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(*Problem 1.6.3 (a) *)

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

AB=0.4;
BC=1.;
phi=pi/6;

n=1600; (*rpm*)
omega=n pi/30.; (*rad/s*)

xA=yA=0;
rA={xA,yA,0};

xB=AB Cos[phi];
yB=AB Sin[phi];
rB={xB,yB,0};

yC=0;
xC=xB+Sqrt[BC^2-(yC-yB)^2];
rC={xC,yC,0};

markers=Table[{Point[{0,0}],Point[{xB,yB}],Point[{xC,yC}]}];

name=Table[{Text["A",{0,0},{1,1}],Text["B",{xB,yB},{-0.5,-1.5}],
Text["C",{xC,yC},{1,1}]}];

graph[increment]=
Graphics[{{RGBColor[1,0,0],Line[{{0,0},{xB,yB}}]}, {RGBColor[0,0,0],
Line[{{xB,yB},{xC,yC}]}}, {RGBColor[0,0,1],PointSize[0.02],
markers},{name}}];

Show[Graphics[graph[increment]],Frame->True,
PlotRange->{{-1,1.6},{-1,.3}},AxesOrigin->{0,0},
FrameLabel->{"x","y"},Axes->{True,True},
AspectRatio->Automatic];

(*0-Ar-1-Br-2-Cr-3-Ct-0*)

omega10={0,0,omega};
omega21v={0,0,omega21};
omega32v={0,0,omega32};
vC03v={vC03,0,0};

eqIkv=(omega10+omega21v+omega32v)[[3]]==0;
eqIijv=Cross[rB,omega21v]+Cross[rC,omega32v]+vC03v;
eqIiv=eqIijv[[1]]==0;
eqIjv=eqIijv[[2]]==0;
solIvel=Solve[{eqIkv,eqIiv,eqIjv},{omega21,omega32,vC03}];

omega21s=omega21/.solIvel[[1]];
omega32s=omega32/.solIvel[[1]];
vC03s=vC03/.solIvel[[1]];

omega21={0,0,omega21s};
omega32={0,0,omega32s};
v03={0,0,vC03s};

omega20=omega10+omega21;
omega30=omega20+omega32;

vB=Cross[omega10,rB];

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vC=vB+Cross[ω20,rC-rB];

α10=D[ω10,t];
α21v={0,0,alpha21};
α32v={0,0,alpha32};
αC03v={αC03,0,0};

eqIka=(α10+α21v+α32v)[[3]]==0;
eqIija=Cross[rB,α21v]+Cross[rC,α32v]+
  αC03v-ω10.ω10 rB-ω20.ω20 (rC-rB);
eqIia=eqIija[[1]]==0;
eqIja=eqIija[[2]]==0;
solIacc=Solve[{eqIka,eqIia,eqIja},{alpha21,alpha32,αC03}];
alpha21s=alpha21/.solIacc[[1]];
alpha32s=alpha32/.solIacc[[1]];
αC03s=αC03/.solIacc[[1]];

α21={0,0,alpha21s};
α32={0,0,alpha32s};
αC03s={αC03s,0,0};

α20=α10+α21;
α30={0,0,0};

aB=Cross[α10,rB]-ω10.ω10 rB;
aC=aB+Cross[α20,rC-rB]-ω20.ω20 (rC-rB);

Print["rB = ",rB," m"];
Print["rC = ",rC," m"];
Print["aB = ",aB," m/s^2"];
Print["aC = ",Chop[aC]," m/s^2"];

α1 = α10;
α2 = α20;
α3 = α30;

Print["α1 = ",α1," rad/s^2"];
Print["α2 = ",α2," rad/s^2"];

h=0.01;
hSlider=0.02;
wSlider=0.05;
d=0.001;
ρ=8000.;
g=9.807;

Fext=-Sign[vC]{800.,0,0};
Print["Fext = ",Fext," N m"];

(*Link 1*)
Print["Link 1"]
m1=ρ AB h d;
rC1=rB/2;
aC1=aB/2;
Print["rC1 = ",rC1," m"];
Print["aC1 = ",aC1," m/s^2"];
Fin1=-m1 aC1;
G1={0,-m1 g,0};
F1=(Fin1+G1);
IC1=m1 (AB^2+h^2)/12;
M1=Min1=-IC1 α1;
Print["m1 = ",m1," kg"];
Print["IC1 = ",IC1," kg m^2"];
Print["Fin1 = -m1 aC1 = ",Fin1," N "];
Print["G1 = -m1 g = ",G1," N "];

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Print["F1 = -m1 aC1 + G1 = ",F1," N "];
Print["M1 = Min1 = -IC1 α1 = ",M1," N m"];

(*Link 2*)
Print["Link 2"]
m2=ρ BC h d;
rC2=(rB+rC)/2;
aC2=(aB+aC)/2;
Print["rC2 = ",rC2," m"];
Print["aC2 = ",aC2," m/s^2"];
Fin2=-m2 aC2;
G2={0,-m2 g,0};
F2=(Fin2+G2);
IC2=m2 (BC^2+h^2)/12;
M2=Min2=-IC2 α2;
Print["m2 = ",m2," kg"];
Print["IC2 = ",IC2," kg m^2"];
Print["Fin2 = -m2 aC2 = ",Fin2," N "];
Print["G2 = -m2 g = ",G2," N "];
Print["F2 = -m2 aC2 + G2 = ",F2," N "];
Print["M2 = Min2 = -IC2 α2 = ",M2," N m"];

(*Link 3*)
Print["Link 3"]
m3=ρ hSlider wSlider d;
rC3=rC;
aC3=Chop[aC];
Print["rC3 = ",rC3," m"];
Print["aC3 = ",aC3," m/s^2"];
Fin3=-m3 aC3;
G3={0,-m3 g,0};
F3=(Fin3+G3);
IC3=m3 (hSlider^2+wSlider^2)/12;
M3=Min3=-IC3 α3;
Print["m3 = ",m3," kg"];
Print["IC3 = ",IC3," kg m^2"];
Print["Fin3 = -m3 aC3 = ",Fin3," N "];
Print["G3 = -m3 g = ",G3," N "];
Print["F3 = -m3 aC3 + G3 = ",F3," N "];
Print["M3 = Min3 = -IC3 α3 = ",M3," N m"];

Print[" "]
Print["Force Analysis"]
Print["-----"]

(*Link 3*)
F03={0,F03y,0};
F23={F23x,F23y,0};
eq3F=F3+F03+F23+Fext;
eq3Fx=eq3F[[1]]==0;
eq3Fy=eq3F[[2]]==0;

(*Link 2*)
F12={F12x,F12y,0};
eq2F=F2+F12-F23;
eq2Fx=eq2F[[1]]==0;
eq2Fy=eq2F[[2]]==0;
eq2M=Cross[rC-rC2,-F23]+Cross[rB-rC2,F12]+M2;
eq2Mz=eq2M[[3]]==0;

equations32={eq3Fx,eq3Fy,eq2Fx,eq2Fy,eq2Mz};
sol32=Solve[equations32,{F03y,F23x,F23y,F12x,F12y}];

F03s = F03/.sol32[[1]];

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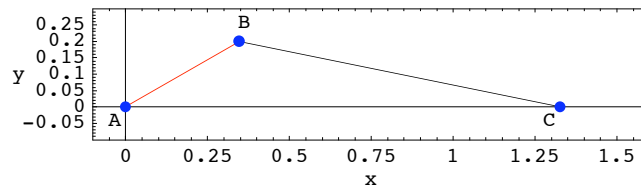
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F23s = F23/.sol32[[1]];
F12s = F12/.sol32[[1]];

Print["F03 = ",F03/.sol32[[1]]," N"];
Print["F23 = ",F23/.sol32[[1]]," N"];
Print["F12 = ",F12/.sol32[[1]]," N"];

Print[" "]
(*Link 1*)
F01=-F1+F12s;
Print["F01 = ",F01," N"];
Mm=-Cross[rB,-F12s]-Cross[rC1,F1]-M1;
Print["Meq = ",Mm," N m"];

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rB = {0.34641, 0.2, 0} m
rC = {1.32621, 0, 0} m
aB = {-9724.96, -5614.71, 0.} m/s^2
aC = {-12160.4, 0, 0} m/s^2
α1 = {0, 0, 0} rad/s^2
α2 = {0, 0, 5014.18} rad/s^2
Fext = {800., 0, 0} N m
Link 1
rC1 = {0.173205, 0.1, 0} m
aC1 = {-4862.48, -2807.35, 0.} m/s^2
m1 = 0.032 kg
IC1 = 0.000426933 kg m^2
Fin1 = -m1 aC1 = {155.599, 89.8353, 0.} N
G1 = -m1 g = {0, -0.313824, 0} N
F1 = -m1 aC1 + G1 = {155.599, 89.5215, 0.} N
M1 = Min1 = -IC1 α1 = {0, 0, 0} N m
Link 2
rC2 = {0.836308, 0.1, 0} m
aC2 = {-10942.7, -2807.35, 0.} m/s^2
m2 = 0.08 kg
IC2 = 0.00666733 kg m^2

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Fin2 = -m2 aC2 = {875.415, 224.588, 0.} N
G2 = -m2 g = {0, -0.78456, 0} N
F2 = -m2 aC2 + G2 = {875.415, 223.804, 0.} N
M2 = Min2 = -IC2 α2 = {0, 0, -33.4312} N m

Link 3

rC3 = {1.32621, 0, 0} m
aC3 = {-12160.4, 0, 0} m/s^2
m3 = 0.008 kg
IC3 = 1.93333×10-6 kg m^2
Fin3 = -m3 aC3 = {97.2833, 0, 0} N
G3 = -m3 g = {0, -0.078456, 0} N
F3 = -m3 aC3 + G3 = {97.2833, -0.078456, 0} N
M3 = Min3 = -IC3 α3 = {0, 0, 0} N m
```

Force Analysis

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F03 = {0, -350.207, 0} N
F23 = {-897.283, 350.285, 0} N
F12 = {-1772.7, 126.481, 0} N

F01 = {-1928.3, 36.9599, 0.} N
Meq = {0., 0., 398.408} N m
```