Initialization

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In[2]:= (*Body Parameters*)
rua = 30.3;   rfa = 36.7;   rth = 47.2;   rca = 53.6;   rft = 21;   rhw = 22.3; rhh = -3.7; rsw = 34.8; rsh = 47.2;
ruacm = 14.9; rfacm = 12.2; rthcm = 21.0; rcacm = 18.3; rftcm = 11.7; rabcm = 12.7; rtxcm = 34.2; rnecm = 59.3; rhecm = 73.5;

masses = {mhe = 4.4, mne = 1.2, mtx = 30.5, mab = 2.9, mpe = 14.6, mua = 2.4, mua, mla = 1.6, mla, mha = .6, mha, mth = 11.8,
   mth, mca = 4.5, mca, mft = 1.1, mft};
M = Total@masses;

(*Functions*)
rotxyz[φ_, θ_, ψ_] := {{Cos[θ] Cos[ψ], -Cos[θ] Sin[ψ], Sin[θ]},
   {Cos[ψ] Sin[θ] Sin[φ] + Cos[φ] Sin[ψ], Cos[φ] Cos[ψ] - Sin[θ] Sin[φ] Sin[ψ], -Cos[θ] Sin[φ]},
   {-Cos[φ] Cos[ψ] Sin[θ] + Sin[φ] Sin[ψ], Cos[ψ] Sin[φ] + Cos[φ] Sin[θ] Sin[ψ], Cos[θ] Cos[φ]}};

CM[bodycoordinates_] := Dot[masses, bodycoordinates[[{2, 3, 4, 5, 6, 9, 12, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30}]]] / M;

moments[bodycoordinates_] := Block[{indicies = {2, 3, 4, 5, 6, 9, 12, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30}},
  {masses.(((Part[bodycoordinates, #, 2]/100)^2 + (Part[bodycoordinates, #, 3]/100)^2) & /@ indicies),
   masses.(((Part[bodycoordinates, #, 1]/100)^2 + (Part[bodycoordinates, #, 3]/100)^2) & /@ indicies),
   masses.(((Part[bodycoordinates, #, 1]/100)^2 + (Part[bodycoordinates, #, 2]/100)^2) & /@ indicies)}]

Clear[bodycoordinates];
bodycoordinates[{φab_, θab_, φsh_, φshr_, θshr_, φebr_, θebr_, φshl_, θshl_, φebl_, θebl_, φhir_, θhir_, φknr_, θknr_, φanr_,
    φhil_, θhil_, φknl_, θknl_, φanl_, φ_, θ_, ψ_, h_}] :=
  Block[{bc, rotbc, mi, cm, he, ne, tx, ab, pe, shr, ebr, har, shl, ebl, hal, hir, knr, anr, ftr, hil, knl, anl, ftl, uar, ual, far,
    fal, thr, thl, car, cal, fcmr, fcml},
   pe = {0, 0, 0}; ab = pe + rotxyz[.5 φab, 0, θab].{0, rabcm , 0}; tx = ab + rotxyz[φab, 0, θab].{0, rtxcm - rabcm, 0};
   ne = tx + rotxyz[φab, 0, θab].{0, rnecm - rtxcm, 0}; he = ne + rotxyz[φab, 0, θab].{0, rhecm - rnecm, 0};
   bc = {(*1 Center of Mass*)cm, (*2 CM Head*)he, (*3 CM Neck*)ne, (*4 CM Thorax*)tx, (*5 CM Abdomen*)ab, (*6 CM Pelvis*)pe,
     (*7,8,9 Right Arm*)
      shr = tx + rotxyz[φab, 0, θab].{-rsw/2 Cos[φsh], rsh - rtxcm, rsw/2 Sin[φsh]},
      ebr = shr + rotxyz[φab, 0, θab].rotxyz[0, φsh, 0].RotationMatrix[θshr, {0, -1, 0}].RotationMatrix[φshr, {{0, -1, 0}, {0, 0, 1}}].
       {0, -rua, 0},
      har = ebr + rotxyz[φab, 0, θab].rotxyz[0, φsh, 0].RotationMatrix[θshr, {0, -1, 0}].RotationMatrix[φshr, {{0, -1, 0}, {0, 0, 1}}].
       RotationMatrix[θebr, {0, 1, 0}].RotationMatrix[φebr, {{0, -1, 0}, {0, 0, 1}}].{0, -rfa, 0},
     (*10,11,12 Left Arm*)
      shl = tx + rotxyz[φab, 0, θab].{rsw/2 Cos[φsh], rsh - rtxcm, -rsw/2 Sin[φsh]},
      ebl = shl + rotxyz[φab, 0, θab].rotxyz[0, φsh, 0].RotationMatrix[θshl, {0, 1, 0}].RotationMatrix[φshl, {{0, -1, 0}, {0, 0, 1}}].
       {0, -rua, 0},
      hal = ebl + rotxyz[φab, 0, θab].rotxyz[0, φsh, 0].RotationMatrix[θshl, {0, 1, 0}].RotationMatrix[φshl, {{0, -1, 0}, {0, 0, 1}}].
       RotationMatrix[θebl, {0, -1, 0}].RotationMatrix[φebl, {{0, -1, 0}, {0, 0, 1}}].{0, -rfa, 0},
     (*13,14,15,16 Right Leg*)
      hir = pe + {-rhw/2, rhh, 0},
      knr = hir + RotationMatrix[θhir, {0, -1, 0}].RotationMatrix[φhir, {{0, -1, 0}, {0, 0, 1}}].{0, -rth, 0},
      anr = knr + RotationMatrix[θhir, {0, -1, 0}].RotationMatrix[φhir, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknr, {0, -1, 0}].RotationMatrix[φknr, {{0, 0, 1}, {0, -1, 0}}].{0, -rca, 0},
      ftr = anr + RotationMatrix[θhir, {0, -1, 0}].RotationMatrix[φhir, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknr, {0, -1, 0}].RotationMatrix[φknr, {{0, 0, 1}, {0, -1, 0}}].
        RotationMatrix[φanr, {1, 0, 0}].{0, 0, rft},
     (*17,18,19,20 Left Leg*)
      hil = pe + {rhw/2, rhh, 0},
      knl = hil + RotationMatrix[θhil, {0, 1, 0}].RotationMatrix[φhil, {{0, -1, 0}, {0, 0, 1}}].{0, -rth, 0},
      anl = knl + RotationMatrix[θhil, {0, 1, 0}].RotationMatrix[φhil, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknl, {0, 1, 0}].RotationMatrix[φknl, {{0, 0, 1}, {0, -1, 0}}].{0, -rca, 0},
      ftl = anl + RotationMatrix[θhil, {0, 1, 0}].RotationMatrix[φhil, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknl, {0, 1, 0}].RotationMatrix[φknl, {{0, 0, 1}, {0, -1, 0}}].
        RotationMatrix[φanl, {1, 0, 0}].{0, 0, rft},
     (*21,22 CM Upper Arm*)
      rotxyz[-1.38 φab, 0, θab].rotxyz[0, φsh, 0].
     (uar = shr + RotationMatrix[θshr, {0, -1, 0}].RotationMatrix[φshr, {{0, -1, 0}, {0, 0, 1}}].{0, -ruacm, 0}),
      rotxyz[-1.38 φab, 0, θab].rotxyz[0, φsh, 0].
     (ual = shl + RotationMatrix[θshl, {0, 1, 0}].RotationMatrix[φshl, {{0, -1, 0}, {0, 0, 1}}].{0, -ruacm, 0}),
     (*23,24 CM Forearm*)
      rotxyz[-1.38 φab, 0, θab].rotxyz[0, φsh, 0].(fal = ebl + RotationMatrix[θshl, {0, 1, 0}].RotationMatrix[φshl, {{0, -1, 0}, {0, 0, 1}}].
         RotationMatrix[θebl, {0, -1, 0}].RotationMatrix[φebl, {{0, -1, 0}, {0, 0, 1}}].{0, -rfacm, 0}),
      rotxyz[-1.38 φab, 0, θab].rotxyz[0, φsh, 0].(far = ebr + RotationMatrix[θshr, {0, -1, 0}].RotationMatrix[φshr, {{0, -1, 0}, {0, 0, 1}}].
         RotationMatrix[θebr, {0, 1, 0}].RotationMatrix[φebr, {{0, -1, 0}, {0, 0, 1}}].{0, -rfacm, 0}),
     (*25,26 CM Thigh*)
      thl = hil + RotationMatrix[θhil, {0, 1, 0}].RotationMatrix[φhil, {{0, -1, 0}, {0, 0, 1}}].{0, -rthcm, 0},
      thr = hir + RotationMatrix[θhir, {0, -1, 0}].RotationMatrix[φhir, {{0, -1, 0}, {0, 0, 1}}].{0, -rthcm, 0},
     (*27,28 CM Calf*)
      cal = knl + RotationMatrix[θhil, {0, 1, 0}].RotationMatrix[φhil, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknl, {0, 1, 0}].RotationMatrix[φknl, {{0, 0, 1}, {0, -1, 0}}].{0, -rcacm, 0},
      car = knr + RotationMatrix[θhir, {0, -1, 0}].RotationMatrix[φhir, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknr, {0, -1, 0}].RotationMatrix[φknr, {{0, 0, 1}, {0, -1, 0}}].{0, -rcacm, 0},
     (*29,30 CM Foot*)
      fcml = anl + RotationMatrix[θhil, {0, 1, 0}].RotationMatrix[φhil, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknl, {0, 1, 0}].RotationMatrix[φknl, {{0, 0, 1}, {0, -1, 0}}].
        RotationMatrix[φanl, {1, 0, 0}].{0, 3, rftcm},
      fcmr = anr + RotationMatrix[θhir, {0, -1, 0}].RotationMatrix[φhir, {{0, -1, 0}, {0, 0, 1}}].
        RotationMatrix[θknr, {0, -1, 0}].RotationMatrix[φknr, {{0, 0, 1}, {0, -1, 0}}].
        RotationMatrix[φanr, {1, 0, 0}].{0, 3, rftcm}};
   cm = CM[bc]; rotbc = Map[(Plus[Dot[rotxyz[φ, θ, ψ], Plus[-cm, #]]]) &, bc]; mi = moments[rotbc];
   If[h < 1, MiN = Min[Part[#, 2] & /@ rotbc]];
   Map[Plus[{0, h - MiN + 5, 0}, #] &, rotbc] ~Join~ {{-100, 0, -100}, {100, 0, -100}, {100, 0, 100}, {-100, 0, 100}} ~Join~ {mi}];

frame[bodycoordinates_, v_: π/6] :=
 Graphics3D[GraphicsComplex[bodycoordinates, {Sphere[2, 10.5], Blue, PointSize[.009], Point[Table[i, {i, 7, 20}]],
    Black, Thickness[.004], Line[{{2, 3}, {6, 13, 17, 6}, {10, 7, 4, 10}, {7, 8, 9}, {10, 11, 12}, {13, 14, 15, 16}, {17, 18, 19, 20}}],
    BSplineCurve[{{17, 5, 10}, {13, 5, 7}, {3, 4, 5, 6}, {7, 3, 10}}, SplineWeights → {{1, 2, 3}, {1, 2, 3}, {1, 1, 3, 1}, {1, 1, 1}}],
    Red, Point[{2, 3, 4, 5, 6}], PointSize[Large], Point[1],
    (*Ground*)Thickness[.01], Green, Polygon[{31, 32, 33, 34}]}], PlotRange → {{-130, 130}, {-30, 300}, {-100, 100}},
  ImageSize → {700, 700}, SphericalRegion → True, ViewVector → {{600 Sin[v], 200, 600 Cos[v]}, {0, 150, 0}}, ViewVertical → {0, 1, 0},
  ViewAngle → All, Boxed → False]
ntable[{a_: 1, b_: 0, c_: 0, e_: 1}, min_, max_, n_, i_: 0, f_: 1] := Drop[
  Table[min + (max - min) (1/(a + b + c) (a Sin[π/2. (x^e)]^2 + b (x^e)^2 + c (-((x^e) - 1.)^2 + 1.))), {x, i, f, Abs[f - i]/n}], -1];

animate[anim_, fps_] := ListAnimate[Flatten[frame /@ bodycoordinates /@ Thread@Flatten[anim, 1]], fps]
animatrix[anim_] := (bodycoordinates /@ Thread@Flatten[#, 1]) & /@ anim // MatrixForm
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In[15]:= Manipulate[

  frame[bodycoordinates[{φab, θab, φsh, φshr, θshr, φebr, θebr, φshl, θshl, φebl, θebl, φhir, θhir, φknr, θknr, φanr, φhil,
     θhil, φknl, θknl, φanl, φ, θ, ψ, h}], v],
 {{φab, 0}, -π, π}, {{θab, 0}, -π, π}, {{φsh, 0}, -π, π}, {φshr, .001, 2π}, {θshr, 0, 2π}, {φebr, 0, 2π}, {θebr, 0, 2π},
  {φshl, .001, 2π}, {θshl, 0, 2π}, {φebl, 0, 2π}, {θebl, 0, 2π}, {φhir, .001, 2π}, {θhir, 0, 2π}, {φknr, 0, π},
  {θknr, 0, 2π}, {{φanr, 0}, -π/2, π/2}, {φhil, .001, 2π}, {θhil, 0, 2π}, {φknl, 0, π}, {θknl, 0, 2π}, {{φanl, 0}, -π/2, π/2},
  {φ, 0, 2π}, {θ, 0, 2π}, {ψ, 0, 2π}, {h, 0, 50},
 {v, 0, 2π}]
```

Animation Lists

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{(*φab*){0}, (*θab*){0}, (*φsh*){0}, (*φshr,θshr*){0}, {0}, (*φebr,θebr*){0}, {0}, (*φshl,θshl*){0}, {0}, (*φebl,
  θebl*){0}, {0}, (*φhir,θhir*){0}, {0}, (*φknr,θknr*){0}, {0}, (*φanr*){0}, (*φhil,θhil*){0}, {0}, (*φknl,θknl*){0},
  {0}, (*φanl*){0}, (*φ*){0}, (*θ*){0}, (*ψ*){0}, (*h*){0}}

(*55 Frames*)backflip = {(*φab*){Join[ntable[{}, 0, 20*2.π/360., 16], ntable[{}, 20*2.π/360., -π/24., 11],
   ntable[{}, -π/24., -π/16, 4], ntable[{}, -π/16., π/15, 6], Table[π/15., {i, 1, 10}], ntable[{}, π/15., π/3, 4],
     ntable[{}, π/6., π/20., 4]]},
  (*θab*){0}, (*φsh*){0},
  (*φshr,θshr*){Join[ntable[{}, π, -π/2., 16], ntable[{}, -π/2., 13π/12., 11], Table[13π/12., {i, 1, 4}],
     ntable[{}, 13π/12., π/6., 6], Table[π/6., {i, 1, 10}], ntable[{}, π/6., π/2., 4], Table[π/2., {i, 1, 4}]]},
  {0},
  (*φebr,θebr*){0},
  {0},
  (*φshl,θshl*){Join[ntable[{}, π, -π/2., 16], ntable[{}, -π/2., 13π/12., 11], Table[13π/12., {i, 1, 4}],
     ntable[{}, 13π/12., π/6., 6], Table[π/6., {i, 1, 10}], ntable[{}, π/6., π/2., 4], Table[π/2., {i, 1, 4}]]},
  {0},
  (*φebl,θebl*){0},
  {0},
  (*φhir,θhir*){Join[ntable[{}, 0., π/4., 16], Table[π/4, {i, 1, 5}], ntable[{}, π/4., 0., 6], ntable[{0, 1, 0, 2}, 0, π/1.3, 10],
     Table[π/1.3, {i, 1, 10}], ntable[{1, .5, 0}, π/1.3, π/6., 4], ntable[{0, 0, 1}, π/6., 2π/6., 4]]},
  {0},
  (*φknr,θknr*){Join[ntable[{}, 0., π/4., 16], Table[π/4, {i, 1, 5}], ntable[{}, π/4., 0., 6], Table[0, {i, 1, 4}],
     ntable[{}, 0, 2.3, 6], Table[2.3, {i, 1, 10}], ntable[{1, .5, 0}, 2.3, π/6., 4], ntable[{0, 0, 1}, π/6., 2π/6., 4]]},
  {0},
  (*φanr*){Join[ntable[{}, π/3., π/24., 8], Table[π/24., {i, 1, 8}], Table[π/24, {i, 1, 5}], ntable[{}, π/24., 2π/6, 6],
     Table[2π/6., {i, 1, 20}], Table[2π/6., {i, 1, 3}], ntable[{0, 0, 1}, 2π/6., π/10., 5]]},
  (*φhil,θhil*){Join[ntable[{}, 0., π/4., 16], Table[π/4, {i, 1, 5}], ntable[{}, π/4., 0., 6], ntable[{0, 1, 0, 2}, 0, π/1.3, 10],
     Table[π/1.3, {i, 1, 10}], ntable[{1, .5, 0}, π/1.3, π/6., 4], ntable[{0, 0, 1}, π/6., 2π/6., 4]]},
  {0},
  (*φknl,θknl*){Join[ntable[{}, 0., π/4., 16], Table[π/4, {i, 1, 5}], ntable[{}, π/4., 0., 6], Table[0, {i, 1, 4}],
     ntable[{}, 0, 2.3, 6], Table[2.3, {i, 1, 10}], ntable[{1, .5, 0}, 2.3, π/6., 4], ntable[{0, 0, 1}, π/6., 2π/6., 4]]},
  {0},
  (*φanl*){Join[ntable[{}, π/3., π/24., 8], Table[π/24., {i, 1, 8}], Table[π/24, {i, 1, 5}], ntable[{}, π/24., 2π/6, 6],
     Table[2π/6., {i, 1, 20}], Table[2π/6., {i, 1, 3}], ntable[{0, 0, 1}, 2π/6., π/10., 5]]},
  (*φ*){Join[Table[0, {i, 1, 16}], Table[0, {i, 1, 5}], ntable[{}, 0, π/24., 6], ntable[{}, π/24., -π/24., 3],
     ntable[{1, 1, 0}, -π/24., -5π/4., 17], ntable[{0, 0, 1}, -5π/4., -2.π, 4], Table[0, {i, 1, 4}]]},
  (*θ*){(*Join[Table[0, {i, 1, 30}], ntable[{},0,2.π,19], Table[0, {i, 1, 6}]]*)0},
  (*ψ*){0}, (*h*){Join[Table[0, {i, 1, 25}], ntable[{0, 0, 1}, 0, 64., 13], ntable[{0, 1, 0}, 64., 0, 13], Table[0, {i, 1, 4}]]}};
```