SPRING LOADED SEE SAW

In[•]:=
```
Quit[];


(*************************************************************************)
(*FUNCTIONS*)
SkewSym[w_] :=
  {{0, -w[[3, 1]], w[[2, 1]]}, {w[[3, 1]], 0, -w[[1, 1]]}, {-w[[2, 1]], w[[1, 1]], 0}};
unSkewSym[V_] := {{V[[3, 2]]}, {V[[1, 3]]}, {V[[2, 1]]}}

(*Functions from the MR Library *)
VectToSE3[V_] :=
 ArrayFlatten[{{VecToso3[{V[[1 ;; 3, 1]]}^T], {V[[4 ;; 6, 1]]}^T}, {0, 0}}]
SE3ToVec[se3mat_] := {{se3mat[[3, 2]], se3mat[[1, 3]],
    se3mat[[2, 1]], se3mat[[1, 4]], se3mat[[2, 4]], se3mat[[3, 4]]}}^T
TransInv[T_] := ArrayFlatten[{{T[[1 ;; 3, 1 ;; 3]]^T,
    -T[[1 ;; 3, 1 ;; 3]]^T.{T[[1 ;; 3, 4]]}^T}, {0, 1}}]
(*************************************************************************)
```

(*Transforms*)

```
(*SQUARE1 COM*)
q = {{x1[t]}, {y1[t]}, {θ1[t]}, {x2[t]}, {y2[t]}, {θ2[t]}, {θ3[t]}};
gWSq1 = {{Cos[θ1[t]], -Sin[θ1[t]], 0, x1[t]},
   {Sin[θ1[t]], Cos[θ1[t]], 0, y1[t]}, {0, 0, 1, 0}, {0, 0, 0, 1}};
Print["gWSq1 = " MatrixForm[gWSq1]]
(*SQUARE2 COM*)
gWSq2 = {{Cos[θ2[t]], -Sin[θ2[t]], 0, x2[t]},
   {Sin[θ2[t]], Cos[θ2[t]], 0, y2[t]}, {0, 0, 1, 0}, {0, 0, 0, 1}};
Print["gWSq2 = " MatrixForm[gWSq2]]

TL = {-1.5, 1.5, 0, 1};
BL = {-1.5, -1.5, 0, 1};
BR = {1.5, -1.5, 0, 1};
TR = {1.5, 1.5, 0, 1};
```

```
(*SEE SAW*)
gWMid = {{Cos[θ3[t]], -Sin[θ3[t]], 0, 0},
   {Sin[θ3[t]], Cos[θ3[t]], 0, 6}, {0, 0, 1, 0}, {0, 0, 0, 1}};
Print["gWSSMid = " MatrixForm[gWMid]]
gMidSend1 = {{1, 0, 0, -15}, {0, 1, 0, -15 * Tan[θ3[t]]}, {0, 0, 1, 0}, {0, 0, 0, 1}};
Print["gMidWSSend1 = " MatrixForm[gMidSend1 ]]
gMidSend2 = {{1, 0, 0, 15}, {0, 1, 0, 15 * Tan[θ3[t]]}, {0, 0, 1, 0}, {0, 0, 0, 1}};
Print["gMidWSSend2 = " MatrixForm[gMidSend2]]
gWS1 = gWMid.gMidSend1;
gWS2 = gWMid.gMidSend2;
Print["gWSSend1 = gWSSMid.gMidWSSend1"]
Print["gWSSend2 = gWSSMid.gMidWSSend2"]
```

(*parameters*)

```
g = 9.8;
(*Square1*)
m1 = 5;
J1 = 1;
(*Square2*)
m2 = 2;
J2 = 1;
(*Seesaw*)
ms = 8;
Js = 1;
(*Springs*)
k1 = 6; (*MAX 12, MIN 3, RECOMMENDED 6*)
k2 = 6; (*MAX 12, MIN 3, RECOMMENDED 6*)

(*FIRST AND SECOND TIME DERIVATIVES*)
dq = D[q, t];
ddq = D[dq, t];
```

(*LAGRANGIAN*)

```
Sq1MassInertiaMatrix = {{m1, 0, 0, 0, 0, 0}, {0, m1, 0, 0, 0, 0},
   {0, 0, m1, 0, 0, 0}, {0, 0, 0, J1, 0, 0}, {0, 0, 0, 0, J1, 0}, {0, 0, 0, 0, 0, J1}};
Sq2MassInertiaMatrix = {{m2, 0, 0, 0, 0, 0}, {0, m2, 0, 0, 0, 0},
   {0, 0, m2, 0, 0, 0}, {0, 0, 0, J2, 0, 0}, {0, 0, 0, 0, J2, 0}, {0, 0, 0, 0, 0, J2}};
SSMassInertiaMatrix = {{ms, 0, 0, 0, 0, 0}, {0, ms, 0, 0, 0, 0}, {0, 0, ms, 0, 0, 0},
   {0, 0, 0, Js, 0, 0}, {0, 0, 0, 0, Js, 0}, {0, 0, 0, 0, 0, Js}};
(*SQUARE1*)
Sq1Twist = SE3ToVec[(TransInv[gWSq1].D[gWSq1, t])];
```

```
KESq1 = (1/2) * (Sq1Twist^T.Sq1MassInertiaMatrix.Sq1Twist);
VSq1 = m1 * g * gWSq1[[2, 4]];
LSq1 = KESq1 - VSq1 ;

(*SQUARE2*)
Sq2Twist = SE3ToVec[(TransInv[gWSq2].D[gWSq2, t])];
KESq2 = (1/2) * (Sq2Twist^T.Sq2MassInertiaMatrix.Sq2Twist);
VSq2 = m2 * g * gWSq2[[2, 4]];
LSq2 = KESq2 - VSq2 ;

(*SEE SAW*)
SSTwist = SE3ToVec[(TransInv[gWMid].D[gWMid, t])];
KESS = (1/2) * (SSTwist^T.SSMassInertiaMatrix.SSTwist);
VSS = ms * g * gWMid[[2, 4]];
ΔSpring1 = Sqrt[((gWS1[[1, 4]] - 15)) ^2 + ((gWS1[[2, 4]] - 6)) ^2];
ΔSpring2 = Sqrt[((gWS2[[1, 4]] - 15)) ^2 + ((gWS2[[2, 4]] - 6)) ^2];
VSpring = (1/2) * k1 * (ΔSpring1) ^2 + (1/2) * k2 * (ΔSpring2) ^2;
LSS = KESS - VSS - VSpring;

L = LSq1 + LSq2 + LSS;
```

(*CONSTRAINTS*)

```
ϕ1 = 15 * Cos[θ3[t]] - ((gWSq2.BL)[[1]]);
ϕ2 = 6 - 15 * Sin[θ3[t]] - ((gWSq2.BL)[[2]]) ;
(*((gWSq2.BL)[[2]]+(1.5*Tan[θ3[t]])) - gWS1[[2,4]];*)
ϕ3 = θ2[t] - θ3[t];
```

(*IMPACT*)

```
ϕ4 := (*Sqrt[((gWS2[[1,4]]-(x1[t] +1.5)))^2+((gWS2[[2,4]]-(y1[t] -1.5)))^2]*)
  ((y1[t] - 1.5) - (gWS2[[2, 4]]));
ϕ5 := (*Sqrt[((gWS1[[1,4]]-(x2[t] +1.5)))^2+((gWS1[[2,4]]-(y2[t] -1.5)))^2]*)
  ((y2[t] - 1.5) - (gWS1[[2, 4]]));

(*SQUARE1*)
Eq1 = D[D[L, x1'[t]], t] - D[L, x1[t]] ==
   λ1[t] * D[ϕ1, x1[t]] + λ2[t] * D[ϕ2, x1[t]] + λ3[t] * D[ϕ3, x1[t]];
Eq2 = D[D[L, y1'[t]], t] - D[L, y1[t]] ==
   λ1[t] * D[ϕ1, y1[t]] + λ2[t] * D[ϕ2, y1[t]] + λ3[t] * D[ϕ3, y1[t]];
Eq3 = D[D[L, θ1'[t]], t] - D[L, θ1[t]] ==
   λ1[t] * D[ϕ1, θ1[t]] + λ2[t] * D[ϕ2, θ1[t]] + λ3[t] * D[ϕ3, θ1[t]];

(*SQUARE2*)
Eq4 = D[D[L, x2'[t]], t] - D[L, x2[t]] ==
```

```
   λ1[t] * D[ϕ1, x2[t]] + λ2[t] * D[ϕ2, x2[t]] + λ3[t] * D[ϕ3, x2[t]];
Eq5 = D[D[L, y2'[t]], t] - D[L, y2[t]] ==
   λ1[t] * D[ϕ1, y2[t]] + λ2[t] * D[ϕ2, y2[t]] + λ3[t] * D[ϕ3, y2[t]];
Eq6 = D[D[L, θ2'[t]], t] - D[L, θ2[t]] ==
   λ1[t] * D[ϕ1, θ2[t]] + λ2[t] * D[ϕ2, θ2[t]] + λ3[t] * D[ϕ3, θ2[t]];

(*SEE SAW*)
Eq7 = D[D[L, θ3'[t]], t] - D[L, θ3[t]] ==
   λ1[t] * D[ϕ1, θ3[t]] + λ2[t] * D[ϕ2, θ3[t]] + λ3[t] * D[ϕ3, θ3[t]];
Eq8 = D[D[ϕ1, t], t] == 0;
Eq9 = D[D[ϕ2, t], t] == 0;
Eq10 = D[D[ϕ3, t], t] == 0;

(*Initialising config variable updates*)
x1n = Piecewise[{{0, t > 0 && t < 0}}];
y1n = Piecewise[{{0, t > 0 && t < 0}}];
θ1n = Piecewise[{{0, t > 0 && t < 0}}];
x2n = Piecewise[{{0, t > 0 && t < 0}}];
y2n = Piecewise[{{0, t > 0 && t < 0}}];
θ2n = Piecewise[{{0, t > 0 && t < 0}}];
θ3n = Piecewise[{{0, t > 0 && t < 0}}];

ELtemp = Solve[Eq1 && Eq2 && Eq3 && Eq4 && Eq5 && Eq6 && Eq7 && Eq8 && Eq9 && Eq10, {x1''[t],
    y1''[t], θ1''[t], x2''[t], y2''[t], θ2''[t], θ3''[t], λ1[t], λ2[t], λ3[t]}];
EL = {x1''[t] == ELtemp[[1, 1, 2]], y1''[t] == ELtemp[[1, 2, 2]],
   θ1''[t] == ELtemp[[1, 3, 2]], x2''[t] == ELtemp[[1, 4, 2]], y2''[t] ==
    ELtemp[[1, 5, 2]], θ2''[t] == ELtemp[[1, 6, 2]], θ3''[t] == ELtemp[[1, 7, 2]]};
InitCon = {x1[0] == 13.5, y1[0] == 35, x1'[0] == 0, y1'[0] == 0,
   θ1'[0] == 0, θ1[0] == 0, x2[0] == -13.5, y2[0] == 7.7, x2'[0] == 0,
   y2'[0] == 0, θ2'[0] == 0, θ2[0] == 0, θ3'[0] == 0, θ3[0] == -(0)};

(*HAMILTONAIN*)
p = D[L, dq^T];
H = {p}.dq - L;

(*Solve the equations of motion before impact*)
sol = NDSolve[Join[EL, InitCon], {x1[t], y1[t], θ1[t], x2[t], y2[t], θ2[t], θ3[t]},
   {t, 0, 10}, Method → {"EventLocator", "Event" → ((y1[t] - 1.5) - (gWS1[[2, 4]])),
     "EventAction" :→ Throw[tmax = t, "StopIntegration"]}];
Print["The impact is at time ", tmax]

(*Updating variables leading upto impact*)
x1n = Piecewise[{{x1n, 0 ≤ t ≤ 0}, {sol[[1, 1, 2]], t > 0 && t < tmax}}];
y1n = Piecewise[{{y1n, 0 ≤ t ≤ 0}, {sol[[1, 2, 2]], t > 0 && t < tmax}}];
θ1n = Piecewise[{{θ1n, 0 ≤ t ≤ 0}, {sol[[1, 3, 2]], t > 0 && t < tmax}}];
```

```
x2n = Piecewise[{{x2n, 0 ≤ t ≤ 0}, {sol[[1, 4, 2]], t > 0 && t < tmax}}];
y2n = Piecewise[{{y2n, 0 ≤ t ≤ 0}, {sol[[1, 5, 2]], t > 0 && t < tmax}}];
θ2n = Piecewise[{{θ2n, 0 ≤ t ≤ 0}, {sol[[1, 6, 2]], t > 0 && t < tmax}}];
θ3n = Piecewise[{{θ3n, 0 ≤ t ≤ 0}, {sol[[1, 7, 2]], t > 0 && t < tmax}}];
tmax1 = tmax;(*TIME OF IMPACT - Important*)
```

(*IMPACT LAWS*)

```
(*ELASTIC*)
(*Hplus =
 H/.sol/.{x1'[t] → x1plus,y1'[t] → y1plus,θ1'[t]→ θ1plus, x2'[t] → x2plus,
    y2'[t] → y2plus, θ2'[t]→ θ2plus, θ3'[t]→ θ3plus,θ4'[t]→ θ4plus}/. t→ tmax;
Hminus = H/.sol/.{x1'[t] →D[x1[t]/.sol,t],y1'[t] →D[y1[t]/.sol,t],
    θ1'[t]→ D[θ1[t]/.sol,t],x2'[t] →D[x2[t]/.sol,t],
    y2'[t] →D[y2[t]/.sol,t],θ2'[t]→ D[θ2[t]/.sol,t],
    θ3'[t]→ D[θ3[t]/.sol,t],θ4'[t]→ D[θ4[t]/.sol,t]}/. t→ tmax;
EQ1 = (Flatten[Hplus]-Flatten[Hminus])[[1]] == 0;*)
(*************************************************************************
 ************)(*PLASTIC*)
plastic = (D[ϕ4, q^T].dq)[[1]] /. sol /.
    {x1'[t] → x1plus, y1'[t] → y1plus, θ1'[t] → θ1plus, x2'[t] → x2plus,
     y2'[t] → y2plus, θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax;

EQ1 = Flatten[plastic] == 0;
(*************************************************************************
 ************)
EQ2 =
  Flatten[p[[1, 1, 1]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus, θ1'[t] → θ1plus,
            x2'[t] → x2plus, y2'[t] → y2plus, θ2'[t] → θ2plus,
            θ3'[t] → θ3plus} /. t → tmax][[1]] -
      Flatten[p[[1, 1, 1]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t],
            θ2'[t] → D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[
       1]] == λ * (D[ϕ4, x1[t]] + D[ϕ5, x1[t]]) /. sol /. t → tmax;
EQ3 = Flatten[p[[1, 1, 2]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus,
            θ1'[t] → θ1plus, x2'[t] → x2plus, y2'[t] → y2plus,
            θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax][[1]] -
      Flatten[p[[1, 1, 2]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t],
            θ2'[t] → D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[
       1]] == λ * (D[ϕ4, y1[t]] + D[ϕ5, y1[t]]) /. sol /. t → tmax;
EQ4 = Flatten[p[[1, 1, 3]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus,
            θ1'[t] → θ1plus, x2'[t] → x2plus, y2'[t] → y2plus,
```

```
            θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax][[1]] -
       Flatten[p[[1, 1, 3]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t], θ2'[t] →
             D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[1]] ==
     λ * (D[ϕ4, θ1[t]] + D[ϕ5, θ1[t]]) /. sol /. t → tmax;
EQ5 = Flatten[p[[1, 1, 4]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus,
            θ1'[t] → θ1plus, x2'[t] → x2plus, y2'[t] → y2plus,
            θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax][[1]] -
       Flatten[p[[1, 1, 4]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t],
            θ2'[t] → D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[
        1]] == λ * (D[ϕ4, x2[t]] + D[ϕ5, x2[t]]) /. sol /. t → tmax;
EQ6 = Flatten[p[[1, 1, 5]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus,
            θ1'[t] → θ1plus, x2'[t] → x2plus, y2'[t] → y2plus,
            θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax][[1]] -
       Flatten[p[[1, 1, 5]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t],
            θ2'[t] → D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[
        1]] == λ * (D[ϕ4, y2[t]] + D[ϕ5, y2[t]]) /. sol /. t → tmax;
EQ7 = Flatten[p[[1, 1, 6]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus,
            θ1'[t] → θ1plus, x2'[t] → x2plus, y2'[t] → y2plus,
            θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax][[1]] -
       Flatten[p[[1, 1, 6]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t],
            θ2'[t] → D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[
        1]] == λ * (D[ϕ4, θ2[t]] + D[ϕ5, θ2[t]]) /. sol /. t → tmax;
EQ8 = Flatten[p[[1, 1, 7]] /. sol /. {x1'[t] → x1plus, y1'[t] → y1plus,
            θ1'[t] → θ1plus, x2'[t] → x2plus, y2'[t] → y2plus,
            θ2'[t] → θ2plus, θ3'[t] → θ3plus} /. t → tmax][[1]] -
       Flatten[p[[1, 1, 7]] /. sol /. {x1'[t] → D[x1[t] /. sol, t],
            y1'[t] → D[y1[t] /. sol, t], θ1'[t] → D[θ1[t] /. sol, t],
            x2'[t] → D[x2[t] /. sol, t], y2'[t] → D[y2[t] /. sol, t],
            θ2'[t] → D[θ2[t] /. sol, t], θ3'[t] → D[θ3[t] /. sol, t]} /. t → tmax][[
        1]] == λ * (D[ϕ4, θ3[t]] + D[ϕ5, θ3[t]]) /. sol /. t → tmax;
EQ9 = λ ≠ 0;

NewInitCon = NSolve[{EQ1, EQ2[[1]], EQ3[[1]], EQ4[[1]], EQ5[[1]], EQ6[[1]], EQ7[[1]],
    EQ8[[1]], EQ9}, {x1plus, y1plus, θ1plus, x2plus, y2plus, θ2plus, θ3plus, λ}];

PostImpactConditions = {x1[tmax1] == (x1[t] /. sol /. t → tmax)[[1]],
   y1[tmax1] == (y1[t] /. sol /. t → tmax)[[1]],
```

```
    θ1[tmax1] == (θ1[t] /. sol /. t → tmax)[[1]], x2[tmax1] ==
     (x2[t] /. sol /. t → tmax)[[1]], y2[tmax1] == (y2[t] /. sol /. t → tmax)[[1]],
    θ2[tmax1] == (θ2[t] /. sol /. t → tmax)[[1]],
    θ3[tmax1] == (θ3[t] /. sol /. t → tmax)[[1]], x1'[tmax1] == NewInitCon[[1, 1, 2]],
    y1'[tmax1] == NewInitCon[[1, 2, 2]], θ1'[tmax1] == NewInitCon[[1, 3, 2]],
    x2'[tmax1] == NewInitCon[[1, 4, 2]], y2'[tmax1] == NewInitCon[[1, 5, 2]],
    θ2'[tmax1] == NewInitCon[[1, 6, 2]], θ3'[tmax1] == NewInitCon[[1, 7, 2]]};

(*Release Constraints Post Impact*)
(*ϕ1 = 15*Cos[θ3[t]] - ((gWSq1.BR)[[1]]); (*((y1[t] -1.5) - (gWS2[[2,4]]))*);
ϕ2 = 6-15*Sin[θ3[t]] -((gWSq1.BR)[[2]]) ;
(*((gWSq2.BL)[[2]]+(1.5*Tan[θ3[t]])) - gWS1[[2,4]];*)*)
(*ϕ3 = θ2[t] -θ3[t];*)

(*SQUARE1*)
Eq1 = D[D[L, x1'[t]], t] - D[L, x1[t]] == 0
 (*λ1[t]*D[ϕ1, x1[t]]+ λ2[t]*D[ϕ2, x1[t]]*)(*+ λ3[t]*D[ϕ3, x1[t]]*);
Eq2 = D[D[L, y1'[t]], t] - D[L, y1[t]] == 0
 (*λ1[t]*D[ϕ1, y1[t]] + λ2[t]*D[ϕ2, y1[t]]*)(*+ λ3[t]*D[ϕ3, y1[t]]*);
Eq3 = D[D[L, θ1'[t]], t] - D[L, θ1[t]] == 0
 (*λ1[t]*D[ϕ1, θ1[t]]+ λ2[t]*D[ϕ2, θ1[t]]*)(*+ λ3[t]*D[ϕ3, θ1[t]]*);

(*SQUARE2*)
Eq4 = D[D[L, x2'[t]], t] - D[L, x2[t]] == 0
 (*λ1[t]*D[ϕ1, x2[t]]+ λ2[t]*D[ϕ2, x2[t]]*)(*+ λ3[t]*D[ϕ3, x2[t]]*);
Eq5 = D[D[L, y2'[t]], t] - D[L, y2[t]] == 0
 (*λ1[t]*D[ϕ1, y2[t]]+ λ2[t]*D[ϕ2, y2[t]]*)(*+ λ3[t]*D[ϕ3, y2[t]]*);
Eq6 = D[D[L, θ2'[t]], t] - D[L, θ2[t]] == 0
 (*λ1[t]*D[ϕ1, θ2[t]]+ λ2[t]*D[ϕ2, θ2[t]]*)(*+ λ3[t]*D[ϕ3, θ2[t]]*);

(*SEE SAW*)
Eq7 = D[D[L, θ3'[t]], t] - D[L, θ3[t]] == 0
 (*λ1[t]*D[ϕ1, θ3[t]]+ λ2[t]*D[ϕ2, θ3[t]]*)(*+ λ3[t]*D[ϕ3, θ3[t]]*);
(*Eq8 = D[D[ϕ1,t],t] == 0;
Eq9 = D[D[ϕ2,t],t] ==  0;*)
(*Eq10 = D[D[ϕ3,t],t] ==  0;*)

ELtemp = Solve[Eq1 && Eq2 && Eq3 && Eq4 && Eq5 && Eq6 && Eq7
    (*&&Eq8&&Eq9&&Eq10*), {x1''[t], y1''[t], θ1''[t], x2''[t],
     y2''[t], θ2''[t], θ3''[t](*,λ1[t],λ2[t],λ3[t]*)}];
EL = {x1''[t] == ELtemp[[1, 1, 2]], y1''[t] == ELtemp[[1, 2, 2]],
   θ1''[t] == ELtemp[[1, 3, 2]], x2''[t] == ELtemp[[1, 4, 2]], y2''[t] ==
     ELtemp[[1, 5, 2]], θ2''[t] == ELtemp[[1, 6, 2]], θ3''[t] == ELtemp[[1, 7, 2]]};
(*Solve the equations of motion after impact*)
sol = NDSolve[Join[EL, PostImpactConditions],
```

```
    {x1[t], y1[t], θ1[t], x2[t], y2[t], θ2[t], θ3[t]}, {t, 0, 10},
    Method → {"EventLocator", "Event" → ((y1[t] - 1.5) - (gWS1[[2, 4]])),
      "EventAction" :→ Throw[tmax = t, "StopIntegration"]}];


(*Updating variables after impact*)
x1n = Piecewise[{{x1n, 0 ≤ t ≤ tmax1}, {sol[[1, 1, 2]], t > tmax1 && t < 10}}];
y1n = Piecewise[{{y1n, 0 ≤ t ≤ tmax1}, {sol[[1, 2, 2]], t > tmax1 && t < 10}}];
θ1n = Piecewise[{{θ1n, 0 ≤ t ≤ tmax1}, {sol[[1, 3, 2]], t > tmax1 && t < 10}}];
x2n = Piecewise[{{x2n, 0 ≤ t ≤ tmax1}, {sol[[1, 4, 2]], t > tmax1 && t < 10}}];
y2n = Piecewise[{{y2n, 0 ≤ t ≤ tmax1}, {sol[[1, 5, 2]], t > tmax1 && t < 10}}];
θ2n = Piecewise[{{θ2n, 0 ≤ t ≤ tmax1}, {sol[[1, 6, 2]], t > tmax1 && t < 10}}];
θ3n = Piecewise[{{θ3n, 0 ≤ t ≤ tmax1}, {sol[[1, 7, 2]], t > tmax1 && t < 10}}];

(*Getting all Config Variables*)
fullx1 = PiecewiseExpand[x1n];
fully1 = PiecewiseExpand[y1n];
fullθ1 = PiecewiseExpand[θ1n];
fullx2 = PiecewiseExpand[x2n];
fully2 = PiecewiseExpand[y2n];
fullθ2 = PiecewiseExpand[θ2n];
fullθ3 = PiecewiseExpand[θ3n];
```

In[•]:=

```
(*ANIMATE*)
(*SQUARE1*)
TL1t[T_] :=
  (((gWSq1.TL) /. x1[t] → fullx1 /. y1[t] → fully1 /. θ1[t] → fullθ1) /. t → T)[[
   1 ;; 2]];
BL1t[T_] := (((gWSq1.BL) /. x1[t] → fullx1 /. y1[t] → fully1 /. θ1[t] → fullθ1) /.
     t → T)[[1 ;; 2]];
BR1t[T_] := (((gWSq1.BR) /. x1[t] → fullx1 /. y1[t] → fully1 /. θ1[t] → fullθ1) /.
     t → T)[[1 ;; 2]];
TR1t[T_] := (((gWSq1.TR) /. x1[t] → fullx1 /. y1[t] → fully1 /. θ1[t] → fullθ1) /.
     t → T)[[1 ;; 2]];

(*SQUARE2*)
TL2t[T_] :=
  (((gWSq2.TL) /. x2[t] → fullx2 /. y2[t] → fully2 /. θ2[t] → fullθ2) /. t → T)[[
   1 ;; 2]];
BL2t[T_] := (((gWSq2.BL) /. x2[t] → fullx2 /. y2[t] → fully2 /. θ2[t] → fullθ2) /.
     t → T)[[1 ;; 2]];
BR2t[T_] := (((gWSq2.BR) /. x2[t] → fullx2 /. y2[t] → fully2 /. θ2[t] → fullθ2) /.
     t → T)[[1 ;; 2]];
```

```
TR2t[T_] := (((gWSq2.TR) /. x2[t] → fullx2 /. y2[t] → fully2 /. θ2[t] → fullθ2) /.
      t → T)[[1 ;; 2]];


(*SEE SAW*)
SS1t[T_] := (((gWMid.{-30/2, -1/2, 0, 1}) /. θ3[t] → fullθ3) /. t → T)[[1 ;; 2]];
SS2t[T_] := (((gWMid.{30/2, -1/2, 0, 1}) /. θ3[t] → fullθ3) /. t → T)[[1 ;; 2]];
SS3t[T_] := (((gWMid.{30/2, 1/2, 0, 1}) /. θ3[t] → fullθ3) /. t → T)[[1 ;; 2]];
SS4t[T_] := (((gWMid.{-30/2, 1/2, 0, 1}) /. θ3[t] → fullθ3) /. t → T)[[1 ;; 2]];

(*Spring1*)
Spring2D[start_, end_, loops_, radius_] :=
 Module[{detail = 40, steps}, steps = detail (loops + .5);
  Translate[Rotate[Line@Table[
      {radius + (Norm[end - start] - 2 radius) a / steps + radius Cos[2 Pi a/detail + Pi],
       radius Sin[2 Pi a/detail]}, {a, 0, steps}], {{1, 0}, end - start}], start]]

Animate[Show[
  Graphics[{(*Square1*)Green, Thick, Line[{{TL1t[t], TR1t[t]}, {TR1t[t], BR1t[t]},
      {BR1t[t], BL1t[t]}, {BL1t[t], TL1t[t]}}], (*Square2*)Red, Thick,
    Line[{{TL2t[t], TR2t[t]}, {TR2t[t], BR2t[t]}, {BR2t[t], BL2t[t]},
      {BL2t[t], TL2t[t]}}], (*SeeSaw*)Black, Thick,
    Line[{{SS1t[t], SS2t[t]}, {SS2t[t], SS3t[t]}, {SS3t[t], SS4t[t]},
      {SS4t[t], SS1t[t]}}], (*SeeSaw Pivot*)Black, Thick,
    Line[{{-4, 0}, {0, 6}, {4, 0}, {-4, 0}}], (*Spring1*)Blue, Thick,
    Spring2D[{15, 0}, SS2t[t], 7, 0.2], (*Spring2*)Blue, Thick,
    Spring2D[{-15, 0}, SS1t[t], 7, 0.2], Black, Thick, Line[{{-20, 0}, {20, 0}}]},
   Axes → False, PlotRange → {{-20, 20}, {-5, 60}}]],
 {t, 0, 7}, AnimationRunning → False,
 AnimationRate → 1]
```