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(* R-RTR-RRT Problem 9.9 *)
(* positions *)

Apply[Clear,Names["Global`*"]];
Off[General::spell];
Off[General::spell1];

omega = 60*N[Pi]/30 ; (* rad/s *)

(* Input data *)
initdata = {AB->0.020, AE->0.050, BC->0.030, CD->0.060,
La->0.02, xE->-0.050, yE ->0., xD->0.02,
phi[t]->N[Pi]/6, phi'[t]->omega, phi''[t]->0};

(* Position of joint A *)
xA = yA = 0;

(* Position of joint B *)
xB = AB Cos[ phi[t] ] ;
yB = AB Sin[ phi[t] ] ;
Print["xB[t] = ", xB];
Print["yB[t] = ", yB];
pxB=xB/.initdata;
pyB=yB/.initdata;
Print["xB = ",pxB, " m" ];
Print["yB = ",pyB, " m" ];
Print["rB = ",{pxB,pyB,0}, " m" ];

Bdata={xB[t]->pxB, yB[t]->pyB};

(*****
(* Joint C *)
(*****

(* Parameters m and n of line EBC: y = m x + n *)

mBC=(yB[t]-yE)/(xB[t]-xE)/.initdata/.Bdata;
nBC=yE-(yB[t]-yE)/(xB[t]-xE) xE /.initdata/.Bdata;
Mdata={m[t]->mBC, n[t]->nBC};

Print["m[t]= ",(yB[t]-yE)/(xB[t]-xE)];
Print["m= ",mBC];
Print["n[t]= ",yE-m[t]xE ];
Print["n= ",nBC];

eqCI =(xC[t]-xB[t])^2+(yC[t]-yB[t])^2-BC^2 == 0;
eqCII= yC[t] - m[t] xC[t] - n[t] == 0;

Print["Equations for C (xC[t], yC[t])"];
Print[eqCI];
Print[eqCII];
Print["Solution for C (xC[t], yC[t])"];

solutionC=Simplify[Solve[{eqCI,eqCII},{xC[t],yC[t]}]];

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(* Two solutions for C *)
xC1 = xC[t]/.solutionC[[1]];
yC1 = yC[t]/.solutionC[[1]];
xC2 = xC[t]/.solutionC[[2]];
yC2 = yC[t]/.solutionC[[2]];

If[(xC1/.initdata/.Bdata/.Mdata)>(xb/.initdata),
  xc[t]=xC1;yC[t]=yC1,xc[t]=xC2;yC[t]=yC2];
Print["xC[t] = ",Simplify[xc[t]]];
Print["yC[t] = ",Simplify[yc[t]]];

pxC=xc[t]/.initdata/.Bdata/.Mdata;
pyC=yc[t]/.initdata/.Bdata/.Mdata;

Print["xC = ",pxC," m"];
Print["yC = ",pyC," m"];
Print["rC = ",{pxC,pyC,0}, " m" ];

Cdata={xC[t]->pxC, yC[t]->pyC};

(*****
(* Joint D *)
(*****

eqD=(xC[t]-xD)^2+(yC[t]-yD[t])^2-CD^2==0;

Print["Equations for D (xD, yD[t])"];
Print[eqD];
Print["Solution for D (xD, yD[t])"];

solutionD=Simplify[Solve[eqD,yD[t]]];

(*Two solutions for D*)
yD1=yD[t]/.solutionD[[1]];
yD2=yD[t]/.solutionD[[2]];
If[(yD1/.initdata/.Cdata)<(yC[t]/.Cdata),
  yd[t]=yD1,yd[t]=yD2];
Print["xD[t] = ",xD/.initdata];
Print["yD[t] = ",yd[t]];
pxD=xD/.initdata;
pyD=yd[t]/.initdata/.Cdata;
Print["xD = ",pxD," m"];
Print["yD = ",pyD," m"];
Print["rD = ",{pxD,pyD,0}, " m" ];

Ddata={yD[t]->pyD};

(*****
(*Link 2*)
(*****

Phi2=ArcTan[m[t]/.initdata/.Bdata/.Mdata];
eqphi2=Sin[phi2[t]](xB[t]-xE)==Cos[phi2[t]](yB[t]-yE);
Print["Equation for phi2[t]"];
Print[eqphi2];
Print["Solution for phi2[t]=phi3[t]"];

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Print["phi2[t]=",ArcTan[m[t]]];
Print["phi2= ",Phi2," rad = ",Phi2*180/N[Pi]," deg "];

(*****)
(*Link 4*)
(*****)

mDC=(yC[t]-yD[t])/(xC[t]-xD);
eqphi4=Sin[phi4[t]](xC[t]-xD)==Cos[phi4[t]](yC[t]-yD[t]);
Phi4=ArcTan[mDC]/.initdata/.Cdata/.Ddata;
Print["Equation for phi4[t]"];
Print[eqphi4];
Print["Solution for phi4[t]"];
Print["phi4[t]=",ArcTan[mDC]];
Print["phi4= ",Phi4," rad = ",Phi4*180/N[Pi]," deg "];

markers=Table[{Point[{0,0}],
Point[{pxB,pyB}],
Point[{pxC,pyC}],
Point[{pxD,pyD}],
Point[{-0.05,0}]}];

name=Table[{Text["A",{0,0},{1,0}],
Text["B",{pxB,pyB},{-1,-1}],
Text["C",{pxC,pyC},{-1,-1}],
Text["D",{pxD,pyD},{1,0}],
Text["E",{-0.05,0},{1,0}]}];

graph[increment]=Graphics[{
{RGBColor[1,0,0],Line[{0,0},{pxB,pyB}]},
{RGBColor[0,0,1],Line[{pxB,pyB},{-0.05,0}]},
{RGBColor[0,1,0],Line[{pxB,pyB},{pxC,pyC}]},
{RGBColor[0,0,0],Line[{pxC,pyC},{pxD,pyD}]},
{RGBColor[0,1,1],PointSize[0.01],markers},{name}];

Show[Graphics[graph[increment]],
PlotRange->{{-0.06,0.06},{-0.06,0.06}},
Frame->True,AxesOrigin->{0,0},FrameLabel->{"x","y"},
Axes->{True,True},AspectRatio->Automatic];

xB[t] = AB Cos[phi[t]]

yB[t] = AB Sin[phi[t]]

xB = 0.0173205 m

yB = 0.01 m

rB = {0.0173205, 0.01, 0} m

m[t]=  $\frac{-yE + yB[t]}{-xE + xB[t]}$ 

m= 0.148543

n[t]= yE - xEm[t]

n= 0.00742716

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Equations for C (xC[t], yC[t])

$$-BC^2 + (-xB[t] + xC[t])^2 + (-yB[t] + yC[t])^2 == 0$$

$$-n[t] - m[t] xC[t] + yC[t] == 0$$

Solution for C (xC[t], yC[t])

$$xC[t] = \frac{1}{2(1+m[t]^2)} \left(2xB[t] - 2m[t](n[t] - yB[t]) + \sqrt{(-4(1+m[t]^2)(-BC^2 + n[t]^2 + xB[t]^2 - 2n[t]yB[t] + yB[t]^2) + 4(xB[t] + m[t](-n[t] + yB[t]))^2)} \right)$$

$$yC[t] = \frac{1}{2(1+m[t]^2)} \left(2n[t] + m[t](2xB[t] + 2m[t]yB[t] + \sqrt{(-4(1+m[t]^2)(-BC^2 + n[t]^2 + xB[t]^2 - 2n[t]yB[t] + yB[t]^2) + 4(xB[t] + m[t](-n[t] + yB[t]))^2)} \right)$$

$$xC = 0.0469949 \text{ m}$$

$$yC = 0.0144079 \text{ m}$$

$$rC = \{0.0469949, 0.0144079, 0\} \text{ m}$$

Equations for D (xD, yD[t])

$$-CD^2 + (-xD + xC[t])^2 + (yC[t] - yD[t])^2 == 0$$

Solution for D (xD, yD[t])

$$xD[t] = 0.02$$

$$yD[t] = -\sqrt{CD^2 - xD^2 + 2xDxC[t] - xC[t]^2} + yC[t]$$

$$xD = 0.02 \text{ m}$$

$$yD = -0.0391763 \text{ m}$$

$$rD = \{0.02, -0.0391763, 0\} \text{ m}$$

Equation for phi2[t]

$$\text{Sin}[\text{phi2}[t]](-xE + xB[t]) == \text{Cos}[\text{phi2}[t]](-yE + yB[t])$$

Solution for phi2[t]=phi3[t]

$$\text{phi2}[t] = \text{ArcTan}[m[t]]$$

$$\text{phi2} = 0.147465 \text{ rad} = 8.44911 \text{ deg}$$

Equation for phi4[t]

$$\text{Sin}[\text{phi4}[t]](-xD + xC[t]) == \text{Cos}[\text{phi4}[t]](yC[t] - yD[t])$$

Solution for phi4[t]

$$\text{phi4}[t] = \text{ArcTan}\left[\frac{yC[t] - yD[t]}{-xD + xC[t]}\right]$$

$$\text{phi4} = 1.10413 \text{ rad} = 63.2618 \text{ deg}$$

