Lecture 5

Chapter 2

Freely Falling Objects

Kinematic Equations – summary

TABLE 2.2

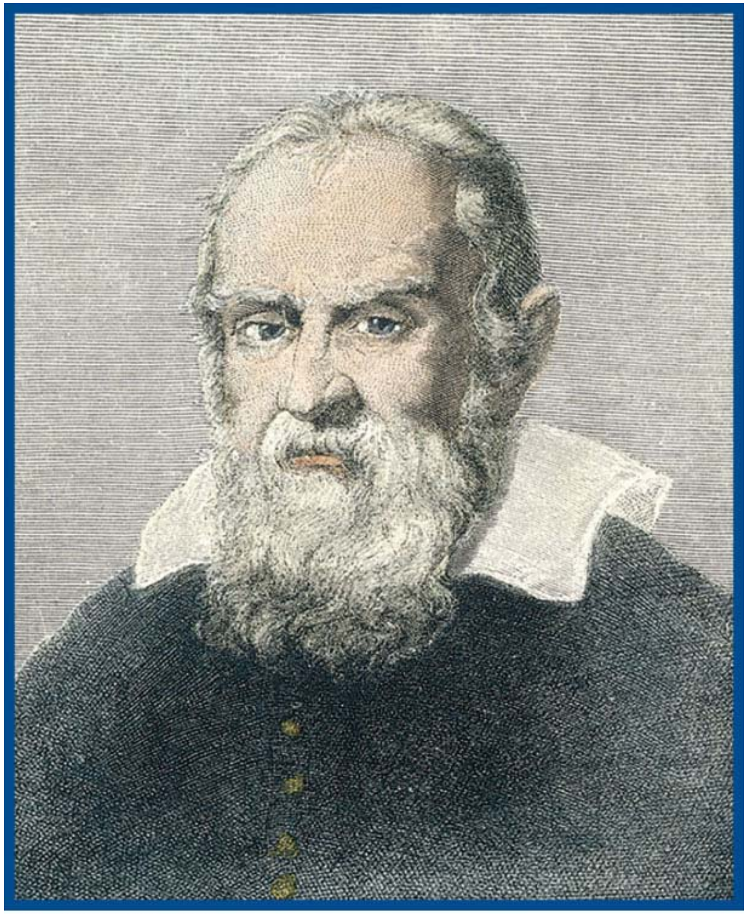
Kinematic Equations for Motion of a Particle Under Constant Acceleration

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.

Galileo Galilei

- 1564 – 1642
- Italian physicist and astronomer
- Developed the methodology of science
- Supported heliocentric universe
- Formulated laws of motion for objects in free fall



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

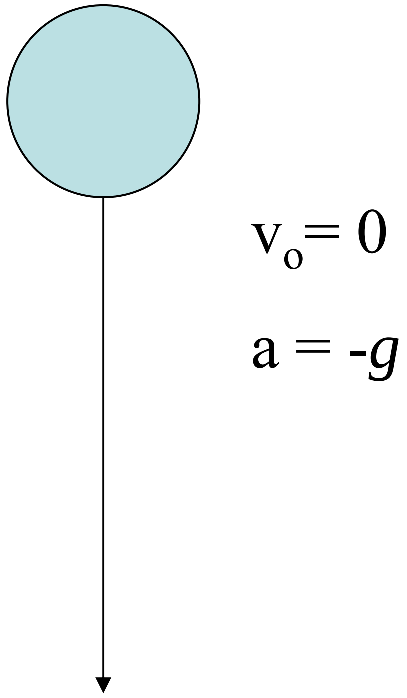
- The acceleration of an object in free fall is directed downward, regardless of the initial motion
- The magnitude of free fall acceleration is g = 9.80 m/s^2
  - g decreases with increasing altitude
  - g varies with latitude (two reasons)
  - 9.80 m/s^2 is the average at the Earth's surface
  - The 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
- Let upward be positive
- Use the kinematic equations with $a_y = -g = -9.80 \text{ m/s}^2$

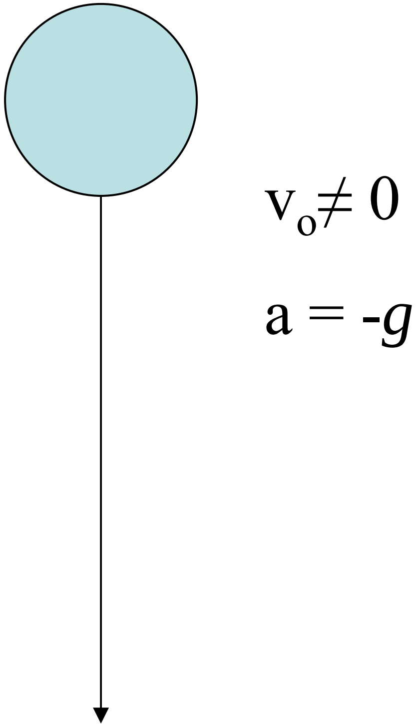
Free Fall – an object dropped

- Initial velocity is zero
- Let up be positive
- Use the kinematic equations
  - Generally use y instead of x since vertical
- Acceleration is
  - $a_y = -g = -9.80\ \text{m/s}^2$



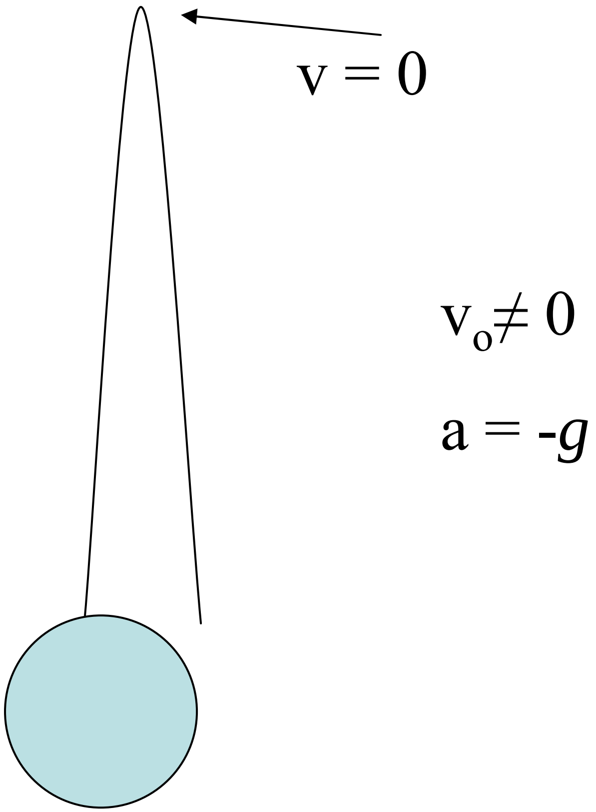
Free Fall – an object thrown downward

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

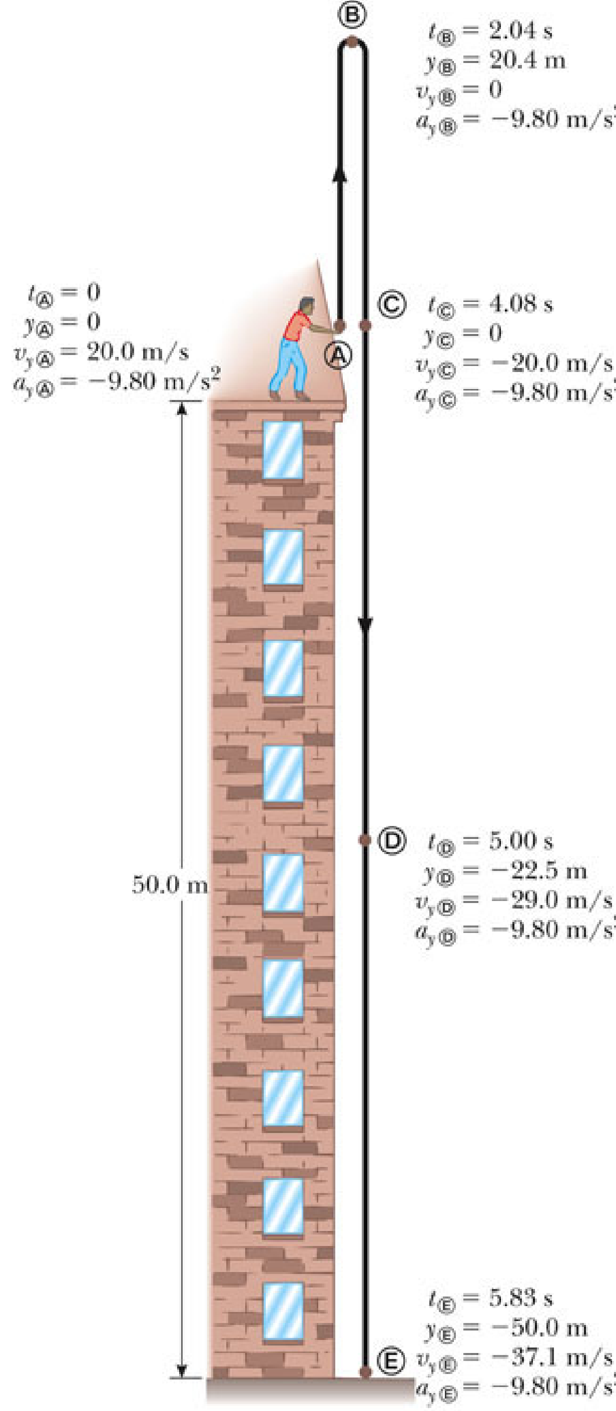


Thrown upward, cont.

- 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)



① Find t when stone reaches its max X

have: $v = f(a, t)$ – good

unknowns:

$x = f(v, t)$

$x = f(a, t)$

$v = f(a, x)$

$v_f = v_i + at$

$t_B = \frac{v_f - v_i}{a} = \frac{0 - 20}{-10\ m/s^2} \approx 2\ s$

② find X_{max}.

– easy now, since we have t_B

use $x = f(a, t) \Rightarrow x_f = x_i + v_i t + \frac{1}{2} a t^2$

$\Rightarrow x_B = 0 + 20 \cdot 2 + \frac{1}{2}(-10) \cdot 2^2 \approx 20\ m$

③ find v at point E

we don't know t ⇒

use $v = f(a, x)$

$$v_f^2 = v_i^2 + 2a(x_f - x_i) \Rightarrow$$

$$\Rightarrow v_f^2 = 20^2 - 2\cdot 10(-50 - 0) = 400 + 1000 = 1400 \ \frac{m^2}{s^2}$$

$$v_f = \pm\sqrt{1400} \approx \pm 37 \ m/s$$ use "−"

$$\boxed{v_E = -37 \ m/s}$$

General Problem Solving Strategy

- 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

Homework 2
(from Physics for Scientists and Engineers, 7th edition)

Chapter 3: vectors
Questions: 1,3, 7, 8
Problems: 5, 8, 14, 30

Due date : Fr. Sept. 5, 08 (in class)