SKAA 1213 - Engineering Mechanics

TOPIC 4

Equilibrium of a Particle

Lecturers:
Rosli Anang
Dr. Mohd Yunus Ishak
Dr. Tan Cher Siang

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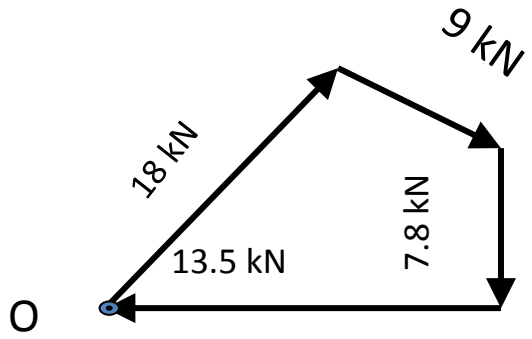
Introduction

Definition : When the resultant of all forces acting on a particle is zero, the particle is in equilibrium.

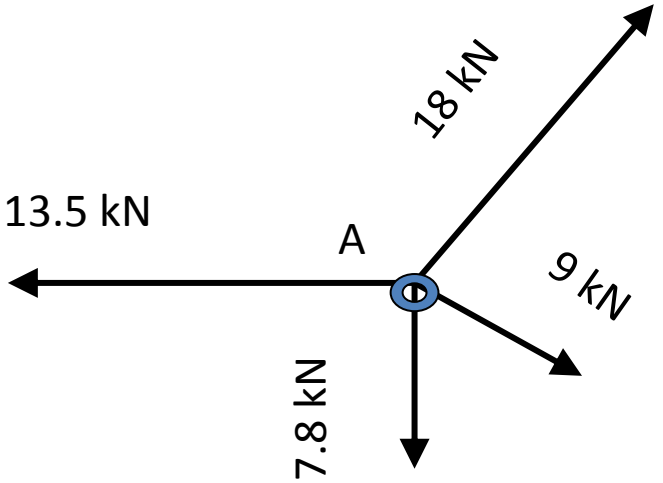
Condition : satisfied Newton's first law which states that a particle is in equilibrium if it is at rest or move in a straight line with a constant speed provided that no external forces exerts on it.

$$F_R = \sum F = 0$$

Example



Polygon of forces

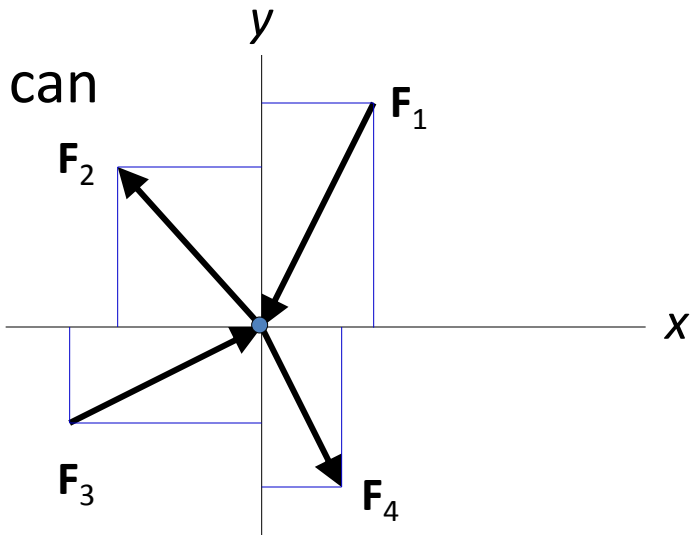


Polygon of forces ends at the same point as the start point. Which means the resultant force of forces in the system is zero. i.e., the particle is in equilibrium

Four forces acting on a particle

Coplanar Forces

When a subject lies in the x-y axis, forces can be describe in *i* and *j* forms.



For Equilibrium : $\Sigma F = 0$

$$\Sigma(F_x\mathbf{i} + F_y\mathbf{j}) = 0$$

For this vector equation to be satisfied:

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

The sense of direction of each components is accounted by an algebraic sign which correspond to the arrow head direction of the component along axis.

The arrowhead sense of a force of an unknown magnitude can be assumed. If the solution produce a negative scalar, it indicates that the sense of the force acts in the opposite direction of the assumed direction at the beginning.

Free Body Diagram(FBD)

- FBD of a particle is a sketch of the particle which represent it as being isolated, free from its surroundings.
- On the sketch it is necessary to show all the forces that act on the particle.

Method :

1. Choose a significant particle
2. Draw a separate diagram showing the particle(s) and all the forces acting on it

FBD is of primary importance for solving problems in mechanics.

Weight & Centre of Gravity

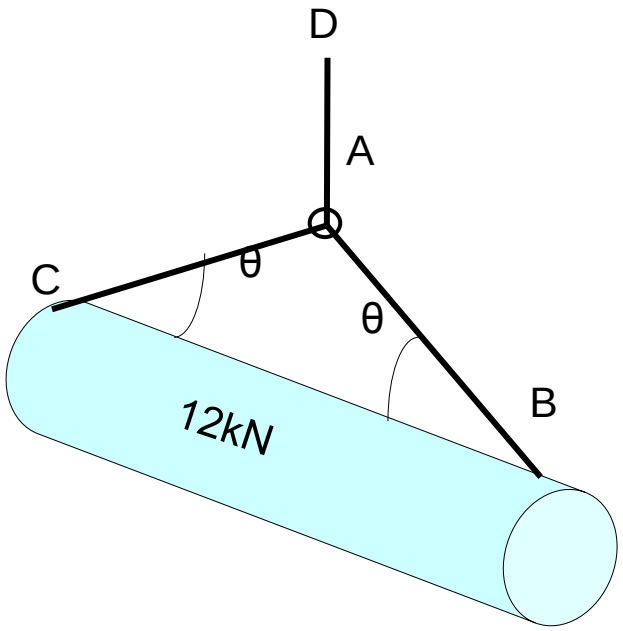
- The resultant force due to gravity for the an entire body is known as the weight.
- The location of the point of weight is at the centre of gravity.
- If the body is uniform the centre of gravity is located at the centroid.

Example

A sling is used to support a pipe of 12 kN.

Determine the force in the cables if θ = 25°.

*[Answer :F_{AC} = **14.2** kN, F_{AB} = **14.2** kN]*



Frictionless Pulley

- The force in the cable that runs through a frictionless pulley is constant.

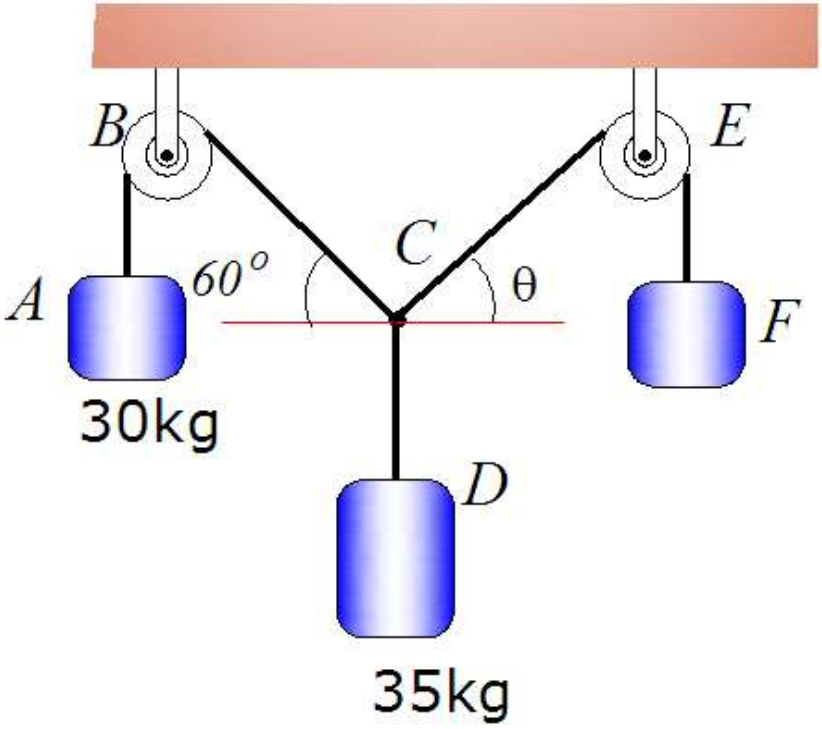
Example

The system is held in equilibrium by the mass supported at F and the angle θ of the connecting chord.

(a) Draw the FBD for the connecting knot C,

(b) Determine the force in the chord CE and angle θ.

[Answer: T_{CB} *= 294.3 N,* T_{CE} = 171.7 N, Θ = 31°]



Springs

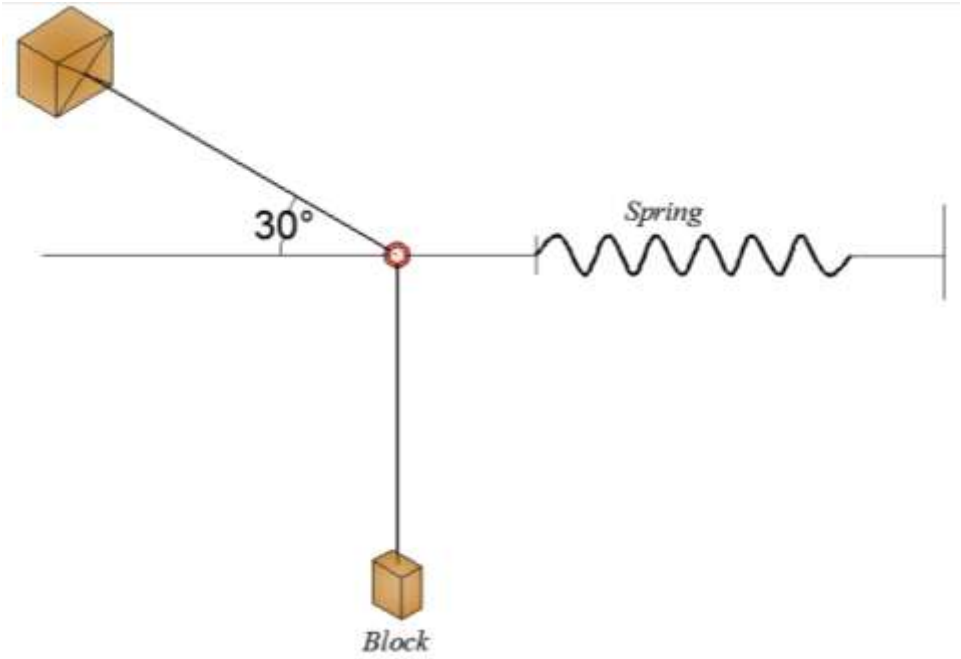
When linear elastic spring is used as support, the magnitude of the force exerted, $F = ks$

Where k = stiffness/spring constant

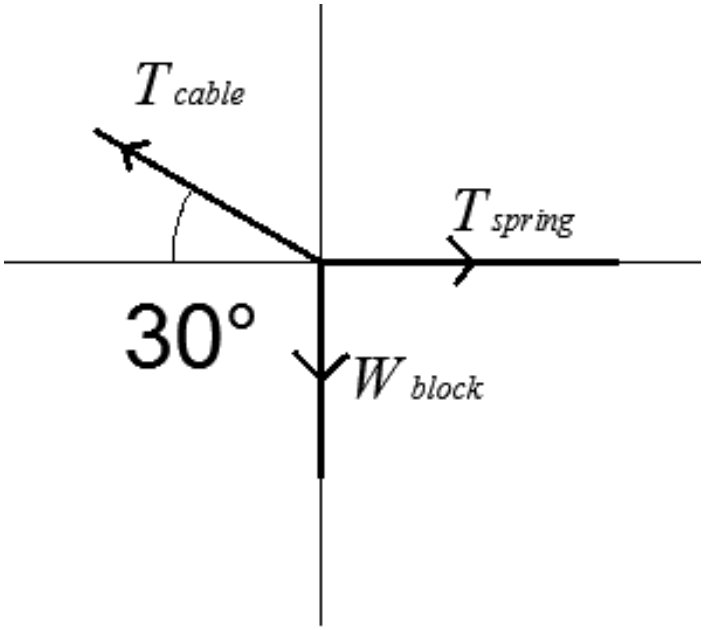
s = deformation of spring

Example

Situation



FBD

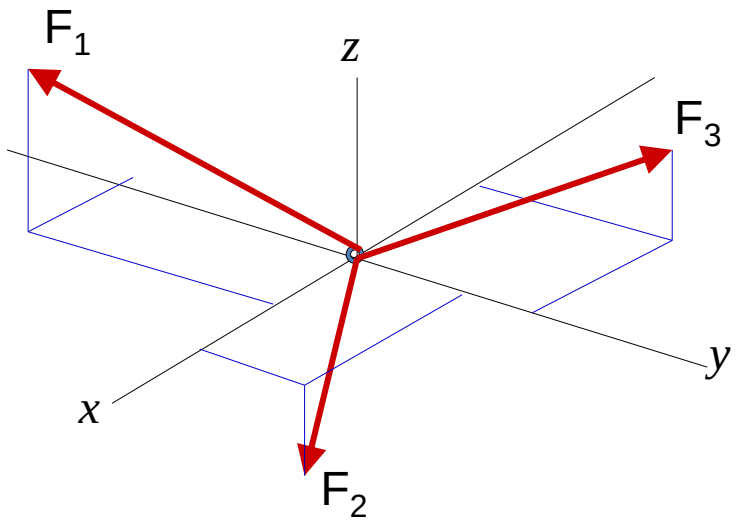


Three-Dimensional (3D)Force System

- For equilibrium; $\Sigma F = 0$
- Resolving the forces into

  i, j, k components:

  $\Sigma F_x \mathbf{i} + \Sigma F_y \mathbf{j} + \Sigma F_z \mathbf{k} = 0$
- Therefore to satisfy the equation;



$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma F_z = 0$$

Example

Determine the force developed in each cable used to support the 20kN steel ball. *[Answer :* $F_C = F_D = 13$ kN , $F_B = 13.3$ kN]