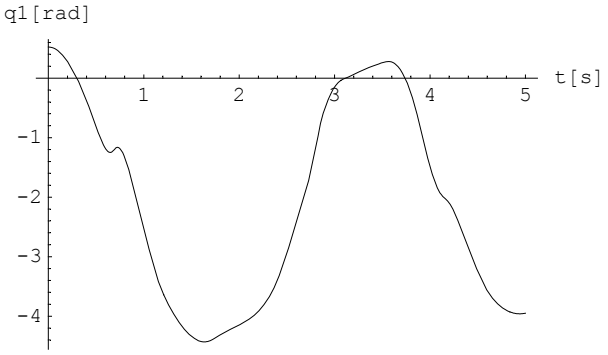
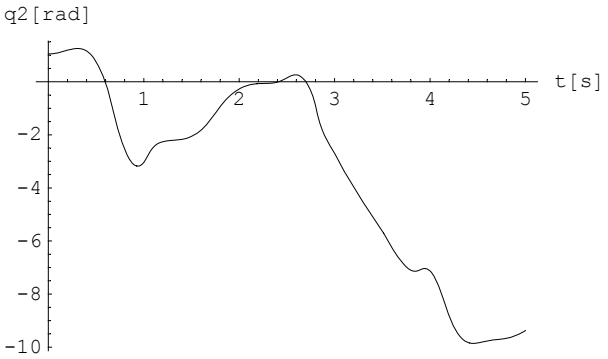
```
Apply[Clear, Names["Global`*"]];
Off[General::spell];
Off[General::spell1];

(*Input data*)

data = {m1 → 1., m2 → 1., L1 → 1., L2 → 1., g → 10};

(*data={m1→m, m2→m,L1→L,L2→L};*)

IC1 = m1 / 12 * (L1^2);
IA = IC1 + m1 (L1 / 2)^2;
IC2 = m2 / 12 * (L2^2);

(*Position,velocity and acceleration vectors*)

xB = L1 * Cos[q1[t]];
yB = L1 * Sin[q1[t]];
rB = {xB, yB, 0};
rC1 = rB / 2.;
vC1 = D[rC1, t];
aC1 = D[vC1, t];

xC = xB + L2 * Cos[q2[t]];
yC = yB + L2 * Sin[q2[t]];
rC = {xC, yC, 0};
rC2 = (rB + rC) / 2.;
vC2 = D[rC2, t];
aC2 = D[vC2, t];

Print["rC1=", rC1];
Print["rB=", rB];
Print["rC2=", rC2];
Print["rC=", rC];
Print["aC1=", aC1];
Print["aC2=", rC2];

(*Angular velocities and accelerations*)

omega1 = {0, 0, q1'[t]};
omega2 = {0, 0, q2'[t]};
alpha1 = {0, 0, q1''[t]};
alpha2 = {0, 0, q2''[t]};

Print["alpha1=", alpha1];
Print["alpha2=", alpha2];


F01 = {F01x, F01y, 0};
F21 = {F21x, F21y, 0};
```

```
Print["Joint reaction at B: F21={F21x,F21y,0}"];

G1 = {0, -m1 g, 0};
G2 = {0, -m2 g, 0};

(*Newton equations*)

"LINK 1"
"Sum M for 1 wrt A:"
"-IA alpha1 + AB x F21 + AC1 x G1 = 0"
EA = -IA * alpha1 + Cross[rB, F21] + Cross[rC1, G1];
eq1 = (EA[[3]] /. data) == 0;
Print["(z): ", eq1, ", (1)"];

"LINK 2"
"Sum F for link 2:"
"-m2 aC2 + G2 + (-F21) = 0"
N2 = -m2 * aC2 + (-F21) + G2;
eq2 = (N2[[1]] /. data) == 0;
eq3 = (N2[[2]] /. data) == 0;
Print["(x): ", eq2, ", (2)"];
Print["(y): ", eq3, ", (3)"];
"Sum M for 2 wrt C2:"
"-IC2 alpha2 + C2B x (-F21) = 0"
E2 = -IC2 * alpha2 + Cross[rB - rC2, -F21];
eq4 = (E2[[3]] /. data) == 0;
Print["(z): ", eq4, ", (4)"];

Print["From Eqs.(2)(3) => {F21x,F21y}"];

sol = Solve[{eq2, eq3}, {F21x, F21y}];

Print["F21x = ", Simplify[F21x /. sol[[1]]]];
Print["F21y = ", Simplify[F21y /. sol[[1]]]];

Print["From Eqs.(1)(4) => equations of motion"];
eI = Simplify[(eq1 /. sol)[[1]]];
eII = Simplify[(eq4 /. sol)[[1]]];
Print[eI, ", (5)"];
Print[eII, ", (6)"];


rC1={0.5 L1 Cos[q1[t]], 0.5 L1 Sin[q1[t]], 0}

rB={L1 Cos[q1[t]], L1 Sin[q1[t]], 0}

rC2={0.5 (2 L1 Cos[q1[t]] + L2 Cos[q2[t]]), 0.5 (2 L1 Sin[q1[t]] + L2 Sin[q2[t]]), 0}

rC={L1 Cos[q1[t]] + L2 Cos[q2[t]], L1 Sin[q1[t]] + L2 Sin[q2[t]], 0}

aC1={-0.5 L1 Cos[q1[t]] q1'[t]^2 - 0.5 L1 Sin[q1[t]] q1''[t],
  -0.5 L1 Sin[q1[t]] q1'[t]^2 + 0.5 L1 Cos[q1[t]] q1''[t], 0}
```

```
aC2={0.5 (2 L1 Cos[q1[t]] + L2 Cos[q2[t]]), 0.5 (2 L1 Sin[q1[t]] + L2 Sin[q2[t]]), 0}

alpha1={0, 0, q1''[t]}

alpha2={0, 0, q2''[t]}

Joint reaction at B: F21={F21x,F21y,0}

LINK 1

Sum M for 1 wrt A:

-IA alpha1 + AB x F21 + AC1 x G1 = 0

(z): -5. Cos[q1[t]] + 1. F21y Cos[q1[t]] - 1. F21x Sin[q1[t]] - 0.333333 q1''[t] == 0, (1)

LINK 2

Sum F for link 2:

-m2 aC2 + G2 + (-F21) = 0

(x): -F21x - 0.5
    (-2. Cos[q1[t]] q1'[t]^2 - 1. Cos[q2[t]] q2'[t]^2 - 2. Sin[q1[t]] q1''[t] - 1. Sin[q2[t]] q2''[t]) == 0, (2)

(y): -10. - F21y - 0.5
    (-2. Sin[q1[t]] q1'[t]^2 - 1. Sin[q2[t]] q2'[t]^2 + 2. Cos[q1[t]] q1''[t] + 1. Cos[q2[t]] q2''[t]) == 0, (3)

Sum M for 2 wrt C2:

-IC2 alpha2 + C2B x (-F21) = 0

(z):
 0. F21y Cos[q1[t]] + 0.5 F21y Cos[q2[t]] + 0. F21x Sin[q1[t]] - 0.5 F21x Sin[q2[t]] - 0.0833333 q2''[t] == 0
 , (4)

From Eqs.(2)(3) => {F21x,F21y}

F21x = 1. Cos[q1[t]] q1'[t]^2 + 0.5 Cos[q2[t]] q2'[t]^2 + 1. Sin[q1[t]] q1''[t] + 0.5 Sin[q2[t]] q2''[t]

F21y = -10. + 1. Sin[q1[t]] q1'[t]^2 + 0.5 Sin[q2[t]] q2'[t]^2 - 1. Cos[q1[t]] q1''[t] - 0.5 Cos[q2[t]] q2''[t]

From Eqs.(1)(4) => equations of motion

(-1. Cos[q2[t]] Sin[q1[t]] + 1. Cos[q1[t]] Sin[q2[t]]) q2'[t]^2 ==
  30. Cos[q1[t]] + 2.66667 q1''[t] + 1. Cos[q1[t] - q2[t]] q2''[t], (5)

(1. Cos[q2[t]] Sin[q1[t]] - 1. Cos[q1[t]] Sin[q2[t]]) q1'[t]^2 ==
  10. Cos[q2[t]] + 1. Cos[q1[t] - q2[t]] q1''[t] + 0.666667 q2''[t], (6)


solution = NDSolve[{eI, eII, q1[0] == N[Pi] / 6, q2[0] == N[Pi] / 3, q1 '[0] == 0, q2 '[0] == 0},
   {q1[t], q2[t]}, {t, 0, 5}, MaxSteps → 2000];

Plot[Evaluate[q1[t] /. solution], {t, 0, 5}, AxesLabel → {"t[s]", "q1[rad]"}];
Plot[Evaluate[q2[t] /. solution], {t, 0, 5}, AxesLabel → {"t[s]", "q2[rad]"}];
```


q1[rad]
t[s]
1
2
3
4
5
-1
-2
-3
-4


q2[rad]
t[s]
1
2
3
4
5
-2
-4
-6
-8
-10