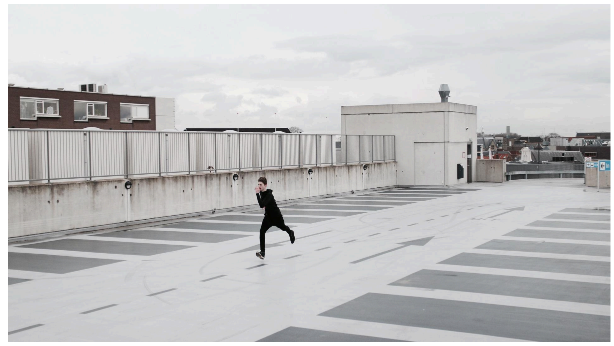
GS104 Motion Tip Sheet

Erik Jensen
Chemeketa Community College
sites.google.com/chemeketa.edu/erikjensen

Introduction

In this chapter, you will study motion (kinematics) without normally considering the causes of motion (or causes of changes in motion). The causes will be explored more fully in the next chapter.



Concepts

- Speed is how fast something is moving.
- Velocity is the speed plus a direction.
- Acceleration is the rate of change in velocity. It can be speeding up, slowing down, or changing direction. The term "deceleration" is not normally used in physics.

Physical Quantities

Word	Symbol	Definition	SI Units (words)	SI Units (symbols)	Other Units
position or distance	x, y, d		meters	m	miles, km, feet
time	t		seconds	s	hours, minutes, days
velocity	v	Rate of change in position, or speed plus direction	meters per second	m/s	mile/hour, any distance unit over any time unit
acceleration	a	Rate of change in velocity	meters per second squared	m/s^2	$feet/s^2$, any distance unit over any time unit squared

Constant Velocity Formula

Formula in words	Formula in symbols	Conditions When True
distance = velocity*time	d = vt v = d/t t = d/v	Only when velocity is constant (so acceleration is zero)

Free-Fall With Initial Velocity of Zero Formulas

Formula in words	Formula in symbols	Conditions When True
distance = ½*little g*time squared	$d = ½gt^2$	Only for free-fall and an initial vertical velocity of zero
velocity = little g*time	$v = g*t$	Only for free-fall and an initial vertical velocity of zero

Constant Acceleration Formulas

Formula in words	Formula in symbols	Conditions When True
distance = initial velocity*time + 1/2*acceleration*time squared	$d = v_{initial}t + ½at^2$	Only when acceleration is constant (including free-fall)
distance = (initial velocity + final velocity)/2 * time	$d = (v_{initial} + v_{final})/2 *t$	Only when acceleration is constant (including free-fall)
final velocity = initial velocity + acceleration*time	$v_{final} = v_{initial} + at$ $a = (v_{final} - v_{initial})/t$	Only when acceleration is constant (including free-fall)
average velocity = (initial velocity + final velocity)/2	$v_{ave} = (v_{initial} + v_{final})/2$	Only when acceleration is constant (including free-fall)
average velocity = distance/time	$v_{ave} = d/t$ $d = v_{ave}*t$	Always

Notes on Formulas

1) By convention with these formulas, the initial position is taken to be zero.
2) By convention, positive numbers typically indicate physical quantities to the right or up. Negative numbers indicate physical quantities to the left or down. For example, an object moving to the left has a negative velocity. But sometimes we ignore this convention.
3) A special case of acceleration for vertical motion with minimal air resistance ("free-fall") on Earth is $a = 9.8 \text{ m/s}^2$ (sometimes denoted as a negative value). This quantity is referred to as "g" or "little g". This acceleration can be assumed for dense objects moving at reasonable speeds (not balloons or bullets) in the air. You may normally round this value to 10 m/s^2 to simplify calculations.
4) Projectiles in free-fall have no acceleration in the horizontal direction and an acceleration of g in the vertical direction. So the constant-velocity equations can be used to quantify its horizontal motion, while the constant-acceleration equations can be used to quantify its vertical motion. A projectile launched horizontally can use the free-fall with initial velocity of zero formulas for the vertical motion.
5) There is no fundamental physical principle stating that every object in the universe obeys one or more of the given equations; some objects move with changing acceleration.

Examples of Applying Motion Equations

1) You need to drive 120 miles at a constant velocity of 60 miles per hour. Predict the time.

   Use the constant velocity equation solved for time:

   $t = d/v = 120$ miles/(60 miles/hour) = 2 hours.

2) You drop a ball from a height of 125 meters. Determine the time it takes to hit the ground and the velocity of impact.

   Use the “free-fall with initial velocity of zero” formulas:

   $d = \frac{1}{2}gt^2$

   $125\text{ m} = \frac{1}{2}(10\text{ m/s}^2)t^2$

   $125\text{ m} = (5\text{ m/s}^2)t^2$

   $t = 5$ seconds since $5*5^2 = 125$

   $v = g*t$

   $v = 10*5$

   $v = 50$ m/s

3) You are driving at a speed of 18 m/s and accelerate at a constant rate for 6 seconds to obtain a velocity of 30 m/s. Determine the distance, acceleration, and average velocity.

   Use the constant-acceleration equations:

   $d = (v_{initial} + v_{final})/2 * t$

   $d = (18\text{ m/s} + 30\text{ m/s})/2 * 6\text{ s}$

   $d = 144$ m

   $a = (v_{final} - v_{initial})/t$

   $a = (30\text{ m/s} - 18\text{ m/s})/6\text{ s}$

   $a = 2\text{ m/s}^2$

   $v_{ave} = (v_{initial} + v_{final})/2$

   $v_{ave} = (18\text{ m/s} + 30\text{ m/s})/2$

   $v_{ave} = 24$ m/s