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Announcements

- Quiz 1 This Week!!!
  - Are you signed up?
  - Know your MATLAB commands
  - Practice quiz available on PL

❑ Upcoming deadlines:

- Tuesday (9/12)
  - PL HW4
- Thursday (9/14)
  - ME HW5

1 L5 - Force along a line Cross product

$\vec{A}\cdot\vec{B} = \text{dot}(A,B)$

$\vec{A} = 3\hat{i} - 4\hat{k}$

$\vec{A} = 3\hat{i} - 4\hat{j}$

$A = [3, -4]$

$= [3 \;\; 0 \;\; -4]$

$|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$

$= \text{norm}(A)$

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Recap

- Equilibrium of a particle – neglect dimension
  – has mass
- General procedure for analysis
- Free body diagram 1.) Id body 2) Forces 3) Geometry 4.) coord. sys.
- Equation of equilibrium $\Sigma \vec{F} = 0$
- Idealizations (pulleys, springs, smooth surfaces)

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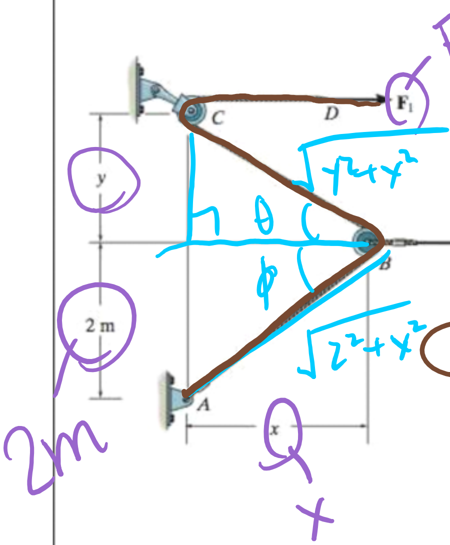


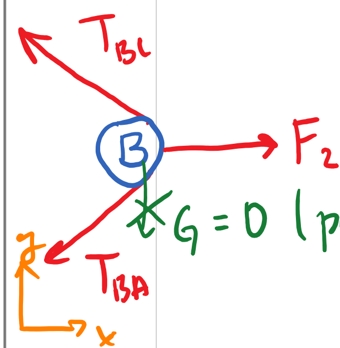
If $F_1 = 800$ N and $F_2 = 1000$ N, what is the value of y for the system to remain at equilibrium?

A) y < 2 m ?

B) y = 2 m

C) y > 2 m ?

D) Not enough information



$\cancel{G} = 0$ (pulley is massless)

$\sum \vec{F} = 0$

$\sum F_x = F_2 - T_{BCx} - T_{BAx} = 0$

$\sum F_y = T_{BCy} - T_{BAy} = 0 \Rightarrow T_{BCy} = T_{BAy}$

$T_{BA} = T_{BC} = F_1$

$\Rightarrow \theta = \phi$

$T_{BCy} = T_{BC} \sin\theta = T_{BC}\left(\frac{y}{\sqrt{y^2+x^2}}\right)$

$T_{BAy} = T_{BA} \sin\phi = T_{BA}\left(\frac{2}{\sqrt{2^2+x^2}}\right)$

$\Big\} \; y = 2$

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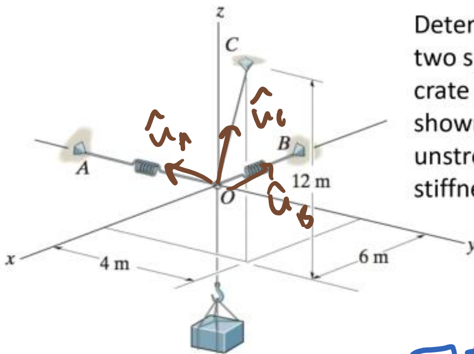
Example – 3D



Determine the stretch in each of the two springs required to hold the 20-kg crate in the equilibrium position shown. Each spring has an unstretched length of 2 m and a stiffness of k = 360 N-m.

5 L5 - Force along a line Cross product

Given: $\underline{m}, k, \hat{u}_A, \hat{u}_B, \hat{u}_C$

Find: $s = l - l_0$

FBD

$\vec{F}_C$, F_B, F_A, $W = \underline{mg}$

EoE

$\Sigma F_x = 0 = -F_B + F_{cx}$

$\Sigma F_y = 0 = -F_A + F_{cy}$

$\Sigma F_z = 0 = -mg + F_{cz}$ ✓

$\vec{F}_A = -F_A\hat{j}$

$\vec{F}_B = -F_B\hat{i}$

$\vec{F}_C = F_c\hat{u}_c$

$$\hat{u}_c = \frac{6\hat{i} + 4\hat{j} + 12\hat{k}}{\sqrt{6^2 + 4^2 + 12^2}} = \frac{\vec{r}_c}{r_c}$$

$\vec{W} = -mg\hat{k}$

$z: F_{cz} = mg \Rightarrow F_c = \frac{mg}{u_{cz}}$.

$y: F_A = F_{cy} \Rightarrow F_A = F_c(u_{cy}) = \underbrace{ks_A}_{F_A}$

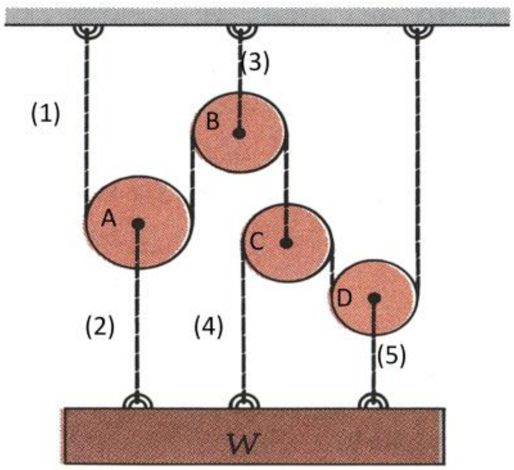
$F_A = ks_A$

$F_B = ks_B$

$$\boxed{s_A = \frac{F_c u_{cy}}{k} \qquad s_B = \frac{F_c u_{cx}}{k}}$$

Equilibrium of a system of particles

Some practical engineering problems involve the statics of interacting or interconnected particles. To solve them, we use Newton's first law: $\Sigma \mathbf{F} = \mathbf{0}$ on selected multiple free-body diagrams of particles or groups of particles.



The five ropes can each take 1500 N without breaking. How heavy can *W* be without breaking any?

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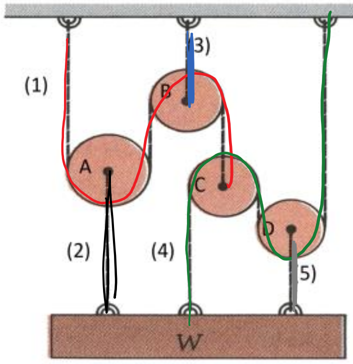
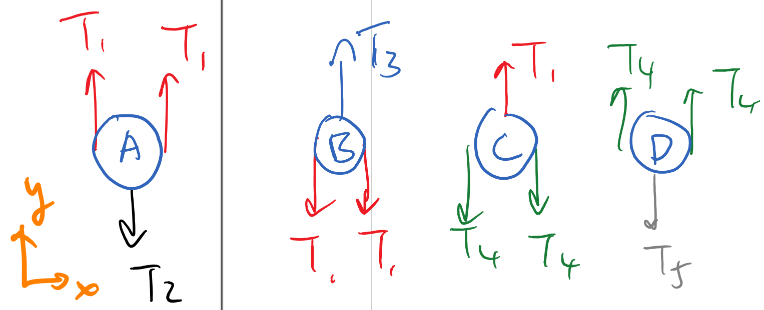
Which cable will break first?



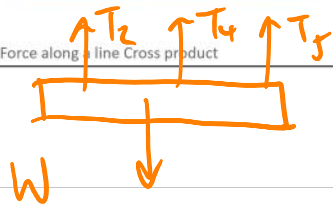
A) 1
B) 2
C) 3 ?
D) 4
E) 5



$\Sigma F_y = 0: T_2 = 2T_1$

$T_3 = 2T_1$

$T_1 = 2T_4$ $\quad T_5 = 2T_4$



T_1 = 10

$T_1 = T_1 = 10$

✓ $T_2 = 2T_1 = 20$

✓ $T_3 = 2T_1 = 20$

$T_4 = \frac{1}{2}T_1 = 5$

$T_5 = 2\left(\frac{1}{2}\right)T_1 = T_1 = 10$

$W = 2T_1 + \frac{1}{2}T_1 + T_1$

$$\boxed{W = 3\tfrac{1}{2}T_1}$$