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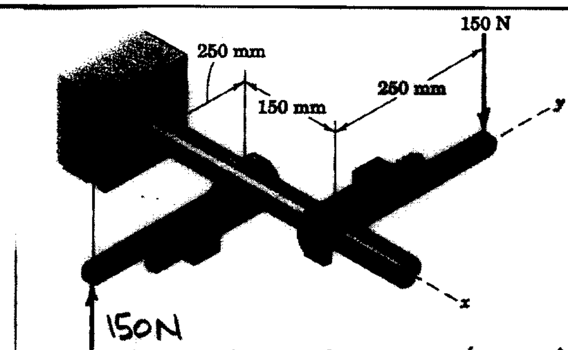

202 HW 3 Solution provided by Prof. Burns, Prof. Ruina & Tian Tang
2/113, 2/153, 3.C.1, 3.C.3, 3.C.5, 3/17, 3/33 due 02/04/03

Since the two forces ($\underline{F} = \pm 150\text{N}\,\hat{k}$) are equal & opposite, they form a couple. The value of any couple is independent of the point about which it is measured. So we can compute the equivalent couple by taking the moment of one force around the point of application of the other force.

$$\underline{M} = \underline{r} \times \underline{F} = \left[(250+250)\hat{j} + 150\,\hat{i}\right] \times (-150\,\hat{k}) \ \text{N-mm}$$

$$= -(.15\,\hat{i} + .5\,\hat{j})\text{m} \times 150\text{N}\,\hat{k} = \boxed{(-75\,\hat{i} + 22.5\,\hat{j})\ \text{N-m}}$$

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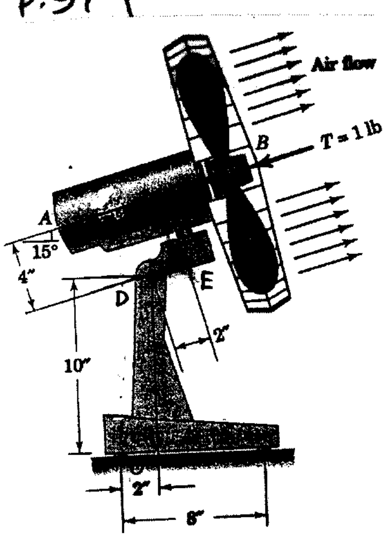
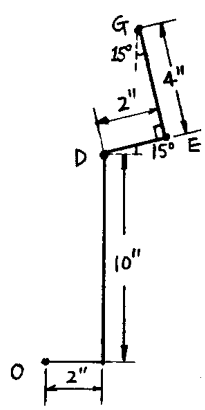
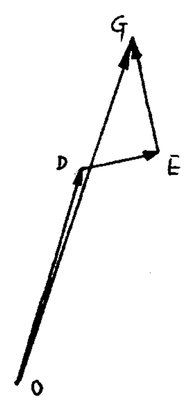
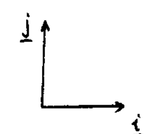
p.97



① Geometry







$$\underline{r}_{G/O} = \underline{r}_{D/O} + \underline{r}_{E/D} + \underline{r}_{G/E}$$

$$= (2''\,\underline{i} + 10''\,\underline{j}) + 2''\,(\cos 15^\circ\,\underline{i} + \sin 15^\circ\,\underline{j}) + 4''\,(-\sin 15^\circ\,\underline{i} + \cos 15^\circ\,\underline{j})$$

$$= 2.9''\,\underline{i} + 14.38''\,\underline{j}$$

(Continued)

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(Cont'd)

② $\underline{M}_{T/0} = \underline{r}_{G/0} \times \underline{T}$

$= (2.9''\,\underline{i} + 14.38''\,\underline{j}) \times 1\text{ lb}\,(-\cos 15°\,\underline{i} - \sin 15°\,\underline{j})$

$= (13.14 \text{ lb-in})\,\underline{k}$

③ $\underline{M}_{G/0} = \underline{r}_{G/0} \times \underline{G}$

$= (2.9''\,\underline{i} + 14.38''\,\underline{j}) \times 9\text{ lb}\,(-\underline{j})$

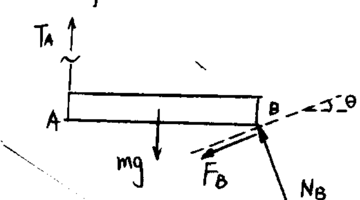
$= (-26.1 \text{ lb-in})\,\underline{k}$

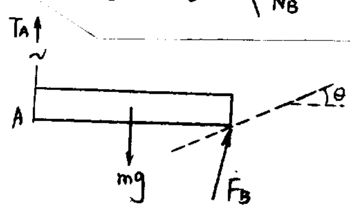
Note: To calculate $\underline{M}_{T/0}$, slide force along its line of action to G.

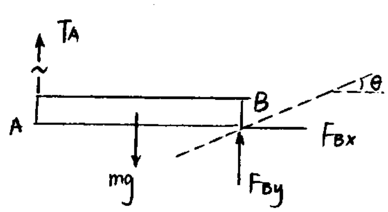
3C/p. 114

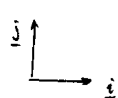
1. Uniform horizontal bar of mass m suspended by vertical cable at A and supported by rough inclined surface at B.

All of these are ok.

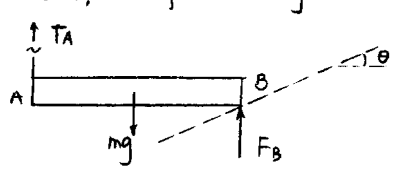








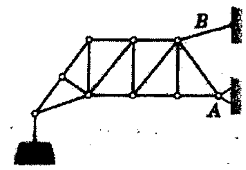
Note: In the end, after using the laws of statics, you will find this

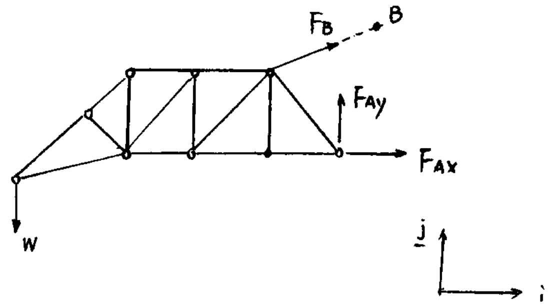


but your FBD need not show the results of such reasoning.

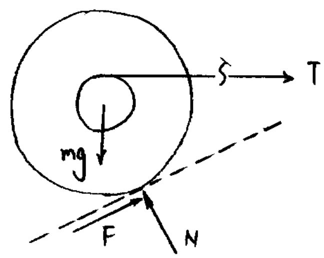
3C/p.114 (Cont'd)

3. Loaded truss supported by pin joint at *A* and by cable at *B*.

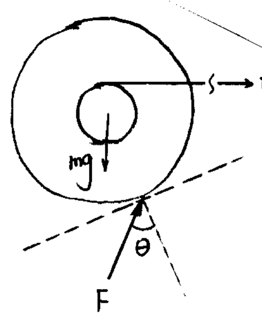




5. Uniform grooved wheel of mass *m* supported by a rough surface and by action of horizontal cable.



OR



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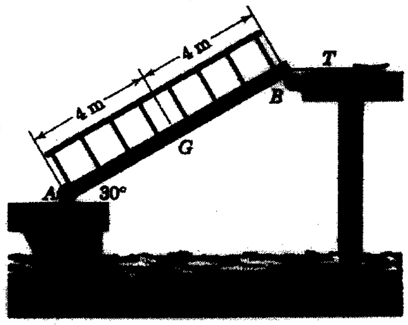
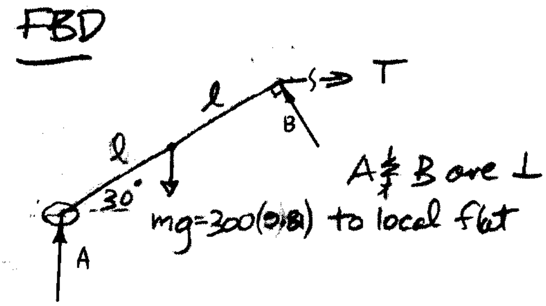
3/17 To accommodate the rise and fall of the tide, a walk- [redacted] horizontal cable which is attached to the cleat and find the force under the roller at *A*.

Ans. $T = 850$ N, $A = 1472$ N



FBD

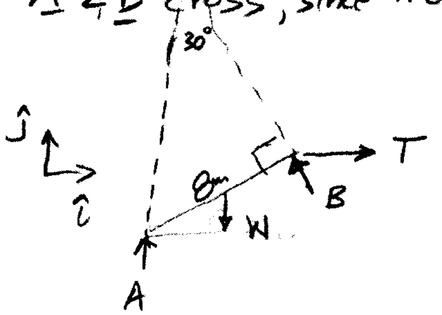


We don't know A, B or T but can solve for the 3 of them for this 2-D prob

by $\Sigma \underline{F} = 0$, $\Sigma \underline{M} = 0$

We could solve systematically by finding $\Sigma M_B = 0$ to get A, compute B from $\Sigma F_y = 0$, and then use $\Sigma F_x = 0$ to evaluate T

However it is easier if we can write 1 eqn that contains only the unknown T. We'll get this if we sum moments about the point where $\underline{A}$ & $\underline{B}$ cross, since their moments there are zero



$$\Sigma \underline{M}_O = 0$$

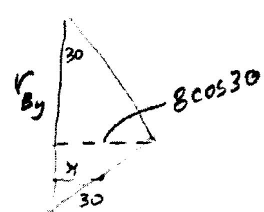
$$= \underline{r}_{G} \times (-mg\hat{j}) + \underline{r}_{B/O} \times T\hat{i}$$

$$= -x_G \hat{i} \times mg\hat{j} + (-r_{By})\hat{j} \times T\hat{i}$$

y position of B

where we've ignored $\hat{i} \times \hat{i}$ & $\hat{j} \times \hat{j}$ terms

$$0 = -x_G mg + r_{By} T$$

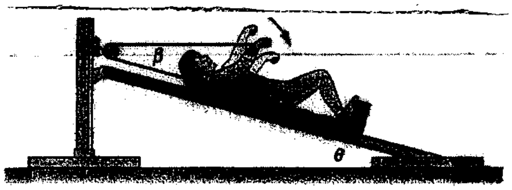


$$\therefore T = mg\left(\frac{x}{r_{By}}\right) = 300(9.81)\frac{4\cos 30}{8\cos 30/\tan 30} \text{ N}$$

$$= 150(9.81)\tan 30 \text{ N} = \boxed{850 \text{ N} = T}$$

Then: $\Sigma M_B = 0 = -A(8\cos 30) + W(4\cos\theta) \Rightarrow A = W/2 = \frac{300(9.81)}{2} \text{ N} = \boxed{1472 \text{ N} = A}$

3/33

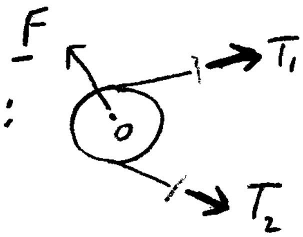


Problem 3/33

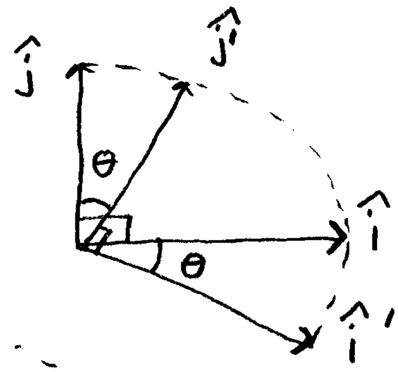
$\theta = 15^\circ$
$\beta = 18^\circ$
$W = 70\,kg \cdot 9.81\ N/kg$

pulley

FBD:



$\sum \underline{M}_O = \underline{0} \Rightarrow T_1 = T_2$



person

$$\left\{ \sum \underline{F}_i = \underline{0} \Rightarrow T(-\hat{i}') + T(-\cos\beta\,\hat{i}' - \sin\beta\,\hat{j}') - W\hat{j} + R\hat{j}' = \underline{0} \right\} (1)$$

$$\underbrace{\{(1)\}\cdot\hat{i}'}_{\sum F_{x'} = 0} \Rightarrow -T - T\cos\beta - W\underbrace{\hat{j}\cdot\hat{i}'}_{-\sin\theta} + 0 = 0 \Rightarrow T = \frac{W\sin\theta}{1+\cos\beta}$$

$$\Rightarrow \boxed{P = \frac{T}{2} = 45.5\,N}\ (2)$$

force on one hand

$$\underbrace{\{(1)\}\cdot\hat{j}'}_{\sum F_{y'} = 0} \Rightarrow -T\sin\beta' - W\underbrace{\hat{j}\cdot\hat{j}'}_{\cos\theta} + R = 0$$

$$\Rightarrow R = T\sin\beta + W\cos\theta$$

$$(2) \Rightarrow \quad = W\left[\frac{\sin\theta\sin\beta}{1+\cos\beta} + \cos\theta\right]$$

$$\boxed{R = 691\,N}$$