# Phys 103

# Chapter 2

# Motion in One Dimension

By

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# LECTURE OUTLINE

- **2.1 Position, Velocity, and Speed**
- **2.2 Instantaneous Velocity and Speed**
- **2.3 Acceleration**
- **2.5 One-Dimensional Motion with Constant Acceleration**
- **2.6 Freely Falling Objects**

# Lecture Summary

- **After a particle moves along the x axis from some initial position $x_i$ to some final position $x_f$, its displacement is**

$$\Delta x = x_f - x_i$$

- **The average velocity of a particle during some time interval is the displacement Δx divided by the time interval Δt during which that displacement occus:**

$$\overline{v_x} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}$$

- **The average speed of a particle is equal to the ratio of the total distance it travels to the total time interval during which it travels that distance:**

$$\text{Average speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

# Lecture Summary

- **The instantaneous velocity of a particle is defined as:**

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

**The instantaneous speed of a particleis equal to the magnitude of its instantaneous velocity.**

# Lecture Summary

The average acceleration of a particle is defined as the ratio of the change in its velocity $v_x$ divided by the time interval $\Delta t$ during which that change occurs:

$$\overline{a_x} = \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xi}}{t_f - t_i}$$

The instantaneous acceleration is equal to the limit of the ratio $\frac{\Delta \mathrm{v_x}}{\Delta \mathrm{t}}$ as $\Delta$t approaches 0. By definition, this limit equals the derivative of $\mathrm{v_x}$ with respect to t, or the time rate of change of the velocity:

$$\mathrm{a_x} = \lim_{\Delta \mathrm{t} \to 0} \frac{\Delta \mathrm{v_x}}{\Delta \mathrm{t}} = \frac{\mathrm{dv_x}}{\mathrm{dt}} = \frac{\mathrm{d}}{\mathrm{dt}}\left(\frac{\mathrm{dx}}{\mathrm{dt}}\right) = \frac{\mathrm{d^2x}}{\mathrm{dt^2}}$$

When the object's velocity and acceleration are in the same direction, the objectis speed in gup. On the other hand, when the object's velocity and acceleration are in opposite directions, the objectis slowing down.

# Lecture Summary

**The equations of kinematics for a particle moving along the x axis with uniform acceleration $a_x$ are:**

| Kinematic Equations for Motion of a Particle Under Constant Acceleration | |
|---|---|
| **Equation** | **Information Given by Equation** |
| $v_{xf} = v_{xi} + a_x t$ | Velocity as a function of time |
| $x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})t$ | Position as a function of velocity and time |
| $x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2$ | Position as a function of time |
| $v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i)$ | Velocity as a function of position |

# PROBLEMS

- **Section 2.1 Position, Velocity, and Speed**

**4.** A particle moves according to the equation $x = 10t^2$ where $x$ is in meters and $t$ is in seconds.

(a) Find the average velocity for the time interval from 2.00 s to 3.00 s.

(b) Find the average velocity for the time interval from 2.00 to 2.10 s.

# PROBLEMS

- **Section 2.1 Position, Velocity, and Speed**

**5.** A person walks first at a constant speed of 5.00 m/s along a straight line from point $A$ to point $B$ and then back along the line from $B$ to $A$ at a constant speed of 3.00 m/s.

What is (a) her average speed over the entire trip?

(b) her average velocity over the entire trip?

# PROBLEMS

- **Section 2.3 Acceleration**

**11.** A 50.0-g superball traveling at 25.0 m/s bounces off a brick wall and rebounds at 22.0 m/s.

A high-speed camera records this event. If the ball is in contact with the wall for 3.50 ms, what is the magnitude of the average acceleration of the ball during this time interval?

(*Note:* 1 ms = $10^{-3}$ s.)

# PROBLEMS

- **Section 2.3 Acceleration**

**15.** A particle moves along the $x$ axis ccording to the equation
$x = 2.00 + 3.00t - 1.00t2$,
where $x$ is in meters and $t$ is in seconds.
At $t = 3.00$ s,
find (a) the position of the particle,
(b) its velocity,
and (c) its acceleration.

# PROBLEMS

- **Section 2.3 Acceleration**

**16.** An object moves along the *x* axis ccording to the equation

$x(t) = (3.00t^2 - 2.00t + 3.00)\text{m}$.

Determine (a) the <u>average speed</u> between $t = 2.00$ s and $t = 3.00$ s,

(b) the <u>instantaneous speed</u> at $t = 2.00$ s and at $t = 3.00$ s,

(c) the <u>average acceleration</u> between $t = 2.00$ s and $t = 3.00$ s,

and (d) the <u>instantaneous acceleration</u> at $t = 2.00$ s and $t = 3.00$ s.

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

20. A truck covers 40.0 m in 8.50 s while smoothly slowing down to a final speed of 2.80 m/s.

(a) Find its original speed.

(b) (b) Find its acceleration.

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

21. An object moving with uniform acceleration has a velocity of 12.0 cm/s in the positive x direction when its x coordinate is 3.00 cm.

If its x coordinate 2.00 s later is -5.00 cm, what is its acceleration?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

22. A 745i BMW car can brake to a stop in a distance of 121 ft. from a speed of 60.0 mi/h. To brake to a stop from a speed of 80.0 mi/h requires a stopping distance of 211 ft.

What is the average braking acceleration for

(a) 60 mi/h to rest,

(b) 80 mi/h to rest,

(c) 80 mi/h to 60 mi/h?

Express the answers in mi/h/s and in m/s2.

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

23. A speedboat moving at 30.0 m/s approaches a no-wake buoy marker 100 m ahead. The pilot slows the boat with a constant acceleration of -3.50 m/s2 by reducing the throttle.

(a) How long does it take the boat to reach the buoy?

(b) What is the velocity of the boat when it reaches the buoy?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

25. A particle moves along the x axis. Its position is given by the equation $x = 2 + 3t - 4t^2$ with x in meters and t in seconds.

Determine (a) its position when it changes direction and

(b) its velocity when it returns to the position it had at $t = 0$.

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

27. A jet plane lands with a speed of 100 m/s and can accelerate at a maximum rate of -5.00 m/s2 as it comes to rest.

(a) From the instant the plane touches the runway, what is the minimum time interval needed before it can come to rest?

(b) Can this plane land on a small tropical island airport where the runway is 0.800 km long?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

28. A car is approaching a hill at 30.0 m/s when its engine suddenly fails just at the bottom of the hill. The car moves with a constant acceleration of -2.00 m/s2 while coasting up the hill.

(a) Write equations for the position along the slope and for the velocity as functions of time, taking $x = 0$ at the bottom of the hill, where $v_i = 30.0$ m/s.

(b) Determine the maximum distance the car rolls up the hill.

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

29. The driver of a car slams on the brakes when he sees a tree blocking the road. The car slows uniformly with an acceleration of -5.60 m/s2 for 4.20 s, making straight skid marks 62.4 m long ending at the tree.

With what speed does the car then strike the tree?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

32. A truck on a straight road starts from rest, accelerating at 2.00 m/s2 until it reaches a speed of 20.0 m/s. Then the truck travels for 20.0 s at constant speed until the brakes are applied, stopping the truck in a uniform manner in an additional 5.00 s.

(a) How long is the truck in motion?

(b) What is the average velocity of the truck for the motion described?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

33. An electron in a cathode ray tube (CRT) accelerates from $2.00 \times 10^4$ m/s to $6.00 \times 10^6$ m/s over 1.50 cm.

(a) How long does the electron take to travel this 1.50 cm?

(b) What is its acceleration?

# PROBLEMS

- **Section 2.6 Freely Falling Objects**

40. A golf ball is released from rest from the top of a very tall building.

Neglecting air resistance,

calculate

(a) the position

(b) and (b) the velocity of the ball after 1.00, 2.00, and 3.00 s.

# PROBLEMS

- **Section 2.6 Freely Falling Objects**

42. A ball is thrown directly downward, with an initial speed of 8.00 m/s, from a height of 30.0 m. After what time interval does the ball strike the ground?

# PROBLEMS

- **Section 2.6 Freely Falling Objects**

43. A student throws a set of keys vertically upward to her sorority sister, who is in a window 4m above. The keys are caught 1.5s later by the sister’s outstretched hand.

(a) With what initial velocity were the keys thrown?

(b) What was the velocity of the keys just before they were caught?

# PROBLEMS

- **Section 2.6 Freely Falling Objects**

46. A ball is dropped from rest from a height h above the ground. Another ball is thrown vertically upwards from the ground at the instant the first ball is released.

Determine the speed of the second ball if the two balls are to meet at a height h/2 above the ground.

# PROBLEMS

- **Section 2.6 Freely Falling Objects**

48. It is possible to shoot an arrow at a speed as high as 100 m/s.

(a) If friction is neglected, how high would an arrow launched at this speed rise if shot straight up?

(b) How long would the arrow be in the air?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

51. The height of a helicopter above the ground is given by $h = 3.00t^3$, where h is in meters and t is in seconds. After 2.00 s, the helicopter releases a small mailbag. How long after its release does the mailbag reach the ground?

# PROBLEMS

- **Section 2.5 One-Dimensional Motion with Constant Acceleration**

52. A freely falling object requires 1.50 s to travel the last 30.0 m before it hits the ground.

From what height above the ground did it fall?

# Thank You


ACKNOWLEDGEMENTS