Chapter 11: The Description of Human Motion

KINESIOLOGY

Scientific Basis of Human Motion, 11th edition

Hamilton, Weimar & Luttgens

Presentation Created by

TK Koesterer, Ph.D., ATC

Humboldt State University

Revised by Hamilton & Weimar

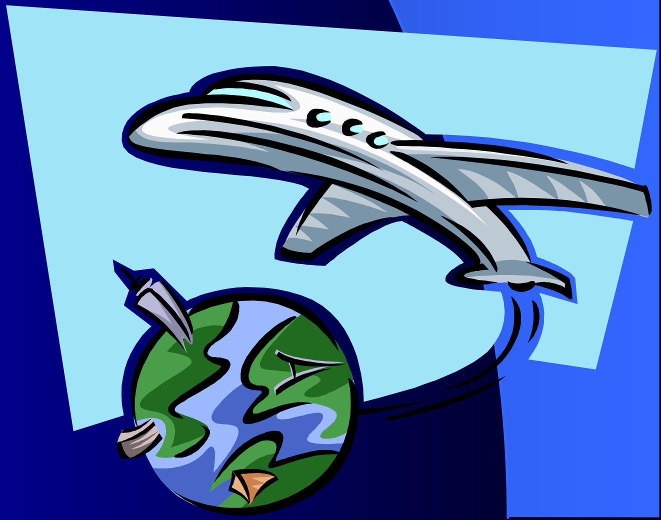
REVISED FOR FYS by J. Wunderlich, Ph.D.

Objectives

- Linear & rotary motion
- Displacement, velocity, acceleration
- Projectiles
- Kinematics to describe a motor task

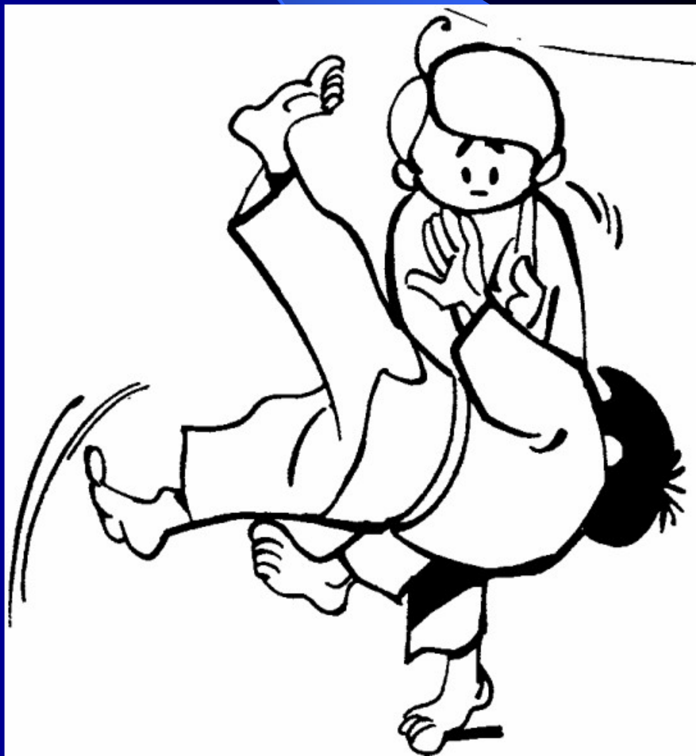
Relative Motion

- At rest or in motion depends on the reference
- Sleeping passenger in a flying plane:
  - At rest in reference to plane
  - In motion in reference to earth

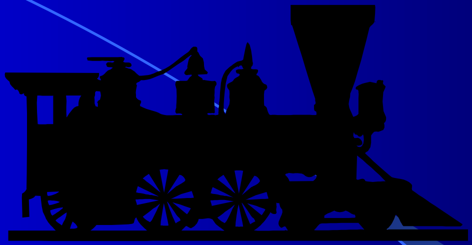


Cause of Motion

- Force is instigator of movement
- Force must be enough to overcome object's inertia, or resistance to motion
  - – But if judo done right, force should be minimal

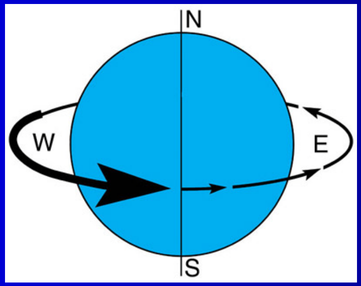


Kinds of Motion



- Translatory
  - Linear or Cuvilinear

- Rotary ("angular")



Translatory Movement

- Object translates from location to location
  - Rectilinear: straight-line
  - Curvilinear: curved translatory movement

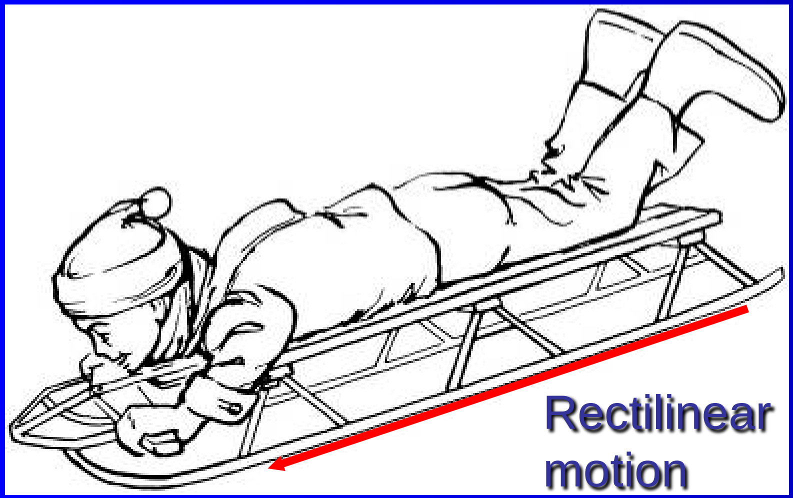


Fig 11.1

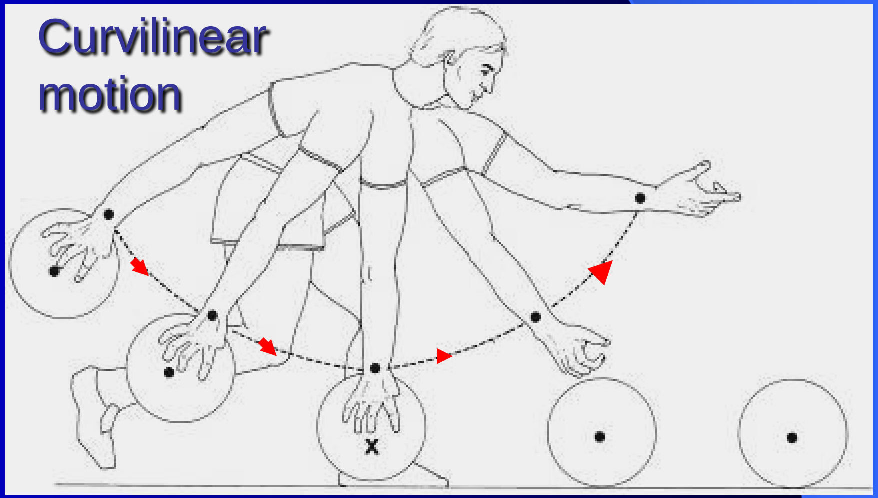


Fig 11.2

Translatory Circular Motion

- Curvilinear
- Object moves along circumference
  - constant radius
- Force on object keeps it in circle
  - if force stops, object moves in a linear path tangent to circle

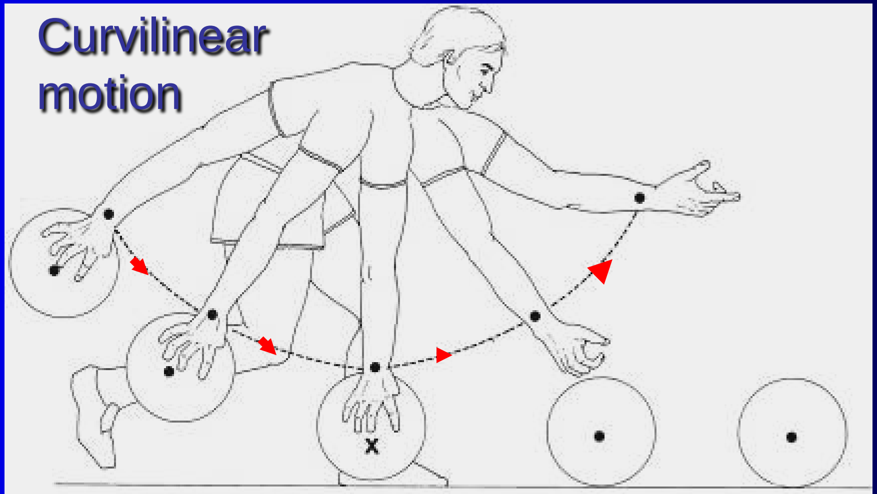
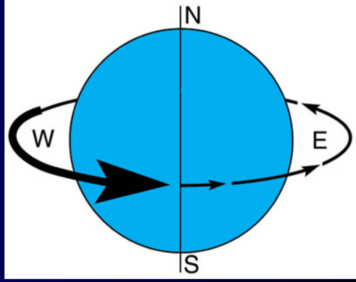


Fig 11.2

Rotary (“Angular”) Motion



- Levers, wheels, axles, globes, Judo players
- Measure angle of rotation
- Body parts move in an arc about a fixed point

Kinds of Motion

- BOWLERS ARM moving in Rotary ("Angular") Motion
- BALL moving in Translatory Circular Motion
  - then translatory linear motion when released

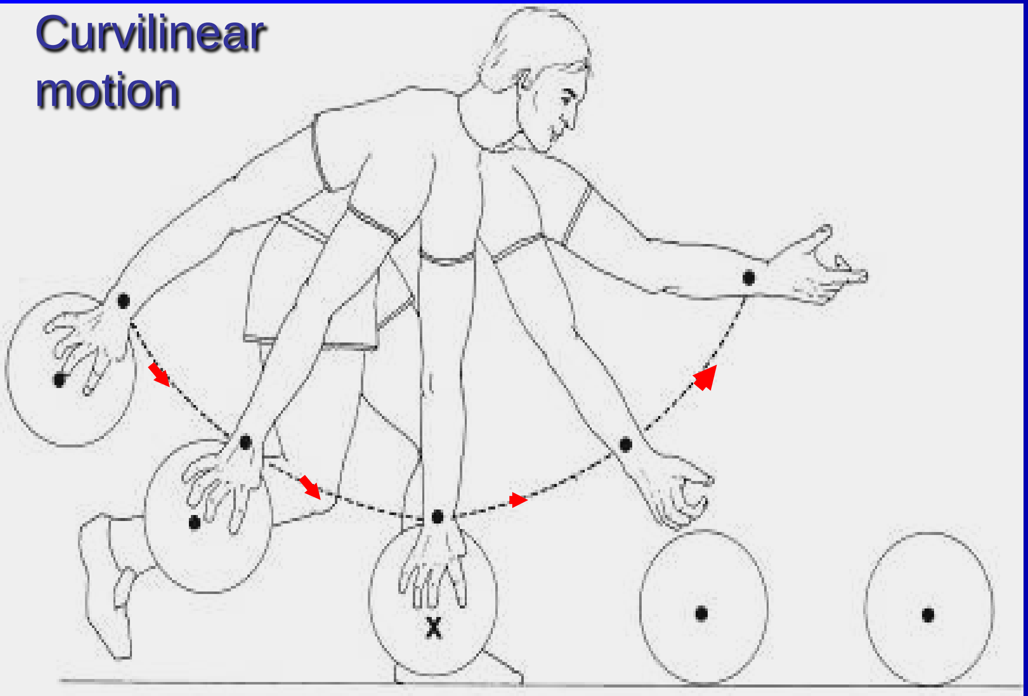


Fig 11.2

Combined Movement

- Combination of rotary & translatory called general motion
- Angular motions of forearm, upper arm & legs.
- Hand travels linearly and imparts linear force to the foil

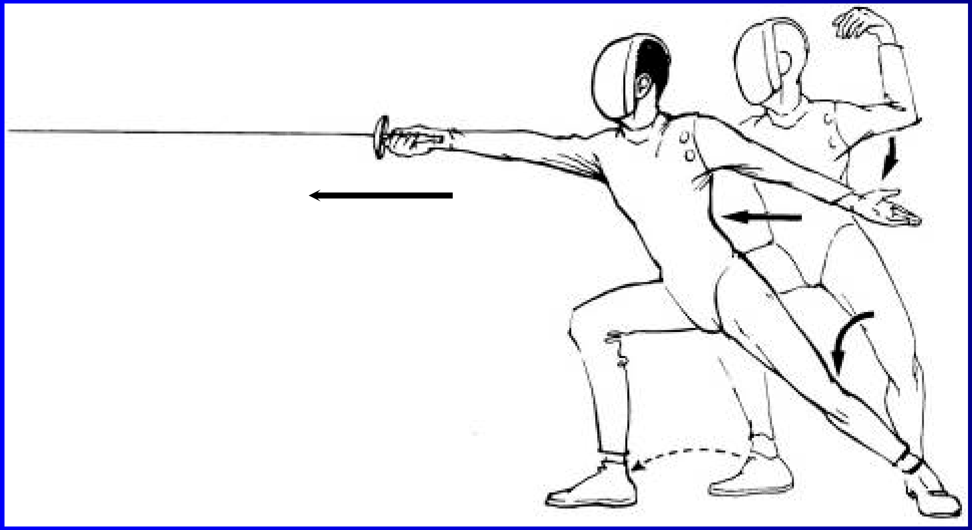


Fig 11.4

Kinds of Motion Experienced by the Body

- Most joints are axial
- Segments undergo primarily angular motion
- Slight translatory motion in gliding joints

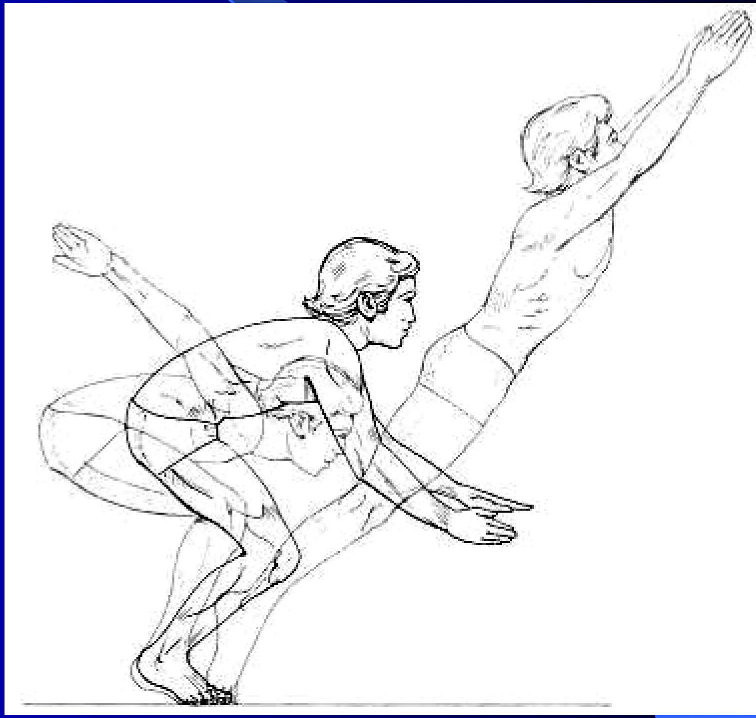


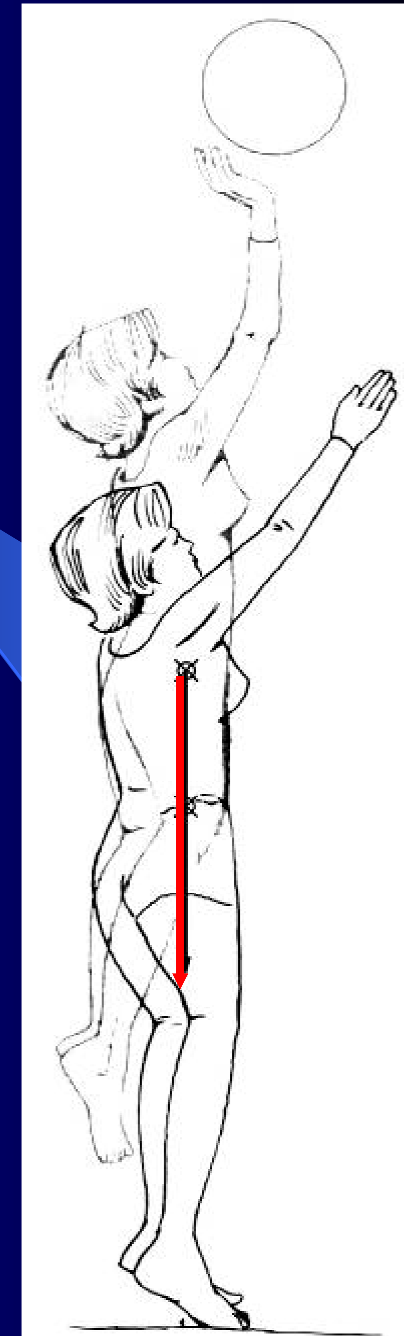
Fig 11.5

Kinds of Motion Experience by the Body

- Rectilinear movement when the body is acted on by the force of gravity or a linear external force

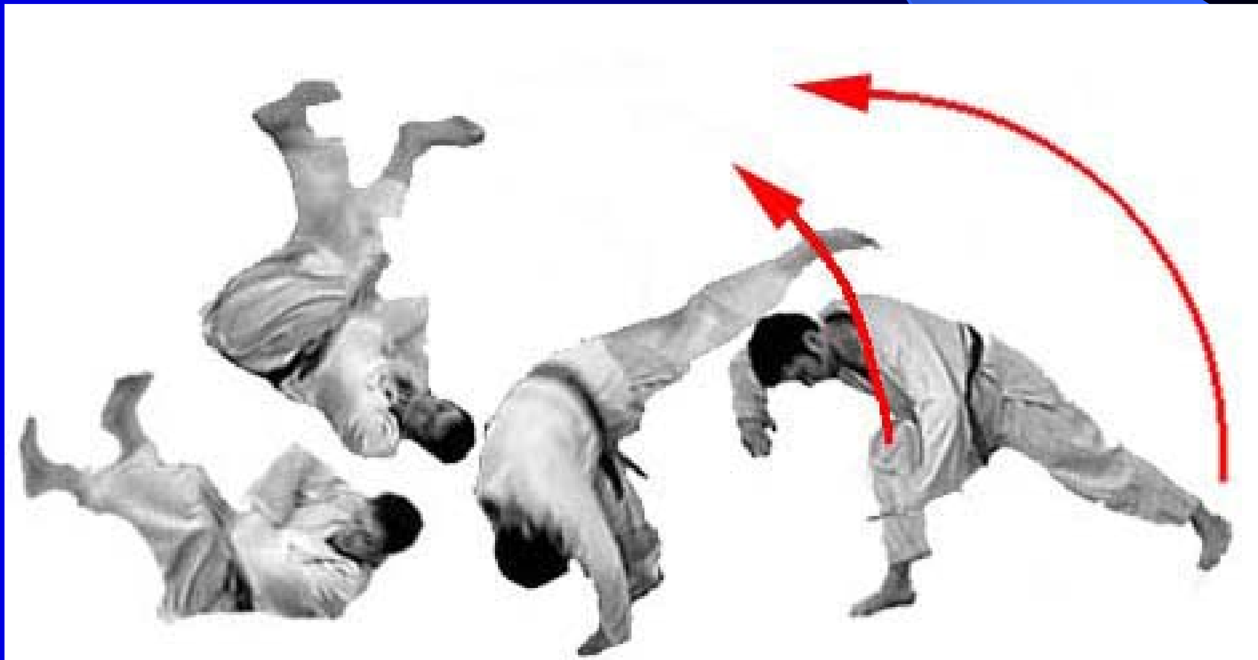
Fig 11.7

Fig 11.6



Motion Experience by Body

- Rotary
  - Parts of many Judo throws
- Translatory
  - diving over someone in Judo
- General
  - Judo rolls combine translation and rotation



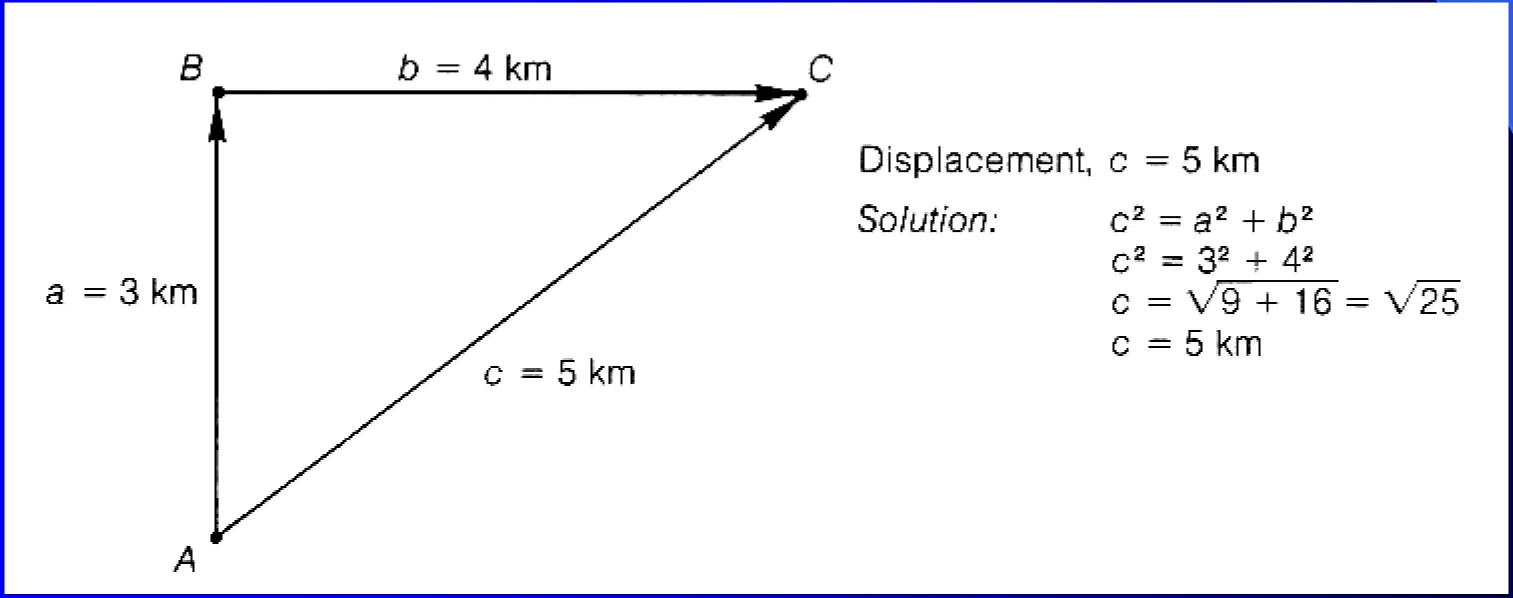
KINEMATICS OF MOTION Linear

- Distance
  - How far an object has traveled
- Displacement
  - Distance object moved <u>from a reference point</u>

Linear Kinematics

- Walk north 3 km, then east 4 km
- 7 km <u>distance</u> traveled
- 5 km of <u>displacement</u>

Fig 11.8



Speed and Velocity *V*

- Speed is how fast object is moving; nothing about direction of movement
  - a scalar quantity

Speed and Velocity *V*

- Velocity involves direction as well as speed
  - speed in a given direction
  - rate of displacement ***(X,Y, and/or Z)***
  - a vector quantity

Acceleration *a*

- The rate of change in velocity
- If acceleration positive, velocity will increase
- If acceleration negative, velocity will decrease

Acceleration

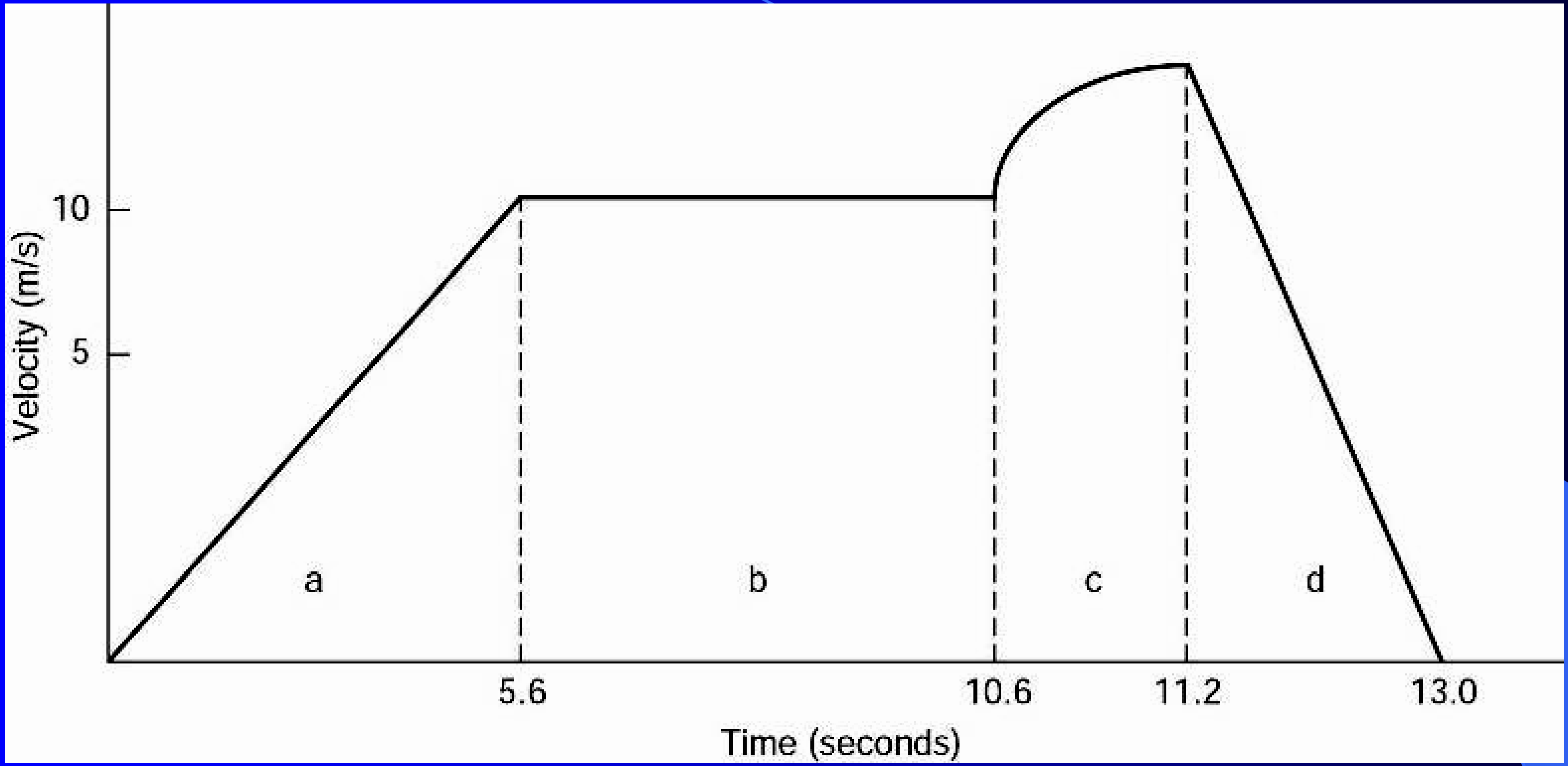


Fig 11.10

Section a:

v- increasing (+)

a-constant (+)

Section b:

v- constant (+)

a-zero

Section c:

v- non-linear increase (+)

a- non-constant (+)

Section d:

v- decreasing (+)

a- constant (-)

Acceleration Units

$\bar{a}$ = (m/sec) / sec

$\bar{a}$ = m/sec^2

Uniformly Accelerated Motion

- Constant acceleration rate
- Common with freely falling objects
  - Objects will accelerate at a uniform rate due to acceleration of gravity
- Object projected upward will be slowed at the same uniform rate due to gravity

Acceleration of Gravity

- 32 ft/sec^2 or 9.8 m/sec^2
- Velocity will increase 9.8 m/sec every second when an object is dropped from some height

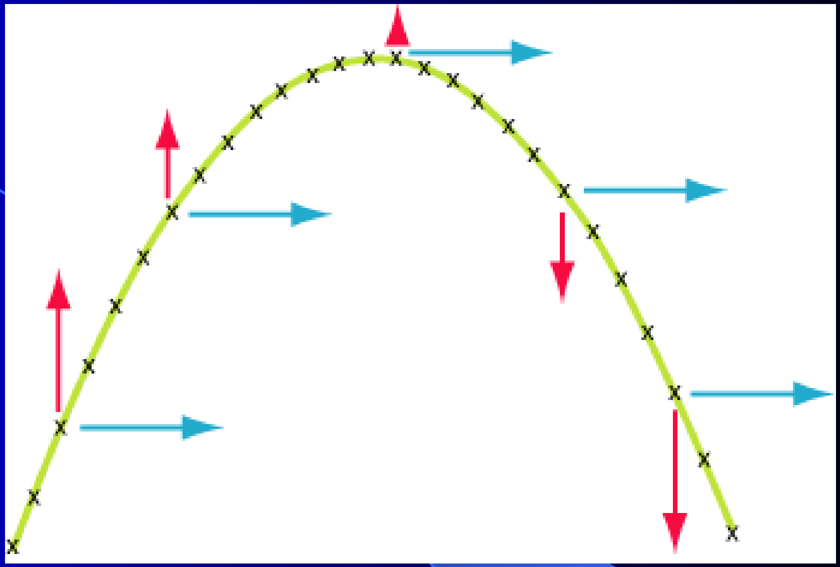
Acceleration of Gravity

- Since acceleration due to gravity is 9.8 m/sec^2
  - after 1 sec, V = 9.8 m/sec
  - after of 2 sec, V = 19.6 m/sec
  - after of 3 sec, V = 29.4 m/sec

Air Resistance

- Lighter objects affected more:
  - may stop accelerating (feather) and fall at a constant rate
- Terminal velocity – air resistance is increased to equal accelerating force of gravity
  - Object no longer accelerating, velocity stays constant
  - Sky diver = approximately 120 mph (53 m/sec)

Laws of Uniformly Accelerated Motion



$$v_f = v_i + at$$

$$x = v_i t + {}^1/_2 a t^2$$

$$v_f^{\,2} = v_i^{\,2} + 2ax$$

Where:

v_f = *final velocity*

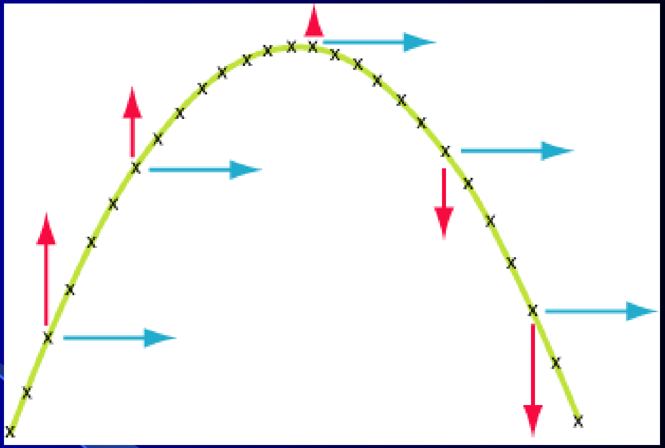
v_i = *initial velocity*

a = *acceleration*

t = *time*

x = *displacement*

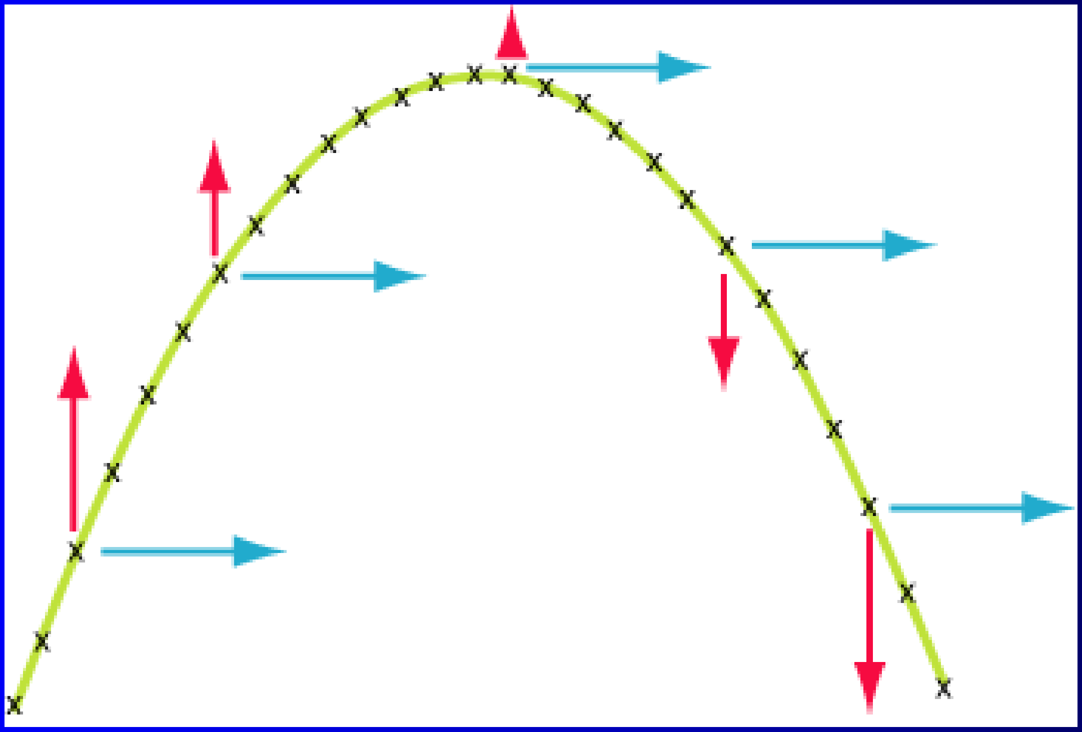
Laws of Uniformly Accelerated Motion



- Time for an object to rise to highest point of trajectory equal to time to fall to starting point
- Upward flight is mirror image of downward
- Release & landing velocities equal, but opposite
- Upwards velocities are positive, downward are negative

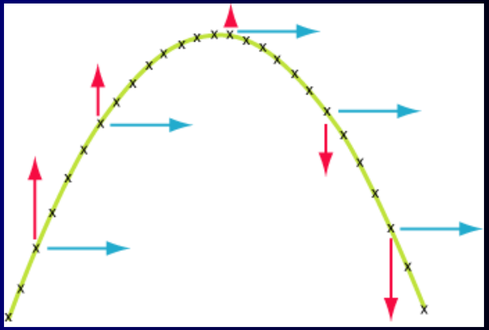
Projectiles

- Objects given an initial velocity and released
- If Neglecting air resistance, gravity is only influence after release



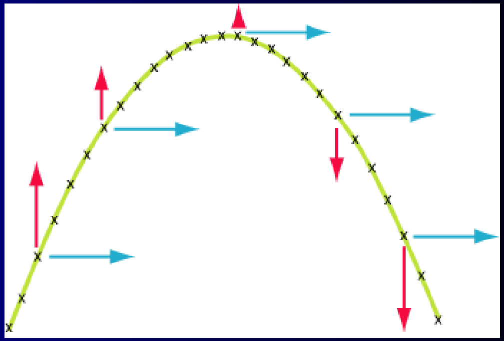
Projectiles

- Want maximum horizontal displacement for long jumper



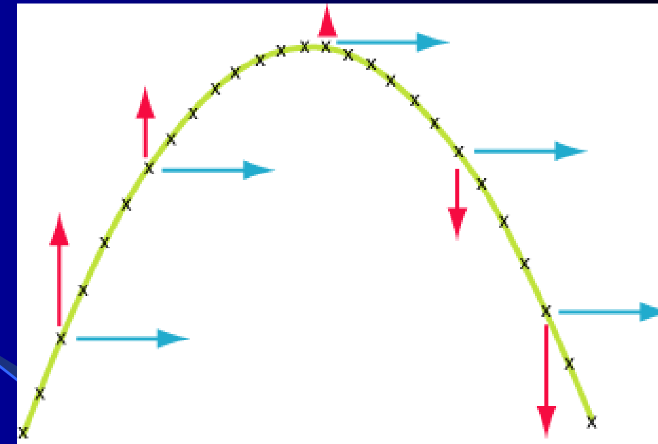
Projectiles

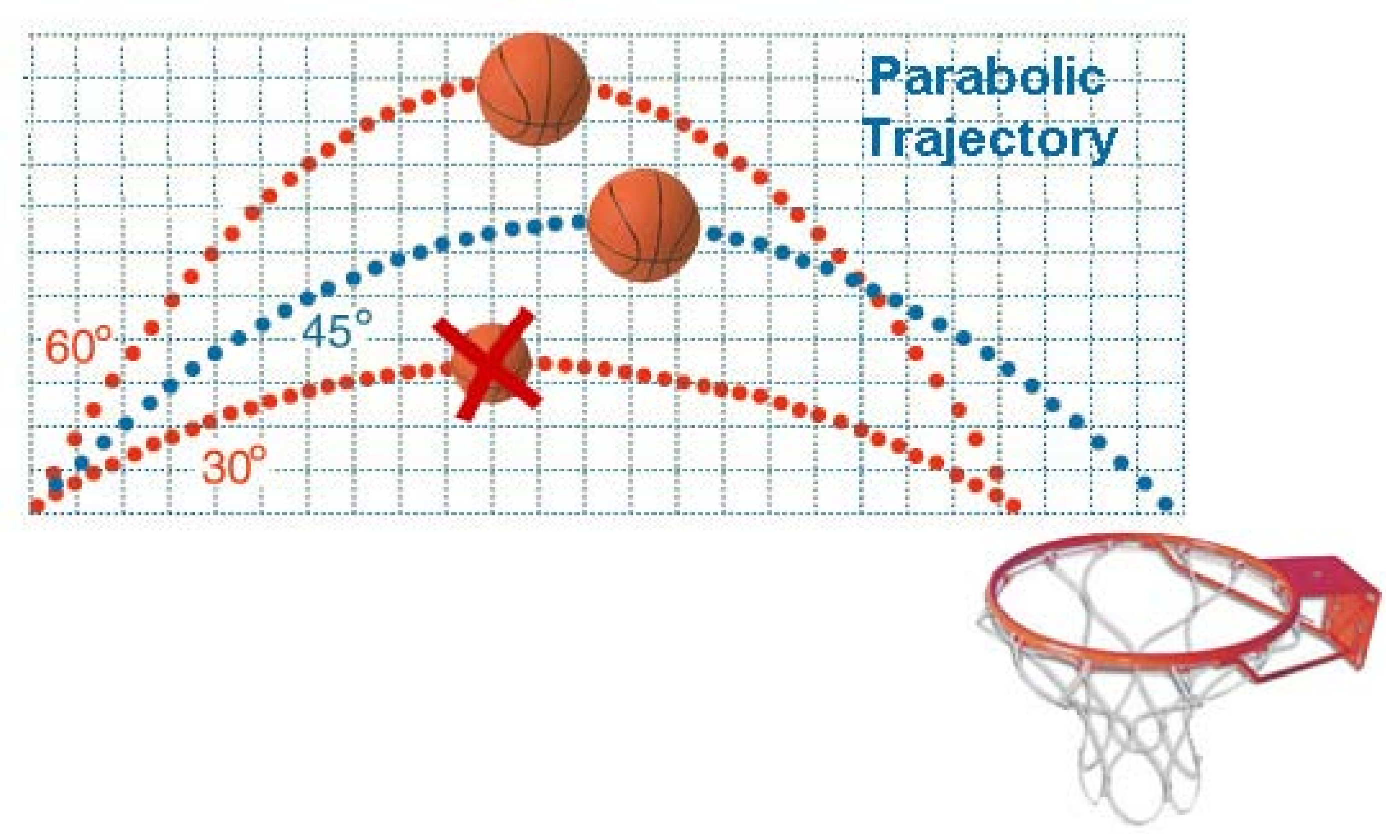
- Want maximum vertical displacement for high jumper



Projectiles

Want maximum accuracy for shooting basketball

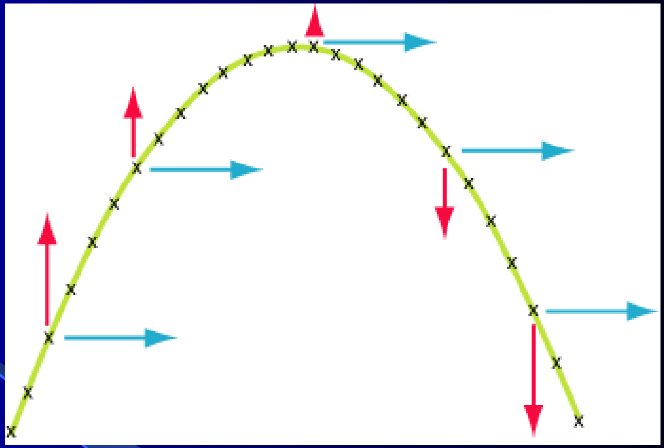




VIDEO

Projectiles

Want maximum accuracy for shooting basketball



VIDEO

B.E.E.F

Projectiles

Gravity will
- slow upward motion
- increase downward motion
- at 9.8 m/sec^2

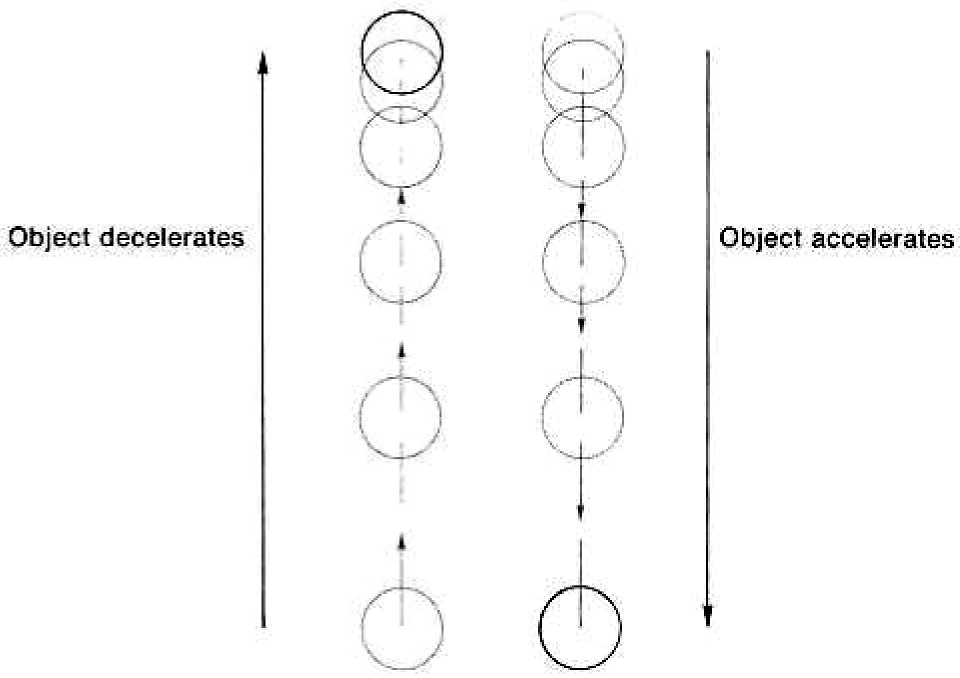
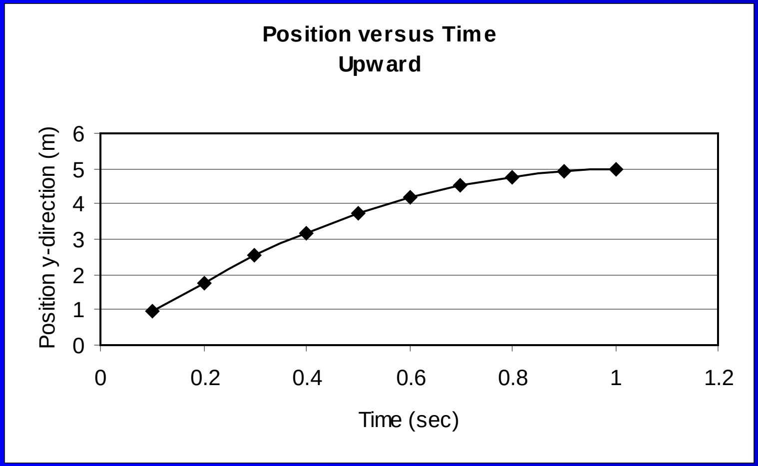
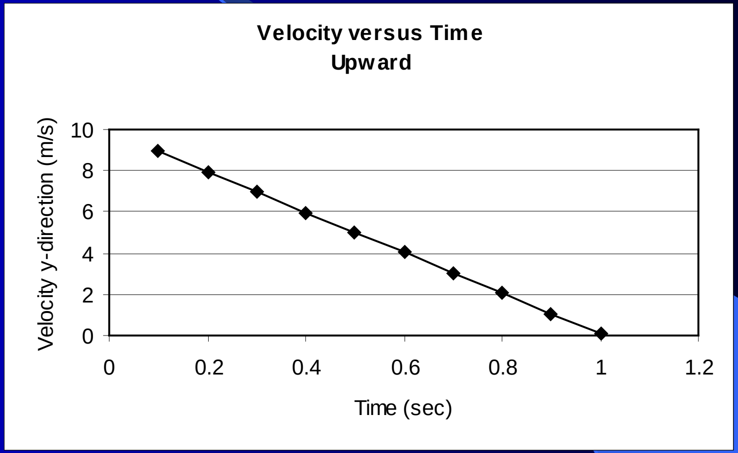
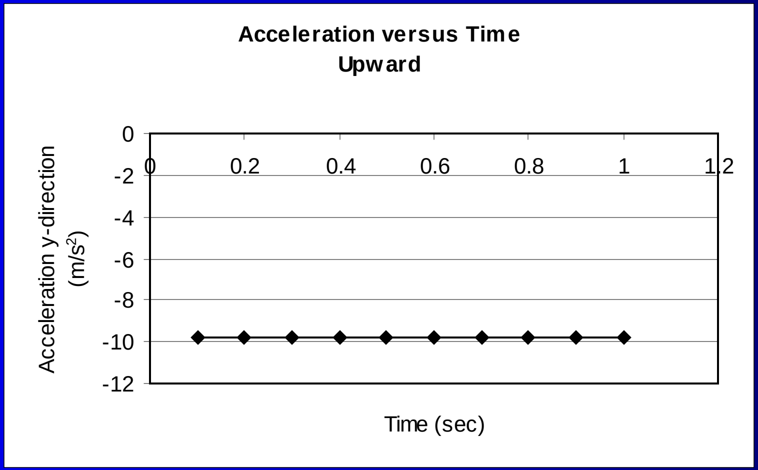


Fig 11.11

Projectiles
Upward portion

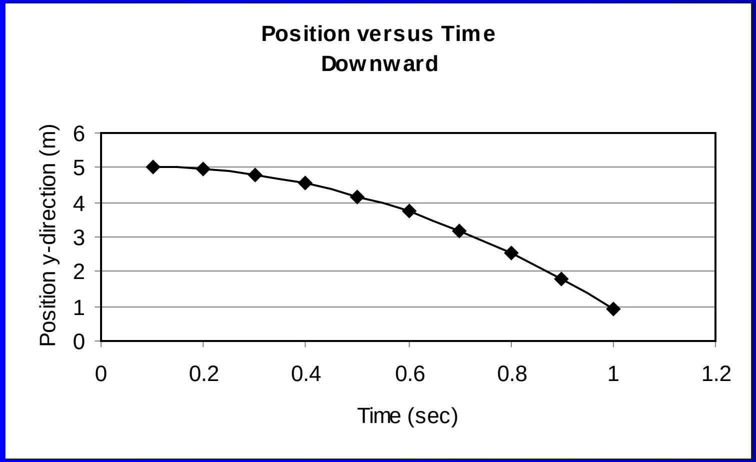


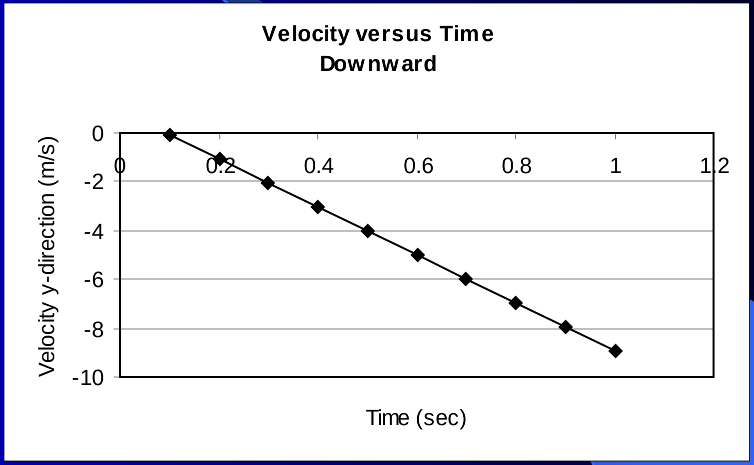


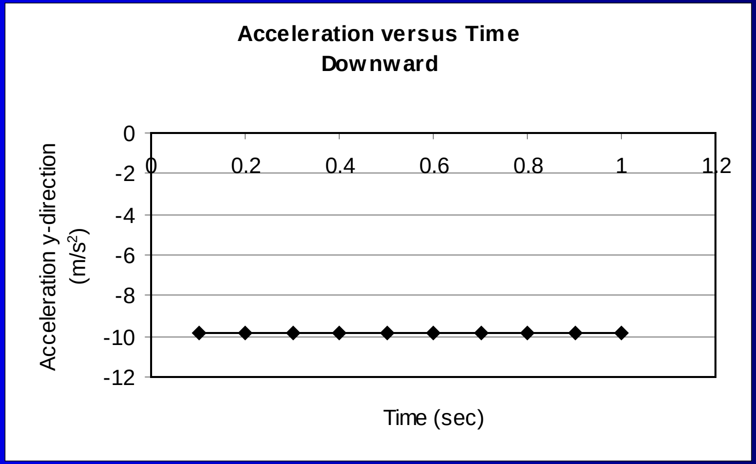


Projectiles

Downward portion



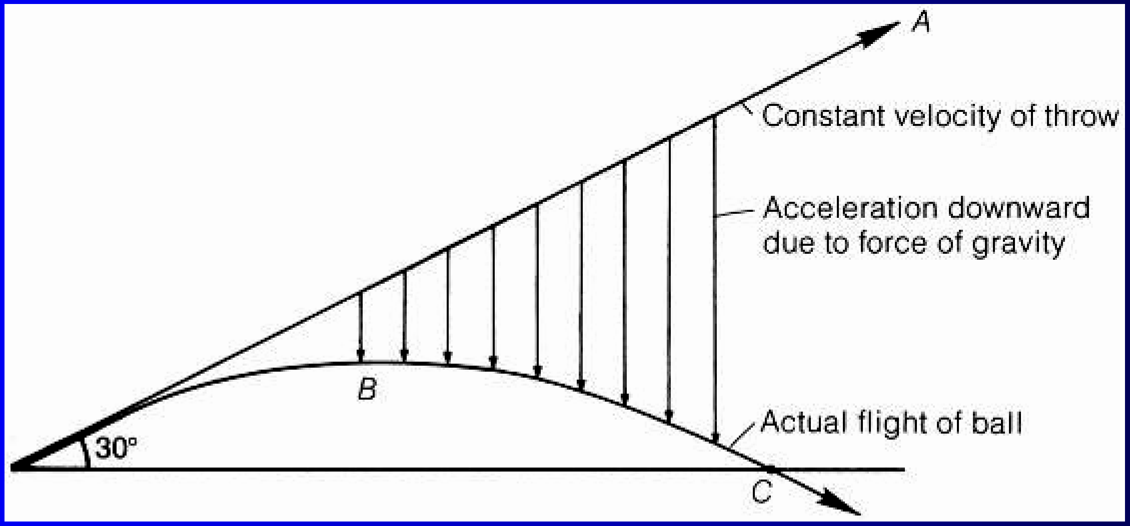




Projectiles

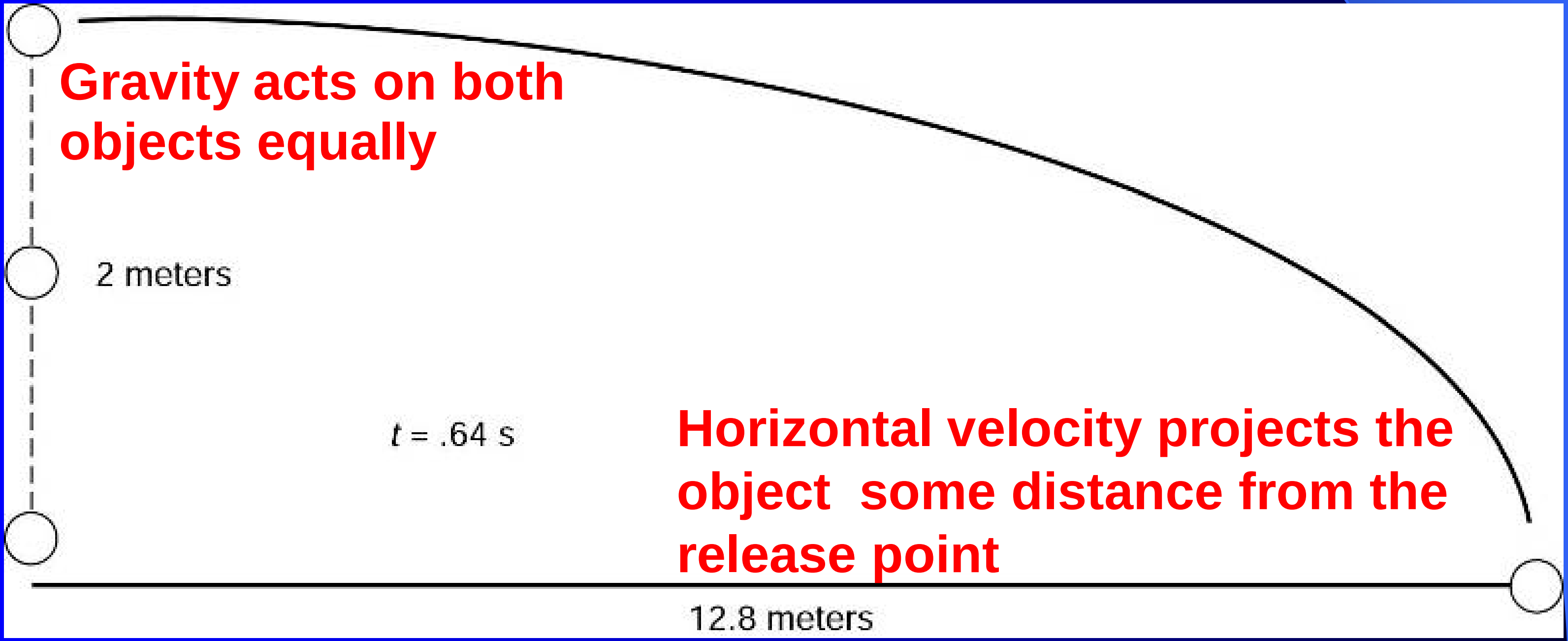
- Initial velocity at an angle of projection:
  - – Components
    - Vertical velocity: affected by gravity
    - Horizontal velocity: not affected by gravity

Fig 11.12



Projectiles with Horizontal Velocity

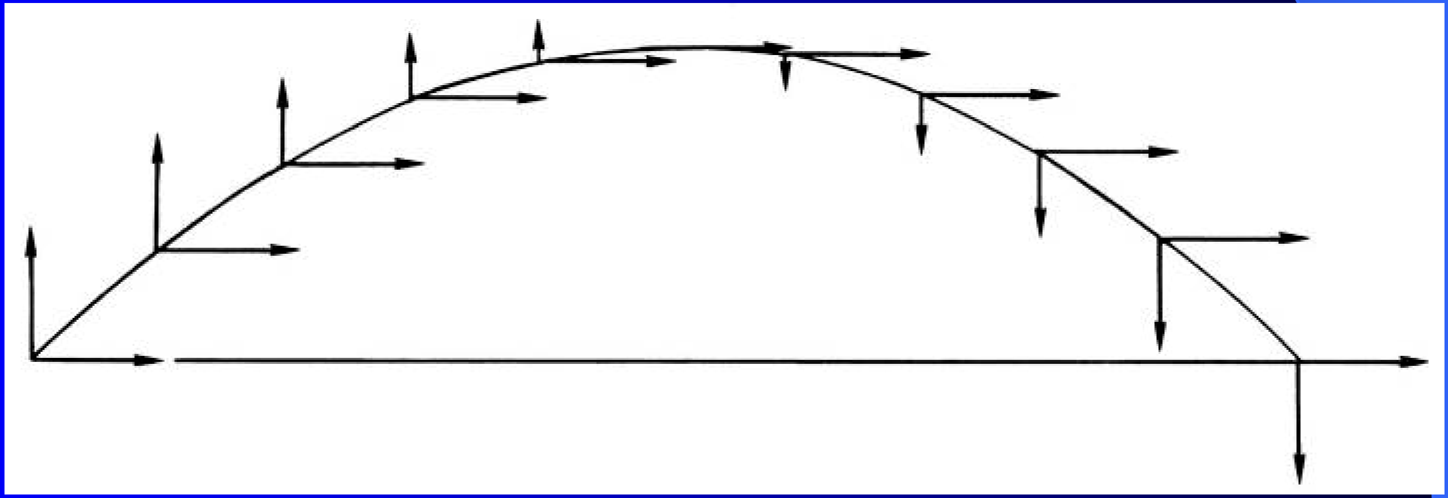
- If one object simply falling while another is projected horizontally, which will hit the ground first?
  - Tie if air effects ignored (e.g., drag, lift)



Projectiles with Vertical and Horizontal Velocities

- Case for most projectiles
- Horizontal velocity remains constant
- Vertical velocity subject to uniform acceleration of gravity

Fig 11.14

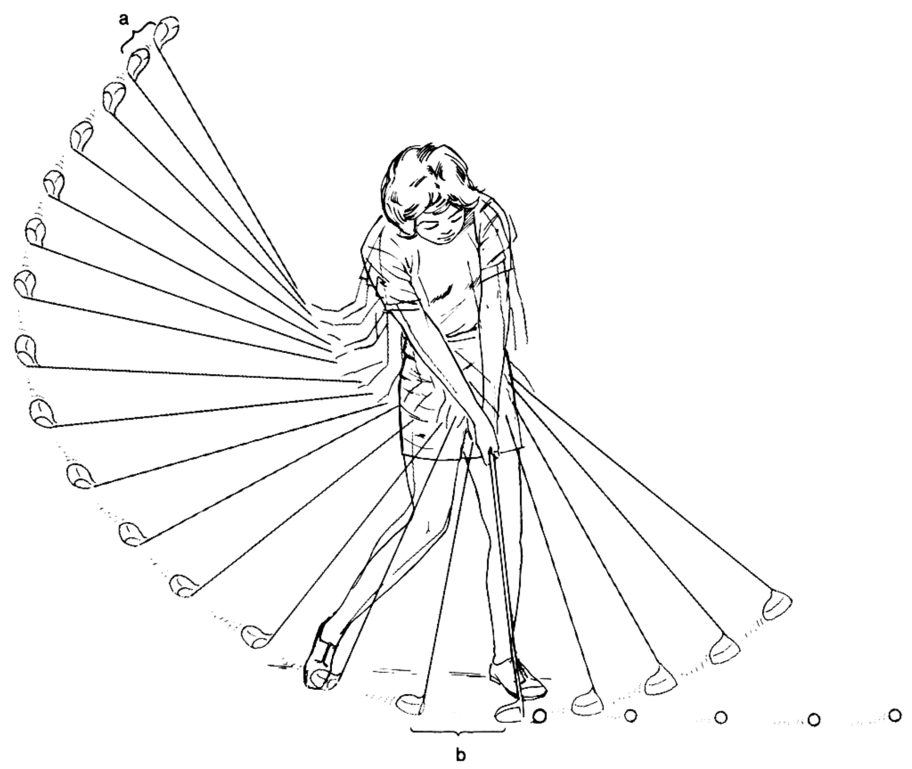


Horizontal Distance of a Projectile

- Depends on
  - initial velocity
  - angle of projection

Angular Kinematics

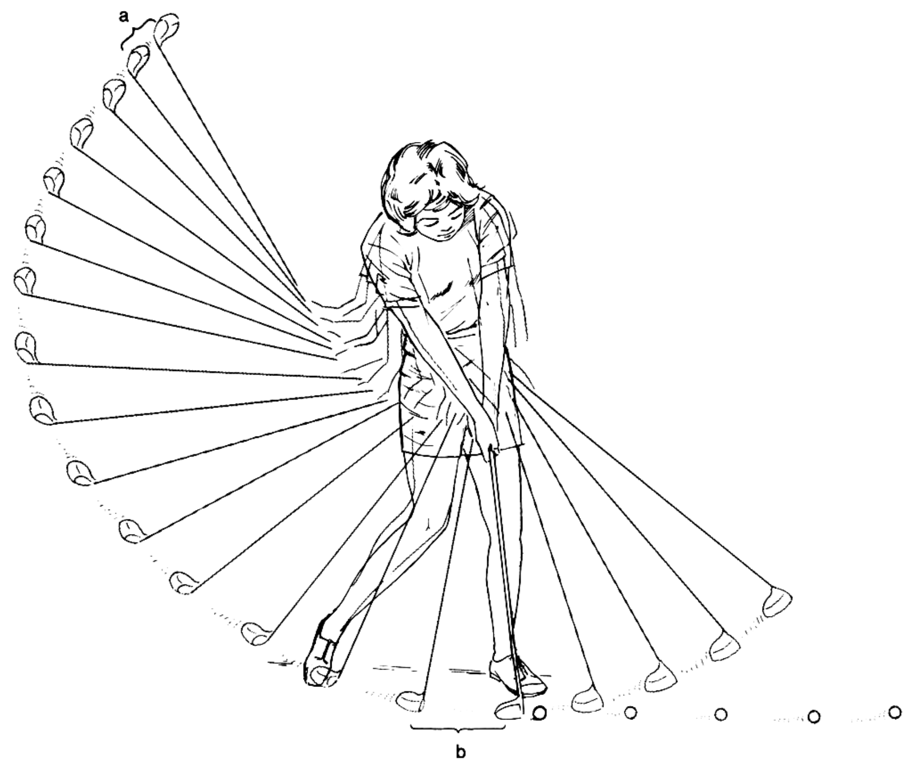
- Similar to linear kinematics
- Also concerned with displacement, velocity, and acceleration
- Difference is relates to rotary rather than linear motion
- Equations similar



Angular Displacement

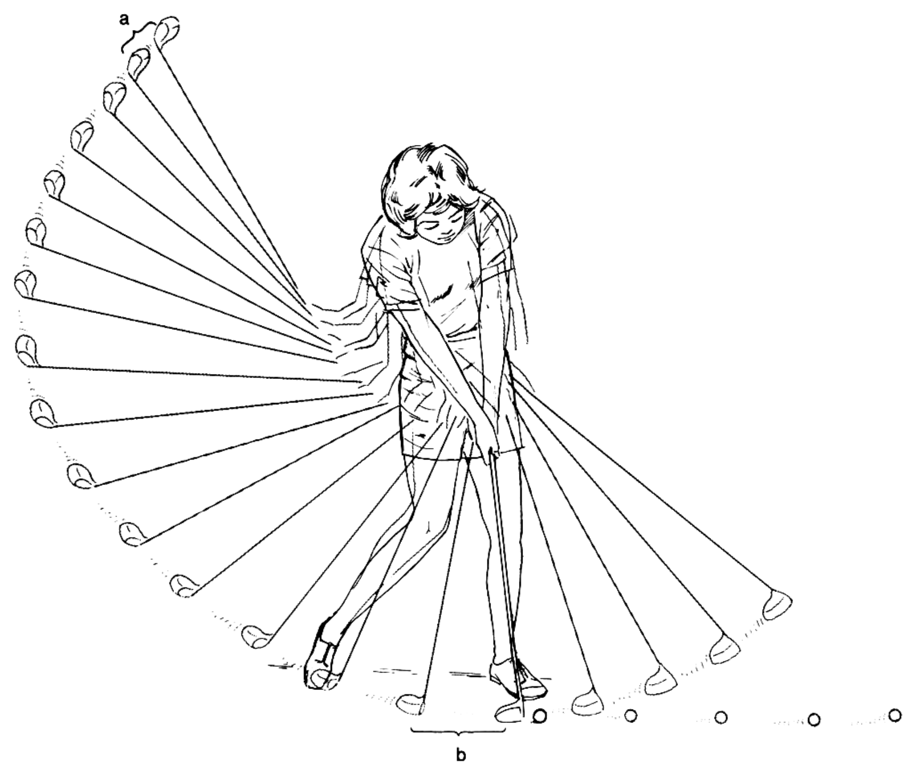
$C = 2\pi r$

- Skeleton is system of levers that rotate about fixed points
- Parts near axis have displacement less than those farther away
- Units of a circle:
  - Circumference = C
  - Radius = r
  - Constant (3.1416) = π



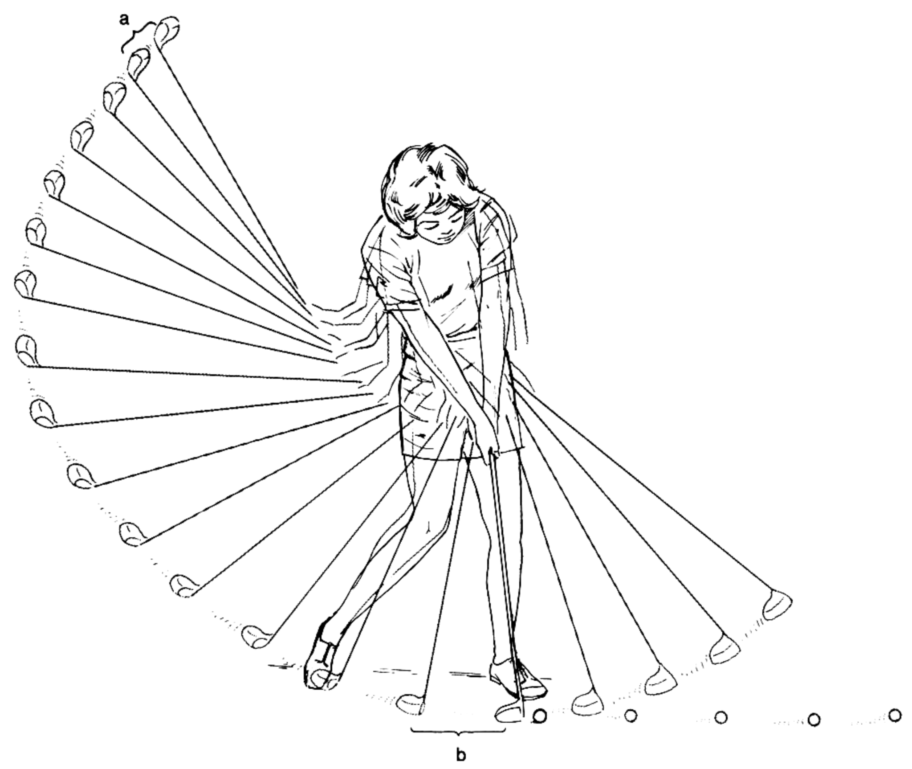
Units of angular Displacement

- Degrees:
  - Used most frequently
- Revolutions:
  - 1 revolution = 360° = 2π radians
- Radians:
  - 1 radian = 57.3°
  - Favored by engineers & physicists
  - Required for most equations
- Symbol for angular displacement - θ (theta)



Angular Velocity $\omega = \theta / t$

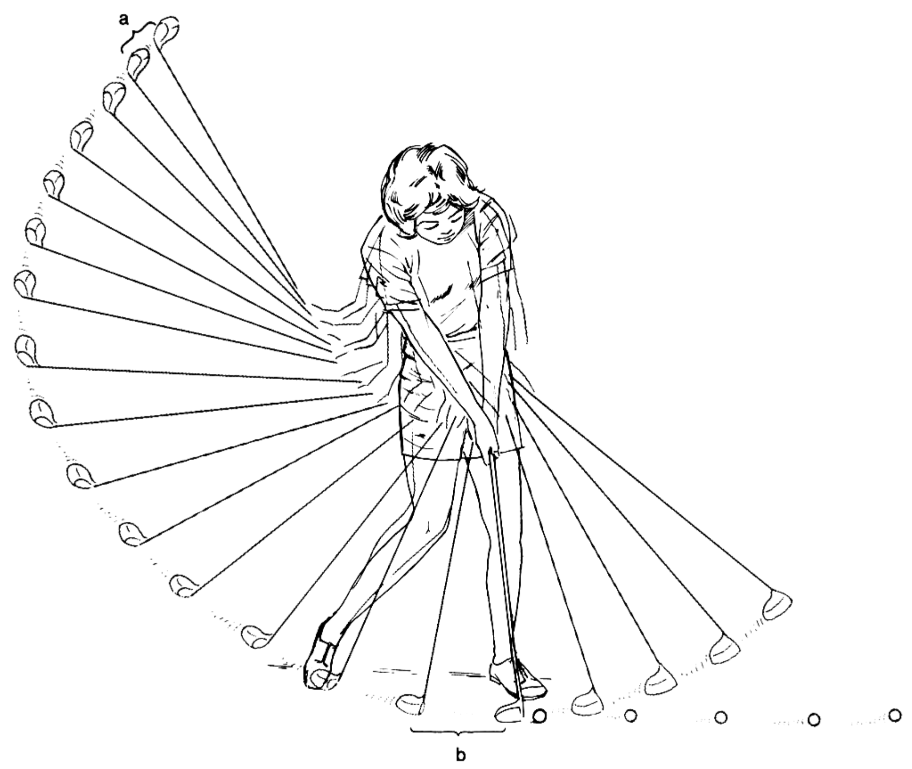
- Rate of rotary displacement - ω (omega)
- Equal to the angle through which the radius turns divided by time
- Expressed in degrees/sec, radians/sec, revolutions/sec, or RPM (Revolutions Per Minute)



Angular Acceleration

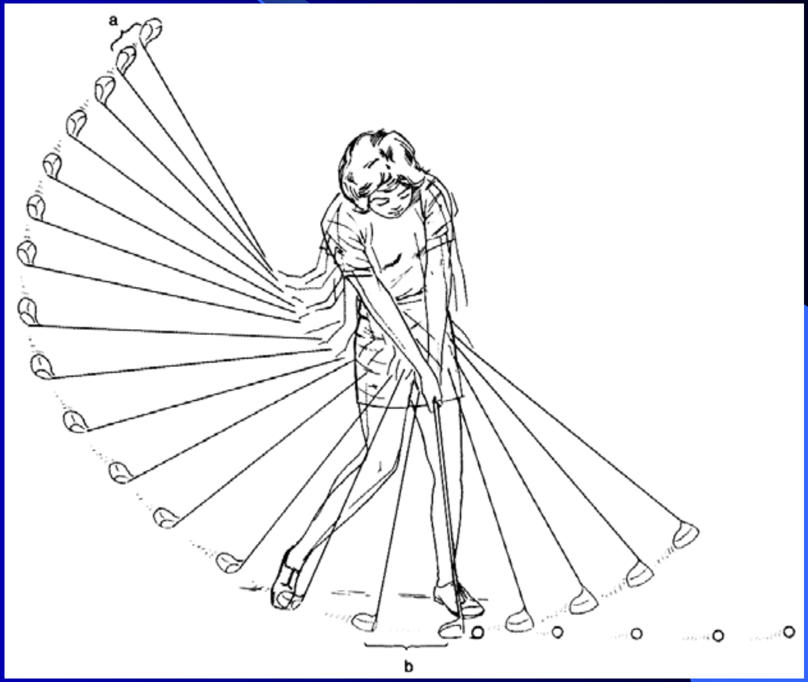
$$\alpha = (\omega_f - \omega_i)/ t$$

- α (alpha) is the rate of change of angular velocity and expressed by above equation.
  - ω_f is final velocity
  - ω_i is initial velocity



Angular Acceleration

- ω_a is 25 rad/sec
- ω_b is 50 rad/sec
- Time lapse = 0.11 sec



$$\alpha = \omega_f - \omega_i / t$$

$$\alpha = (50 – 25) / 0.11$$

$$\alpha = 241 \text{ rad/sec/sec}$$

Velocity increases by 241 radians per sec each second

Relationship Between Linear and Angular Motion

- A,B, and C have same angular displacement and velocity; but different linear displacements and velocities

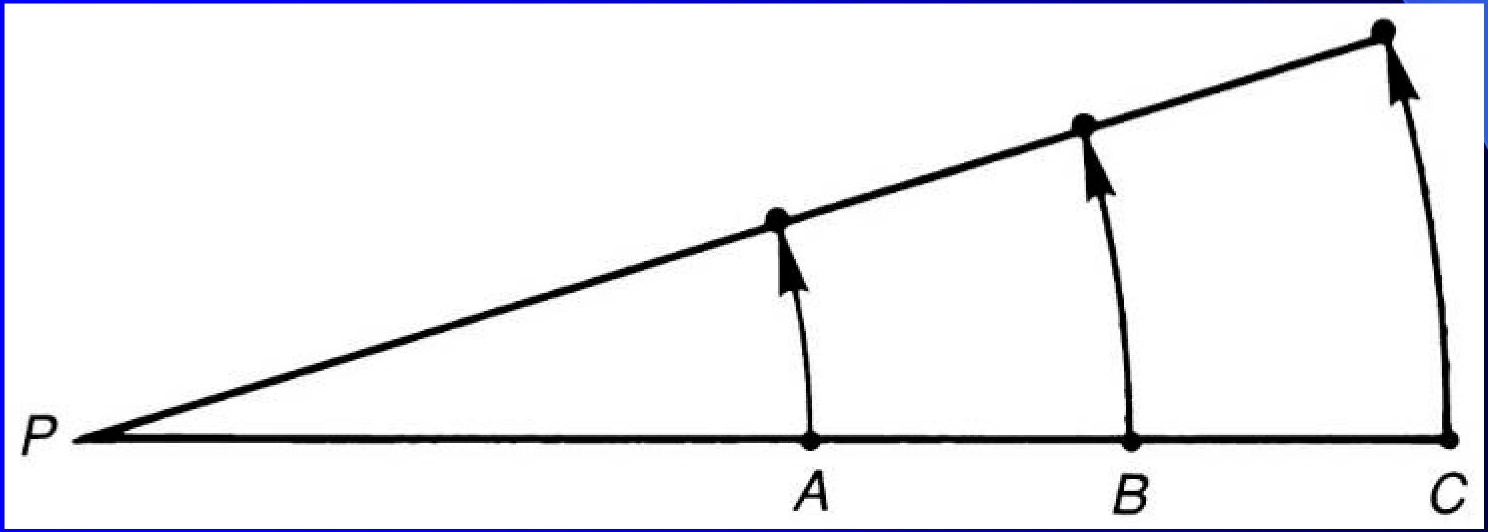


Fig 11.17

Relationship Between Linear and Angular Motion

Linear displacements of A,B, and C:

$$x = \theta r$$

where *r* is the radius (i.e., distance from P)

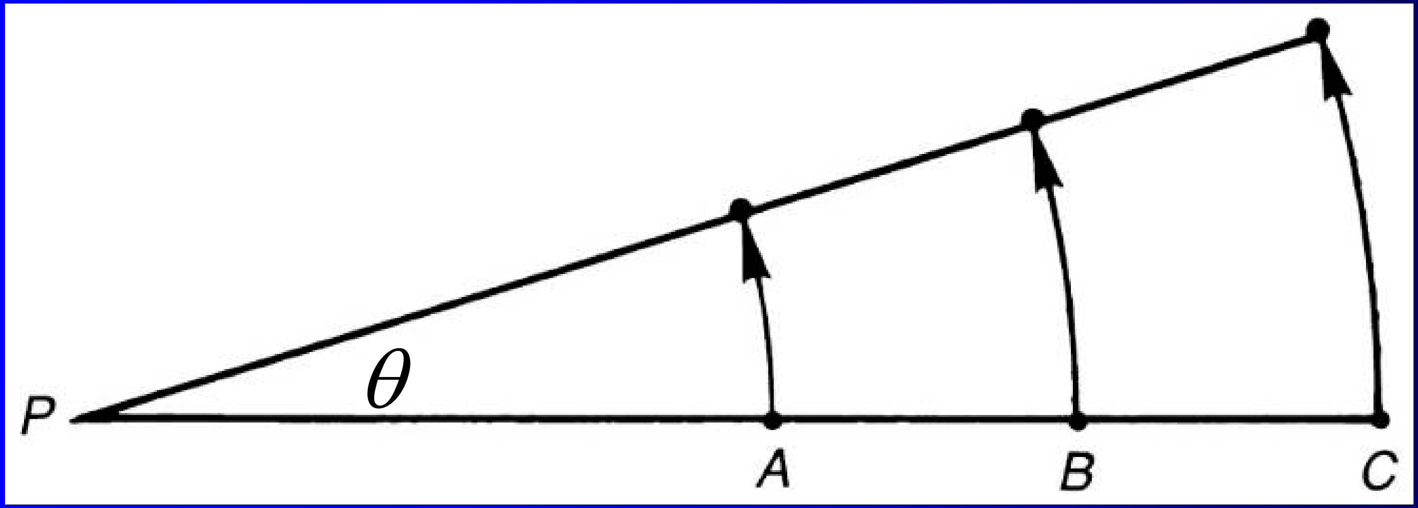


Fig 11.17

Relationship Between Linear and Angular Motion

Linear velocities of A,B, and C:

$$v = \omega r$$

where *r* is the radius (i.e., distance from P)

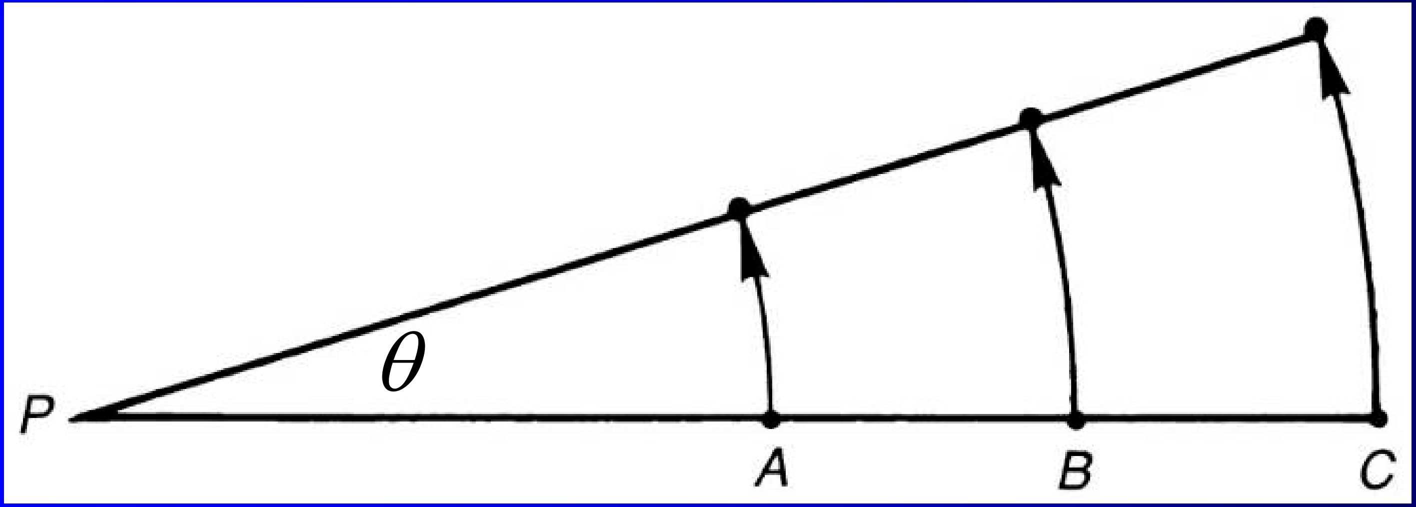


Fig 11.17