indices in Γ^μ_νρ *)
 Do[
  Do[
   Do[
    Do[
     xμ = coordinateList[[μ]];
     xν = coordinateList[[ν]];
     xρ = coordinateList[[ρ]];

     Γ[[μ, ν, ρ]] += 1/2 (Inverse[g])[[σ, μ]] (∂_xν g[[ρ, σ]] + ∂_xρ g[[ν, σ]] - ∂_xσ g[[ν, ρ]]); ,
     {σ, {1, 2}}],
    {ρ, {1, 2}}],
   {ν, {1, 2}}],
  {μ, {1, 2}}];

 (* Initialize R^λ_μνκ as a rank 4 tensor *)
 tmp[a_, b_, c_, d_] := 0;
 R = Array[tmp, {2, 2, 2, 2}];
```

```
(* Loop over indices in R^ρ_μνκ *)
Do[
 Do[
  Do[
   Do[
    xκ = coordinateList[[κ]];
    xν = coordinateList[[ν]];

    (* R^λ_μνκ = ∂Γ^λ_μν/∂x^κ - ∂Γ^λ_μκ/∂x^ν + Γ^η_μν Γ^λ_κη - Γ^η_μκ Γ^λ_νη *)
    R[[λ, μ, ν, κ]] += ∂_xν Γ[[λ, μ, κ]] - ∂_xκ Γ[[λ, μ, ν]];
    Do[
     R[[λ, μ, ν, κ]] += Γ[[η, μ, κ]] × Γ[[λ, ν, η]] - Γ[[η, μ, ν]] × Γ[[λ, κ, η]],
     {η, {1, 2}}],

    {κ, {1, 2}}],
   {ν, {1, 2}}],
  {μ, {1, 2}}],
 {λ, {1, 2}}];


Print["R^θ_θνκ = ", MatrixForm[FullSimplify[R[[1, 1]]]]];
Print["R^θ_ϕνκ = ", MatrixForm[FullSimplify[R[[1, 2]]]]];
Print["R^ϕ_θνκ = ", MatrixForm[FullSimplify[R[[2, 1]]]]];
Print["R^ϕ_ϕνκ = ", MatrixForm[FullSimplify[R[[2, 2]]]]];

(* Initialize Ricci^μ_ν as rank 2 tensor *)
tmp[a_, b_] := 0;
Ricci = Array[tmp, {2, 2}];

(* Loop over indices in Ricci_μν *)
Do[
 Do[
  Do[
   Ricci[[μ, ν]] += R[[σ, μ, σ, ν]],
   {σ, {1, 2}}],
  {ν, {1, 2}}],
 {μ, {1, 2}}];
```

```
Print["Ricciμν = ", MatrixForm[FullSimplify[Ricci]]];

(* Calculate curvature scalar *)
Print["R = ", FullSimplify[Tr[Inverse[g].Ricci]]];,
{k, {-1, 0, 1}}]
```

------------ k = -1 ------------

$R^{\theta}{}_{\theta\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\theta}{}_{\phi\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\phi}{}_{\theta\nu\kappa} = \begin{pmatrix} 0 & \frac{2}{L^2+r^2} \\ -\frac{2}{L^2+r^2} & 0 \end{pmatrix}$

$R^{\phi}{}_{\phi\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$\mathrm{Ricci}_{\mu\nu} = \begin{pmatrix} -\frac{2}{L^2+r^2} & 0 \\ 0 & 0 \end{pmatrix}$

$R = -\frac{2}{L^2}$

------------ k = 0 ------------

$R^{\theta}{}_{\theta\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\theta}{}_{\phi\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\phi}{}_{\theta\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\phi}{}_{\phi\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$\mathrm{Ricci}_{\mu\nu} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R = 0$

------------ k = 1 ------------

$R^{\theta}{}_{\theta\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\theta}{}_{\phi\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$

$R^{\phi}{}_{\theta\nu\kappa} = \begin{pmatrix} 0 & -\frac{2}{L^2-r^2} \\ \frac{2}{L^2-r^2} & 0 \end{pmatrix}$

$$R^{\phi}{}_{\phi\nu\kappa} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

$$\mathrm{Ricci}_{\mu\nu} = \begin{pmatrix} \frac{2}{L^2-r^2} & 0 \\ 0 & 0 \end{pmatrix}$$

$$R = \frac{2}{L^2}$$