```
(* RT *)
Apply [Clear,Names["Global`*"]];
Off[General::spell];
Off[General::spell1];
"Method II: polar coordinates "
rC= {L/2, 0, 0} ;
rA= {r[t], 0, 0} ;
rP= {p, 0, 0} ;
Print["rC = ",rC];
Print["rA = ",rA];
Print["rP = ",rP];
F21= {0, f21, 0} ;
Print["F21 = ", F21];
" F21 joint forces at Q ( f21 and p  unknowns ) "
G1= {-m g Sin[theta[t]], -m g Cos[theta[t]], 0};
G2= {-m g Sin[theta[t]], -m g Cos[theta[t]], 0};
Print["G1 = G2 = ", G1];
alpha= {0, 0, theta''[t]};
IO=m L^2/3;
"IO alpha - rC x G1 - rP x F21 = 0 , (1)"
e1=IO alpha-Cross[rC,G1]-Cross[rP,F21];
e1z=Simplify[e1[[3]]]==0
aAr=r''[t] - r[t] (theta'[t])^2;
aAt=r[t]theta''[t] + 2 r'[t] theta'[t];
aA={aAr,aAt,0};
Print["aA = ", aA];
"m2 aA  = - F21 + G2 => "
e2= m aA  +  F21 - G2;
"(r): Equation (2) on r"
e2x=e2[[1]]==0
"(t): Equation (3) on t"
e2y=e2[[2]]==0
"IA alpha - (rP-rA) x (-F21) = 0 , (4)"
e2=IA alpha-Cross[(rP-rA),-F21];
e2z=Simplify[e2[[3]]]==0
"From Eq.(4) => "
solP=Solve[e2z,p];
ps=p/.solP[[1]];
Print["p = ",ps];
"From Eq.(3) => "
solf=Solve[e2y,f21];
f21s=f21/.solf[[1]];
Print["f21 = ",f21s];
"From Eqs. (1) and (3) => two ODE "
eq1=e1z/.solP[[1]]/.solf[[1]]
eq2=e2x/.solP[[1]]/.solf[[1]]


"numerical application"
rule={m→1.,L→1,IA→1.,g→10.};
equation1=Simplify[eq1/.rule]
equation2=Simplify[eq2/.rule]
sol=NDSolve[{equation1,equation2,r[0]==.1,theta[0]==.1,
        r'[0]==0.,theta'[0]==0.},{r,theta},{t,0.,1.}];
Plot[Evaluate[r[t]]/.sol,{t,0.,1.},PlotRange→All,
    AxesLabel→{"t[s]","r[m]"}];
Plot[Evaluate[theta[t]]/.sol,{t,0.,1.},PlotRange→All,
```

```
  AxesLabel→{"t[s]","theta[rad]"}]

 r5= (Evaluate[r[t]]/.sol/.t->.5)[[1]];
 t5= (Evaluate[theta[t]]/.sol/.t->.5)[[1]];
Print["r[.5] = ",r5, " m"];
Print["theta[.5] = ",t5, " rad"];
```

Method II: polar coordinates

$rC = \{\frac{L}{2}, 0, 0\}$

rA = {r[t], 0, 0}

rP = {p, 0, 0}

F21 = {0, f21, 0}

F21 joint forces at Q (f21 and p unknowns)

G1 = G2 = {-g m Sin[theta[t]], -g m Cos[theta[t]], 0}

IO alpha - rC x G1 - rP x F21 = 0 , (1)

$\frac{1}{6}$ (-6 f21 p + 3 g L m Cos[theta[t]] + 2 L^2 m theta''[t]) == 0

aA = {-r[t] theta'[t]^2 + r''[t], 2 r'[t] theta'[t] + r[t] theta''[t], 0}

m2 aA = - F21 + G2 =>

(r): Equation (2) on r

g m Sin[theta[t]] + m (-r[t] theta'[t]^2 + r''[t]) == 0

(t): Equation (3) on t

f21 + g m Cos[theta[t]] + m (2 r'[t] theta'[t] + r[t] theta''[t]) == 0

IA alpha - (rP-rA) x (-F21) = 0 , (4)

f21 p - f21 r[t] + IA theta''[t] == 0

From Eq.(4) =>

p = $\frac{\text{f21 r[t] - IA theta''[t]}}{\text{f21}}$

From Eq.(3) =>

f21 = -g m Cos[theta[t]] - m (2 r'[t] theta'[t] + r[t] theta''[t])

From Eqs. (1) and (3) => two ODE

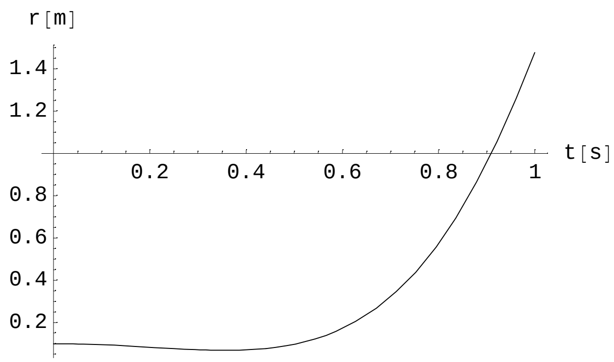
$\frac{1}{6}$ (3 g L m Cos[theta[t]] + 2 L^2 m theta''[t] -
6 (-IA theta''[t] + r[t] (-g m Cos[theta[t]] - m (2 r'[t] theta'[t] + r[t] theta''[t])))) == 0

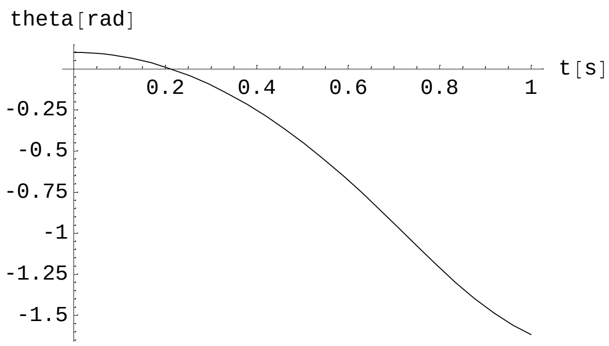
g m Sin[theta[t]] + m (-r[t] theta'[t]^2 + r''[t]) == 0

numerical application

5. Cos[theta[t]] + r[t] (10. Cos[theta[t]] + 2. r′[t] theta′[t]) +
 1.33333 theta″[t] + 1. r[t]^2 theta″[t] == 0

10. Sin[theta[t]] + 1. r″[t] == 1. r[t] theta′[t]^2





- Graphics -

r[.5] = 0.0971902 m

theta[.5] = −0.444956 rad