**Static Force Analysis for Skid Loader – Virtual Work**

A trunnion mount hydraulic cylinder actuates the arm of a skid steer loader as shown below. At this position, e = 40 inches,  = 61.131°, = -12 ips, = -0.3625 rad/s.

Determine the force on the hydraulic cylinder required to lower an 800 lbf payload attached to point D by a cable. The payload moves with constant velocity at the position shown. You may neglect the effects of friction. The weight of the arm and cylinder are small compared to the payload. Show your work.

from Newtonian solution

FC = 2261.9 lbf

 = 77.131°

 = 90°-- = 12.869°

VD = AD  = 34.8 ips

power



-FC () + P (cos ) VD = 0

2261.7 lbf up/left

FCYLINDER \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

A

B

C

e

Not to scale

AB = 36 inches

AC = 42 inches

AD = 96 inches

= 16°



D



Payload







What corresponding hydraulic pressure would be required for a cylinder with a 3 inch DIA bore?

0.1 lubricated

pressure pushes up

friction force will be up opposing piston motion

OK, industrial hydraulics often go to 3000 psi

A =  D2 / 4 = 7.069 in2

320 psi

PCYLINDER \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Is this value reasonable? Why?

If you include friction between the piston and cylinder wall, will it increase or decrease your computation for pressure.

increase decrease Why?

What value would you use for the coefficient of friction between the piston and cylinder wall?

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Why?

Should your analysis be different if the cylinder were retracting at constant velocity instead of the payload moving at constant velocity?

constant  means  will not be constant means velocity of the payload will not be constant, therefore must account for acceleration of payload mass

yes no Why?

**Static Force Analysis for Sewing Machine – Virtual Work**

Determine crank torque T12 required to maintain this sewing machine linkage in static equilibrium as shown below for applied load P = 10 N. Assume that friction and the weight of the links are negligible.

from velocity solution

2 = +8 rad/sec

= 64.71 cps down

actual power, no friction, no springs



assume T12 is CCW

( +T12 ) ( +8 rad/sec)

+ ( -64.72 cm/sec ) ( +10 N ) = 0

T12 = + 25.75 N.cm

15.4°

45°

32.7°

62.7°

2

4

3

A

5

6

D

B

C

E

G

F

AB = 1.60 cm

BC = 3.57 cm

DC = 2.24 cm

CE = 1.60 cm

DE = 2.74 cm

EF = 3.81 cm

AG = 1.42 cm

DG = 3.81 cm

DCE = 90°

CDE = 35.7°

constant

2

**T12**

**P**

**Static Force Analysis for Four Bar – Virtual Work**

3

FP = 150 N

C

AB = 30 cm

BC = 60 cm

CD = 45 cm

AD = 90 cm

BP = 23 cm

DQ = 24 cm

FQ = 200 N

P

60°

13.151°

4

B

77°

2

Q

T12

65.173°

D

A

65°

D

1

1

 Assume = + 1 rad/sec virtual velocity

rad/sec



= 150 N @ 133.151° = - 102.589 + j 109.433 N

= 200 N @ 217.827° = - 157.973 - j 122.656 N



T12+ ( 2579.91 + 431.60 ) N.cm/sec + ( 1840.86 + 661.24 ) N.cm/sec = 0

T12 = -5513.6 N.cm

from Newtonian matrix solution T12 = -5514.89 N.cm

**Static Force Analysis for Pushups – Virtual Work**

A person doing pushups can be modeled as a four bar linkage. The ground is the base link, the forearms are link 2, the upper arms are link 3, and the torso and legs are link 4 as shown below. The wrists are revolute O2, the elbows are revolute A, the shoulders are revolute B, and the toes are revolute O4. Mass of the torso/legs is 180 lbm and the mass center is located at G4. Assume that all muscular effort is provided by the triceps as torque T32 across the elbows.

For an initial estimate, use the additional assumptions:

a) 4 is constant at this position

b) Weight of the arms is negligible compared to weight of the torso/legs.

c) Friction is negligible at A, B, C and D.

d) No muscular torque is generated at A, C and D.

W4

°4

VG4

2/3

T32

2 = 45°

3 = 149.14°

4 = 164.24°

2 = 0.5 rad/sec

3 = -1.435 rad/sec

4 = -0.387 rad/sec

AD = 52 inch

AB = 12 in

BC = 14 in

CD = 57.7 in

DG4 = 39 in

C

3

C

G4

B

3

2

4

4

B

2

A

D

Determine angular velocity across the elbows 2/3 for the position and velocity provided above.

2/3 = 2 - 3 = +1.935 rad/sec

Determine elbow torque T32 for the position and velocity provided above.

VG4 = DG4 4 = 15.093 ips UP, AG4T= DG4 4 = 0, AG4N= DG4 42 = 5.84 ips2 = 0.015 G negligible

 -W4 cos(180°-4) VG4 + T32 2/3 = 0 T32 = +1351.2 in.lbf

Do the magnitude and direction for your answer seem reasonable? Why?

from Newtonian solution T32 = 1351.2 in.lbf CCW

Rate the last four assumptions and state your reasoning.

b) constant 4 1=poor 2=acceptable for an approximation 3=very good

c) weight of arms is negligible 1=poor 2=acceptable for an approximation 3=very good

d) friction is negligible 1=poor 2=acceptable for an approximation 3=very good

e) no muscle force at A, C, D 1=poor 2=acceptable for an approximation 3=very good

4 = 

Determine 4 of the torso/legs when the forearm is aligned with the upper arms (2 = 3).