SEEM1113 ENGINEERING MECHANICS

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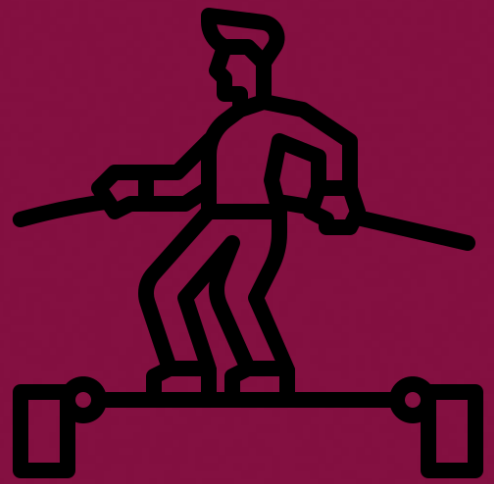
CH3
Equilibrium of Particle



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OBJECTIVES

At the end of this lesson, you should be able to:

1. Describe the concept of **free body diagram** for **particle**.
2. Identify **two types of connections** often encountered in particle equilibrium problems.
3. Solve **particle equilibrium** problems using the **equation of equilibrium**.

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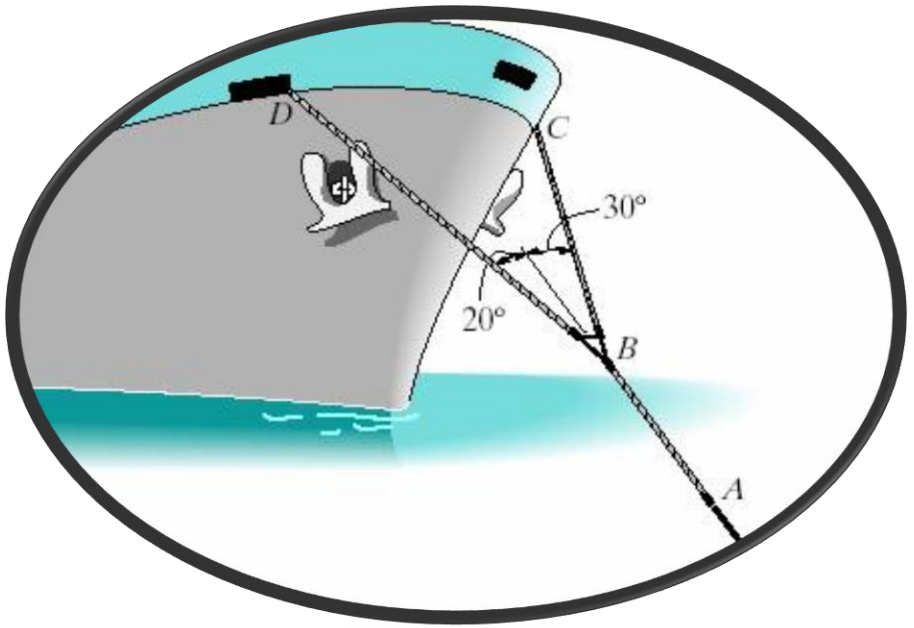
Equilibrium in Coplanar Vector

EQUILIBRIUM

APPLICATION



For a given force exerted on the boat's towing pendant, what are the forces in the bridle cables? What size of cable must you use?

EQUILIBRIUM IN COPLANAR VECTOR

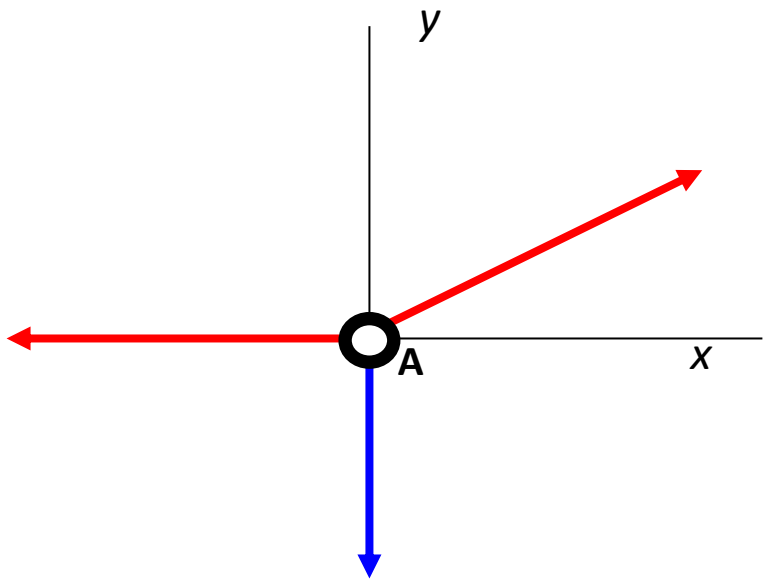
GENERAL PRINCIPLE : CONDITION FOR PARTICLE EQUILIBRIUM

A particle is at equilibrium if at rest or moving at a constant speed.

To maintain equilibrium, Newton's first law of motion must be satisfied

EQUILIBRIUM IN COPLANAR VECTOR

FREE BODY DIAGRAM (FBD)



FBD

It is a drawing that **shows all external forces** acting on the particle.

What?

are one of the **most important things** for you to know how to draw and use

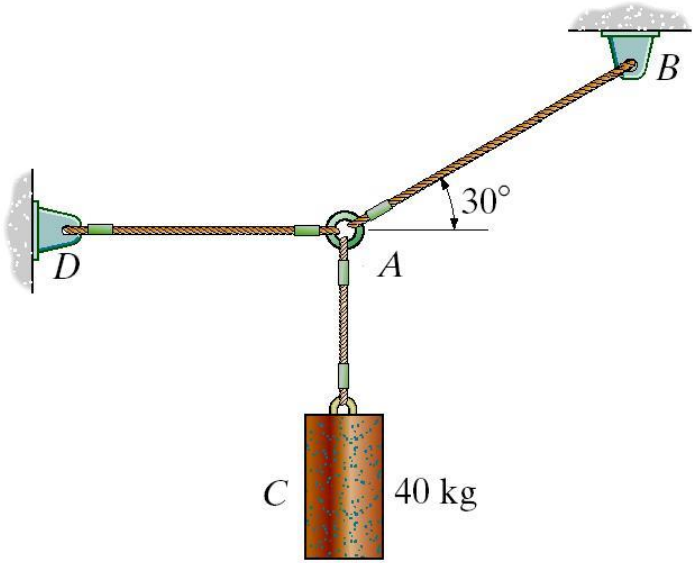
It is **key** to being able to write the equations of equilibrium—which are used to **solve** for the **unknowns** (usually forces or angles).

Why?

EQUILIBRIUM IN COPLANAR VECTOR

FREE BODY DIAGRAM (FBD) : HOW?

1. Imagine the particle to be **isolated** or cut free from its surroundings.



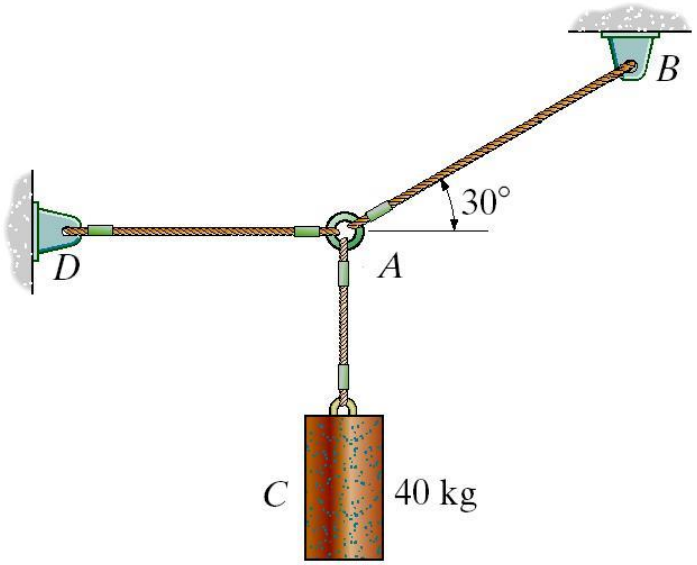
Note : Cylinder mass = 40 Kg

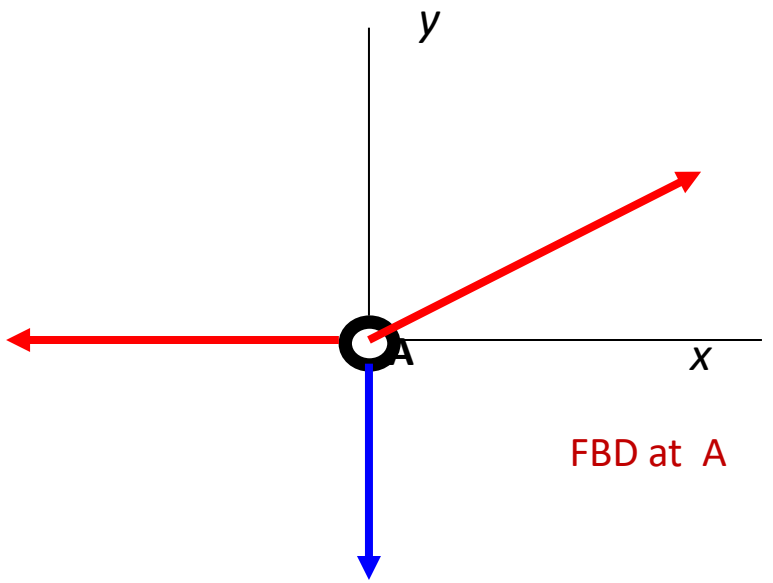
EQUILIBRIUM IN COPLANAR VECTOR

FREE BODY DIAGRAM (FBD) : HOW?

2. Show all the **forces** that act on the particle.

Active forces: They want to move the particle.
Reactive forces: They tend to resist the motion.





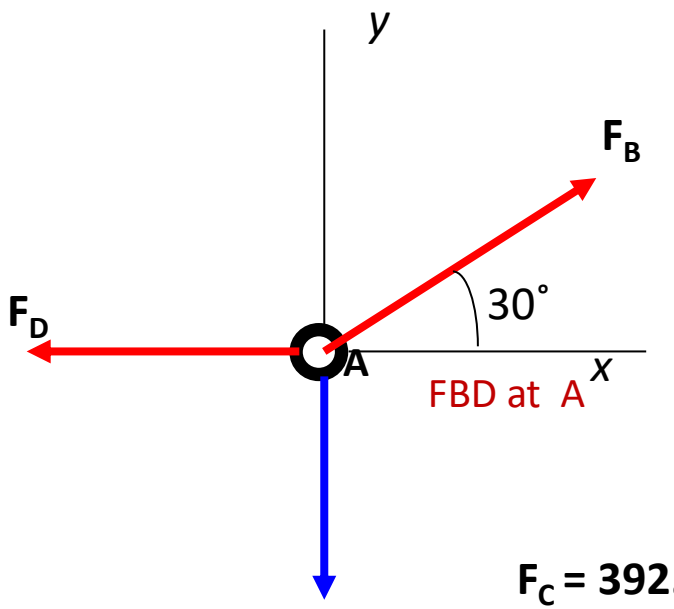
FBD at A

Note : Cylinder mass = 40 Kg

EQUILIBRIUM IN COPLANAR VECTOR

FREE BODY DIAGRAM (FBD) : HOW?

3. Identify each force and show all known magnitudes and directions. Show all unknown magnitudes and / or directions as variables .

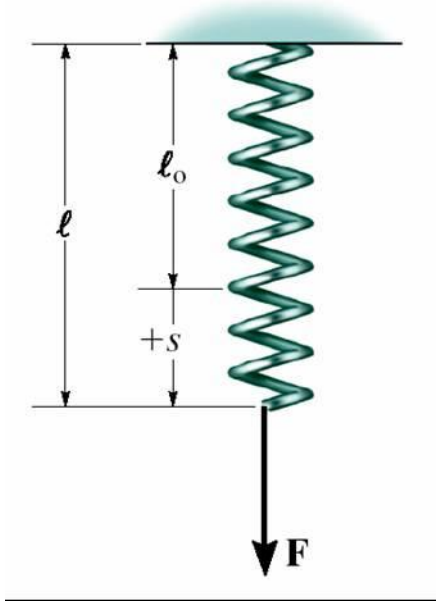


F_C = 392.4 N (What is this?)

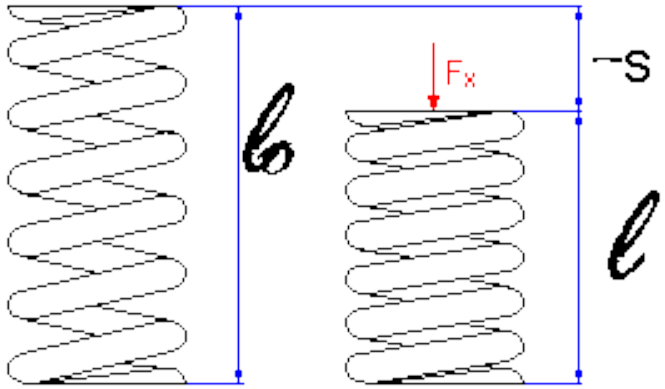
Note : Cylinder mass = 40 Kg

EQUILIBRIUM IN COPLANAR VECTOR

TYPE OF CONNECTIONS : SPRINGS, PULLEY & CABLES



Elongation



Shortening

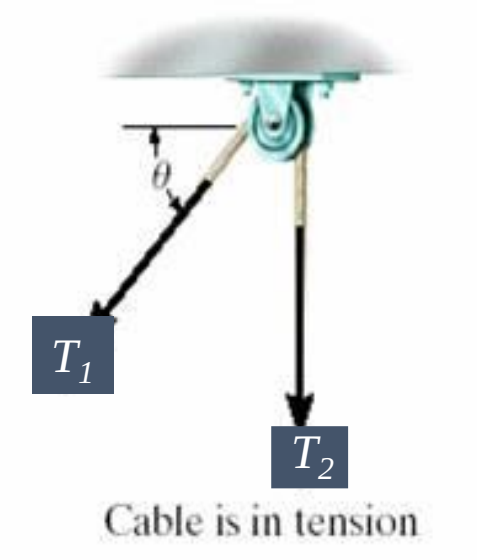
$$F = ks$$

$k = stiffness\ or\ spring\ constant$

where s = $l - l_o$

EQUILIBRIUM IN COPLANAR VECTOR

TYPE OF CONNECTIONS : SPRINGS, PULLEY & CABLES

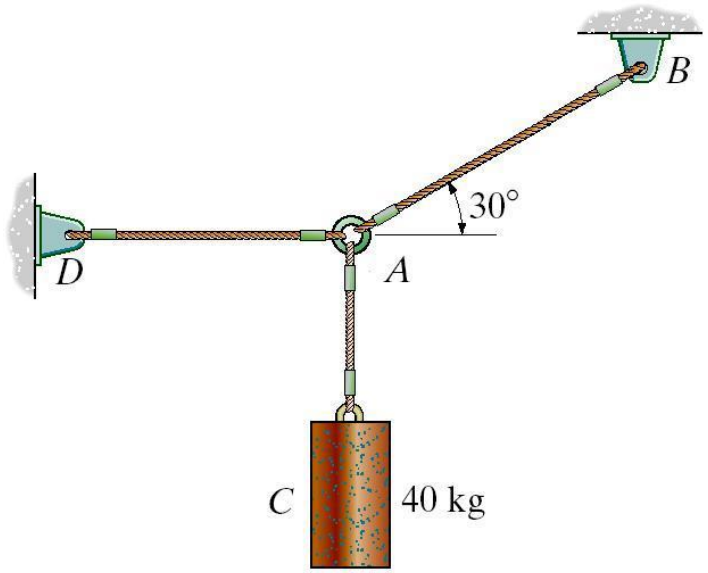


With a frictionless pulley,

$$T_1 = T_2$$

EQUILIBRIUM IN COPLANAR VECTOR

COPLANAR FORCE SYSTEM



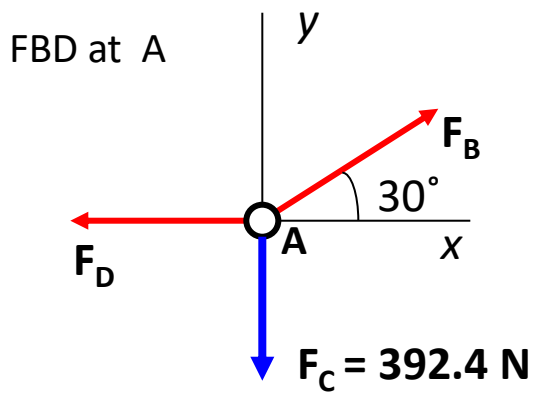
This is an example of a 2-D or coplanar force system.

If the whole assembly is in equilibrium, then particle A is also in equilibrium.

To determine the tensions in the cables for a given weight of the cylinder, we need to learn how to draw a free body diagram and apply equations of equilibrium.

EQUILIBRIUM IN COPLANAR VECTOR

COPLANAR FORCE SYSTEM : EQUATION OF 2-D EQUILIBRIUM



Since particle A is in equilibrium, the net force at A is zero.

$$\sum \boldsymbol{F} = 0$$

So

$$\sum F_x \boldsymbol{i} + \sum F_y \boldsymbol{j} = 0$$

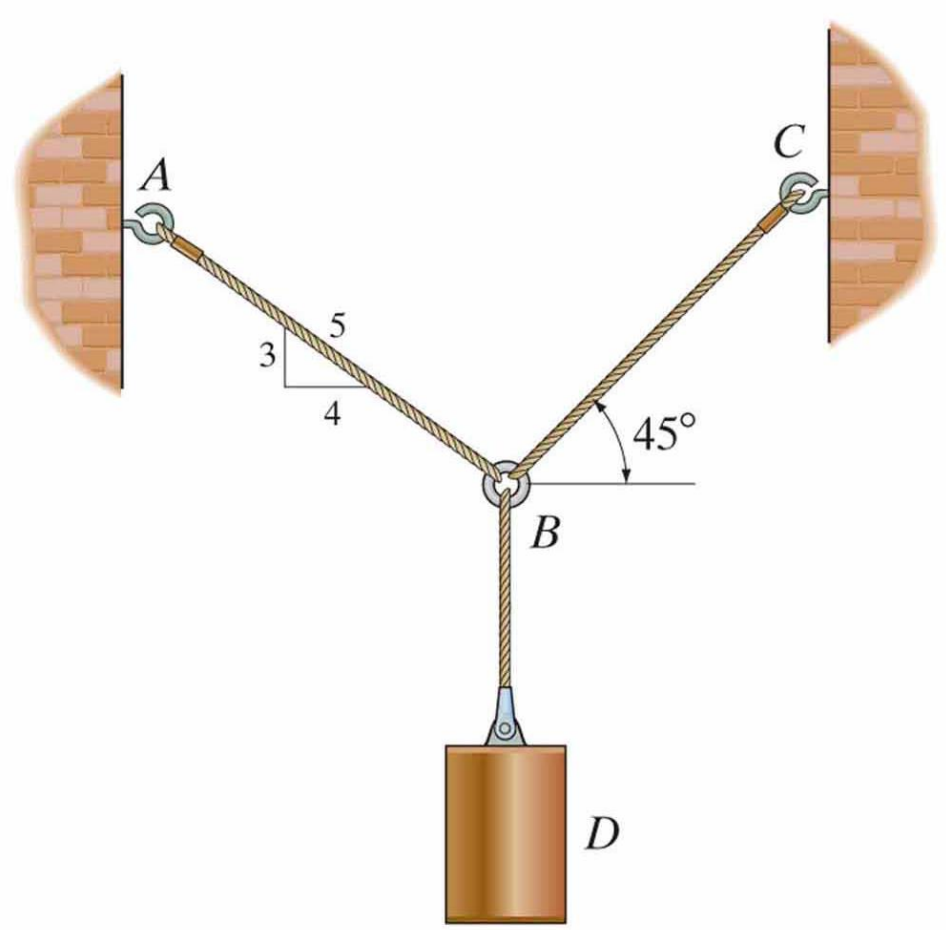
Or

$$\sum F_x = 0 \; and \; \sum F_y = 0$$

EQUILIBRIUM IN COPLANAR VECTOR

Example 1

Determine the tensions in cables BA and BC necessary to support the 60 kg cylinder.



Equilibrium in 3-D Vector

EQUILIBRIUM IN 3-D VECTOR

THE EQUATION OF 3D EQUILIBRIUM

For particle equilibrium

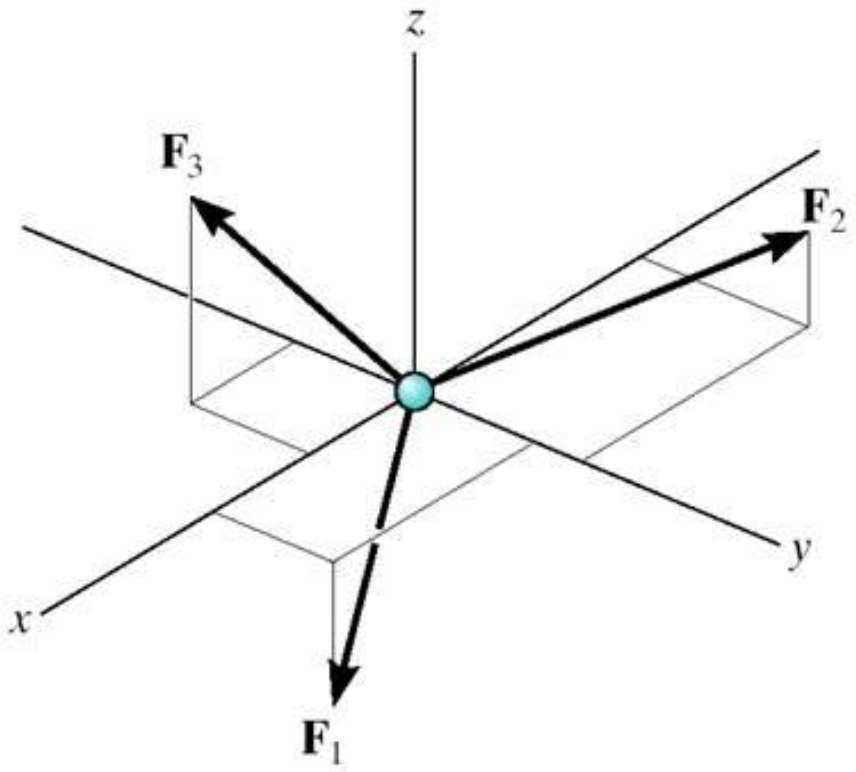
$$\sum \boldsymbol{F} = 0$$

Resolving in ***i, j, k*** components:

$$\sum F_x \boldsymbol{i} + \sum F_y \boldsymbol{j} + \sum F_z \boldsymbol{k} = 0$$

Therefore

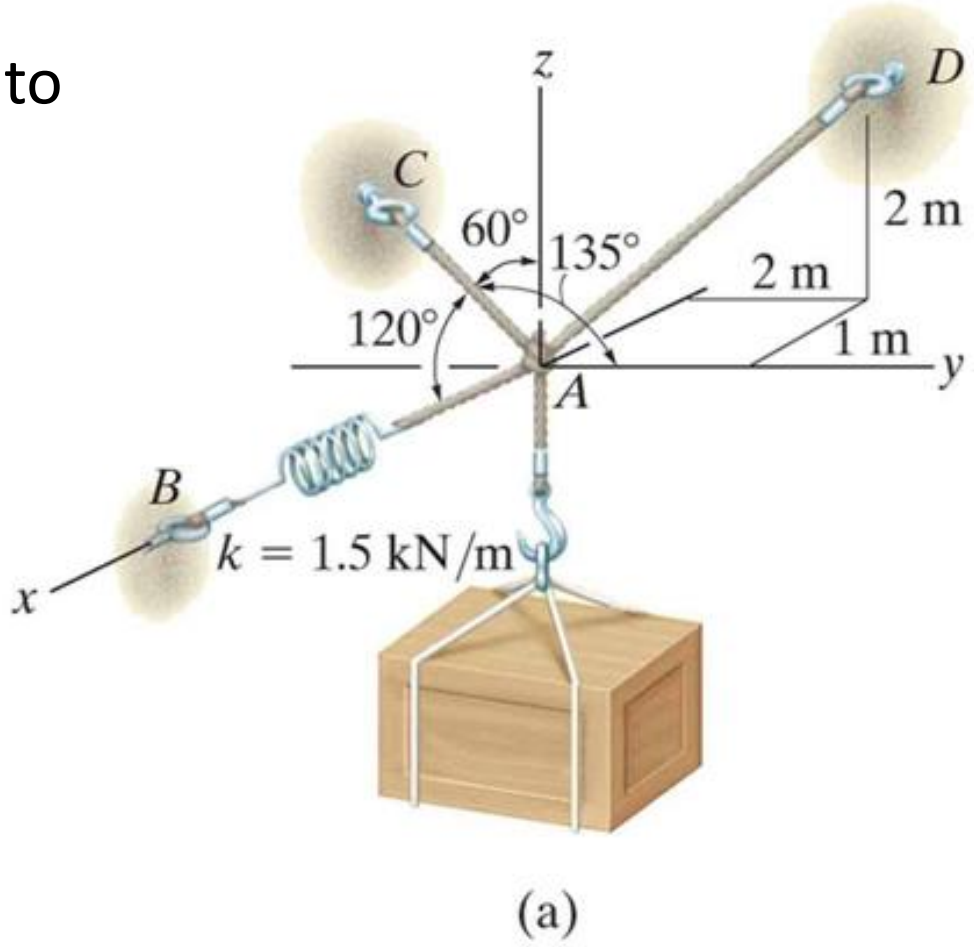
$$\sum F_x = 0 \, , \sum F_y = 0 \; and \sum F_z = 0$$



EQUILIBRIUM IN 3-D VECTOR

Example 2

Determine the tension in each cord used to support the 100 kg crate shown in the Figure



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