**Forward Versus Inverse Dynamics**

**Inverse dynamics**

1) kinematically driven

2) know desired position, velocity and acceleration kinematics

3) know external forces (torques) on system

4) find driver forces (torques) and joint reactions to cause desired motion

5) statics is a subset of inverse dynamics

 true statics - velocities = 0, accelerations = 0

 quasi-statics - velocities = constant, accelerations = 0

**Forward dynamics**

1) dynamically driven - no knowledge of exact motion trajectory

2) know current state of system - positions and velocities of links

3) know external forces (torques) on system

4) compute accelerations (translational and rotational) of links using differential equations

5) forward time integration of accelerations to get new positions and velocities

**Inverse Dynamics**

Pin B at the end of crank link 2 forms a pin-in-slot joint with the horizontal slot in hammer link 4 as shown below. The mechanism is drawn approximately to scale. The weight of crank link 2 is very small compared to the weight of hammer link 4. You may neglect the effects of friction at A, B and C. The hammer face is not yet in contact with its platen. Show your work.

m4 = 2.3 kg

JG4 = 30 N.cm.sec2

2 = 50 rpm CCW constant

4 = 2.32 rad/sec CW

4 = 20.13 rad/sec2 CW

45˚

A

B

C

G4

20 cm

30 cm

40 cm

AB = 25 cm

**2**

**4**

face

2

50.7 N.cm.sec2

a) Determine the mass moment of inertia of link 4 about C. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b) Determine the magnitude and direction of  required to cause this motion at this position.

25.5 N @ 90°

 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c) Determine the magnitude and direction of motor torque T1\_on\_2 on crank 2 required to cause this motion at this position.

451 N.cm CCW

 T1\_on\_2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

d) Determine the magnitude and direction of motor torque T1\_on\_2 on crank 2 required to cause 2 = 50 rpm CW constant at this position.

same as part c)

 T1\_on\_2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

JC = JG4 + m4(CG4)2 = 30 N.cm.sec2 + (2.3 kg)(30 cm)2= 50.7 N.cm.sec2

45˚

A

B

F4\_on\_2Y

T1\_on\_2

F1\_on\_2X

F1\_on\_2Y

B

C

G4

20 cm

30 cm

40 cm

**4**

F1\_on\_4y

F1\_on\_4x

F2\_on\_4X

VB2\_wrt\_B4

F2\_on\_4Y

m4g

**assume no friction** F2\_on\_4X = 0

**M on 4 about C CCW +** - F2\_on\_4Y (40 cm) = JC 4

F2\_on\_4Y = - (50.7 N.cm.sec2) (-20.13 rad/sec2) / (40 cm) = 25.5 N up

F4\_on\_2Y = 25.5 N down

**M on 2 about A CCW +** T1\_on\_2 - F4\_on\_2 (AB sin 45°) = 0

T1\_on\_2 = 451 N.cm CCW

part d) all normal and Coriolis accelerations will be the same magnitude AND the same direction as part c), which causes 4 to have the same magnitude and direction

B

C

G4

20 cm

30 cm

40 cm

**4**

F1\_on\_4y

F1\_on\_4x

F2\_on\_4X

VB2\_wrt\_B4

F2\_on\_4Y

m4g

# F on 4 right + + F2\_on\_4X + F1\_on\_4X = m4 AG4X

# F on 4 up + + F2\_on\_4Y + F1\_on\_4Y - m4g = m4 AG4Y

**M on 4 about G4 CCW +** + F2\_on\_4X (10 cm) - F2\_on\_4Y (40 cm) + F14x (30 cm) = JG4 4

**friction** F2\_on\_4X =  F2\_on\_4Y

AG4T = (CG4) 4 = 603.9 cps2 right

m4 AG4X = (2.3 kg) (603.9 cm/sec2) (1 m / 100 cm) = +13.89 N

AG4N = (CG4) 42 = 161.5 cps2 down

m4 AG4y = -3.71 N

m4g = 22.56 N

JG4 4 = (30 N.cm.sec2) (-20.13 rad/sec2) = -603.9 N.cm

 = 0

 =

