PHYSICS I

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Kinematic Equations – summary

TABLE 2.2 *Kinematic Equations for Motion of a Particle Under Constant Acceleration*

Equation Number	Equation	Information Given by Equation
2.13	$v_{xf} = v_{xi} + a_x t$	Velocity as a function of time
2.15	$x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})t$	Position as a function of velocity and time
2.16	$x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2$	Position as a function of time
2.17	$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i)$	Velocity as a function of position

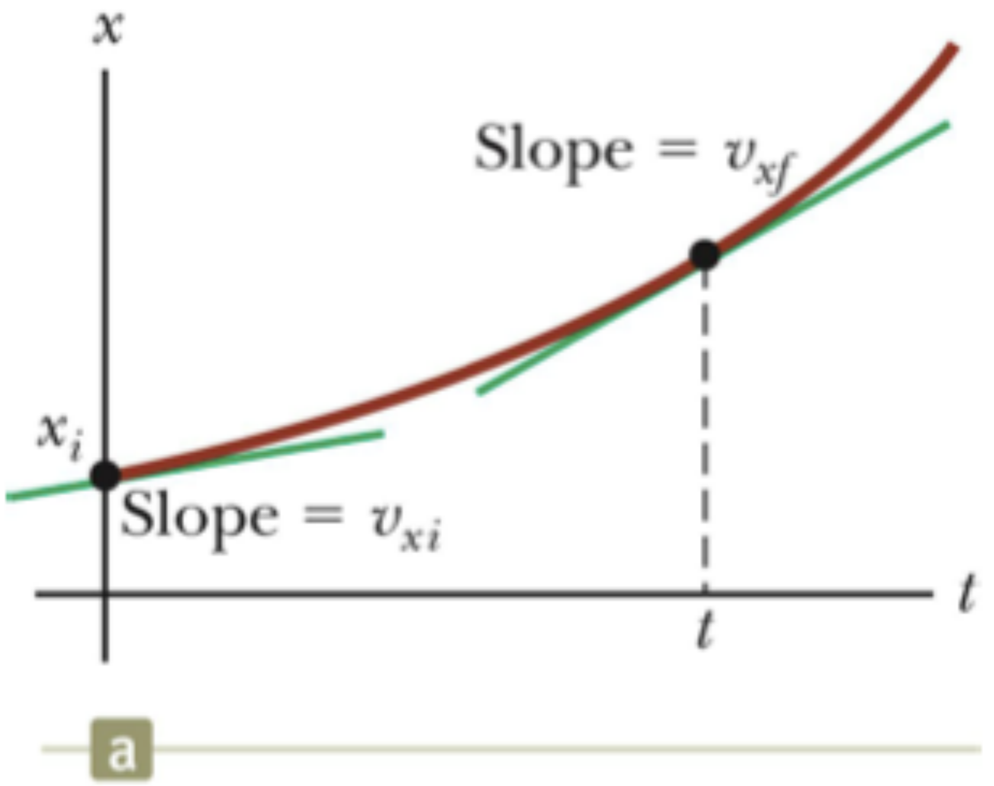
Note: Motion is along the x axis.

Graphical Look at Motion: Displacement – Time curve

The slope of the curve is the velocity.

The curved line indicates the velocity is changing.

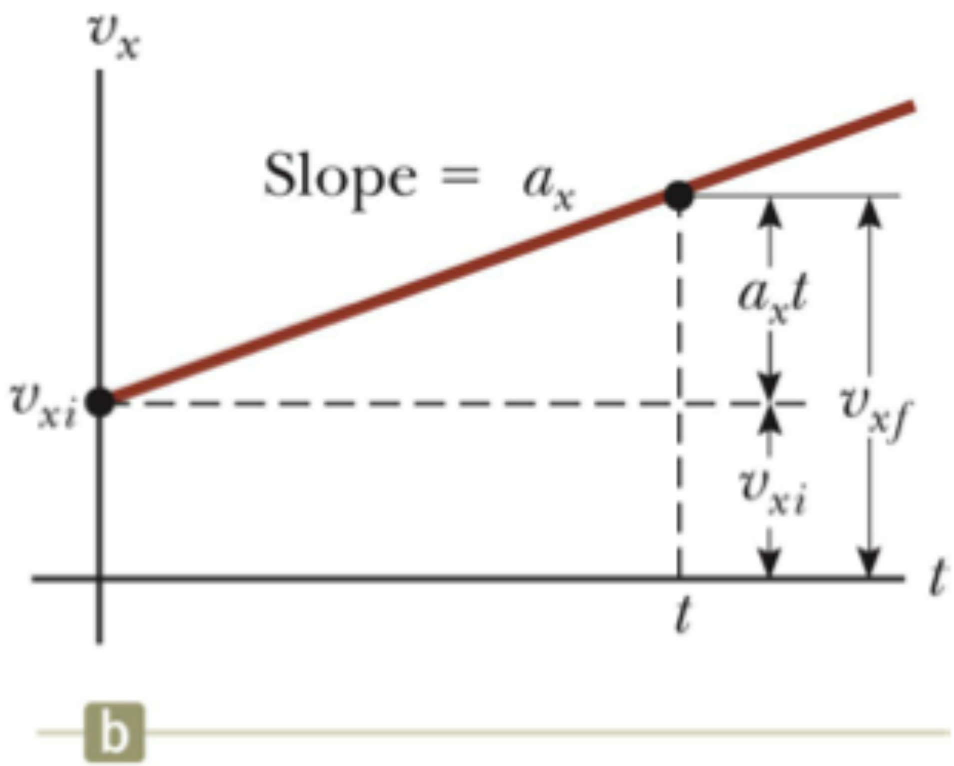
- Therefore, there is an acceleration.



Graphical Look at Motion: Velocity – Time curve

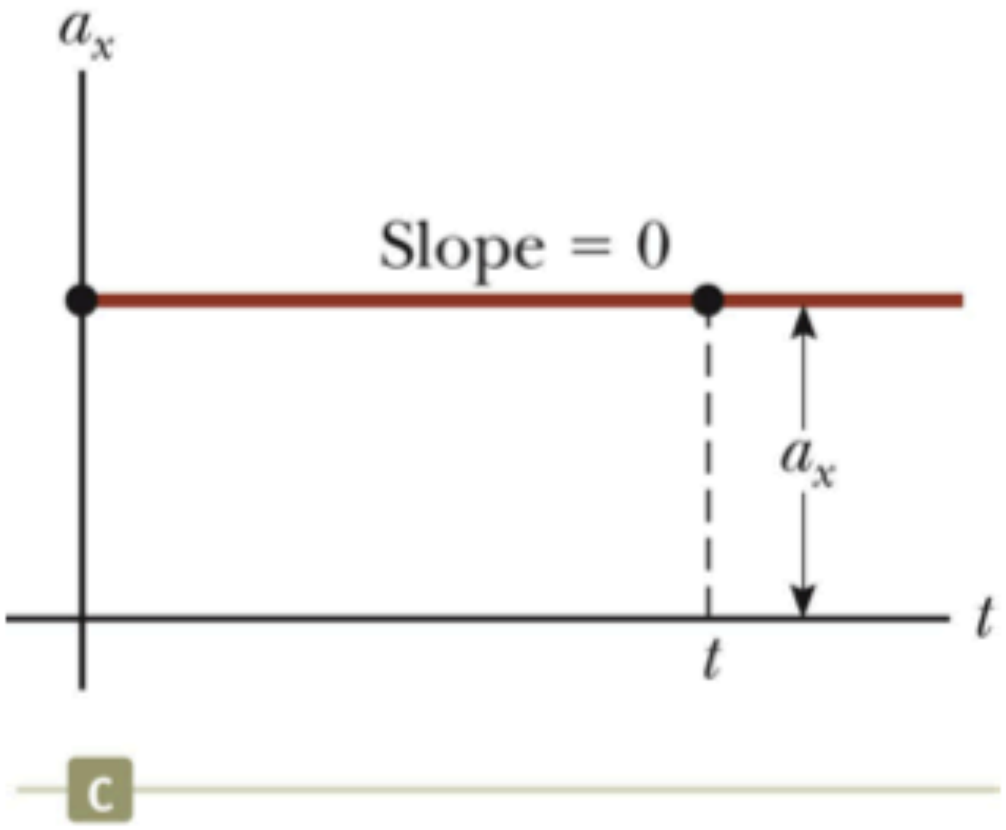
The slope gives the acceleration.

The straight line indicates a constant acceleration.



Graphical Look at Motion: Acceleration – Time curve

The zero slope indicates a constant acceleration.



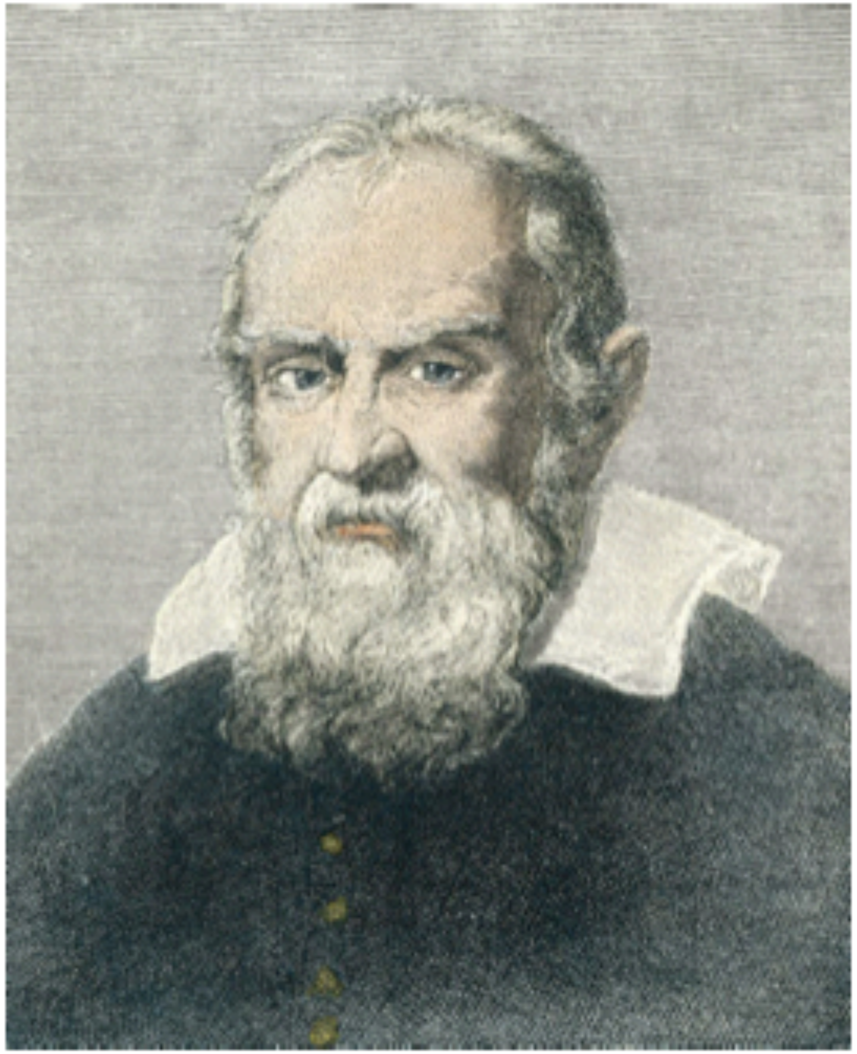
Galileo Galilei

1564 – 1642

Italian physicist and astronomer

Formulated laws of motion for objects in free fall

Supported heliocentric universe



Freely Falling Objects

A ***freely falling object*** is any object moving freely under the influence of gravity alone.

It does not depend upon the initial motion of the object.

- Dropped – released from rest
- Thrown downward
- Thrown upward

Acceleration of Freely Falling Object

The acceleration of an object in free fall is directed downward, regardless of the initial motion.

The magnitude of free fall acceleration is $g = 9.80\ \text{m/s}^2$.

- g decreases with increasing altitude
- g varies with latitude
- $9.80\ \text{m/s}^2$ is the average at the Earth's surface
- The italicized g will be used for the acceleration due to gravity.
  - Not to be confused with g for grams

Acceleration of Free Fall, cont.

We will neglect air resistance.

Free fall motion is constantly accelerated motion in one dimension.

- Use model of a particle under constant acceleration

Let upward be positive

Use the kinematic equations

- With $a_y = -g = -9.80\ m/s^2$
- Note displacement is in the vertical direction

Free Fall – An Object Dropped

Initial velocity is zero

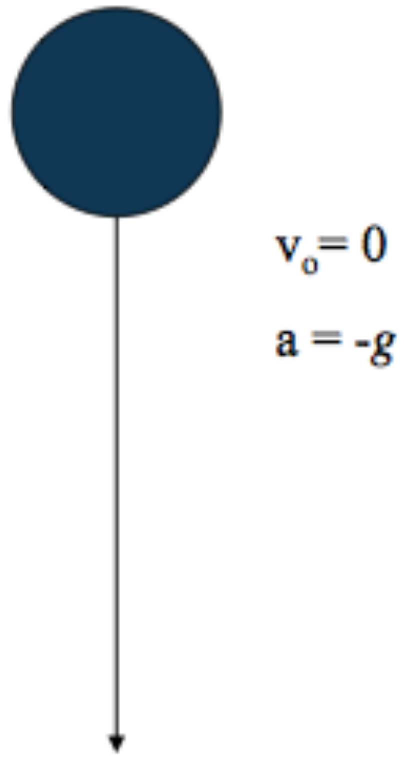
Let up be positive

Use the kinematic equations

- Generally use y instead of x since vertical

Acceleration is

- $a_y = -g = -9.80 \text{ m/s}^2$

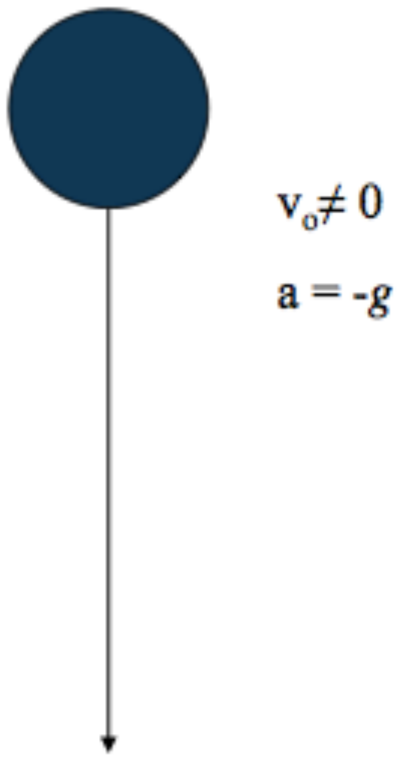


Free Fall – An Object Thrown Downward

$a_y = -g = -9.80 \text{ m/s}^2$

Initial velocity $\neq 0$

- With upward being positive, initial velocity will be negative.

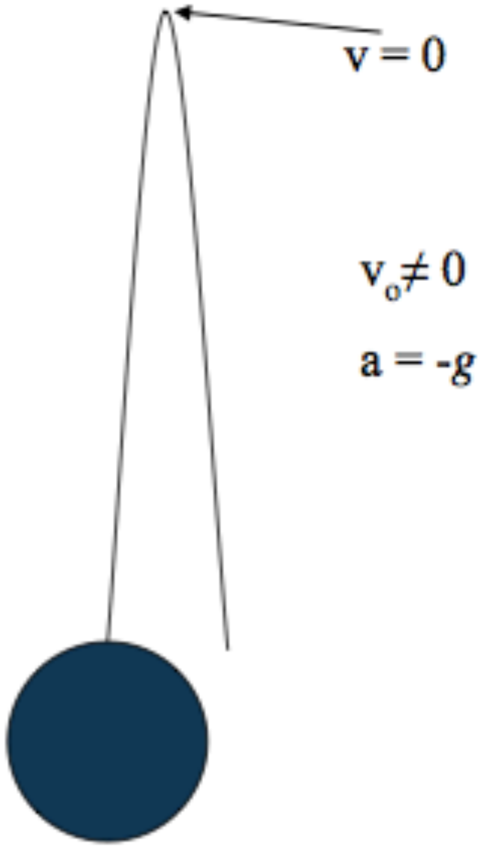


Free Fall – Object Thrown Upward

Initial velocity is upward, so positive

The instantaneous velocity at the maximum height is zero.

$a_y = -g = -9.80\ m/s^2$ everywhere in the motion



Thrown upward, cont.

The motion may be symmetrical.

- Then $t_{up} = t_{down}$
- Then $v = -v_o$

The motion may not be symmetrical.

- Break the motion into various parts.
  - Generally up and down

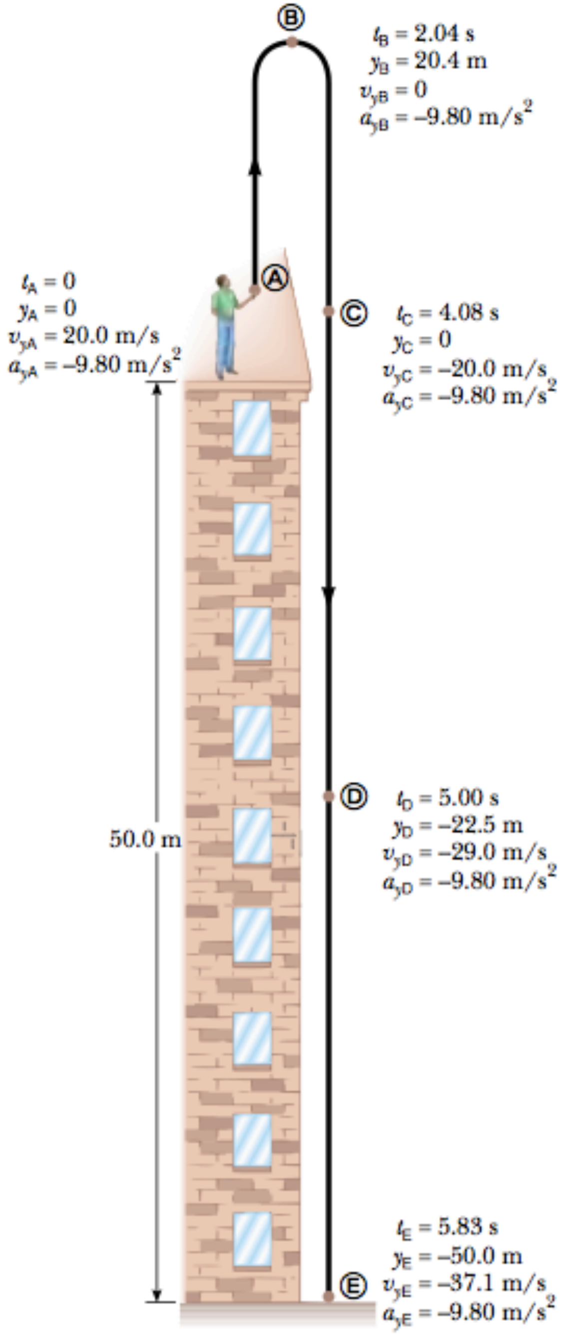
Free Fall Example

Initial velocity at A is upward (+) and acceleration is $-g$ (-9.8 m/s^2).

At B, the velocity is 0 and the acceleration is $-g$ (-9.8 m/s^2).

At C, the velocity has the same magnitude as at A, but is in the opposite direction.

The displacement is –50.0 m (it ends up 50.0 m below its starting point).



Kinematic Equations – General Calculus Form

$$a_x = \frac{dv_x}{dt}$$

$$v_{xf} - v_{xi} = \int_0^t a_x dt$$

$$v_x = \frac{dx}{dt}$$

$$x_f - x_i = \int_0^t v_x dt$$

Kinematic Equations – From Integration

The integration form of $v_f - v_i$ gives

$$v_{xf} - v_{xi} = a_x t$$

The integration form of $x_f - x_i$ gives

$$x_f - x_i = v_{xi} t + \frac{1}{2} a_x t^2$$

General Problem Solving Strategy

In addition to basic physics concepts, a valuable skill is the ability to solve complicated problems.

Steps in a general problem solving approach:

- Conceptualize
- Categorize
- Analyze
- Finalize

Problem Solving – Conceptualize

Think about and understand the situation.

Make a quick drawing of the situation.

Gather the numerical information.

- Include algebraic meanings of phrases.

Focus on the expected result.

- Think about units.

Think about what a reasonable answer should be.

Problem Solving – Categorize

Simplify the problem.

- Can you ignore air resistance?
- Model objects as particles

Classify the type of problem.

- Substitution
- Analysis

Try to identify similar problems you have already solved.

- What analysis model would be useful?

Problem Solving – Analyze

Select the relevant equation(s) to apply.

Solve for the unknown variable.

Substitute appropriate numbers.

Calculate the results.

- Include units

Round the result to the appropriate number of significant figures.

Problem Solving – Finalize

Check your result.

- Does it have the correct units?
- Does it agree with your conceptualized ideas?

Look at limiting situations to be sure the results are reasonable.

Compare the result with those of similar problems.

Problem Solving – Some Final Ideas

When solving complex problems, you may need to identify sub-problems and apply the problem-solving strategy to each sub-part.

These steps can be a guide for solving problems in this course.