Comments from students at Westwood cyber high school on the physics course (2009-2013)

Comment 1:

“Hey Nada,

WOW! Thanks I really appreciate this! I've been feeling like I'm lost in the woods, and the only way out is to go down each and every path to make sure I've checked every route. So having this list of projects I haven't done/proficiencies I haven't earned is essentially a compass pointing towards the way out. This will definitely help, and again, I really do appreciate it!

Also, it's not all to my credit -- Your projects are about subjects that seem very advanced, but with your examples and the way you explain theories, equations, graphs, and what have you -- really makes an advanced subject understandable and approachable. I remember a while back when I first joined WCHS, I looked at the the physics projects and at a glance they are pretty scary especially when you see equations/formulas, tiny numbers next to big numbers, variables, and terms you've never heard before. If you take the time to go through it, which I admit took me some time to do since I lost interest in anything science related after chemistry in my old high school... but once you do, it is very understandable and approachable. You reach that "ohhhhh" moment very fast, lol. So it's not just me, you do a very good job as well creating these projects.

Thank you so much! :)
~ Dylan”

Comment 2:

“Thank you so much for the kind words as it does mean a lot to me. :)
I did enjoy the Physics course a lot as it did fill me with a lot of useful knowledge that actually began to show itself in the real world to me, especially since I'm taking Flight School right now and the whole plane diagrams and what not were cool to learn about and actually get to see how those things work. As for the Pros, I enjoyed the project lengths. A lot of the classes I've been taking have been almost too long (30+ slides) and I notice those projects drag on and on. I enjoyed the Physics ones because they were at a good length and it kept me focused. I loved how on each answering slide, the equation was right there to use instead of going back and forth between the slide on which I learned the equation.
Also, I enjoyed the help I received from Mr. Saab. He did an excellent job in response and an excellent job going step by step on what to do so Mr. Saab himself is an excellent expert and project creator.
I don't have any cons, to be honest. There was nothing that really bothered me. Everything was a pretty positive experience and my grade goes to show how good my experience was. Thank you so much for the help, Mr. Saab and I even look forward to possibly having you as an expert on an upcoming subject. :)

Alex
Westwood Cyber High School
Cohort 4 / 18 Credits”

References:

1) Humanic. (2013). www.physics.ohio-state.edu/~humanic/. In Thomas Humanic Brochure Page.

Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current.* *www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

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3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

4) Zitzewitz, P. W. (1999). *Glencoe Physics Principles and Problems*. New York: McGraw-Hill Companies, Inc.

5) Nada H. Saab (Saab-Ismail), (2010-2013) Westwood Cyber High School, Physics.

6) Nada H. Saab (Saab-Ismail), (2009- 2017) Wayne RESA, Bilingual Department.

Physics

by
Nada Saab-Ismail

1. Motion of Objects

1.A) Speed and Velocity

1. Scalar and Vector quantities.
2. Distance and Displacement
3. Speed Using and Time.
4. Velocity Using Displacement and Time.

1.B) Acceleration

1. Acceleration, Velocity and Time.
2. Positive Acceleration.
3. Negative Acceleration (Deceleration)

1.C) Kinematic in One Dimension

1. The Five Kinematic Variables.
2. Equations Related to Uniform Motion.
3. Free-Fall.

1.D) Graphical Velocity and Acceleration

1. Velocity: Slope of Position versus Time Graph.

2. Instantaneous Velocity.
3. Acceleration: Slope of Velocity versus Time Graph.

1.E) Displacement from Velocity-Time Graph

1. Displacement: Area Under Velocity- Time Graph.
2. Uniform Motion Graph.
3. Changing Motion Graph.

1.F) Relative Motion

1. Vector, Scalar Quantities.
2. Adding Vector Quantities in the Same or Opposite Directions.
3. Relative Motion.

1.D) Concept Map: Motion of Objects

2. Newton’s Laws of Motion

2.A) Newton’s First Law of Motion

1. Newton’s First Law of Motion.
2. Net Force.
3. Calculation of the Net Force.

2.B) Newton’s Second Law of Motion

1. Newton’s Second Law of Motion.
2. Net Force, Acceleration.

2.C) Newton’s Second Law of Motion - Vector Component

1. Newton’s Second Law of Motion.
2. X and Y Components of the Net Force.
3. Acceleration along the X and Y axis.
4. X and Y Components of Displacement.

2.D) Newton's Third Law of Motion

1. Newton's Third Law of Motion.
2. Normal Force (FN).
3. Equilibrium Relationship to F net and Acceleration.

2.E) Newton's Law of Universal Gravitation

1. Law of Universal Gravitation.
2. Acceleration due to gravity of the Earth.
3. Planetary gravitation.

2.F) Laws for Gravitational Force

1. Kepler's Laws of Planetary Motions.
2. Kepler's 3rd Law of Motion and Newton's Inverse Square Law of Gravity.
3. Einstein and Nature of Gravity.

2.G) Mass and Weight

1. Mass.
2. Acceleration Due to Gravity (*g*).

3. Weight.

2.H) Apparent Weight

2.I) Forces and Newton's Laws

1. Frictional Static Force.
2. Frictional Kinetic Force.
3. Tension Force.

2.J) Motion Along an Inclined Plane

1. Inclined Plane and Newton's Second Law of Motion.
2. Objects at Rest and in Motion Along an Inclined Plane.
3. Objects in Motion Along an Inclined Plane.
4. Analysis of the Acting Forces along the Axis
5. Analysis of the Acceleration along the Axis.

2.K) Uniform Circular Motion

1. Uniform Circular Motion, Speed, Acceleration.
2. Speed of uniform circular motion.

3. Centripetal Force of Uniform Circular Motion.
4. Satellites in Orbits.

2. L) Math or Trigonometry for Two Dimensional Motion and Vectors

2. M) Concept Map- Newton's Laws of Motion

3. Kinematic in Two Dimensions- Projectiles

3.A) Projectile Motion

6. Projectile.
7. Projectile Launched at an Angle.
8. Symmetry in the Motion of Projectile.

3.B) Projectile Launched at an Angle

1. Variable along the x axis.
2. Variable along the y axis.
3. Maximum Height Reached.
4. Hang Time.
5. Range.

3.C) Projectile Launched Horizontally

3.D) Concept Map: Kinematic in Two Dimensions

4. Work

4.A) Work

1. Work.
2. Power.
3. Work and Energy .

4.B) Work Down a Slope

1. General Formula of Work.
2. Work Done on an Object by a Constant Force (F), through a Displacement (s), with an Angle (θ).
3. Work Down a Slope.

4.C) Concept Map: Work

5. Energy

5.A) Energy

1. Renewable and Nonrenewable Resources.
2. Some Types of Energy.

5.B) Kinetic Energy and Work

1. Kinetic Energy.
2. Work-Energy Theorem.

5.C) Gravitational Potential Energy and Work

1. Gravitational Potential Energy.
2. Work-Energy Theorem.

5.D) Conservation of Energy

1. Mechanical Energy.
2. Conservation of Energy.

5.E) Impact Speed

1. Mechanical Energy.
2. Conservation of Mechanical Energy.
3. Speed of Impact.

5.F) Concept Map: Energy

6. Momentum

6.A) Momentum

4. Linear Momentum.
5. Comparing the Momentum of Two Moving Objects.
6. Angular Momentum.

6.B) Impulse-Momentum

1. Impulse.
2. Linear Momentum and Impulse.
3. Impulse-Momentum Theorem.
4. Factors Affecting Impulse.

6.C) Conservation of Momentum

1. Conservation of Momentum.

2. Collision and Coupling of Two Objects Moving in the Same Direction.
3. Collision and Coupling of Two Objects Moving in Opposite Directions.
4. Collision and Coupling of Two Objects, One at Rest and One is Moving.
5. Ballistic Pendulum.

6.D) Linear Momentum

1. Types of Collisions and Kinetic Energy

7. Electricity

7.A) Electricity

6. Net Electric Charge.
7. Conductor and Insulators.
8. Charging by Contact, Friction, Induction.

7.B) Coulomb's Law

1. Net Electric Charge.
2. Coulomb's Law.
3. Net Electrostatic Force.

7.C) Electric Field

1. Electric Field.
2. Electric Field Calculation.
3. Electrostatic Force.

7.D) Electric Potential, Current, Resistance

1. Electric Potential Energy.
2. Work and Electric Potential.
3. Electric Current.
4. Resistance in Electric Circuit.
5. Electric Circuit.

7.E) Electric Circuit, Ohm's Law

1. Electric Circuit.
2. Capacitor.

3. Ohm's Law.
4. Power in Electric Circuit.
5. Electric Energy.

7.F) Kirchhoff's Laws

1. Kirchhoff's Voltage Law (Loop Rule).
2. Kirchhoff's Current Law (Junction Rule).

7.G) Series Circuits

1. Series Circuits.
2. Equivalent Voltage.
3. Equivalent Resistor.

7.H) Parallel Circuits

1. Parallel Circuits.
2. Equivalent Voltage.
3. Equivalent Resistor.

7.I) Concept Map: Electricity

8. Thermodynamic Laws

8.A) Heat/Thermal Energy

4. Heat Energy.
5. Specific Heat Capacity.
6. Conservation of Heat Energy.

8.B) Randomness/Entropy

1. Entropy.
2. Entropy and Second Law of Thermodynamics.
3. Third Law of Thermodynamics.

8.C) Thermodynamic Laws

1. Thermodynamics.
2. First Law of Thermodynamics.
3. Second Law of Thermodynamics.
4. Heat Engine and Refrigeration Process.

5. Efficiency.

8.D) <u>Concept Map: Thermodynamic Laws</u>

9. Harmonic Motion

9.A) <u>Spring</u>

6. Hooke's Law, Spring.
7. Elastic Force.
8. Elastic Potential Energy.
9. Elastic Work.
10. Conservation of Mechanical Energy.

9.B) <u>Pendulum</u>

1. Pendulum.
2. Period of Pendulum.
3. Transformation of Energy.
4. Period of Planets.

9.C) Concept Map: Harmonic Motion

10. Light

10.A) Light and Flat Mirrors

5. Light and Mirrors.
6. Reflection.
7. Image Formation by Plane Mirror.

10.B) Light and Concave Mirrors

1. Concave Mirror.
2. Ray Tracing and Images in Concave Mirrors.

10.C) Light and Convex Mirrors

1. Convex Mirror.
2. Ray Tracing and Images in Convex Mirror.

10.D) Mirror Equations

1. Mirror Equation.
2. Magnification Equation.
3. Summary of Sign Conventions for Spherical Mirrors.

10.E) Refraction, Snell's Law

1. Light, Refraction.
2. Index of Refraction.
3. Snell's Law of Refraction.
4. Apparent Depth.

10.F) Concept Map: Light

Speed and Velocity

by

Nada Saab-Ismail, PhD, MAT, MEd, IB

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P2.1A Calculate the average speed of an object using the change of position and elapsed time.

P2.2A Distinguish between the variables of distance, displacement, speed, velocity, and acceleration.

Items:

1. Scalar and Vector quantities.

2. Distance and Displacement.

3. Speed Using Distance and Time.

4. Velocity Using Displacement and Time.

Introduction

In this universe, most things are in constant motion, whether it be planets orbiting suns, electrons in atoms, or birds in the sky. Describing these motions mathematically is the first step toward understanding them.

Kinematics deals with the concepts that are needed to describe motion.

Dynamics deals with the effect that forces have on motion.

Together, kinematics and dynamics form the branch of physics known as **Mechanics**.

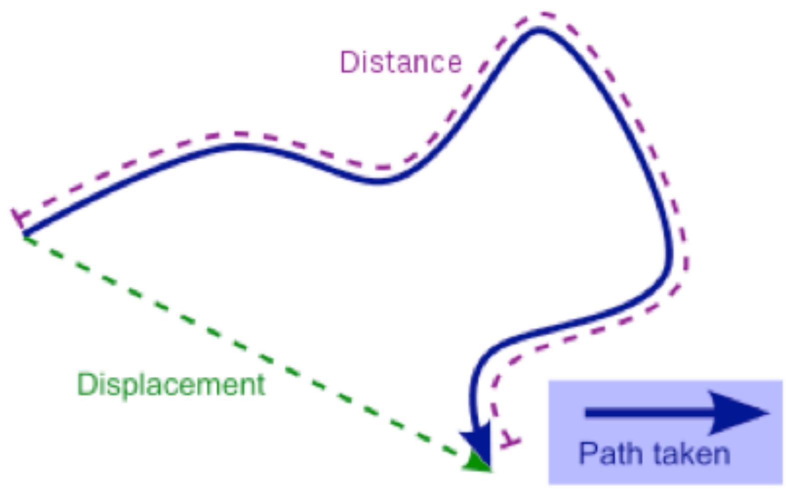
Translational motion refers to motion without rotation. Strictly linear motion can be viewed in one dimension.

Distance

Distance is the total measure of the path traveled from starting to finishing position. It is a scalar quantity. Scalar quantities have a magnitude and a unit. A distance of 2.0 m (2.0 is the magnitude, m is the unit meter)

Displacement

Displacement is a vector that points from an object's initial position to its final position. It is strictly the shortest difference in the starting and finishing position.



Vector quantities have a <u>magnitude</u>, a <u>unit</u> and a <u>direction</u>. The direction is an important piece of information.

Example: A displacement 2 meters north from where you are standing is expressed as 2.0 m[N]. That means (2.0 is the magnitude, m is the unit meter and N is north direction)

Distance and **displacement** are different. When you traveled 50 km to the East and then 20 km to the West, the total distance you traveled is 70 km (50 + 20), but your displacement is 30 km (50 -20) East.

<u>Note:</u> N is for North. S is for South. E is for East. W is for West

Displacement Formula
$\vec{\Delta x} = \vec{x} - \vec{x}_0$
Displacement = Final position - Initial position

Δ is the Greek Letter **delta,** commonly used in mathematics and science. It means "**change in**". It is usually used to express difference. The SI unit for displacement is meter (m).

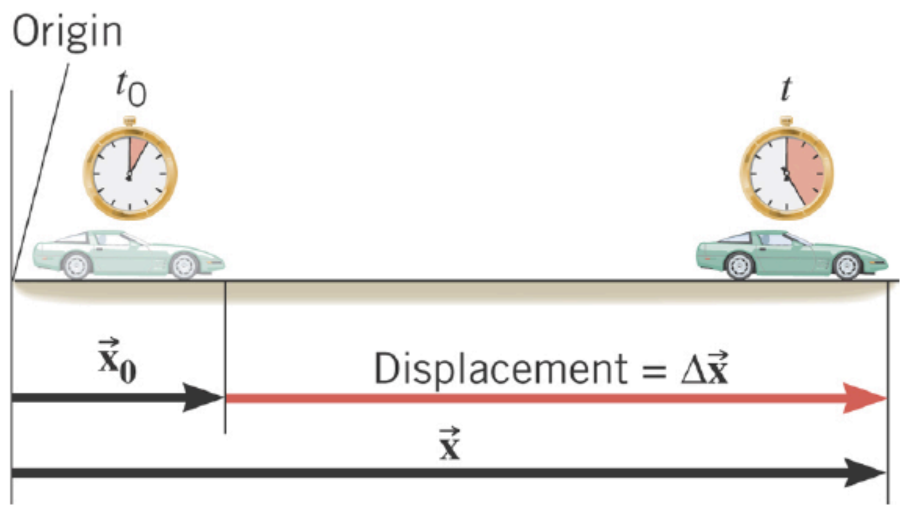
$\rightarrow$: means that this is a vector quantity with direction

X_0 is the initial position

X is the final position.

How to calculate displacement or change in position?

To describe the motion of an object, we must be able to specify the location of the object at all times as shown in the figure below. The figure shows the initial position of a car and the final position of a car after 20 minutes.



$\vec{x}_o$ = initial position $\qquad \vec{x}$ = final position

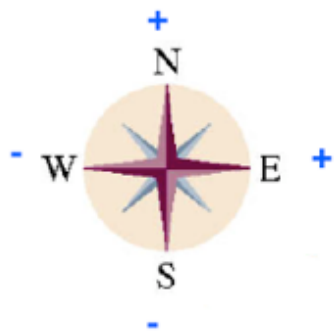
$$\Delta\vec{x} = \vec{x} - \vec{x}_o = \text{displacement}$$

Displacement Along a Straight Line:

Often we deal with motion along a straight line. We assign a positive value for a displacement in one direction along the line. A displacement in the opposite direction is assigned a negative value.

We normally assume that the east direction has the positive values. So, the west direction has a negative value.

We also can assume that the north direction has the positive values. So, the south direction has a negative value.

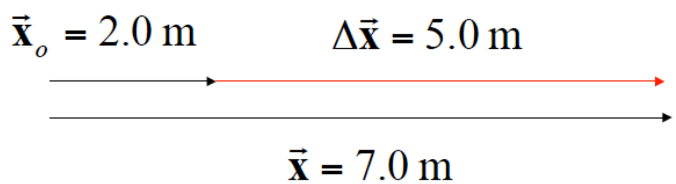


Examples are shown below.

Example 1:

Assuming that the east direction has the positive values. So, the west direction has a negative value.

Assuming that Suppose that the original position of the car was + 2.0 m in the east direction. The driver drove the car in the east direction to a final position of + 7.0 m. The car displacement is 5.0 m toward the east direction as shown below.

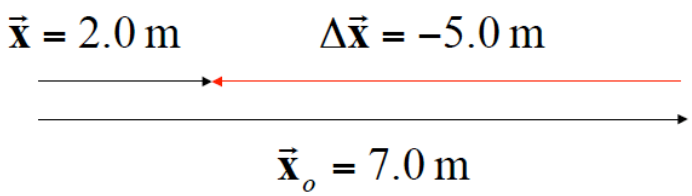


$$\Delta\vec{\mathbf{x}} = \vec{\mathbf{x}} - \vec{\mathbf{x}}_o = 7.0\ \mathrm{m} - 2.0\ \mathrm{m} = 5.0\ \mathrm{m}$$

Example 2:

Assuming that the east direction has the positive values. So, the west direction has a negative value.

Suppose that the original position of the car was + 7.0 m in the east direction. The driver drove the car in the west direction to a final position of + 2.0 m. The car displacement is - 5.0 m, or 5.0 m in the west direction.

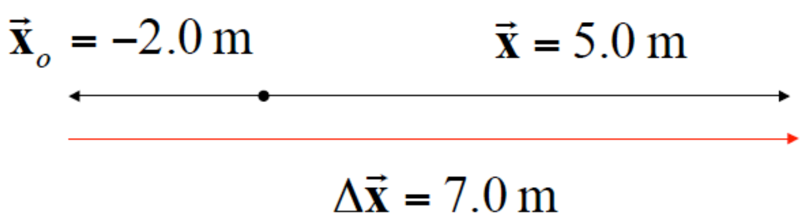


$$\Delta\vec{\mathbf{x}} = \vec{\mathbf{x}} - \vec{\mathbf{x}}_o = 2.0\,\mathrm{m} - 7.0\,\mathrm{m} = -5.0\,\mathrm{m}$$

Example 3:

Assuming that the east direction has the positive values. So, the west direction has a negative value.

Suppose that the original position of the car was 2.0 m in the west direction, or - 2.0 m. The driver drove the car in the east direction to a final position of + 5.0 m. The car displacement is 7.0 m in the east direction.

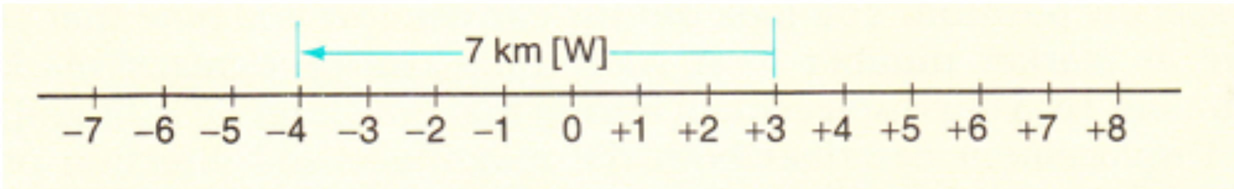


$$\Delta\vec{\mathbf{x}} = \vec{\mathbf{x}} - \vec{\mathbf{x}}_o = 5.0\,\mathrm{m} - \left(-2.0\right)\mathrm{m} = 7.0\,\mathrm{m}$$

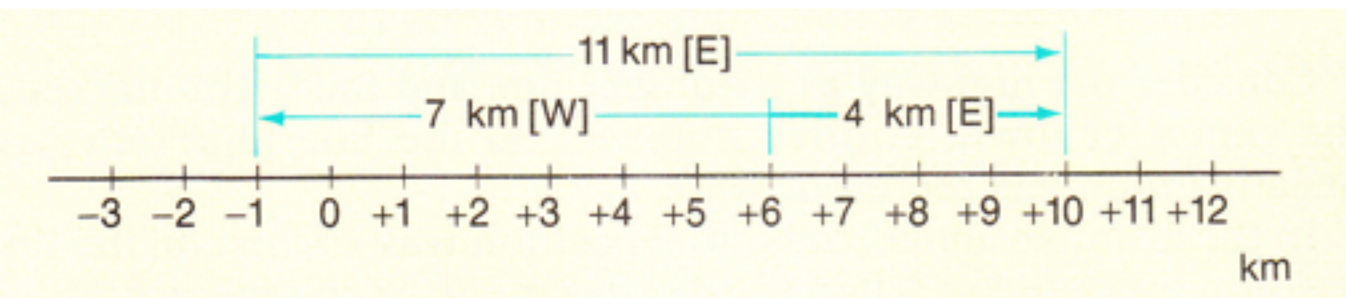
Notes:

Remember that displacement for an interval is simply the difference between the final position and the initial position.

1. The displacement for a driver who started at marker +3 km (in the east direction) and ended at marker -4 km (in the west direction) is 7 km [W]



2. The displacement of a cyclist who starts at maker + 6 km moves to -1 km and then proceeds to marker +10 km is 11 km [E]



Average Speed and Distance

Average speed is the distance traveled divided by the time required to cover the distance. The formula of average speed in shown in the table below as well as two derivatives (a, b) of the formula. The symbol for speed is v.

Formula of Average Speed	Derivatives of the Formula
$\text{Average speed} = \dfrac{\text{Distance}}{\text{Elapsed time}}$	**a**) Distance = (Average Speed) x (Time) **or** b) Time = (Distance) / (Average Speed)

Speed is a scalar quantity. A speed of 80 km/h means the the object moves 80 km every one hour (80 is the magnitude, km/h is the unit kilometer/hour). SI units for speed: meters per second (m/s) or km/h

Example 4:

What is the speed of a train that travels a distance of 480 km in 8.0h?

Average Speed = Distance / Time

= 480 / 8

= 60 km/h

Example 5:

How far does a jogger run in 1.5 hours (5400 s) if his average speed is 2.22 m/s?

Average Speed = Distance / Time

or

Distance = (Average Speed) x (Time)

= (2.22) x (4500)

= 12000m

Average Velocity and Displacement

Average Velocity is the displacement divided by the elapsed time.

The symbol for velocity is ($\vec{v}$)

The formula of average speed in shown in the table below as well as two derivatives (a, b) of the formula.

Uniform motion is motion at a constant velocity.

Formula of Average Velocity	Derivatives (a, b) of the Formula
$\text{Average velocity} = \dfrac{\text{Displacement}}{\text{Elapsed time}}$	**a**) Displacement = (Average Velocity) x (Time) **or** b) Time = (Displacement) / (Average Velocity)

Velocity is a vector quantity and has a direction. It shows how fast an object is moving to which direction.   A velocity of 80 km/h[E] , means that the object is moving with a speed of 80 km/h in the east direction (80 is the magnitude, km/h is the unit kilometer/hour and E is East direction).

Average velocity can be calculated mathematically as shown below:

$$\overline{\vec{\mathbf{v}}} = \frac{\vec{\mathbf{x}} - \vec{\mathbf{x}}_o}{t - t_o} = \frac{\Delta \vec{\mathbf{x}}}{\Delta t}$$

In this formula:

$\vec{\mathbf{x}}_o$ = initial position $\vec{\mathbf{x}}$ = final position

$\Delta \vec{\mathbf{x}} = \vec{\mathbf{x}} - \vec{\mathbf{x}}_o$ = displacement

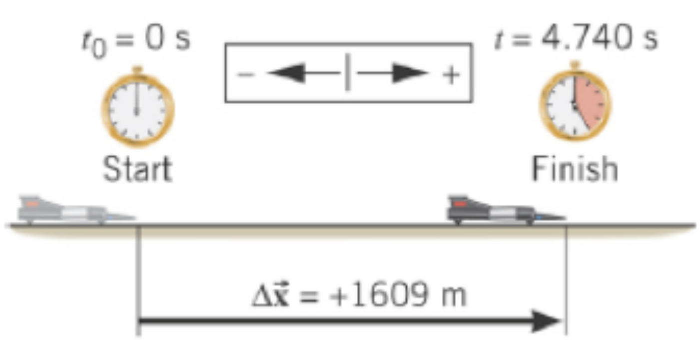
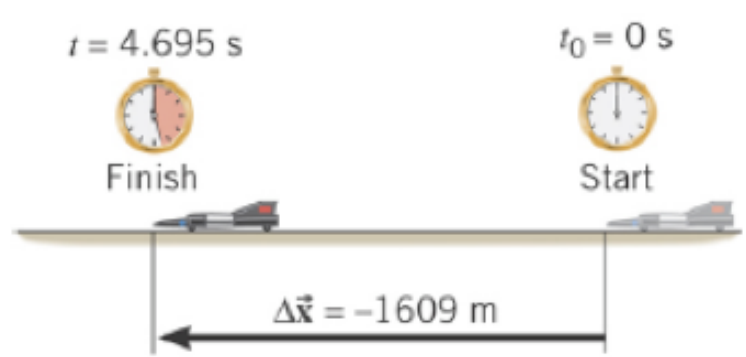
t = final time

t_o = initial time

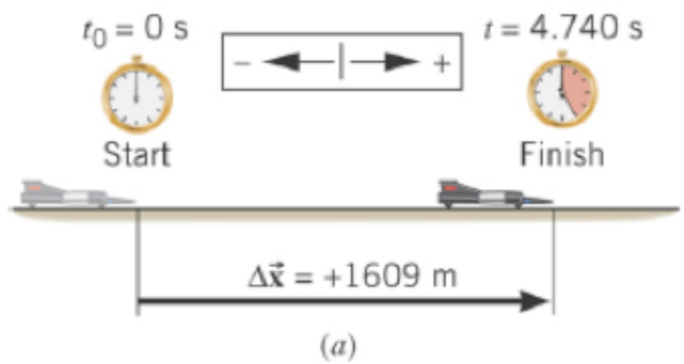
$$\Delta t = \text{elapsed time} = t - t_o$$

Example 6: The World’s Fastest Jet-Engine

in 1997, Car Andy Green in the car Thrust SSC set a world record of 341.1 m/s. To establish such a record and nullify wind effects, the driver makes two runs through the course, one in each direction. From the data given in the figure below, determine the average velocity for each run a (east) and b (west).

a) Run in the forward east direction (+) **Displacement = +1609 m** **Elapsed time = 4.740 s**	**b) Run in backward west direction (-)** **Displacement = -1609 m** **Elapsed time = 4.695 s**
 (a)	 (b)

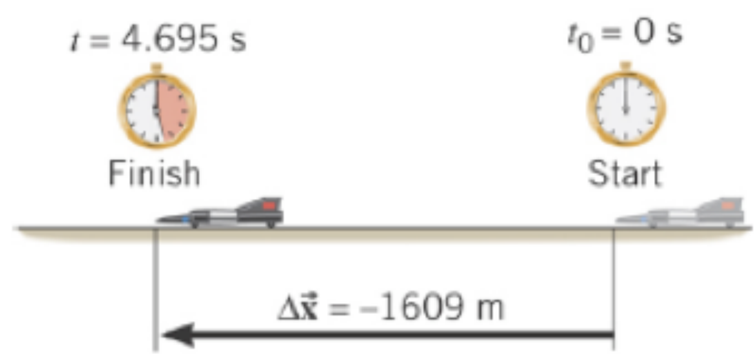
a) In forward east direction (+): the driver moves 1609 m forward during 4.695 seconds. So, the displacement is +1609 m. The velocity is +339.5 m/s or 342.7 m/s [west] as calculated below;



Velocity ($\vec{v}$) = displacement / elapsed time

$$\bar{\vec{v}} = \frac{\Delta\vec{x}}{\Delta t} = \frac{+1609\ \text{m}}{4.740\ \text{s}} = +339.5\ \text{m/s}$$

g) Backward west direction (-): the driver moves 1609 m backward during 4.695 seconds. So, the displacement is -1609 m. The velocity is -342.7 m/s or 342.7 m/s [west] as calculated below;



(b)

Velocity ($\vec{v}$) = displacement / elapsed time

$$\bar{\vec{v}} = \frac{\Delta\vec{x}}{\Delta t} = \frac{-1609\ \text{m}}{4.695\ \text{s}} = -342.7\ \text{m/s}$$

Example 7: Speed and Velocity

Suppose a car travels with uniform motion from a position of 2.0 km[N] to a position of 20 km[S] in 0.5h. Find the car's a) displacement, b) velocity, c) distance travelled and d) speed. In this case (+) will be used for north and (-) will be used for south.

a) Displacement = Final position - Initial position = -20 - 2.0 = - 22 km or 22 km [S],

b) Average velocity= Displacement / Time = -22 / 0.5 = - 44 km/h or 44 km/h [S]

c) Distance = 20 + 2 = 22 km

d) Speed = Distance / Time = 22 / 0.5 = 44 km/h

Note that since the car does not change direction, the distance is the same as the magnitude of the displacement, and the speed is the same as the magnitude of the velocity.

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1) Humanic. (2013). www.physics.ohio-state.edu/~humanic/. In Thomas Humanic Brochure Page.

Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current.* *www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

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3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

4) Zitzewitz, P. W. (1999). *Glencoe Physics Principles and Problems*. New York: McGraw-Hill Companies, Inc.

5) Nada H. Saab (Saab-Ismail), (2010-2013) Westwood Cyber High School, Physics.

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Acceleration

by

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saab1055@gmail.com

P2.1B Represent the velocities for linear and circular motion using motion diagrams (arrows on strobe pictures).

P2.1C Create line graphs using measured values of position and elapsed time.

Items:

1. Acceleration, Velocity and Time.

2. Positive Acceleration.

3. Negative Acceleration (Deceleration) .

Acceleration (Symbol: a)

Acceleration shows the change in velocity in a unit time. When an object's velocity changes, it accelerates. Acceleration is the rate of change of velocity.

Acceleration ($\vec{a}$) is a vector quantity. It has a magnitude, a unit and a direction. Acceleration units are (km/h)/s or (m/s)/s = m/s^2.

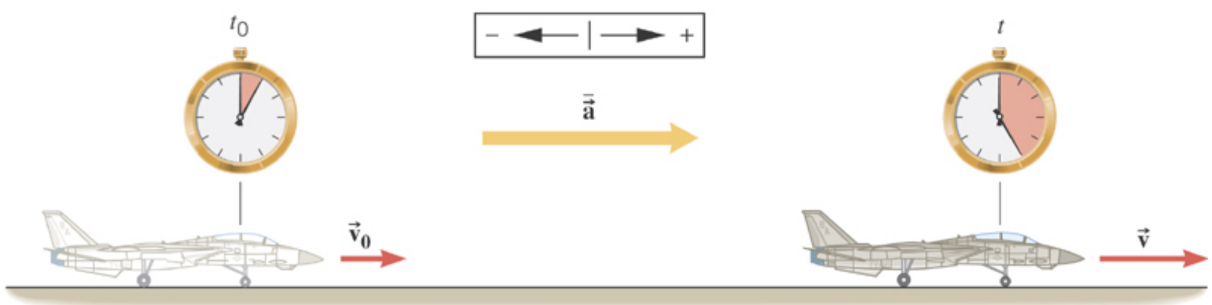
If a car acceleration is 1 m/s^2 [E]: We say that 1 is the magnitude (number, value), m/s^2 is the unit and E is the east direction.

Acceleration can be both positive (speeding up) and negative (slowing down).

The picture below shows a plane during a takeoff. The plane accelerates from an initial velocity v_0 at an initial time t_0, to a final velocity v at the final time t toward east. So, the velocity changes ($\Delta v = v - v_0$) during the time interval $\Delta t = t - t_0$

Note that we call the east direction to be the positive direction, so the west direction is negative direction.

The plane is moving forward toward the east positive direction. The acceleration (a) is positive (yellowish arrow)



The average acceleration can be calculated with the formula:

Average Acceleration	
$\vec{\bar{a}} = \dfrac{\vec{v} - \vec{v}_o}{t - t_o} = \dfrac{\Delta\vec{v}}{\Delta t}$	Acceleration = <u>(final velocity - initial velocity)</u> final time - initial time

$\vec{a}$: the object's average acceleration

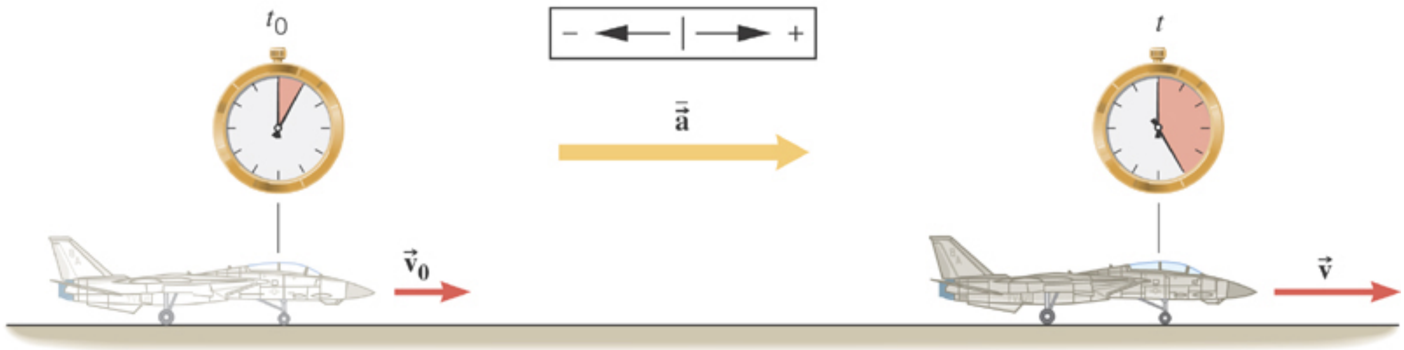
Δt: time interval over which the object's velocity changed

$\vec{v}$: The object's final velocity at the end of the time interval

$\vec{v_0}$: the object's initial velocity at the beginning of the time interval

Example 1: if a car moves from the rest to 5 m/s in 5 seconds, its average acceleration = 5/5 = 1 m/s^2

Positive Acceleration: Increasing Velocity ($a > 0$, speeding up)



Suppose the plane starts from rest (v_0 = 0 m/s) when t_0 = 5 s. The plane accelerates down the runway and at t = 25 s attains a velocity (v) of 240 km/h, where the plus sign indicates that the velocity points to the right.

Plane Data				
v	v_o	a	t	t_o
240 km/h	0 m/s	?	25 s	5 s

we can determine the average acceleration of the plane as follows:

$$\text{Acceleration} = \frac{\text{(final velocity - initial velocity)}}{\text{final time - initial time}}$$

a = 240 - 0 / 25 - 5

= 240 / 20

= 12 m/s^2 [East]

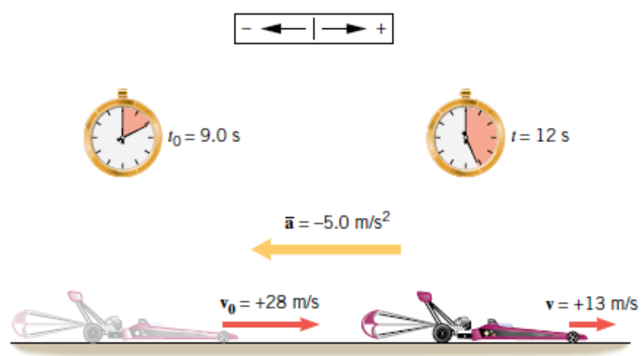
So, the velocity of the of the plane increases 12 m/s every one second.

Negative Acceleration: Decreasing Velocity (deceleration $a < 0$, slowing down)

When an object slows down, its acceleration is in the opposite direction to its velocity. We call slowing down deceleration. it is easier an acceleration in the opposite direction to the velocity.

A drag racer slowing down in figures (a) and (b) below. The drag racer was moving with a velocity of $v_0 = 28$ m/s. At $t = 9.0$ s , the drag racer started slowing down using a parachute and braking. When $t = 12$ s, the velocity was reduced to v = 13 m/s. What is the average acceleration of the dragster?

(a)



(b)

Drag Racer Data Table				
v	v_o	a	t	t_o
13 km/h	28 m/s	?	12 s	9 s

$$\text{Acceleration} = \frac{\text{(final velocity - initial velocity)}}{\text{final time - initial time}}$$

a = 13 - 28 / 12- 9 = -15 / 3 = - 5.0 m/s² [East] or 5.0 m/s² [West]

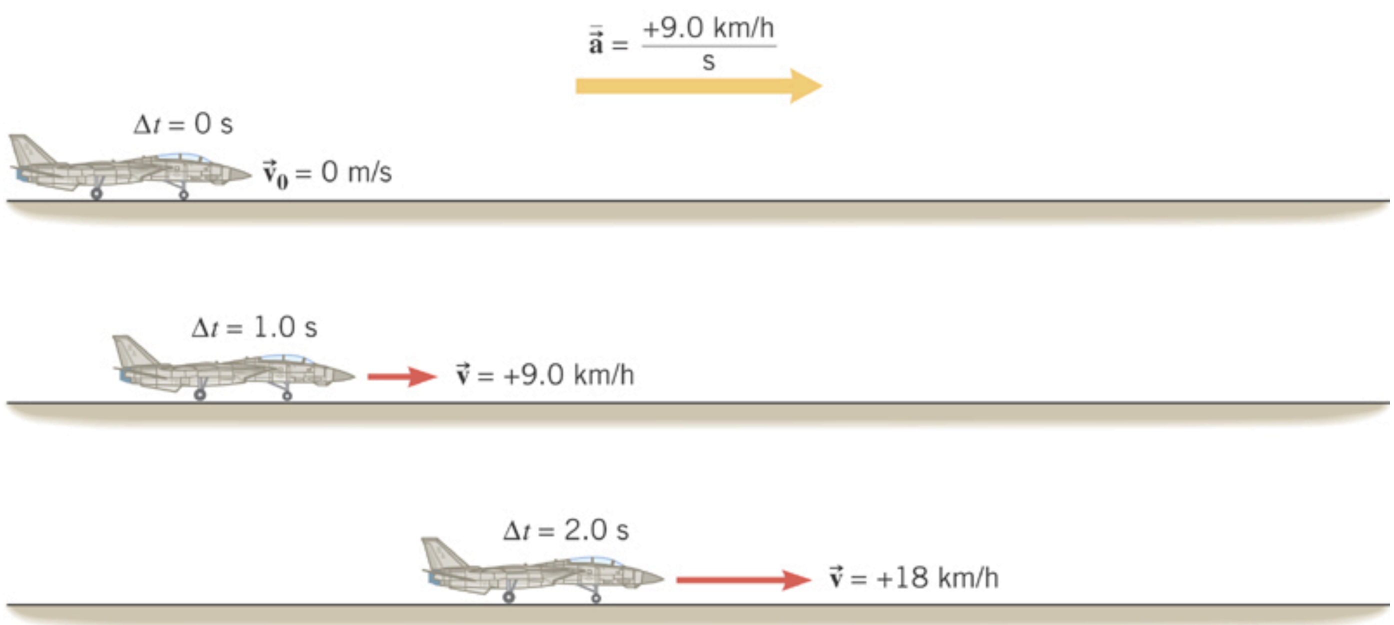
So, the velocity of the drag racer decreases -5.0 m/s every one second.

Notice how the negative sign in the final answer (**-** 5.0 m/s^2 [E]) is removed and replace with the opposite direction west (5.0 m/s^2 [w])

Example 2: *A Plane, Accelerating;*

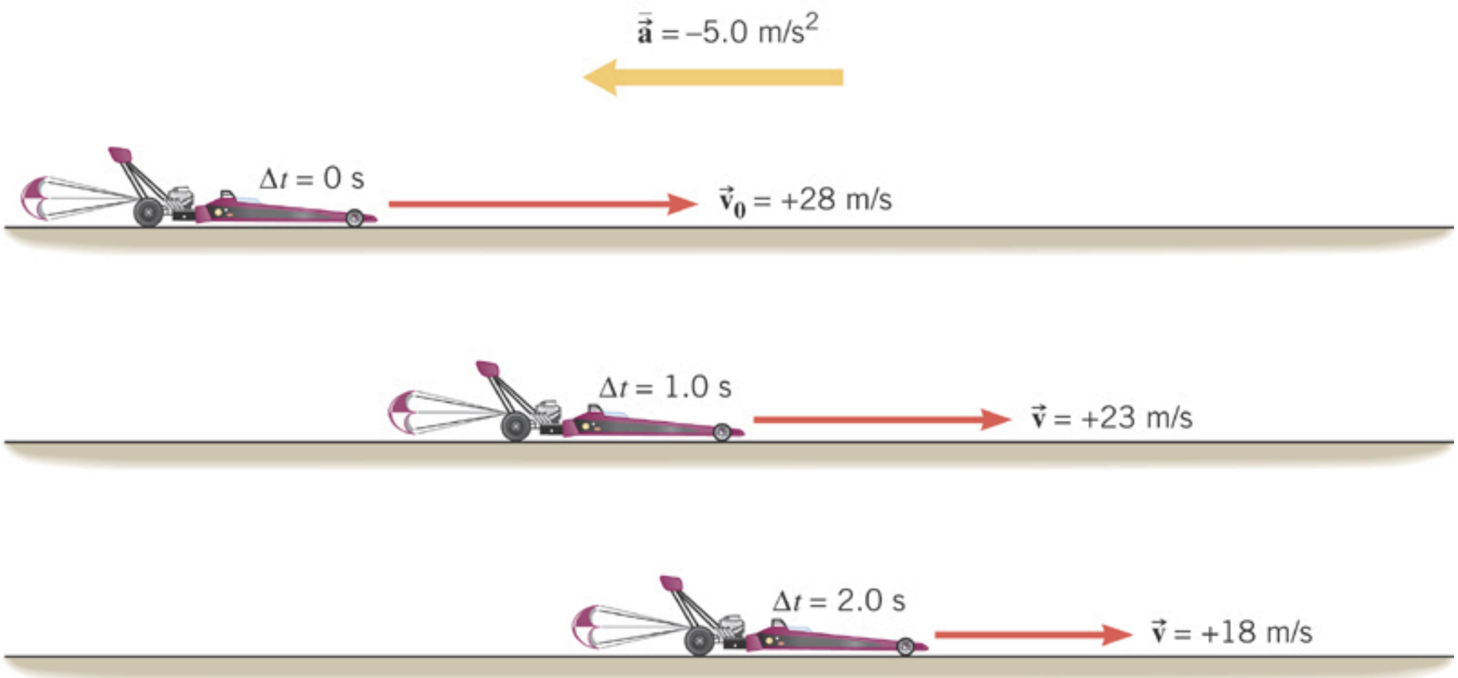
A plane has an acceleration (a) of +9.0 km/h/s, which means that the velocity (v) of the plane increases by 9.0 km/h during each second of the motion toward the positive direction. The "+" direction for (a) and (v) is to the right.

During the first second ($\Delta t = 1.0$ s), the velocity increases from 0 to 9.0 km/h; during the next second ($\Delta t = 2.0$ s), the velocity increases to 18 km/h, and so on.



Example 3: A Dragster, Deccelerating;

The picture below shows how the velocity (v) of the dragster changes during the braking, assuming that the acceleration (a) is constant throughout the motion. The acceleration and velocity point are in opposite direction. The initial velocity is + 28 m/s. Here, an acceleration of - 5.0 m/s^2 means the velocity decreases by 5.0 m/s each second of elapsed time (Δt).



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Kinematic in One Dimension

by

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P2.1g Solve problems involving average speed and constant acceleration in one dimension.

P2.2B Use the change of speed and elapsed time to calculate the average acceleration for linear motion.

Items:

1. The Five Kinematic Variables.

2. Equations Related to Uniform Motion.

3. Free-Fall.

Equations of Kinematics for Constant Acceleration

In this universe, most things are in constant motion, whether it be planets orbiting suns, electrons in atoms, or birds in the sky. Describing these motions mathematically is the first step toward understanding them.

Kinematics deals with the concepts that are needed to describe motion.

There are five kinematic variables related to motion with constant acceleration. They are:

1. displacement, x
2. acceleration (constant), a
3. final velocity (at time t), v
4. initial velocity, v_o
5. elapsed time, t

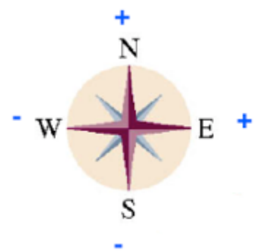
There are 4 kinematic equations that relate the 5 variables and deal with motion.

Kinematic Equations for Motion with Constant Acceleration
$v = v_o + at$
$x = \frac{1}{2}(v_o + v)t$
$v^2 = v_o^2 + 2ax$
$x = v_o t + \frac{1}{2}at^2$

Steps to solve kinematic problems:

1. Make a drawing.

2. Decide which directions are to be called positive (+) and negative (-).

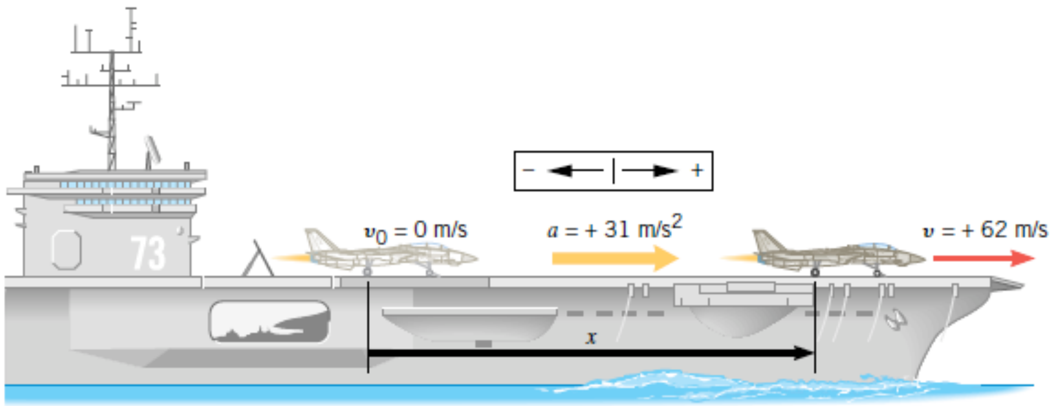


3. Make a Data Table: Write down the values that are given for any of the five kinematic variables:

Data Table				
x	a	t	v_o	v

4. Verify that the information contains values for at least three of the five kinematic variables. Select the appropriate equation.

Example 1: **Jet taking off:** A jet is taking off from the deck of an aircraft carrier as shown in the figure below. Starting from rest, the jet is catapulted with a constant acceleration (a) of +31 m/s² (east direction) along a straight line and reaches a velocity (v) of +62 m/s. Find the displacement (x) of the jet.

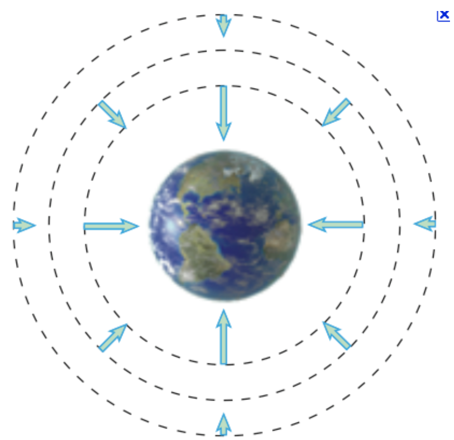


Jet Data				
x	a	v	v_0	t
?	+31 m/s²	+62 m/s	0 m/s	

$$x = \frac{v^2 - v_o^2}{2a} = \frac{(62\,\text{m/s})^2 - (0\,\text{m/s})^2}{2(31\,\text{m/s}^2)} = +62\ \text{m}$$

Free Falling Body

Earth is surrounded by a gravitational force field (blue- greenish vectors $\Rightarrow$, in the picture below). This means that every mass large or small feels a force pulling it towards its center.



In the absence of air resistance, all bodies at the same location above the Earth fall vertically with the same acceleration due to gravity.

This idealized motion is called **free-fall.**

Acceleration due to gravity (g)

The acceleration of a freely falling body is called the acceleration due to gravity.

The acceleration due to gravity is:

a) directed toward the center of the Earth,

b) has the symbol g

c) has the constant value of $9.80 m/s^{2.}$

Acceleration due to gravity = a = g = $9.80 m/s^2$ or $32.2\ ft/s^2$

In the absence of air resistance, all bodies at the same location above the Earth fall vertically with the same acceleration due to gravity **= a = g = $9.80 m/s^2$**

Example is shown next.

Effect of air resistance on the speed of falling objects

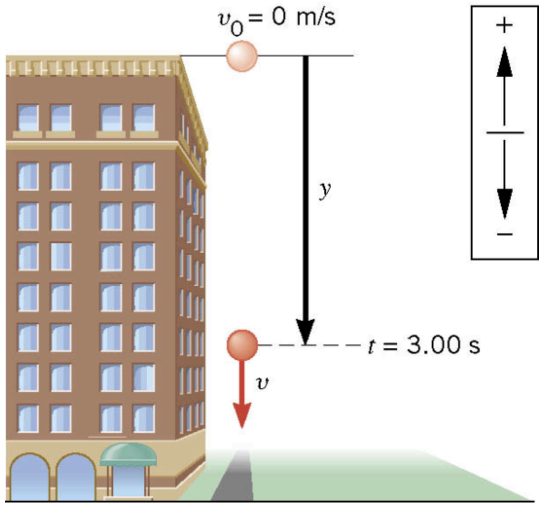
The figure show the effect of air resistance on the speed of falling objects.

a) Air filled tube: In the presence of air resistance, the acceleration of the rock is greater than that of the paper. The effect of air resistance is responsible for the slower fall of the paper.

b) Evacuated tube: In the absence of air resistance, both the rock and the paper have the same acceleration due to gravity ($g = 9.80 m/s^2$ or $32.2 ft/s^2$).

Example 2: ***A Falling Stone:*** A stone is dropped from the top of a tall building. After t = 3.00s of free fall, what is the displacement y of the stone?

Because it is a free fall, a = **-9.80m/s² (**negative because the up direction is +).



y	a	v	v_o	t
?	-9.80 m/s²		0 m/s	3.00 s

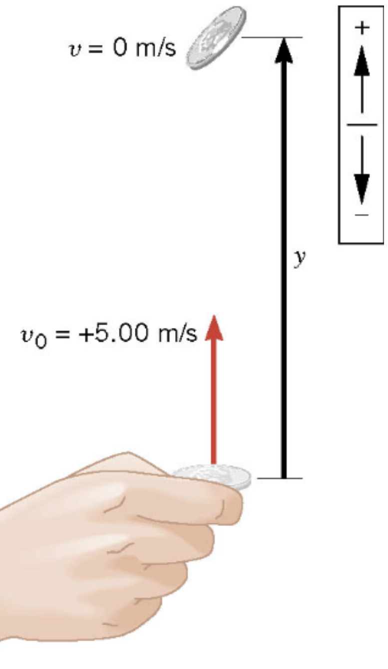
$$y = v_o t + \tfrac{1}{2} a t^2$$

$$= (0\,\text{m/s})(3.00\,\text{s}) + \tfrac{1}{2}(-9.80\,\text{m/s}^2)(3.00\,\text{s})^2$$

$$= -44.1\,\text{m}$$

Example 3: A Referee Tosses the Coin Up.

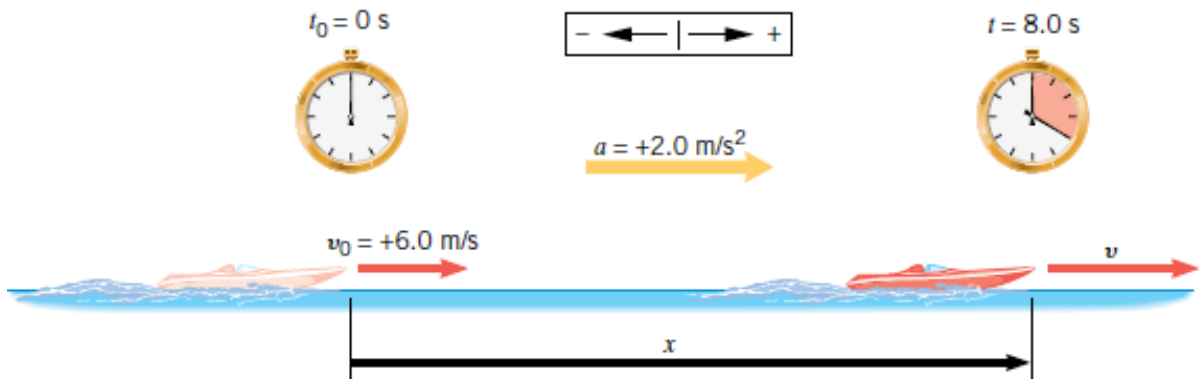
The referee tosses the coin up with an initial speed of 5.00m/s. In the absence of air resistance, what kinematic variables can you calculate?



Data Table				
y	a	t	v_o	v

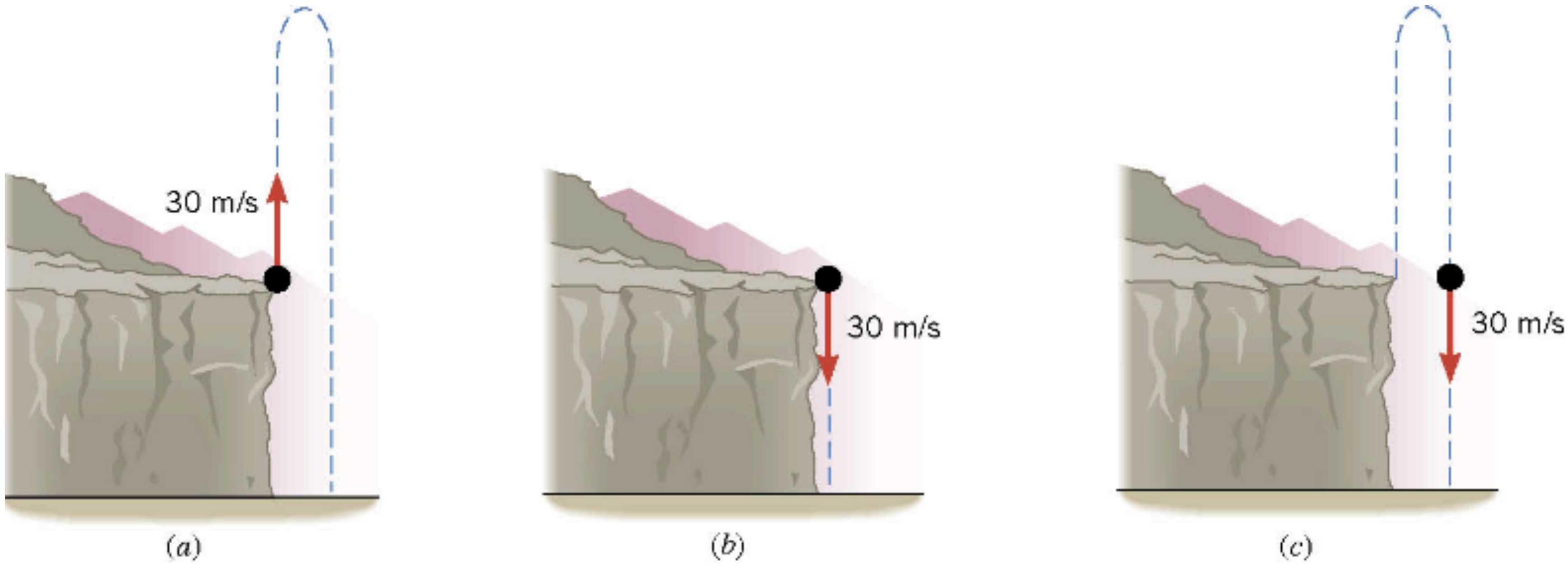
Example 4: *Speedboat with a Constant Acceleration;*

The speedboat below has a constant acceleration of $+2.0\ m/s^2$. If the initial velocity of the boat is +6.0 m/s, what kinematic variables can you calculate after 8.0 seconds?



Data Table				
x	a	t	v_o	v

Example 5: *From the Edge of a Cliff, a Pellet is Fired from a Gun;*



Picture (a): From the edge of a cliff, a pellet is fired straight upward from a gun. The pellet's initial speed is 30 m/s.

Picture (b): From the edge of a cliff, the pellet is fired straight downward with an initial speed of 30 m/s.

Compare the speed of both pellets when they hit the water surface.

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