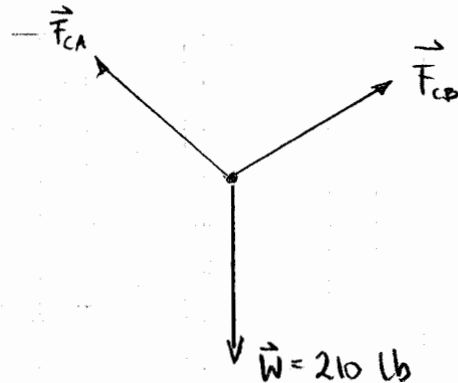


Homework #4 - Solution

Problem 1

FBD:



Vector Equation:

$$\sum \vec{F} = 0 = \vec{F}_{CA} + \vec{F}_{CB} + \vec{W} = 0$$

Unit vectors:

$$\hat{u}_{CA} = \frac{8,2\hat{i} + 1,6\hat{j}}{\sqrt{8,2^2 + 1,6^2}} = 0,981\hat{i} + 0,191\hat{j}$$

$$\hat{u}_{CB} = \frac{-0,8\hat{i} + 0,5\hat{j}}{\sqrt{0,8^2 + 0,5^2}} = -0,848\hat{i} + 0,530\hat{j}$$

$$\hat{i}: 0,981 F_{CA} - 0,848 F_{CB} = 0$$

$$\hat{j}: 0,191 F_{CA} + 0,530 F_{CB} - 210 = 0$$

$$\begin{bmatrix} 0,981 & -0,848 \\ 0,191 & 0,530 \end{bmatrix} \begin{bmatrix} F_{CA} \\ F_{CB} \end{bmatrix} = \begin{bmatrix} 0 \\ 210 \end{bmatrix}$$

$$\boxed{\begin{array}{l} F_{CA} = 302 \text{ lb (T)} \\ F_{CB} = 261 \text{ lb (T)} \end{array}}$$

Both F_{CA} and F_{CB} are less than 420 lb. Therefore, the ropes will hold.

When the burglar climbs back down, all that changes in the problem is \vec{W} .

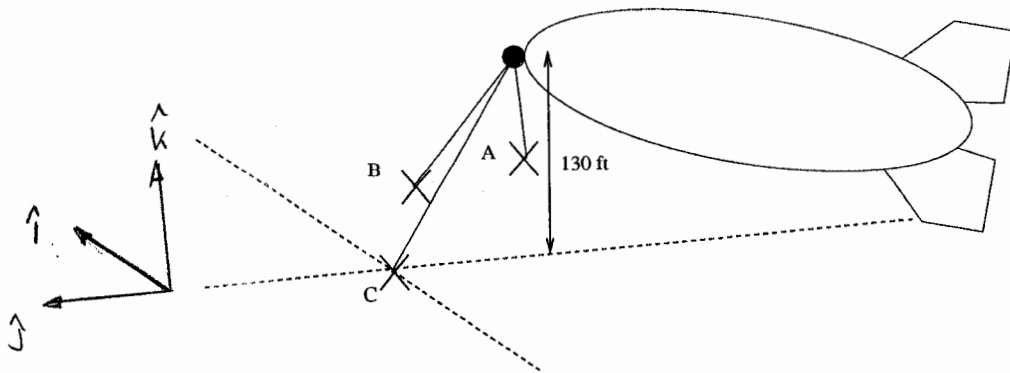
$$\vec{W} = 210 + 75 = 285 \text{ lbs}$$

$$\begin{bmatrix} 0,981 & -0,848 \\ 0,191 & 0,530 \end{bmatrix} \begin{bmatrix} F_{CA} \\ F_{CB} \end{bmatrix} = \begin{bmatrix} 0 \\ 285 \end{bmatrix}$$

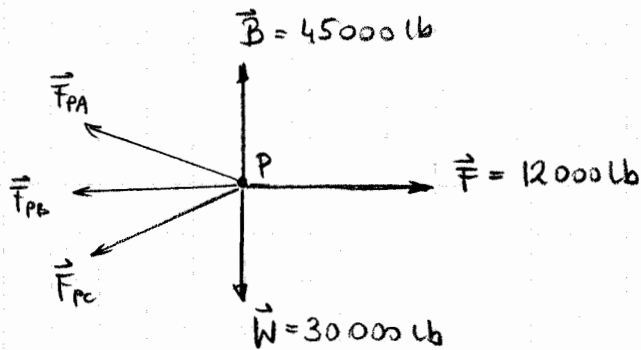
| | |
|---------------------------|-----|
| $F_{CA} = 410 \text{ lb}$ | (T) |
| $F_{CB} = 354 \text{ lb}$ | (T) |

Even with the extra weight the ropes will still hold. The burglar can escape.

Problem 2



FBD



$$\Sigma \vec{F} = \vec{F}_{PA} + \vec{F}_{PB} + \vec{F}_{PC} + \vec{W} + \vec{B} + \vec{F} = 0$$

$$\hat{u}_{PA} = 0,340 \hat{i} - 0,319 \hat{j} - 0,884 \hat{k}$$

$$\hat{u}_{PB} = 0,225 \hat{i} + 0,0225 \hat{j} - 0,974 \hat{k}$$

$$\hat{u}_{PC} = 0,365 \hat{j} - 0,931 \hat{k}$$

$$\vec{W} = -30,000 \hat{k}$$

$$\vec{B} = 45,000 \hat{k}$$

$$\vec{F} = 12,000 [-\cos 50^\circ \hat{i} - \sin 50^\circ \hat{j}] = -7713,4 \hat{i} - 9192,5 \hat{j}$$

$$\hat{i}: -7713,5 + 0,340 F_{PA} + 0,225 F_{PB} = 0$$

$$\hat{j}: -9192,5 - 0,319 F_{PA} + 0,0225 F_{PB} + 0,365 F_{PC} = 0$$

$$\hat{k}: -30000 - 0,884 F_{PA} - 0,974 F_{PB} - 0,931 F_{PC} + 45000 = 0$$

$$\begin{bmatrix} 0,340 & 0,225 & 0 \\ -0,319 & 0,0225 & 0,365 \\ -0,884 & -0,974 & -0,931 \end{bmatrix} \begin{bmatrix} F_{PA} \\ F_{PB} \\ F_{PC} \end{bmatrix} = \begin{bmatrix} 7713,5 \\ 9192,5 \\ -15000 \end{bmatrix}$$

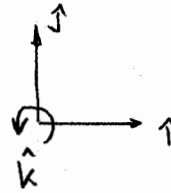
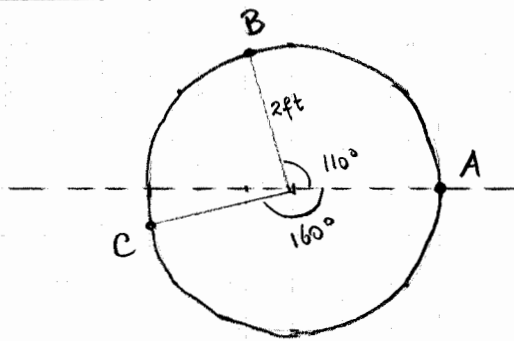
$$F_{PA} = -127557 \text{ lb} = -127,6 \text{ kip} \quad (C)$$

$$F_{PB} = 227036 \text{ lb} = 227,0 \text{ kip} \quad (T)$$

$$F_{PC} = -100292 \text{ lb} = -100,3 \text{ kip} \quad (C)$$

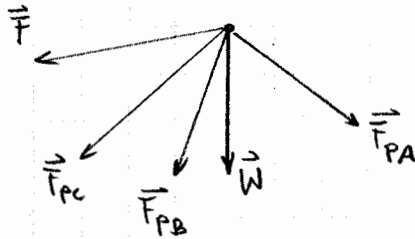
Two of the calculated forces in the cables turn out to be compression forces. This means that the system as it is will not work (cannot have cables in compression!).

Problem 3



FORM C
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FBD



$$\hat{u}_{PA} = 0,5 \hat{i} - 0,875 \hat{k}$$

$$\hat{u}_{PB} = -0,171 \hat{i} + 0,469 \hat{j} - 0,875 \hat{k}$$

$$\hat{u}_{PC} = -0,469 \hat{i} - 0,171 \hat{j} - 0,875 \hat{k}$$

$$\vec{W} = -45 \text{ lb } \hat{k}$$

$$\vec{F} = -45 \cdot \cos 40 \hat{i} - 45 \cdot \sin 40 \hat{k} = -34,5 \hat{i} - 28,9 \hat{k} \text{ lb}$$

$$\hat{i}: 0,5 F_{PA} - 0,171 F_{PB} - 0,469 F_{PC} - 34,5 = 0$$

$$\hat{j}: 0,469 F_{PB} - 0,171 F_{PC} = 0$$

$$\hat{k}: -0,875 F_{PA} - 0,875 F_{PB} - 0,875 F_{PC} - 45 - 28,9 = 0$$

$$\begin{bmatrix} 0,5 & -0,171 & -0,469 \\ 0 & 0,469 & -0,171 \\ -0,875 & -0,875 & -0,875 \end{bmatrix} \begin{bmatrix} F_{PA} \\ F_{PB} \\ F_{PC} \end{bmatrix} = \begin{bmatrix} 34,5 \\ 0 \\ 73,9 \end{bmatrix}$$

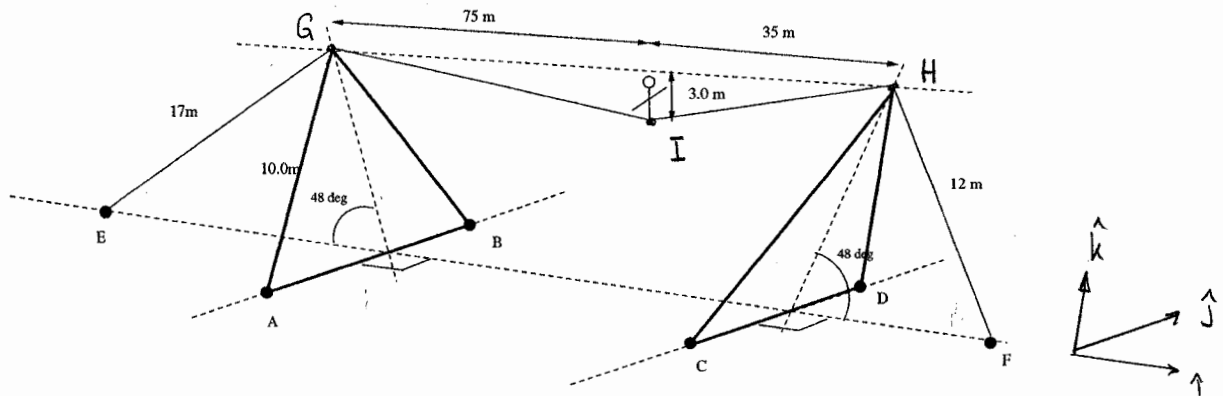
$$F_{PA} = 1,8 \text{ lb (T)}$$

$$F_{PB} = -23 \text{ lb (C)}$$

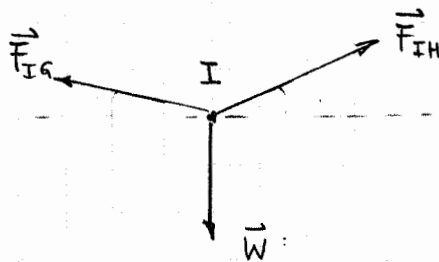
$$F_{PC} = -63 \text{ lb (C)}$$

Problem 4

FORM C
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FBD :



$$\vec{W} = -(63 \cdot 9,81) \frac{\text{kgm}}{\text{s}^2} = -618 \text{ N } \hat{k}$$

$$\hat{u}_{IH} = 0,996 \hat{i} + 0,085 \hat{k}$$

$$\hat{u}_{IG} = -0,999 \hat{i} + 0,039 \hat{k}$$

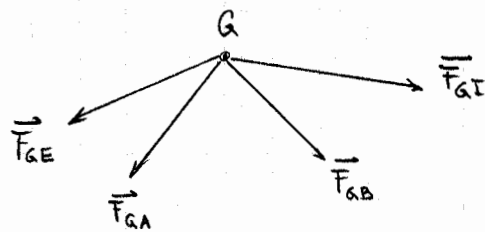
$$\hat{i}: 0,996 F_{IH} - 0,999 F_{IG} = 0$$

$$\hat{k}: 0,085 F_{IH} + 0,039 F_{IG} - 618 = 0$$

$$F_{IG} = 4973 \text{ N (T)}$$

$$F_{IH} = 4988 \text{ N (T)}$$

Joint G:



$$\sum \vec{F} = \vec{F}_{GE} + \vec{F}_{GA} + \vec{F}_{GB} + \vec{F}_{GT} = \vec{0}$$

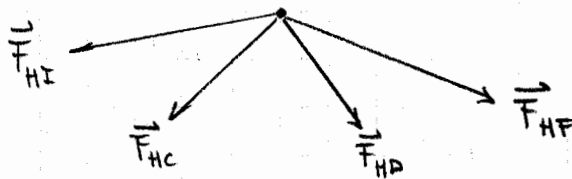
$$\hat{u}_{GA} = 0,579 \hat{i} - 0,5 \hat{j} - 0,643 \hat{k}$$

$$\hat{u}_{GB} = 0,579 \hat{i} + 0,5 \hat{j} - 0,643 \hat{k}$$

$$\hat{u}_{GE} = -0,925 \hat{i} - 0,378 \hat{k}$$

$$\hat{u}_{GT} = 0,999 \hat{i} - 0,0399 \hat{k}$$

Joint H



$$\sum \vec{F} = \vec{F}_{HI} + \vec{F}_{HC} + \vec{F}_{HD} + \vec{F}_{HF} = \vec{0}$$

$$\hat{u}_{HI} = -0,996 \hat{i} - 0,085 \hat{k}$$

$$\hat{u}_{HC} = -0,579 \hat{i} - 0,5 \hat{j} - 0,643 \hat{k}$$

$$\hat{u}_{HD} = -0,579 \hat{i} + 0,5 \hat{j} - 0,643 \hat{k}$$

$$\hat{u}_{HF} = 0,844 \hat{i} - 0,535 \hat{k}$$

Joint G:

$$\uparrow: 0,579 F_{GA} + 0,579 F_{GB} - 0,925 F_{GE} + 4968 = 0$$

$$\hat{j}: -0,5 F_{GA} + 0,5 F_{GB} = 0$$

$$\hat{k}: -0,643 F_{GA} - 0,643 F_{GB} - 0,378 F_{GE} - 198 = 0$$

Joint H:

$$\uparrow: -4968 - 0,579 F_{HC} - 0,579 F_{HD} + 0,844 F_{HF} = 0$$

$$\hat{j}: -0,5 F_{HC} + 0,5 F_{HD} = 0$$

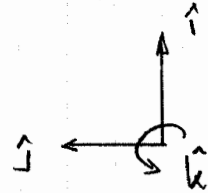
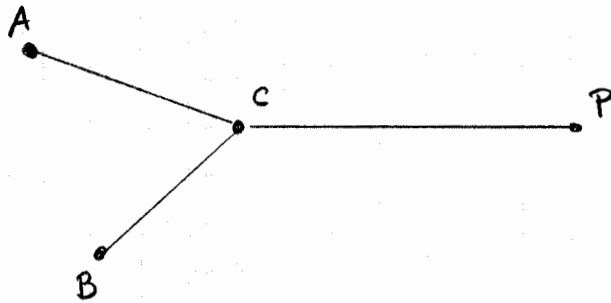
$$\hat{k}: -424 - 0,643 F_{HC} - 0,643 F_{HD} - 0,535 F_{HF} = 0$$

6 equations - 6 unknowns

| | | | | |
|----------|---|-------|---|-----|
| F_{GA} | = | -1273 | N | (C) |
| F_{GB} | = | -1273 | N | (C) |
| F_{GE} | = | 3777 | N | (T) |
| F_{HC} | = | -1768 | N | (C) |
| F_{HD} | = | -1768 | N | (C) |
| F_{HF} | = | 3459 | N | (T) |

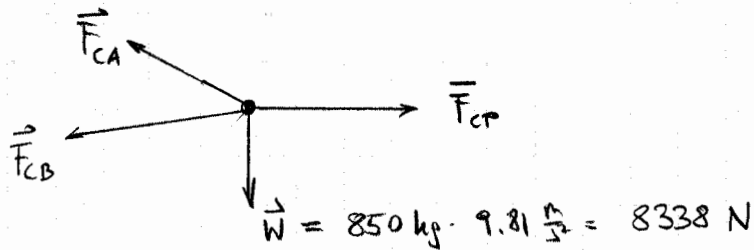
Problem 5

Top View



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FBD



$$\Sigma \vec{F} = \vec{F}_{CA} + \vec{F}_{CB} + \vec{F}_{CP} + \vec{W} = \vec{0}$$

$$\hat{u}_{CA} = 0,304 \hat{i} + 0,478 \hat{j} + 0,826 \hat{k}$$

$$\hat{u}_{CB} = -0,470 \hat{i} + 0,342 \hat{j} + 0,812 \hat{k}$$

$$\hat{u}_{CP} = -0,619 \hat{j} + 0,785 \hat{k}$$

$$\hat{i}: 0,304 F_{CA} - 0,470 F_{CB} = 0$$

$$\hat{j}: 0,478 F_{CA} + 0,342 F_{CB} - 0,619 F_{CP} = 0$$

$$\hat{k}: 0,826 F_{CA} + 0,812 F_{CB} + 0,785 F_{CP} - 8338 = 0$$

| |
|-------------------------------|
| $F_{CA} = 3726 \text{ N (T)}$ |
| $F_{CB} = 2410 \text{ N (T)}$ |
| $F_{CP} = 4208 \text{ N (T)}$ |