ME 245

Engineering Mechanics and Theory of Machines

Portion 8

Introduction to Dynamics: Kinematics

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Dynamics

Kinematics:

Deals with the motion (position, velocity, acceleration, time) of a body without considering the cause of motion (Force)

- **Kinematics of a point** (The body is treated as a point whose rotation about its own center can be neglected)
- **Kinematics of a rigid body** (The body is treated as a point whose rotation about its own center can not be neglected)

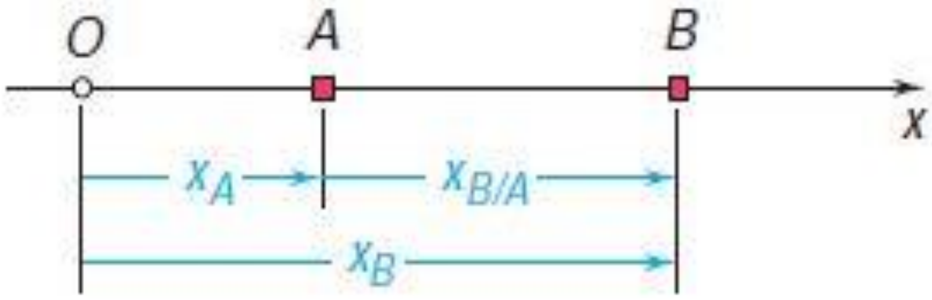
Kinetics:

Deals with the motion (position, velocity, acceleration, time) of a body without considering the cause of motion (Force)

- **Kinetics of a point** (The body is treated as a point whose rotation about its own center can be neglected)
- **Kinetics of a rigid body** (The body is treated as a point whose rotation about its own center can not be neglected)

Kinematics of a Point:
Relative Motion

Suppose, **O** is any reference point.
The relative position of **B** with respect to **A** is given by,



$$\boldsymbol{x}_{B/A} = \boldsymbol{x}_B - \boldsymbol{x}_A$$

If it is divided by *t*, then similar formula can found for velocity.

$$\boldsymbol{v}_{B/A} = \boldsymbol{v}_B - \boldsymbol{v}_A$$

Similarly, for acceleration,

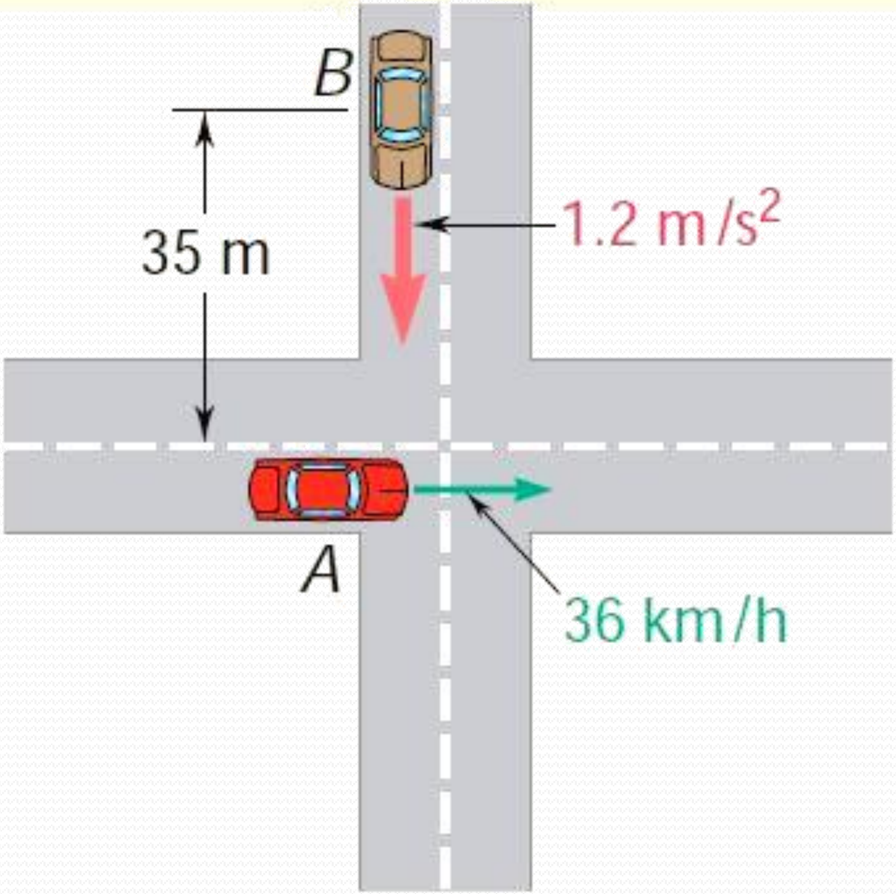
$$\boldsymbol{a}_{B/A} = \boldsymbol{a}_B - \boldsymbol{a}_A$$

In vector form,

$$\mathbf{X}_{B/A} = \mathbf{X}_B - \mathbf{X}_A$$
$$\mathbf{V}_{B/A} = \mathbf{V}_B - \mathbf{V}_A$$
$$\mathbf{a}_{B/A} = \mathbf{a}_B - \mathbf{a}_A$$

Problem 8.1 (Beer Johnston_10th edition_Ex11.9)

Automobile A is traveling east at the constant speed of 36 km/h. As automobile A crosses the intersection shown, automobile B starts from rest 35 m north of the intersection and moves south with a constant acceleration of 1.2 m/s². Determine the position, velocity, and acceleration of B relative to A, 5 s after A crosses the intersection.



Kinematics of a Point:
Dependent Motion

<u>Total Length</u> of the Rope is constant during the motion of any loads or pulleys.

Neglecting the distance from the support and load to the pulleys center, we can write,

$$x_A + 2x_B = \text{constant} \text{ ----(1)}$$

So, any small disturbance Δx_A will cause the disturbance Δx_B according to the formula.

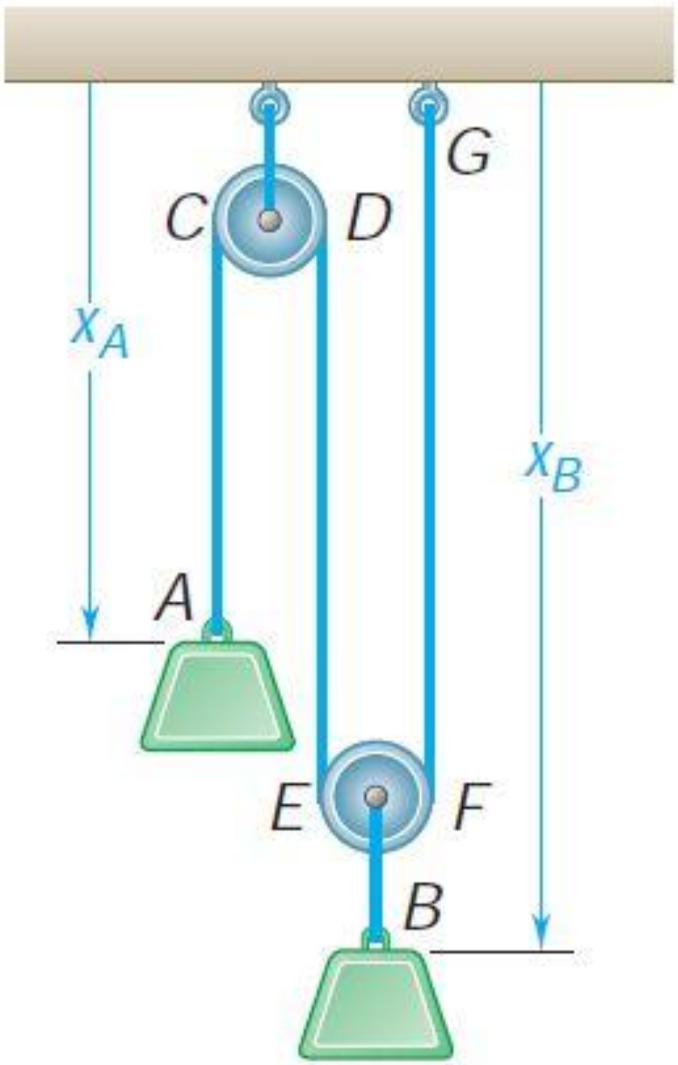
So, $\Delta x_B = -0.5\ \Delta x_A$

Differentiating equation (1) wrt t,

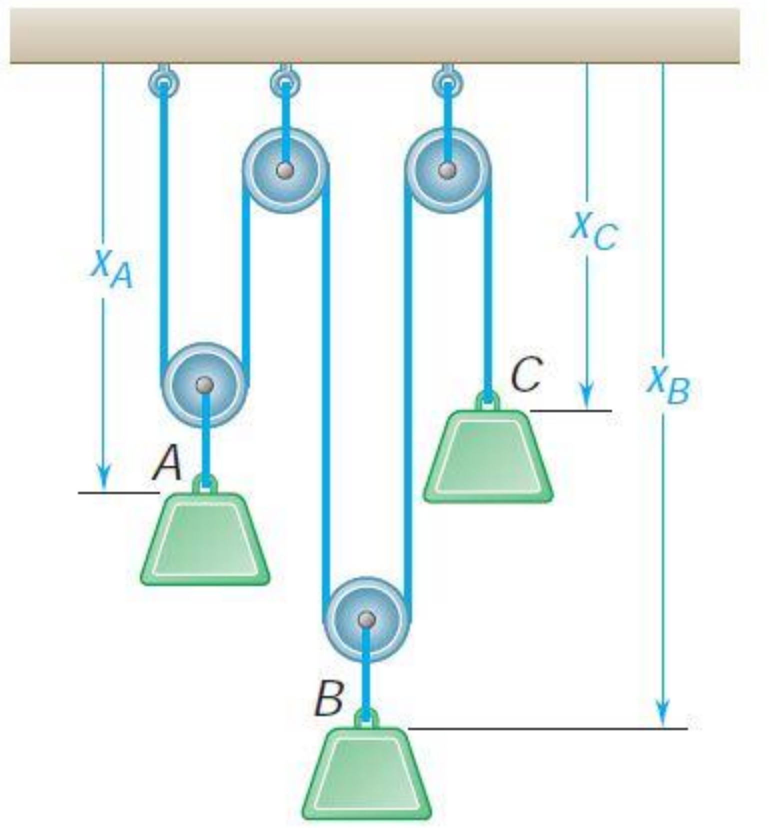
$$v_A + 2v_B = 0 \text{ -----(2)}$$

Similarly,

$$a_A + 2a_B = 0 \text{ -----(3)}$$



Class Performance



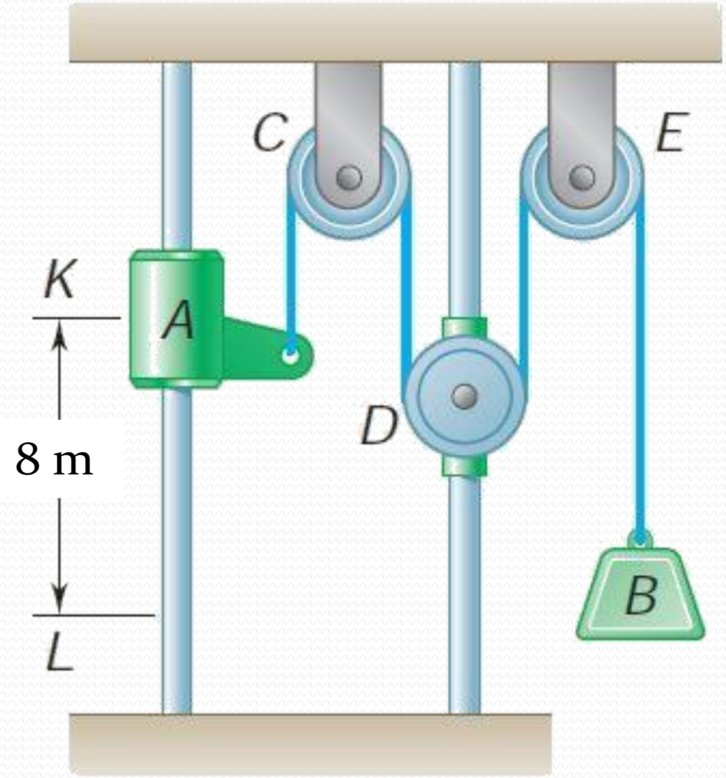
Position Equation: $2x_A + 2x_B + x_C = \text{constant}$

Velocity Equation: $2v_A + 2v_B + v_C = 0$

Acceleration Equation: $2a_A + 2a_B + a_C = 0$

Problem 8.2 (Beer Johnston_10th edition_Ex11.5)

Collar *A* and block *B* are connected by a cable passing over three pulleys *C*, *D*, and *E* as shown. Pulleys *C* and *E* are fixed, while *D* is attached to a collar which is pulled downward with a constant velocity of 3 m/s. At $t = 0$, collar *A* starts moving downward from position *K* with a constant acceleration and no initial velocity. Knowing that the velocity of collar *A* is 12 m/s as it passes through point *L*, determine the change in elevation, the velocity, and the acceleration of block *B* when collar *A* passes through *L*.



References

- **Vector Mechanics for Engineers: Statics and Dynamics**
Ferdinand Beer, Jr., E. Russell Johnston, David Mazurek, Phillip Cornwell.