Mr. Wright's Math Extravaganza

Physical Sciences
(Chemistry, Physics, Physical Science)
Motion
Unit 01 Motion

Level 2.0: 70% on test, Level 3.0: 80% on test, Level 4.0: 80% on test and success on projectile motion lab

Score	I Can Statements
4.0	☐ I can predict the graph of complex motion for different objects.
3.5	In addition to score 3.0 performance, partial success at score 4.0 content.
3.0	☐ I can use vector analysis to characterize change in position and motion. ☐ I can use graphs to characterize change in position and motion. ☐ I can use kinematics equations to characterize change in position and motion.
2.5	No major errors or omissions regarding score 2.0 content, and partial success at score 3.0 content.
2.0	☐ I can compare vector and scalar quantities. I can add vectors algebraically. ☐ I can use vectors to describe relative motion. ☐ I can interpret graphs for change in position and motion. I can create graphs for change in position and motion. ☐ I can use graphs to interpret the slope and area for motion. ☐ I can use kinematics equations to solve for missing 1D motion variables. I can use kinematics equations to solve for missing 2D motion variables. I can use kinematics equations to solve free-fall motion.
1.5	Partial success at score 2.0 content, and major errors or omissions regarding score 3.0 content.
1.0	With help, partial success at score 2.0 content and score 3.0 content.
0.5	With help, partial success at score 2.0 content but not at score 3.0 content.
0.0	Even with help, no success.

Physics 1-01 Introduction, Units, and Uncertainty *Name: _____*

What is Physics?

Physics studies _____ that can be _____ with our five senses.

Model - _____
Theory - _____
Law - Uses _____ language to describe _____ patterns that have been verified _____ times

Scientific Method - used to solve many types of problems, not just science
Usually begins with _____ and question about the phenomenon to be studied
Next preliminary research is done and _____ is developed
Then experiments are performed to _____ the hypothesis
Finally the tests are analyzed and a _____ is drawn

Prefix	Symbol	Value	Prefix	Symbol	Value
exa	*E*	10^{18}	*deci*	*d*	10^{-1}
peta	*P*	10^{15}	*centi*	*c*	10^{-2}
tera	*T*	10^{12}	*milli*	*m*	10^{-3}
giga	*G*	10^{9}	*micro*	*μ*	10^{-6}
mega	*M*	10^{6}	*nano*	*n*	10^{-9}
kilo	*k*	10^{3}	*pico*	*p*	10^{-12}
hecto	*h*	10^{2}	*femto*	*f*	10^{-15}
decka	*da*	10^{1}	*atto*	*a*	10^{-18}

Units

Science uses _____ System (SI System)

Base Units
Length - _____ (m)
Time - _____ (s)
Mass - _____ (kg)

Others are _____ units

Unit Conversions

Multiply by _____ factors so that unwanted units _____ out

Convert 20 Gm to m

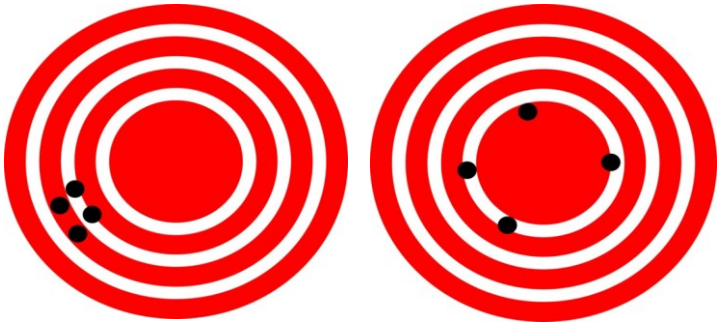
Convert 5 cg to kg

Convert 25 km/h to m/s

Accuracy and Precision

Accuracy is how _____ a measurement is to the _____ value for that measurement.
Precision of a measurement system is refers to how _____ the agreement is between _____ measurements.

Accuracy and precision mean there is some _____.
A device can repeatedly get the same _____ (precise), but always be _____ (not accurate).



Physics 1-01 Introduction, Units, and Uncertainty *Name: _____*

Practice Work

1. Classify each as a **model**, **theory**, or **law**.
   a. _____Bohr model of atom
   b. _____Gravity
   c. _____Drawing a picture to represent a physics problem
   d. _____The Earth is round
   e. _____The Big Bang
   f. _____Creation
2. The altitude of the International Space Station is 409 km. What is this in meters? (RW) **409000 m**
3. The elevation of Berrien Springs is 209 m. What is this in cm? (RW) **20900 cm**
4. Convert 1 hour to seconds. (RW) **3600 s**
5. The speed limit on some highways is 100 km/h. How fast is that in m/s? (RW) **27.8 m/s**
6. The Earth orbits the sun at 29.78 km/s. What is this in km/h? (RW) **107200 km/h**
7. The Earth orbits the sun at 29.78 km/s. What is this in mph (assume 1 mile = 1.609 km)? (RW) **66630 mph**
8. The surface area of the Earth is 510,072,000 km^2. What is this in m^2? (RW) $\mathbf{5.10072 \times 10^{14}\ m^2}$
9. Water covers approximately 361,132,000 km^2 of the Earth's surface. What is this in ft^2 (assume 1 m = 3.2808 ft)? (RW) $\mathbf{3.8871 \times 10^{15}\ ft^2}$
10. The average density of Earth is 5.514 g/cm^3. What is this in kg/m^3? (RW) **5514 kg/m^3**
11. What is meant when a physical law is said to be universal? (HSP 1.7)
    a. The law can explain everything in the universe.
    b. The law is applicable to all physical phenomena.
    c. The law applies everywhere in the universe.
    d. The law is the most basic one and all laws are derived from it.
12. Describe how modeling is useful in studying the structure of the atom. (HSP 1.11)
    a. Modeling replaces the real system by something similar but easier to examine.
    b. Modeling replaces the real system by something more interesting to examine.
    c. Modeling replaces the real system by something with more realistic properties.
    d. Modeling includes more details than are present in the real system.
13. Which of the following does not contribute to the uncertainty? (HSP 1.13)
    a. the limitations of the measuring device
    b. the skill of the person making the measurement
    c. the regularities in the object being measured
    d. other factors that affect the outcome (depending on the situation)
14. A friend says that he doesn't trust scientific explanations because they are just theories, which are basically educated guesses. What could you say to convince him that scientific theories are different from the everyday use of the word theory? (HSP 1.26)
    a. A theory is a scientific explanation that has been repeatedly tested and supported by many experiments.
    b. A theory is a hypothesis that has been tested and supported by some experiments.
    c. A theory is a set of educated guesses, but at least one of the guesses remain true in each experiment.
    d. A theory is a set of scientific explanations that has at least one experiment in support of it.
15. While watching some ants outside of your house, you notice that the worker ants gather in a specific area on your lawn. Which of the following is a testable hypothesis that attempts to explain why the ants gather in that specific area on the lawn. (HSP 1.46)
    a. The worker thought it was a nice location.
    b. because ants may have to find a spot for the queen to lay eggs
    c. because there may be some food particles lying there
    d. because the worker ants are supposed to group together at a place.
16. Design an experiment that will test the following hypothesis: driving on a gravel road causes greater damage to a car than driving on a dirt road. (HSP 1.59)
    a. To test the hypothesis, compare the damage to the car by driving it on a smooth road and a gravel road.
    b. To test the hypothesis, compare the damage to the car by driving it on a smooth road and a dirt road.
    c. To test the hypothesis, compare the damage to the car by driving it on a gravel road and the dirt road.
    d. This is not a testable hypothesis.
17. Explain the advantages and disadvantages of using a model to predict a life-or-death situation, such as whether or not an asteroid will strike Earth. (HSP 1.61)
    a. The advantage of using a model is that it provides predictions quickly, but the disadvantage of using a model is that it could make erroneous predictions.
    b. The advantage of using a model is that it provides accurate predictions, but the disadvantage of using a model is that it takes a long time to make predictions.
    c. The advantage of using a model is that it provides predictions quickly without any error. There are no disadvantages of using a scientific model.
    d. The disadvantage of using models is that it takes longer time to make predictions and the predictions are inaccurate. There are no advantages to using a scientific model.
18. A friend tells you that a scientific law cannot be changed. State whether or not your friend is correct and then briefly explain your answer. (HSP 1.62)
    a. Correct, because laws are theories that have been proved true.
    b. Correct, because theories are laws that have been proved true.
    c. Incorrect, because a law is changed if new evidence contradicts it.
    d. Incorrect, because a law is changed when a theory contradicts it.

Physics 1-02 Relative Motion, Distance, and Displacement *Name: _____*

Kinematics

Studies _____ without thinking about its _____

Position (d)

The _____ where something is relative to a _____ system called a _____

The most common coordinate system the _____ coordinate system

Relative Motion

Relative motion is how to describe the motion of an object based on different _____.

Displacement (Δd)

The change in position

_____

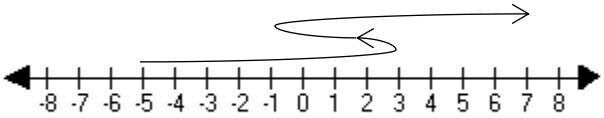
_____

Has _____ and _____

Path does _____ matter

Only _____ and _____ position matters

What is the displacement of the path in the diagram?



Distance

The _____ of the path traveled

_____

Has only _____

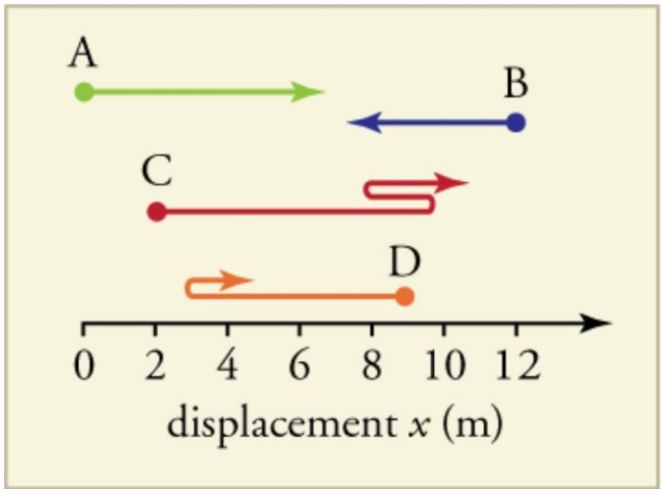
You drive 20 km east, then turn around and drive 15 km west. What is your displacement?

What was your distance traveled?

Physics 1-02 Relative Motion, Distance, and Displacement ***Name: _____***

Practice Work

1. What was difficult about measuring the 3x5 card? Why?
2. How are distance and displacement the same? How are they different?
3. How are scalars and vectors the same? How are they different?
4. Classify each measurement as a scalar or vector.
   a. _____ 20 books on a shelf
   b. _____ A car travels 25 km east
   c. _____ A plane flies 500 km
   d. _____ The car drives 100 km/h west
   e. _____ The plane flies 200 mph north
   f. _____ In an experiment, a toy car moves –15 cm
   g. _____ In an experiment, a mouse moves +20 cm
   h. _____ The temperature is –5 °C
5. Betty is riding in a subway train. While sitting at rest in a station, another train passes going from the right to left with reference to Betty's window. What direction does Betty appear to move with reference to a passenger in the other train? (RW)
6. Two subway trains are sitting in a station side by side. Clarence is looking out the window as the other train begins to move forward. Using the other train as the reference frame, which way does Clarence seem to move? (RW)
7. What is the meaning of a negative displacement? (RW)
8. A doe and a fawn are walking in the woods. The fawn runs zigzags and circles around its mother. If they both start walking at the same spot and stop to rest at the same spot, which walked the greater (a) distance? (b) displacement? (RW)
9. The road I live on goes east and west. One day, my family and I decide to go west to the beach. I travel 2 miles west when my wife realizes we passed a flock of wild turkeys. I turn around and drive back 1/2 miles before we find the turkeys. What is my displacement at the flock of turkeys (make west negative)? (RW) **–1.5 miles**
10. What is the distance I traveled to where I stopped by the turkeys? (RW) **2.5 miles**
11. Find the following for path A in the diagram: (a) The distance traveled. (b) The magnitude of the displacement from start to finish. (c) The displacement from start to finish. (OpenStax 2.1) **7 m, 7 m, 7 m**
12. Find the following for path B in the diagram: (a) The distance traveled. (b) The magnitude of the displacement from start to finish. (c) The displacement from start to finish. (OpenStax 2.2) **5 m, 5 m, –5 m**
13. Find the following for path C in the diagram: (a) The distance traveled. (b) The magnitude of the displacement from start to finish. (c) The displacement from start to finish. (OpenStax 2.3) **13 m, 9 m, 9 m**
14. Find the following for path D in the diagram: (a) The distance traveled. (b) The magnitude of the displacement from start to finish. (c) The displacement from start to finish. (OpenStax 2.4) **8 m, 4 m, –4 m**



Physics 1-03 Speed, Velocity, and Graphs **Name: _____**

Speed and Velocity

- Speed
  - Rate of change of _____
  - $v_{ave} = \frac{distance}{time}$
  - $v_{ave} = \frac{dist}{\Delta t}$
  - _____(no direction)
- Velocity
  - Rate of change of _____
  - $v_{ave} = \frac{displacement}{time}$
  - $v_{ave} = \frac{\Delta d}{\Delta t} = \frac{d_f - d_0}{t_f - t_0}$
  - _____
- Instantaneous velocity is the exact velocity at a given moment

A coyote walks east 2 km, then turns around and walks back west 3 km. If this trip takes 1.5 hours, what is the coyote's average speed?

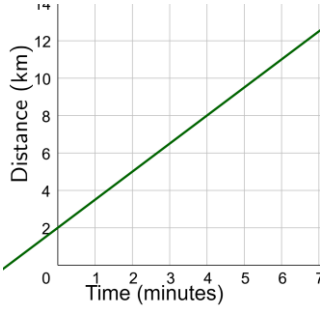
A coyote walks east 2 km, then turns around and walks back west 3 km. If this trip takes 1.5 hours, what is the coyote's average velocity?

A black bear at top speed can run about 13.5 m/s. If its friend is 50.0 m away, how much time does it have to prepare for a bear hug before the it gets there?

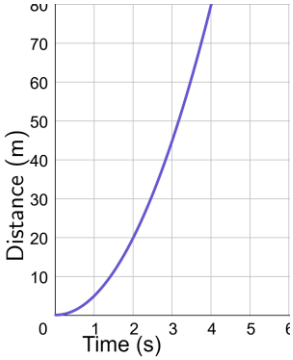
Position vs. Time graph

- $slope = \frac{rise}{run} = \frac{\Delta d}{\Delta t} = v$
- _____of d vs. t is _____
- If the graph is _____, use the _____of the _____line at the given time

The graph shows the distance a car is from its house. What is the velocity of the car at 5 minutes? (Give the answer in m/s.)



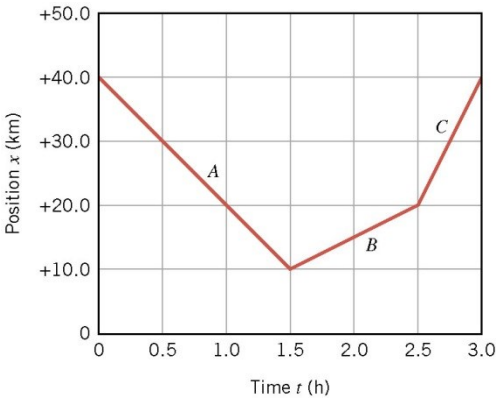
The graph shows the distance a car is from the starting point of a race. What is the velocity of the car at 3 seconds?



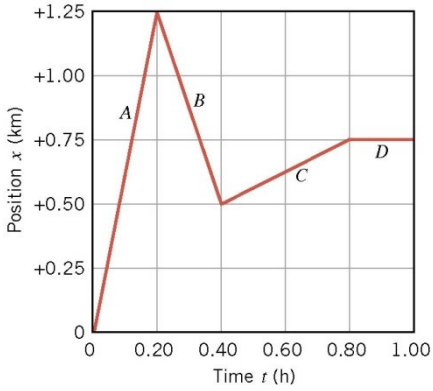
Physics 1-03 Speed, Velocity, and Graphs ***Name:*** _____

Practice Work

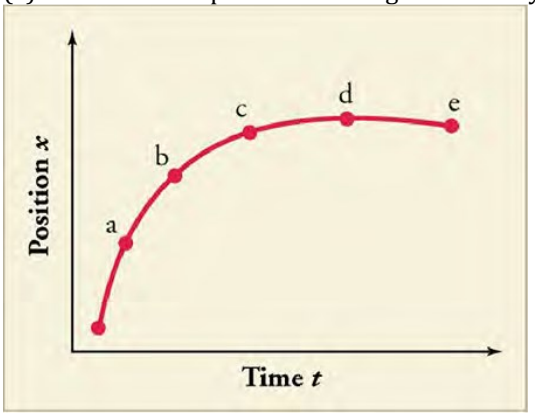
1. What is the difference between speed and velocity?
2. (a) Does a car's odometer measure distance or displacement? (b) Does its speedometer measure speed or velocity?
3. If you divide the total distance traveled on a car trip (as determined by the odometer) by the time for the trip, (a) are you calculating the average speed or the magnitude of the average velocity? (b) Under what circumstances are these two quantities the same?
4. What does a negative velocity mean?
5. (a)Draw a quick sketch of position–time graph of a ball being thrown up so that it goes up, then comes back down. (b) Describe the graph using mathematical terms.
6. What is the slope of a position vs. time graph?
7. When the average velocity is zero, there are two options for the object's motion. What are they? (RW)
8. What is the average velocity of running completely around an oval 400 m track in 160 s? (RW)
9. The spine-tailed swift is the fastest bird in powered flight. On one flight, a particular bird flies 306 m east, then turns around and flies 406.5 m back west. This flight takes 15 s. (a) What is the bird's average velocity? (b) Average speed? (RW) **6.7 m/s west, 47.5 m/s**
10. You are traveling down a highway in your car. When the clock is at 30 min, you are at the 124 km distance marker. When the clock says 50 min, you are at the 157 km marker. What is the magnitude of your average velocity? (RW) **99 km/h**
11. Conversations with astronauts on the lunar surface were characterized by a kind of echo in which the earthbound person's voice was so loud in the astronaut's space helmet that it was picked up by the astronaut's microphone and transmitted back to Earth. It is reasonable to assume that the echo time equals the time necessary for the radio wave to travel from the Earth to the Moon and back (that is, neglecting any time delays in the electronic equipment). Calculate the distance from Earth to the Moon given that the echo time was 2.56 s and that radio waves travel at the speed of light (3.00×10^8 m/s). (OpenStax 2.13) **384,000 km**
12. A football quarterback runs 15.0 m straight forward 2.50 s. He is then hit and pushed 3.00 m straight backward in 1.75 s. He breaks the tackle and runs straight forward another 21.0 m in 5.20 s. Calculate his average velocity (a) for each of the three intervals and (b) for the entire motion. (OpenStax 2.14) **6.00 m/s, –1.71 m/s, 4.04 m/s, 3.49 m/s**
13. A bus makes a trip according to the position–time graph shown in the drawing. What is the average velocity (magnitude and direction) of the bus during each of the segments labeled A, B, and C? Express your answers in km/h. (Cutnell 2.48) **–20 km/h, 10 km/h, 40 km/h**



14. A person who walks for exercise produces the position–time graph given with this problem. (a) Without doing any calculations, decide which segments of the graph (A, B, C, or D) indicate positive, negative, and zero average velocities. (b) Calculate the average velocity for each segment to verify your answers to part (a). (Cutnell 2.60) **6.3 km/h, –3.8 km/h, 0.63 km/h, 0 km/h**



15. (a) Which labeled point has the highest velocity? (b) Lowest velocity? (RW)



Physics 1-04 Velocity vs. Time Graphs **Name: _____**

Acceleration

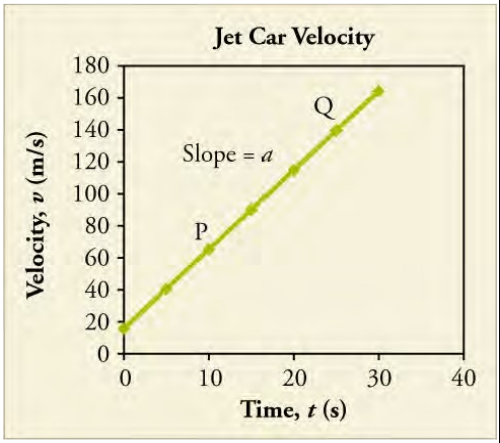
- Rate of change of _____
- _____of _____vs. time graph

Displacement

- _____between graph and _____ of a _____vs. time graph

Calculate

a. Displacement over the 30s.



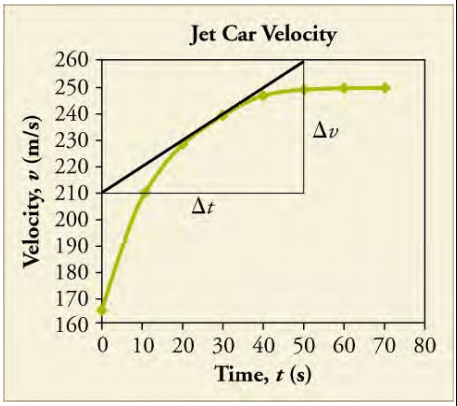
b. Acceleration over the 30s.

c. Instantaneous velocity at 20s.

d. Average velocity over the 30s.

Calculate

a. Displacement over the first 20s.



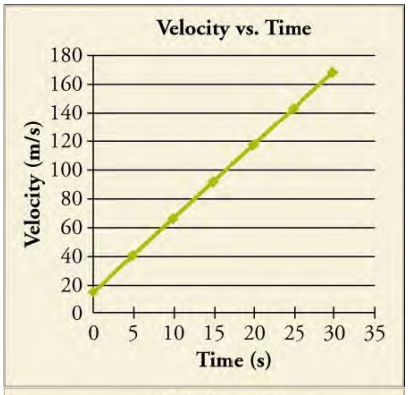
b. Instantaneous acceleration at 30s.

Physics 1-04 Velocity vs. Time Graphs ***Name:*** _____

Practice Work

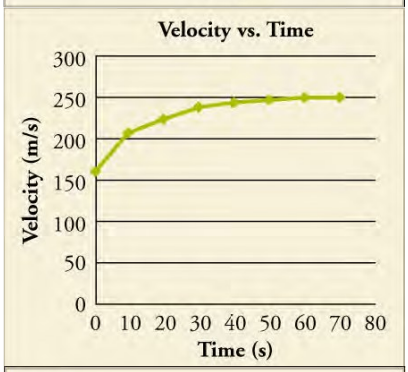
1. Explain how to find (a) displacement, (b) velocity, (c) acceleration from velocity vs. time graph. (RW)
2. How do you estimate the area on a curved graph? (RW)

Use the graph to answer the following questions.



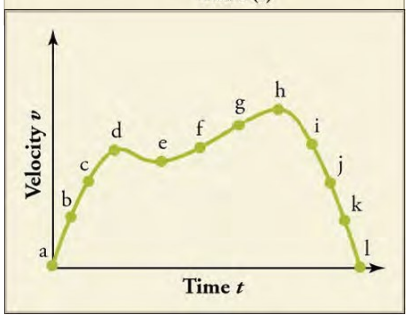
3. What is the displacement of the object after 5 seconds? (RW) **138 m**
4. What is the velocity of the object at 20 s? (RW) **118 m/s**
5. What is the acceleration of the object at 20 s? (RW) **5 m/s²**
6. What is the average velocity over the entire 30 s? (RW) **92.5 m/s**
7. What is the shape of the acceleration vs time for this situation? (Hint: Think about calculating the acceleration at several times.) (RW)

Use the graph to answer the following questions.



8. What is the displacement of the object after 10 seconds? (RW) **1850 m**
9. What is the displacement of the object between 10 and 30 seconds? (RW) **4500 m**
10. What is the velocity of the object after 60 s? (RW) **250 m/s**
11. What is the acceleration of the object at 20 s? (RW) **1.5 m/s²**
12. What is the acceleration of the object at 70 s? (RW) **0 m/s²**

Use the graph to answer the following questions.



13. Which point on the graph has the highest acceleration? (RW) **a or b**
14. Which point on the graph has the lowest acceleration? (RW) **k or l**
15. Where does the object have negative acceleration? (List all intervals) (RW) **d-e; h-l**

Acceleration

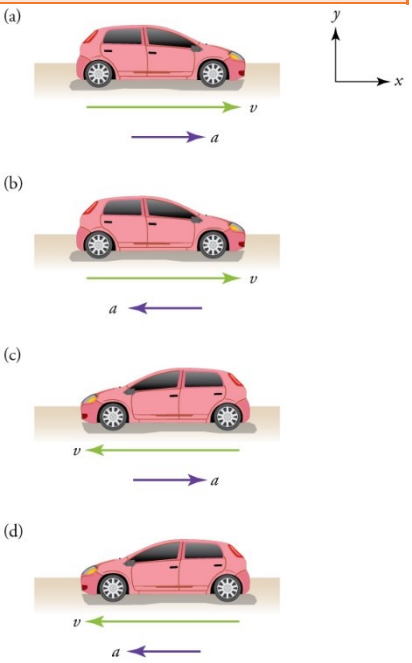
- Rate of change of _____

$$\overline{a} = \frac{\Delta v}{\Delta t}$$

$$\overline{a} = \frac{v_f - v_0}{t_f - t_0}$$

$$v = at + v_0$$

- _____
- Unit: _____
- If the acceleration is _____direction as motion, then the object is _____speed.
- If the acceleration is _____direction as motion, then the object is _____speed.

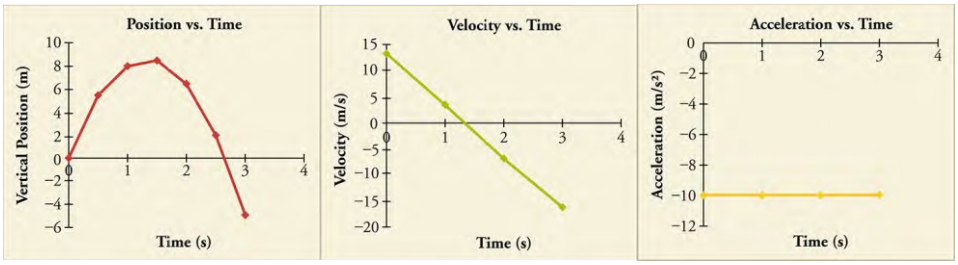


A horse starts running. If it goes from 0 to 55 km/h in 3.5 s, what is the horse's acceleration?

A car slows from 15 m/s to 10 m/s by an acceleration of 4 m/s². How much time did it take to slow down?

Constant acceleration

- The graph of position–time is _____
  - ($d = \frac{1}{2}at^2 + v_0t + d_0$ is _____)
- The graph of velocity–time is _____
  - ($v = at + v_0$ is _____)
- The graph of acceleration-time is _____
  - ($a = a$)



Physics 1-05 Acceleration ***Name: _____***

Practice Work

1. Is it possible to have a nonzero acceleration and a (a) constant velocity? (b) constant speed? (RW)
2. A horse is running towards the east and has a westward acceleration. Is the horse speeding up or slowing down? (RW)
3. If a car is traveling forwards, but slowing down, which direction is its acceleration? (RW)
4. An object has a constant positive acceleration. Describe the (a) position vs. time graph, (b) velocity vs. time graph, and (c) acceleration vs. time graph. Include the direction of the curve or line. (RW)
5. A cheetah can accelerate from rest to a speed of 30.0 m/s in 7.00 s. What is its acceleration? (OpenStax 2.16) **4.29 m/s^2**
6. A motorcycle has a constant acceleration of 2.5 m/s^2. Both the velocity and acceleration of the motorcycle point in the same direction. How much time is required for the motorcycle to change its speed from (a) 21 to 31 m/s, and (b) 51 to 61 m/s? (Cutnell 2.13) **4.0 s, 4.0 s**
7. A runner accelerates to a velocity of 5.36 m/s due west in 3.00 s. His average acceleration is 0.640 m/s^2, also directed due west. What was his velocity when he began accelerating? (Cutnell 2.15) **3.44 m/s W**
8. A motorcycle moving at a constant velocity suddenly accelerates at a rate of 4.0 m/s^2 to a speed of 35 m/s in 5.0 s. What was the initial speed of the motorcycle? (HSP 3.8) **15 m/s**
9. A deer is walking through the woods at 1.0 m/s when it sees a coyote. The deer accelerates to 5.0 m/s in 2.0 seconds. What was the deer's acceleration? (RW) **2.0 m/s^2**
10. The deer out runs the coyote and slows down at a rate of 0.50 m/s^2 from the 5.0 m/s that it was running. If it decelerates for 3 seconds, what is its final speed? (RW) **3.5 m/s**
11. Next, the deer decides it is hungry for some corn, so it continues jogging towards a cornfield at 3.5 m/s. If it continues to run at 3.5 m/s for 3.0 minutes, what is the deer's acceleration? (RW) **0 m/s^2**
12. Then, the deer gets thirsty after eating all that corn, so it accelerates from rest to 3.0 m/s at a rate of 0.70 m/s^2 and trots towards a stream. For how much time did the deer accelerate? (RW) **4.3 s**

Physics 1-06 Representing Acceleration with Equations Part 1 **Name: _____**

Equations of 1-D Motion

Assume _____, so _____ and acceleration is _____

$$d = \overline{v}t + d_0$$

$$\overline{v} = \frac{v_0 + v}{2}$$

$$v = at + v_0$$

$$d = \frac{1}{2}at^2 + v_0 t + d_0$$

$$v^2 = v_0^2 + 2a(d - d_0)$$

Problem Solving Strategy

1. Examine the situation to determine which _____ are involved.
    a. Maybe _____
2. List the _____.
3. Identify the _____.
4. Find an _____ or set of equations that can help you solve the problem.
5. _____ the knowns along with their _____ into the appropriate equation, and Solve
6. Check the answer to see if it is _____: Does it make sense?

A plane starting from rest accelerates to 40 m/s in 10 s. How far did the plane travel during this time?

To avoid an accident, a car decelerates at 0.50 m/s^2 for 3.0 s and covers 15 m of road. What was the car's initial velocity?

A cheetah is walking at 1.0 m/s when it sees a zebra 25 m away. What acceleration would be required to reach 20.0 m/s in that distance?

Physics 1-06 Representing Acceleration with Equations Part 1 *Name: _____*

The left ventricle of the heart accelerates blood from rest to a velocity of +26 cm/s. (a) If the displacement of the blood during the acceleration is +2.0 cm, determine its acceleration (in cm/s^2). (b) How much time does blood take to reach its final velocity?

Practice Work

1. Give an example in which velocity is zero yet acceleration is not.
2. An object moving with a constant acceleration can certainly slow down. But can an object ever come to a permanent halt if its acceleration truly remains constant? Explain.
3. A marble is dropped from 2.5 m and hits the ground in 0.71 s. What is the final velocity before it hits the ground? (RW) **−7.0 m/s**
4. A jet takes off from an aircraft carrier starting from rest and travels 93 m in 1.2 s when being pushed by the catapult. What is its final velocity at takeoff? (RW) **160 m/s**
5. An Olympic-class sprinter starts a race with an acceleration of 4.50 m/s^2. (a) What is her speed 2.40 s later? (b) Write an equation for position as a function of time. (c) Sketch a graph of her position vs. time for this period. (OpenStax 2.20) **10.8 m/s**
6. Freight trains can produce only relatively small accelerations and decelerations. (a) What is the final velocity of a freight train that accelerates at a rate of 0.0500 m/s^2 for 8.00 min, starting with an initial velocity of 4.00 m/s? (b) If the train can slow down at a rate of 0.550 m/s^2, how long will it take to come to a stop from this velocity? (c) How far will it travel in each case? (OpenStax 2.29) **28.0 m/s, 50.9 s, 7680 m, 713 m**
7. A fireworks shell is accelerated from rest to a velocity of 65.0 m/s over a distance of 0.250 m. (a) How long did the acceleration last? (b) Calculate the acceleration. (OpenStax 2.30) $\mathbf{7.69 \times 10^{-3}\ s,\ 8.45 \times 10^{3}\ m/s}$
8. A car skids to a stop to try to avoid hitting a deer. The car skids 21 m in 2.3 s. How fast was the car originally going? (RW) **18.3 m/s**
9. What is the final velocity of a car that starts from rest and accelerates at 3.90 m/s^2 for a distance of 100 m? (RW) **27.9 m/s**
10. A hockey puck slides across the ice with an initial velocity of 7.2 m/s. It has a deceleration of 1.1 m/s^2 and is traveling toward the goal 5.0 m away. How much time does the goalie have to stop the puck? (RW) **0.74 s**
11. If a moose can accelerate at 2.1 m/s^2 from rest, how much time will it take for it to accelerate to a speed of 4 km/h? (RW) **0.53 s**
12. When you try to stop your car in an emergency, there is some time before you can react. Your car is going 25 m/s and your reaction time is 0.20 s, then after you hit your brakes it decelerates at 9.5 m/s^2. How far will your car travel before it stops? (RW) **38 m**

Physics 1-07 Representing Acceleration with Equations Part 2 ***Name: _____***

Free Fall

Free fall is when an object is moving only under the influence of _____.
Ignoring air resistance, all objects fall to the earth with the _____ acceleration due to gravity (g)

$$g = \_\_\_\_\_ \frac{m}{s^2} \_\_\_\_\_$$

_____ object thrown up, down, or dropped has this _____.
Use the one-dimensional _____.

You drop a coin from the top of a hundred story building (1000 m). If you ignore air resistance, how fast will it be falling right before it hits the ground?

How long does it take to hit the ground?

A baseball is hit straight up into the air. If the initial velocity was 20 m/s, how high will the ball go?

How long will it be until the catcher catches the ball at the same height it was hit?

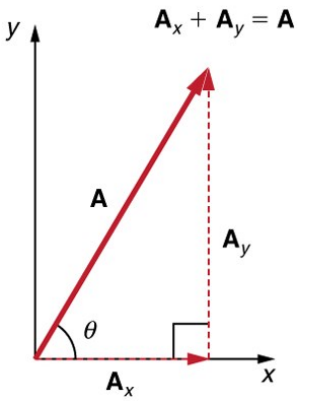
How fast is it going when catcher catches it?

Practice Work

1. What is the acceleration of a rock thrown straight upward on the way up? At the top of its flight? On the way down?
2. An object that is thrown straight up falls back to Earth. This is one-dimensional motion. (a) When is its velocity zero? (b) Does its velocity change direction? (c) Does the acceleration due to gravity have the same sign on the way up as on the way down?
3. A penny is dropped from rest from the top of the Willis (Sears) Tower in Chicago. Considering that the height of the building is 427 m and ignoring air resistance, find the speed with which the penny strikes the ground. (Cutnell 2.37) **91.5 m/s**
4. At the beginning of a basketball game, a referee tosses the ball straight up with a speed of 4.6 m/s. A player cannot touch the ball until after it reaches its maximum height and begins to fall down. What is the minimum time that a player must wait before touching the ball? (Cutnell 2.42) **0.47 s**
5. A basketball referee tosses the ball straight up for the starting tipoff. At what velocity must a basketball player leave the ground to rise 1.25 m above the floor in an attempt to get the ball? (OpenStax 2.43) **4.95 m/s**
6. A diver springs upward with an initial speed of 1.8 m/s from a 3.0-m board. (a) Find the velocity with which he strikes the water. (b) What is the highest point he reaches above the water? (Cutnell 2.44) **-7.9 m/s, 3.2 m**
7. (a) Calculate and graph the displacement at times of 0.500, 1.00, 1.50, 2.00, and 2.50 s for a rock thrown straight down with an initial velocity of 14.0 m/s from the Verrazano Narrows Bridge in New York City. The roadway of this bridge is 70.0 m above the water. (b) Repeat, but now calculate and graph the velocity. (OpenStax 2.42)
   61.8 m, 51.1 m, 38.0 m, 22.4 m, 4.4 m; -18.9 m/s, -23.8 m/s, -28.7 m/s, -33.6 m/s, -38.5 m/s
8. A rescue helicopter is hovering over a person whose boat has sunk. One of the rescuers throws a life preserver straight down to the victim with an initial velocity of 1.40 m/s and observes that it takes 1.8 s to reach the water. (a) List the knowns in this problem. (b) How high above the water was the preserver released? *Note that the downdraft of the helicopter reduces the effects of air resistance on the falling life preserver, so that an acceleration equal to that of gravity is reasonable.* (OpenStax 2.44) **18 m**
9. A dolphin in an aquatic show jumps straight up out of the water at a velocity of 13.0 m/s. (a) List the knowns in this problem. (b) How high does his body rise above the water? To solve this part, first note that the final velocity is now a known and identify its value. Then identify the unknown, and discuss how you chose the appropriate equation to solve for it. After choosing the equation, show your steps in solving for the unknown, checking units, and discuss whether the answer is reasonable. (c) How long is the dolphin in the air? Neglect any effects due to his size or orientation. (OpenStax 2.45) **8.62 m, 2.65 s**
10. A very strong, but inept, shot putter puts the shot straight up vertically with an initial velocity of 11.0 m/s. How long does he have to get out of the way if the shot was released at a height of 2.20 m, and he is 1.80 m tall? (OpenStax 2.48) **2.28 s**
11. You throw a ball straight up with an initial velocity of 15.0 m/s. It passes a tree branch on the way up at a height of 7.00 m. How much additional time will pass before the ball passes the tree branch on the way back down? (OpenStax 2.49) **1.91 s**

Physics 1-08 Vector Addition *Name:* _____

Vectors



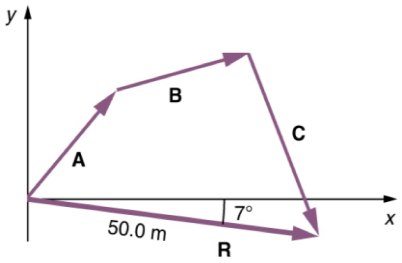
- Vectors are measurements with _____ and _____.
  - They are represented by _____.
  - The length of the arrow is the _____.
  - The direction of the arrow is the _____.
- Can be represented in _____ form
  - Make a _____ using the vector as the _____
  - Use _____ and _____ to find the horizontal (x) component and the vertical (y) component
  - Assign _____ signs to any component going _____ or _____
- $\sin(\theta) = \frac{opposite}{hypotenuse}$ $\cos(\theta) = \frac{adjacent}{hypotenuse}$ $\tan(\theta) = \frac{opposite}{adjacent}$

A football player kicks a ball at 15 m/s at 30° above the ground. Find the horizontal and vertical components of this velocity.

Scalar Multiplication

- Multiplying a vector by a _____ number
- Draw the vector that many times in a _____
- Or multiply the _____ by that number
- A negative vector means multiply by -1, so it goes in the _____ direction

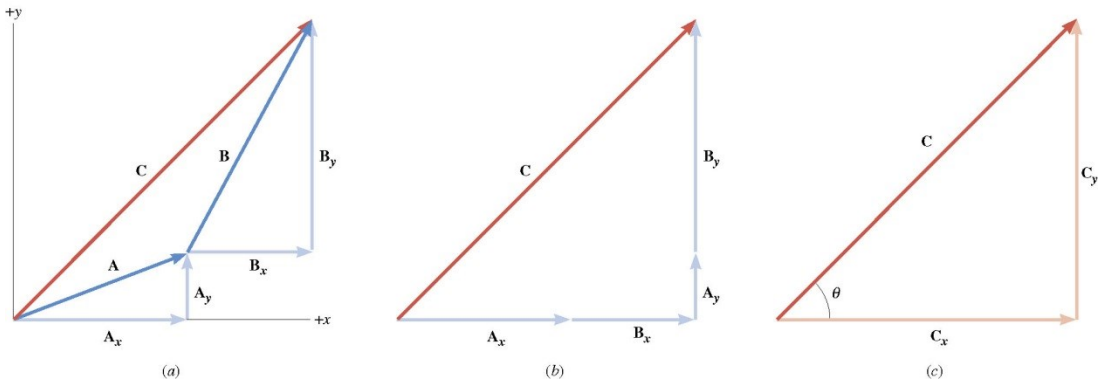
Vector Addition - Graphical Method



- Draw the _____ vector.
- Draw the second vector where the _____ (tip-to-tail).
- Draw the resultant vector from where the _____ vector begins to where the _____ vector ends.
- _____ the resultant's length and direction.

Vector Addition - Component Method

Vectors can be described by its _____ to show how far it goes in the x and y directions. To add vectors, you simply add the _____ and _____ to get total (_____) x and y components.



1. Find the _____ for _____ the vectors to be added
2. _____ all the _____ components
3. _____ all the _____ components
4. Use the _____ Theorem to find the _____ of the resultant
5. Use _____ to find the _____ (the direction is always found at the _____ of the resultant)

Note: Drawing pictures and triangles helps immensely.

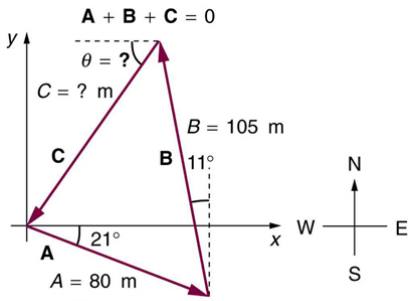
Add the following vectors. $\boldsymbol{C} = 15\ m$ at 25° N of E; $\boldsymbol{D} = 20\ m$ at 60° S of E

Physics 1-08 Vector Addition *Name:* _____

A jogger runs 145 m in the direction 20.0° east of north and then 105 m in a direction 35.0° south of east. Determine the magnitude and direction of jogger's position from her starting point.

Practice Work

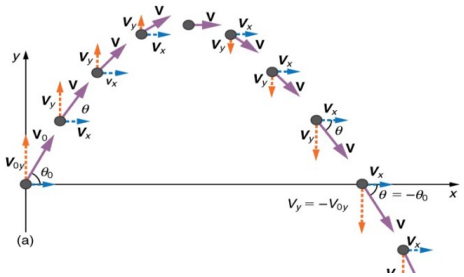
1. (a) Is it possible for one component of a vector to be zero, while the vector itself is not zero? (b) Is it possible for a vector to be zero, while one component is not zero? Explain.
2. Can two nonzero perpendicular vectors be added together so their sum is zero? Explain.
3. Can three or more vectors with unequal magnitudes be added together so their sum is zero? If so, show by means of a tip-to-tail arrangement of the vectors how this could occur.
4. An ostrich is running at a speed of 17.0 m/s in a direction of 68.0° north of west. What is the magnitude of ostrich's velocity component that is directed (a) due north and (b) due west? (RW) **15.8 m/s, 6.37 m/s**
5. An ocean liner leaves New York City and travels 18.0° north of east for 155 km. How far east and how far north has it gone? In other words, what are the magnitudes of the components of the ship's displacement vector in the directions (a) due east and (b) due north? (Cutnell 1.33) **147 km, 47.9 km**
6. A new landowner has a triangular piece of flat land she wishes to fence. Starting at the west corner, she measures the first side to be 80.0 m long and the next to be 105 m. These sides are represented as displacement vectors A and B in Figure 3.61. She then correctly calculates the length and orientation of the third side C. What is her result? (Hint: Since A + B + C = 0, then A + B = −C.) (OpenStax 3.20) **92.3 m at 53.7° S of W**



7. Suppose you first walk 12.0 m in a direction 20° west of north and then 20.0 m in a direction 40.0° south of west. How far are you from your starting point, and what is the compass direction of a line connecting your starting point to your final position? (OpenStax 3.5) **19.5 m at 4.65° S of W**
8. A golfer, putting on a green, requires three strokes to "hole the ball." During the first putt, the ball rolls 5.0 m due east. For the second putt, the ball travels 2.1 m at an angle of 20.0° north of east. The third putt is 0.50 m due north. What displacement (magnitude and direction relative to due east) would have been needed to "hole the ball" on the very first putt? (Cutnell 1.41) **7.1 m at 9.9° N of E**
9. You are on a treasure hunt and your map says, "Walk due west for 52 paces, then walk 30.0° north of west for 42 paces, and finally walk due north for 25 paces." What is the magnitude of the component of your displacement (a) due north and (b) due west? (Cutnell 1.42) **46 paces, 88 paces**
10. On a safari, a team of naturalists sets out toward a research station located 4.8 km away in a direction 42° north of east. After traveling in a straight line for 2.4 km, they stop and discover that they have been traveling 22° north of east, because their guide misread his compass. What are (a) the magnitude and (b) the direction (relative to due east) of the displacement vector now required to bring the team to the research station? (Cutnell 1.45) **2.7 km at 60° N of E**
11. While snorkeling in the ocean, you swim directly towards shore at 2 m/s. The current of the water pushes you directly sideways at 3 m/s. What is your resultant velocity (magnitude and direction relative to your intended path of straight towards shore)? (RW) **3.6 m/s at 56.3°**
12. An airplane flies at 200 km/h at 30.0° N of W. The wind blows it at 30 km/h at 45.0° E of N. What is the resultant velocity of the airplane (magnitude and direction)? (RW) **194 km/h at 38.6° N of W**
13. You are trying to row a boat directly across a river that is 50.0 m wide. You can row at 3.1 m/s in a direction directly across the river perpendicular to the shore. The current is 4.8 m/s parallel to shore. (a) What is your velocity relative to the shore? (b) How much time does it take to get to the other side of the river? (c) How far downstream do you land? (RW) **5.71 m/s at 32.9° downstream from shore, 16.1 s, 77.4 m**

Physics 1-09 Projectile Motion *Name:* _____

- Objects in _____ only under influence of _____
- *x* and *y* components are _____
- _____ is only quantity that is the _____ in both dimensions
- *x*-component velocity _____ since nothing pulling it sideways
  - Use _____
- *y*-component _____ because gravity pulling it down
  - Use _____
- If the starting and ending height are the _____, the distance the object goes can be found with the _____ equation.



_____

A Veggie-meatball with v = 5.0 m/s rolls off a 1.0 m high table. How long does it take to hit the floor if no one sneezes?

What is its velocity when it hits the floor?

A truck (v = 11.2 m/s) turned a corner too sharp and lost part of the load. A falling box will break if it hits the ground with a velocity greater than 15 m/s. The height of the truck bed is 1.5 m. Will the box break?

While driving down a road a bad guy shoots a bullet straight up into the air. If there was no air resistance where would the bullet land in front, behind, or on him?

If a gun were fired horizontally and a bullet were dropped from the same height at the same time, which would hit the ground first?

A batter hits the ball at 35° with a velocity of 32 m/s. How high did the ball go?

How long was the ball in the air?

Physics 1-09 Projectile Motion *Name:* _____

How far did the ball go?

Practice Work

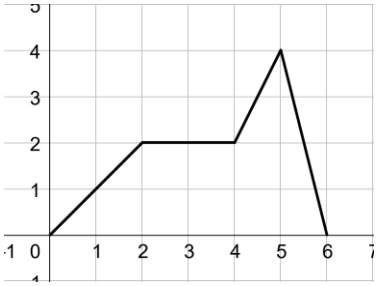
1. Is the acceleration of a projectile equal to zero when it reaches the top of its trajectory? If not, why not?
2. A tennis ball is hit upward into the air and moves along an arc. Neglecting air resistance, where along the arc is the speed of the ball (a) a minimum and (b) a maximum? Justify your answers.
3. A tennis ball is hit upward into the air and moves along an arc. Neglecting air resistance, where along the arc is the acceleration of the ball (a) a minimum and (b) a maximum? Justify your answers.
4. A wrench is accidentally dropped from the top of the mast on a sailboat. Will the wrench hit at the same place on the deck whether the sailboat is at rest or moving with a constant velocity? Justify your answer.
5. A stone is thrown horizontally from the top of a cliff and eventually hits the ground below. A second stone is dropped from rest from the same cliff, falls through the same height, and also hits the ground below. Ignore air resistance. Discuss whether each of the following quantities is different or the same in the two cases; if there is a difference, describe the difference: (a) displacement, (b) speed just before impact with the ground, and (c) time of flight.
6. A projectile is launched at ground level with an initial speed of 50.0 m/s at an angle of 30.0° above the horizontal. It strikes a target above the ground 3.00 seconds later. What are the x and y distances where the projectile was launched to where it lands? (OpenStax 3.25) **130 *m*, 30.9 m**
7. A ball is thrown horizontally from the top of a 60.0-m building and lands 100.0 m from the base of the building. Ignore air resistance. (a) How long is the ball in the air? (b) What must have been the initial horizontal component of the velocity? (c) What is the vertical component of the velocity just before the ball hits the ground? (d) What is the velocity (including both the horizontal and vertical components) of the ball just before it hits the ground? (OpenStax 3.27) **3.50 s, 28.6 m/s, - 34.3 m/s, 44.7 m/s at 50.2° below x-axis**
8. (a) A daredevil is attempting to jump his motorcycle over a line of buses parked end to end by driving up a 32° ramp at a speed of 40.0 m/s (144 km/h). How many buses can he clear if the top of the takeoff ramp is at the same height as the bus tops and the buses are 20.0 m long? (b) Discuss what your answer implies about the margin of error in this act—that is, consider how much greater the range is than the horizontal distance he must travel to miss the end of the last bus. (Neglect air resistance.) (OpenStax 3.28) **7 buses**
9. An arrow is shot from a height of 1.5 m toward a cliff of height H. It is shot with a velocity of 30 m/s at an angle of 60° above the horizontal. It lands on the top edge of the cliff 4.0 s later. (a) What is the height of the cliff? (b) What is the maximum height reached by the arrow along its trajectory? (c) What is the arrow's impact speed just before hitting the cliff? (OpenStax 3.34) **27.0 m, 36.0 m, 20 m/s**
10. The world long jump record is 8.95 m (Mike Powell, USA, 1991). Treated as a projectile, what is the maximum range obtainable by a person if he has a take-off speed of 9.5 m/s? State your assumptions. (OpenStax 3.36) **9.21 m**
11. An eagle is flying horizontally at a speed of 3.00 m/s when the fish in her talons wiggles loose and falls into the lake 5.00 m below. Calculate the velocity of the fish relative to the water when it hits the water. (OpenStax 3.40) **10.3 m/s, 73.1° below the horizontal**
12. Can a goalkeeper at his goal kick a soccer ball into the opponent's goal without the ball touching the ground? The distance will be about 95 m. A goalkeeper can give the ball a speed of 30 m/s. (OpenStax 3.43) **91.8 m, No**
13. A tennis ball is struck such that it leaves the racket horizontally with a speed of 28.0 m/s. The ball hits the court at a horizontal distance of 19.6 m from the racket. What is the height of the tennis ball when it leaves the racket? (OpenStax 3.14) **2.40 m**
14. A diver runs horizontally with a speed of 1.20 m/s off a platform that is 10.0 m above the water. What is his speed just before striking the water? (RW) **14.1 m/s**
15. The 1994 Winter Olympics included the aerials competition in skiing. In this event skiers speed down a ramp that slopes sharply upward at the end. The sharp upward slope launches them into the air, where they perform acrobatic maneuvers. In the women's competition, the end of a typical launch ramp is directed 63° above the horizontal. With this launch angle, a skier attains a height of 13 m above the end of the ramp. What is the skier's launch speed? (Cutnell 3.24) **18 m/s**

Physics Unit 1: Motion Review

Level 2: 70% on test, Level 3: 80% on test, Level 4: 80% on test and success on Projectile Motion Lab

1. Know about scientific method, units, fundamental units, unit prefixes, precision, accuracy, significant figures, vectors, scalars, projectile motion
2. Know how to find velocity from a position vs. time graph
3. Know how to find displacement and acceleration from a velocity vs. time graph
4. Convert 120 Tm to m
5. In the process of delivering milk, a milkman, walks 100 m due east from his truck. He then turns around and walks 20 m due west. What is the milkman's displacement relative to his truck (magnitude and direction)? What distance did he travel?
6. A pigeon flew 10 km across town with an average speed of 5 m/s. How long, in hours, did it take the pigeon to make this journey?

Use the graph to answer questions 7-9.



7. If this is a position vs. time graph of an object moving in a straight line. Find the velocity of the object at 4.5 s.
8. If this is a velocity vs. time graph of an object moving in a straight line. Find the displacement of the object after 4 seconds.
9. If this is a velocity vs. time graph of an object moving in a straight line. Find the acceleration of the object at 1 second.
10. A deer, starting from rest, accelerates in a straight-line path at a constant rate of 1.5 m/s^2. What will the deer's final velocity be after 3 seconds?
11. A car, starting from rest, accelerates in a straight-line path at a constant rate of 2 m/s^2. How far will the car travel in 10 seconds?
12. The minimum takeoff speed for a certain airplane is 50 m/s. What minimum acceleration is required if the plane must leave a runway of length 2000 m? Assume the plane starts from rest at one end of the runway.
13. Water drips from rest from a leaf that is 2 m above the ground. Neglecting air resistance, what is the speed of each water drop when it hits the ground?
14. Water drips from rest from a leaf that is 2 m above the ground. Neglecting air resistance, how long will it take each water drop to hit the ground?
15. What maximum height will be reached by a stone thrown straight up with an initial speed of 5 m/s?
16. A cheetah is walking at a speed of 0.5 m/s when it observes a gazelle 15 m directly ahead. If the cheetah accelerates at 3 m/s^2, how long does it take the cheetah to reach the gazelle if the gazelle doesn't move?
17. A sailboat leaves a harbor and sails 21 km in the direction 15° north of east, where the captain stops for lunch. A short time later, the boat sails 2 km in the direction 75° south of east. What is the magnitude of the resultant displacement?
18. A swimmer swims with a velocity of 15 m/s south relative to the water. The current of the water is 2 m/s relative to the shore. If the current is moving west, what is the velocity of the swimmer relative to the shore?
19. An eagle is flying due east at 5 m/s carrying a gopher in its talons. The gopher manages to break free at a height of 50 m. What is the magnitude of the gopher's velocity as it reaches the ground?

Physics Unit 1: Motion Review

Answers

4. $\frac{120\ Tm}{\square}\left(\frac{10^{12}\ m}{1\ Tm}\right) = \mathbf{1.2 \times 10^{14}\ m}$
5. Displacement: $100\ m - 20\ m = \mathbf{80\ m}$;
   Distance: $100\ m + 20\ m = \mathbf{120\ m}$
6. $\overline{v} = 5\frac{m}{s}, \Delta d = 10\ km$
   Convert: $\frac{10\ km}{\square}\left(\frac{10^3\ m}{1\ km}\right) = 10000\ m$
   $\overline{v} = \frac{\Delta d}{\Delta t}$
   $5\frac{m}{s} = \frac{10000\ m}{t}$
   $t = \frac{10000\ m}{5\frac{m}{s}} = \mathbf{2000\ s}$
   Convert: $\frac{2000\ s}{\square}\left(\frac{1\ h}{3600\ s}\right) = 0.56\ h$
7. Find the slope at 4.5 s.
   $v = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4-2}{5-4} = \frac{2}{1} = \mathbf{2}$
8. Find the area between the graph and the *x*-axis between $t = 0$ and $t = 4$.
   $d = \left(\frac{1}{2}bh\right) + (bh)$
   $d = \left(\frac{1}{2}(2)(2)\right) + (2)(2) = \mathbf{6}$
9. Find the slope of the graph at 1 s.
   $a = \frac{y_2 - y_1}{x_2 - x_1} = \frac{2-0}{2-0} = \mathbf{1}$
10. $v_0 = 0\frac{m}{s}, a = 1.5\frac{m}{s^2}, v = ?, t = 3s$
    $a = \frac{v - v_0}{t - t_0}$
    $1.5\frac{m}{s^2} = \frac{v - 0\frac{m}{s}}{3\ s - 0\ s}$
    $\mathbf{4.5\frac{m}{s}} = v$
11. $a = 2\frac{m}{s^2}, t = 10\ s, v_0 = 0\frac{m}{s}, d = ?$
    $d = d_0 + v_0 t + \frac{1}{2}at^2$
    $d = 0\ m + \left(0\frac{m}{s}\right)(10\ s) + \frac{1}{2}\left(2\frac{m}{s^2}\right)(10\ s)^2$
    $d = \mathbf{100\ m}$
12. $v = 50\frac{m}{s}, d = 2000\ m, v_0 = 0\frac{m}{s}, a = ?$
    $v^2 = v_0^2 + 2a(d - d_0)$
    $\left(50\frac{m}{s}\right)^2 = \left(0\frac{m}{s}\right)^2 + 2a(2000\ m - 0\ m)$
    $2500\frac{m^2}{s^2} = (4000\ m)a$
    $a = \mathbf{0.625\ m/s^2}$
13. $y_0 = 2\ m, v_0 = 0\frac{m}{s}, a = -9.8\frac{m}{s^2}, v = ?$
    $v^2 = v_0^2 + 2a(y - y_0)$
    $v^2 = \left(0\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)(0\ m - 2\ m)$
    $v^2 = 39.2\frac{m^2}{s^2}$
    $v = \mathbf{6.26\frac{m}{s}}$
14. $y_0 = 2\ m, v_0 = 0\frac{m}{s}, a = -9.8\frac{m}{s^2}, t = ?$
    $y = y_0 + v_0 t + \frac{1}{2}at^2$
    $0\ m = 2\ m + \left(0\frac{m}{s}\right)t + \frac{1}{2}\left(-9.8\frac{m}{s^2}\right)t^2$
    $-2\ m = \left(-4.9\frac{m}{s^2}\right)t^2$
    $0.408\ s^2 = t^2 \rightarrow \mathbf{0.639\ s} = t$
15. $v_0 = 5\frac{m}{s}, v = 0\frac{m}{s}, a = -9.8\frac{m}{s^2}, y = ?$
    $v^2 = v_0^2 + 2a(y - y_0)$
    $\left(0\frac{m}{s}\right)^2 = \left(5\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)(y - 0\ m)$
    $-25\frac{m^2}{s^2} = \left(-19.6\frac{m}{s^2}\right)y$
    $y = \mathbf{1.28\ m}$
16. $v_0 = 0.5\frac{m}{s}, d = 15\ m, a = 3\frac{m}{s^2}, t = ?$
    $d = d_0 + v_0 t + \frac{1}{2}at^2$
    $15\ m = 0\ m + \left(0.5\frac{m}{s}\right)t + \frac{1}{2}\left(3\frac{m}{s^2}\right)t^2$
    $0 = \left(\frac{3}{2}\frac{m}{s^2}\right)t^2 + \left(0.5\frac{m}{s}\right)t - 15\ m$
    $t = \frac{-0.5 \pm \sqrt{(0.5)^2 - 4\left(\frac{3}{2}\right)(-15)}}{2\left(\frac{3}{2}\right)} = \mathbf{3\ s}, \sout{-3.33\ s}$
17.

	x	y
21 km @ 15° N of E	20.28	5.44
2 km @ 75° S of E	0.52	−1.93
	20.80	3.51

    $r = \sqrt{20.80^2 + 3.51^2} = 21.1\ km$
    $\theta = tan^{-1}\frac{3.51}{20.80} = 9.67°\ N\ of\ E$
18.

	x	y
15 m/s S	0	-15
2 m/s W	-2	0
	-2	-15

    $v_{SG} = \sqrt{(-2)^2 + (-15)^2} = 15.1\ m/s$
    $\theta = tan^{-1} - \frac{15}{-2} = 82.4°$
    $v_{SG} = \mathbf{15.1\frac{m}{s}\ at\ 82.4°\ S\ of\ W}$
19. $x: v_{0x} = 5\frac{m}{s}, y: v_{0y} = 0\frac{m}{s}, y_0 = 50\ m, a_y = -9.8\frac{m}{s^2}, y = 0\ m, v_y = ?$
    $v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$
    $v_y^2 = \left(0\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)(0\ m - 50\ m)$
    $v_y^2 = 980\frac{m}{s}$
    $v_y = 31.30\frac{m}{s}$
    combine: $v = \sqrt{v_x^2 + v_y^2}$
    $v = \sqrt{\left(5\frac{m}{s}\right)^2 + \left(31.30\frac{m}{s}\right)^2} = \mathbf{31.7\ m/s}$