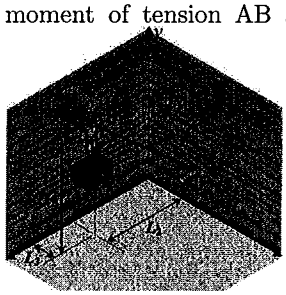
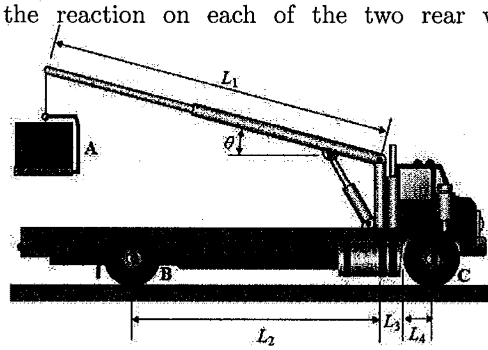
p313s12 **Section 2**
Due Wed, Feb 1, 2012 at 08:00 Set 2
Physics 313: Applied Mechanics CAPA ID 4345

1. [4pt] A crate is held using a block-and-tackle pulley group attached to the bottom of an I-beam by a hook at point B. The moments about the y axis of the force exerted at point B by rope AB is 155 N*m. Given: H_A = 1.3 m, H_B = 4 m, L_1 = 2.5 m, L_2 = 3.2 m, and L_3 = 0.4 m. What is the moment of tension AB about the z axis?

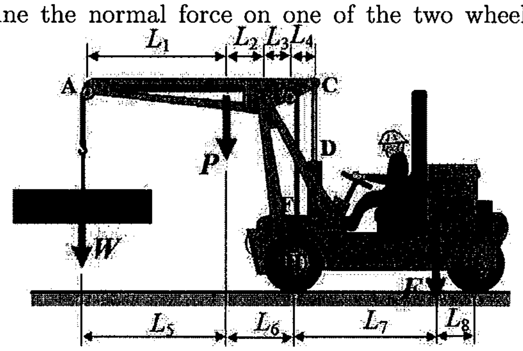


2. [3pt] The boom on a 5000kg truck is used to unload a pallet of shingles of mass 1700kg. The center of mass of the truck is at "G". Given that L_1 = 6.30m, L_2 = 4.20m, L_3 = 0.40m, L_4 = 0.80m and θ = 12°, determine the reaction on each of the two rear wheels B.



3. [3pt] What is the reaction at each of the two front wheels?

4. [3pt] A load of lumber of weight W = 20kN is being raised by a mobile crane. The weight of the boom ABC is P = 1.5kN. The weight of the truck with the driver is F = 70kN. AEF is a single cable. L_1 = 2.8m, L_2 = 0.75m, L_3 = 0.25m, L_4 = 0.30m, L_5 = 2.8m, L_6 = 0.85m, L_7 = 2.8m, and L_8 = 0.35m. Determine the normal force on one of the two wheels at H.



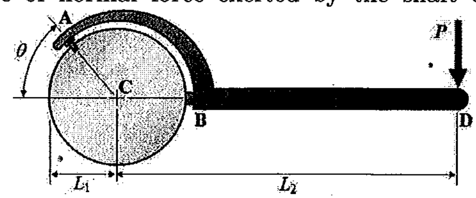
5. [3pt] Find the normal force on one of the two wheels at K.

6. [2pt] Determine the tension in rod CD.

7. [3pt] Determine the 1) vertical and 2) horizontal force components exerted by pin B on boom ABC.

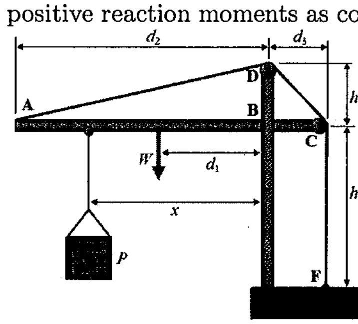
8. [2pt] Determine the maximum weight W allowed without the crane tipping.

9. [3pt] The spanner wrench shown is used to rotate a shaft. The sides and the tip of pin A push against the walls and the bottom of a hole in the shaft of radius L_1 = 64mm, and the flat, frictionless surface B rests against the shaft. θ = 44° and L_2 = 365mm are given. If P = 450N, what is the magnitude of normal force exerted by the shaft on pin A?

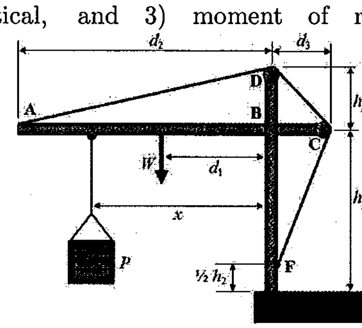


10. [3pt] What is the normal force exerted by the shaft on the wrench at B?

11. [6pt] The rig shown, consisting of horizontal member ABC welded to vertical member DBE, is being used to hold a crate. W = 2500lb, P = 4400lb, x = 8.4ft, and the tension in cable ADCF is 5200lb. d_1 = 5.9ft, d_2 = 17.5ft, d_3 = 3.75ft, h_1 = 10.00ft, and h_2 = 5.00ft are also given. Determine the 1) horizontal reaction, 2) vertical reaction, and 3) moment of the reaction at E. Take positive reactions forces as up and right, and positive reaction moments as counter-clockwise.



12. [6pt] If the rig was set up in such a way that cable ADCF is now attached to DBE at a point F located 1.20ft above E. Determine the 1) horizontal, 2) vertical, and 3) moment of reaction at E.



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zzPogo, E

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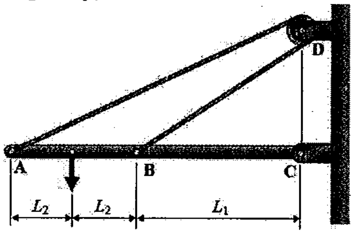
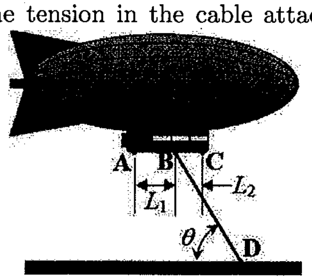
13. [5pt] In the figure below, pully D is a height 13 in directly above pin C and a weight W = 36lb is applied to bar ABC. L_1 = 20in and L_2 = 6in. Neglecting friction and the radius of the pulley, determine the tension in cable ADB.



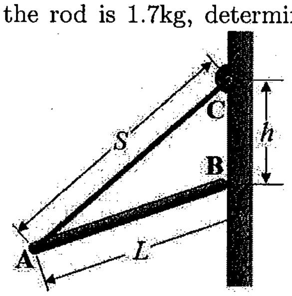
14. [5pt] What are the 1) horizontal and 2) vertical reactions at C? For this and other problems below, take positive as up or to the right.

15. [3pt] A dirigible can be tethered by a single cable at point B (as shown), or by a pair of parallel cables at points A and C. L_1 = 6.1 m, L_2 = 4.1 m, and $\theta = 65^o$. When using a single cable, the tension is 1300 N. If two cables are used instead, what is the tension in the cable attached to point A?



16. [3pt] If two cables are used instead, what is the tension in the cable attached to point C?

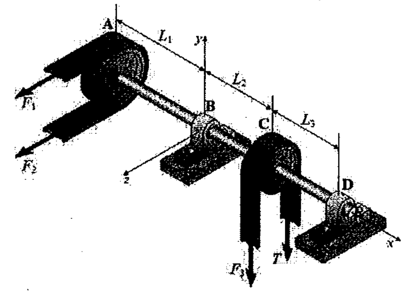
17. [5pt] A slender rod of length L = 210mm is held in equilibrium as shown, with one end against a frictionless wall and the other end attached to a cord of length S = 300mm. Knowing that the mass of the rod is 1.7kg, determine the distance h.



18. [3pt] What is the tension in the cord?

19. [3pt] What is the magnitude of the normal force at B?

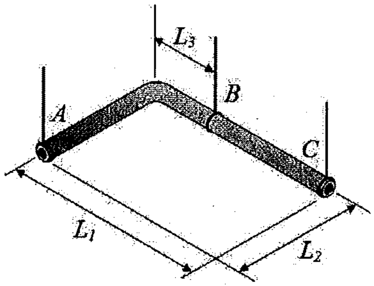
20. [2pt] Two transmission belts pass over sheaves welded to an axle supported by bearings at B and D. The sheave at A has a radius of 56mm and the sheave at C has a radius of 45mm. The rod is made up of lengths L_1 = 135mm, and L_2 = L_3 = 125mm. There are known forces F_1 = 280N, F_2 = 145N, and F_3 = 325N. Knowing that the system rotates with a constant rate, determine the tension T.



21. [6pt] What are the 1) x, 2) y, and 3) z components of the reaction at B?

22. [5pt] What are the 1) x, 2) y and 3) z components of the reaction at D?

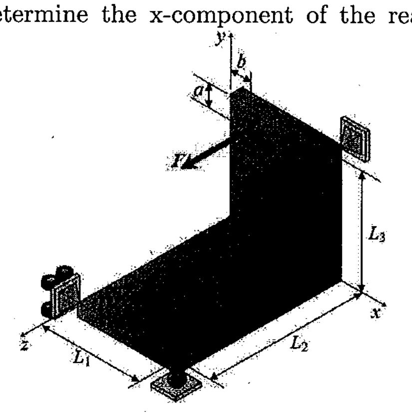
23. [3pt] Two steel pipes having a weight per unit length 5.5 lb/ft are welded together at a right angle and suspended from a ceiling by three cables. Given L_1 = 4.5 ft, L_2 = 1.75 ft, and L_3 = 1.75 ft, determine the tension in the cable at point A.



24. [2pt] Determine the tension in the cable at point B.

25. [2pt] Determine the tension in the cable at point C.

26. [2pt] A folded steel plate (of negligible thickness) is held in place at corners B, C, and D. The support at B is a ball-and-socket joints. Corner C merely rests on a small ball. The support at D is a wheel on a rail. Given: L_1 = 70 mm, L_2 = 115 mm, L_3 = 80 mm, a = 25 mm, b = 20 mm, and F = 210 N, determine the x-component of the reaction at D.



27. [2pt] Determine the x-component of the reaction at B.

28. [2pt] Determine the z-component of the reaction at B.

29. [2pt] Determine the y-component of the reaction at B.

30. [2pt] Determine the y-component of the reaction at C.

31. [2pt] Determine the y-component of the reaction at D.

Assign 2

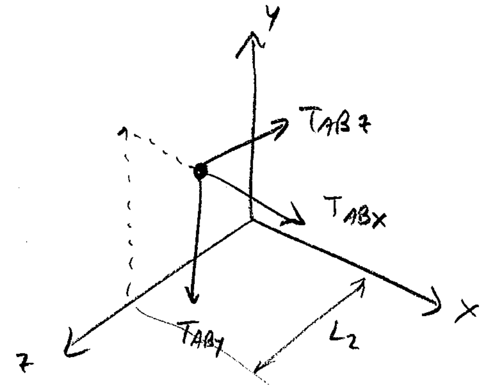
(1)

$L_{ABx} = L_1 - L_3 = 2.1m$

$L_{ABy} = H_B - H_A = 2.7m$

$L_{ABz} = L_2 = 3.2m$

$L_{AB} = 4.684\ m$



$M_{By} = T_{ABx} \cdot L_2 + T_{ABz} L_3$

$M_{By} = \frac{L_{ABx}}{L_{AB}} \cdot T_{AB} L_2 + \frac{L_{ABz}}{L_{AB}} \cdot T_{AB} L_3$

$M_{By} = T_{AB} \left(\frac{L_2 \cdot L_{ABx} + L_3 L_{ABz}}{L_{AB}} \right) \rightarrow$

$$\boxed{T_{AB} = \frac{L_{AB} \cdot M_{By}}{L_2 \cdot L_{ABx} + L_3 \cdot L_{ABz}}}$$

$M_{By} = 155 Nm \rightarrow$ $\underline{T_{AB} = 90.753 N}$

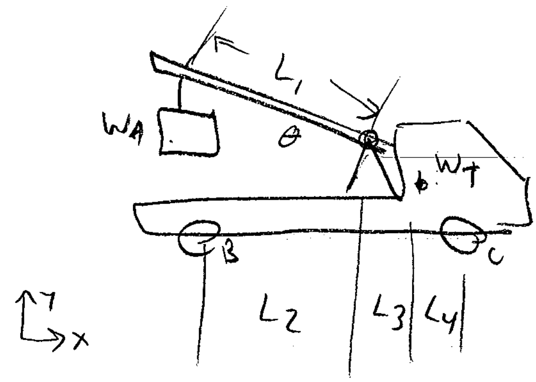
$M_{Bz} = -T_{ABy} \cdot L_3 - T_{ABx} \cdot H_B$

$$\boxed{M_{Bz} = -T_{AB} \frac{L_{ABy}}{L_{AB}} \cdot L_3 - T_{AB} \frac{L_{ABx}}{L_{AB}} \cdot H_B}$$

$\underline{M_{Bz} = -183,675\ Nm}$

(2) $W_A = m_A g$

$W_T = m_T g$

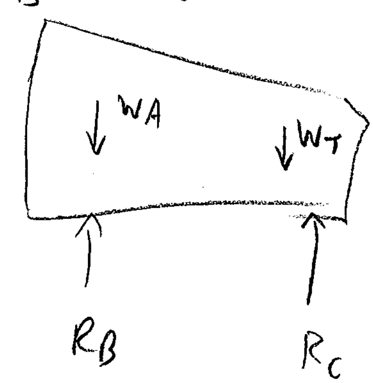


$L_{ABx} = (L_1 \cos\theta - L_2)$

$L_{BGx} = L_2 + L_3$

$L_{BCx} = L_2 + L_3 + L_4$

FB is truck



$\Sigma M_B = 0$

$$W_A L_{ABx} + 0 \cdot R_B - W_T \cdot L_{BGx} + R_C L_{BCx} = 0$$

$$(m_A g)(L_1 \cos\theta - L_2) - m_T g (L_2 + L_3) + R_C (L_1 + L_2 + L_3) = 0$$

$N_{FRONT} = \frac{1}{2} R_C$

$$N_{FRONT} = \frac{m_T g (L_2 + L_3) - m_A g (L_1 \cos\theta - L_2)}{2(L_2 + L_3 + L_4)}$$

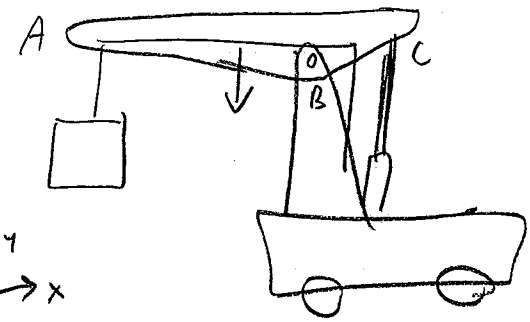
$\Sigma F_y = 0 = R_B + R_C - W_A - W_T$

$R_B = W_A + W_T - R_C$

$N_{BACK} = \frac{1}{2} R_B = $ $$N_{BACK} = \frac{m_A g + m_T g - R_C}{2}$$

Assign 2

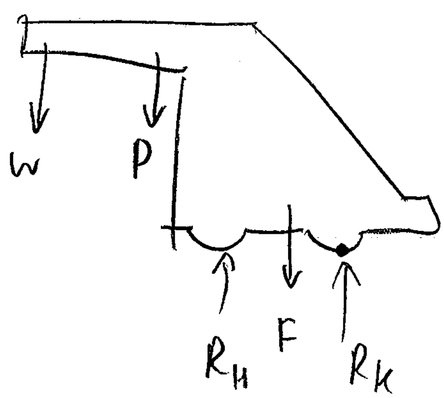
④ $\Sigma M_K = 0$



$$W \cdot (L_5 + L_6 + L_7 + L_8) + P(L_6 + L_7 + L_8) + F(L_8) - R_H(L_7 + L_8) = 0$$

$$\boxed{R_H = \frac{W(L_5+L_6+L_7+L_8) + P(L_6+L_7+L_8) + F L_8}{L_7 + L_8}}$$

object is crane



$N_{front} = \frac{1}{2} R_H$

$$\boxed{N_{front} = \frac{W(L_5+L_6+L_7+L_8) + P(L_6+L_7+L_8) + F L_8}{2(L_7+L_8)}}$$

$\Sigma F_y = 0 = R_H + R_K - W - P - F$

$R_K = W + P + F - R_H$

$N_{rear} = \frac{1}{2} R_K = \boxed{N_{rear} = \frac{1}{2}(W + P + F - R_H)}$

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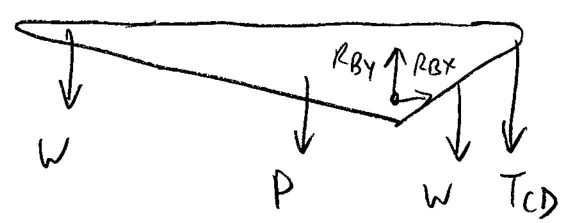
object is beam ABC

$\Sigma M_B = 0$



$$0 = W(L_1 + L_2) + P(L_2) + 0 + 0 - W L_3 - T_{CD}(L_3 + L_4)$$

$$\boxed{T_{CD} = \frac{W(L_1 + L_2 - L_3) + P L_2}{L_3 + L_4}}$$

$\Sigma F_x = 0 \rightarrow \boxed{R_{Bx} = 0}$

$\Sigma F_y = 0 \rightarrow \boxed{R_{By} = 2W + P + T_{CD}}$

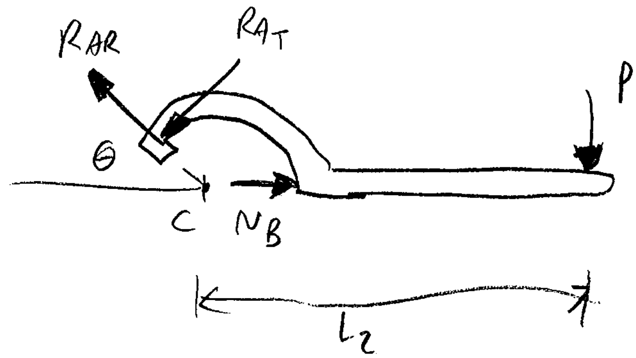
(8) CONTINUED   Using 1st FBD:

To prevent tipping, $R_K = 0$

$$\Sigma M_H = 0 = W_{max}(L_5 + L_6) + P L_6 - F L_7$$

$$W_{max} = \frac{F L_7 - P L_6}{L_5 + L_6}$$

(9) $R = L_1$



$$\Sigma M_A = 0$$

$$+N_B \cdot R\sin\theta - P(L_2 + R\cos\theta) = 0$$

$$N_B = \frac{P(L_2 + R\cos\theta)}{R\sin\theta}$$

$$\Sigma M_C = 0 = -PL_2 + 0 + 0 + R_{AT} \cdot R \rightarrow R_{AT} = \frac{PL_2}{R}$$

$$\Sigma F_y = 0 = -P + R_{AR} \cdot \sin\theta - R_{AT}\cos\theta$$

$$R_{AR} = \frac{P + R_{AT}\cos\theta}{\sin\theta} = R_{AR} = P\frac{(1 + L_2/R)}{\sin\theta}$$

$$R_A = \sqrt{R_{AT}^2 + R_{AR}^2}$$

(11) $\Sigma F_x = 0 \rightarrow$ $R_{Ex} = 0$

$\Sigma F_y = 0 = R_{Ey} - P - W - T$

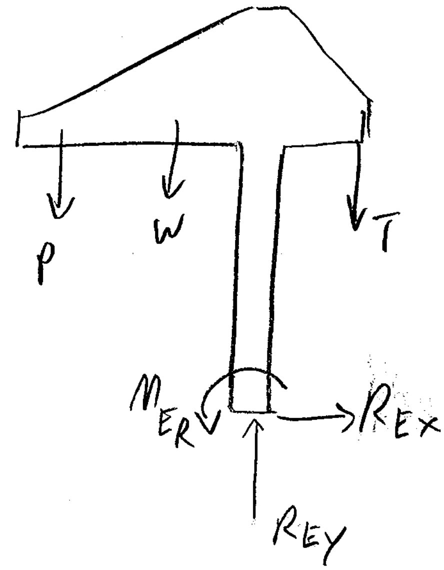
$R_{Ey} = P + W + T$

$\Sigma M_E = 0$

$M_{ER} + P_x + Wd_1 - Td_3 = 0$

$M_{ER} = Td_3 - P_x - Wd_1$

Object is Rig



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(12) Again, $R_{Ex} = 0$

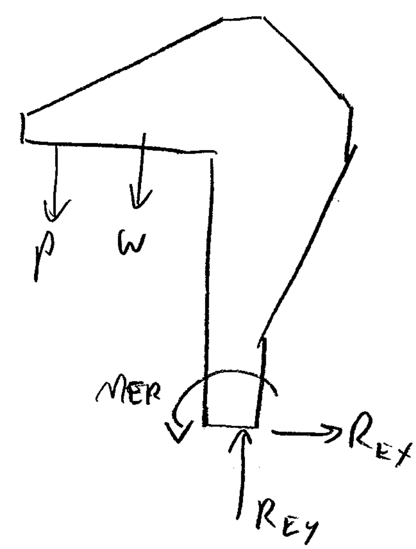
$\Sigma F_y = 0 = R_{Ey} - P - W$

$R_{Ey} = P + W$

$\Sigma M_E = 0$

$M_{ER} + P_x + Wd_1 = 0$

$M_{ER} = -P_x - Wd_1$

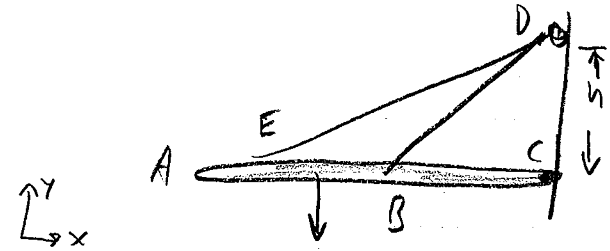


→ Moving the cable improved R_{Ey}, but worsened M_{ER}.

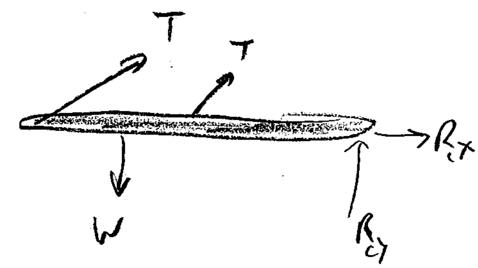
Probably M_{ER} is more critical than R_{Ey}.

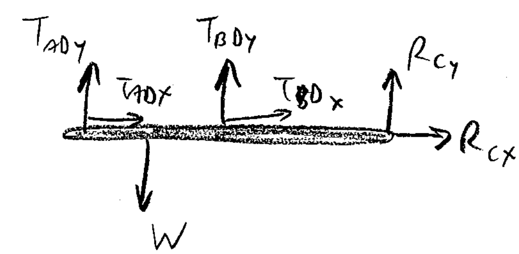
(6)

(13)



Object is ABC





$$\Sigma M_D = 0$$

$$W(L_1+L_2) + R_{cx} \cdot h = 0$$

$$\boxed{R_{cx} = \frac{-W(L_1+L_2)}{h}}$$

$$\Sigma F_x = 0 = T_{ADx} + T_{BDx} + R_{cx} = 0$$

$$T_{AD}\frac{L_{ADx}}{L_{AD}} + T_{BD}\frac{L_{BDx}}{L_{BD}} + R_{cx} = 0$$

Note : $T = T_{AD} = T_{BD}$

$$T\left(\frac{L_{ADx}}{L_{AD}} + \frac{L_{BDx}}{L_{BD}}\right) = -R_c$$

$$T = \frac{W(L_1+L_2)}{h\left(\frac{L_{ADx}}{L_{AD}} + \frac{L_{BDx}}{L_{BD}}\right)} = \boxed{T = \frac{W(L_1+L_2)}{h\left(\frac{L_1+2L_2}{L_{AD}} + \frac{L_1}{L_{BD}}\right)}}$$

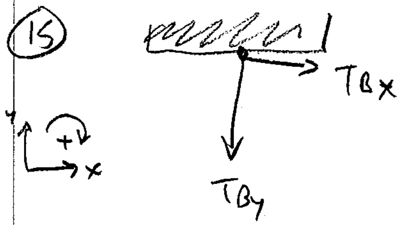
$$\Sigma F_y = 0 = T_{ADy} + T_{BDy} - W + R_{cy} = 0$$

$$R_{cy} = W - T_{ADy} - T_{BDy} = W - T_{AD}\frac{L_{ADy}}{L_{AD}} - T_{BD}\frac{L_{BDy}}{L_{BD}}$$

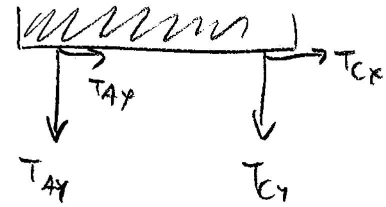
Rc

$$\boxed{R_{cy} = W - T\left(\frac{h}{L_{AD}} + \frac{h}{L_{BD}}\right)}$$

(15)



must be equivalent to:



Here: $T_{Bx} = T_B \cdot \cos\theta = 549.4\,N$

$T_{By} = T_B \cdot \sin\theta = 1178.2\,N$

Also, $\Sigma M_A = 0 \cdot T_{Bx} + L_1 T_{By}$

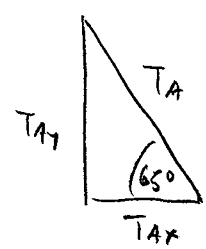
$\Sigma M_A = L_1 T_{By} = 7187\,Nm$

Here: $\Sigma M_A = T_{Cy}(L_1 + L_2)$

$\rightarrow T_{Cy} = 704.6\,N$

Next, since $T_{By} = T_{Ay} + T_{Cy}$, we get $T_{Ay} = 473.6\,N$

Finally, $\frac{T_{Ay}}{T_A} = \sin\theta$,



so $T_A = \frac{T_{Ay}}{\sin 65°}$

$$T_A = 522.6\,N$$

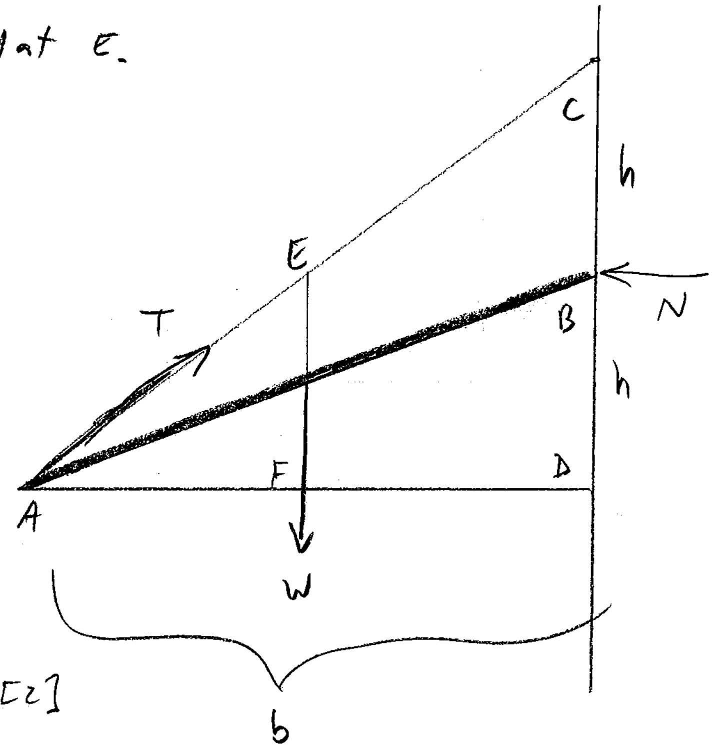
(16) $\frac{T_{Cy}}{T_C} = \sin\theta \rightarrow$ $T_C = 777.4\,N$

(17) 3 force body - forces concurrent at E.

W bisects AB, and bisects AD,
so AF = FD

Triangle AFE = EBC, so

h = BD = CB



Triangle ADB:

$$b^2 + h^2 = L^2 \quad [1]$$

Triangle ADC: $b_2^2 + (2h)^2 = S'^2 \quad [2]$

$[2] - [1] \rightarrow \quad 3h^2 = S'^2 - L^2$

$$h = \sqrt{\frac{S'^2 - L^2}{3}}$$

$\Sigma F_y = 0 = T_y - W = T\frac{(2h)}{S'} - W \rightarrow$

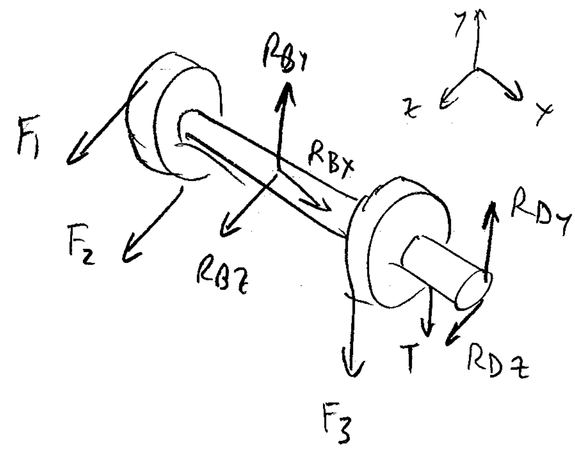
$$T = \frac{WS'}{2h}$$

Finally, $N^2 + W^2 = T^2$, so

$$N = \frac{W}{2h}\sqrt{S'^2 - 4h^2}$$

(20)

$\Sigma F_x = 0 \rightarrow$ $R_{Bx} = 0$



$\Sigma M_x = 0 = +F_1 R_A - F_2 R_A + F_3 R_C - T R_C = 0$

$$T = \frac{(F_1 - F_2) R_A}{R_C} + F_3$$

$\Sigma M_{Bz} = 0 = -(F_3 + T) L_2 + R_{Dy}(L_1 + L_2)$

$$R_{Dy} = \frac{(F_3 + T) L_2}{L_1 + L_2}$$

$\Sigma F_y = 0 = R_{By} + R_{Dy} - F_3 - T$

$$R_{By} = T + F_3 - R_{Dy}$$

$\Sigma M_{yB} = 0 = (F_1 + F_2) L_1 - R_{Dz}(L_2 + L_3)$

$$R_{Dz} = \frac{(F_1 + F_2) L_1}{L_2 + L_3}$$

$\Sigma F_z = 0 = F_1 + F_2 + R_{Bz} + R_{Dz}$

$R_{Bz} = -F_1 - F_2 - R_{Dz}$

$$R_{Bz} = -F_1 - F_2 - \frac{(F_1 + F_2) L_1}{L_2 + L_3}$$

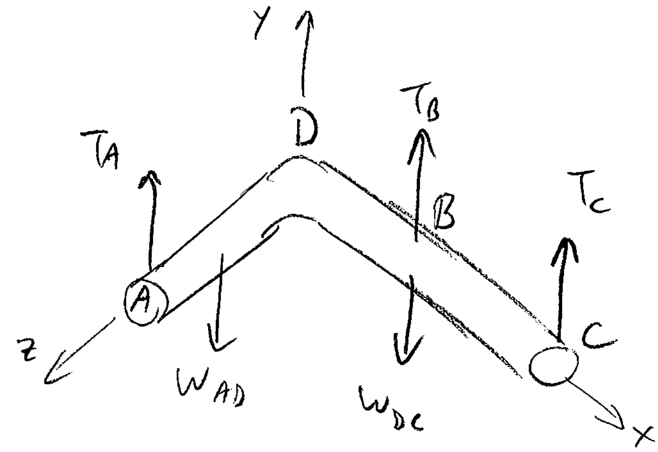
(23)
(24)
(25)

$\gamma = 8\ lb/ft$

$L_1 = 4.25\ ft$

$L_2 = 2.5\ ft$

$L_3 = 0.75\ ft$

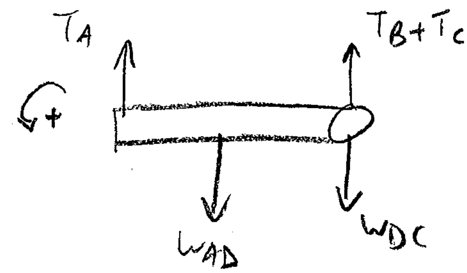


$W_{AD} = \gamma L_2$

$W_{DC} = \gamma L_1$

$\Sigma M_x = 0$

looking down x-axis

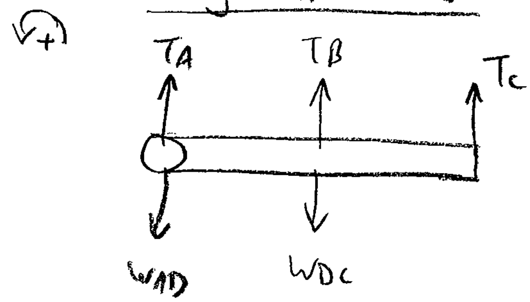


$W_{AD} \cdot \frac{1}{2} L_2 - T_A L_2 = 0$

$$T_A = \frac{1}{2} W_{AD} = \boxed{\frac{1}{2}\gamma L_2 = T_A}$$

$\Sigma M_{Bz} = 0$

looking down z-axis



$W_{AD} \cdot L_3 - T_A L_3 + T_C (L_1 - L_3) = 0$

$$T_C = \frac{-\gamma L_2 L_3 + (\frac{1}{2}\gamma L_2) L_3}{L_1 - L_3}$$

$$T_C = \frac{-\frac{1}{2}\gamma L_2 L_3}{L_1 - L_3}$$

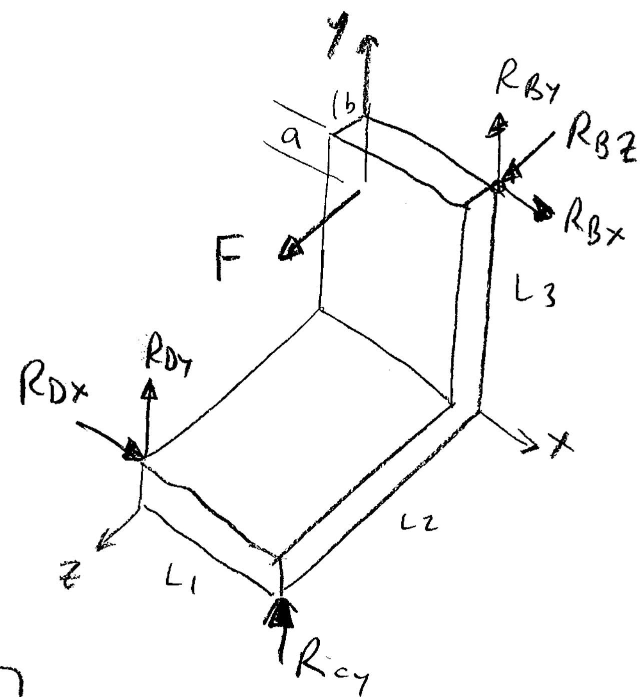
$$\boxed{T_C = + \frac{\gamma L_2 L_3}{2(L_3 - L_1)}}$$

$\Sigma F_y = 0 = T_A + T_B + T_C - W_{AD} - W_{DC} = 0$

$$T_B = W_{AD} + W_{DC} - T_A - T_C$$

$$\boxed{T_B = \frac{1}{2}\gamma L_2 + \gamma L_1 - \frac{\gamma L_1 L_2}{2(L_3 - L_1)}}$$

(26) - (31)



$\Sigma F_z = 0$

$+F + R_{Bz} = 0$

(28) $\boxed{R_{Bz} = -F}$

$\Sigma M_{By} = 0$

$+F(L_1 - b) + R_{Dx} L_2 = 0$

(26) $\boxed{R_{Dx} = -\frac{F(L_1-b)}{L_2}}$

$\Sigma F_x = 0 = R_{Bx} + R_{Dx} \rightarrow R_{Bx} = -R_{Dx}$

$\boxed{R_{Bx} = \frac{F(L_1-b)}{L_2}}$

(27) $\Sigma M_{Dx} = 0$

$+F(L_3 - a) + R_{By} L_2 + R_{Bz} L_3 = 0$

(29) $R_{By} = \frac{1}{L_2}\left(-R_{Bz} L_3 - F(L_3 - a)\right) = \boxed{+\frac{Fa}{L_2} = R_{By}}$

$\Sigma M_{Dz} = 0$

$R_{cy} L_1 + R_{By} L_1 - R_{Bx} L_3 = 0$

(30) $R_{cy} = -R_{By} + R_{Bx}\frac{L_3}{L_1} = \boxed{-\frac{Fa}{L_2} + \frac{F(L_1-b)}{L_1 L_2} L_3 = R_{cy}}$

$\Sigma F_y = 0 = R_{Dy} + R_{cy} + R_{By} = 0$

$R_{Dy} = -R_{cy} - R_{By} = \boxed{+\frac{F(b-L_1)L_3}{L_1 L_2} = R_{Dy}}$