

Course Code: ESC106A

**Course Title: Construction Materials and Engineering
Mechanics**

Lecture No. 57:

Curvilinear Translation

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Lecture Intended Learning Outcomes

At the end of this lecture, student will be able to:

- Define and describe projectile and related terms velocity of projection, angle of projection, trajectory, horizontal range, time of flight
- Derive equations of motion of trajectory
- Evaluate time required to reach maximum height, maximum height, horizontal range and time of flight from equation of motion of trajectory

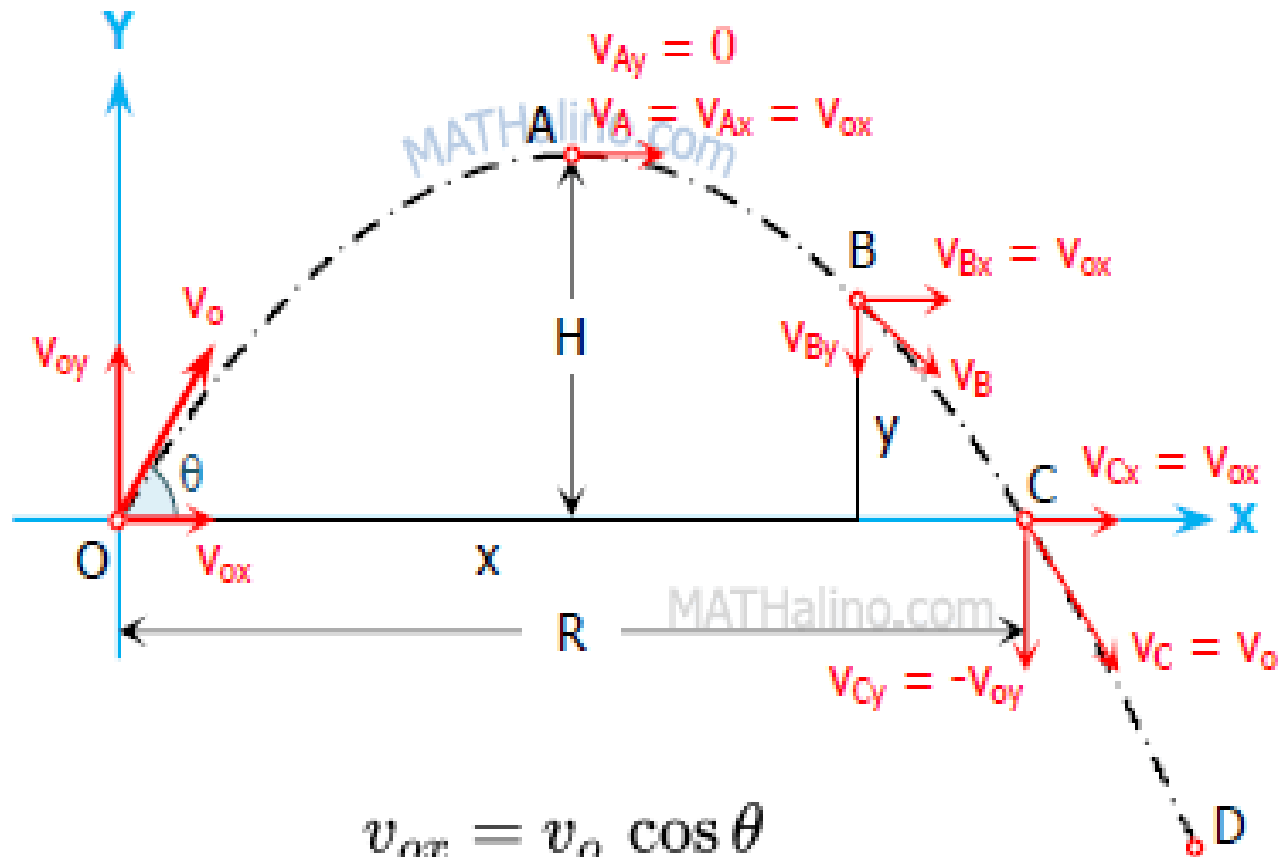


Contents

- Projectile Motions
- Motions of Trajectory
- Numerical problems



Curvilinear Translation (Projectile Motion)



$$v_{ox} = v_o \cos \theta$$

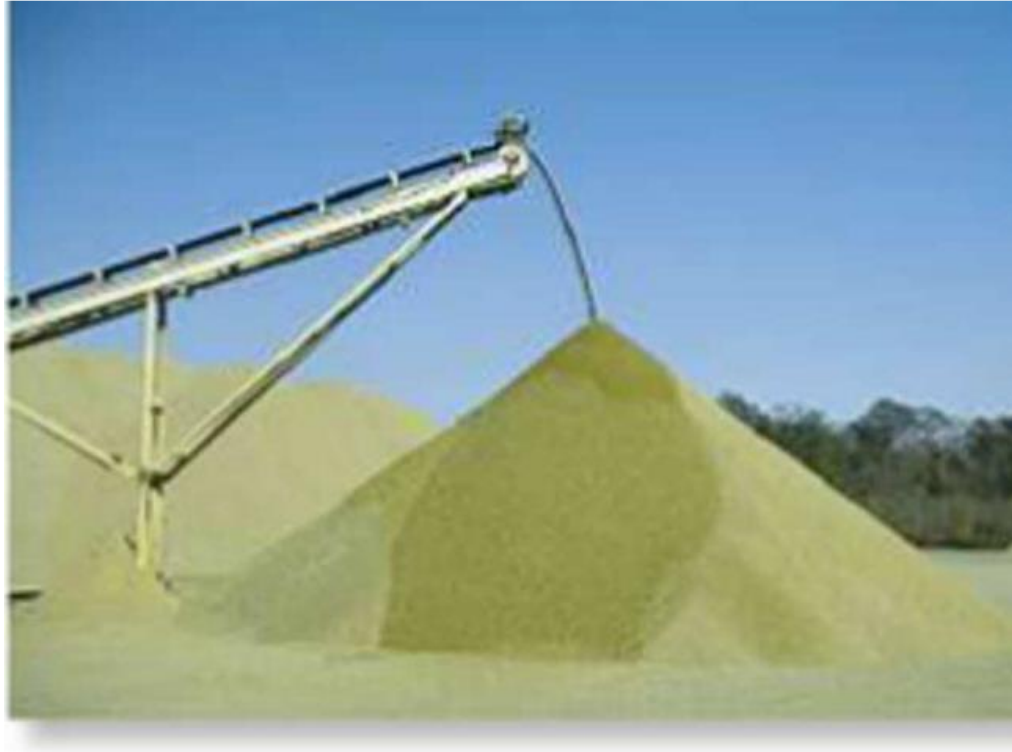
$$v_{oy} = v_o \sin \theta$$

Projectiles

- Particles move along a curved path if they are freely projected in the air in the direction other than vertical.
- These freely projected particles which are having the combined effect of a vertical and a horizontal motion are called projectiles.
- The motion of a projectile has a vertical component and a horizontal component.



Projectiles



Gravel falling off the end of this conveyor belt follows a path that can be predicted using the equations of constant acceleration. In this way the location of the accumulated pile can be determined. Rectangular coordinates are used for the analysis since the acceleration is only in the vertical direction.

Projectiles

- The vertical component of the motion is subjected to gravitational acceleration/retardation while horizontal component remains constant, if air resistance is neglected.
- The motion of a projectile can be analysed independently in vertical and horizontal directions and then combined suitably to get the total effect.



Projectiles

Velocity of projection : The velocity with which the particle is projected is called as velocity of projection (u m/sec).

Angle of projection : The angle between the direction of projection and horizontal direction is called as angle of projection (α).

Trajectory : The path traced by the projectile is called as its trajectory.

Horizontal range : The horizontal distance through which the projectile travels in its flight is called the horizontal range or simply range of the projectile.

Time of flight: The time interval during which the projectile is in motion is called the time of flight.



Projectiles

Vertical Motion

Initial velocity = $u \sin \alpha$ upward

Horizontal Motion

Horizontal component of velocity = $u \cos \alpha$.

Equation of the Trajectory

$$y = (u \sin \alpha) t - \frac{1}{2} g t^2$$

Time Required to Reach Maximum Height

$$t = \frac{u \sin \alpha}{g}$$

Maximum Height

$$h = \frac{u^2 \sin^2 \alpha}{2g}$$

Horizontal Range

$$R = \frac{u^2 \sin 2\alpha}{g}$$

Maximum Range

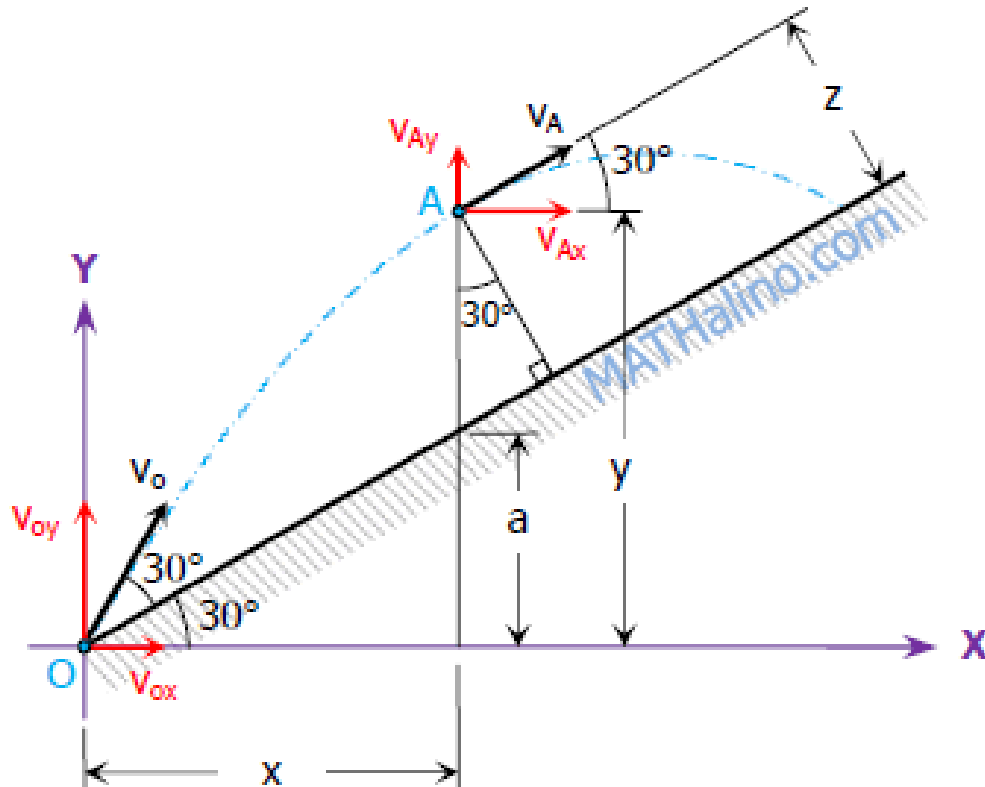
$$\text{Hence the maximum range} = \frac{u^2}{g}$$

Angle of Projection for the Required Range



Projectiles: Problem 1

A projectile is fired up the inclined plane at an initial velocity of 15 m/s. The plane is making an angle of 30° from the horizontal. If the projectile was fired at 30° from the incline, compute the maximum height z measured perpendicular to the incline that is reached by the projectile. Neglect air resistance.



Ans: $Z=3.31\text{m}$

Summary

- Particles move along a curved path if they are freely projected in the air in the direction other than vertical
- The velocity with which the particle is projected is called as velocity of projection
- The angle between the direction of projection and horizontal direction is called as angle of projection
- The path traced by the projectile is called as its trajectory



Summary

- The horizontal distance through which the projectile travels in its flight is called the horizontal range or simply range of the projectile
- The time interval during which the projectile is in motion is called the time of flight

