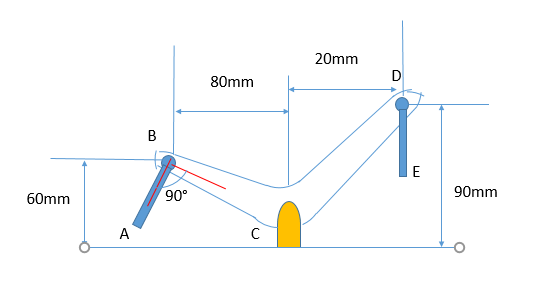
**WEEK 4: EQUILIBRIUM OF RIGID BODIES**

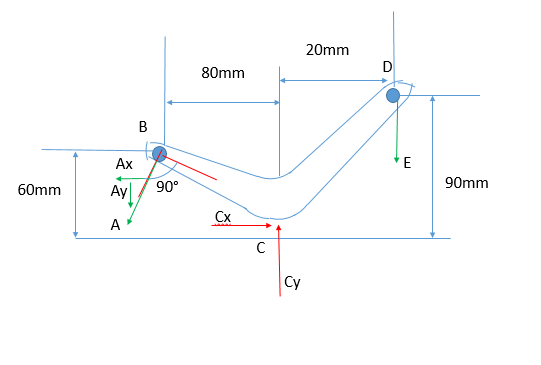
Question 1: Two links AB and DE are connected by a bell crank as shown. Knowing that the tension in link AB is 720 N, determine (a) the tension in link DE, (b) the reaction at C.



**Theoretical Concept: Use technique of static equilibrium**

**SOLUTION:**

Free Body Diagram:



1. Tension in link FDE

FAB = 20N = A

∑MC = 0: (602 + 802)1/2 FAB = (120) FDE

FDE = (720N)

**FDE = 600N**

b) Reactions at C

∑FH = 0: Ax = Cx

Cx = (60/100) (720N)

**Cx = 432 N**

∑FV = 0: Ay + FDE = Cy

Cy = (80/100)(720N) + ( 600N)

**Cy = 1176 N**

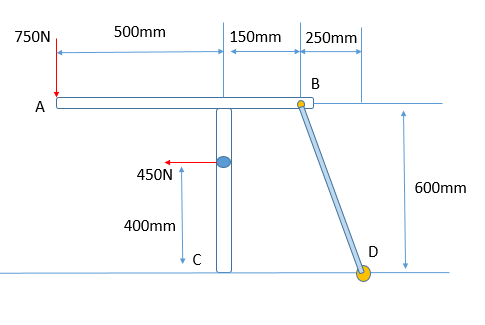
**C = (Cx2 + Cy2)1/2 = ((4322 + 11762))1/2 = 1252.84 N**

**ϴ = arctan (1176/432) =69.83°**

**Critical Thinking:**

The reaction force in C is closer to the longer side of the body to create balance in the body based from the body’s position. More likely, the higher the value of force BA, the higher the force that tension DE needed.

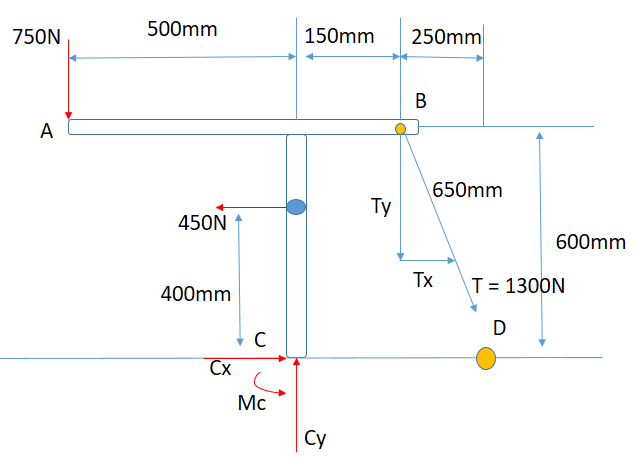
**Question 2:** Knowing that the tension in wire BDis 1300 N, determine the reaction at the fixed support Cof the frame shown.



**Theoretical Concept: Use technique of static equilibrium**

SOLUTION:

Free Body Diagram:



T= 1300 N

Tx = (250/650) (1300N) = 500N

Ty = (600/650)(1300N) = 1200N

∑FH = 0: 450N = Tx + Cx

Cx = -500N + 450N

**Cx = -50 N**

∑FV = 0: 750N + Ty = Cy

Cy = -750N + 1200N

**Cy = 450 N**

**C = (Cx2 + Cy2)1/2 = (502 + 4502) = 1951N**

**ϴ = arctan (450/-50) = 88.5°**

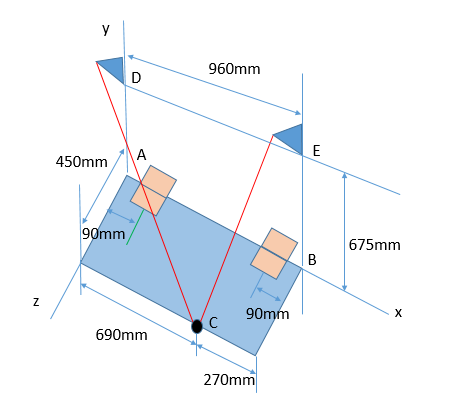
∑MC = 0: 750N(0.6m) + 450N (0.4m) + Mc = 1200N (0.25m)

**Mc = 75 N.m**

**Critical Thinking:**

The force 750N applied along A caused the amount on the tension BD. In other words, tension BD is dependent on the force applied at A.

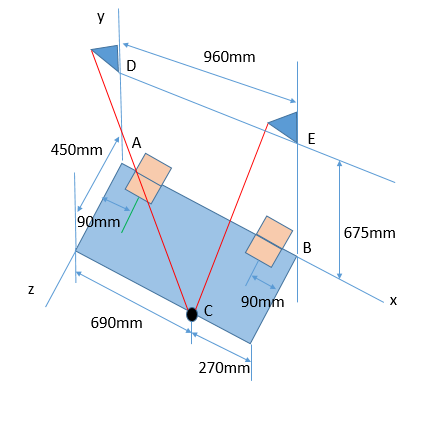
**Question 3:** A 100-kg uniform rectangular plate is supported in the position shown by hinges A and Band by cable DCE that passes over a frictionless hook at C. Assuming that the tension is the same in both parts of the cable, determine (a) the tension in the cable, (b) the reactions at A and B. Assume that the hinge at B does not exert any axial thrust.



**Theoretical Concept: Use technique of static equilibrium**

**SOLUTION:**

Free Body Diagram:



**r**(B/A) = (960 -180)**i = 780i**

**r(G/A) =** ((960/2) – 90)**i** + (450/2)**k** = 390**i**  + 225**k**

**r**(C/A)  **= 600i + 450k**

**a)**

Solving the tension T in cable DCE:

CD = -690i +675j - 450k

CE = 270i + 675j - 450k

Tcd = (T/1065)( -690i +675j - 450k) =

Tce = (T/855)( 270i + 675j - 450k)

W =mgi = (100kg)(-9.81m/s2)j

W= -981 N j

∑MA = 0: **r**(C/A)(Tcd) + **r**(C/A)(Tce) + **r(G/A)(-Wj) + r**(B/A)(**B**)

Solving the coefficient of i:

-450(675)(T/1065) – (450)(675)(T/855) + 220.73x102

**T = 344.64 N**

**j coefficient:**

(-690(450)) + 600(450)(344.64/1065) + (220(450) + 600(450)(344.64) – 780Bz = 0

Bz = 185.516 N

**k coefficient:**

(600(675)(344.64/1065) + (600)(675)(344.64/855) – 382.59x103 + 780 By = 0

By = 113.178 N

**b)**

∑F = 0: A + B + Tcd + Tce + W = 0

i coefficient: Ax – (690/1065)(344.64) + (675/855)(344.64) – 981 =0

Ax = 114.454 N

j coefficient: Ay + 113.178 + (675/1065)(344.64)-(450/855)(344.64) =0

Ay = 377.3 N

k coefficient: Az + 185.516 –(450/1065)(344.64) – (450/855)(344.64) =0

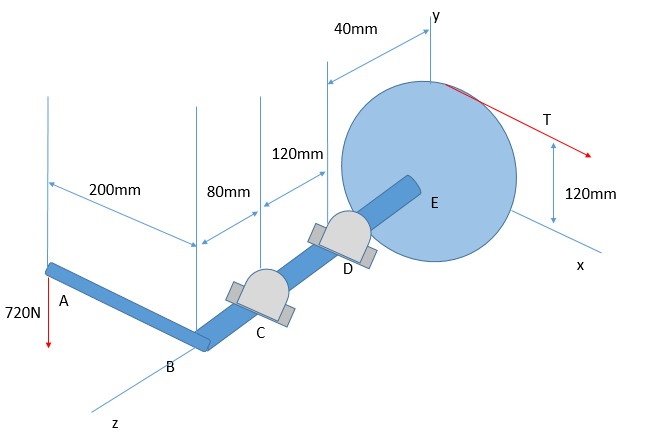
Az = 141.496 N

**A = 114.4N i + 377N j + 141.5N k**

**Critical Thinking:**

In 3 dimensional diagram, it can be easily solved by identifying first the vectors of every forces acting on the system.

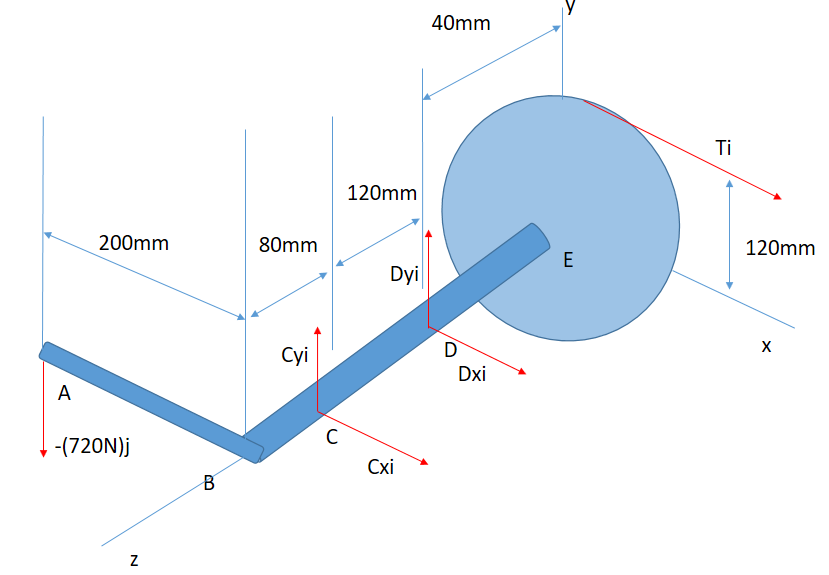
**Question 4: A 200-mm lever and a 240-mm-diameter pulley are welded to the axle BE that is supported by bearings at C and D. If a 720-N vertical load is applied at A when the lever is horizontal, determine (a) the tension in the cord, (b) the reactions at C and D. Assume that the bearing at D does not exert any axial thrust.**



**Theoretical Concept: Use technique of static equilibrium**

**SOLUTION:**

Free Body Diagram:



∑Mc = 0: (-120 k)(Dxi + Dyj) + (120j – 160k) Ti + (80k – 200i)(-720j) = 0

-120 Dxj + 120 Dyi – 120Tk -160Tj + 57x103i + 144x103 = 0

Six equation six unknowns:

Equating to zero each:

k: -120T + 144x103 = 0

**T = 1200 N**

i: 120 Dy + 57.6 x 103 = 0

Dy = -480N

j: -120Dx = 160(1200N)

Dx = -1600N

∑Fx = 0: Cx + Dx + T = 0

Cx = 1600 – 1200 = 400N

∑Fy = 0: Cy + Dy – 720 = 0

Cy = 480 + 720 = 1200N

∑Fz = 0: ∑Cz = 0:

b)

**C = 400N i + 1200N j**

**D = -1600N i – 480N j**

**Critical Thinking:**

The force 720N applied on A balances the tension experienced at E.