A2

PHY 111 Unit conversions

1. 1.609 km = 1 mile 3.78 liters = 1 gallon

If a car consumes gets 14 km/liter, what is the car's gas mileage in miles/gallon?

2. 1 dollar = 10.7 pesos 1 kg = 2.24 pounds

A certain type of produce sells for 18 pesos/kg in a Mexican market. What is the cost in dollars/pound?

3. 1 square mile = 640 acres

If the Amazon rainforest is diminishing at a rate of 2000 square miles per year, by what rate is it diminishing in acres per hour?

2

PHY 111 Metric System

One of the great advantages of the metric system (besides the fact that it is used in almost every country of the world) is that to convert from one unit to another, it is simply a matter of moving a decimal point.

Physicists, by agreement, have decided to use the **second (s or sec)** as the standard unit of time, the **meter (m)** as the standard unit of distance, and the **kilogram (kg)** as the standard as the standard unit of mass. (There will be occasions however when another unit may be more convenient.)

The metric system works on a system of prefixes. The prefixes between one thousand and one thousandth are listed below.

kilo	hecto	deka	**UNIT (meter) (gram) (second) (liter) etc.**	deci	**centi**	**milli**
1000	100	10	1	0.1	0.01	0.001

---

7 m = cm

32 cm = m

16 mm = m

250 g = kg

12 kg = g

25 km = m

50 mg = g = kg

PHY 111 **Velocity, distance, time**

1. The record for the 200-m dash (as of 1988) is 19.75 sec. What is the runner's average speed? Give the answer in a) m/sec and b) mph.

2. Kangaroos have been clocked at speeds of 65 km/h. How far can a kangaroo hop in 2 minutes at this speed? Give the answer in a) km and b) meters.

3. You see a flash of lightning and 3.5 seconds later you hear the thunder. How far away was the lightning in a) meters and b) miles? (The speed of sound is 340 m/sec.)

4

PHY 111 Velocity Practice Questions

1. Joe stands at the rim of the Grand Canyon and yells down toward the bottom. He hears his echo back from the canyon floor 5.2 sec later. Assume that the speed of sound is 340 m/sec. How deep is the canyon in meters? In feet?
(1 mile = 1609 m = 5280 ft)

2. For many years it was the dream of runners to break the "4-minute mile". Now, quite a few runners have achieved what was once considered to be an impossible goal. In 1988, Steve Cram ran a mile in 3 min and 49 seconds. What was his average speed in miles per hour? In m/sec?

PHY 111 **Motion Diagrams**

In the following motion diagrams, show several velocity arrows (vectors) and the appropriate acceleration arrow.

1. A man runs at constant speed (not speeding up or slowing down) to the left.

2. A car starts from rest (speed = 0) and picks up speed traveling to the left.

3. An object is dropped from the roof of a house.

4. A ball is thrown straight upward and reaches its highest point.

5. A toy rocket launches from the ground, gaining speed as it gains altitude. Then the engine turns off. Eventually, the rocket reaches its highest point. (Two part diagram.)

6. A car is initially at rest at a stop light. When the light turns green, the car accelerates to 40 mph, moves for several seconds at a constant speed of 40 mph, and then slows to a stop as it approaches the next light. The motion diagram has three parts. For each part, draw several velocity arrows and an acceleration arrow.

6

PHY 111 **Introduction to Acceleration: Questions**

1. A car begins at rest (speed zero). It accelerates at 6 miles/hour/sec over the next 4 seconds.
(a) Give the speed of the car in mph at each second.

$t = 0$ $t = 1$ $t = 2$ $t = 3$ $t = 4$
0 mph

b) Draw a motion diagram. Include the acceleration vector.

c) Suppose the car continues to accelerate at this same rate of acceleration. How many seconds would it take the car to reach a speed of 42 mph? 63 mph?

2. A car has an initial speed of 10 m/sec. It is picking up speed with an acceleration of 6 m/sec/sec over the next 5 seconds.
(a) Give the speed of the car in m/sec at each second.

$t = 0$ $t = 1$ $t = 2$ $t = 3$ $t = 4$ $t = 5$

b) After reaching the speed you calculated at $t = 5$, the immediately begins to decelerate at 2 m/sec/sec for the next 5 seconds (until $t = 10$ seconds). Find the speed for the next 5 seconds.

$t = 6$ $t = 7$ $t = 8$ $t = 9$ $t = 10$

3. A car is traveling at a speed of 27 m/s. It decelerates at a rate of 6 m/sec^2.
a) What is the speed of the car after 1 second? After 2 seconds?

b) How many seconds will it take for the car to come to a stop?

c) Draw a motion diagram. Include the acceleration vector.

For each of the following questions, draw a motion diagram.

4. A car has an initial velocity of 6 m/s and 8 seconds later has a velocity of 26 m/s. What is the acceleration of the car?

5. A car has an initial velocity of 10 m/s. It undergoes an acceleration of 1.5 m/sec^2 for 4 seconds then an acceleration of -2 m/sec^2 for 6 seconds. What is the final velocity of the car?

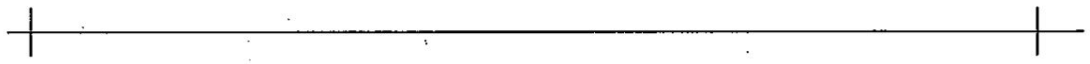
8

PHY 111 Find the distance traveled #2

1. A car slows down from 35 m/sec to a stop in 10 seconds.

Draw a motion diagram (including the acceleration). Fill in the information.

$t_0 = 0$ $t_f =$
$x_0 = 0$ $x_f =$
$v_0 =$ $v_f =$

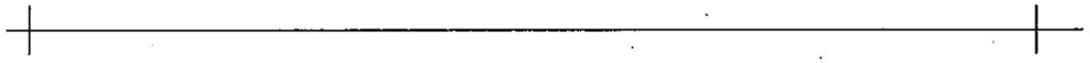


Average speed of car = Distance traveled for that time interval =

2. A car speeds up from 5 m/sec to 25 m/sec over a time interval of 10 seconds.

Draw a motion diagram (including the acceleration). Fill in the information.

$t_0 = 0$ $t_f =$
$x_0 = 0$ $x_f =$
$v_0 =$ $v_f =$



Average speed of car = Distance traveled for that time interval =

3. A runner accelerates from 0 to 10 m/sec over a time of 4 sec (point A to point B). He then continues at 10 m/sec for 15 more seconds (point B to point C).

Find the distance traveled in each segment.
Find the cumulative distance traveled from point A to point C.
Draw a motion diagram. Include an acceleration arrow for each segment of the trip. Fill in the information.

$t_A = 0$ $t_B =$ $t_C =$

$x_A = 0$ $x_B =$ $x_C =$

$v_A = 0$ $v_b =$ $v_C =$

On the planet Mars, an object is dropped from a height and falls to the ground.

The acceleration on Mars is 4 m/sec/sec. That means $g = 4\ m/sec^2$.

a) Draw a motion diagram for the falling object.
b) Give the speed of the object at each second.
c) Give the distance fallen of the object at each second.

	motion diagram	speed	distance fallen
t = 0	•	**0**	**0**
t = 1			
t = 2			
t = 3			
t = 4			
t = 5			
t = 6			

10

PHY 111 Gravity on Jupiter, Two-part motion

The acceleration on the planet Jupiter is about 24 m/sec^2.

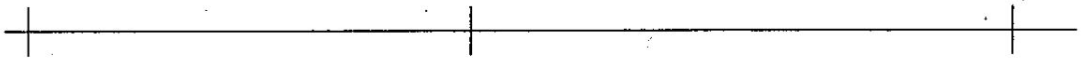
1. Suppose a ball at rest is dropped at $t = 0$ from a cliff on Jupiter (probably no cliffs exist on Jupiter.) Give the distance fallen and the velocity of the ball at

$t = 1$ sec	$t = 2$ sec	$t = 3$ sec
$d =$	$d =$	$d =$
$v =$	$v =$	$v =$

What will be the speed of the ball after 4.5 seconds? What distance will it have fallen?

2. A car passes a traffic light at a speed of 30 m/sec. The car travels at this constant speed for 2 seconds. The driver hits the brakes and slows down at a rate of 5 m/sec^2, until the car comes to a stop.
Draw the motion diagram (with appropriate acceleration arrows). Fill in the information below. Find the total distance the car travels from passing the traffic light until it comes to a stop.

$t_A = 0$	$t_B =$	$t_C =$
$x_A = 0$	$x_B =$	$x_C =$
$v_A = 30$	$v_b =$	$v_C =$



PHY 111 Find the distance traveled: alternate formulas (#2)

1. A car initially traveling at 32 m/s comes to a stop in 8 seconds.

Draw a motion diagram (including the acceleration). Fill in the information.

$t_0 = 0$ $t_f =$
$x_0 = 0$ $x_f =$
$v_0 =$ $v_f =$

Average speed of car =

Find the distance traveled for that time interval using

a) $d = v_{ave} * t$

b) $2ad = v_f^2 - v_o^2$

c) $d = \frac{1}{2}at^2$

2. A car speeds from 15 to 35 m/sec over a time interval of 4 seconds.

Draw a motion diagram (including the acceleration). Fill in the information.

$t_0 = 0$ $t_f =$
$x_0 = 0$ $x_f =$
$v_0 =$ $v_f =$

Average speed of car =

Find the distance traveled for that time interval using

a) $d = v_{ave} * t$

b) $2ad = v_f^2 - v_o^2$

c) Try $d = \frac{1}{2}at^2$

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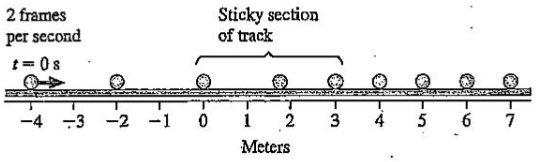
PHY 111 Distance of falling object, frame by frame of a rolling ball

1. A ball initially at rest is dropped from tall building. It hits the ground 3.5 seconds later. How tall is the building? What is the speed of the object when it hits the ground in m/sec?

2. A building is 100 m tall. How many seconds would it take for an object dropped from the top at that building to hit the ground? How fast would the object be going when it hit?

3. The diagram shows a ball rolling to the right along a track. The position of the ball is shown at ½ second intervals. The ball is traveling at constant speed to the left of $x = 0$ and to the right of $x = 3$. The ball is decelerating in the interval from $x = 0$ to $x = 3$.

a) Draw a motion diagram for the ball's motion.
b) What is the ball's speed to the left of $x = 0$?
c) What is the ball's speed to the right of $x = 3$?
d) Find the ball's deceleration in the sticky section using $a = \Delta v/\Delta t$.
e) Find the ball's deceleration in the sticky section using an alternate equation that does not need values for time.



PHY 111 Distance, Velocity, Acceleration: Review

1. An object travels 20 m in 4 seconds at constant speed. What is the constant speed?

2. An starts at rest and accelerates forward. It travels 20 m in 4 seconds at constant acceleration.
a) What is the acceleration?

b) What is the average speed?

c) What is the final speed?

3. An object falls a height of 50 m to the ground. (Its initial speed is zero.)
a) In the margin of the paper, draw the motion diagram. Include the acceleration vector.

b) What is the acceleration of the object as it falls? (This does not have to be calculated.)

c) How many seconds will it take for the object to reach the ground?

d) What is the impact speed of the object?

e) What is the average speed of the object for its fall to the ground?

4. An object moves forward, accelerating from an initial speed of 10 m/sec to a final speed of 40 m/sec. It takes 10 seconds accelerate.
a) What is the acceleration?

b) Use two different methods to find the distance traveled in the time interval.

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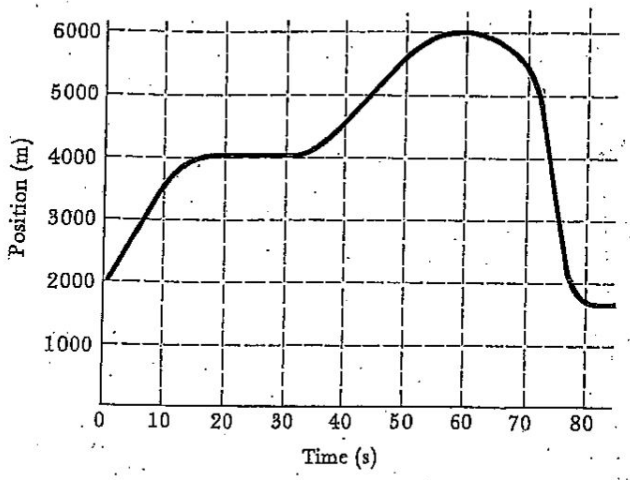
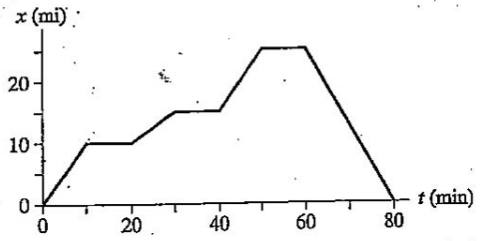
2.9 Graphical Analysis of Velocity and Acceleration

1. A car's changing position as a function of time is shown in Fig. 2.26. During what time period(s) was the car (a) at rest, (b) moving in the positive direction, and (c) moving in the negative direction? Estimate the car's greatest speed in (d) the positive direction and (e) the negative direction and the times at which these speeds occurred.



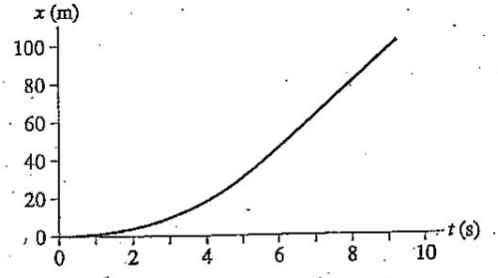
2. Moving car

Find the velocity of the car for each segment.



3. Sprinter

At the beginning, the sprinter accelerates, then runs at a constant top speed.
a) Make a motion diagram of the sprinter's motion.
b) Find the top speed of the sprinter.
c) Estimate the sprinter's acceleration in the first part of the race.



PHY 111 **Kinematics problems (homework)**

1. An Air Force fighter jet can accelerate from a speed of 220 mph (100 m/sec) to a speed of 670 mph (300 m/sec) over a distance of about 1 mile (1600 m).
a) What is the acceleration of the jet over this interval?
b) What is the time to travel this distance?
c) How many "g's" of acceleration does the pilot feel? (1 g = 10 m/sec^2)

2. What is the acceleration of a car that gets to a speed of 18 m/s (starting from rest) while traveling a distance of 240 m? How many seconds does it take the car to reach that speed? (Draw a motion diagram and fill in the known values.)

$t_o =$ $\qquad$ $t_f =$
$x_o =$ $\qquad$ $x_f =$
$v_o =$ $\qquad$ $v_f =$

16

3. An arrow is fired upwards leaving the bow at a speed of 25 m/s sec. If air resistance is negligible, how many seconds will it take the arrow to reach its highest point? How high will the arrow rise? (Draw a motion diagram and fill in the known values.)

4. A skydiver slows from 52 m/s to 8 m/s in 1.6 seconds as her parachute opens. Calculate her deceleration (assumed constant) and the distance traveled while the parachute is opening. (Draw a motion diagram and fill in the known values.)

1.6 Skier Races Downhill

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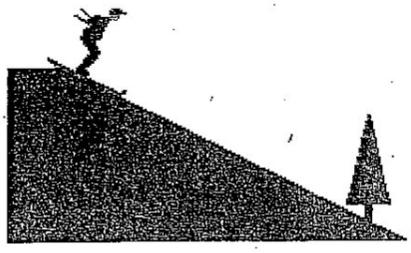
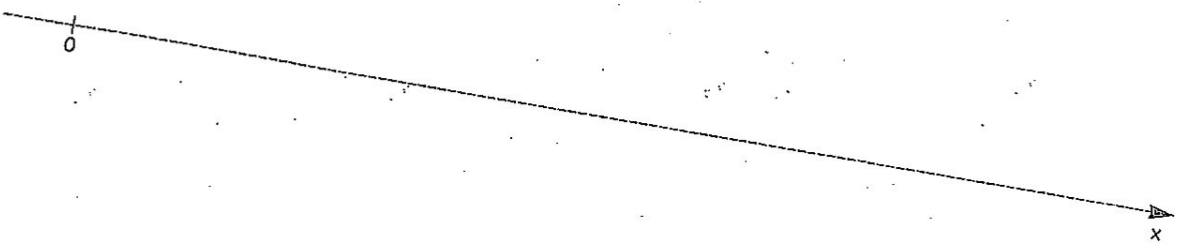
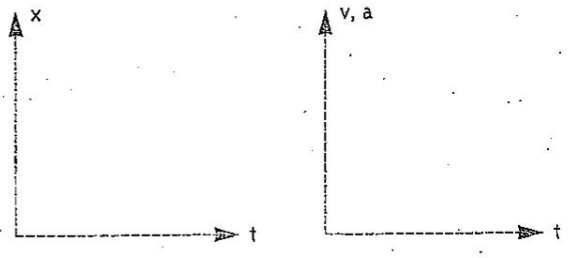


A skier travels 200 m to a finish line, a pole at the last tree. She starts at rest and her speed at the finish line is 31.7 m/s. Describe the process using a pictorial description, a motion diagram, kinematics graphs, and equations. Then determine the time interval needed for the trip and her constant acceleration. (Complete the descriptions below to answer Question 1.)

Question 1: Pictorial Description: Include a sketch, axis, symbols, and values.



Graphs: Construct the graphs.



Find the velocity at t=5.

at t=10.

18

PHY 111 100-meter dash

An athlete runs a race which is 100 m from start to finish. He begins at rest and accelerates for the first 4 seconds at 3 m/sec^2, at which point he reaches his top speed. He then continues the rest of the race at that speed.

a) Draw the motion diagram. Fill in values you know at this point.

$t_A = 0$ $t_B =$ $t_C =$

$x_A = 0$ $x_B =$ $x_C = 100$

$v_A = 0$ $v_b =$ $v_C =$

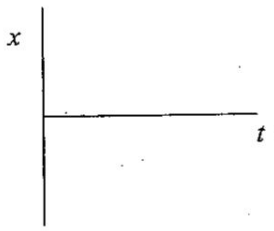
a = a =

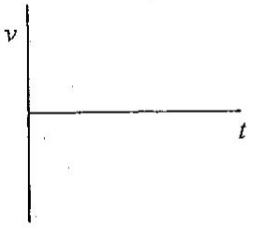
b) What is the top speed the runner reaches?

c) How far does the runner go in the first 4 seconds?

d) This runner is competing in a 100-meter dash. What is the total time it will take him to run 100 meters?

e) Sketch the position vs. time graph and the velocity vs. time graph.





1.9 Screeching to a Halt

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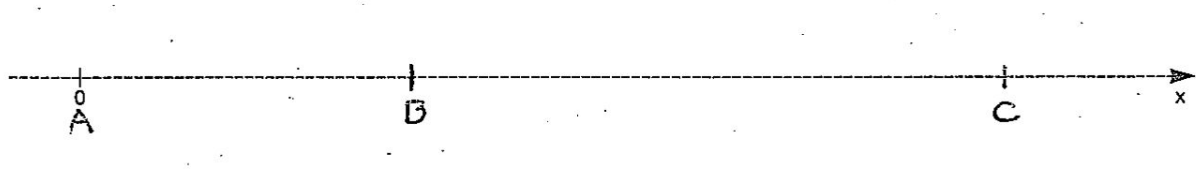
You are asked to help the state motor-vehicle department construct a table that gives the car-stopping distance for different initial car speeds. Suppose that a car's initial speed is 24 m/s (about 54 mph) and that the car's acceleration when the brakes are applied is $-6.0\ m/s^2$. There is a 0.80-s reaction time from the instant the driver sees the need to stop until the brake is applied and acceleration starts. Your goal is to predict the car's stopping distance. Note: This is a two-part problem. (Complete the descriptions below to answer Questions 1–3.)

Pictorial Description:



2

Sketch a graph of position vs time.

Sketch a graph of velocity vs time.

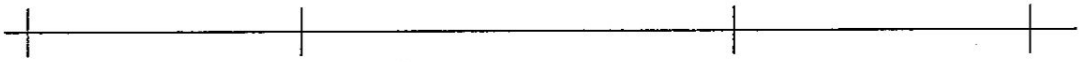
20

PHY 111 **Light to Light**

A car starts at rest at a stop light (point A) and accelerates uniformly at 4 m/sec^2 until it reaches a speed of 20 m/sec (point B). The car then travels for an unknown time at a constant speed of 20 m/sec. At point C the car starts to decelerate at 4 m/sec^2 until it stops at the next light (point D). The car travels a total distance of 300 m from light to light (A to D).

Draw a motion diagram. Include an acceleration arrow for each segment of the trip. Fill in the information you know.

$t_A = 0$	$t_B =$	$t_C =$	$t_D =$
$x_A = 0$	$x_B =$	$x_C =$	$x_D =$
$v_A = 0$	$v_b =$	$v_C =$	$v_D =$



a) What is the time to reach point B?

b) What is the distance between A and B?

c) What is the distance between C and D?

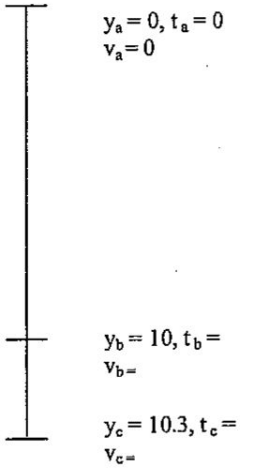
d) Find the remaining values in the diagram above.

PHY 111 **High dive into 1 foot of water** **Google: Stan Lee high diver**

http://www.history.com/shows/stan-lees-superhumans/videos/super-high-diver#super-high-diver

A man jumped from a height of 33 feet (10 meters) and "belly flopped" into a small shallow pool of water 12 inches (30 cm) deep. (He comes to a stop after sinking 30 cm into the water.) Note: You can use g = 10 m/sec^2. Using g = 10 instead of 9.8 has only a minor effect on the answers below.

It will be convenient to let y = 0 at the top of the high dive and define down as the positive direction.



a) Draw a motion diagram.
The given values are on the diagram.

b) Find the velocity of the diver as he first hits the water. (What is his speed after falling 10 m?)
(The video claims 34 mph. Is this correct?)

c) What is his deceleration as he slows to a stop in a distance of 30cm?

d) How many g's does he feel as he slows to a stop? (The video says he feels 40 g's. Is this accurate?)

22

PHY 111 **A ball rolls down a ramp**

A ball (initially at rest) rolls down a ramp (from A to B). The ball reaches top speed at point B, then continues to roll at that speed without slowing to point C.

The distance from A to B is 4 meters, and the time from A to B is 5 seconds. The acceleration from A to B is constant. The time from B to C is also 5 seconds.

Fill in the values in the following chart. Draw a motion diagram. Include an acceleration arrow for each segment of the trip. The position and times values at C are cumulative.