Accelerated Motion

An object moves when the location or position of the object changes. The rate at which the position changes is the velocity of the object. When the velocity of an object changes, the object undergoes acceleration. ***The velocity of an object will change when the speed and/or direction of the object*** ***changes.*** An object that is NOT accelerating will have constant speed in a straight line. Acceleration

results when:

1. an object speeds up

OR

2. an object slows

OR

3. an object moves along a nonlinear path

**Please note: Acceleration does not mean “speeding up.”**

Your car has three acceleration controls: the gas pedal, the brake pedal, and the steering wheel.

Some authors will use the term *deceleration*. They use this term to mean an object slows and use *acceleration* to mean the object speeds up. I do not like the term *deceleration* and will try not to use it.

Along with acceleration, there are several other terms that describe accelerated motion over time.

**reference point -**  point from which all distances and displacements are measured – the origin of the frame of reference coordinates

**location or position –** how far the object is from the reference point and in what direction (vector)

**velocity –** speed of an object and the direction in which the object moves (vector) – rate of change of position

**speed -**  how fast and object is moving (scalar) – rate of change of distance

**distance –** length of the path an object travels during a time interval (scalar)

**displacement -**  change in position during a time interval (vector) – comparison of where an object is at the end of the time interval to where it was at the beginning of the time interval

**instantaneous -**  describes a quantity that we examine at a specified instant of time

**average –** describes a quantity over a period of time longer than an instant

The units for each quantity are as follows:

acceleration meters/second/second or m/s/s or m/s2

velocity and speed meters/second or m/s

distance and displacement meters

From Newton’s second law of motion we know that a nonzero NET force must act on the object for the object to accelerate. The acceleration of the object is directly proportional to the NET force and inversely proportional to the mass of the object.

IF an object moves in a straight line **at constant speed** THEN the acceleration of the object is **ZERO**.**Equations of Accelerated Motion**

There are quite a few equations that we use to mathematically describe accelerated motion.

When the problem does not ask about force, these are the BIG EQUATIONS:

average a = =  or ΔV = aΔt

average speed = distance / Δt

average V = ½ (Vf + V0)

ΔX = Xf – X0

average V = ΔX / Δt

Vf = V0 + ΔV or Vf = V0 + aΔt (equation I)

ΔX = V0Δt + ½ a(Δt)2 (equation II)

Vf2 = V02 + 2aΔX (equation III)

ΔX = ½ (Vf + V0)Δt (equation IV)

ΔX = VfΔt - ½ a(Δt)2 (equation V)

You can use the equation to solve for an unknown quantity. Each of the BIG FIVE equation contains four symbols. You will use the equation if you know any three and want to find the fourth variable. There are five variables of accelerated motion. Each equation is missing one of the five.

IF you do not know You must know

this variable AND three of these four

you do not want THEN use variables and want

to calculate its value this equation to calculate the fourth

ΔX I Vf V0 a Δt

Vf II ΔX V0 a Δt

Δt III Vf V0 a ΔX

a IV ΔX Vf V0 Δt

V0 V ΔX Vf a Δt

**Sign for acceleration:**

IF an object speeds up THEN velocity and acceleration have the **SAME** sign.

IF an object slows THEN velocity and acceleration have **OPPOSITE** signs.

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**Comparison of UNIFORM MOTION and ACCELERATED MOTION**

**UNIFORM MOTION ACCELERATED MOTION**

DIRECTION: moves in a straight line **linear** – moves in a straight line but may change

direction along this line

**nonlinear** – moves in a curved path

SPEED: Speed will not change. **linear –** Speed may increase and/or decrease.

**nonlinear** – Speed may increase and/or decrease or

may be constant.

Same speed each second **linear** – Speed will **change** by the same amount

each second.

DISPLACEMENT

Same amount and direction **linear** – Displacement will not be the same each second.

of displacement each second. Amount and/or direction may change.

**Comparison of *distance,* *displacement, and position***

**DEFINITIONS:**

distance – the length of the path the object travels – *scalar quantity*

displacement – comparison of where the object ends up to where it started – how far and in which direction is the object at the TO position compared to where it was at the FROM position – *vector quantity*

position – comparison of where the object is to the reference point – how far and in which direction is the object from the reference point – *vector quantity*

IF a moving object does not change direction THEN distance and displacement have the same number value. The displacement will be positive or negative to indicate direction.

An object that moves cannot have a distance of zero.

An object that moves and ends up where it started will have a displacement of zero.

An object that starts at the reference point has the same position as its displacement.

**How to work problems involving linear, accelerated motion that do not involve forces**

STEP 1: Draw a sketch of the situation described in the problem.

STEP 2: Identify the system – the object that you want to investigate.

***STEP 3:******IDENTIY A “TO” POSITION AND A “FROM” POSITION!***

STEP 4:Assign a reference point and positive and negative direction along the line of motion.

STEP 5: List the variables from the equations of accelerated motion.

V0 =

Vf =

a =

Δt =

Xf – X0 = ΔX =

STEP 6: Assign numbers from the problem to the symbols. Use the equations of accelerated motion to solve for what you want to find.

**Important words and phrases in problems**

**starts from rest**  MEANS V0 = zero

**a stationary object** MEANS V0 = zero

**stops** MEANS Vf = zero

**at constant speed** MEANS a = zero

**returns to its**

**starting point** MEANS ΔX = zero

**falls freely** MEANS a = *g* with the sign you choose for downward direction

**at its highest point** MEANS V at that point = zero

**is dropped from a**

**nonmoving platform** MEANS V0 = zero

**is dropped from a**

**platform moving** MEANS V0 = velocity of the moving platform

**upward or downward**

**is thrown straight**

**upward** MEANS V0 = speed of throw with the sign you choose for upward

direction

**speeds up** MEANS V0 and a have the same sign

**slows** MEANS V0 and a have opposite signs