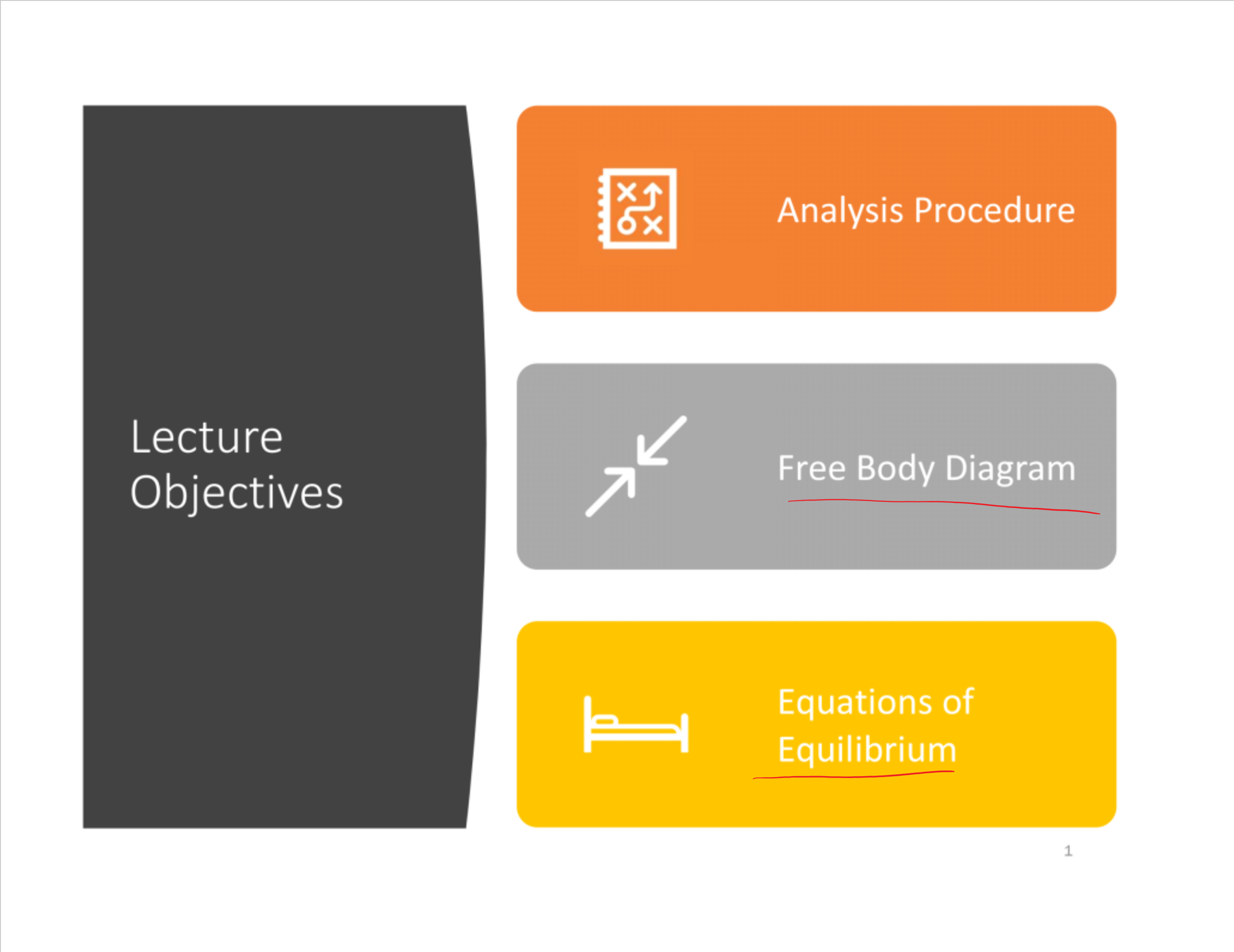
Lec05

Wednesday, September 23, 2020 7:51 AM



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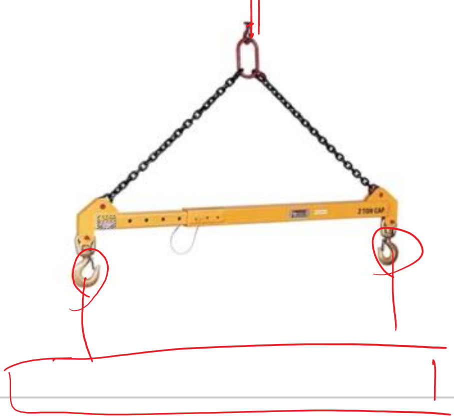
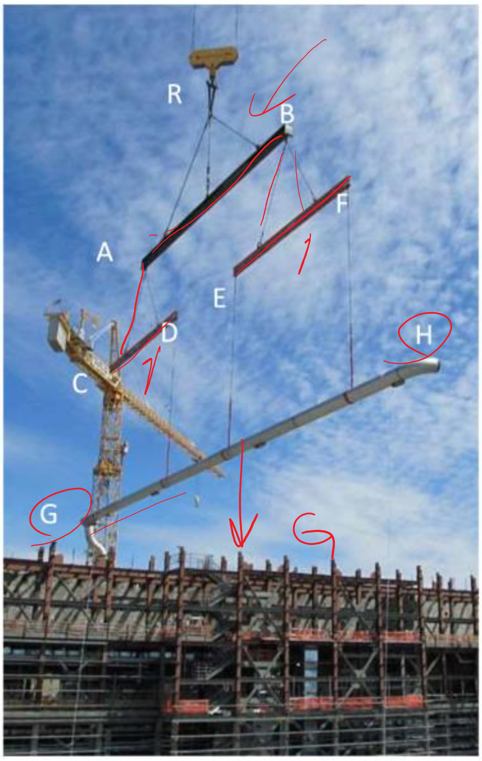
Applications

For the pipe (GH) of a given weight, how would you find the forces in each of the cables (e.g. cable AC)?

If designing spreader bars (AB, CD, EF) like the ones shown in the picture, you need to know the forces to make sure the rigging (R) doesn't fail.





General procedure for analysis

1. Read the problem carefully; write it down carefully.

2. MODEL THE PROBLEM: Draw given diagrams neatly and construct additional figures as necessary.

3. Apply principles needed.

4. Solve problem symbolically. 1 Make sure equations are dimensionally homogeneous 2

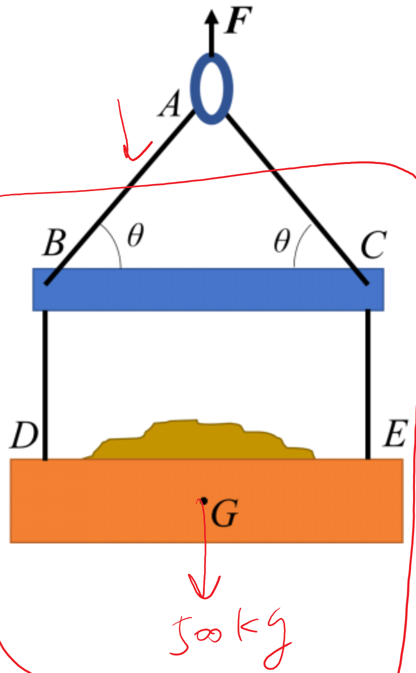
$F + V$

5. Substitute numbers. Provide proper units *throughout*. Check significant figures. Box the final answer(s).

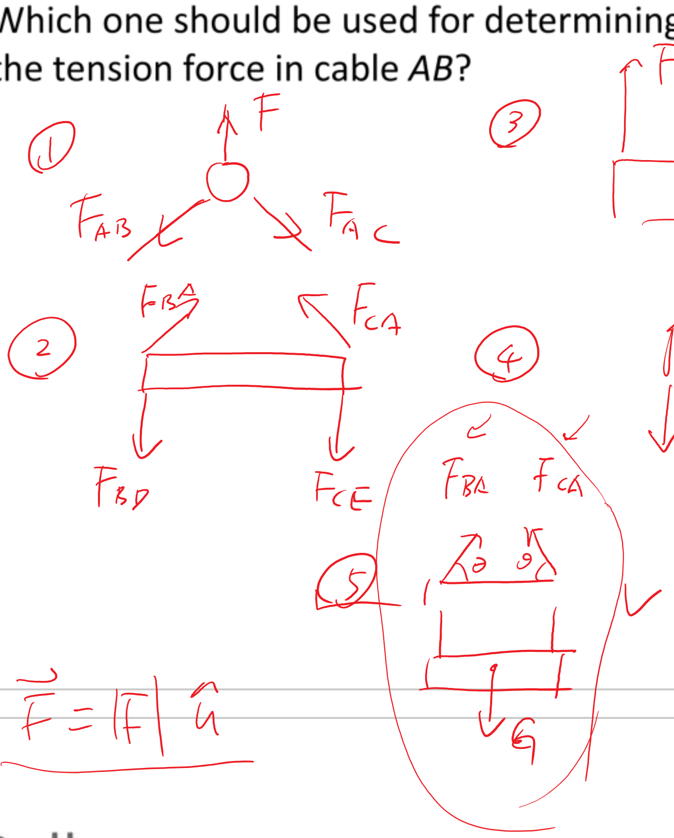
$\boxed{a = 1}$

6. See if answer is reasonable.

Free body diagram



The lift sling is used to hoist a container having a mass of 500 kg. What are the possible FBD you can draw for the system? Which one should be used for determining the tension force in cable *AB*?



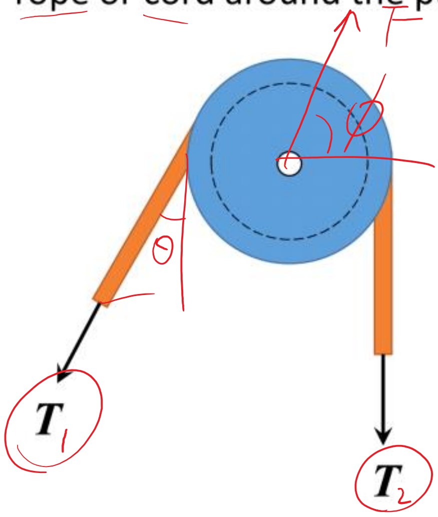
$$\sum F_x = 0$$
$$\sum F_y = 0$$

$$F_x \hat{i} + F_y \hat{j} + F_z \hat{k}$$

$$\vec{F} = |F|\,\hat{u}$$

Idealizations – Pulleys

Pulleys are (usually) regarded as frictionless; then the tension in a rope or cord around the pulley is the same on either side.



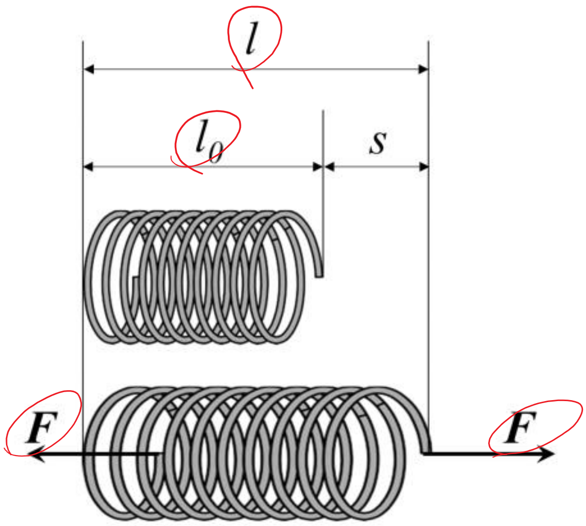
$$T_1 = T_2 = T$$

$$F \cdot \cos\phi = T \cdot \sin\theta$$

$$F \cdot \sin\phi = T + T \cdot \cos\theta$$

Idealizations – Springs

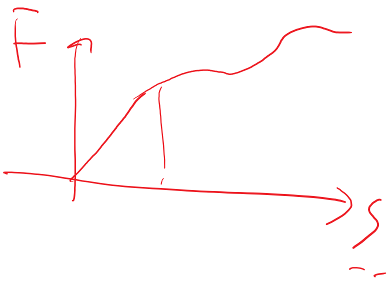
Springs are (usually) regarded as linearly elastic; then the tension is proportional to the *change* in length *s*.



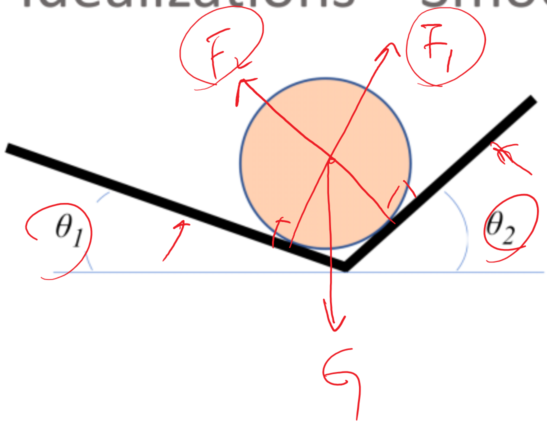
$F = k s$

k: spring stiffness

$s \rightarrow (l - l_0)$



Idealizations – Smooth Surface

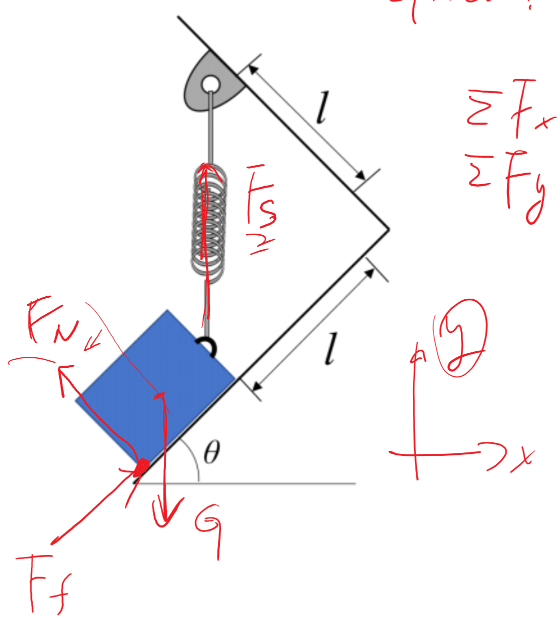


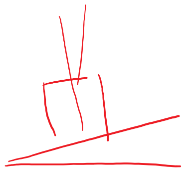
Contact force on smooth surface:

$\Sigma F_x = 0$
$\Sigma F_y = 0$

Free Body Diagram Example

Given: G.



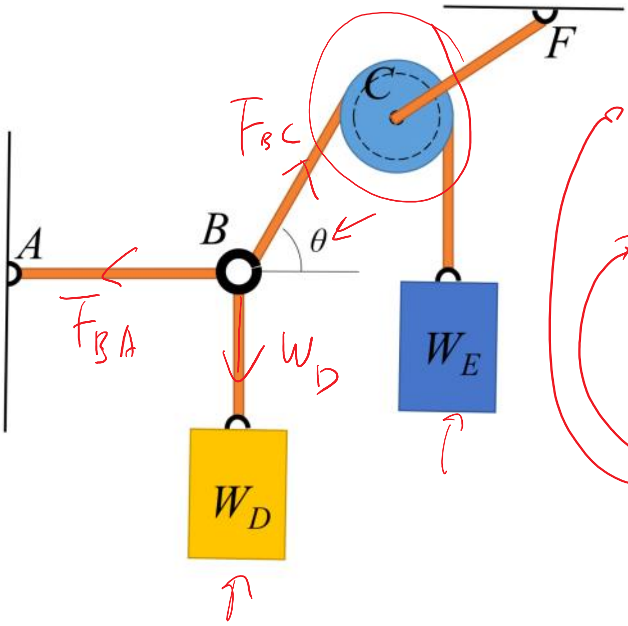


$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$

$$F \sin\theta = 0 \Rightarrow F = 0$$
$$F_s + F \cdot \cos\theta = G$$

$$F_s = G$$

Free Body Diagram Example



W_D , W_E ?

$F_{BC} \cdot \sin\theta = W_D$

$F_{BC} \cos\theta = F_{BA}$?

$F_{BC} = W_E$

Equilibrium of a particle

According to Newton's first law of motion, a particle will be in **equilibrium** (that is, it will remain at rest or continue to move with constant velocity) if and only if

$$\vec{F} = m\vec{a} = 0 \qquad \vec{F} = 0$$

In three dimensions, equilibrium requires:

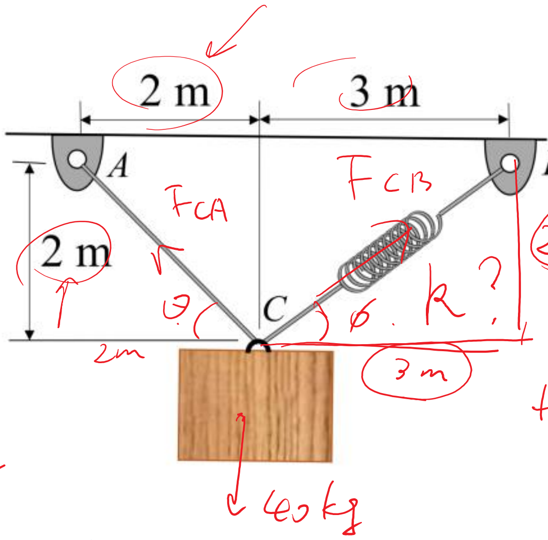
$$\begin{cases} \Sigma F_x = 0 \\ \Sigma F_y = 0 \\ \Sigma F_z = 0 \end{cases}$$

Coplanar forces: if all forces are acting in a single plane, such as the "xy-plane", then the equilibrium condition becomes

$$\begin{cases} \Sigma F_x = 0 \\ \Sigma F_y = 0 \end{cases}$$

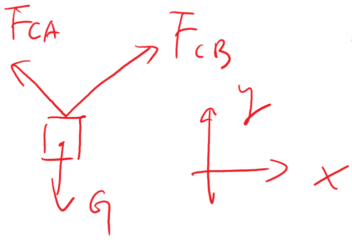
Example

If the spring BC has an unstretched length of 2 m, determine the stiffness of the spring to hold the 40-kg crate in the position shown.



$\tan\phi = \frac{2}{3}$

① FBD



② EoEs :

$$\begin{cases} \Sigma F_x = 0 \\ \Sigma F_y = 0 \end{cases} \Rightarrow \begin{cases} \boxed{F_{CA}} \cdot \cos\theta = \boxed{F_{CB}} \cos\phi \\ \boxed{F_{CA}} \cdot \sin\theta + \boxed{F_{CB}} \cdot \sin\phi = G \end{cases}$$

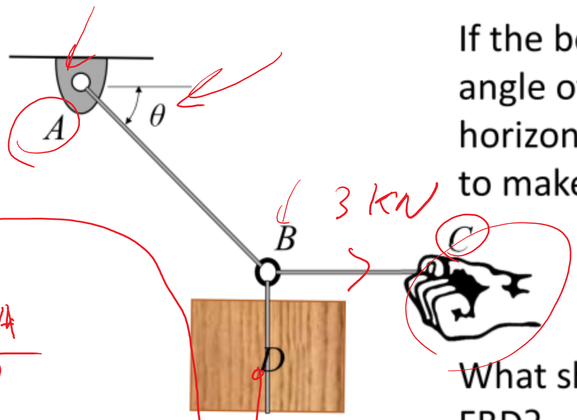
$F_{CB} = k\, s$

$s = (l - l_0)$

$l = \sqrt{4+9} = \sqrt{13}$ m

$l_0 = 2$ m

i-Clicker Time



If the box weighs 2 kN, determine the angle of the cable at A when a horizontal force of 3 kN is applied at C to make the system in equilibrium.

What should be the "body" in the FBD?

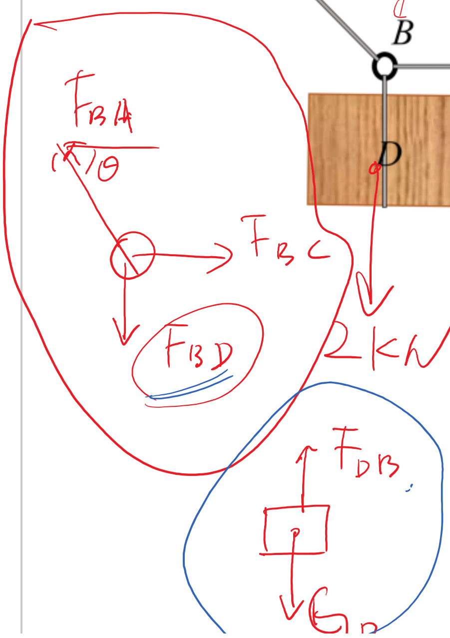
(A) Anchor A

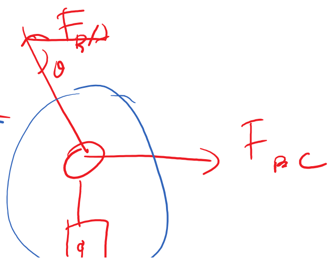
(B) Ring B

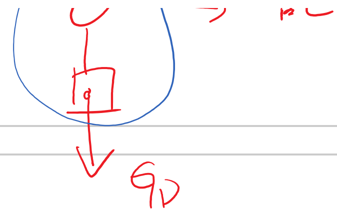
(C) Hand C

(D) Box D

(E) Ring B + Box D

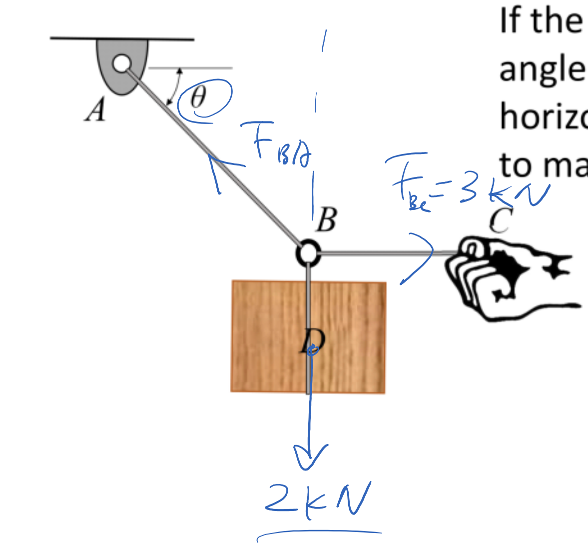






~~i-Clicker Time~~

If the box weighs 2 kN, determine the angle of the cable at *A* when a horizontal force of 3 kN is applied at *C* to make the system in equilibrium.



$$F_{BA} \cdot \sin\theta = W$$

$$F_{BA} \cdot \cos\theta = F_{BC}$$

$$\tan\theta = \frac{W}{F_{BC}}$$