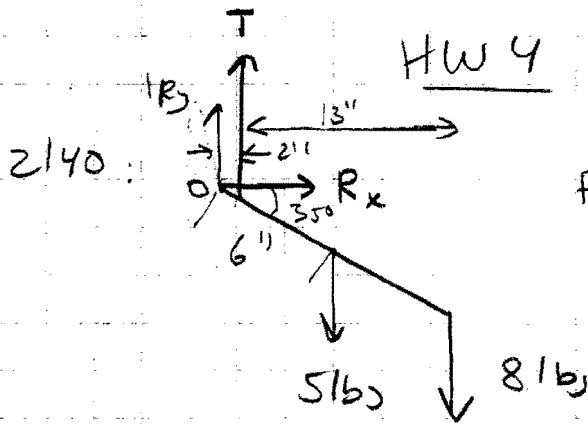
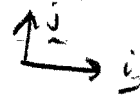


# HW 4

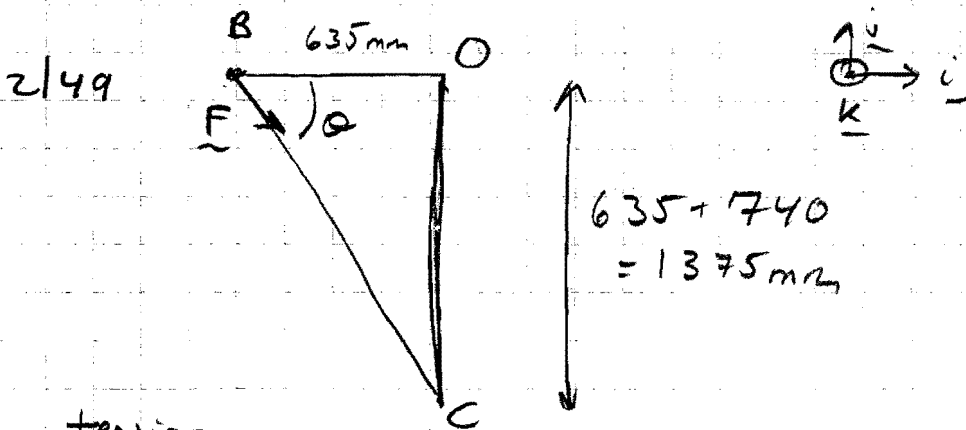


FBD for the arm  
(not required)



$$\sum \underline{M}_O = 0 = (-8 \text{ lb}_j (13'') - 5 \text{ lb}_j (6'' \cos 35^\circ + 2T) \underline{k} = 0$$

$$\Rightarrow T = 64.3 \text{ lb}_j$$



tension

$$T = kx \quad k = 60 \text{ N/m} \quad x = \text{extension of the band}$$

$$x = (\sqrt{635^2 + 1375^2} - 740) / 1000 \text{ meters}$$

$$\Rightarrow T = 46.5 \text{ N}$$

$$\underline{M}_O = \underline{r} \times \underline{F} = -0.635 \underline{i} \times (T \cos \theta \underline{i} - T \sin \theta \underline{j})$$

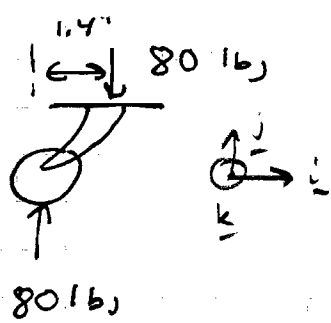
$$= 0.635 T \sin \theta \underline{k}$$

$$T = 46.5 \text{ N}$$

$$\sin \theta = \frac{1.375}{\sqrt{0.635^2 + 1.375^2}}$$

$$\underline{M}_O = 26.8 \underline{k} \text{ N-m}$$

2.57



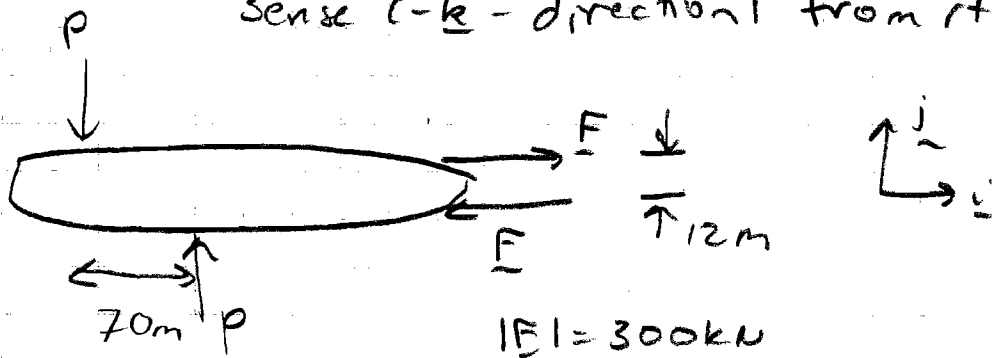
Force couple

$$\underline{M} = -80 \text{ lbs} \cdot 1.4 \text{ in } \underline{k} = -112 \underline{k} \text{ in-lb}$$

magnitude is Force (80 lbs) times the distance b/w lines of action (1.4")

sense (-k - direction) from rt-hand rule

2.64



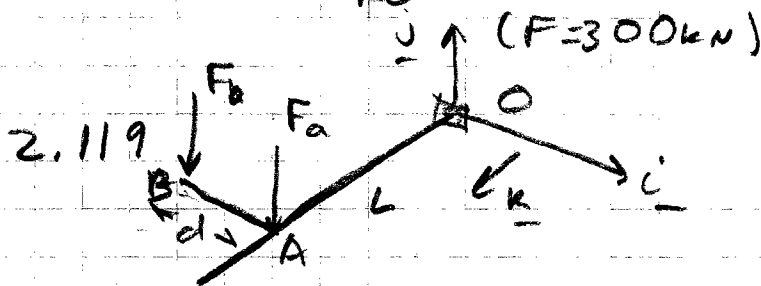
Force equilib holds  $\sum \underline{F} = \underline{0}$

$$\sum \underline{M}_O = \underline{0} = -F(12m) \underline{k} + P(70m) \underline{k} = \underline{0}$$

↑  
moment due to rear force couple

↑  
moment due to side force couple

$$P = \frac{12F}{70} = 54.1 \text{ kN}$$

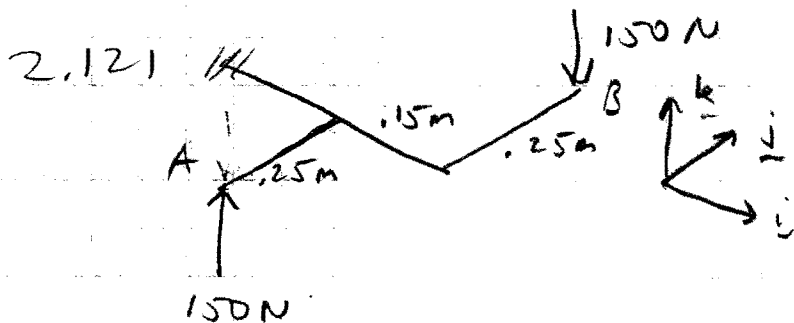


a) Force applied @ a

$$\begin{aligned} \underline{M}_O &= \underline{r}_A \times \underline{F} \\ &= L \underline{k} \times (-F \underline{j}) \\ &= FL \underline{i} \end{aligned}$$

b) Force applied @ B  $\underline{M}_O = (L \underline{k} - d \underline{i}) \times (-F \underline{j})$

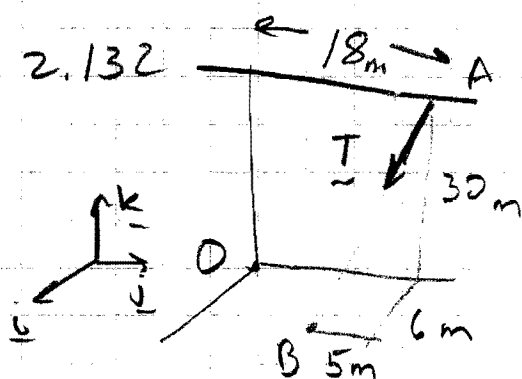
$$= FL \underline{i} + Fd \underline{k}$$



$\underline{M} = \underline{M}_A$  since moment for a couple is independent of the pt about which you take moments

$$\underline{M} = \underline{M}_A = \underline{AB} \times \underline{F} = (0.5 \underline{j} + 0.15 \underline{i}) \times (-150) \underline{k} \quad \text{N-m}$$

$$= -75 \underline{i} + 22.5 \underline{j} \quad \text{N-m}$$



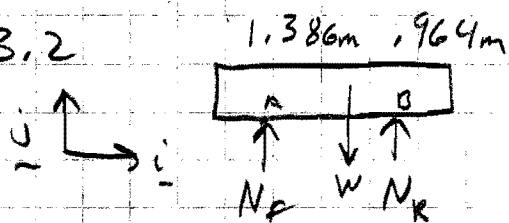
$$|\underline{T}| = 24 \text{ kN}$$

$$\underline{T} = T \frac{\underline{AB}}{|\underline{AB}|} = T \frac{6 \underline{i} - 5 \underline{j} - 30 \underline{k}}{\sqrt{6^2 + 5^2 + 30^2}}$$

$$\underline{M}_O = \underline{r}_A \times \underline{T} = 18 \underline{j} + 30 \underline{k} \quad \text{m}$$

See Maple  $\underline{M}_O = -302 \underline{i} + 139 \underline{j} - 83.6 \underline{k} \quad \text{kNm}$

3.2



assume brakes unlocked -  
only normal forces act

$$W = 1400(9.8) \text{ N}$$

$$\sum \underline{M}_A = \underline{0} = N_R (0.964 \text{ m}) \underline{k} - 1.386 W \underline{k} = \underline{0}$$

$$N_R = W \frac{(1.386)}{0.964} = 8100 \text{ N both wheels (rear)}$$

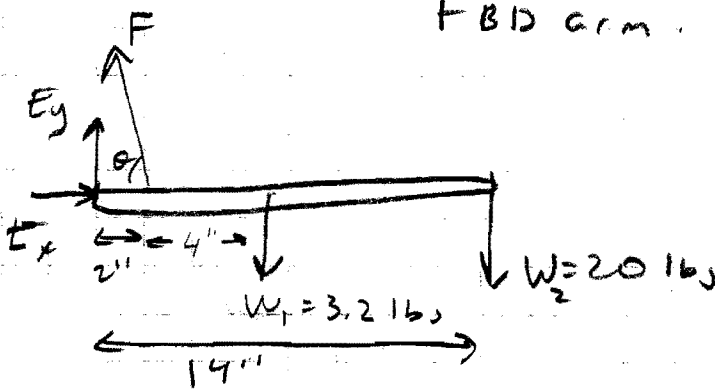
14050 N per wheel

$$\sum \underline{F} = \underline{0} \quad (N_F + N_R - W) \underline{k} = \underline{0}$$

$$\Rightarrow N_F = W - N_R = 5640 \text{ N both front wheels}$$

2820 N/wheel.

3.33



FBD arm.  $E_x, E_y$  are force components transmitted through the elbow joint

$$\theta = \tan^{-1} 4$$

$$\left. \begin{aligned} \sum \underline{F} &= E_x \underline{i} + E_y \underline{j} \\ &+ F \cos \theta \underline{i} + F \sin \theta \underline{j} \\ &- (W_1 + W_2) \underline{j} = \underline{0} \end{aligned} \right\} \begin{aligned} \sum F_x = 0 &= E_x - F \cos \theta \quad (1) \\ \sum F_y = 0 &= E_y + F \sin \theta \\ &- (W_1 + W_2) = 0 \quad (2) \end{aligned}$$

$$\sum \underline{M}_E = \underline{0} = (-6'' W_1 - 14'' W_2) \underline{k} + F \sin \theta (2'') \underline{k} = \underline{0}$$

put in numbers, solve for F

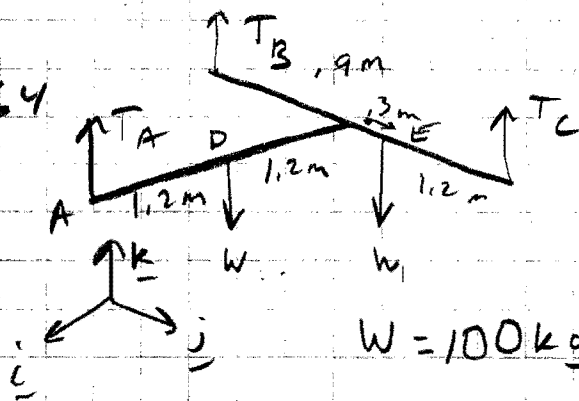
$$\underline{F} = 154.2 \text{ lb}$$

$$(1) \Rightarrow E_x = F \cos \theta = 37.4 \text{ lb}$$

$$(2) \Rightarrow E_y = W_1 + W_2 - F \sin \theta = -126.4 \text{ lb}$$

$$E = \sqrt{E_x^2 + E_y^2} = 131.8 \text{ lb}$$

3.64



$$\sum \underline{F} = (T_A + T_B + T_C) \underline{k}$$

$$-2W \underline{k} = \underline{0}$$

$$\Rightarrow \sum F_z = T_A + T_B + T_C - 2W = 0$$

$$W = 100 \text{ kg} (9.8) \text{ m/s}^2$$

$$\sum \underline{M}_A = \underline{0} = \underline{r}_B \times \underline{F}_B + \underline{r}_C \times \underline{F}_C + \underline{r}_E \times (-W \underline{k}) + \underline{r}_D \times (-W \underline{k})$$

$$\underline{r}_B = (-2.4 \underline{i} - .9 \underline{j}) \text{ m} \quad \underline{r}_C = (-2.4 \underline{i} + 1.5 \underline{j}) \text{ m}$$

$$\underline{r}_D = (-1.2 \underline{i}) \text{ m}, \quad \underline{r}_E = (-2.4 \underline{i} + .3 \underline{j}) \text{ m} \quad \text{See map!}$$

```

> restart; prob 2/121
> with(linalg):
> AB:=[6,-5,-30]; #meters
      AB := [6, -5, -30] (1)
> T:=evalm(24*AB/sqrt(dotprod(AB,AB))); #kN
      T := [ 144/31  -120/31  -720/31 ] (2)
> ra:=[0,18,30];
      ra := [0, 18, 30] (3)
> Mo:=evalm(crossprod(ra,T)); #kN-m
      Mo := [ -9360/31  4320/31  -2592/31 ] (4)
> evalf(evalm(evalf(Mo))); #moment values, kN-m
      [ -301.9354839  139.3548387  -83.61290323 ] (5)
> restart;with(linalg):
> rB:=[-2.4,-0.9,0];rC:=[-2.4,1.5,0];rD:=[-1.2,0,0];rE:=[-2.4,.3,
0];
      rB := [-2.4, -0.9, 0] (6)
      rC := [-2.4, 1.5, 0]
      rD := [-1.2, 0, 0]
      rE := [-2.4, 0.3, 0]
> Fc:=[0,0,Tc];Fb:=[0,0,Tb];Fw:=[0,0,-W];
      Fc := [0, 0, Tc] (7)
      Fb := [0, 0, Tb]
      Fw := [0, 0, -W]
> MA:=evalm(crossprod(rB,Fb)+crossprod(rC,Fc)+crossprod(rE,Fw)+
crossprod(rD,Fw));
      MA := [ -0.9 Tb + 1.5 Tc - 0.3 W  2.4 Tb + 2.4 Tc - 3.6 W  0. ] (8)
> Fz:=Ta+Tb+Tc-2*W;
      Fz := Ta + Tb + Tc - 2 W (9)
> solve({MA[1],MA[2],Fz},{Ta,Tb,Tc});
      {Tb=0.8125000000 W, Ta=0.5000000000 W, Tc=0.6875000000 W} (10)
> subs(W=100*9.8,%); #answers in Newtons!
      {Ta=490.0000000, Tb=796.2500000, Tc=673.7500000} (11)
>

```