Sideways or Left-Right Motion

AKA

Horizontal Motion along a Straight Path

Henceforth Called the

X-Mode Motion

7-0 Prelude

(a) *Sideways*, left-right, *east-west*, *horizontal*, *x-axis* and *x-mode* are all synonyms and convey the sense of motion taking place in a straight line, on a flat surface (solid or fluid); as opposed to either being up-down or being along an inclined surface (such as a ramp). Whatever the direction of motion of the objecct, we can always rotate our reference frame so as to coincide the x-axis of our refrnece frame with the straight line along which the object is moving.

Henceforth we shall call all of the above as "x-mode" motion.

(b) Euclidean space is spanned by Cartesian coordinates comprising of x-, y- and z-axes. It is customary to assume that the x-axis lies east-west and y-axis lies north-south.

There are *two* horizontal axes

When an object moves along a straight line, we usually call it the x-mode motion. In almost all books, y-axis is used to represent the north-south mode **as well as** the up-down mode; which is kind of confusing. We shall use the y-axis *only* for north-south (front & back) mode.

(c) The axes are all independent of one another and this independence is very important indeed. Because of this independence, goings-on in one axis are completely opaque to other axes.

(d) The three axes make three planes. These are the (x,y) plane, the (y,z) plane and the (x,z) planes. Of these only the (x,y) plane is horizontal.

There is only *one* horizontal plane.

(e) An object or a system of objects is said to be in a state of equilibrium in x-mode, if it is (i) at rest (ii) moving with uniform (constant) speed or velocity, *in a straight line*, in a horizontal plane.

(f) Objects and systems of objects around us tend to stay in states of equilibrium. At times, they move from one equilibrium state to another. As they do so, they pass through *activity regions*. Activity regions are, in general, short lived. Hence the activity time, Δt, is usually small.

(g) All objects and systems of objects are represented by their centers of mass. It is the center of mass that follows the path (trajectory) of motion.

(f) The supporting flat surface is a next-door neighbor of the object because the two are in contact with one another. In this chapter we shall treat this neighbor as an un-neighbor. In a future chapter, this *ban* on interaction will be lifted.

(h) The general form of a quadratic equation is:

$$ax^2 + bx + c = 0$$

The two solutions for x are:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

The quantity $\sqrt{b^2 - 4ac}$ is known as the *discriminant* of the quadratic equation. It has some interesting applications.

7-1 ***In this chapter we shall study the following:***

(A) Uniform motion *in a straight line on flat Surfaces*

Some examples of objects that usually travel in a straight line are: cars, trucks, trains, air planes, boats, joggers, marbles, bowling balls, etc.

Please note that we shall be dealing strictly with motion in a straight line. The moment an object deviates from straight line motion, for example to go around a bend or to move along a curved path, we shall quit!

(B) Non-uniform motion with uniform acceleration, *in a straight line on flat surface*.

Some examples are: objects that begin to move from rest; objects that come to a complete stop; objects that increase or decrease their velocities from one uniform velocity to another uniform velocity. It is assumed here that all changes in velocities take place at a uniform rate.

7-2 ***In this chapter, we shall not study the following***

Non-uniform motion with non-uniform acceleration.

As an example, consider the motion of an elastic cords, springs, that are being stretched or compressed horizontally. Not that such motions do not exist; they do. We shall not deal with them here. This is like being a store owner who tells you that the store does not carry *that* brand of merchandise.

7-3 ***Kinematics of the x-mode Motion: The Variables.***

The variables of the x-mode motion are:

$\boldsymbol{d}$: displacement, in a flat plane in a straight line; hence forth written as $\boldsymbol{d}$

$\boldsymbol{a}$: uniform acceleration, in a flat plane in a straight line, $\boldsymbol{a}$

$\boldsymbol{v}_o$: uniform initial velocity of an object, in a flat plane in a straight line, $\boldsymbol{v}_o$

$\boldsymbol{v}$: uniform final velocity of an object, in a flat plane in a straight line, $\boldsymbol{v}$

t : time, t

7-4 ***The algebraic sign of acceleration***

The table for the algebraic signs of accelerations, relative to those of velocity, is reproduced here for ready reference.

Table 1: The Algebraic Sign of the Acceleration Vector

Direction of Motion of the Object in a Reference Frame Attached to the Object's Center of Mass		Algebraic Sign of the Velocity Vector in the Said Reference Frame	Is the Speed of the Object Increasing or Decreasing?	Algebraic Sign of Acceleration
x- and y-modes	z-mode			
Forward	up	+	Increasing	+
Forward	up	+	Decreasing	−
Backward	down	−	Increasing	−
Backward-	down	−	Decreasing	+

7-5 *Importing the "Kinematic Equations".*

We shall now import the kinematic equations from Chapter (6). Both, the regular and the short-form sets will be imported. To adapt those equations to the x-mode environment, we should paste the subscript x to the variables. However, since everything is purely in x-mode, there is no reason to give our equations a complicated look.

7-6 *Importing the "Regular" or the "full length" Equations*

Here are the equations.

Table 2: The Four Kinematic Equations; The General Equations

Eqn. #	Equation	Identifying the "absentee" parameter in the equation				Name of equation	Is the name useful?
		$\boldsymbol{d}$	$\boldsymbol{v}$	$\boldsymbol{a}$	t		
1	$t = (\boldsymbol{v} - \boldsymbol{v}_o)/\boldsymbol{a}$ or $\boldsymbol{v} = \boldsymbol{v}_o + \boldsymbol{a}t$	no	yes	yes	yes	distance independent	not really
2	$\boldsymbol{d} = \boldsymbol{v}_o t + (1/2)\boldsymbol{a}t^2$	yes	no	yes	yes	time dependent	yes
3	$\boldsymbol{d} = (1/2)(\boldsymbol{v} + \boldsymbol{v}_o)t$	yes	yes	no	yes	acceleration independent	not really
4	$\boldsymbol{d} = (\boldsymbol{v}^2 - \boldsymbol{v}_o^2)/(2\boldsymbol{a})$	yes	yes	yes	no	time independent	yes

As the left hand sides of these kinematic equations must remain positive (for reasons of being real physical quantities), it is imperative that negative $(\boldsymbol{v} - \boldsymbol{v}_o)$ or $(\boldsymbol{v}^2 - \boldsymbol{v}_o^2)$ be accompanied by negative $\boldsymbol{a}$.

7-7 *Importing the "Short Form" Equations.*

When either $\boldsymbol{v}_o = 0$ or $\boldsymbol{v} = 0$, we may make use of the *short form* equations. While using these equations, we insert the magnitudes of parameters only and leave out their algebraic signs. The set of four equations is given in table (3), below:

Table 3: The Four Kinematic Equations; The "Short Form" Equations

Eqn. #	Equation	Identifying the "absentee" parameter in the equation				Name of equation	Is the name useful?
		$\boldsymbol{d}$	$\boldsymbol{v}$	$\boldsymbol{a}$	t		
1	$t = \boldsymbol{v}/\boldsymbol{a}$ or $\boldsymbol{v} = \boldsymbol{a}t$	no	yes	yes	yes	distance independent	not really
2	$\boldsymbol{d} = (1/2)\boldsymbol{a}t^2$	yes	no	yes	yes	time dependent	yes
3	$\boldsymbol{d} = (1/2)\boldsymbol{v}t$	yes	yes	no	yes	acceleration independent	not really
4	$\boldsymbol{d} = (\boldsymbol{v}^2)/(2\boldsymbol{a})$	yes	yes	yes	no	time independent	yes

7-8 The Principle of "Matching the Absentee Parameter"
The "Deviate" Format

Table 4: The Four Kinematic Equations; The "Deviate" Format

Eqn #	Full length equation	Short form equations	The *Deviate* principle	Enter values from problem
1	$t = \frac{(\boldsymbol{v} - v_o)}{\boldsymbol{a}}$ or $\boldsymbol{v} = \boldsymbol{v}_o + \boldsymbol{a}t$	$t = \boldsymbol{v}/\boldsymbol{a}$ or $\boldsymbol{v} = \boldsymbol{a}t$	$\boldsymbol{d}$	
2	$\boldsymbol{d} = v_o t + (1/2)\boldsymbol{a}t^2$	$\boldsymbol{d} = (1/2)\boldsymbol{a}t^2$	$\boldsymbol{v}$	
3	$\boldsymbol{d} = (1/2)(\boldsymbol{v} + v_o)\,t$	$\boldsymbol{d} = (1/2)\boldsymbol{v}\,t$	$\boldsymbol{a}$	
4	$\boldsymbol{d} = \left(\frac{\boldsymbol{v}^2 - v_o^2}{2\boldsymbol{a}}\right)$	$\boldsymbol{d} = \frac{(\boldsymbol{v}^2)}{2\boldsymbol{a}}$	t	
			v_o	