MR. WAYNE'S PHYSICS STUDENT WORKBOOK & OBJECTIVES

This workbook is a collection of word problems and unit objectives to augment or replace the problems found in textbooks. Students are to show all work in their physics notebooks. The physics notebook is a bound collection of papers such as a composition notebook or spiral bound notebook.

This workbook is meant to supplement the textbook problems. Every problem, (over 1350 of them,) in this workbook will not be assigned. It provides the teacher with choices on what to assign. Because the class is always changing, additional problems and worksheets will be downloaded. Some of these worksheets will be copied to paper because of their visual nature. But if you forgot a worksheet and need to do a problem at home, you can print it off from this document.

This is the first edition and I'm sure there are some wrong answers, when answers are provided, and a few typos. Hopefully these will be eliminated in the next edition.

Table of Contents

Dimensional Analysis Facts Sheet

(Do not memorize. You will receive a clean copy of this on your assessment.)

POWERS of TEN

Thousand = 10^3

Million = 10^6

Billion = 10^9

Trillion = 10^{12}

Quadrillion =10^{15}

Quintillion = 10^{18}

DISTANCE UNITS

Parsec = 1.91738 X 10^{13} miles

Furlong = $^1/_8$ mile

Rod = Pearch

Rod = 25 links

Football field = 100 yards

Soccer field = 100 METERS

Rod = 5.50 yards

Fathom = 6 feet

Yard = 3 feet

foot = 12 inches

inch = 2.54 centimeters (exactly)

centimeter = 10 millimeters

decimeter = 10 centimeters

meter = 100 centimeters

5280 feet = 1 mile

dekameter = 10 meters

Walking pace (avg) = 22 inches

Story on a building = 3 m

Light year = 9.467 X 10^{15} meters

Barn = 10^{-24} cm^2

League = 3 miles

Cubit = 20 inches

4 rods = chain

TIME UNITS

millennium = 1,000 years

century = 100 years

decade = 10 years

years = 365 days

day = 24 hours

hour = 60 minutes

minute = 60 seconds

$$\text{Blink of an eye} = \frac{1}{10}\ \text{s}$$

fortnight = 14 days

WEIGHTS and METRIC MASSES

Pound = 16 ounces

Ton = 2000 pounds

Tonne = 1000 kilograms (metric ton)

Gram = 1000 milligrams

Kilogram = 1000 grams

Kilogram = 2.205 pounds

Poundal = 14.09808 grams

Dram = 60 grains

Pound = 7000 grains

VOLUME MEASUREMENTS

1 liter = 1000 milliliters

2 liters = 67.63 ounces

1 gallon = 128 ounces

1 milliliter = cm^3

1 milliliter = 20 drops

2 pints = 1 quart

4 quarts = 1 gallon

Objectives

You will get a sheet like this at the beginning of almost every unit. This sheet identifies the kinds of questions and the content you will need to know for the end of unit test.

Dimensional Analysis

Students will be able to:

1. Create a fraction from an equality relationship.

2. Solve unit conversion problems involving single variables.

3. Solve unit conversion problems involving fractions

4. Solve unit conversion problems where a unit or part of the unit is raised to a power.

There is an online pretest (http://www.mrwaynesclass.com).
Do not memorize the unit conversion sheet.

Refer to the "Dimensional Analysis Fact Sheet"

1. How many inches are there in a football field?
2. How many feet are there in a mile?
3. How many yards are there in a mile?
4. How many yards are there in a soccer field?
5. How many feet are there in a furlong?
6. How many paces make up a football field?
7. How many paces make up a furlong?
8. How many fathoms are a 20 foot deep diving well?
9. Every 75 feet down a scuba diver goes makes him feel like he has had a martini. How many fathoms is this?
10. How feet are between the first and second floor of a building (one story)?
11. How many parsecs make up a light year?
12. How many rods make up a mile?
13. How many centimeters are in a fathom?
14. How many seconds are in a year?
15. How many hours are in a fortnight?
16. The average life span a tortoise is 200 years. How many scores is this?
17. A housefly's life span is 3 days. How many minutes is this?

*18. If a person blinks their eyes once every 3 minutes on the average, then how many times do they blink their eye in a day?

19. How many grams are in a pound?

20 How many poundals are in a pound?

21. How many pounds are in a metric ton?
22. A typical locomotive weighs 40,000 tons. How many drams is this?

* 23. A typical car manufactured in 1974 weighs 4000 pounds. How many McDonald's Quarter Pounderstm is this? If the Quarter Poundertm costs $0.65 in 1974 and the car costs $6,000, then which is cheaper the car or the car's weight in Quarter Pounderstm?

*24. What is the speed of a car in feet/second that is traveling at 60 miles/hour?

*25. The space shuttle travels at 28,000 mph while orbiting the Earth. How far does the shuttle travel in feet in the blink of an eye?

*26. How much time, in seconds, passes before a beam of light, traveling at 3.00 X 10^8 meters/second travels one foot?

*27. A stack of ten 3.5 inch diskettes is 34 millimeters high. How many diskettes does it take to make a stack 100 yards high?

*28. A physics book is 1.5 inches thick. How many books would it take to make a stack 2 stories high?

*29. If you earned one penny every 10 seconds of your life then how many dollars would you have after 65 years?

**30. A 5.25 inch diskette spins around once every 0.200 seconds. The disk's diameter is 5.25 seconds. If you were an insect sitting on the edge of the diskette, then how fast would travel in mph?

31. A container holds 16 ounces. What is the volume of this container in $inches^3$?
- If the container is a glass with a diameter of 2 inches, what is its height?

32. An "acre" is a measure of land that is 43,560 $feet^2$. How many square meters is this?
- How many meters on each side of a square is this?

33. A car is traveling at 88 ft/sec. What is the car's speed in miles/hour?

34. In a crazed neighborhood they are replacing the speed limit signs that give the speed in m/s. What would the new sign say if it were to replace a 25 mph sign?

35. When the space shuttle is at its maximum orbit radius it is traveling at 28,000 mph. How many miles/second is this?

36. A tennis ball leaves a racket during a serve at 29.22 fathoms/s. During a yellow flag at a race on the Indianapolis speedway the cars travel 82 mi/hr. A runner travels 0.125 furlong/s. Which object is traveling the fastest?

37. A swimming pool can hold 20,000 gallons of water. A pond holds 2,000,000 cm^3 of water. A well holds 12,000 liters of water. Which vessel holds the most amount of water?

38. A peregrine falcon can travel at 537,600 furlong/fortnight. A racecar travels at 212 ft/s. A spider can jump with a maximum velocity of 9,000,000 cm/hr. Which travels the fastest? Show numbers to support your answer.

39. A 2 liter bottle of Pepsi costs $0.99. A gallon of milk costs $1.89. A 12-ounce can of “Food Lion” cola costs $0.20. Which fluid is the cheapest per unit?

40. Which is the greatest volume; a human’s 8 pints of blood, a 2 liter bottle, a gallon jug of milk, or an old car engine whose displacement is 320 in^3?

41. A quart has an area of 5.06 cm^2. How many square ft is this?

42. A teaspoon of oil can cover the surface of a pond about 10,000 $cubits^2$ in size. How many square yards is this?

43. A fingerprint is about 1.25 in^2. How many cm^2 is this?

44. The continental United States covers about 16,000,000 $miles^2$. How squared walking paces is this?

45. The walls of a room have a total area of 60 square meters. How many rolls of wallpaper will it take to cover all the walls is a single roll can cover 24 ft^2?

Objectives

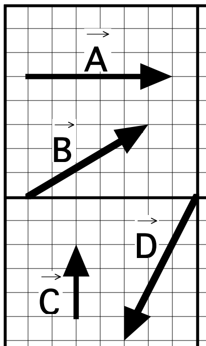
Vectors -Introduction

Students will be able to:

1. Define Sine, Cosine and Tangent in terms of the opposite, adjacent and hypotenuse of a triangle.
2. Use the above trig functions to finds angles and right triangle side lengths.
3. Define a vector in a sentence.
4. Describe a vector's two main features.
5. Define a scalar in a sentence.
6. Give examples of vectors and scalars.
7. Be able to identify if two vectors are equal
8. Graphically show the result of multiplying a vector by a positive scalar.
9. Graphically show the result of multiplying a vector by a negative scalar.
10. Graphically add vectors.
11. Graphically subtract vectors.
12. Graphically add, subtract and multiply vectors by a scalar in one equation.
13. Given a graphical representation of a vector equation, come up with the formula.
14. Calculate the magnitude of any vector's horizontal and vertical components.
15. Draw a vector's horizontal and vertical components.
16. Use trig to calculate a vector's direction.
17. Calculate a vectors direction as a degree measurement combined with compass directions.
18. Calculate a vector's magnitude using trig or Pythagorean theorem.
19. Add and subtract vectors by their components.

Use this for your notes about vectors.

SECTION 1



$2\vec{A}$

$\frac{1}{2}\vec{A}$

$-4\vec{C}$

$-\frac{1}{2}\vec{D}$

SECTION 2

$\vec{A} + \vec{B} = \vec{R_1}$

$\vec{A} + 4\vec{C} = \vec{R_2}$

$\vec{A} + 2\vec{B} + \frac{1}{2}\vec{C} = \vec{R_3}$

SECTION 3

$\vec{A} - \vec{C} = \vec{R_4}$

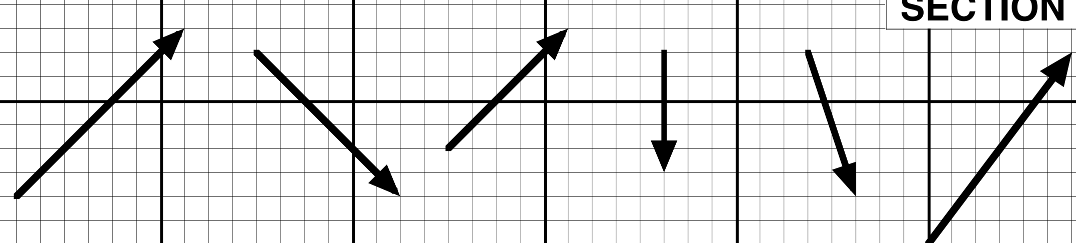
$\vec{B} - \vec{A} = \vec{R_5}$

$2\vec{C} - \vec{B} = \vec{R_6}$

$2\vec{C} - \vec{A} - \vec{B} = \vec{R_7}$

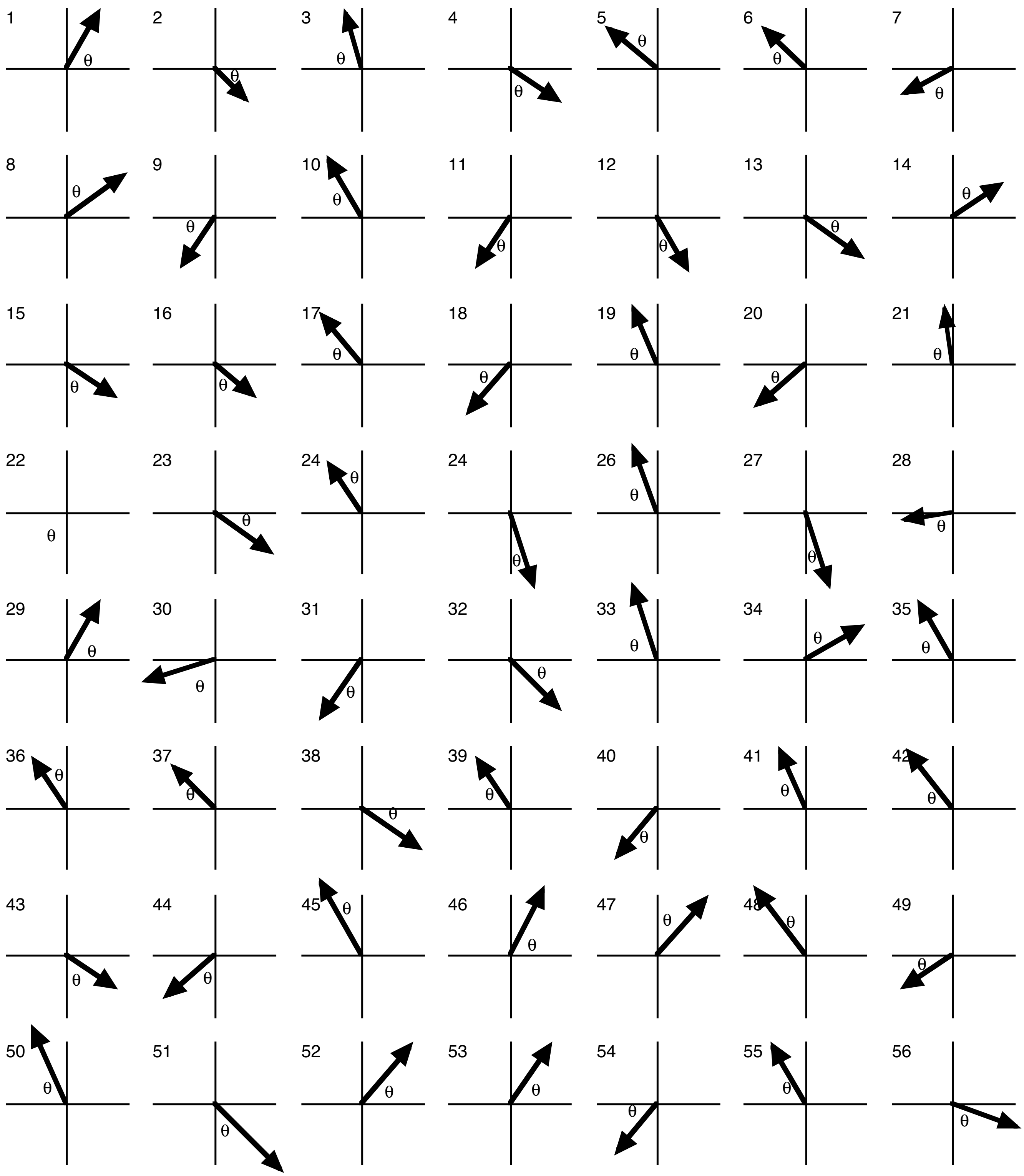
For the vectors below, calculate the vector’s magnitude, and direction.

SECTION 4



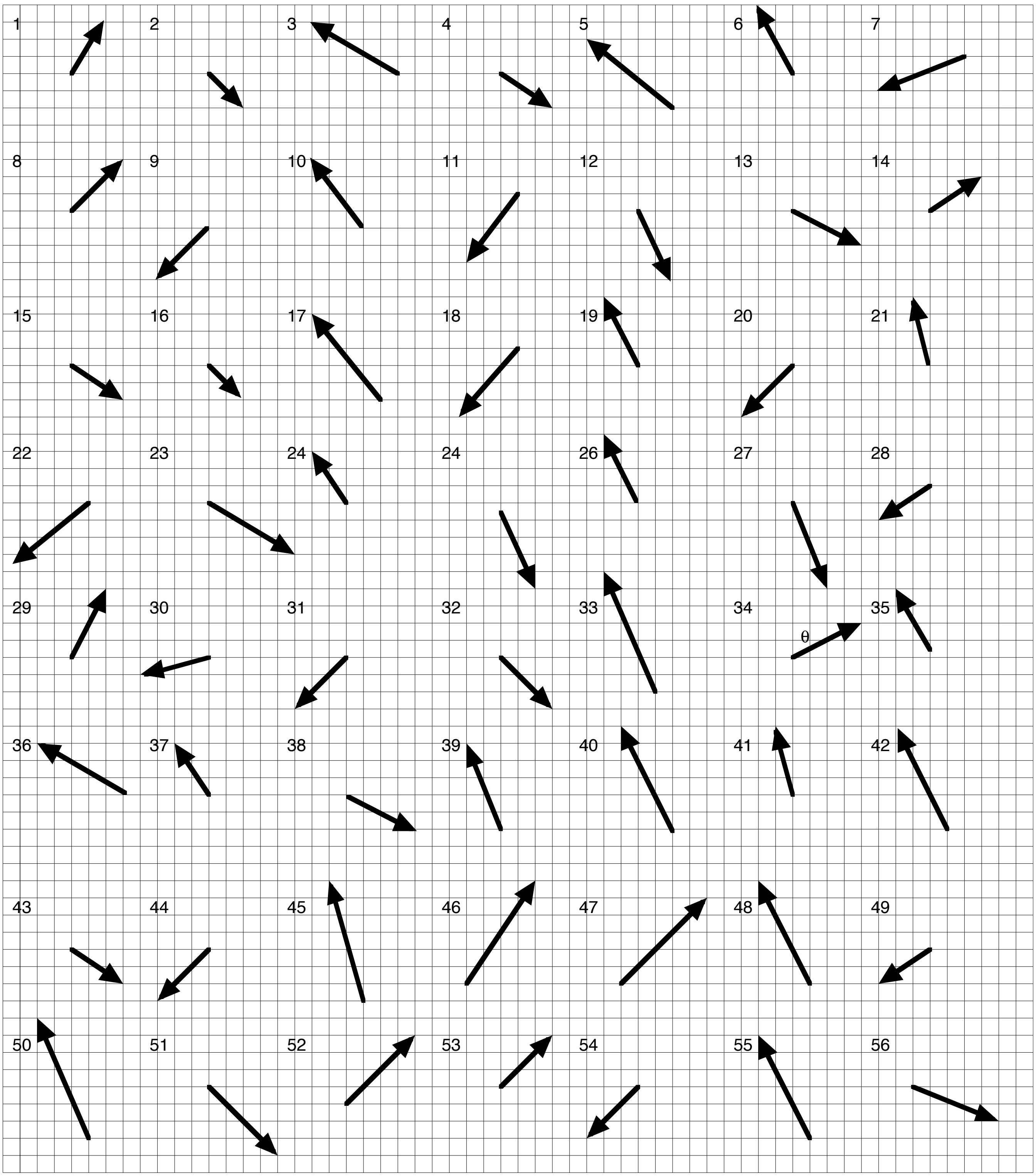
Vectors –Introduction

For each vector drawn below on a coordinate axis, label the shown θ with it proper compass headings, e.g. N of W, S, S of E, etc.



Vectors –Introduction

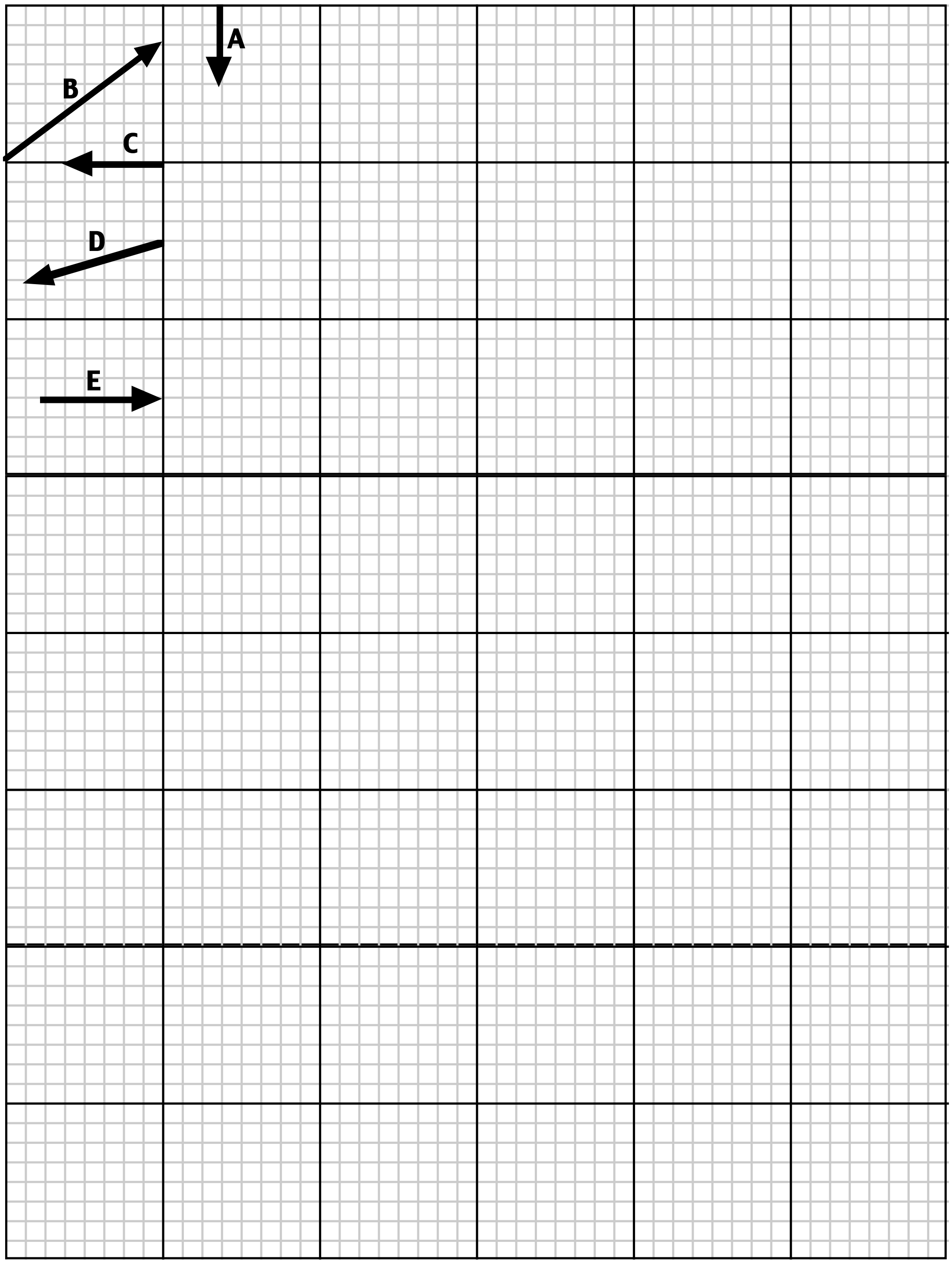
For each vector drawn below, calculate its magnitude and direction. NOTE: For the vector's direction, there will be two possible correct answers for each problem. The two answers are complimentary to each other.



VECTORS - GRAPHICAL MEANS

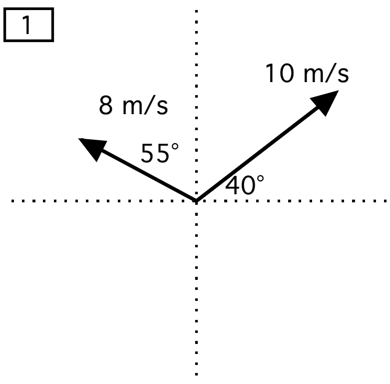
FIND THE RESULATANTS, (**R#**):

A + **B** = **R**1, **B** + **C** = **R**2, **E** + **D** = **R**3, **A** - **B** = **R**4, **B** - **D** = **R**5, **E** - **C** = **R**6,
A + **B** + **D** = **R**7, **E** + **A** + **C** = **R**8, **A** + (**-B**) = **R**9, **-B** + **C** + (**-D**) = **R**10,
E - **A** + **C** - **D** = **R**11,



Adding by Vector Components

1



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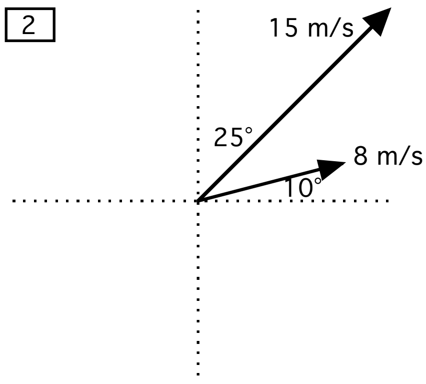

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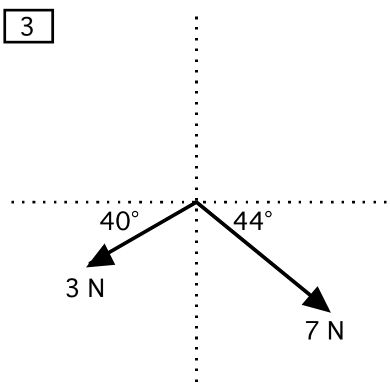

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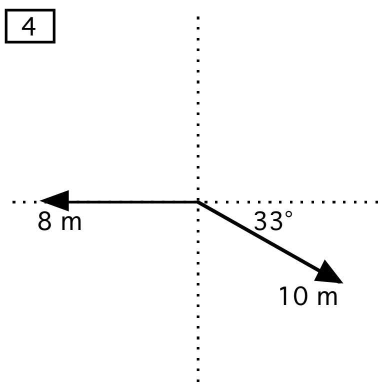
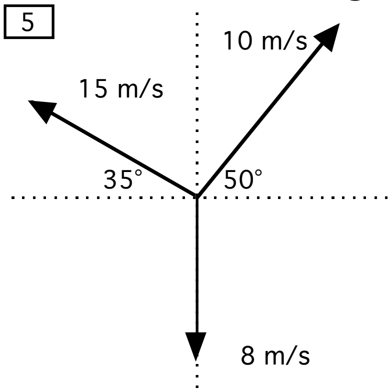


Adding by Vector Components

5



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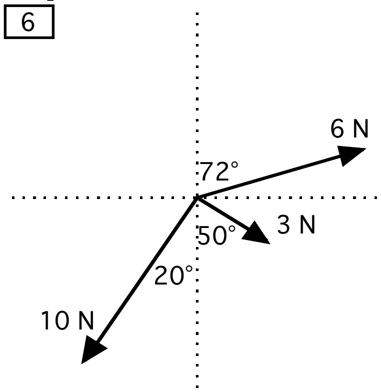

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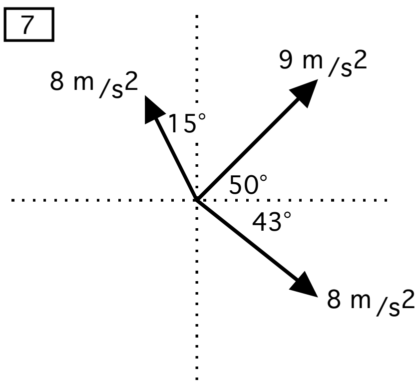

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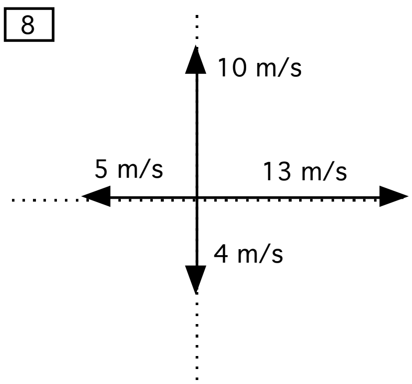
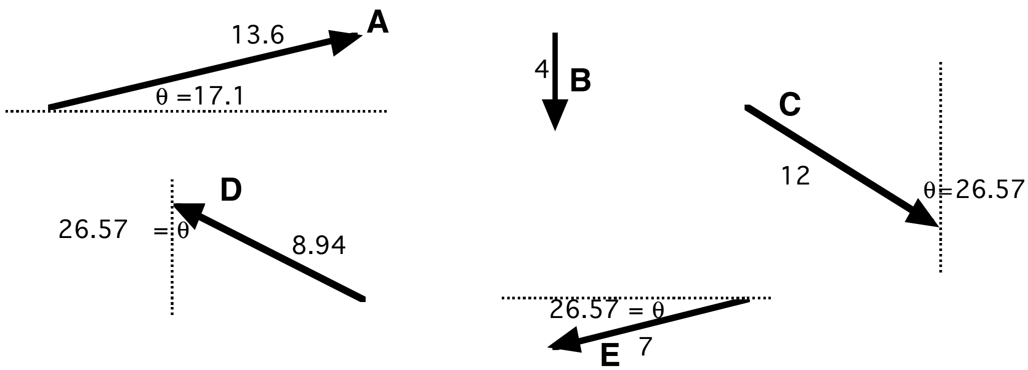


Basic Math by Vector Components

FIND THE RESULATANT'S LENGTH AND ACUTE ANGLE WITH THE HORIZONTAL FOR EACH **R**#:

A + **B** = **R1**, **B** + **C** = **R2**, **E** + **D** = **R3**, **A** - **B** = **R4**, **B** - **D** = **R5**, **E** - **C** = **R6**,
A + **B** + **D** = **R7**, **E** + **A** + **C** = **R8**, **A** + (**-B)** = **R9**, **-B** + **C** + (**-D**) = **R10**,
E - **A** + **C** - **D** = **R11**,



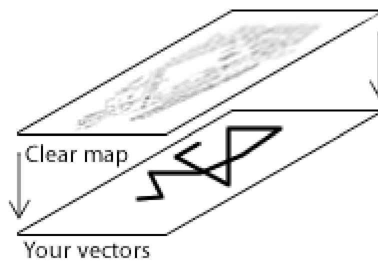
Vector	Magnitude	Direction	**OR**	Direction
R_1	2 √17 =8.25	18.43° N of E		71.57° E of N
R_2	2 √13 = 7.21	56.31° N of W		33.69° W of N
R_3	√5 = 2.24	63.43° S of W		26.57° W of S
R_4	2 √41 = 12.81	38.66° W of S		51.34° S of W
R_5	17	28.07° N of E		61.93° E of N
R_6	11	Due East		----
R_7	1	Due West		----
R_8	17	14.04° E of S		75.96° S of E
R_9	2 √41 = 12.81	38.66° W of S		51.34° S of W
R_{10}	2 √13 = 7.21	56.31° W of S		33.69° S of W

BOMB DISPOSAL DUTY

READ COMPLETELY BEFORE BEGINNING!!!

THE MISSION:

Your team has been recruited by the FBI to assist with the disarmament of a dirty bomb disguised as cafeteria refuse resembling food. The device is located in another room on the first floor of the school. To ensure success of your mission the explosive's location is found by combining a location on a vector map with a clear distorted map of the school. Our agents have obtained (from a spy masquerading as a principal) a complex vector description of the location of the bomb. Your job is to follow the directions to create the vector map. Another FBI operative is bringing a distorted map of the school drawn on clear acetate. You have 30 minutes, from the time you begin reading this, to locate this spot by drawing the whole scenario out on the provided piece of paper and marking the spot with an X. Then notify "the chief" (that would be your teacher).



THE GRADE:

Your grade on this project depends on the accuracy (percent error) of your spot location. However, if you fail to locate a spot before time expires, you will earn a **zero**. If you finish early, re-do your calculations and check your answer. You must clean your lab table before you leave class.

THE MATERIALS:

The only materials you will be allowed for this lab are your calculators, graph paper, ruler, and protractor.

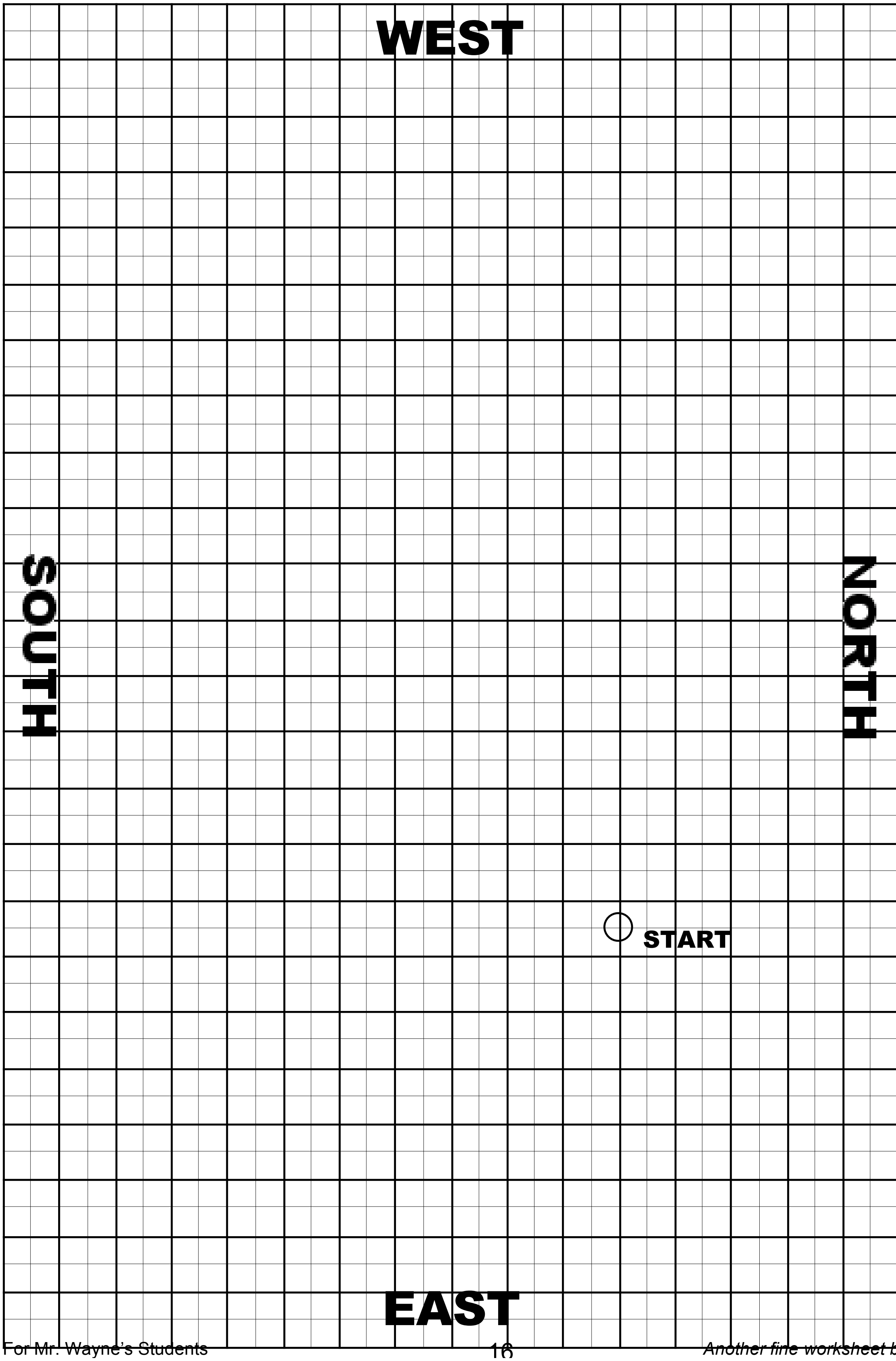
THE SPOT LOCATION:

From the center of the circle on the provided paper:

1. Go 1.00 inch due south
2. Go 6.1 cm east
3. Go 0.0000489 miles in a direction 45^o north of west
4. Go 2.0 cm in a direction 45^o south of east
5. Rotate 115^o clockwise from the last vector direction and travel 100,000,140 nm
6. Go 0.0200 feet west
7. Go 0.152 yards in a direction 67.0^o east of south
8. Go 0.00018288 km in a direction 20^o north of west
9. Go 8.0×10^4 μm in a direction 79.0^o south of west

THE CONVERSION FACTORS:

1 mile = 5280 ft
1 in = 2.54 cm
1.6 km = 1 mile


WEST
SOUTH
NORTH
START
EAST

Objectives

Kinematics by Graphical Means

Student should be able to:

1 In a sentence define

vector (give examples too)
scalar (give examples too)
displacement
speed
velocity
acceleration
jerk

2 Mathematically describe

average velocity
instantaneous velocity
average acceleration
instantaneous acceleration.

Kinematics & Graphing:

3 From a displacement vs time graph be able to answer questions about velocity

Example:

- a Find position
- b Find instantaneous velocity
- c Identify regions, line segments, of constant velocity
- d Identify regions, line segments, of positive velocity
- e Identify regions, line segments, of negative velocity
- f Identify regions, line segments, of acceleration
- g Identify regions, line segments, of positive acceleration
- h Identify regions, line segments, of negative acceleration

4 From a velocity vs. time graph be able to answer questions about acceleration and displacement

Example:

- a Find instantaneous velocity
- b Find instantaneous acceleration
- c Find displacement
- d Identify regions, line segments, of positive net displacement
- e Identify regions, line segments, of negative net displacement
- f Identify regions, line segments, of constant acceleration
- g Identify regions, line segments, of changing acceleration
- h Identify regions, line segments, of positive acceleration
- i Identify regions, line segments, of negative acceleration

5 From an acceleration vs. time graph be able to answer questions about velocity

- a Find instantaneous jerk
- b Identify regions, line segments, of positive net average velocity
- c Identify regions, line segments, of negative net average velocity

6 From a described situation draw either the displacement vs. time graph or a velocity vs. time graph

7 From an acceleration vs. time graph be able to answer questions about velocity

- a Find instantaneous acceleration
- b Find instantaneous jerk
- c Identify regions, line segments, of constant jerk
- d Identify regions, line segments, of positive jerk
- e Identify regions, line segments, of negative jerk

8 From a described situation draw either the displacement vs. time graph or a velocity vs. time graph

This is a note summary page for the unit on kinematics by graphical means.

x vs t **v vs t** **a vs t** **j vs t**

Definitions

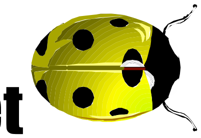
Variable	Name	Definition	Math
" x "			
" t "			
" v "			
" a "			
" j "			

This is a note summary page for the unit on kinematics by graphical means.

In the chart below you can describe how to calculate the different concepts from each graph.

GRAPH	position	velocity	acceleration	jerk
x vs t				
v vs t				
a vs t				
j vs t				

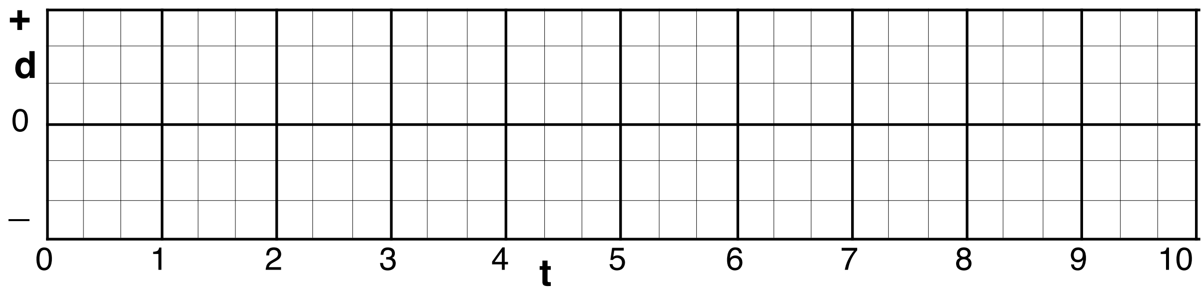
Kinematics Animated Graphs Worksheet



This worksheet is done in conjunction with a projected series of graphs. The animated graphs can be found at
http://www.mrwaynesclass.com/teacher/KinematicsGraph/animatedgraphs/home.html

GRAPH 1

Watch the animation (several times) and draw what you think the position vs time graph should look like for the beetle's motion.

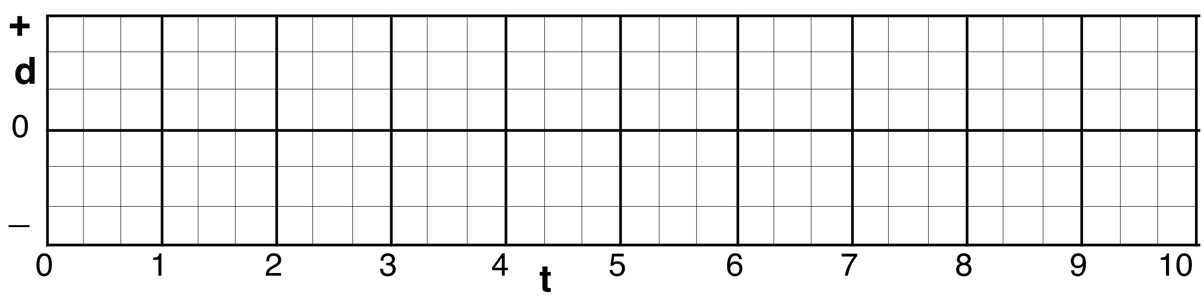


After seeing the animation and the solutions, answer the following:

1) Circle the piece(s) of your graph where the beetle is moving towards the "more negative" direction.
2) What is the sign of the SLOPE of these circle sections of the graph? (Pos or Neg)
3) Draw a dark "**X**" on the graph where the beetle is not moving?
4) What is the value of the slope for these section(s)? ____________
5) During which time interval is the beetle traveling the slowest? _____________
6) During which time interval on the graph is the slope the smallest number, (absolute value), without being zero? _____________
7) What does the slope represent on this graph? _____________

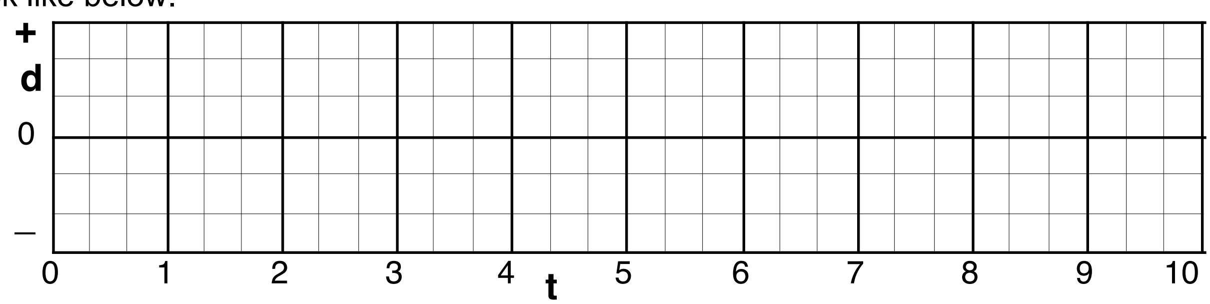
GRAPH 2

Watch the animation (several times) and draw what you think the position vs time graph should look like below.

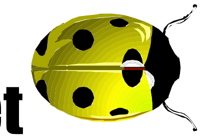


GRAPH 3

Watch the animation (several times) and draw what you think the position vs time graph should look like below.

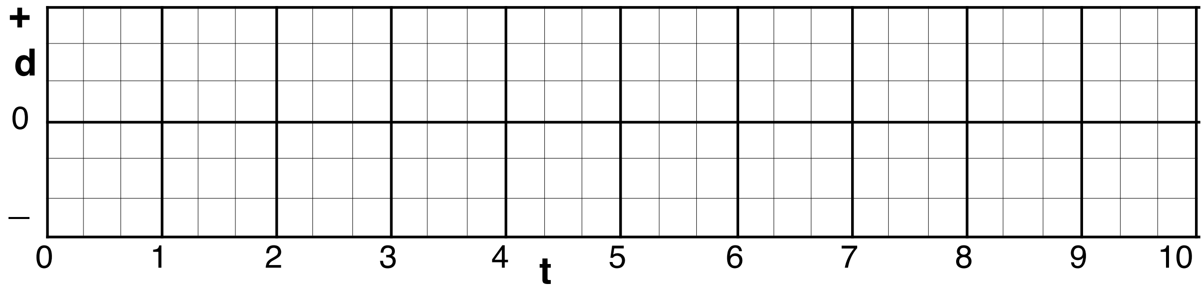


Kinematics Animated Graphs Worksheet



GRAPH 4

Watch the animation (several times) and draw what you think the position vs time graph should look like below.



GRAPH 5

This time you will see a graph. Write the motion of the beetle down. Do not use numbers in your descriptions. (You do not have to use all the blanks below.)

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____

GRAPH 6

This time you will see a graph. Write the motion of the beetle down. Do not use numbers in your descriptions. (You do not have to use all the blanks below.)

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____

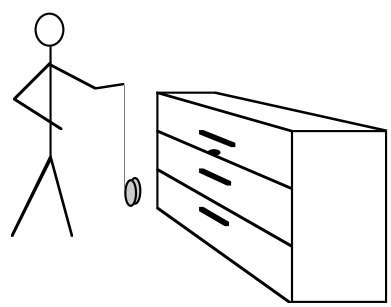
Kinematics Graphs Worksheet

For each situation described below draw a displacement vs. time graph that accurately as possible describes the situation.

1. A man steps out of his house and walks to the mailbox in front of his house.

- At the mailbox he pauses while fumbling through the mail.
- He turns and walks back to his house pausing half way there to smell a flower.
- After smelling the flower he runs into the house.

2. A flea watches a yo-yo pass him while he rests on a drawer that is at the mid-point of the yo-yo's motion.

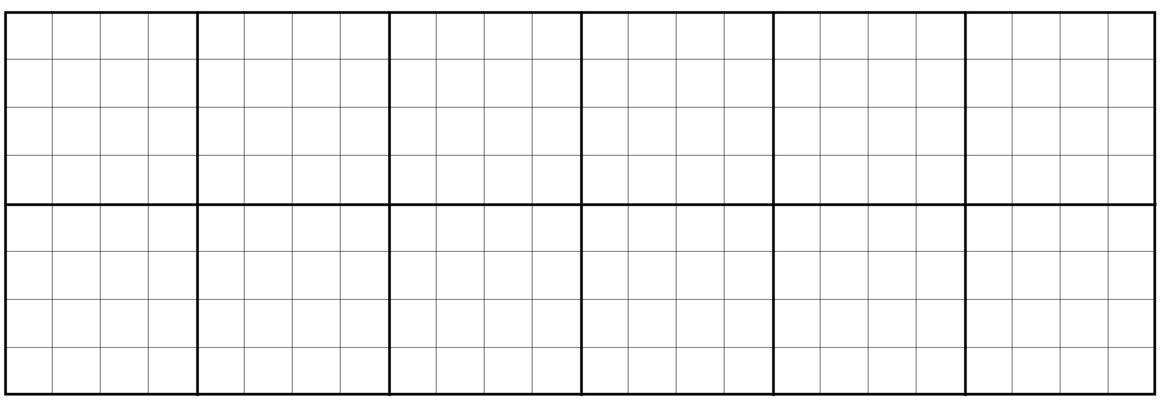


- The first thing the flea sees is the yo-yo passing him at a constant velocity on the way down.
- The yo-yo pauses at the bottom.
- It then travels past him on the way up to the yo-yo master's hand.
- The yo-yo's motion never ceases as the yo-yo master throws it down again.
- On the way down the string gets twisted and yo-yo stops at the exact height of the flea.
- After a moment it slowly drifts down to the end of the string.

Kinematics Graphs Worksheet

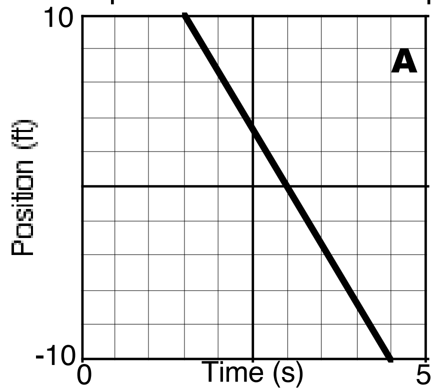
3. A cat and mouse are playing together. The cat has baited the mouse with a piece of cheese resting in front of him.

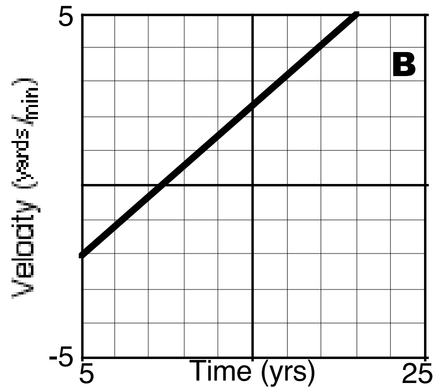
- The mouse slowly walks towards the cheese. 1/4 the way to the cheese he gets spooked and runs back to the safety of a small rock.
- The mouse, this time, walks more quickly towards the cheese. 1/2 the way to the cheese he gets scared and runs back to the safety of a small rock.
- The mouse runs towards the cheese. 3/4 the way to the cheese he gets nervous and runs back to the safety of a small rock. But 1/4 the way to the rock the changes his mind and runs back towards the cheese faster than ever before.
- The mouse picks up the cheese and begins to run back to the rock a little slower now.
- The cat begins to chase the mouse and the mouse begins to move his fastest yet by taking big jump towards the rock.
- He passes the rock and continues 1/4 the distance past the rock
- Pauses (He realizes the cat was actually being chased by a dog)
- Walks back to the rock.

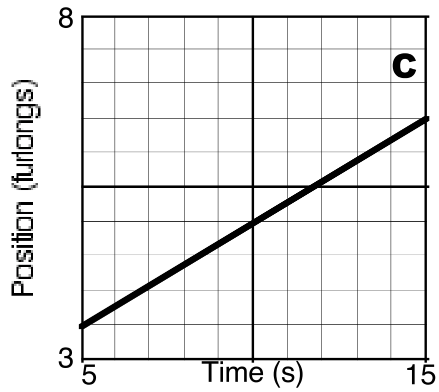


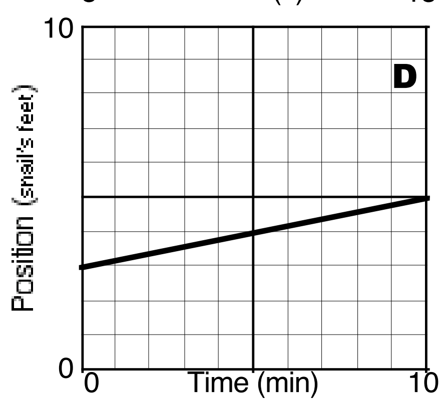
Kinematics Graphs Worksheet

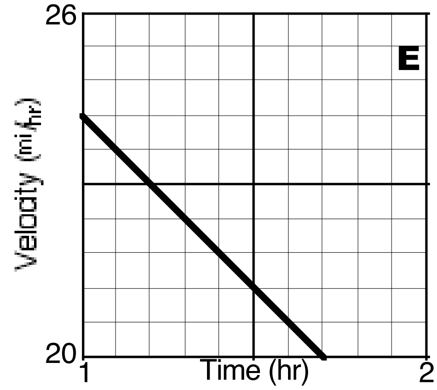
4 Find the slope of the line with its appropriate units.

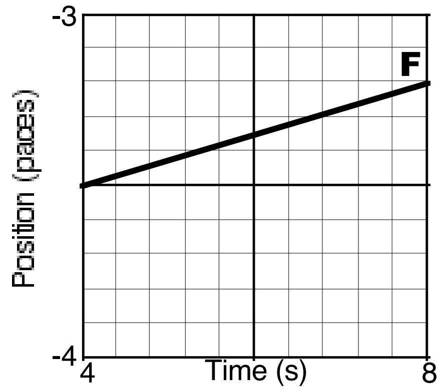


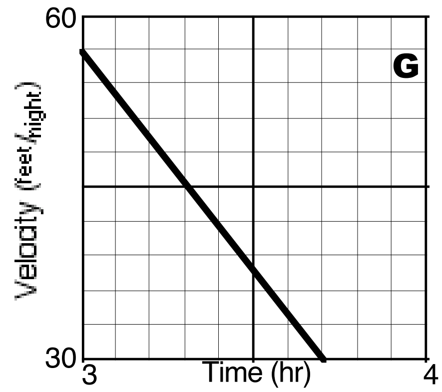


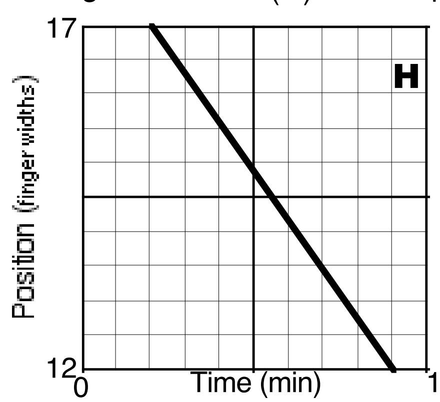






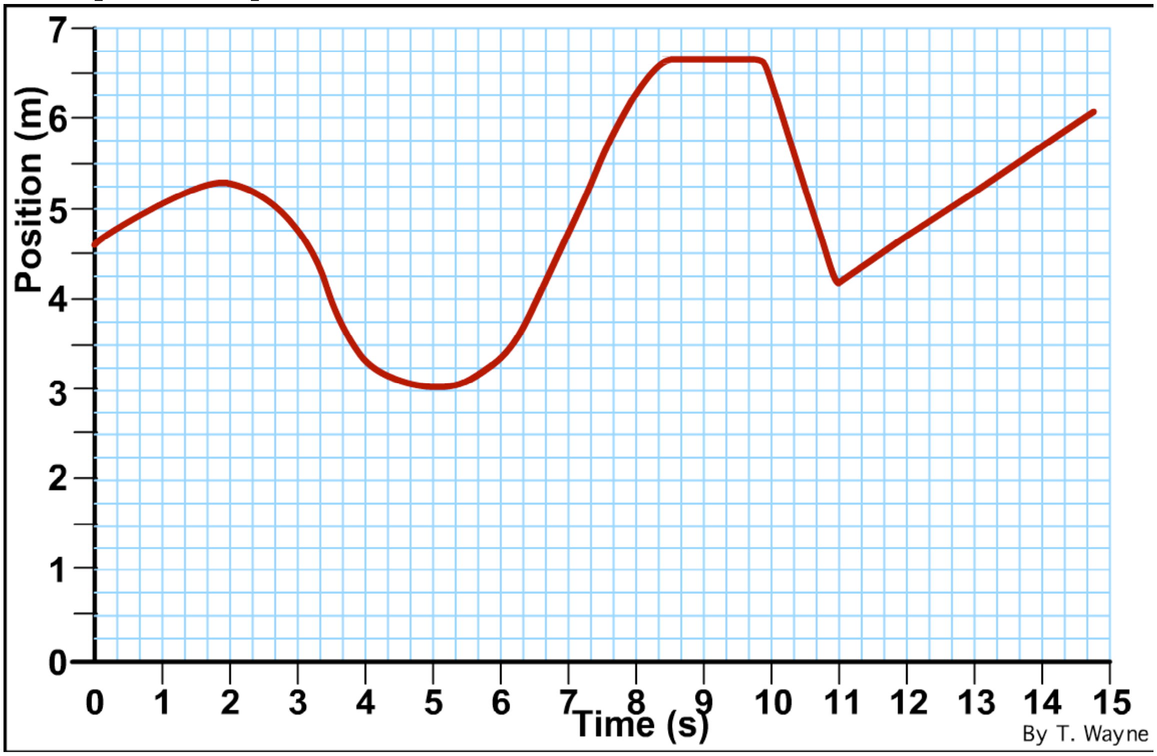


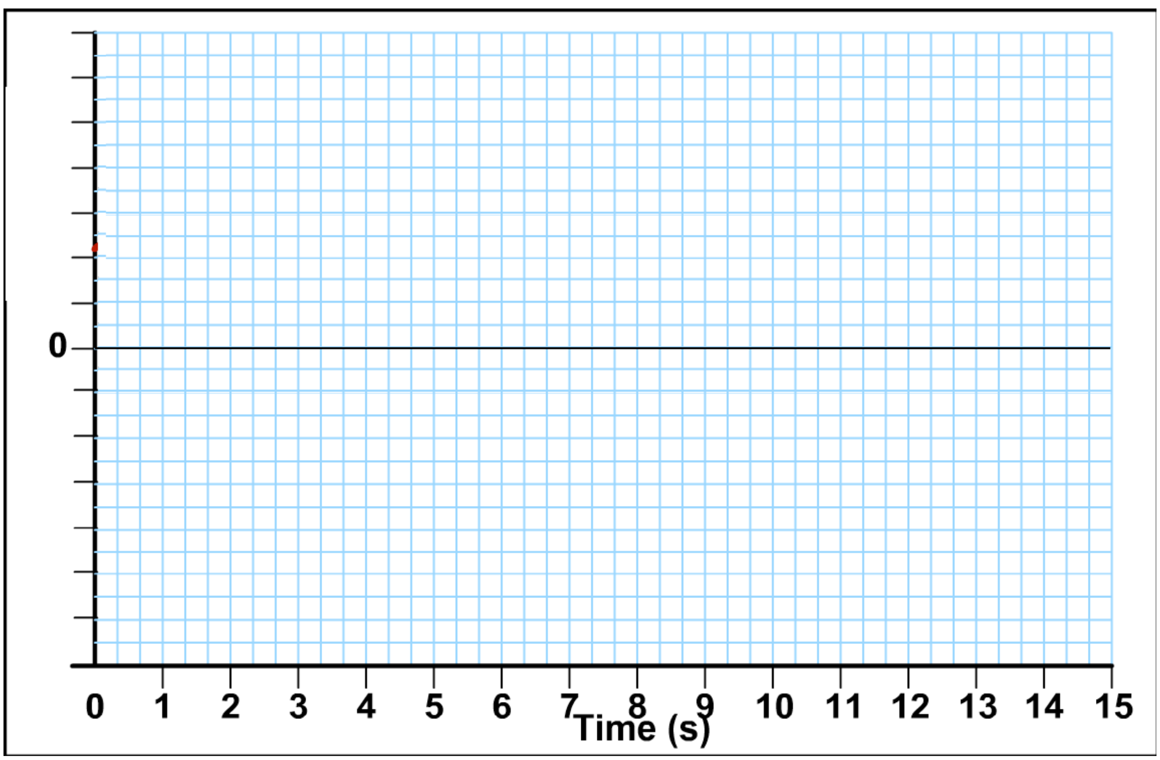




Kinematics Graphs Worksheet

Graph Slope Note Art Sheet

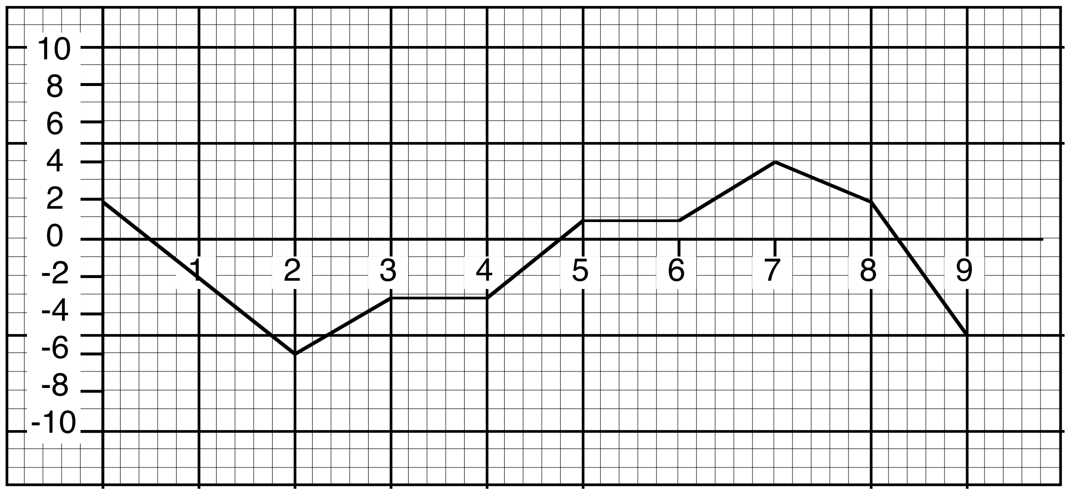




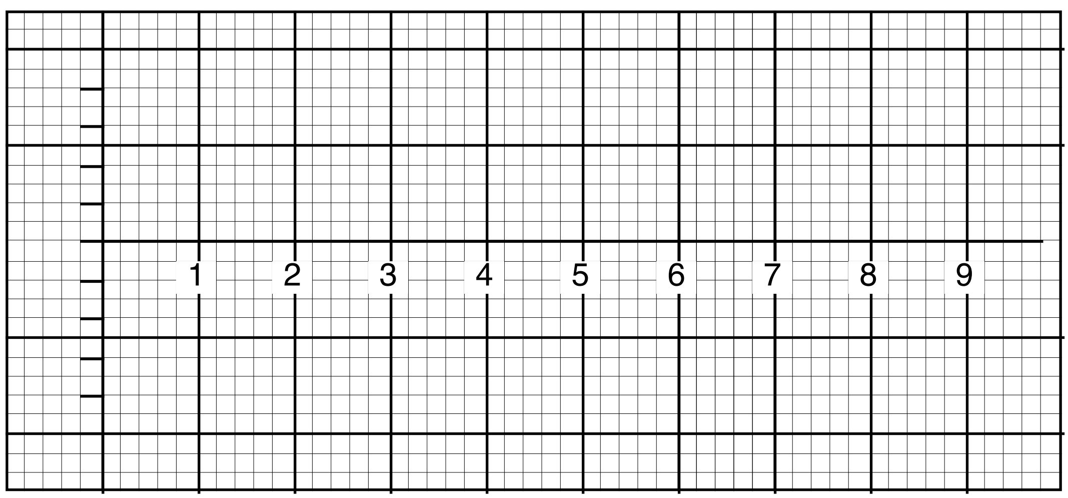
Kinematics Graphs Worksheet

5 Given the position vs. time graph below, draw the appropriate velocity vs. time graph.

Position vs Time

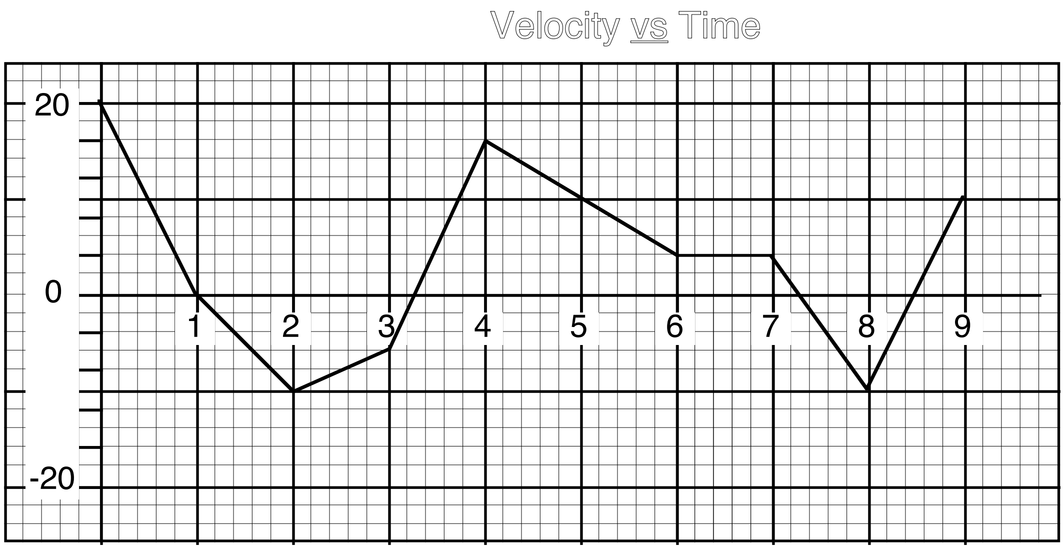


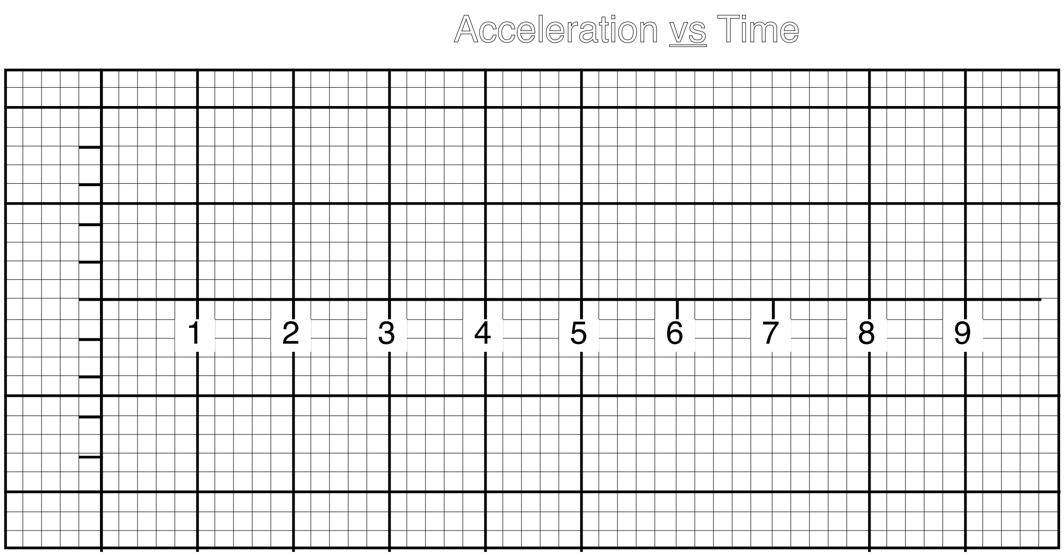
Velocity vs Time



Kinematics Graphs Worksheet

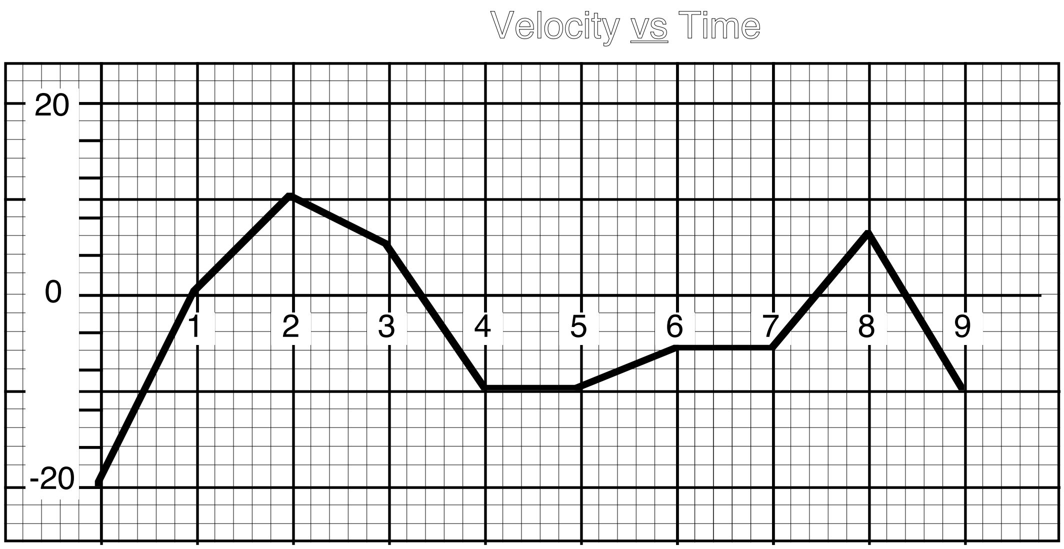
6 From the given velocity vs. time graph, draw the appropriate acceleration vs. time graph.

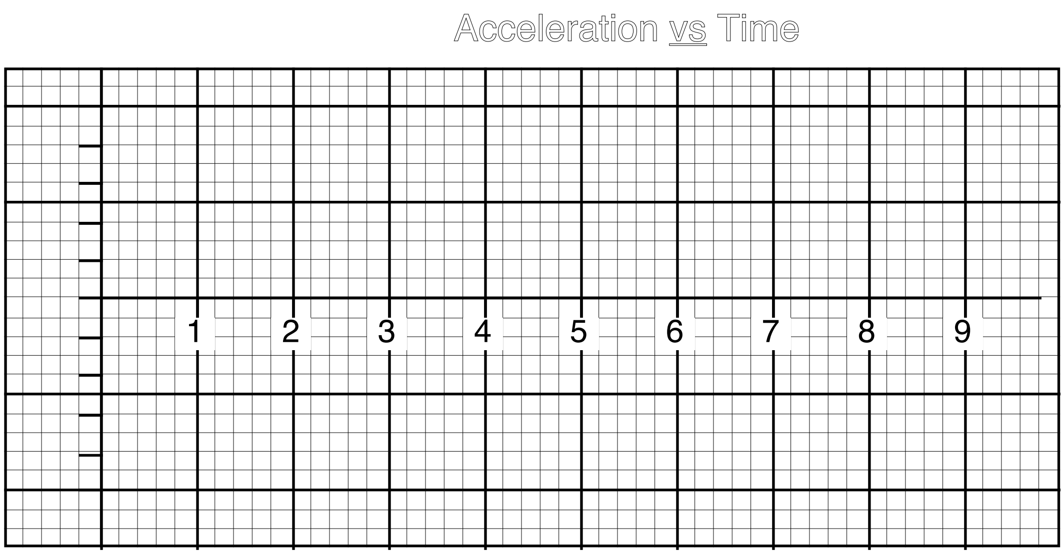




Kinematics Graphs Worksheet

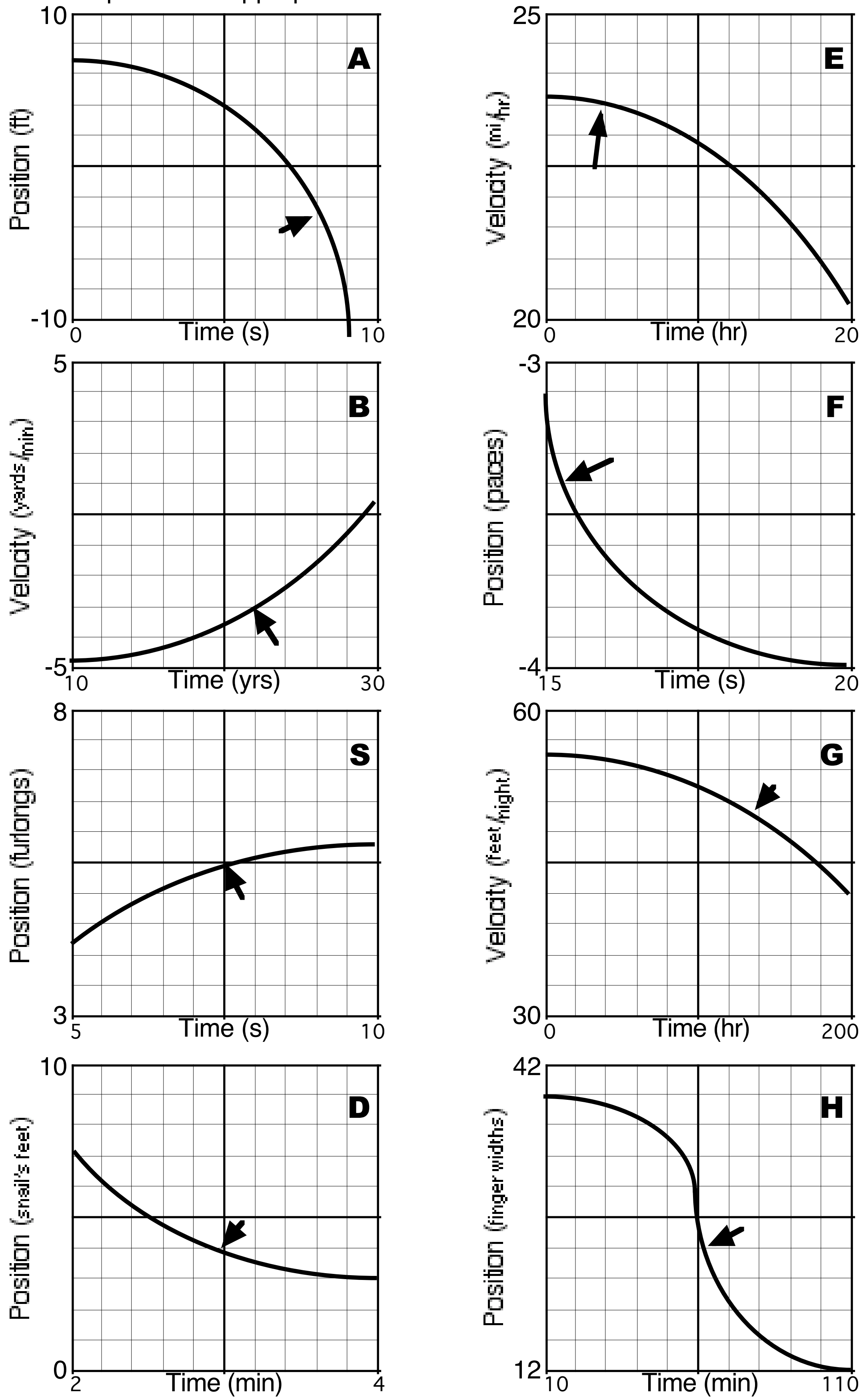
7 Given the velocity vs. time graph below, draw the appropriate acceleration vs. time graph.





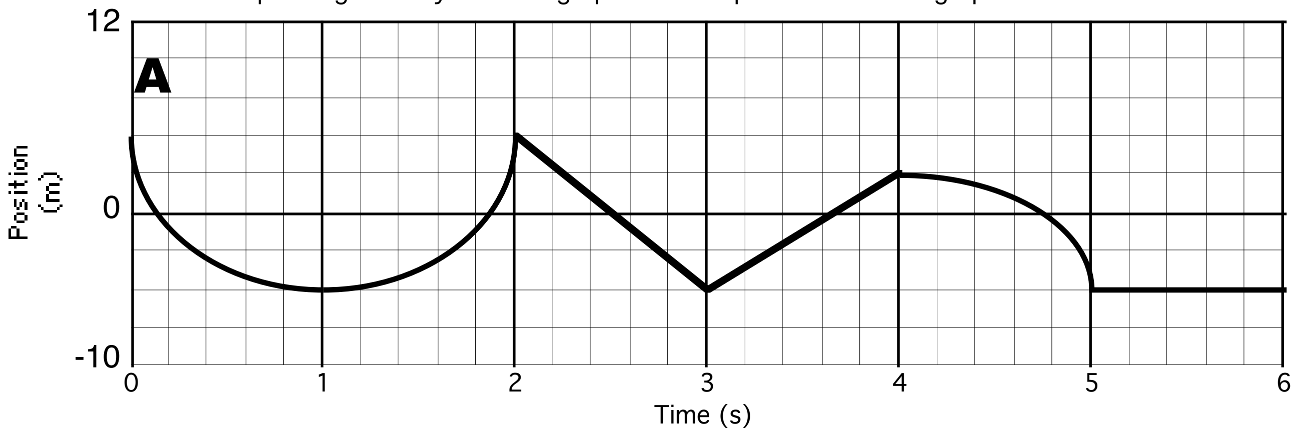
Kinematics Graphs Worksheet

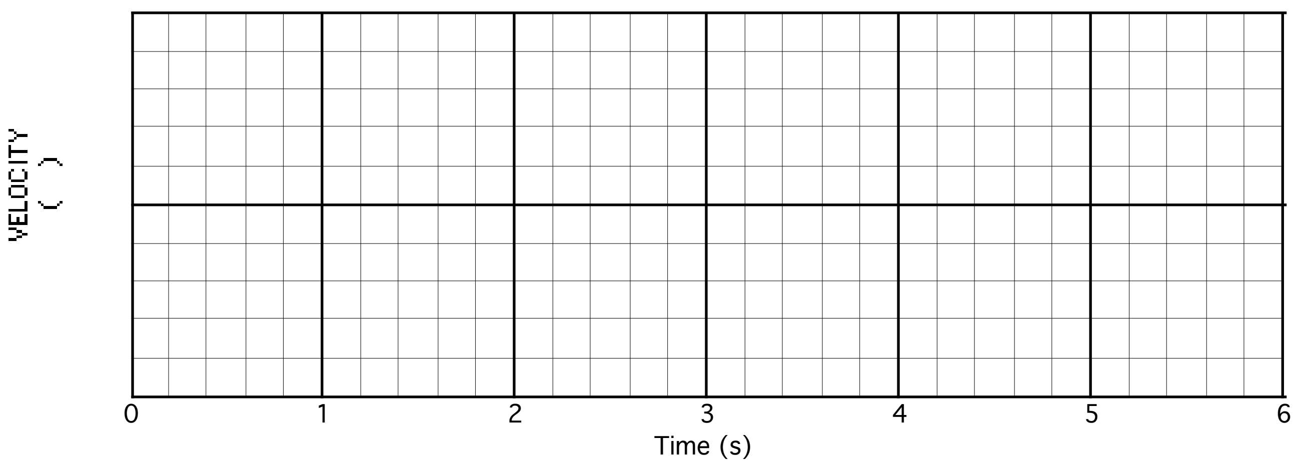
8 Find the slope with its appropriate units on the curve at each arrow.

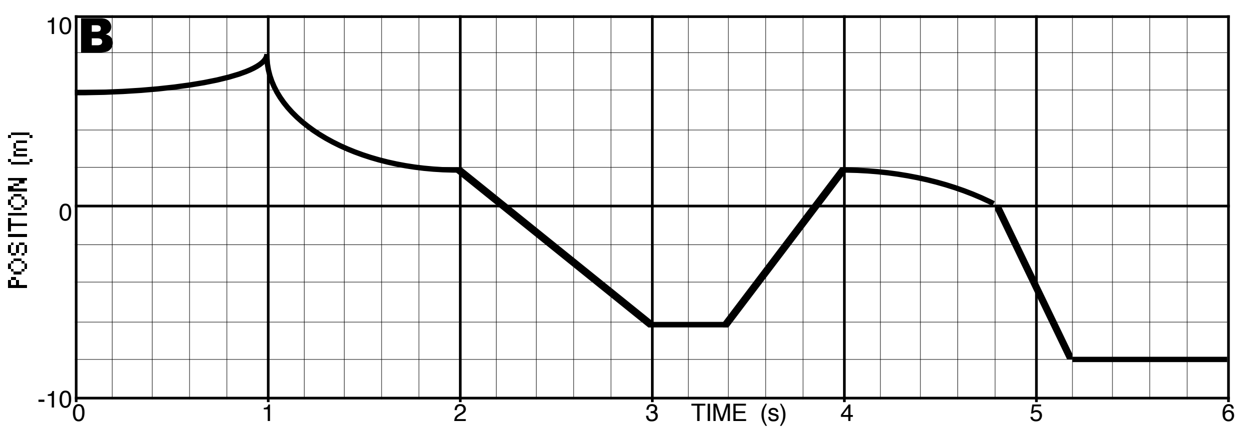


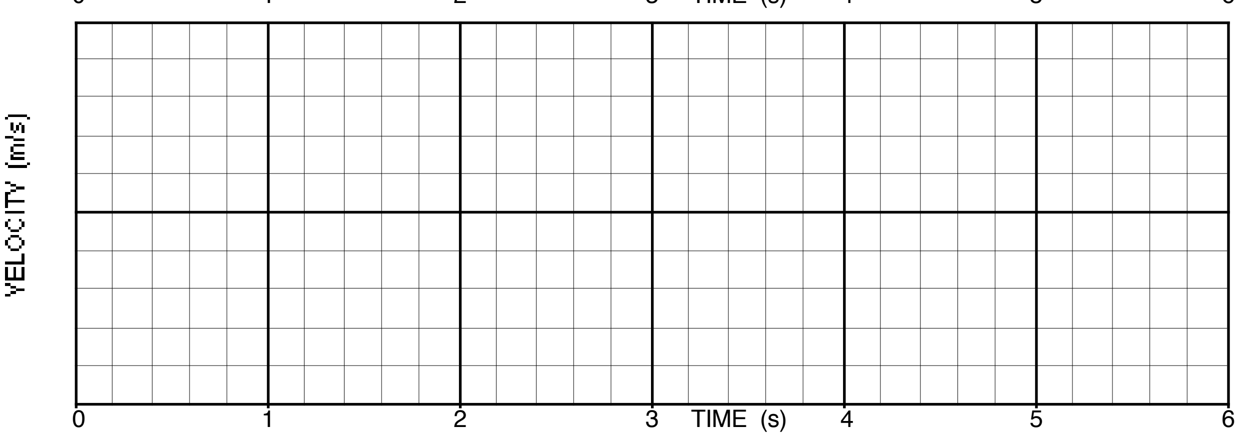
Kinematics Graphs Worksheet

9 Draw the corresponding velocity vs. time graph for each position vs. time graph shown below.



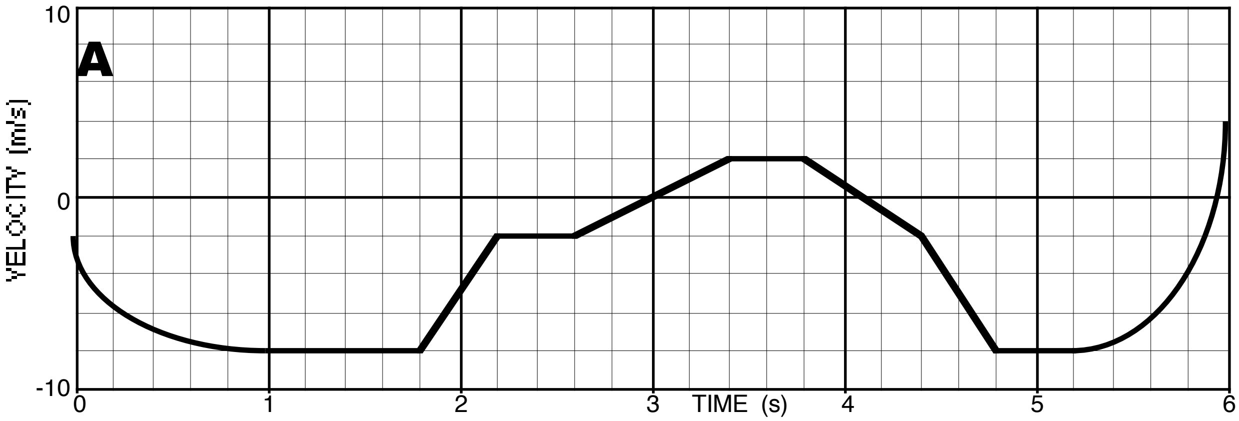


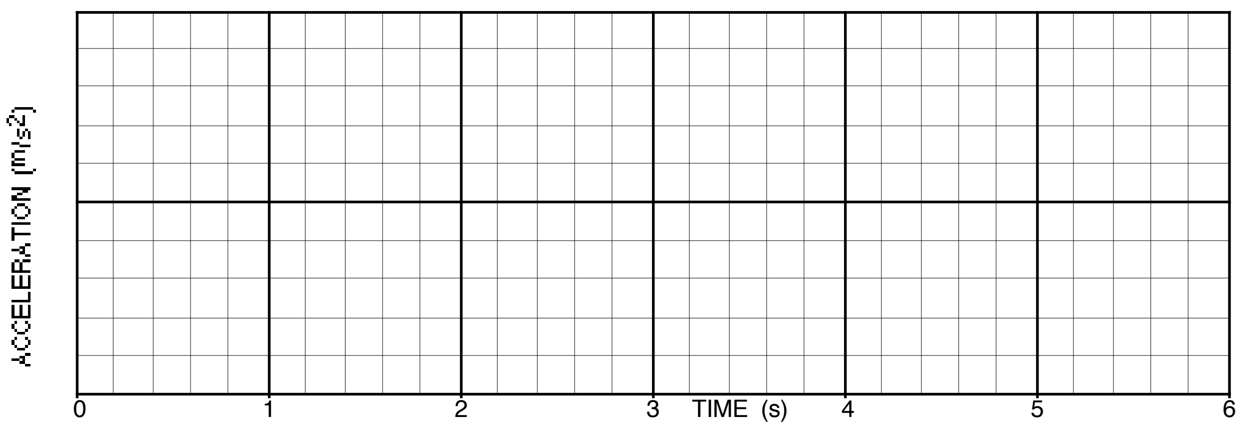


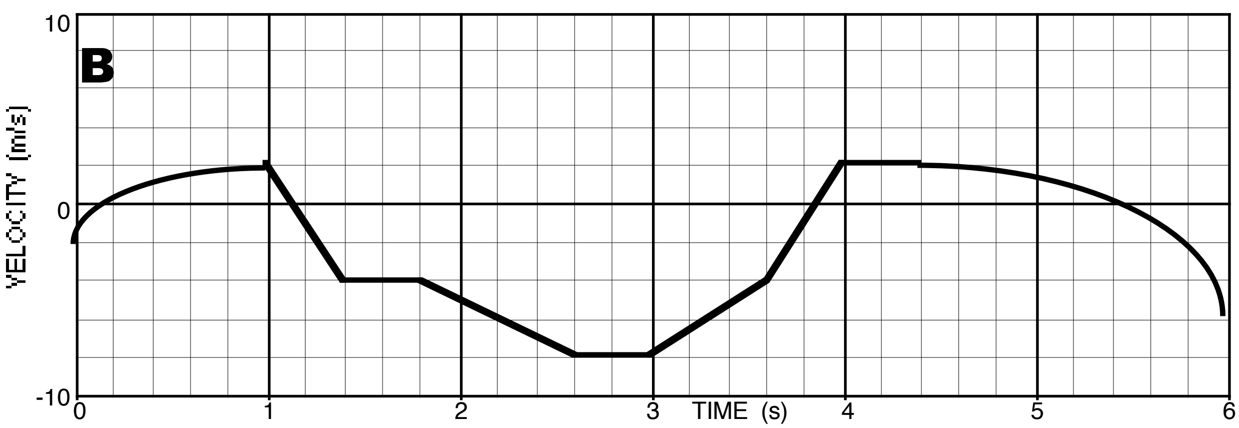


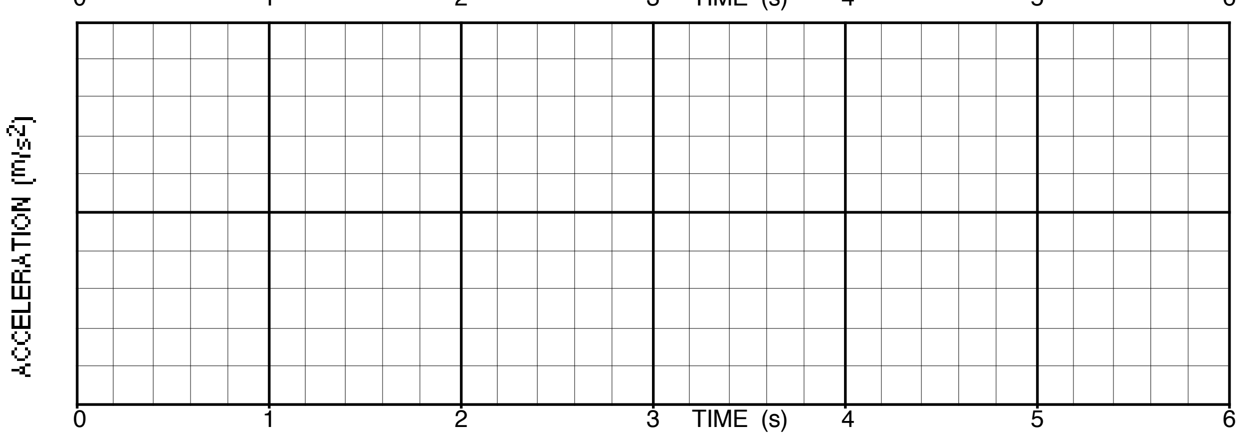
Kinematics Graphs Worksheet

10 Draw the corresponding velocity vs. time graph for each position vs. time graph shown below.



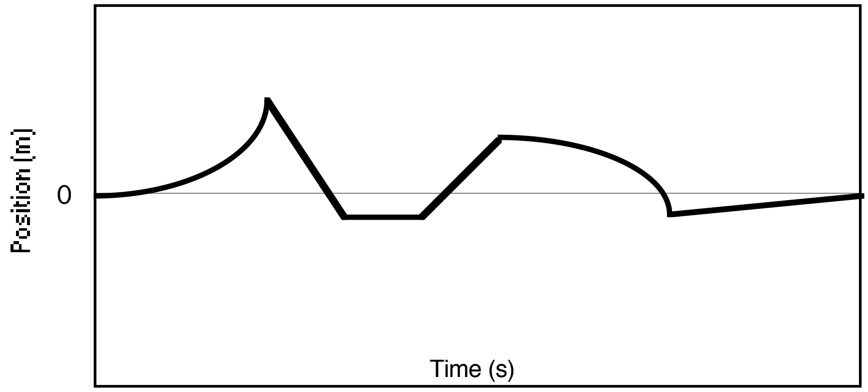




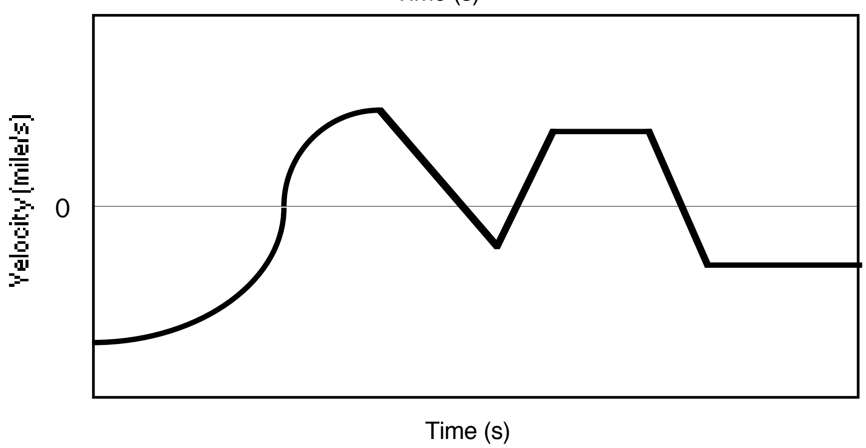


Kinematics Graphs Worksheet

11 For the graph below <u>ESTIMATE</u> what corresponding velocity vs time would look like.

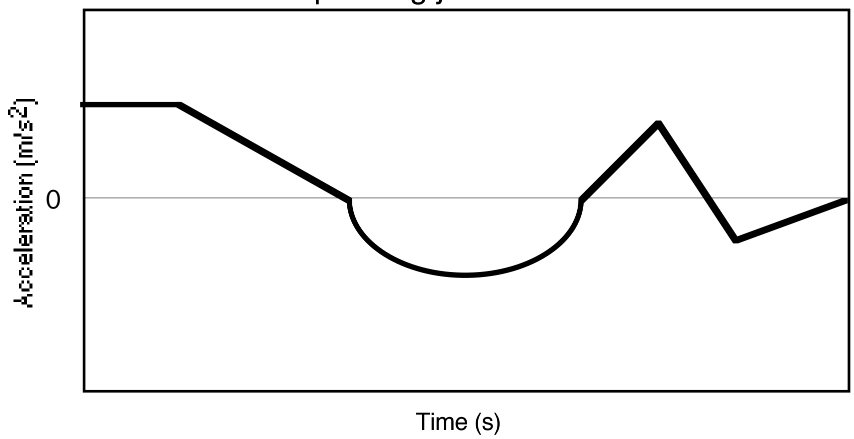


12. For the graph below <u>estimate</u> what a correspond-ing acceleration vs time would look like.

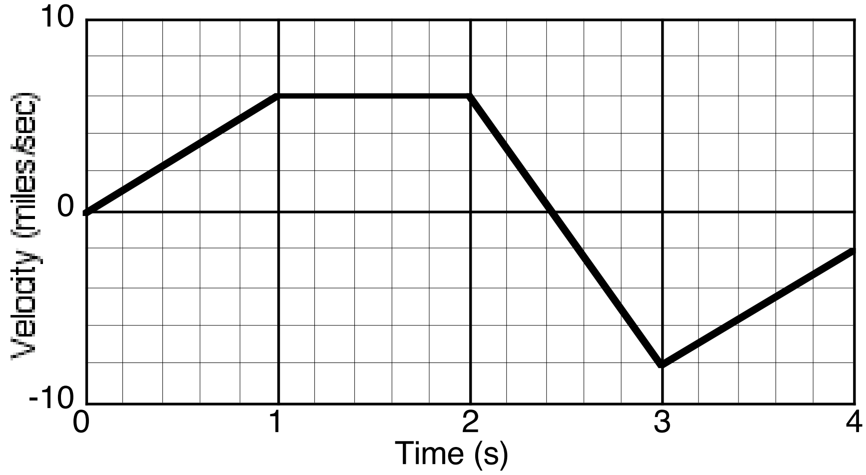


Kinematics Graphs Worksheet

13 For the graph below estimate what a corresponding jerk vs. time would look like.



Kinematics Graphs Worksheet

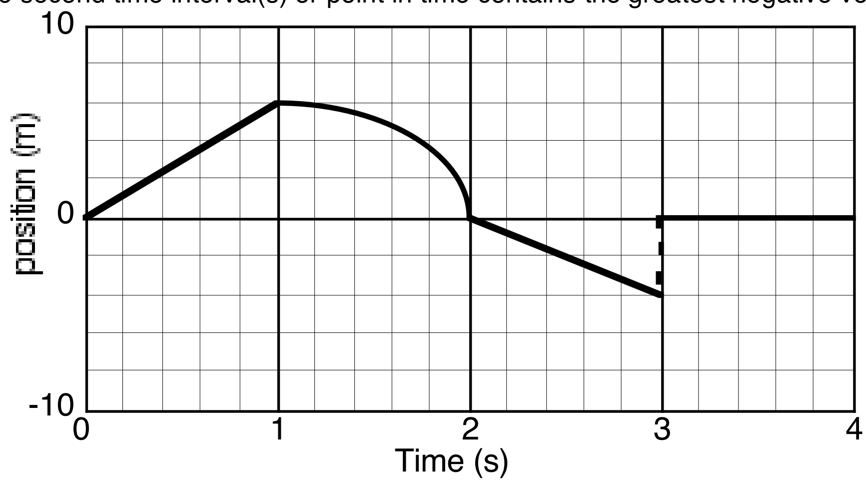


14 Which single second time interval(s) contains the greatest positive acceleration?

15 Which single second time interval(s) contains the greatest negative acceleration?

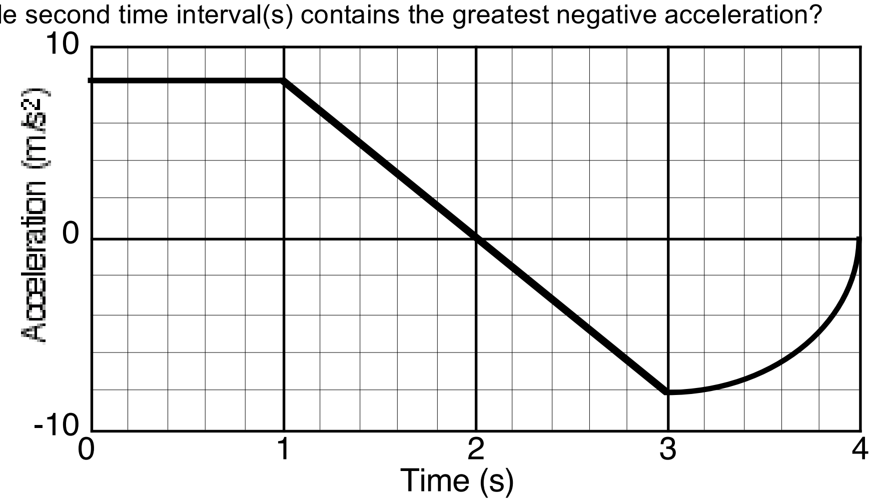
16 Which single second time interval(s) contains the greatest positive velocity?

17 Which single second time interval(s) or point in time contains the greatest negative velocity?



18 Which single second time interval(s) contains the greatest positive acceleration?

19 Which single second time interval(s) contains the greatest negative acceleration?



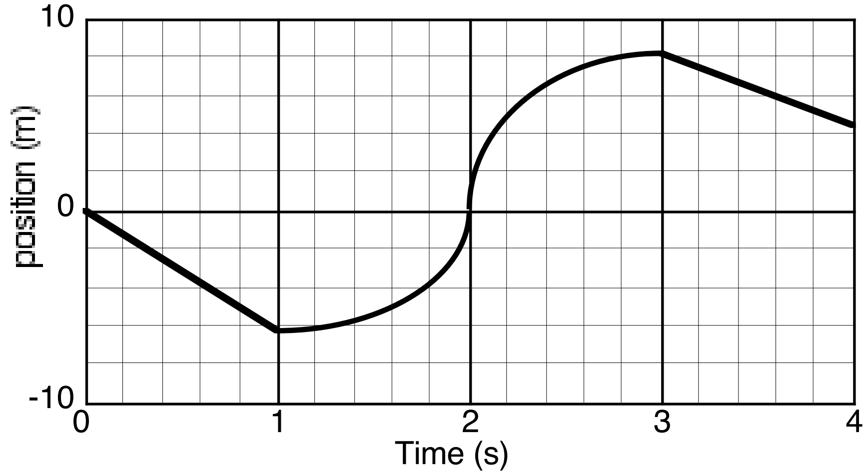
20 What is the jerk at 2 seconds?

21 Which single second time interval(s) shows a changing jerk?

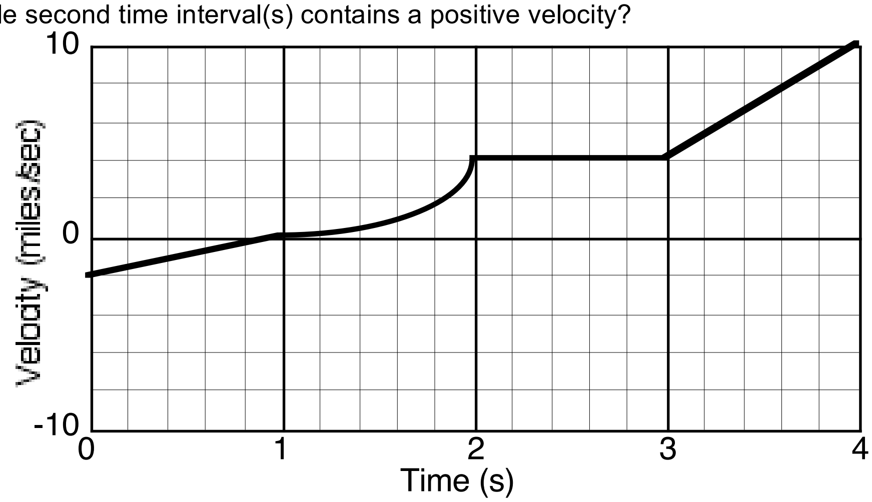
22 Which single second time interval(s) shows a constant acceleration?

23 Which single second time interval(s) contains a constant jerk?

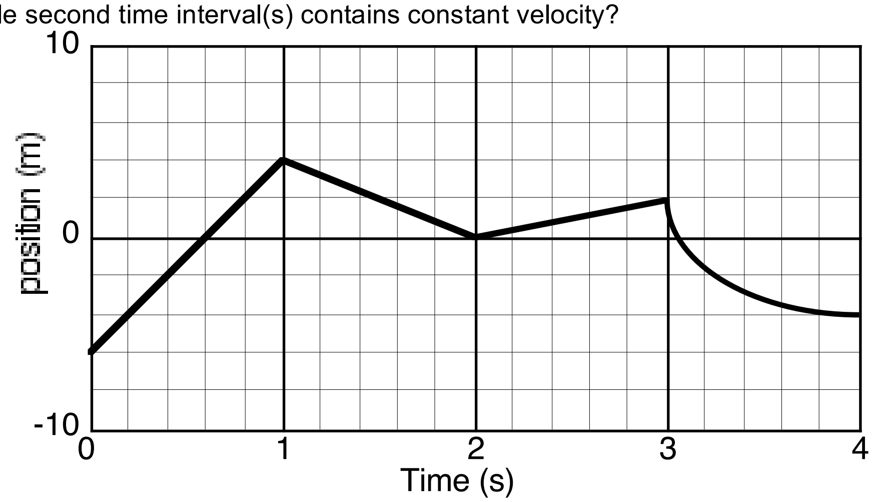
Kinematics Graphs Worksheet



24 Which single second time interval(s) contains a constant velocity?
25 Which single second time interval(s) contains a positive acceleration?
26 Which single second time interval(s) contains a non-zero velocity?
27 Which single second time interval(s) contains a positive velocity?

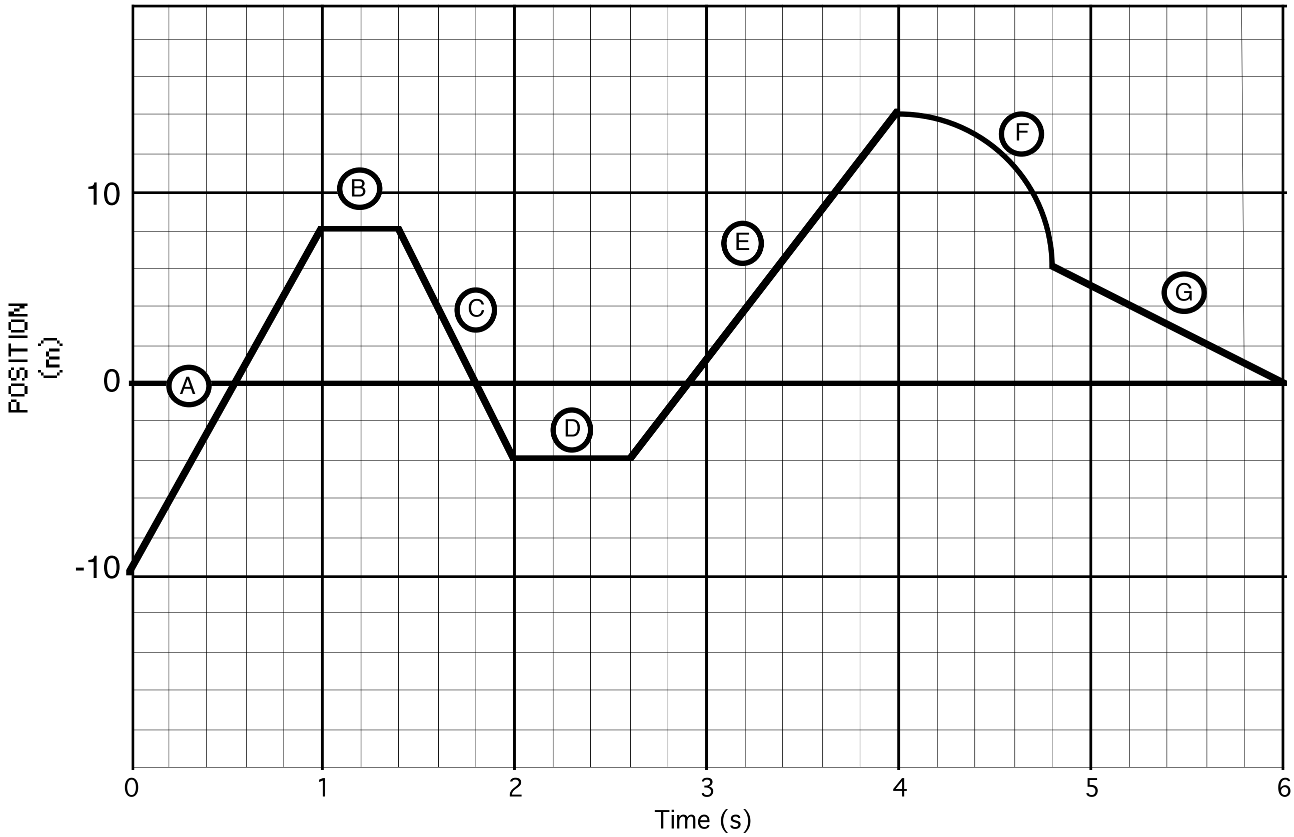


28 Which single second time interval(s) contains a positive velocity?
29 Which single second time interval(s) contains a negative acceleration?
30 Which single second time interval(s) contains constant velocity?



31 Which single second time interval(s) contains a positive velocity?
32 Which single second time interval(s) contains a negative acceleration?
33 What is the velocity at 3.5 seconds?
34 What is the displacement from 0 to 2 seconds?

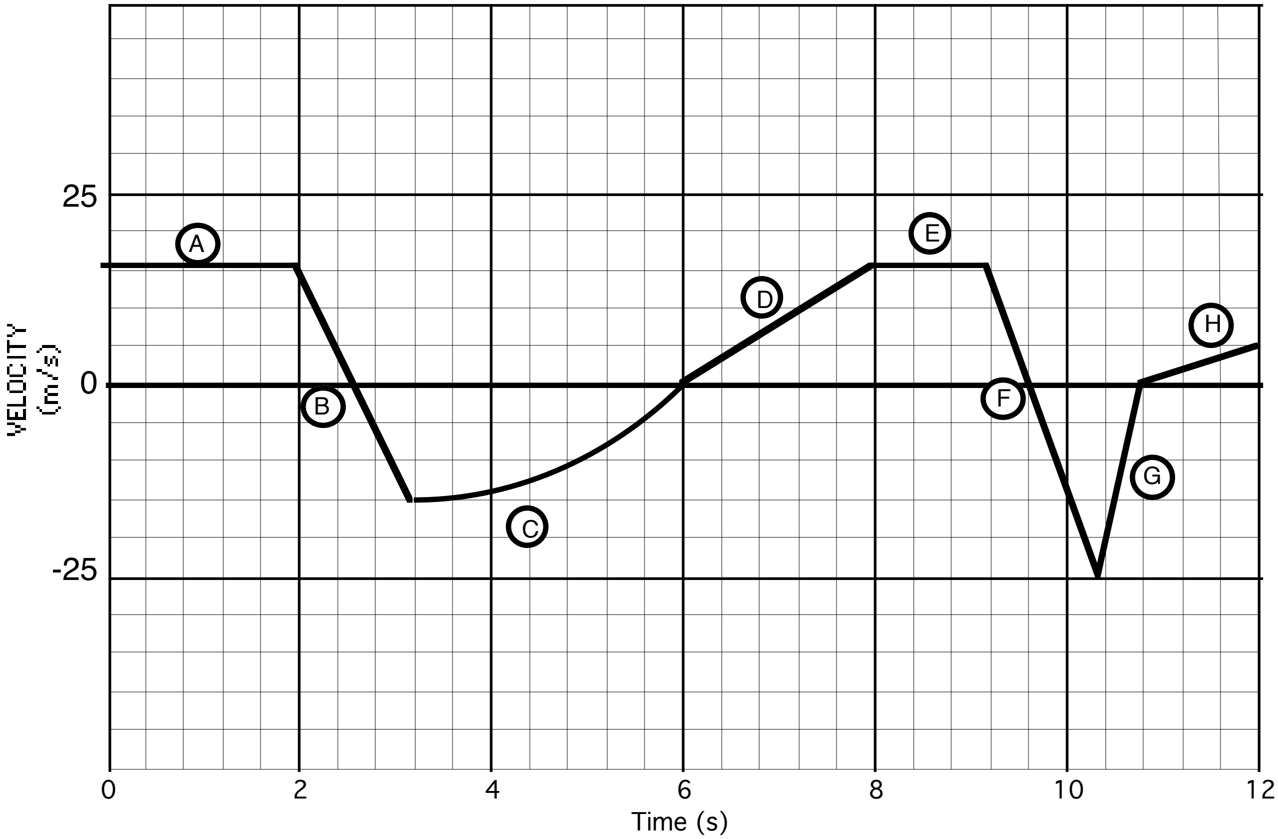
Kinematics Graphs Worksheet



Each change or bend is a segment of the line. The letters in the circles identifies them.

35 Which straight line shows the greatest (absolute value) constant velocity?
36 Which straight line segment(s) has the greatest absolute value of velocity?
37 Which line segment(s) contains the smallest non-zero velocity?(absolute value)
38 Which segment(s) shows an acceleration?
39 Which segment(s) or single point in time shows a constant velocity?
40 Which segment(s) shows a positive velocity?
41 Which segment(s) shows a negative velocity?
42 Which segment(s) shows the smallest non-zero velocity?
43 At which time or region is the distance away from the origin the greatest?
44 Which segment(s) has the greatest negative velocity?
45 Which segment(s) has the greatest positive velocity?
46 Which segment(s) has the greatest negative acceleration?
47 Which segment(s) has the greatest positive acceleration?
48 What is the velocity at 4.5 seconds?
49 What is the velocity at 1.8 seconds?
50 What is the displacement during segment “C?”
51 What is the displacement between 2 and 4 seconds?
52 Which show segment(s) no motion?

Kinematics Graphs Worksheet



Each change or bend is a segment of the line. The letters in the circles identifies them.

50 Which line segment(s) or point in time shows the object moving the fastest? _

51 Which segment(s) shows a non-zero acceleration? ______________________

52 Which segment(s) or single point in time shows a constant velocity? ________

53 Which segment(s) shows the object speeding up? ______________________

54 Which segment(s) shows the object at rest for more than 0.4 s? __________

55 Which segment(s) shows a positive change in acceleration? _____________

56 Which segment(s) shows the smallest, positive, non-zero acceleration? ____

57 Which segment(s) has the most negative velocity? ______________________

58 Which segment(s) has the most positive velocity? ______________________

59 Which segment(s) has the most negative acceleration? _________________

60 Which segment(s) has the most positive acceleration? __________________

61 Which segment(s) shows a positive jerk? ______________________________

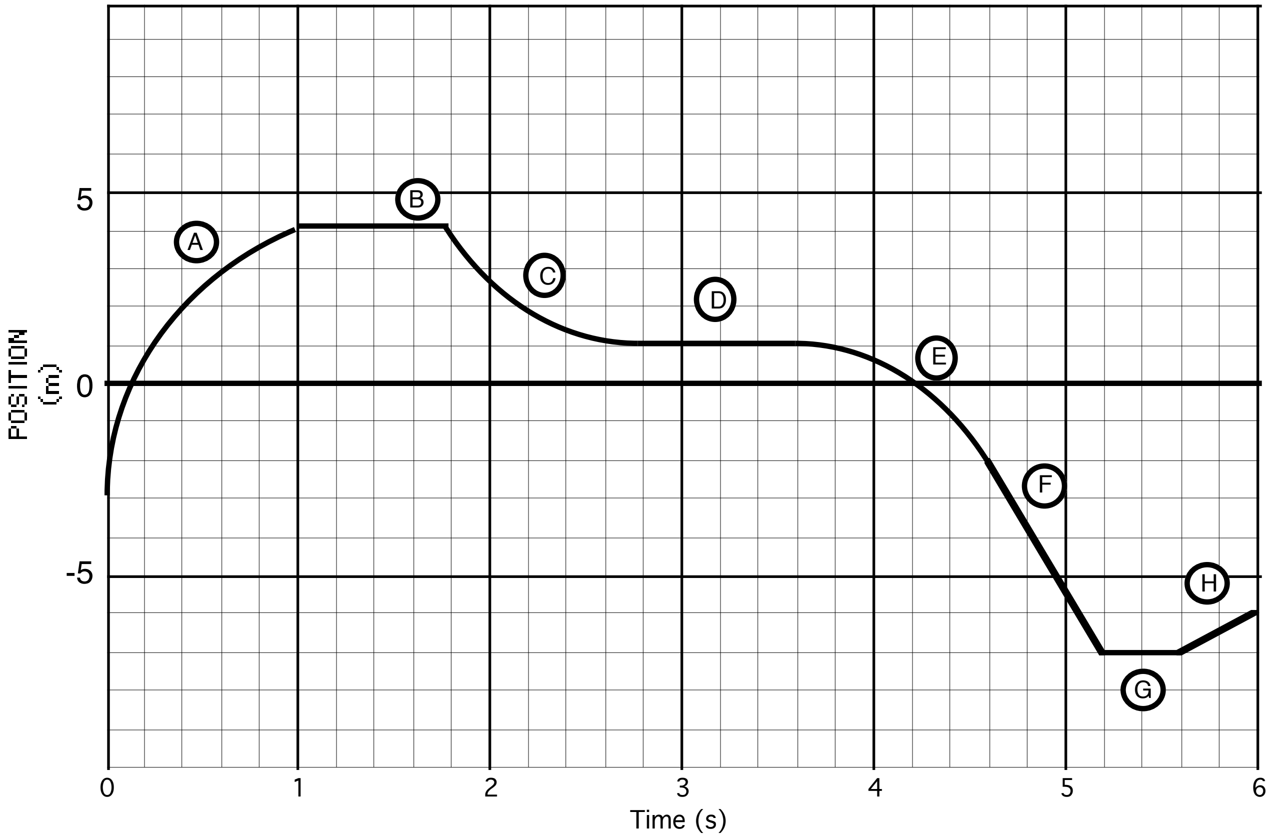
62 What is the instantaneous velocity at 9.0 seconds? _____________________

63 What is the instantaneous acceleration at 9.0 seconds? _________________

64 What is the instantaneous acceleration at 4.0 seconds? _________________

65 What is the instantaneous acceleration at 9.5 seconds? _________________

Kinematics Graphs Worksheet



Each change or bend is a segment of the line. The letters in the circles identifies them. (NOTE "C" AND "E" ARE CURVES AND "D" and F" are straight lines.)

66 Which line segment(s) shows the fastest constant velocity? ___________

67 Which line segment(s) shows the <u>slowest, constant, non-zero</u> velocity? __

68 Which segment(s) shows a positive displacement? __________________

69 Which segment(s) or single point in time shows a <u>constant velocity</u>? ____

70 Which segment(s) shows a <u>positive</u> acceleration? ___________________

71 Which segment(s) shows a <u>negative</u> acceleration? __________________

72 At which time or region is the displacement from initial position the greatest?

73 Which segment(s) shows the object speeding up? __________________

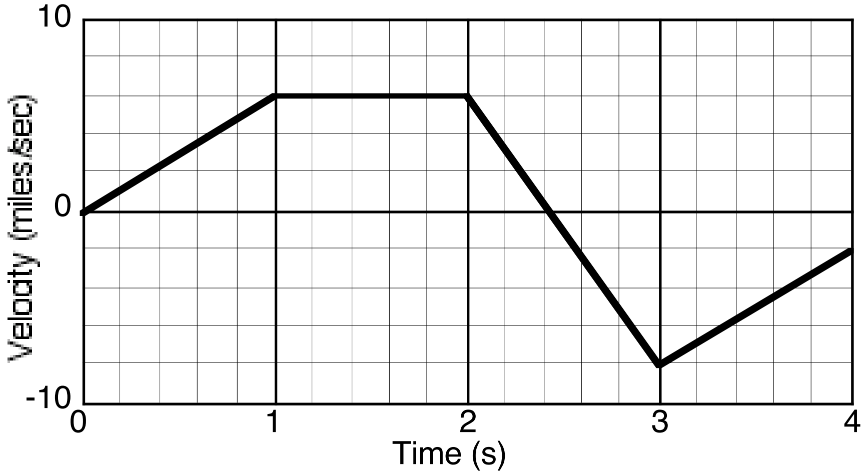
74 Which segment(s) shows the object slowing down? _________________

75 What is the instantaneous velocity at 0.8 seconds? _________________

76 How fast is the object moving at 4.2 seconds? _____________________

77 What is the instantaneous velocity at 5.0 seconds? _________________

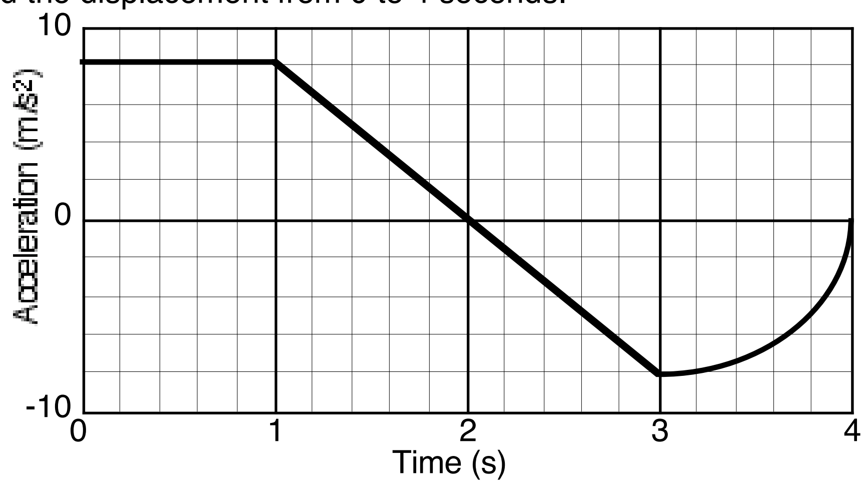
Kinematics Graphs Worksheet



69 Find the displacement from 0 to 2 seconds.

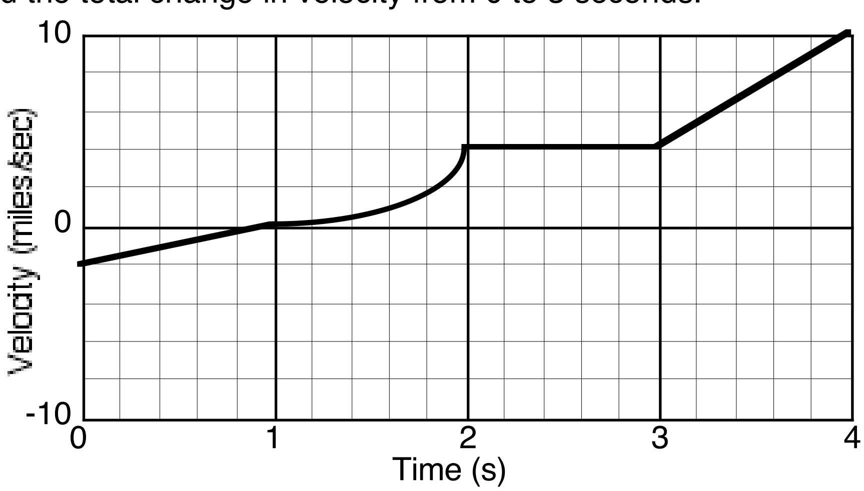
70 Find the displacement from 1 to 3 seconds.

71 Find the displacement from 0 to 4 seconds.



72 Find the total change in velocity from 0 to 1 seconds.

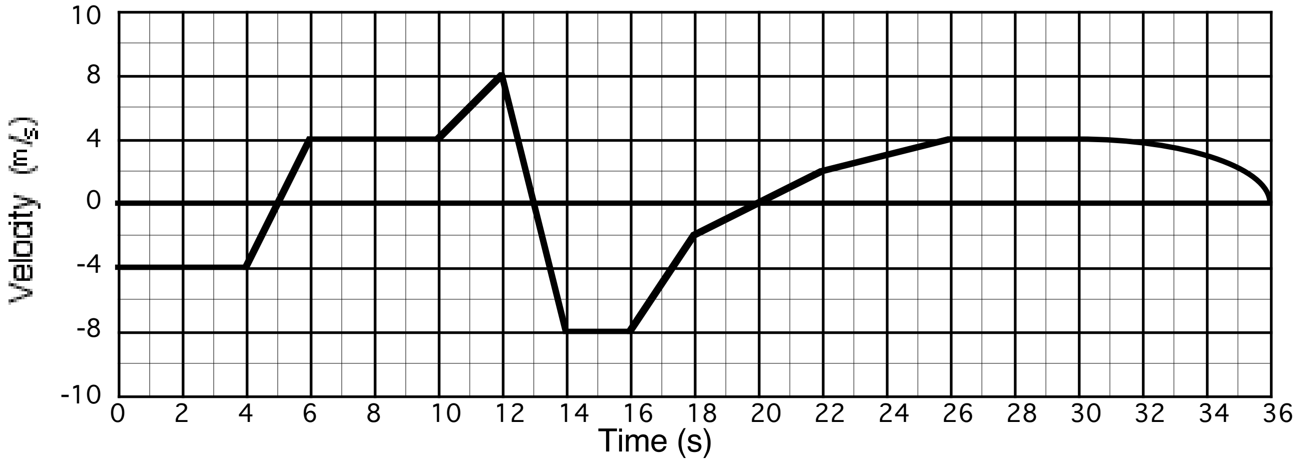
73 Find the total change in velocity from 0 to 3 seconds.



74 Find the displacement from 2 to 4 seconds. ___________________________

75 Find the displacement from 0 to 1 seconds.

Kinematics Graphs Worksheet



76. What is the displacement from 0 to 4 seconds? ____________________

77. What is the displacement from 4 to 6 seconds? ____________________

78. What is the displacement from 6 to 12 seconds? ____________________

79. What is the displacement from 12 to 14 seconds? ____________________

80. What is the displacement from 14 to 22 seconds? ____________________

81. What is the displacement from 22 to 30 seconds? ____________________

82. What is the acceleration at 2 seconds? ____________________

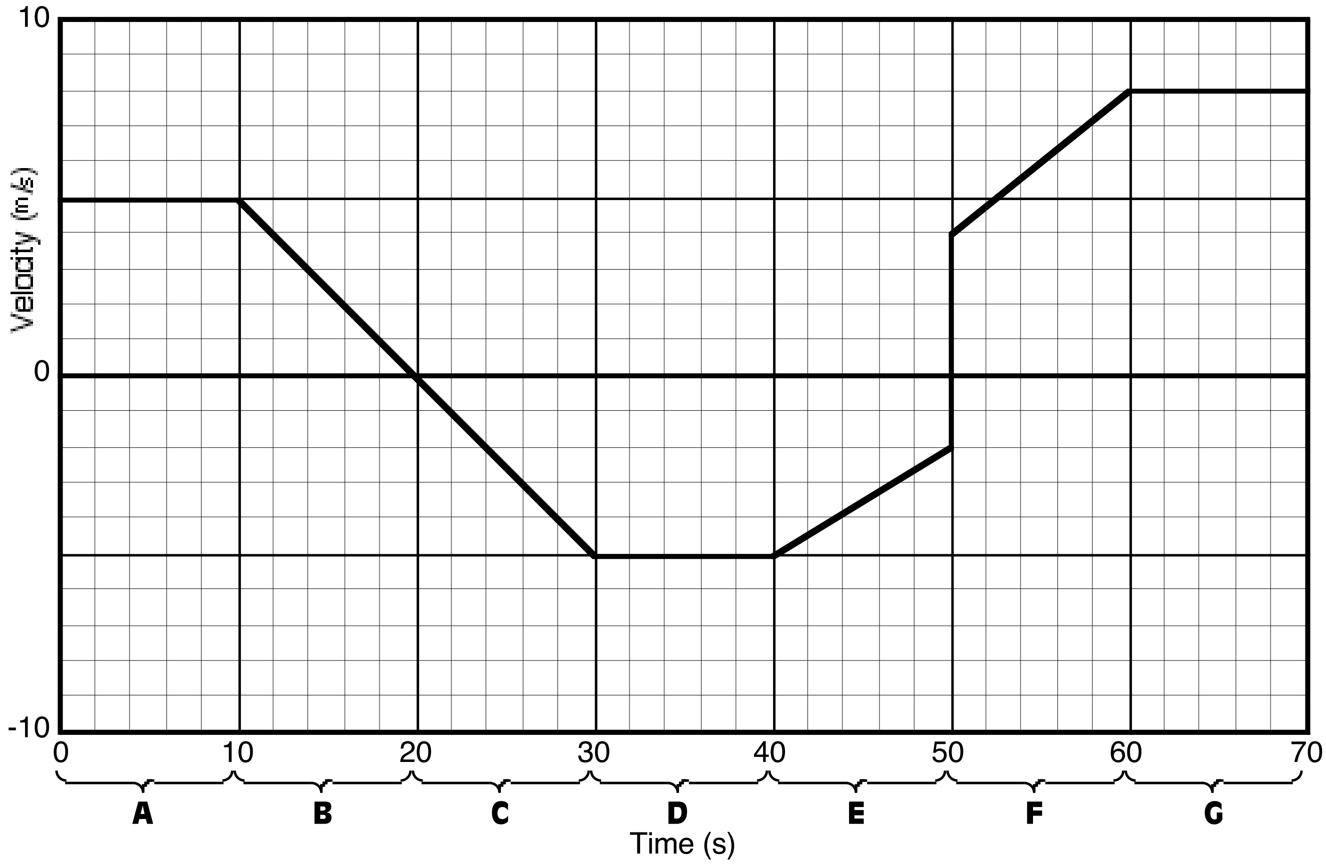
83. What is the acceleration at 5 seconds? ____________________

84. What is the acceleration at 13 seconds? ____________________

85. What is the acceleration at 17 seconds? ____________________

86. What is the acceleration at 19 seconds? ____________________

Kinematics Graphs Worksheet



Answer the following whenever possible

87. Calculate the displacement from 0 to 10 seconds.

88. Calculate the displacement from 10 to 20 seconds.

89. Calculate the displacement from 20 to 30 seconds.

90. Calculate the displacement from 10 to 30 seconds.

91. Calculate the displacement from 30 to 40 seconds.

92. Calculate the displacement from 40 to 60 seconds.

93. Which lettered 10-second time interval(s) contains a positive displacement and a negative **acceleration?**

94. Which lettered 10-second time interval(s) contains a negative displacement and a positive velocity?

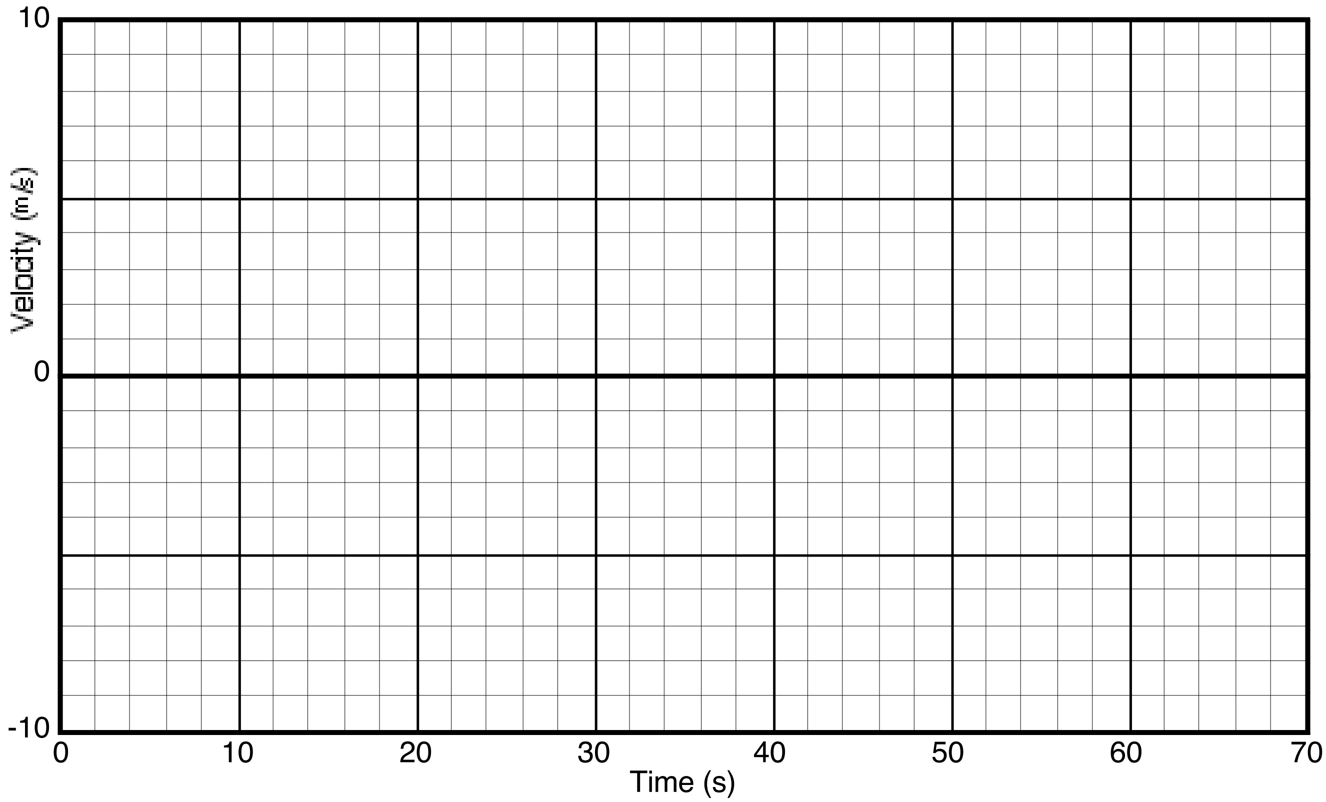
95. Which lettered 10-second time interval(s) contains a positive displacement, a negative velocity and a **negative** acceleration?

96. Which lettered 10-second time interval(s) contains a negative displacement, a negative velocity and a **negative** acceleration?

97. Which lettered 10-second time interval(s) contains a positive displacement, a negative velocity and a **positive** acceleration?

Kinematics Graphs Worksheet

98

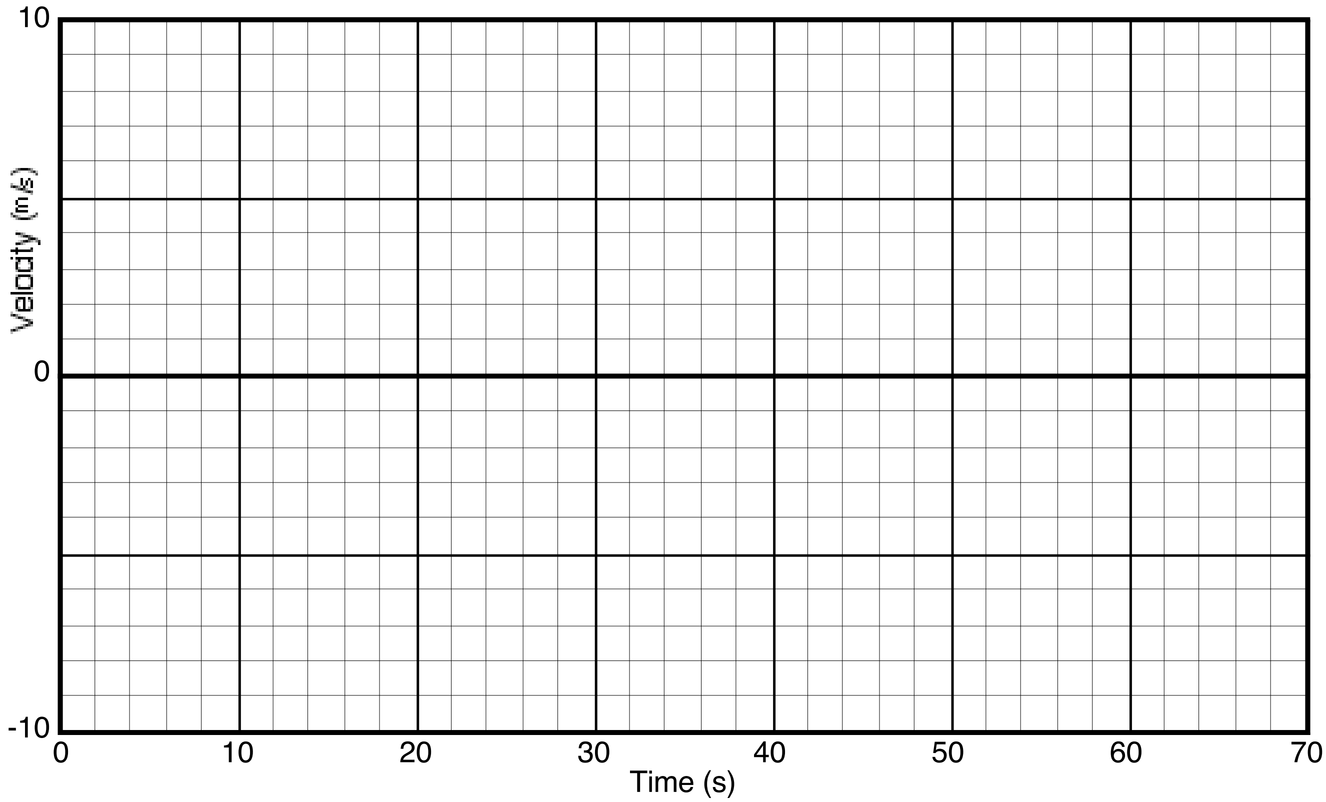


Draw a velocity graph that meets the following criteria.
If a section cannot be drawn that meets given criteria, skip it.

Time Interval	Description
0 - 10	positive displacement, positive velocity, zero acceleration
10 - 20	negative displacement, negative velocity, positive acceleration
20 - 30	positive displacement, positive velocity, positive acceleration
30 - 40	negative displacement, negative velocity, negative acceleration
40 - 50	positive displacement, positive velocity, negative acceleration
50 - 60	positive displacement, negative velocity, positive acceleration
60 - 70	zero displacement, positive and negative velocities, negative acceleration

Kinematics Graphs Worksheet

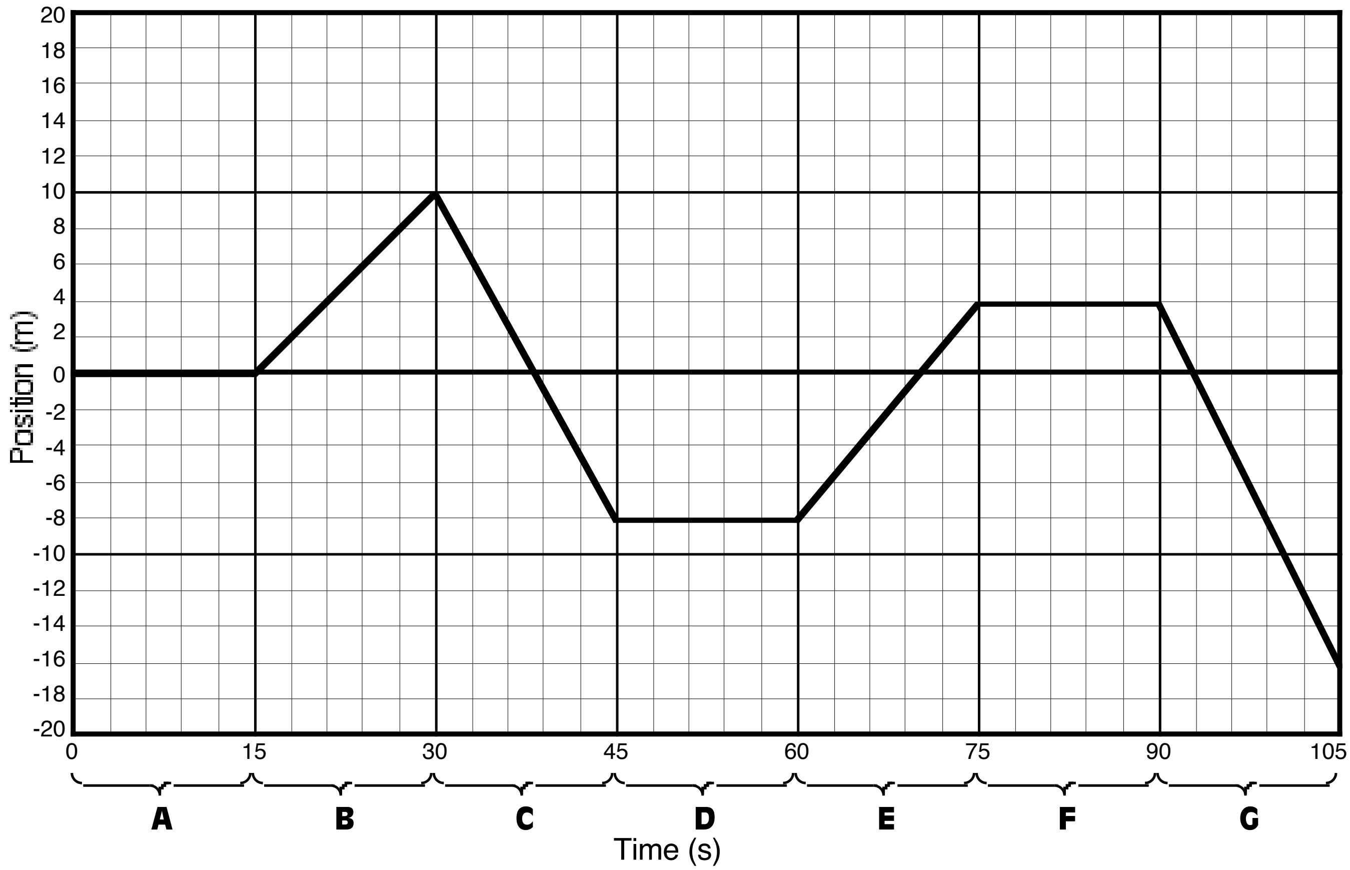
99



Draw a velocity graph that meets the following criteria.
If a section cannot be drawn that meets given criteria, skip it.

Time Interval	Description
0 - 10	negative displacement, negative velocity, zero acceleration
10 - 20	negative displacement, negative & positive velocity, positive acceleration
20 - 30	negative displacement, negative velocity, positive acceleration
30 - 40	positive displacement, positive velocity, zero acceleration
40 - 50	positive displacement, positive & negative velocity, positive acceleration
50 - 60	zero displacement, positive and negative velocities, negative acceleration
60 - 70	negative displacement, negative velocity, negative acceleration

Kinematics Graphs Worksheet



98. Which 15-second interval(s) have the greatest positive velocity? __________

99. Which 15-second interval(s) have the greatest negative velocity? __________

100. Which 15-second interval(s) have the greatest velocity? ________________

101. Which 15-second interval contains the location that is the greatest absolute value of displacement? ____

102. Which 15-second interval(s) indicates no movement? ___________________

103. Which 15-second interval(s) contains a position that is positive and a velocity that is positive? ____

104. Which 15-second interval(s) contains a position that is positive and a velocity that is negative? ____

105. Which 15-second interval(s) contains a position that is negative and a velocity that is positive? ____

106. Which 15-second interval(s) contains a position that is negative and a velocity that is negative? ____

107. Which 15-second interval(s) contains a position that is positive and a velocity that is zero? ____

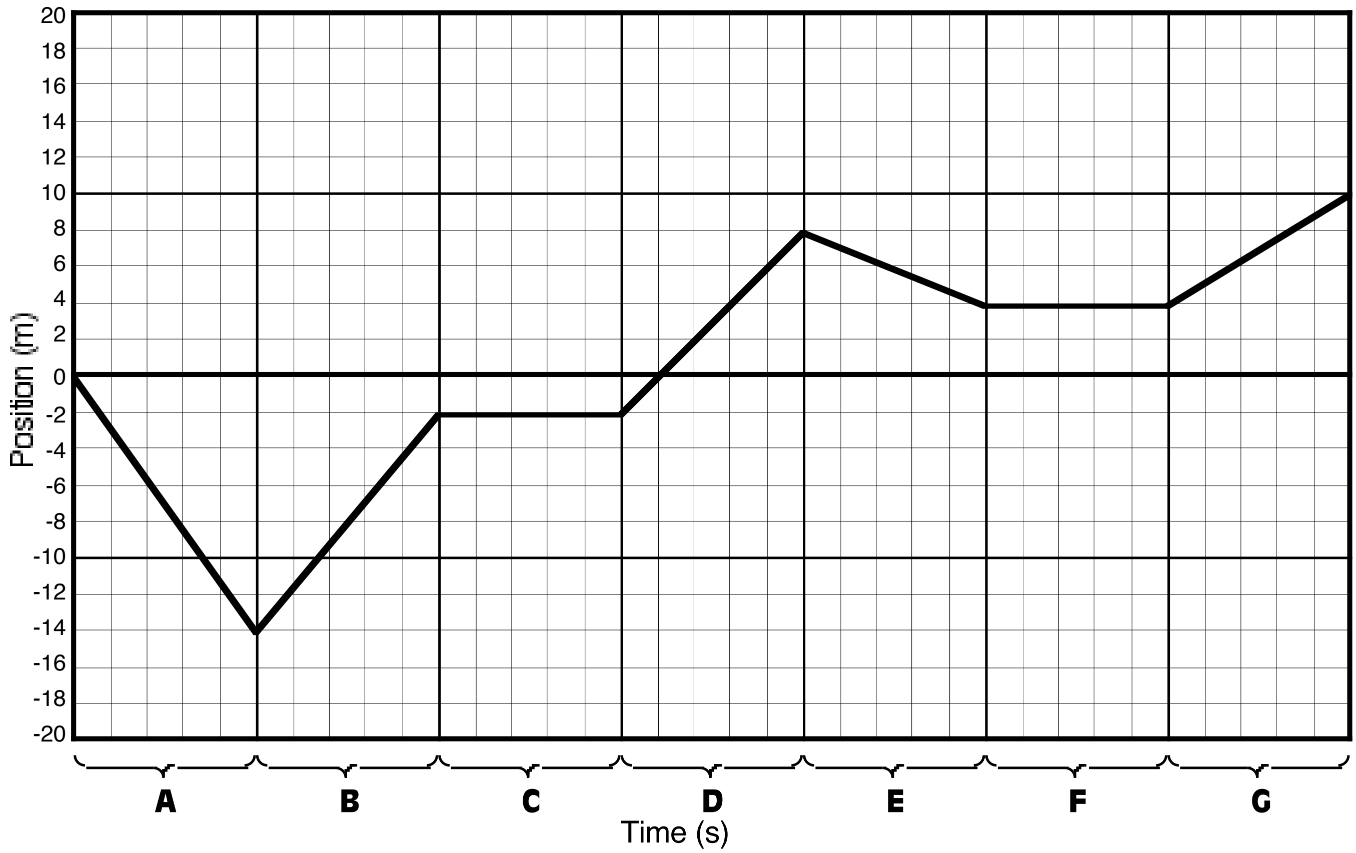
108. What is the velocity at 39 seconds? ______________________________

109. What is the velocity at 48 seconds? ______________________________

110. What is the position at 21 seconds? ______________________________

111. What is the displacement from 20 seconds to 75 seconds? ______________

Kinematics Graphs Worksheet



112. Which 10-second interval(s) have the most <u>positive</u> velocity?

113. Which 10-second interval(s) have the most <u>negative</u> velocity?

114. Which 10-second interval(s) have the greatest absolute value of velocity?

115. Which 10-second interval contains the location that is the positive displacement from the origin?

116. Which 10-second interval(s) indicates no movement?

117. Which 10-second interval(s) contains a position that is positive and a velocity that is positive?

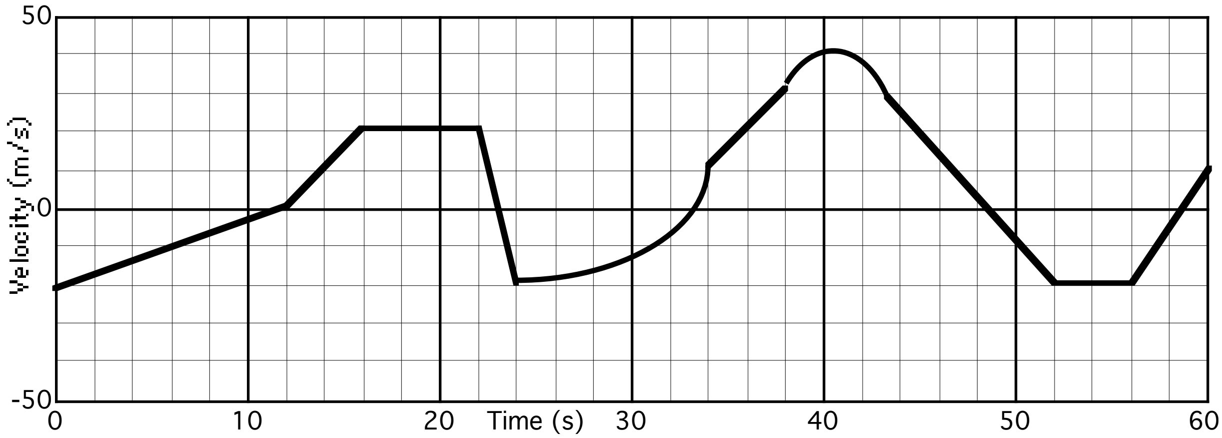
118. Which 10-second interval(s) contains a position that is positive and a velocity that is negative?

119. Which 10-second interval(s) contains a position that is negative and a velocity that is positive?

120. Which 10-second interval(s) contains a position that is negative and a velocity that is negative?

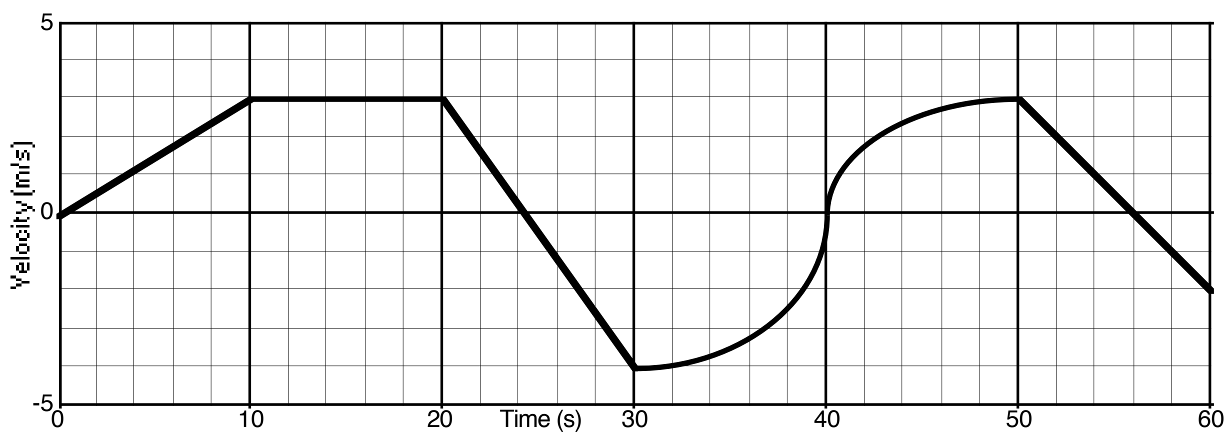
121. Which 10-second interval(s) contains a position that is positive and a velocity that is zero?

Kinematics Graphs Worksheet



The graph above is for the motion of a car in the senior parking lot. Answer each question below with a range of time(s), e.g. (10-12 s).

122 What is the acceleration over the 1st 10 seconds?
123 Over which region(s) is the acceleration constant?
124 Over which region(s) is the acceleration changing?
125 Over which region(s) is the car moving in a negative direction?
126 Over which region(s) is the car speeding up?
127 Over which region(s) is the car slowing down?
128 Over which region(s) is there no acceleration?
129 What is the acceleration at 30 seconds?
130 What is the acceleration at 39 seconds?
131 What is the acceleration at 20 seconds?
132 What is the acceleration at 46 seconds?



133 How do you find the instantaneous velocity?

Kinematics Graphs Worksheet

134 How can you tell if a piece of the curve is negative acceleration?

135 How can you tell if a piece of the curve is positive acceleration?

136 How do you find displacement?

137 How can you tell if a piece of the curve has a zero acceleration?

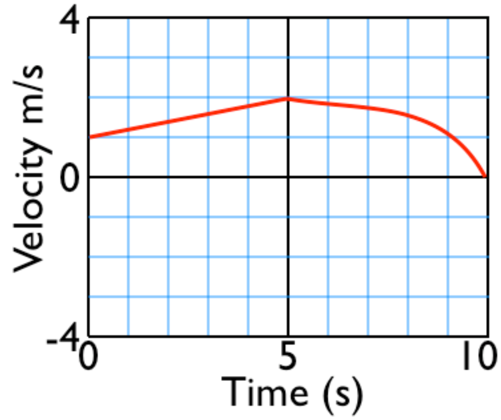
138 How can you tell if an acceleration is constant?

139 How can you tell if an acceleration is changing?

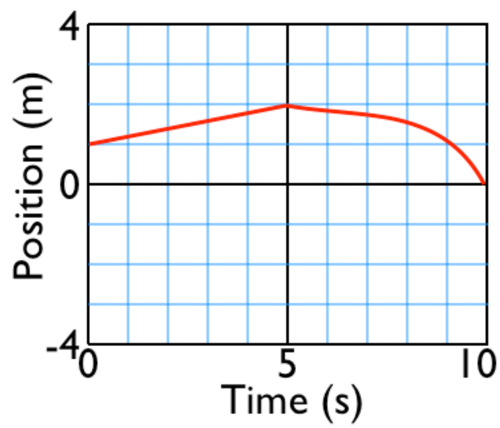
Kinematics Graphs Worksheet

Putting it all together …Summary

How do you find:



1. the velocity at 4 seconds?
2. if the acceleration is positive or negative?
3. the displacement from 1 to 3 seconds?
4. the change in position from 1 to 3 seconds?
5. if the velocity is positive or negative at 3 seconds?
6. the velocity at 9 seconds?



7. the velocity at 4 seconds?
8. if the acceleration is positive or negative?
9. the displacement from 1 to 3 seconds?
10. the change in position from 1 to 3 seconds?
11. if the velocity is positive or negative at 3 seconds?
12. the velocity at 9 seconds?

Objectives

Kinematics by Algebraic Means

Students will be able to:

1. **Describe the basic VECTOR motion concepts of;**
   - displacement,
   - velocity,
   - acceleration,
   - jerk.

2. **Identify a number as being either displacement, velocity, acceleration, jerk or time based solely on its units.**

3. **List the values given in a word problem.**
   These values will be listed and identified as either...
   - initial position
   - final position
   - initial velocity
   - final velocity
   - average velocity
   - acceleration
   - time
   - Also list the "implied" givens.

4. **From memory, the following formulae will need to listed**

   A.

   $$x = x_o + \upsilon_o t + \frac{1}{2}at^2 \qquad \upsilon = \upsilon_0 + at$$

   $$\upsilon^2 = \upsilon_o^2 + 2ax \qquad \upsilon_{AVG} = \frac{x}{t} = \frac{\upsilon + \upsilon_o}{2}$$

   B. You will only be given the right side of each equation

5. **List what the variables of xo, x, vo, v, vavg, a and t stand for**

6. **Write the proper S.I. units for the variables listed in the previous objective.**

7. **Solve word problems while demonstrating proper solution-communication techniques. This includes but is not limited to:**
   - List all the variables in a problem with units
   - Show the formula(s) used to solve the problem with only variables
   - Show the formula(s) used to solve the problem with only numbers
   - Show any necessary math
   - Show the answer with proper units

8. **Be able to convert between accelerations in m/s2 and g's.**

Unit Identification: Identify the following as either, time, displacement, velocity, acceleration. Use the abbreviation “t, x, v,” or “a” respectively.

1	m/s	__________
2	league	__________
3	s	__________
4	m/s2	__________
5	ft	__________
6	mi	__________
7	furlongs/(hr•s)	_________
8	in/day	__________
9	furlongs	__________
10	yd/min	__________
11	m	__________
12	day	__________
13	min	__________
14	s	__________
15	ft/min	__________
16	furlong/s2	__________
17	km/(min•hr)	__________
18	in/(hr•s)	__________
19	mi/hr2	__________
20	fathom/(min•s)	________
21	month	__________
22	mi/hr	___________
23	in/s	___________
24	mph	___________
25	kph	___________
26	in/(month•hr)	__________
27	in	___________
28	nanosecond	___________
29	min	___________
30	m/hr	___________
31	km/hr	___________
32	m/day2	___________
33	cm/(s•min)	___________
34	fathom	___________
35	m/min	___________
36	mm	___________
37	century	___________
38	microsecond	___________
39	arm length	___________
40	mm/(s•min)	___________
41	ft/(s)	___________
42	cm/year	___________

Kinematics by Algebraic Means

For problems 1 – 9, list the givens and the variable to be found in each problem.

1. An angry mob lynches a physics teacher after receiving their grades. They throw the physics teacher off a tall building. They throw the physics teacher straight down with a velocity of 20 m/s. The teacher falls for 3.0 seconds before landing on a stack of empty cardboard boxes. How high was he thrown from?

2. A baseball is rolled horizontally along the ground at 45 m/s. The ball slows down at a rate of 5 $^{m}/_{s^2}$. How long is the ball rolling before coming to rest?

3. A meteor falls from the sky to the Earth. The meteor already had an initial velocity downward when it was spotted. If it hit the Earth at 335 m/s after being seen for 30 seconds, then what was the initial velocity of the meteor?

4. A car started from a rest and accelerated at 9.54 m/s2 for 6.5 seconds. How much distance did the car cover?

5. A paper airplane is thrown horizontally with a velocity of 20 mph. The plane is in the air for 7.43 s before coming to a stand still on the ground. What is the acceleration of the plane?

6. A pile driver drops from a height of 35 meters before landing on a piling. What is the speed of the driver when it hit the piling?

7. An arrow leaves a bow with a speed of 42 m/s. Its velocity is reduced to 34 m/s by the time it hits its target. How much distance did the arrow travel over if it were in the air for 2.4 seconds?

8. At a drag race, a jet car travels 1/4 mile in 5.2 seconds. What is the final speed of the car and its acceleration?

9. A rock is dropped on a newly explored planet. The rock is dropped 1.22 meters. The acceleration due to gravity is 1.3 m/s^2. How much time did is take for the rock to fall?

10. A cheetah can run from 0 to 70 mph in 2.2 seconds.
 a. What is the cheetah's top speed in m/s?
 b. What is the cheetah's acceleration in m/s^2?
 c. What is the cheetah's average speed in mph and m/s?
 d. How much distance did the cheetah cover in traveling from 0 to 70 mph?

11. A ball rolls down a hill with a constant acceleration of 3.0 m/s^2.
 a. If it starts from rest, what is its speed at the end of 4.0 s?
 b. How far did the ball move in that 4.0 s?

12. A car can accelerate from 0 to 60 mph in 8.5 seconds.
 a. What is the car's top speed in m/s?
 b. What is the acceleration of the car?
 c. If the car were to maintain the acceleration in 2b, how long would it take to reach 70 mph from rest?
 d. How much distance would the car travel by the time it reached 70 mph?

13. A bicyclist brakes from 21 m/s to a stop in 32.3 m.
 a. What is the acceleration of the bicyclist?
 b. How much time does it take for the bicyclist to stop?
 c. What is the bicyclist's average speed?

14. A car moving on a straight road increases its speed at a uniform rate from 10 m/s to 20 m/s in 5.0 s.
 (a) What is its acceleration?
 (b) How far did it go during those 5.0 seconds?

15. On a roller coaster ride at an amusement park, a car travels from 7.6 m/s to 56 m/s in 3.0 seconds.
 a. What is the car's acceleration?
 b. How much distance did the car travel in 3.0 seconds?
 c. If the car continued this acceleration, how fast would it be traveling after 150 m?

16. 6.0 seconds after launch, the space shuttle is 529.2 m above the ground.
 a. What is the space shuttle's acceleration?
 b. What is the space shuttle's velocity after 3.0 seconds?
 c. What is the space shuttle's velocity at 6.0 seconds?
 d. What is the space shuttle's average velocity after the first 6.0 seconds?
 e. How high is the space shuttle after 3.0 seconds?

17. Melissa threw a penny straight down off the Empire State building. The building is 354 m tall. If Melissa threw the penny down such that it left her hand at 35 m/s,
 a. How fast will the coin be traveling when it hits the pavement?
 b. How long will the coin be in the air?

18. An hour later, after the sidewalk damage was cleaned up, Paul dropped a coin off the top of the Empire State building.
 a. How fast will the coin be traveling when it hits the pavement?
 b. How long will the coin be in the air?

19. A methanol-powered dragster travels a 1/4-mile from a stand still. The final speed of the best dragster will reach 300 mph.

a. Convert all units to standard SI units
b. Assuming the dragster's acceleration to be constant, what will it be?
c. How long will the dragster take to finish the 1/4-mile?

20. Phoebe threw a Frisbee horizontally that traveled 125 m. The Frisbee left her hand traveling 45 m/s. As the Frisbee travels in the air it slows down with a de-acceleration of 5.6 m/s2.

a. How long was the Frisbee in the air?
b. When Mike caught the Frisbee, how fast was it traveling?

21. In order for Mike to catch the Frisbee Phoebe threw; he had to run 45 m in 7.0 seconds. Mike began his sprint from a resting position.

a. What was Mike's average velocity?
b. Assuming Mike accelerated the whole time he was running, what was his acceleration?
c. What was his final speed if he accelerated the whole time?

22. A bullet it fired at Wonder Woman. The bullet leaves the gun's muzzle at 1000 m/s. Wonder Woman is standing 8.4 meters in front of the bullet. The instant bullet is fired Wonder Woman begins to move her hand to block the bullet. Her hand starts from rest. She has to move her hand 1.25 meters to block the bullet.

a. When the bullet is in the air it will slow down at a rate 35.68 m/s2. How long did it take for the bullet to reach Wonder Woman?
b. How fast was the bullet traveling when Wonder Woman deflected it?
c. What was the average speed that Wonder Woman moved her hands to deflect the bullet?
d. What wad the final speed of Wonder Woman's hand when she deflected the bullet?
e. What was the acceleration of her hand?
f. Wonder Woman stopped her hand in 0.3 m. What is the acceleration of her hand now?

23. A jet plane lands with a velocity of 100 m/s and can accelerate at a maximum of -9.0 m/s2 as it comes to rest.

a. From the minute that the plane touches the runway, what is the minimum time needed before it can come to rest?
b. Can this plane land on a small island airport where the runway is 0.80 km long? (Hint: Is the distance needed with this size acceleration greater than 0.80 km?)

24. A bullet is fired through a board 10.0 cm thick in such a way that the bullet's line of motion is perpendicular to the face of the board. If the initial speed of the bullet is 400 m/s and it emerges from the other side of the board with a speed of 300 m/s, find

a. The acceleration of the bullet as it passes through the board, and
b. The total time the bullet is in contact with the board.

25. While doing an experiment, Tom drops a ball out of a window 2.3 meters above the ground. The instant he does this he fires a starters pistol. Jerry sees the ball hit the ground at the instant he hears the pistols shot. (It takes time for the pistol's sound to reach Jerry.) The speed of pistol's sound is 344 m/s -it is constant and will not change.

a. How long did it take for Tom's ball to reach the ground?
b. How far away was Jerry standing?

26. A certain automobile manufacturer claims that its super-deluxe sports car will accelerate uniformly from rest to a speed of 87 mi/h in 8 s.

a. Determine the acceleration of the car in ft/s2 and mph/s
b. Find the distance the car travels in the first 8 s (in feet).
c. What is the velocity of the car 10 s after it begins its motion, assuming it continues to accelerate at the rate of 16 ft/s2?

27. Flossy Fletcher was curling her hair when she dropped the curling iron. The curling iron fell 1.651m to the floor.

a. How fast was the iron traveling when it hit the floor?
b. How long was it in the air?

28. An electron in a cathode ray tube of a TV set enters a region where it accelerates uniformly from a speed of (3 X 104) m/s to a speed of (5 X 106) m/s in a distance of 2 cm.

b. How long is this electron in this region where it accelerates?
c. What is the acceleration of the electron in this region?

29. A 400-m train is moving on a straight track with a speed of 82.4 km/hr. The engineer applies the brakes at a crossing, and later the last car passes the crossing with a speed of 16.4 km/hr. Assuming constant acceleration, how long did the train take to pass the crossing?

30. A driver in a car traveling at a speed of 60 km/hr sees a deer 100 m away on the road. What is the minimum constant acceleration that the car must undergo so as to avoid hitting the deer (assuming that the deer does not move)?

31. An F-15 jet fighter starts from rest and reaches a speed of 330 m/s in 2 seconds.

a. What is the planes acceleration?
b. How much distance did the jet cover in the 2 seconds?
c. How fast was the jet traveling after 1 second?

32. To calculate the depth of a well a physics student drops a rock into the well. 4.5 seconds after the rock is dropped the student sees it hit the bottom.

a. How deep is the well?
b. How fast is the rock traveling the instant before it hits the bottom?

33. A bicyclist traveled from 15.6 m/s to 21.1 m/s over a distance of 30 meters.

a. What is the acceleration of the bicyclist?
b. How much time does it take the bicyclist to travel the 30 meters?

34. While looking out of her office, Hillary Clinton notices a republican falling past her window at 15 m/s.

a. How fast is the republican traveling after falling 30 m past Hillary's window?
b. How long does it take to travel those 30 meters down?
c. The republican safely lands in some bushes an additional 15 meters farther down from the 30m.
   - What was his speed the instant before he hit the bushes?
   - How long did it take to travel the total 45 meters down from the window?

35. A sandbag dropped from a balloon ascending at 4.2 m/s lands on the ground 10.0 s later. What was the altitude of the balloon at the time the sandbag was dropped?

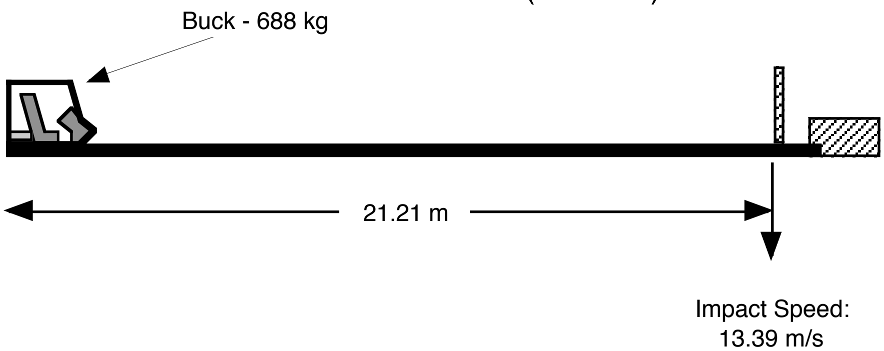
36. A parachutist descending at a speed of 10 m/s drops a camera from an altitude of 50 m.

a. How long does it take the camera to reach the ground?
b. What is the velocity of the camera just before it hits the ground?

37 While looking out a window you see a ball traveling upwards. Resulting from your fine tuned skills of observation you notice the ball is traveling 22.0 m/s upward. How much time will it take to travel up another 15.0 m?

38 While watching a baseball game, from behind the backstop on the second level, you observe a pop foul traveling straight up past you at 41 m/s. How much time will it take for the ball to travel up an additional 55.0 m?

In a car crash test, the sled used to test the effects of crashes on a car's occupants is called a "buck". A buck weighs about 1500 pounds (688 kg). A typical impact speed is 30 mph (13.39 m/s). The test track that the buck slides down is 70 ft (21.21 m).



39. A buck starts from rest and travels up to 30 mph with an acceleration of 0.818 g's. How much time does this test run take?

40. A Mustang GT travels from rest to 55 mph (24.55 m/s) in 7.8 seconds. What is the acceleration of the Mustang in g's? (This will give some feel for the acceleration of the buck).

41. Car seats are designed not to come loose below a 20 g collision. If a car were traveling at 30 mph, how quickly would it have to stop if the seats were to just come loose?

42. What distance would a car have to come to a stop in if it were to undergo the 20 g collision described in the collision in question "c"?

43. If a car collides with a wall at 30 mph and bounces off at 8 mph in the opposite direction, what would be the impact time if the deceleration were 20 g's?

44. In a collision the car changes direction in 0.100 seconds. If a car were to collide with a wall in a 20 g collision with an impact velocity of 30 mph, then what would be the car's rebound speed off the wall?

45. In a collision the air bags deploy and collapse in 0.300 seconds. This is the time for the car to change direction. A car collides with a wall in a 20 g collision. If the car's rebound speed equaled its impact speed, what would be this speed?

46. A seat belt is designed to slow a passenger down with a 10 g deceleration. A typical collision lasts 0.300 seconds. 6 inches are between the passenger's torso, and the steering wheel -this distance is called the rattle distance. At what speed can the car impact, with a final speed of zero, such that the belt is to just do its job and save the passenger's life?

Other facts of interest:

- Airplane seats are designed to withstand a 9 g horizontal deceleration before ripping out of the floor.
- Car seats are designed to withstand a 20 g horizontal deceleration before ripping out of the floor.
- The human body can withstand a 40 g horizontal deceleration before dying -due to compression and tearing of the internal organs. This number is less for older fragile people and higher for people of a more robust nature.
- "60 Minutes," did a story in February 1992 that warned of car seats that collapse during a rear end collision. What they failed to mention was that the probability of injury sustained because of these seats versus non-collapsing seats is the same. Injury occurs with non-collapsing seats by rebounding the passenger into the dash

g's section

47 During a space shuttle launch an astronaut experiences an acceleration of 3.0 g's.

a What is the acceleration of the astronaut in m/s^2?

b If the space shuttle started from rest, how far did it travel in 10 seconds?

48 A top fuel dragster experiences an acceleration of 5 g's during a drag race.

c What is the acceleration of the drive in m/s^2?

d If a driver were to maintain this acceleration for 200.0 m, then how much time and how fast was the driver traveling at this point? The car started from rest.

49 On Jupiter a rock will fall to the ground with an acceleration of 26.94 m/s^2.

e What is the acceleration of the rock in Earth g's?

50 When a golf ball is hit off a tee, it will experience an acceleration of 1000 g's while the club makes contact with the ball. Typically the club will make contact for 0.00080 seconds.

f What is the acceleration of the ball in m/s^2?

g How fast is the ball traveling when it leaves the club?

51 A jet is flying at 175 m/s when it begins to accelerate at 3.50 g's. How much time will it take to travel 1.00 mile?

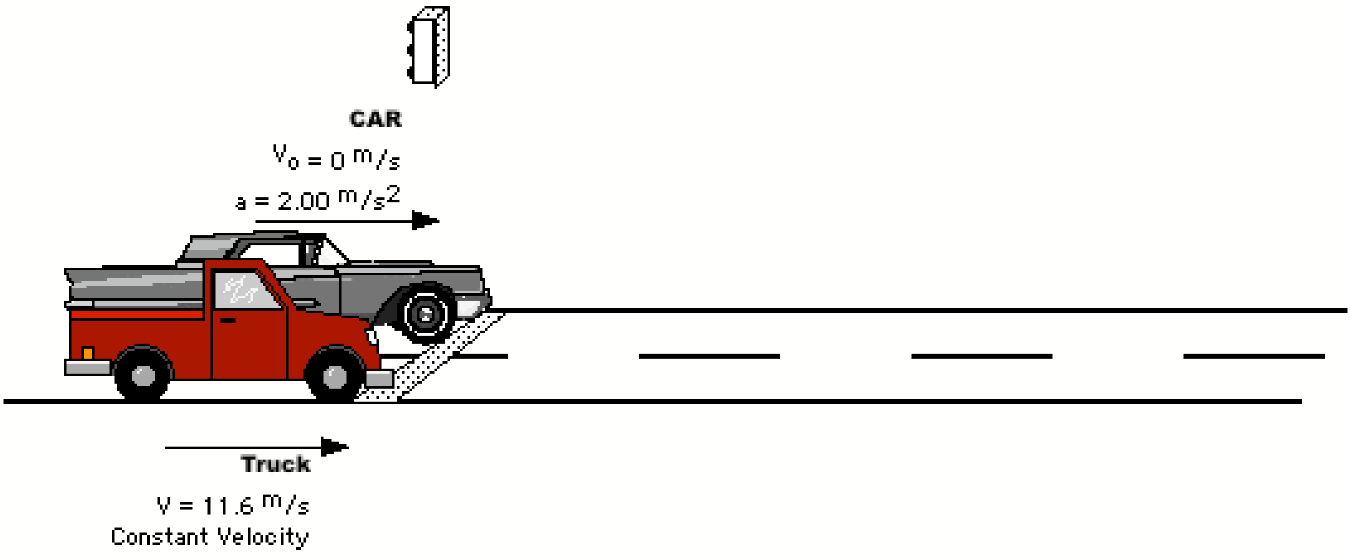
52 The space shuttle is traveling at 7650 m/s when it begins to accelerate at 0.100 g. How much time will it take to travel across the continental United States -a distance of 4.00 X 10^3 miles?

53 A car is at rest at a stoplight. The moment the light turns green a truck rolls up the line with a CONSTANT velocity of 11.6 m/s. At the instant the truck is next to the car; the car begins to accelerate as shown.

a. How much time does it take for the car to catch up to the truck?

b. How much distance is covered when the from the start line to when the car catches up to the truck?

c. What is the velocity of the car when it catches up to the truck?



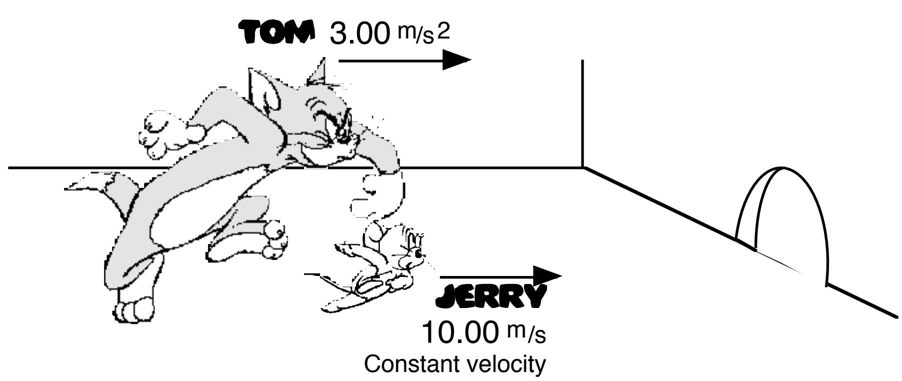
54 In the Savannahs of Africa a gazelle is running in a straight line with a constant velocity is 16.25 m/s. The gazelle startles a cheetah when she runs past. At the instant the cheetah and gazelle are side by side the cheetah accelerates after the gazelle from rest at 12.00 m/s2.

a. How much time does it take for the cheetah to catch up to the gazelle?

b. How much distance is covered when the from the start line to when the cheetah catches up to the gazelle?

c. What is the velocity of the cheetah when it catches up to the gazelle?

55 Tom, the cat, is chasing Jerry, the mouse. Jerry runs past Tom at 10.00 m/s. At the instant Jerry passes Tom, Tom starts from rest and accelerates at 3.00 m/s2.



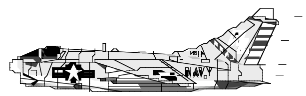
a. How much time does it take for the Tom to catch up to Jerry?

b. What is the velocity of the Tom when he catches up to the Jerry?

c. The mouse hole is 2.1 meters away from Jerry when Tom began to chase Jerry. Will Jerry make it to the hole without being caught? (Support your answer with numbers.)

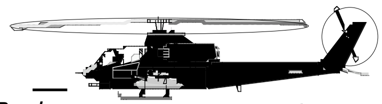
56 A Helicopter is hovering when a jet flies past it as shown. The instant the jet flies past the helicopter, it fires a rocket with the acceleration shown.

a. The pilot of the jet will wait until the last possible moment to roll the jet from the incoming rocket. How much time does it take for the rocket to catch up to the jet?



Corsair Jet

252.50 m/s, 21.5 m/s^2



Rocket

a = 62.00 $^m/_{s^2}$

Helicopter

Hovering (v=0)

b. How much distance is covered from where the rocket is fired to where the rocket would catch up to the jet?

c. What is the velocity of the rocket when it catches up to the jet?

57. A pedestrian is running at his maximum speed of 6.0 m/s to catch a bus stopped at a traffic light. When he is 15 m from the bus, the light changes and the bus accelerates uniformly at 1.00 $^m/_{s^2}$. Does he make it to the bus? If so, how far does he have to run in order to catch it? If not, how close does he get?

58 A car starts from rest and accelerates at 0.500 g's from 50.0 m. the car then travels for 8.52 seconds at a constant velocity. It then slows down for 3.12 seconds with an acceleration of –2.50 $^m/_{s^2}$.

- **a.** What is the final velocity of the car?
- **b.** What was the total distance traveled by the car?
- **c.** What was the car's final acceleration in g's?

59 A top fuel dragster accelerates from a rest with an acceleration of 5.10 g's. Once the dragster reaches its top velocity of 145 $^m/_s$, it travels at a constant velocity for the rest of the 1/4 miles track. How much time did it take for the dragster to travel the length of the track?

60 A bus picks up a passenger and accelerates from a rest at 1.50 $^m/_{s^2}$ for 6.00 seconds. After the initial 6.0 seconds the bus accelerates at 2.50 $^m/_{s^2}$ for an additional 35.5 m. The bus then slams on the brake and accelerates at - 0.75 g's until it comes to a rest.

- **a.** What is the total time for the bus ride?
- **b.** What is the total distance covered by the bus?

61. Suppose that while traveling at 12.0 m/s, a driver sees a traffic light turn red. After 0.510 s has elapsed (their reaction time), the driver applies the brakes and the car slows at -6.20 m/s2. What is the stopping distance of the car, as measured from the point where the driver first notices the red light?

62. A drag racer-starting from rest-speeds up for 402 m with an acceleration of + 17.0 $^m/_{s^2}$. A parachute then opens, slowing the car down with an acceleration of - 6.10 $^m/_{s^2}$. How fast is the racer moving 350 m after the parachute opens

Objectives

Newton’s Laws of Motion

Students should be able to:

1. Describe Aristotle’s Horse Cart theory and what was wrong with it.
2. Describe Galileo's experiment that lead to his conclusions about inertia
   (a) Describe how this experiment is exemplified in modern day amusement parks
3. Define in a sentence Galileo's Law of Inertia (Alias-Newton's first Law of Motion)
4. Describe what affects an object's inertia.
5. Characterize rotational inertia
   (a) Describe the relationship between an objects rate of spin and the object's distribution of its mass.
6. Give examples of how inertia is demonstrated in everyday life (TOYS)
7. Write in words Newton's Second Law of Motion.
   (a) Describe a force
   (b) Give the SI and English unit of force.
   (c) Give the symbols for force in SI and English systems.
8. Describe the relationship between force and acceleration.
9. Describe the relationship between force and mass.
10. Do problems that make proportionality predictions based on Newton’s second law of motion. (F=ma) [Ratio problems]
11. Describe the formula for calculating weight from mass. (w=mg)
    (a) Describe what is means to experience a certain number of g’s.
    (b) Convert back and forth between g’s and m/s^2.
12. Write in a complete sentence Newton's Third Law of Motion.
13. Apply Newton’s Third Law of Motion to Problems.
14. Be able to identify the "reaction force" in a given situation.
15. Distinguish between the concepts of mass and weight.
16. Memorize the value for the acceleration of any object near the surface of the Earth.
    (a) Describe what it means to be weightless.
17. Utilize Newton's Laws in conjunction with the Kinematics equations to solve problems.

1. A little boy pushes a wagon with his dog in it. The mass of the dog and wagon together is 45 kg. The wagon accelerates at 0.85 m/s^2. What force is the boy pulling with?
2. A 1650 kg car accelerates at a rate of 4.0 m/s^2. How much force is the car's engine producing?
3. A 68 kg runner exerts a force of 59 N. What is the acceleration of the runner?
4. A crate is dragged across an ice-covered lake. The box accelerates at 0.08 m/s^2 and is pulled by a 47 N force. What is the mass of the box?
5. 3 women push a stalled car. Each woman pushes with a 425 N force. What is the mass of the car if the car accelerates at 0.85 m/s^2?
6. A tennis ball, 0.314 kg, is accelerated at a rate of 164 m/s2 when hit by a professional tennis player. What force does the player's tennis racket exert on the ball?
7. In an airplane crash a woman is holding an 8.18 kg, 18-pound, baby. In the crash the woman experiences a horizontal de-acceleration of 88.2 m/s^2. How many g's is this de-acceleration? How much force must the woman exert to hold the baby in place?
8. When an F-14 airplane takes-off an aircraft carrier it is literally catapulted off the flight deck. The plane's final speed at take-off is 68.2 m/s. The F-14 starts from rest. The plane accelerates in 2 seconds and has a mass of 29,545 kg. What is the total force that gets the F-14 in the air?
9. A sports car accelerates from 0 to 60 mph, 27 m/s, in 6.3 seconds. The car exerts a force of 4106 N. What is the mass of the car?
10. A sled is pushed along an ice-covered lake. It has some initial velocity before coming to a rest in 15 m. It took 23 seconds before the sled and rider come to a rest. If the rider and sled have a combined mass of 52.5 kg, what is the magnitude and direction of the stopping force? What do "we" call the stopping force?
11. A car is pulled with a force of 10,000 N. The car's mass is 1267 kg. But, the car covers 394.6 m in 15 seconds.
    - (a) What is expected acceleration of the car from the 10,000 N force?
    - (b) What is the actual acceleration of the car from the observed data of x and t?
    - (c) What is the difference in accelerations?
    - (d) What force caused this difference in acceleration?
    - (e) What is the magnitude and direction of the force that caused the difference in acceleration?
12. A little car has a maximum acceleration of 2.57 m/s2. What is the new maximum acceleration of the little car if it tows another car that has the same mass?
13. A boy can accelerate at 1.00 m/s2 over a short distance. If the boy were to take an energy pill and suddenly have the ability to accelerate at 5.6 m/s2, then how would his new energy-pill-force compare to his earlier force? If the boy's earlier force was 45 N, what is the size of his energy-pill-force?
14. A cartoon plane with four engines can accelerate at 8.9 m/s2 when one engine is running. What is the acceleration of the plane if all four engines are running and each produces the same force?
15. While dragging a crate a workman exerts a force of 628 N. Later, the mass of the crate is increased by a factor of 3.8. If the workman exerts the same force, how does the new acceleration compare to the old acceleration?

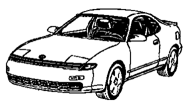
16. A rocket accelerates in a space at a rate of "1 g." The rocket exerts a force of 12,482 N. Later in flight the rocket exerts 46,458 N. What is the rockets new acceleration? What is the rocket's new acceleration in g's?

17. A racecar exerts 19,454 N while the car travels at a constant speed of 201 mph, 91.36 m/s. What is the mass of the car?

(<u>18-31 Weight and Mass</u>)

18. A locomotive's mass is 18181.81 kg. What is its weight?

19. A small car weighs 10168.25 N. What is its mass?



20. What is the weight of an infant whose mass is 1.76 kg?

21. An F-14's mass is 29,545 kg. What is its weight?

22. What is the mass of a runner whose weight is 648 N?

23. The surface gravity of the Sun is 274 m/s2. How many Earth g's is this?

24. The planet Mercury has 0.37 g's compared to the Earth.
What is the acceleration on Mercury in m/s2?

25. A plane crashes with a deceleration of 185 m/s2. How many g's is this?

26. A baseball traveling 38 m/s is caught by the catcher. The catcher takes 0.1 seconds to stop the ball. What is the acceleration of the ball and how many g's is this?

27. A very fast car accelerates from a rest to 32 m/s, (71.68 mph), in 4.2 seconds. What is acceleration of the car and how many g's is this?

28. The Space Shuttle travels from launch to 529.2 m in 6.0 seconds.
What is the acceleration of the shuttle and how many g's is this?

29. The space shuttle's mass, (with boosters) is 654,506 kg. The average force of the shuttle's engines is 25,656,635.2N. What is the acceleration of the shuttle in m/s^2 and g's?

30. How can the answers to #28 and #29 <u>both</u> be correct?

31. What is the SI weight of a McDonald's Quarter Pounder™ sandwich?

32. A little boy, mass = 40 kg, is riding in a wagon pulled by his HUGE dog, Howard. What is the acceleration of the wagon if the dog pulls with a force of 30 N? (Assume the wagon rolls on a friction less surface).

33. The wagon and boy mentioned in the previous problem are let loose by Howard the dog. The wagon freely rolls until it hits a patch of ground that slows down the wagon until it comes to a rest. If it takes 10 seconds to come to a stop in 15 meters, what if the frictional force stopping the wagon?

34. A speedboat in the water experiences an acceleration of 0.524 m/s2. The boat's mass is 842 kg. What is the force that the boat's engines are putting out?

35. A stalled car is pushed with a force of 342 N from rest. How far does the car travel in 12 seconds if its mass is 989 kg?

36. How far does the car travel in the previous problem if the pushing force is doubled?

37. A little boy is pulling a wagon full of 10 bricks. The mass of the wagon is too small to be considered. If the boy later is pulling the wagon with the same force and the wagon has 45 bricks in it, then how does the acceleration of the 45 brick wagon compare to the acceleration of the 10 brick wagon?

38. A car accelerates with a given force. Later the same car accelerates with 1/6 its original acceleration and it now has 1.4 times its earlier mass. (A) How does the car's later force compare with the earlier force? (B) If its earlier force is 1523 N, then what is the car's later force?

39. What force does the car exert if its mass is 1201 kg and the car goes from 5.4 m/s to 16.3 m/s in 107 meters?

40. What are Newton's 3 Laws and which ones are used in shaking a Catsup bottle to get the Catsup out when it is "stuck" in the bottle.

41. An ice skater is spinning when she begins to draw in her arms. As she does this what happens to her rate of spin? Which law does this fall under?

42. A 1027 kg car is resting at a stoplight. The car moves with a force of 1528 N for 22 s. Then the car travels at a constant velocity for 10 seconds. Finally, the car stops with a force of 4056 N. HOW MUCH DISTANCE IS TRAVELED BY THE CAR DURING THIS JOURNEY?

43. By what factor would the acceleration of a car change by if the net force the engine exerted tripled and the mass remained unchanged? What is the new acceleration if the initial acceleration is 2 m/s^2?

44. A truck is traveling down the road carrying a large roll of hay equal in mass to the truck. The roll is delivered to a customer. By what factor would the force the truck must exert change by if the truck is to achieve the same acceleration as before.

45. While tossing a medicine ball back and forth it rips and its mass changes by a factor of $^{3}/_{10^{th}}$'s. If the person catching the ball slowed it down with an acceleration that changed by a factor of ½ then how does the new stopping force compare to a previous stopping force from an earlier catch?

46. A wiffleball has a mass that is $1/50^{th}$ the mass of a baseball. If the ball is hit with 3 times the force of a baseball, then how does the acceleration of the baseball bat compare with the acceleration of the wiffleball?

SOME ANSWERS

1) 38.25 N	2) 6600 N	3) 0.87 m/s2	4) 587.5 kg	5)1500 kg
6) 51.50 N	7) 9 g's; 721.48 N	8) 1,007,484.5 N	9) 958.07 kg	10) 2.98 N
11a) 7.89 m/s2	11b) 2.62 m/s2	11c) 5.27 m/s2	11d) ???	11e) 6682.15 N
12) 1.285 N	13) 252 N	14) 35.6	15) New Accel = (0.26) Old Acceleration	
16) 3.72 g's	17) ???	18) 178181.74 N	19) 1037.58 kg	20) 17.25 N
21) 289541 N	22) 66.12 kg	23) 27.96 g's	24) 3.63 m/s2	25)18.88 g's
26) 380 m/s2, 38.78 g's	27) 134.4 m/s2, 13.71 g's	28) 29.4 m/s , 3 g's	29) 29.4 m/s , 3 g's	30) ???
31) ???	32) 0.75 m/s2	33) 40 N (0.3 m/s2)	34) 441.21 N	35) 24.90 m, (0.34 m/s2)

36) 49.80 (twice as far) 37) accel of 45 brick wagon = (1/(4.5))[accel of the 10 brick wagon)

38) new froce = 0.233(old force; 355.37 N 39) 1327.44 N, (1.1053 m/s2) 40) 1st

41) Spin faster (1st) 42) 360.05m + 327.32 + 135.64m = <u>823.02</u>

Objectives

Newton's Laws of Motion (Free Body Diagrams)

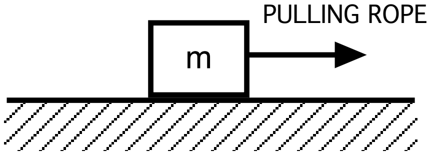
Students will be able to:

1. Identify when to include any of the forces listed below in a free body diagram, (abbreviated - fbd).
    a. Normal force
    b. Friction (Surface)
    c. Friction (Air resistance)
    d. Tension
    e. Weight
    f. Net force

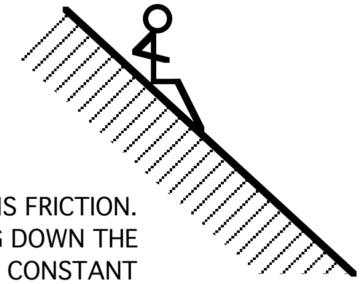
2. Define the directions of any of the forces listed above, (a–f).
3. Define friction in words and mathematically.
4. Define weight mathematically
5. Define what is wrong with a "weightless" object near the surface of the Earth.
6. Explain what it means on a free body diagram to travel at a constant velocity.
7. Create an equation based on a free body diagram.

Newton's Laws of Motion– Free Body Diagrams (fdb)

PULLING ROPE

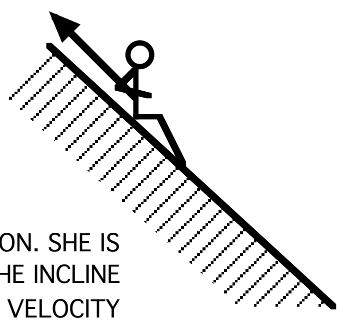


FRICTION, NO MOTION



THERE IS FRICTION.
HE IS MOVING DOWN THE
INCLINE AT A CONSTANT
VELOCITY

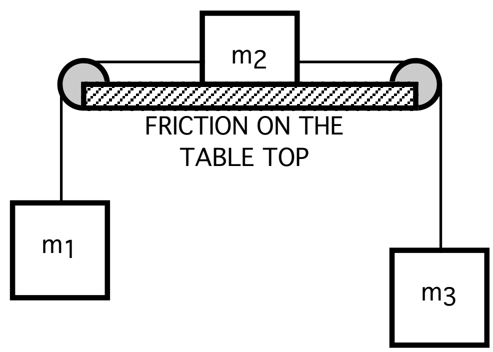
PULLING ROPE



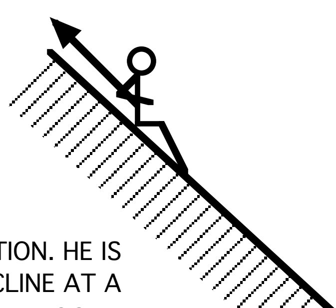
THERE IS FRICTION. SHE IS
MOVING <u>DOWN</u> THE INCLINE
AT A CONSTANT VELOCITY

DRAW A FREE BODY DIAGRAM
FOR EACH MASS

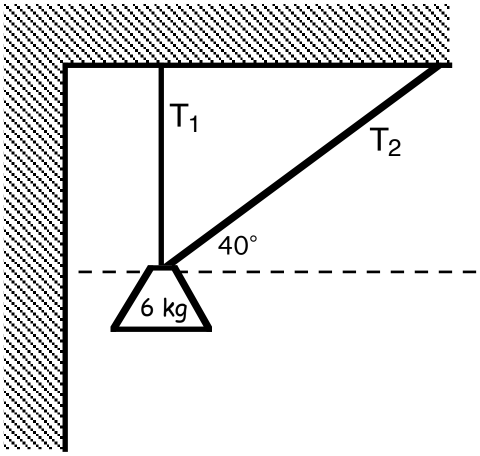
→ CONSTANT VELOCITY OF 3 M/S

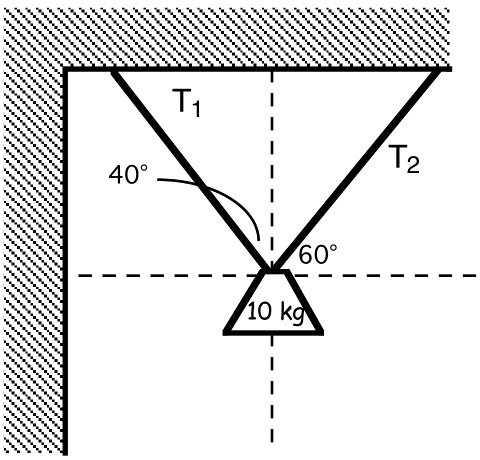


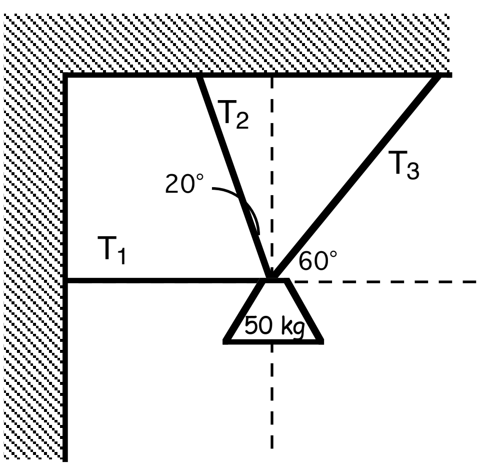
PULLING ROPE



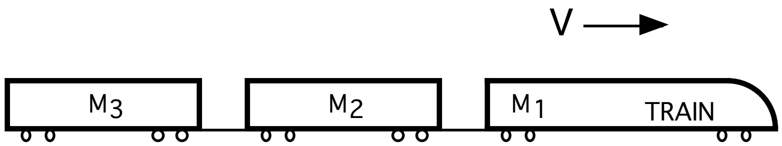
THERE IS FRICTION. HE IS
MOVING <u>UP</u> THE INCLINE AT A
CONSTANT VELOCITY


T1
T2
40°
6 kg


T1
T2
40°
60°
10 kg

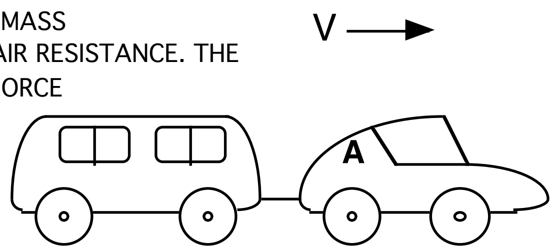

T2
T3
20°
T1
60°
50 kg

Newton's Laws of Motion– Free Body Diagrams (fdb)

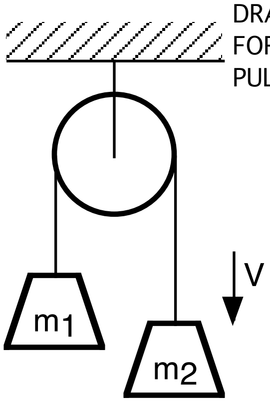


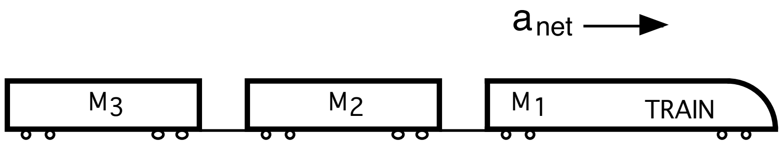
DRAW A FREE BODY DIAGRAM FOR EACH MASS
THERE IS FRICTION WITH THE ROAD. THERE IS AIR RESISTANCE. THE FRONT ENGINE IS SUPPLYING A FORWARD FORCE TO MOVE THE TRAIN.

DRAW A FREE BODY DIAGRAM FOR EACH MASS
THERE IS FRICTION WITH THE ROAD. NO AIR RESISTANCE. THE CAR IS SUPPLYING THE ONLY FORWARD FORCE



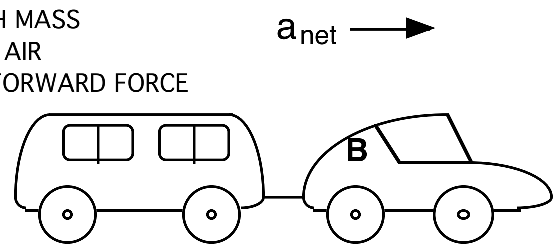
DRAW A FREE BODY DIAGRAM FOR EACH MASS AND THE PULLEY.





DRAW A FREE BODY DIAGRAM FOR EACH MASS
THERE IS FRICTION WITH THE ROAD. THERE IS AIR RESISTANCE.
THE FRONT ENGINE IS SUPPLYING A FORWARD FORCE

DRAW A FREE BODY DIAGRAM FOR EACH MASS
THERE IS FRICTION WITH THE ROAD. NO AIR RESISTANCE. THE CAR IS SUPPLYING A FORWARD FORCE



Net Force	Weight	Tension	Normal	Friction	<-Force’s <-Name
					When is it on the diagram?
					Formula and other notes:

Please do all of your work on a separate piece of paper.

Objectives

Projectile Motion

Students should be able to:

1. Calculate the horizontal and vertical components of a velocity vector given the initial vector.
2. Define givens as being either horizontal or vertical.
3. Place appropriate S.I. units on all givens and answers.
4. Calculate the apogee of any projectile motion.
5. Calculate the time in the air for any projectile motion.
6. Calculate the impact SPEED of any projectile motion.
7. Calculate the time to any given height in a projectile's motion.

Honors

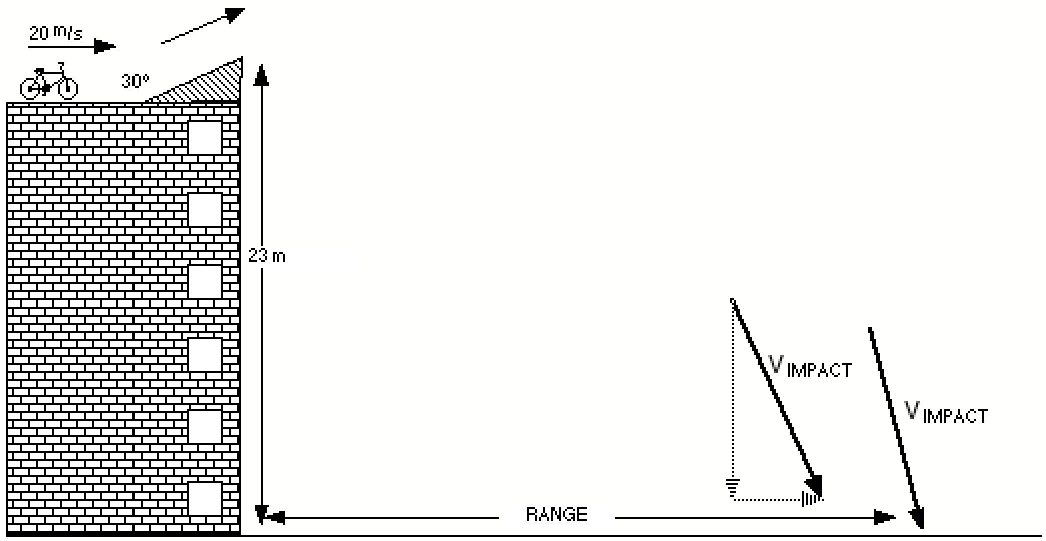
A. Calculate the impact velocity (magnitude and direction)

B. Calculate the velocities angle and speed at any given location in a projectile's path.

Please do all of your work on a separate piece of paper.

CLASS EXAMPLE

A bicyclist travels off the ramp with an initial velocity of 20 $^{m}/_{s}$ as it leaves the ramp. The 30° angle is between the ramp and the top of the building.



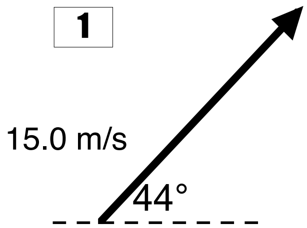
Calculate the RANGE.

Calculate the impact velocity and its angle.

Please do all of your work on a separate piece of paper.
For each problem below you are given the initial velocity for a projectile. Label the vertical and horizontal components in the same manner that we did in class. Use the angle that is given. Do not use its complementary or supplementary angle.

EXERCISE A

1



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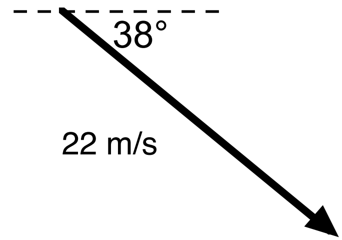

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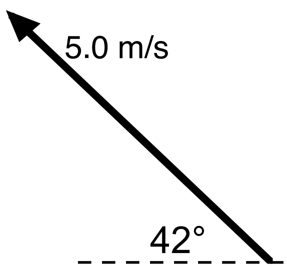

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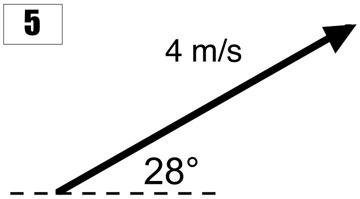

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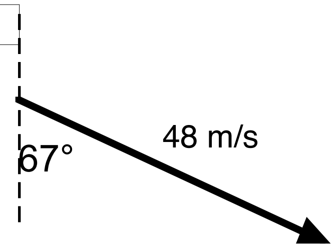

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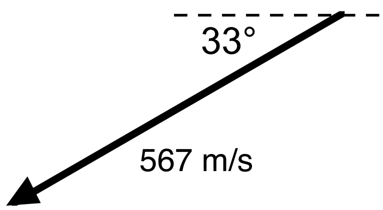

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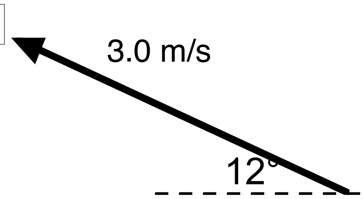

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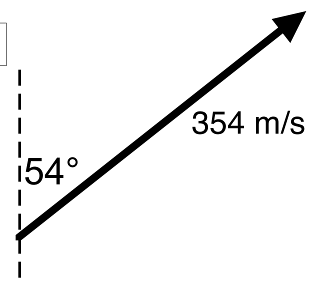

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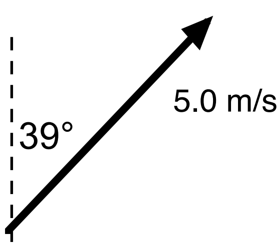


11 A baseball is thrown from center field to second base. It is released 42 m/s at an angle of 35° with the ground. In the space above, draw the initial velocity's triangle with its components.

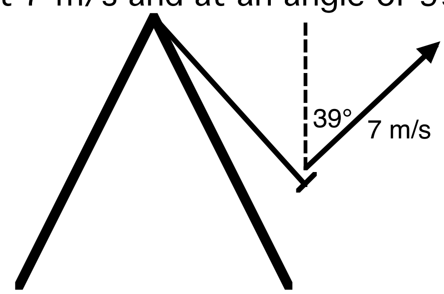
12 A package of food supplies is air dropped into Africa in such a way that it is ejected at 16 m/s downwards at an angle of 62° with the vertical. In the space above draw the initial velocity's triangle with its components.

Please do all of your work on a separate piece of paper.

Find the vertical and horizontal components for each of the velocities given below.

<u>Do not use any angles other than the ones you are given.</u>

1. A rock is thrown with a speed of 46.5 m/s at an angle of 38° with the ground.
2. A Volvo lands after driving off a cliff. It impacted the ground at 32 m/s at an angle of 68° with the ground.
3. An alien space-egg is catapulted from the planet Ork at an angle of 75° with the ground and a speed of 459 m/s.
4. A meteor hits the Earth with a speed of 86 m/s at an angle of 21° with the ground.
5. A girl jumps off a swing at 7 m/s and at an angle of 39° with the vertical.

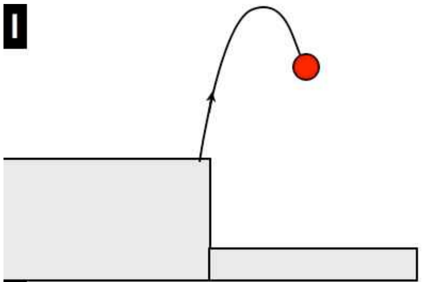


6. A jet lands on an aircraft carrier with a horizontal speed of 109 m/s and a downward vertical speed of 9.0 m/s. What is the VELOCITY (Magnitude and Direction) of the jet?

Please do all of your work on a separate piece of paper.

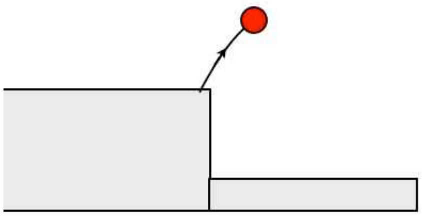
Class practice for determining the variables' signs

1



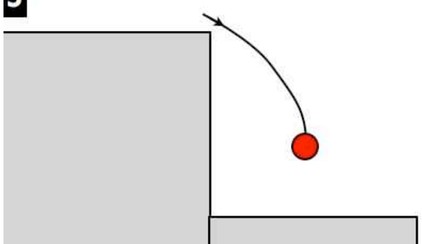
	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

2



	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

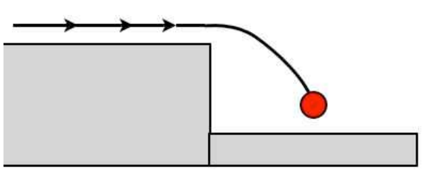
3



	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

4

Try the one below

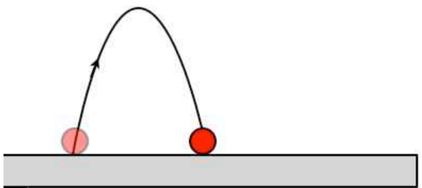


	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

Projectile Motion Problems

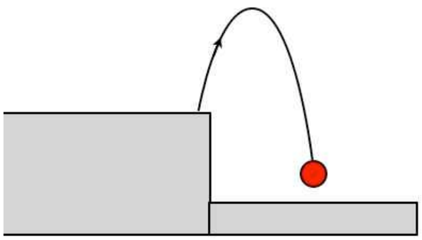
Please do all of your work on a separate piece of paper.

5



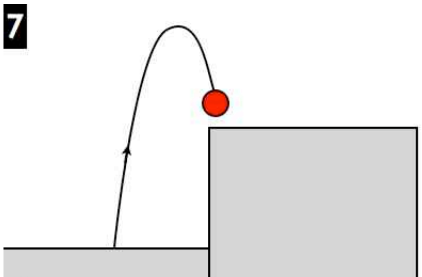
	Vert	Horz
Vo	+ ↑	
x	0	
t	+	
V	- ↓	
a	-9.80 m/s ↓	

6



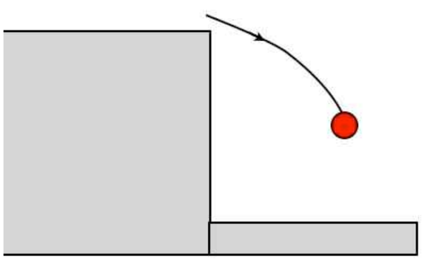
	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

7



	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

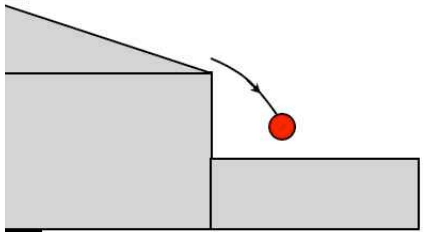
8



	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

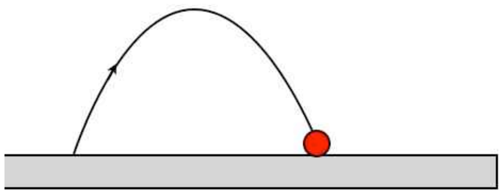
Please do all of your work on a separate piece of paper.

9



	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

10



	Vert	Horz
Vo		
x		
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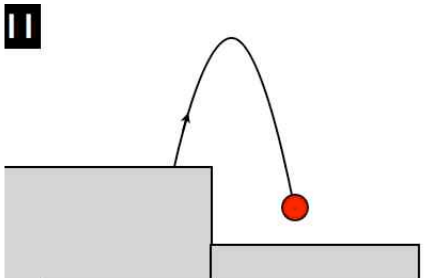
a	9.80 m/s	

11



	Vert	Horz
Vo		
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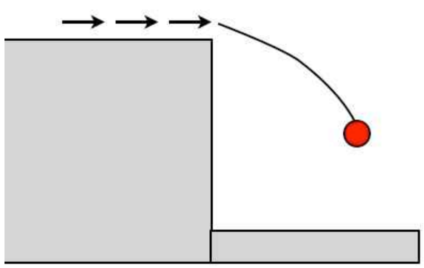
t		
V		
a	9.80 m/s	

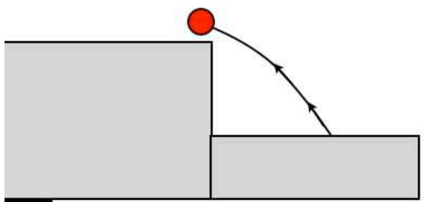
12



	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

Please do all of your work on a separate piece of paper.

15



	Vert	Horz
Vo		
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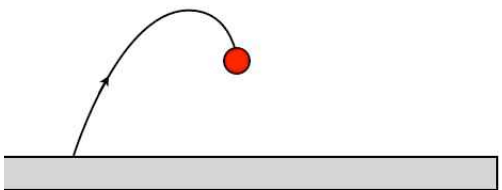
V		
a	9.80 m/s	

16



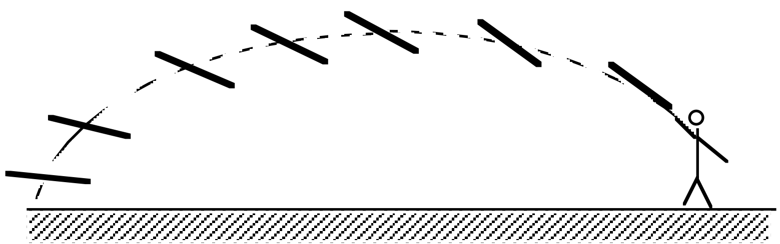
	Vert	Horz
Vo		
x		
t		
V		
a	9.80 m/s	

Please do all of your work on a separate piece of paper.

Symmetrical Projectile Motion

7. `Mike Easter threw a javelin at 57 m/s and at an angle of 25 degrees with the ground. Neglect the height of the javelin when it was thrown. So it lands at the same height it is thrown from.

a. How high did the javelin travel?
b. How long was it in the air?
c. How far along the ground did the javelin travel?
d. How fast, (direction and magnitude), was it traveling when it hit the ground?



8. An arrow is shot up at a 37° angle with the horizontal. The Arrow leaves the bow traveling 68 m/s. Eventually it lands on the ground.

a. How high above the ground did the arrow travel? Neglect the height of the bow from the ground when shot.
b. How long was it in the air?
c. How far across the ground did it travel?

9. The motorcycle daredevil Evil Kinevil is about to make a world record distance jump. He leaves the jump ramp at 45m/s. The ramp is at a 22° angle with the ground. He lands at the same height he took off from.

a. How high does he travel?
b. How long is he in the air?
c. What is the distance of his jump?
d. What is his velocity when he lands?

10. Robbie Knievel is about to make another world record distance jump. He leaves the jump ramp at 45m/s. The ramp is at a 68° (90°-22°) angle with the ground. He lands at the same height he took off from.

a. How high does he travel?
b. How long is he in the air?
c. What is the distance of his jump?
d. What is his velocity when he lands?

11. A spear is thrown with velocity of 30 m/s at a 34° angle with the ground? Neglect the initial height the spear was thrown from.

a. How far did the spear travel?

Please do all of your work on a separate piece of paper.

b. How long was the spear in the air?
c. How high did the spear travel?

12. A dare devil stunt man travels off a jump with velocity of 50 m/s at a 20° angle with the ground? The stunt man lands at the same height he took off from.

a. How far away should the landing ramp be placed?
b. How long was the motorcycle dare devil in the air?
c. How high did the motorcycle dare devil travel?

13. A baseball player bats a ball with a velocity of 60 m/s at an angle of 80° with the ground.

a. How far did the ball travel?
b. How long was the ball in the air?
c. How high did the ball travel?
d. A baseball player from the opposing team is standing 30 m from where the ball is going to land. What average speed does the player have to run to catch the ball?

14. Typically an assault rifle shoots a bullet at 1000 m/s. The rifle is aimed at 10.0° and the bullet lands on the ground. Neglect the height the bullet was shot from.

a. How far did the bullet travel?
b. How long was the bullet in the air?
c. How high did the bullet travel?

15. Not knowing any better, Tom hit Jerry with a tennis racquet. Jerry left the racquet with a velocity of 60 m/s at a 75° angle.

a. How much time passes before Jerry hits the ground?
b. How high does Jerry travel?
c. How far along the ground does Jerry travel?
d. How fast is Jerry traveling when he hits the ground?
e. How far along the ground will Jerry travel if he is launched at a 15° angle with the ground at 60 m/s?
f. What is the relationship between 75° and 15°?
g. Who is Tom and Jerry?

16. In a football game, a quarterback throws a ball to a receiver. The quarterback takes the hike from the center. 3.0 seconds later he passes the ball with a velocity of 20 m/s at a 30° angle with the ground.

a. How high did the ball travel?
b. How long was the ball in the air?
c. How far down the field did the ball travel?
d. What speed will the ball hit the ground with and at what angle?

Please do all of your work on a separate piece of paper.

e. With what average velocity will the receiver have to run with in order to catch the ball the moment it gets to the ground?

17. While traveling down the road, a driver loses control of his car the bounces off a curb at an 8.5° angle with the ground. The car lands at the same height is takes of from. The car was traveling 40.0 m/s when it bounced at 8.5°.

a. How long was the car in the air?
b. How far did the car travel?
c. What velocity did the car impact the ground with? (Magnitude *AND* direction)

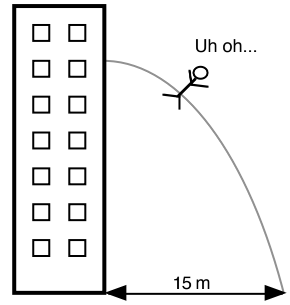
18. Waldo Walenda, one of The Flying Walenda's, was swinging on a trapeze. He let go of the trapeze when it was traveling 20.0 m/s at a 40.0° angle with the vertical. Waldo is to catch another trapeze that is *at the same height* as the one he left. When he catches the other trapeze it is to be at the end of its swinging motion. Try to recreate the situation using these questions as a guide.

a. How long was Waldo in the air?
b. How high above the trapeze did Waldo travel?
c. How far from the trapeze was the waiting trapeze (Horizontal distance)?
• d. If the waiting trapeze has a length of 6 meters, at what time -relative to the moment when Waldo lets go of the trapeze- does the waiting trapeze need to be released?

Please do all of your work on a separate piece of paper.

Vo is Horizontal

19. In a movie Borris Badenough is pushed horizontally out of a window. He exits the window horizontally at 5.0 m/s. Borris lands 15 m from the edge of the building.



a. What is the Borris Badenough's initial horizontal velocity?
b. What is the Borris Badenough's initial vertical velocity?
c. How fast, vertically, is Borris traveling when it hits the ground?
d. How long was Borris in the air?
e. How high was the window Borris fell from?
f. What SPEED did he impact the ground?
•g. What VELOCITY did he impact the ground? (magnitude *AND* direction).

20. A penny is kicked horizontally off the roof of a 10-story building (33.3 m high). It is kicked at 22 m/s.
a. What is the penny's initial horizontal velocity?
b. What is the penny's initial vertical velocity?
c. How long is the penny in the air?
d. How far away from the building did the penny land?
e. What is the penny's SPEED when it hits the ground?
•f. How fast, vertically, is the ball traveling when it hits the ground?
•g. How fast, horizontally, is the penny traveling when it hits the ground?
•h. What is the penny's VELOCITY (magnitude and direction) when it hits the ground?

21. A ball is rolled horizontally out a second story window (7 m high) with a velocity of 10.0 m/s.
a. What is the ball's initial horizontal velocity?
b. What is the ball's initial vertical velocity?
c. How long is the ball in the air?
d. How far away from the building did the ball land?
e. What is the ball's SPEED when it hits the ground?
•f. How fast, horizontally, is the ball traveling when it hits the ground?
•g. How fast, vertically, is the ball traveling when it hits the ground?
•h. What is the ball's VELOCITY (magnitude and direction) when it hits the ground?

22. The Wile E. Coyote was chasing the Road Runner when he ran horizontally off a cliff at 46 m/s. Wile E. Coyote is falling for 12 seconds before hitting the ground.
a. How high is the cliff?

Please do all of your work on a separate piece of paper.

b. How far from the edge of the cliff did the coyote travel before hitting the ground?

c. What was the coyote's impact SPEED

•d. What was the coyote's impact velocity, (MAGNITUDE and DIRECTION)?

23. The Charlottesville parking garage on Market Street is 6.0 stories high, 19.8 m. A car travels horizontally off the top of the garage at 2.2 m/s, (5 mph.)

- **a.** How far from the edge of the building did the car land?
- **b.** How long was the car in the air?
- c. With what speed was the car traveling when he hit the ground?
- •d. What velocity did the car impact the ground? (Magnitude *AND* direction)

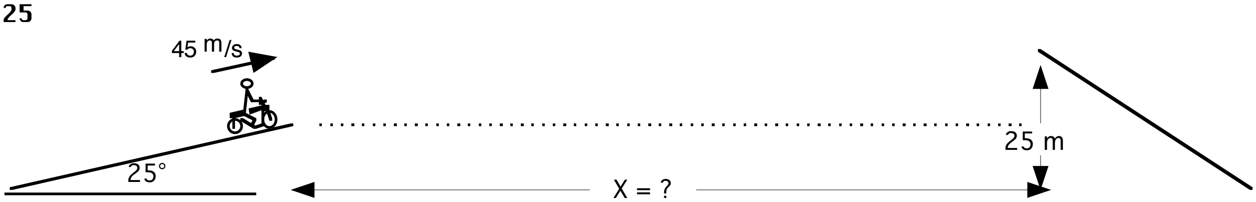
24. A student is at a quarry and attempting to run off the edge of a cliff. They run off the cliff at horizontally at 10 m/s. The edge of the cliff is 5 m above the water.

- **a.** How far from the edge of the building did the student land?
- **b.** How long was the student in the air?
- c. With what speed was the student traveling when he hit the water?
- **•d.** What velocity did the student impact the ground? (Magnitude *AND* direction)

*

Vo is an angle and x & xo are not equal

25



A stunt rider is making a motorcycle jump. Through a planning error the landing ramp's end does not match the take-off ramp's height. The landing ramp is 25 m high . The take off ramp is 10 meters high at the end.

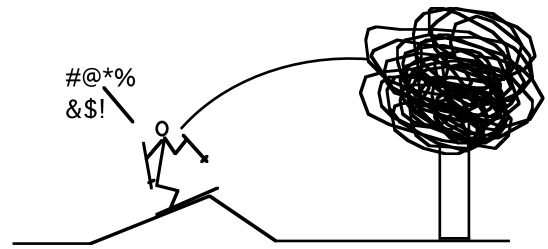
- a. Where should the ramp be placed (x)?
- b. How long is the rider in the air?

Please do all of your work on a separate piece of paper.

26

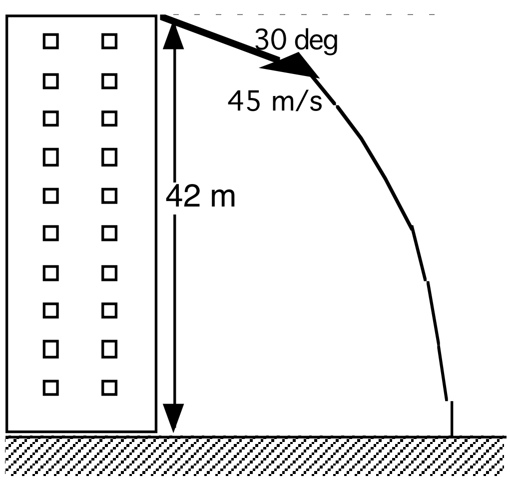
A skier was traveling 20 m/s when they hit a hill and launched themselves up into the air at a 30° angle. They hit a tree when they were at the highest part of the motion.

- **a** How long was the skier in the air?
- **b** How high did the skier travel?
- **c** How far along the ground did the skier travel?



27. A rock is thrown off a tall building at 45 m/s at an angle of 30° below the horizontal.

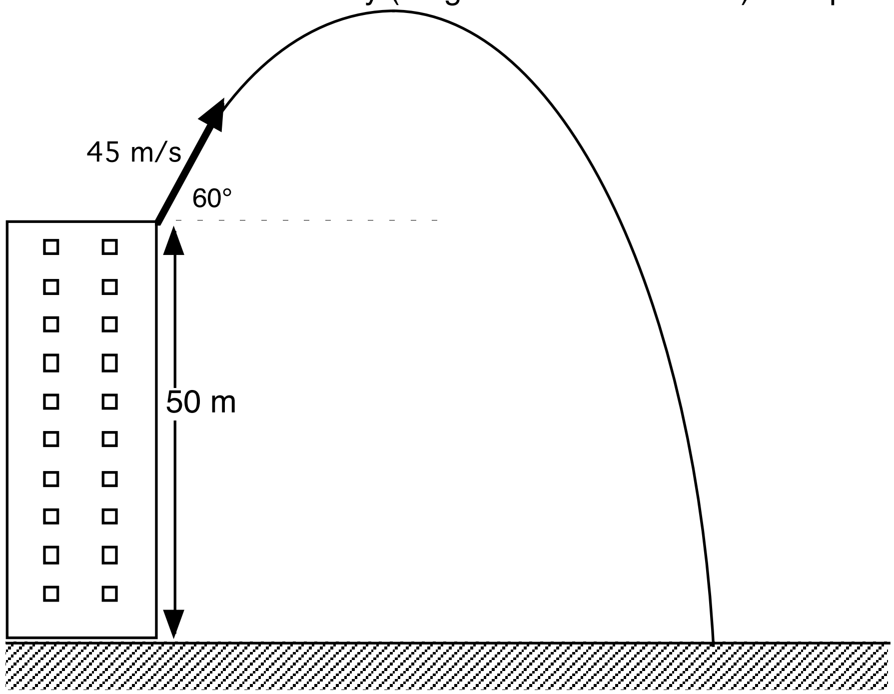
a. How long is the rock in air?
b. How far from the building did the rock land?
c. What is rock's velocity (magnitude and direction)?
At impact?



Please do all of your work on a separate piece of paper.

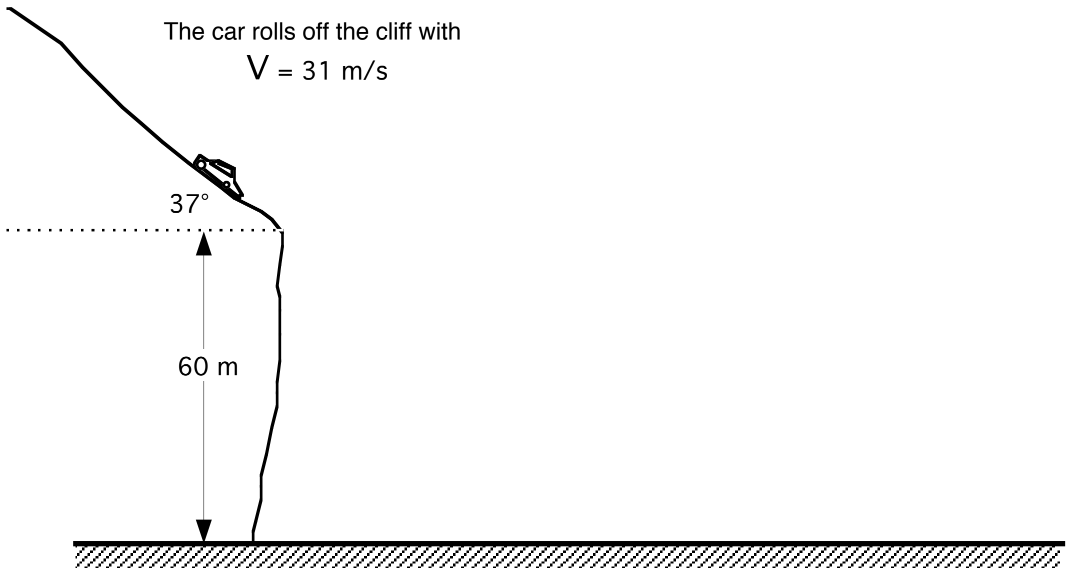
28. A rock is thrown off a tall building at 45 m/s at an angle of 60.0° above the horizontal.

a. How high did the rock travel?
b. How long is the rock in air?
c. How far from the building did the rock land?
•D. What is rock's velocity (magnitude and direction) at impact?



Please do all of your work on a separate piece of paper.

29.



How long is the car in the air?
How far from the cliff's edge will the car land?
How fast and at what angle will the car impact the ground?

30. A snowball is thrown out a second story window (7 m high) with a speed of 32 m/s. It is thrown at an angle of 57° beneath the horizontal.

a. What is the ball's initial horizontal velocity?
b. What is the ball's initial vertical velocity?
c. How long is the ball in the air?
d. How far away from the building did the ball land?
•e. How fast, vertically, is the ball traveling when it hits the ground?
•f. How fast, horizontally, is the ball traveling when it hits the ground?
•g. What is the ball's VELOCITY (magnitude and direction) when it hits the ground?

31. A Penny is thrown out off the Eiffel Tower (303 m high) with a speed of 43 m/s. It is thrown at an angle of 83° beneath the horizontal.

a. What is the penny's initial horizontal velocity?
b. What is the penny's initial vertical velocity?
c. How long is the penny in the air?
d. How far away from the building did the penny land?
•e. How fast, horizontally, is the penny traveling when it hits the ground?
•f. How fast, vertically, is the penny traveling when it hits the ground?
•g. What is the penny's VELOCITY (magnitude and direction) when it hits the ground?

Please do all of your work on a separate piece of paper.

32. While sitting in a tree, Tarzan tried to get a trapper's attention by throwing a banana with a velocity of 20.0 m/s at a 30.0 degree angle beneath the horizontal.
  a) How high was Tarzan if the banana took 2 seconds to hit the ground?
  b) With what speed did the banana hit the ground?
  •c) With what angle did the banana hit the ground?

•33. Tina, the golfer, tees off the tip-top of a tall turf laden hill. Her golf ball is in the air for 6.00 seconds before coming to a rest 5.00 meters below the tee's height.
  a) If the golf is hit with a velocity of 60.00 m/s then what angle was the ball hit with?
  b) How far horizontally did the ball travel before coming to a rest?

•34. Tarzan was swinging on a vine when is snapped. At the moment it snapped the vine was 30° from the VERTICAL in an upwards direction. Tarzan was traveling 25 m/s. Tarzan landed 16 meters along the ground from where the vine broke.
  a. How long was Tarzan in the air?
  b. How fast was Tarzan traveling when he hit the ground, (<u>MAGNITUDE and DIRECTION</u>)?

•35. A rock is thrown at a house with a speed of 30 m/s at an angle of 39 degrees with the ground. If the house is 83 meters away, will the rock hit the house?

•36. In a backyard baseball game Billy Bats bats a ball beyond the bases. The ball is hit at a 58-degree angle with the ground with some yet unknown initial speed. The ball travels 235 meters along the ground.
  a) With what speed does the ball hit the ground?
  b) How long is the ball in the air?
  c) How high did the ball travel?

•37. At <u>THE</u> bodacious mud-bog of the year, a car makes a jump at an angle of 22 degrees with the ground. The truck travels up as high as 5.0 meters.
  a) What is the trucks initial speed when it leaves the ramp?
  b) How long was the truck in the air?
  c) How far across the ground did the truck travel?

•38. Young Billy Joe Bobby Brucey shoots a rock out of a sling shot at an angle of 41 degrees with the ground. The rock travels 78 meters before hitting the ground.
  a) What is the rock's initial speed?
  b) How long is the rock in the air?
  c) How high did the rock travel?

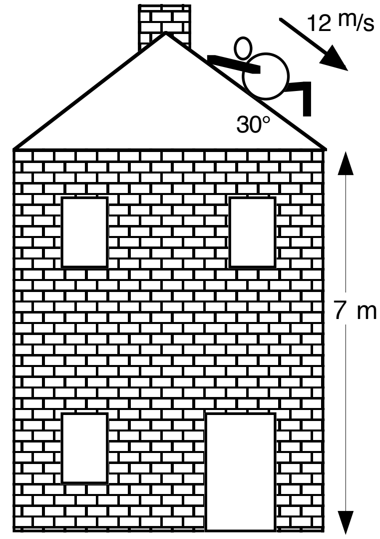
Please do all of your work on a separate piece of paper.

•39. A canon ball is fired from a cannon that it titled at a 33° angle with the ground. The cannon ball travels 568 m down range. It also has a vertical velocity component of 60.12 m/s.

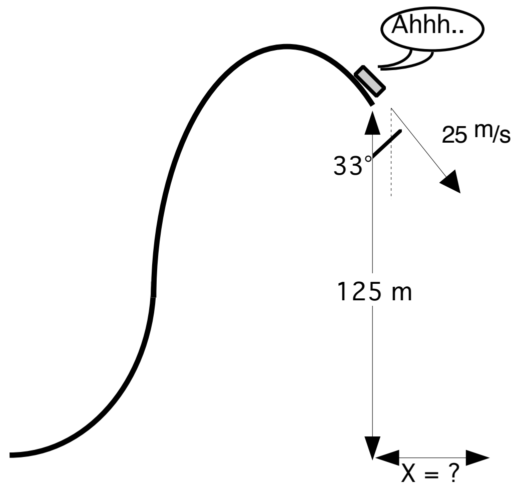
a. How high did the cannon ball travel?
b. What was the cannon ball's initial velocity?
c. How long was it in the air?

8 REVIEW QUESTIONS COVERING THE DIFFERENT SETUPS

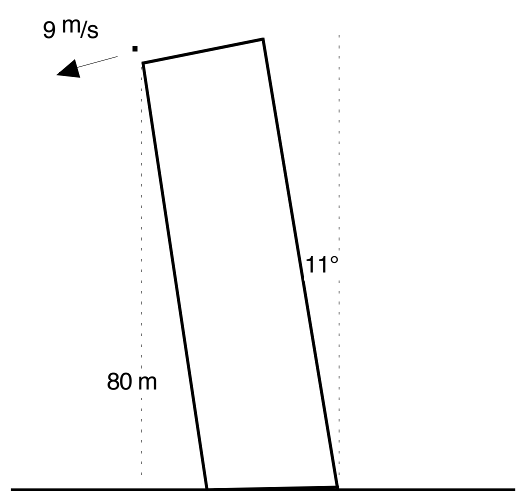
40. While delivering toys Santa Claus slips off the top of a roof. At the edge of the roof he is traveling 12 m/s.
    a. How long is Santa in the air?
    b. How far from the edge of the house will he land?
    c. With what speed and direction will Santa impact the ground?



41. A roller coaster car travels off a hill while traveling downward.
    a. How long is the roller coaster car in the air?
    b. How far from the edge of the broken track will the roller coaster car?
    c. With what speed and direction will roller coaster car impact the ground?

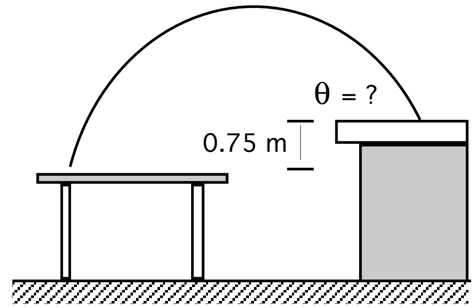


42. A grape rolls off the top of the leaning tower of Pisa at 9 m/s. The tower is 80 m high and tilts at an 11° angle with the <u>vertical</u>.
    a. How long is the grape in the air?
    b. How far from the edge will the grape land?
    c. With what speed and direction will the grape impact the ground?

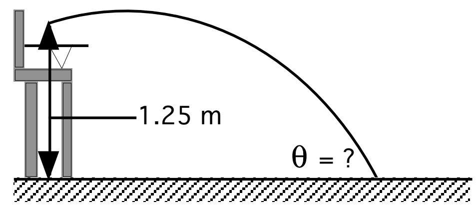


43. A dog is in a field catching a Frisbee. The dog leaves the ground at 7.53 m/s at an angle of 50° with the ground to catch a Frisbee at his apogee.
    a. How long was the dog in the air until it caught the Frisbee?
    b. How far, horizontally, did the dog jump to the location where he caught the Frisbee?
    c. How high did the dog jump?

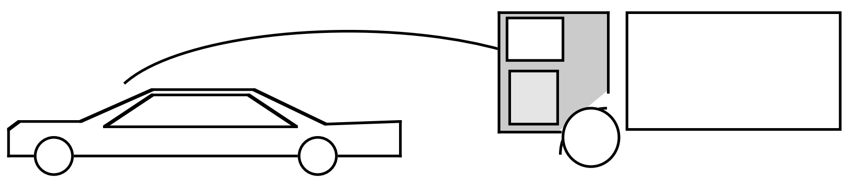
44. Calvin was flicking pennies at Hobbes. One of his pennies flew upwards at 5.0 m/s at a 75° angle with the tabletop. When it landed, it was 0.75 meters higher than it started.
    a. How long was the penny in the air?
    b. How far, horizontally, did the penny travel?
    c. How high did the penny travel?
    d. With what speed and angle will the penny impact the counter top across the room?



45. Little baby Herman threw a green bean upwards with a velocity of 3 m/s at a 30° angle. The bean landed 1.25 meters below where it was thrown.
    a. How long was the bean in the air?
    b. How far, horizontally, did the bean travel?
    c. How high did the bean travel?
    d. With what speed and angle will the bean impact the ground?



46. A bug, 0.06 kg, bounces upwards off a windshield while traveling 55 mph, 26.5 m/s. The bug bounces at a 37° angle with the horizontal. The bug hit the windshield of a truck behind the car at a height of 0.82 m above the bounce.



    a. How long was the bug in the air?
    b. How far, horizontally, did the bug travel?
    c. How high did the bug travel?
    d. With what speed and angle will the bug impact the windshield?

47. While chasing the "Road Runner," Wile E. Coyote makes wrong turn and ends up sliding horizontally off the edge of a high cliff. He leaves the edge of the cliff while traveling 55 m/s. The cliff's edge is 1505 m above a canyon floor.
    a. For how much time was the coyote in the air?
    b. Horizontally, how far did the coyote travel before impacting the canyon floor?
    c. With what speed and angle did the coyote impact the canyon floor?

Objectives

Circular Motion

Students will be able to:

1. Define the period of motion
2. Define the frequency for motion
3. Mathematically relate the period and frequency
4. Convert from RPM's (revolutions per second) to Hertz
5. Use the definitions of period and frequency to solve word problems
6. Discuss the relationship between centrifugal and centripetal forces.
7. Describe why a person slides to the outside of a curve in a car as observed from inside the car.
8. Discuss what supplies the centripetal forces
9. Correctly write the units equations from memory
10. List the S. I. units associates with each quantity
11. Solve word problems utilizing the formulae and concepts in the unit.
12. Calculate the g's felt by a rider in an amusement park when
    a. He/she is spun in a horizontal circle (carousel)
    b. He/she is spun in a vertical circle (roller coaster loops, playground swings.)
13. Describe why an irregular shaped roller coaster loop is better than a circular loop.
14. Solve problems based on an automobiles ability to supply a lateral acceleration and "cornering."
15. Solve problems utilizing formulae and ratios.

CIRCULAR MOTION **Example ratio problems for class notes**

[1] A plane flies in a horizontal circle. If the plane turns with twice the centripetal acceleration and 3 times the speed then how does the new period of motion compare to the old?

[2] A rock is twirled around in a horizontal circle overhead. The centripetal force applied to the string is doubled and the period is halved while the rock's mass remains unchanged. By what factor did the radius change?

Answer all questions in standard SI units.

FREQUENCY AND PERIOD PROBLEMS

1. A turntable rotates an album at 33 revolutions per minute, RPM. What frequency is this?

2. A car's engine spins at 1500 RPM. What is the frequency of the rotating engine?

3. Little Bobby Bolo noticed his bolo swung around his head 3 times every 1.40 seconds. What is the period and frequency is of the rotating bolo?

4. A baton twirler spins her baton 12 times in a second when it is tossed into the air. What is the period and frequency of the rotating baton?

5. Middle "c" on the musical scale has a frequency of 256 Hz. How many times a seconds is the sound wave vibrating?

6. Little Ms. Watchful noticed that some kids rotated on a carousel with a frequency of 0.66 Hz. How many times a second did the carousel rotate?

DISCUSSION PROBLEMS

DIRECTIONS: Pair up with a partner if possible and discuss the following situations in terms of ideas related to centripetal force and circular motion: Identify the direction of the centripetal force and the source of the centripetal force. Write down your conclusions for each problem on a separate sheet of paper.

7. Turns on a racetrack are banked inward.
8. An earth satellite will stay in orbit at some distance from the earth only if it going at the right speed.
9. If a satellite is going faster than the required speed, it will leave its orbit.
10. If a satellite slows down, it will fall to the earth.
11. It is difficult to make a sharp turn if a car is going very fast.
12. A small sports car can negotiate a winding road easier than a large car.
13. A centrifuge is used as a separator in lab.
14. A spin-dry washing machine in operation.
15. A scale attached with a string to a mass shows a greater reading when the mass is swinging than when it is stationary.

16. A small bucket full of water can be swung in a vertical circle without the water spilling out.
17. Astronauts could experience variable g forces in a human centrifuge before manned rocket launches were tried.

18. Riding a bike without a rear fender through a puddle produces a spray of water down the rider's back.

Uniform Circular Motion

General Problems

19. A children's carousel rotates 3 times every 2 seconds. The diameter of the carousel is 3.0 meters.

- What is the period of motion?
- What is the tangential velocity of the carousel?
- What is the centripetal acceleration of the rider at the edge of the carousel?

20. When traveling down the road at a constant speed of 55 mph, 24.6 m/s, the tangential velocity of the wheels is also 55 mph. If a car's tire is 65.0 cm in diameter, then;

- What is the period and frequency of the spinning car tire?
- What is the centripetal acceleration of a rock stuck in the tire's tread?

21. Given that the Earth is 1.49x1011 m from the Sun. And the earth's period of motion is 365.25 days. Calculate how fast it is revolving around the Sun. Put your answer in m/s.

22. Do the same thing for the Moon: Given it is 3.8x108 m from the Earth and revolves around the Earth every 27.31 days. Put your answer in m/s.

23. Given the Earth has a mass of 5.98x1024 kg and the Moon has a mass of 7.34x1022 kg, what centripetal force is necessary to keep each in orbit.

24. A bicycle wheel of radius 0.325 m rotates at a speed of 10.0 m/s (22.4 mph).

a. If a person is riding the bike, how fast are they traveling?

b. What is the frequency and period of rotation of the bicycle's wheel?

25. The time shaft ride at King's Dominion has a radius of 5.0 m and spins with a period of 1.3 seconds (only a guess).

a. What is the tangential velocity of the ride?

b. What is the centripetal acceleration of the ride?

c. How many g's is this?

26. An upright clothes washer spins clothes around 50 times in 20 seconds. Its radius is 0.30 m.

a. What is the period and frequency of the clothes dryer?

b. What is the tangential velocity of the clothes in the washer?

c. What is the centripetal acceleration of the clothes in the washer?

27. A car is traveling at 24.6 m/s (55 mph). The radius of the tire is 0.40 m. a rock is stuck in the tire.

a. What is the tangential velocity of the rock?

b. What is the centripetal acceleration of the rock?

c. What is the frequency and period of motion?

d. If the rock flies off the tire, how fast will it be traveling and how will its path of motion be related to the radius vector?

e. If the rock's mass is 0.0010 kg, what force holds the rock in the tread of the tire?

28. While playing with a HOT WHEELS race set, a child puts together 2 pieces of track on the loop-the-loop. Normally the loop-the-loop is made with only one piece of track. So now the circumference of the track is doubled.

a. How is the radius affected?

b. A car that supplies its own velocity runs along the loop-the-loop. If the same car is used on each size loop-the-loops, then;

- How do the periods compare?
- How do the centripetal accelerations compare?
    - How do the centripetal forces compare?

29. While playing Bolo-Master of the world, the radius the rock is twirled around with is held constant and the velocity is doubled a moment later.

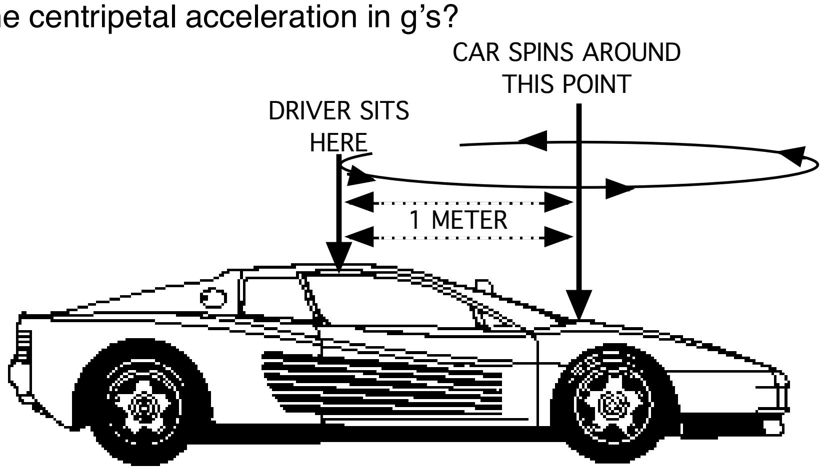
a. How do the centripetal accelerations compare?

b. How do the periods of motion compare?

30. As a car goes around a flat curve, what supplies the centripetal force necessary for the car to go in a curved path?

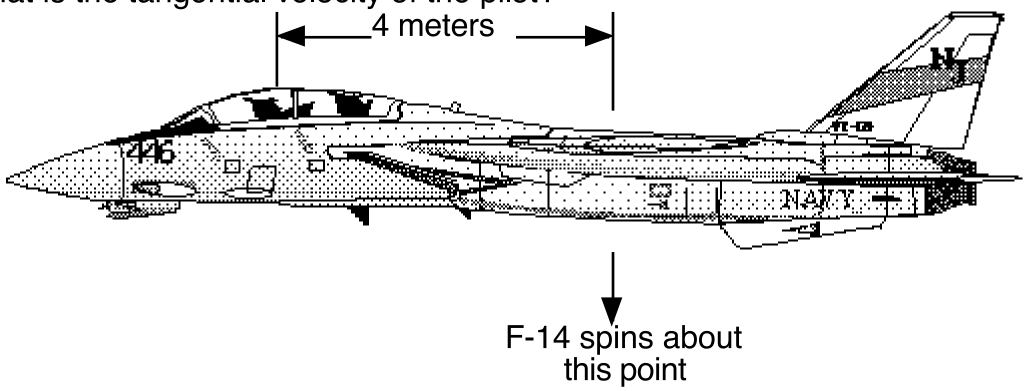
31. A car spins out on an ice-covered road. The car's length is 4 meters. The driver is 1 meter from the car's spin center. The car spins 4 times around in 3 seconds.

• What is the period and frequency of the spinning car?
• What is the period and frequency of the driver in the car?
• What is the tangential velocity of the driver?
• What is the centripetal acceleration of the driver?
• What is the centripetal acceleration in g's?



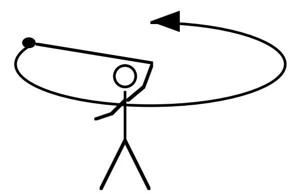
32. In the movie <u>Top Gun</u>, an F-14 fighter jet gets stuck in a flat spin. The jet rotates such that the pilot, 4 meters from the planes spin center, feels a centripetal force of 6 g's. There the pilot's hand weighs 6 times as much as normal.

- What is the centripetal acceleration of the pilot in m/s^2?
- What is the period of motion of the pilot?
- What is the tangential velocity of the pilot?



33. For every problem that describes a person's motion, calculate the centripetal force felt on each rider if their mass is 60 kg.

34. While playing "Bolo Master of the World" little Lisa was spinning a rock around her head on a string 1.32 m long. The rock travels around once every 1.43 seconds.



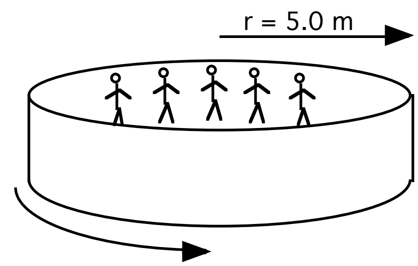
(A) What is the speed of the rock?
(B) What is the centripetal acceleration of the rock?
(C) If the rock has a mass of 0.15 kg then, what is the centripetal force acting on the rock?

35. A racecar is traveling around a race at an average speed of 65.625 m/s (147 mph). The racecar takes 2 minutes and 44 seconds to go around the track once.
(A) What is the centripetal acceleration of the car?
(B) Is the car WEIGHS 7840 N, then what is the centripetal force acting on the car?
(C) What do you think supplies the centripetal force to turn the car?

36. An ice skater spins with her hands stretched out from her body. Her hand is 1.12 meters from the axis she is spinning along. Her hands are spinning at 5.74 m/s.
(A) What is the centripetal acceleration of her hand?
(B) How many g's is your answer in (A)?
(C) If her hand has a mass of 0.2 kg then what is the centripetal force acting on her hand?
(D) How long does it take for her to spin around once?

37.A dog is chasing his tail. The radius of the circle that dog makes is 0.62 meters. The dog runs in a circle 10 times in 7.2 seconds.
a) What is the period of motion of the dog?
b) What is the speed of the dog?
c) What us the centripetal acceleration of the dog?
d) If the dog has a bandanna tied to his neck, mass is 0.024 kg, then what is the centripetal force acting on the bandanna?

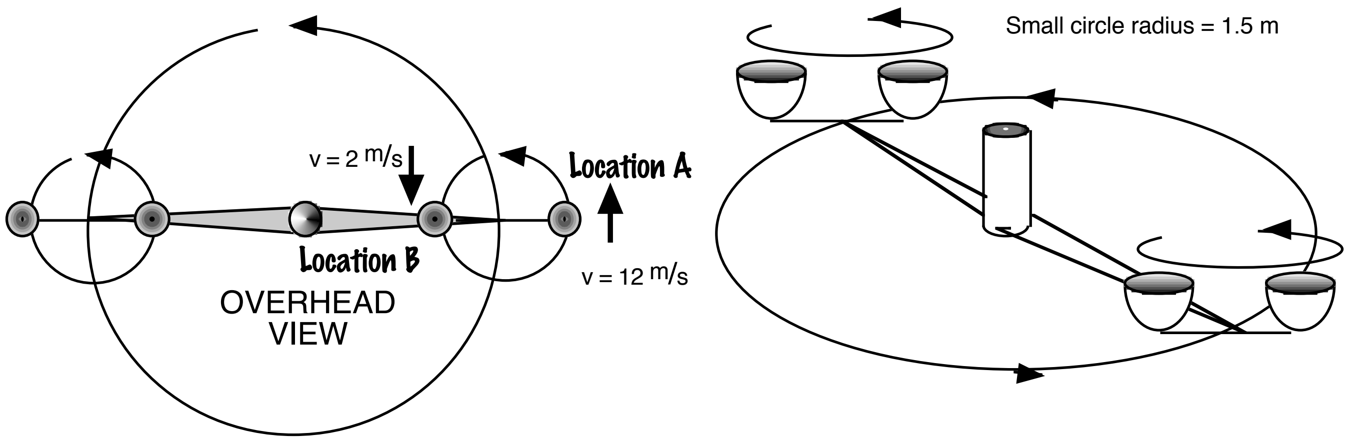
38 A merry-go-round travels with a tangential speed of 3.5 m/s. Its diameter is 34 m across?
a) What is the centripetal acceleration of the merry-go-round?
b) How long does the merry-go-round take to go around once?
c) What is the centripetal force acting on a 45 kg rider 15 meters from the center of merry-go-round?



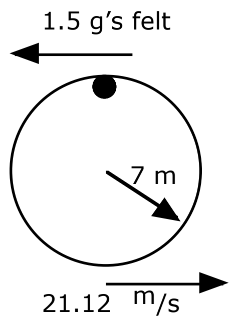
39 In an amusement park, there is a ride called the "Mexican Hat." The ride is basically a big barrel that spins very rapidly. The rides rest standing up against the barrel's wall. While spinning, the floor drops down while inertia holds the passengers in place.

a. A rider feels a force associated with 2 g's of centripetal acceleration when riding this ride. How fast is the ride spinning?
b. How long does it take to complete one cycle of motion?
c. How many times does the ride go around in 1 minute?

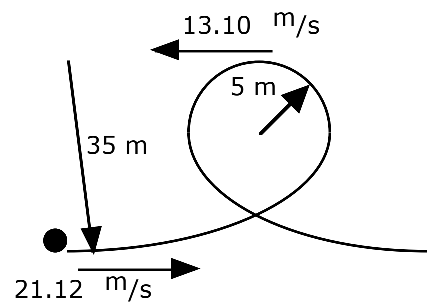
40. In an amusement park, there is a ride called the "Mad Hatter's Teas Party." The ride is basically a pair of teacups that spin very rapidly. The pair itself spin on a larger circle.



a. How many g's of centripetal acceleration does the rider feel at the outer most edge of the circle? (The radius at this point is the large radius plus the small circle's radius.)
b. How many g's of centripetal acceleration does the rider feel at the inner most edge of the circle? (The radius at this point is the large radius minus the small circle's radius.)
c. Use an average velocity between the inner and outer most point to determine the time it takes for the passenger to spin around once in the <u>smaller</u> circle of motion.



Circular Loop



Spiral of Archimedes Loop

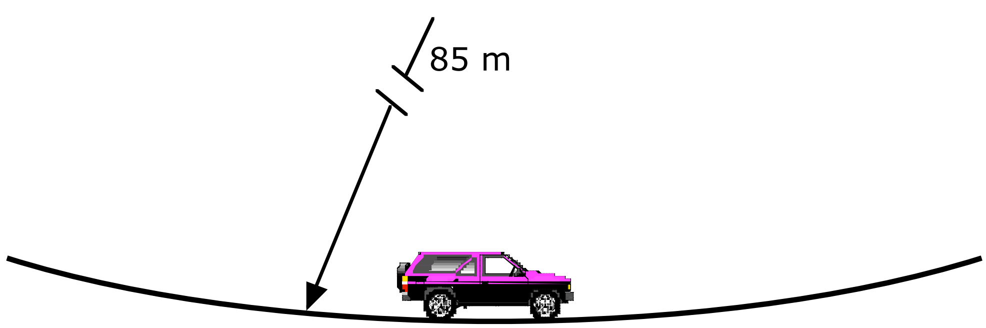
41. For the circular loop, how many g's are felt by the rider at the bottom of the loop as they enter the loop? (7.5 g's)

43. For the circular loop, how fast is the roller coaster car traveling at the top of the loop? (12.10 m/s)

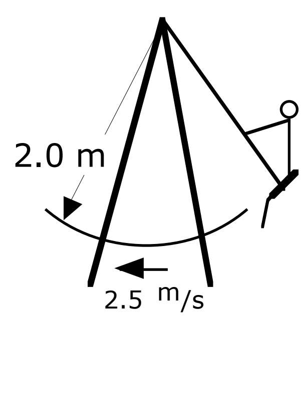
44. For the Spiral of Archimedes loop, how many g's are felt by the rider at the top of the loop as they enter the loop? (2.5 g's)

45. For the Spiral of Archimedes loop, how many g's are felt by the rider at the bottom of the loop as they enter the loop? (2.3 g's)

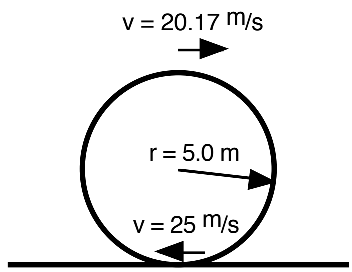
46. How fast is the car traveling if the passenger's feel 1.5 g's at the bottom of the road's dip. (20.41 m/s)



47. How many g's does the child on the swing feel if they are traveling as shown at the right? (1.32 g's)

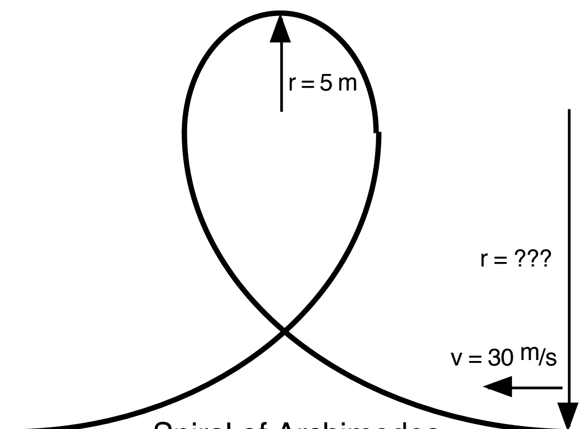


48. A roller coaster travels in a circular loop of radius 5.0 m. At the bottom of the loop the roller coaster car is traveling 25.00 m/s. At the top of the loop the roller coaster car is traveling 20.17 m/s.



a. What is the centripetal acceleration exerted by the track at the top and the bottom of the loop in g's.
b. How many g's are **felt** by the rider at the top and the bottom of the loop?

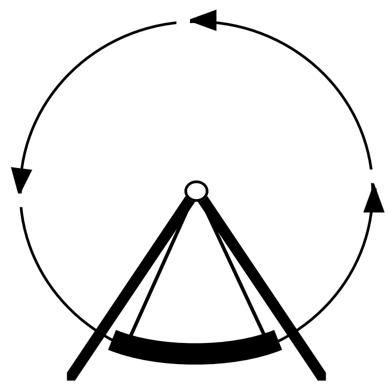
49. A roller coaster travels in a loop whose shape is irregular. The shape is called the spiral of Archimedes or Clothoid. The spiral of Archimedes is a circular shape whose radius changes as its height increases. This spiral has a radius of 5 m at the top.



Spiral of Archimedes

a. What is the centripetal acceleration exerted on the rider by the track at the top of the loop if the rider is traveling 20 m/s at the top in m/s2.
b. How many g's are FELT by the rider at the top of the loop?
c. If the track is to be designed so that the same number of g's are to be FELT by the rider at the bottom of the track, what must the radius be?
d. If the rider's mass is 70 kg, what centripetal force is exerted on the rider at the bottom?

49. THE BERSERKER



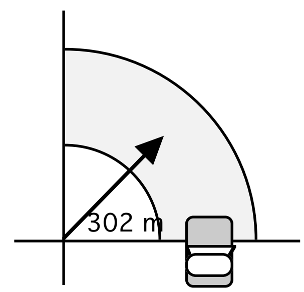
The Berserker is a ride where the passengers are fastened into a "boat." The boat swings back and forth like a swing. Finally, it swings with so much speed that it makes a complete revolution. This ride is not a true example of the type of circular motion that we are studying because its tangential velocity decreases and increases as the ride swings up and down. However, we can still analyze parts of its motion if we ignore the period of motion and remember that it does travel in a circle. (Assume a "Dr. Seuss" world of physics)

The diameter of the Berserker is 25.1 m. When the Berserker reaches the bottom of the ride it is traveling with a speed of 22.2 m/s.

(a) What is the centripetal acceleration of the ride?

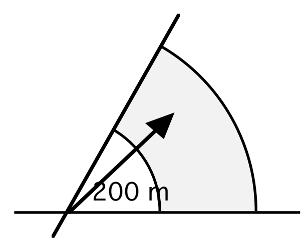
(b) How many g's is this ride?

VEHICULAR APPLICATIONS



50. A 1000 kg car travels around a turn whose radius is 302 m at 20 m/s.

a. What is the centripetal acceleration of the car?
b. What is the centripetal force applied to the car?
c. How much time does it take for the car to travel around the curve if the curve is 90°?

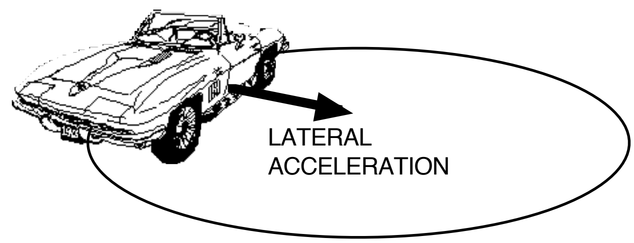


51. A 500 kg car travels around a curve with a centripetal force of 2500 N. The curve's radius is 200 m.

a. What is the velocity of the car?
b. What is the centripetal acceleration of the car?
c. How much time does it take to complete the curve if the curve travels around 60°?

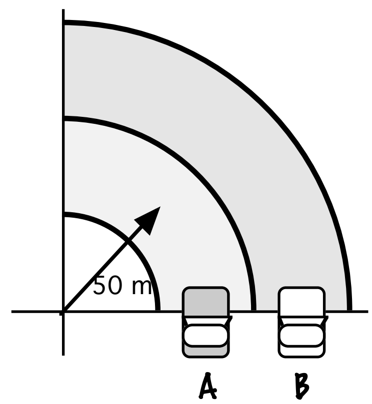
52. A 1500 kg car can travel around in a circle of radius 30 m at a maximum speed of 12.124 m/s.

a. What is the car's centripetal acceleration in m/s2? (This is the maximum centripetal acceleration.)
b. What is the car's lateral acceleration in m/s2?
c. What is the car's centripetal acceleration in g's?
d. The maximum centripetal acceleration for a car will remain the same for the car no matter what size circle it travels in. What is the maximum velocity this car could travel around a curve of radius 300 m?
e. What is the quickest time this car could travel around a curve with a radius of 200 m and 45°?



53. Two cars are traveling around a two-lane curve as shown. The cars stay side by side around the turn. Therefore, the take the same amount of time to finish the 90° curve. The radius of curve "A" is 50 m. Curve "B" is 3.5 m longer. Car "A" is traveling at a constant velocity of 10 m/s. Car "A" has a mass of 1200 kg.

a. How much time does it take for car "A" to finish the curve?
b. How fast must car "B" travel to keep up with car "A?"
c. What centripetal force must car "A" exert to make it around the curve without slipping?
d. If car "B" is to exert the same centripetal force as car "A," then what must car "B's" mass be to make it around the curve in the same amount of time as car "A?"



CAR'S AND CORNERING PROBLEMS

Use your car's acceleration chart to solve the following.

55. What is the maximum velocity that a Lamborghini Diablo can go around a curve if it the curve has a radius of 50 m?

56. What is the maximum velocity that a Range Rover can go around a curve if it the curve has a radius of 50 m?

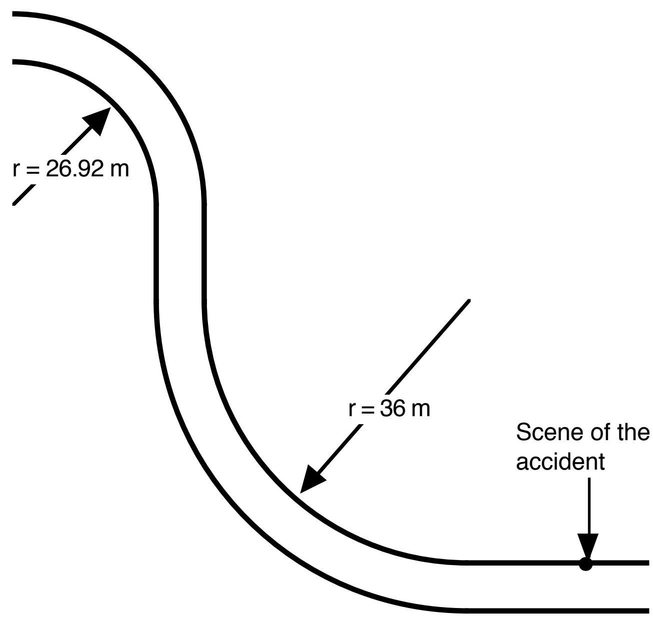
57. a. How much centripetal acceleration is needed so a car can go around a curve at 21 $^{m}/_{s}$ if the curve's radius is 50 m? (Answer in g's and $^{m}/_{s^2}$)
b. Which cars can navigate the curve without slipping?

58. What is the smallest radius curve that a "Nissan 300ZX" can travel around at 25 m/s.

59. How fast could a "Geo Metro LSI" take the same curve as the Nissan in #58?

60. Professor Layton was looking at an accident when he noticed something. He saw that the car traveled around a curve of radius 30 m at 15.43 m/s, 34.6 mph, before the car began to slip to the outside. Professor Layton sends this information to you in the crime lab. It is up to you to send him a list of possible cars that the perpetrator may have been driving. Using physics, which possible cars could the suspect have been driving?

61. In a court trial a suspect is accused of fleeing the scene of an accident. The suspect's car is a dark green "Toyota 4Runner 4WD". A witness testified that they saw a dark green vehicle traveling about 30 mph around the nearby corners. Could he have been at the scene of the crime?



62. A 1000 kg car can travel around in a circle with a centripetal acceleration of 0.7 g's without slipping. When the car loses traction on a road, it exerts a centripetal acceleration of 0.3 g's.

a. What is the car's centripetal acceleration in m/s2 when it is not slipping?
b. What is the car's centripetal acceleration in m/s2 when it is slipping?
c. How big of a turn could the car turn at a constant velocity of 20 m/s without slipping?
d. How big of a turn could the car turn at a constant velocity of 20 m/s when it begins to slip on a road?
e. Here is the scenario. A car is going around a turn without slipping. Suddenly the tires begin to slip thereby reducing the centripetal acceleration. Assuming the curve has a radius equal to that in problem "c," what velocity does the car need to travel at in order to safely navigate the same curve.
f. In each problem (c,d,) how much time does it take to complete a turn of 180°?

RATIO'S

Note: The mass does not change.

Describe the how the first variable is affected assuming the changes mentioned in the other variables.

63. a_C: The velocity is constant while the radius is tripled
64. T: The velocity is constant while the radius is tripled
65. v_t: The acceleration is constant, the radius is halved
66. T: The acceleration is constant, the radius is halved
67. F_C: The velocity doubles and the period remains constant
68. v_t: The radius is doubled and the period is tripled
69. R: The force is changed by a factor of 5/8 and the period is changed by a factor of 3/2
70. T: The force changes by 3/7 and the velocity changes by 3.
71. R: The force changes by 3/7 and the velocity changes by 3.
72. F_C: The radius is tripled and the period changes a factor of 2/3
73. a_C: The velocity changes by a factor of 7/8 and the radius changes by 6
74. T: The radius is quadrupled and the force is tripled
75. v_t: The radius is quadrupled and the force is tripled
76. r: The acceleration changes by 1/4 and the period changes by 5/6
77. r: a_C triples, v remains constant
78. T: v changes by a factor of 3/8, R changes by a factor of 5/2
79. F_c: The radius triples, the velocity remains constant
80. v: a_C remains constant, the time to go around once triples
81. a_C: the velocity changes by a factor of 4/6, the radius is halved
82. T: the velocity changes by a factor of 2/3, the centripetal acceleration changes by a factor of 5/4
83. r: Centripetal force doubles, velocity triples
84. v: Centripetal acceleration changes by a factor of 1/3, period changes by a factor of 4/3

Objectives

Kepler and Newton's Law of Universal Gravity

Students will be able to:

- Define what an "Inverse Square" Law is.
- Use the generic inverse square law to solve word problems
- Define the formula for Newton's Law of Universal Gravity.
- Calculate the gravitational pull between 2 objects with mass.
- Define the relationship between "g," 9.80 $^{m}/s^{2}$, and The Law of Universal Gravity.
- Identify the relationship between centripetal force and gravity for orbiting satellites.
- Use the Law of Universal Gravity and Circular motion concepts to solve orbital mechanics problems.
- Define Kepler's 3 Law of Planetary motion by number.
- When given the location of one object being orbited by a satellite in an eccentric elliptical orbit, identify the location of the other orbited body.

Circular Motion and Planetary Mechanics
(Kepler and Newton's Law of Universal Gravity)

Givens: (Do not memorize.)

$G = 6.673 \times 10^{-11} (N \cdot m^2)/kg^2$

Earth's Radius: 6.37×10^6 m | Earth's Mass: 5.98×10^{24} kg | Orbit: 1.50×10^{11} m

Moon's Radius: 1.74×10^6 m | Moon's Mass: 7.35×10^{22} kg | Orbit: 3.85×10^8 m

Sun's Radius: 6.96×10^8 m | Mass: 1.99×10^{30} kg

---

1 What is the force of attraction between a 60.0 kg student in the senior parking lot and the school? The distance between the two is 100.000 m and the mass of the school 65,000,000 kg.

2 You're on a date with "the significant other." You are getting close. Your centers of masses are 0.50 meters apart. If you have a mass's of 50.00 kg and 70.00 kg then what is the actual scientific force of attraction between the two of you?

3 Two asteroids, ($m_1 = 1.00 \text{ X } 10^{12}$ kg and $m_2 = 5 \text{ X } 10^{12}$ kg), are floating in space. The force of attraction between them is 10.000 N. How far apart are their centers of mass?

4 In a car race, the force of attraction between the 1st and 2nd place cars is $3.0349 \text{ X } 10^{-7}$N. If the 1st place car has a mass of 700 kg and the 2nd place car has a mass of 650 kg, then what is the distance between the two cars?

5 While on the surface of the Earth a student has a weight of 450 N. If she is moved twice as far from the center of the Earth, then how does hew new weight compare to her old?

6 How many Earth Radii distances could fit between the center of the Earth and the Center of the moon when it is in orbit around the Earth? If the same 50 kg student in problem #5 is moved out from the surface of the Earth to this distance away from the center of the Earth, then how does her new weight compare to her old?

7 An alien spacecraft is out in space leaving an unknown planet. It detects the pull of gravity due to this unknown planet to be 100 N. Later the alien rechecks the pull on their spacecraft when it is 9 times farther away from the surface. By what factor has their force of attraction changed since they left the unknown planet?

8 The space shuttle travels at 17,000 mph, 7,589.288 m/s while in orbit. How far away from the SURFACE OF THE EARTH is the shuttle?

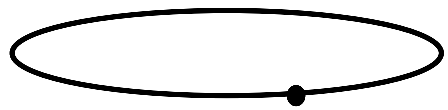
9 How fast is the moon traveling as it orbits the Earth?

10 A geosynchronous orbit is one where a satellite orbits the Earth with the SAME period of motion as the Earth on it own axis. How far from the center of the Earth is the Satellites orbit?

11 Using Kepler's 3rd Law of Planetary motion, determine the distance between the center of the Earth and the center of the Moon.

12 Using Kepler's 3rd Law of Planetary motion, determine the distance between the center of the Earth and the center of the Sun.

13 A planet is in orbit as shown below. Where are the two possible locations for a Sun?



14 The moon Io revolves around Jupiter in 0.0048 sidereal years. Io has a mean orbital radius of 0.0028 Au's. If another Jupiter moon, Europa, has a period of rotation of 0.0097 sidereal years, then how far away is Europa from the center of Jupiter?

15 The planet Mercury takes 0.24 sidereal years to go around the sun. What is the distance from the center of Mercury to the center of the sun?

16 The moon takes 27.32 days to revolve around the Earth once. The moon is 242,000 mi from the center of the Earth. The International Space Station orbits in the same orbit as the space shuttle. The International Space Station makes an orbit around the Earth in 90 minutes, then how high up is the International Space Station from the center of the Earth and the surface of the Earth? (The radius of the Earth is 3950 miles.) Why is this answer different from question #8?

17 The Planet Jupiter's mean orbital radius is 5.2025 Au's. What is the period of Jupiter in sidereal years?

18 The planet Pluto is 39.5 Au's from the Sun. How long does is taking to go around the Sun once?

19 There is belt of asteroids between Mars and Jupiter. This belt circles the "inside" of our solar system and is called the Asteroid belt. This belt has a mean radius from the Sun of 2.6 Au's. How long does it take for 1 asteroid to in the belt to travel around the Sun once?

ORBITAL VELOCITY

20 A satellite is placed in an orbit 16,090,000 meters above the Earth's Surface. How fast is the satellite traveling to remain in orbit?

21 A space ship is to orbit a planet with a mass of 8 X 10^{20} kg. How far, from the plant's center, must the ship travel if it is to travel with a velocity 10,000 m/s?

22 A spacecraft is to orbit an asteroid of mass 5.00 X 1015 kg at a distance of 55,555 m from the asteroid's center. What is the spacecraft's period of motion and orbital velocity?

23 The Hubble Telescope orbits the Earth 596,000 m ABOVE THE SURFACE of the earth. What is the Telescope's Period and tangential velocity?

24 A spaceship is traveling to a planet called Orpheus. The astronauts aboard the ship have a weight of 250 N at one point in their flight. Later they are 5 times closer than when they made the first weight measurement. What will be the new weight at this closer distance?

25 On the Surface of the Earth a test pilot has a weight of 965 N. In an effort to earn her astronaut wings, our pilot travels the necessary distance of 1 000 000 ft above the Earth's surface to be recognized for astronaut wings.

a. What is the ratio of the two radii?

b. What was her weight at this altitude?

26 Calculate the value of "g" using the Earth's radius and its mass.

27 The Hubble Telescope orbits the Earth 598 km above the surface. How fast is it traveling to stay in its stable orbit?

28 At one time an infamous computer company had an idea to put its own satellite in a low orbit about 25 km above the Earth's Surface. How fast would these satellites travel?

A communications satellite stays in the same spot in the sky above the Earth's surface. It also takes 24 hours to complete a single orbit -just like the Earth's rotation. This orbit is unique and called a "geosynchronous orbit." How high above the Earth's surface is the satellite orbiting?

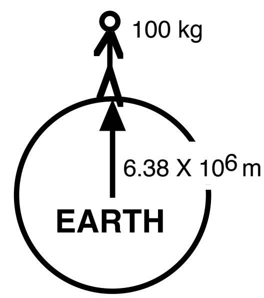
Answers

1. 2.6023 X 10-5N	7. 1/81 times the 100N	15. 5.76 X 1010m
2. 9.3416 X 10-7 N	8. 54,7771.53 m (340 mi)	16. 437.65 miles
3. 5,774,945.887 m	9. 1018.05 m/s	17. 11.87 Au's
4. 10.0 m	10. 42255942.3 m	18. 248 sidereal years
5. 1/4 the weight, therefore 112.5 N		11., 12., 13., 19. 4.192 sidereal years
6. 60; New =$(1/60^2)$OLD	14. 0.00447 Au's	20. 4979.89 m/s
21 5, 338,072		

Circular Motion and Planetary Mechanics Note Sheet

Calculating the mass of the Earth.

[A] We call the force of attraction between us and the Earth, "weight." When you step on a scale, you are measuring the force of attraction between the Earth and you. The radius of the Earth is very well known. (It was first measured accurately by the Greeks using shadows at the vernal equinox.) Using these concepts and Universal Gravity, calculate the mass of the Earth.



[B] The space shuttle orbits the Earth about 417,000 m, 250 miles, above it's surface. This is about 6,797,000 from the center of the Earth. How much time, in minutes, does it take to travel around the Earth?

[C] Using the information in [B] calculate the speed of the shuttle in m/s and miles per hour

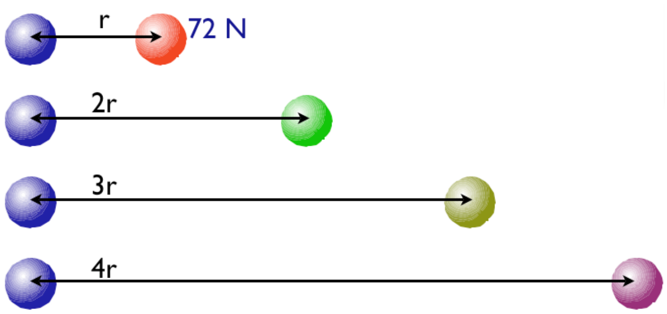
Circular Motion and Planetary Mechanics Class Examples

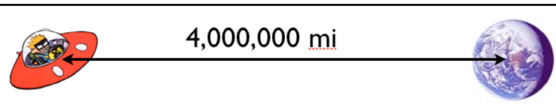
Givens: (Do not memorize.)

$G = 6.673 \times 10^{-11} (N \cdot m^2)/kg^2$

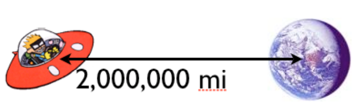
Earth's Radius: 6.37×10^6 m	Earth's Mass: 5.98×10^{24} kg	Orbit: 1.50×10^{11} m
Moon's Radius: 1.74×10^6 m	Moon's Mass: 7.35×10^{22} kg	Orbit: 3.85×10^8 m
Sun's Radius: 6.96×10^8 m	Mass: 1.99×10^{30} kg	

How much force is felt in each situation?





At 4, 000,000 mi a spaceship feels and attractive force of 100 N. How much gravitational force will the spaceship feel at 2,000,000 mi?

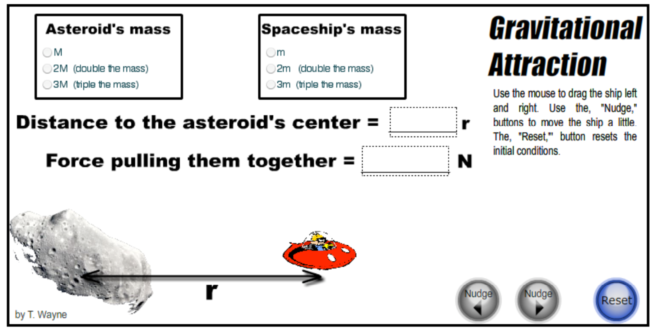


You will need to do this problem on another piece of paper.

1. The Asteroid tractor. Suppose the proposed "Asteroid Tractor's" 1000 kg end hovers 150 meters from a 50,000 kg asteroid. What force will the tractor pull with?
2. What is the pull of gravity on a person on the surface of the Earth if the person's mass is 55.5 kg?
3. What is the period of motion for Earth's moon?
4. What is the velocity of the Earth as it travels around the Sun?
5. How high above the Earth's surface is a geosynchronous orbit?

Universal Gravity Presentation Example Problems

Go to http://www.mrwaynesclass.com/gravity



A page with a simulation looking the one below should open up.

The spaceship can be dragged left and right with the mouse. The, "Nudge," buttons can be used to easily move the spaceship small distances.

Your task is to work with a partner to figure out what affects the pull of gravity. You are to create an experiment to PREDICT how the pull of gravity will be affected by multiplying the distance by some number, "X," and how the pull of gravity will be affected by changing the mass by multiplying it by a number, "N." From these rules that you create you should be able to correctly answer the following questions.

DATA	
R -factor	F-factor
2	
1	
1/2	
1/3	
1/4	
1/5	

The factor "r" changes by is given. However, the factor the force changes by will need to be calculated. Let's say the original force is 200 N and the new force is 800 N. What number must 200 N be multiplied by to equal 800 N? This number is the factor the force changes by. In this case, 200 x 4 = 800. Therefore the force factor of change is "4."

---

1. If the initial force at some distance, r, is 1.00 x 10^2 N, then what is the force of attraction at a distance of exactly <u>3r</u> ? ______________________________
2. If the initial force at some distance, r, is 1.00 x 10^2 N, then what is the force of attraction at a distance of exactly <u>4r</u> ? ______________________________
3. If the initial force at some distance, r, is 1.00 x 10^2 N, then what is the force of attraction at a distance of exactly $^1/_{10}$ r ? ______________________________
4. How does the force of attraction change as the space ship is moved closer to asteroid, "Ida?"
5. If the initial force at some distance, r, is 1.00 x 10^2 N, then what is the force of attraction when the mass of asteroid, "Ida," is halved? __________________________
6. If the initial force at some distance, r, is 1.00 x 10^2 N, then what is the force of attraction when the mass of asteroid, "Ida," is tripled and the mass of the spaceship is doubled?

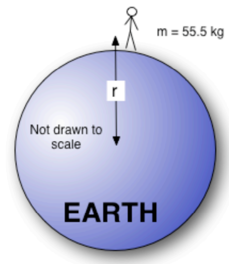
____

Universal Gravity Presentation Example Problems

7. If the initial force at some distance, r, is 1.00 x 10^2 N, then what is the force of attraction if the mass of asteroid, “Ida,” changes by a factor of 6, the spaceship’s mass is tripled and the spaceship is moved away from asteroid, “Ida,” to a distance of the spaceship is increased to 3r? ____________________
8. By what factor has the spaceship’s distance, “r,” changed by if the masses are unchanged from the initial condition and the force of attraction has changed from 3,60 x 10^2 N to 4.00 x 10^2 N ____________________

EXAMPLE 1

What is the pull of gravity on a person on the surface of the Earth if the person's mass is 55.5 kg?



EXAMPLE 2

What is the period of motion for Earth's moon?

EXAMPLE 3

What is the velocity of the Earth as it travels around the Sun?

EXAMPLE 4

How high above the Earth's surface is a geosynchronous orbit?

Mechanical Energy Objectives

Objectives

Mechanical Energy

Students will be able to:

1. For all equations, write what each variable stands for and its S.I. unit.
2. Identify the correct S.I. units for ALL forms of Energy.
3. Recall the name of the person who the energy unit is named after.
4. Write the equation for kinetic energy.
5. Define kinetic energy.
6. Identify when an object possesses kinetic energy.
7. Calculate the kinetic energy of an object.
8. Write the equation for potential energy due to gravity.
9. Define potential energy.
10. Identify when an object possesses potential energy.
11. Calculate the potential energy of an object.
12. Solve problems based on conservation of mechanical energy. -Neglect friction and normal forces.
13. Correctly identify the S.I. unit of “work.”
14. Define what “work” is.
15. Write the equation for “work.”
16. Calculate “work” when the force and displacement are parallel.
17. Calculate “work” when the force and displacement are not parallel.
18. Identify “work” as being positive or negative.
19. Identify “work” as being done “on” or “by” the system.
20. Calculate the work on a graph of force vs. displacement.
21. Solve problems using energy – work relationships and ratios.
22. Solve problems involving up to all two types of energies and work.
23. Recall the person who the unit of power is named after.
24. Write the two equations for power.
25. Define power 2 ways –in terms of work and in terms of force.
26. Calculate the power delivered or received by an object

Kinetic Energy Basics

1. What is the kinetic energy of an 80 kg football player running at 8 m/s?

2. What is the kinetic energy of a 0.01 kg dart that is thrown at 20 m/s?

3. What is the kinetic energy of the space shuttle (mass = 68,000 kg) when it is orbiting the Earth at 13,000 m/s?

4. What is the kinetic energy of a bolt (0.002 kg) -lost off the space shuttle in a previous flight- floating in space at 13,000 m/s?

5. If the bolt lost off the space shuttle above hit an astronaut at 13,000 m/s, it would feel like a 105 kg running at what velocity? (Hint: Use energy to solve.)

6. What is the kinetic energy of a 20,000 kg locomotive traveling at 2 m/s?

7. How fast must a 0.0050 kg bullet travel if it is to have the same kinetic energy as a 20,000 kg locomotive traveling at 2 m/s?

8. How does the kinetic energy change if a car's mass changes by a factor of 1/4?

9. How does the kinetic energy change if a car's mass changes by a factor of 1/3 and changes its speed by a factor of 4/3?

10. The kinetic energy of a bicyclist changes by a factor of 2 while his velocity changes by a factor of 2. What factor did the rider's mass change by?

11. By what factor did the velocity change by if the kinetic energy changed by a factor of 7/5 and the mass changed by a factor of 7/8?

12. How must the velocity change if the kinetic energy is to be quadrupled, and the mass changed by a factor of 4/6?

13. How must the velocity change if the kinetic energy is to be tripled, and the mass changed by a factor of 2/5?

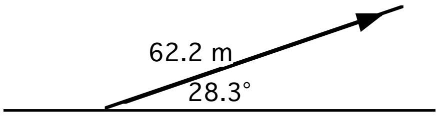
Gravitational Potential Energy Basics

14. A 7.3 kg gallon paint can is lifted 1.78 meters vertically to a shelf. What is the change in potential energy of the paint can?

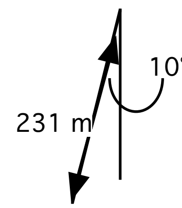
15. A roller coaster car of mass 465 kg rolls up a hill with a vertical height of 75 m from the ground. What is the change in potential energy relative to the ground?

16. A 783 kg elevator rises straight up 164 meters. What is the change in potential energy of the elevator relative to the ground?

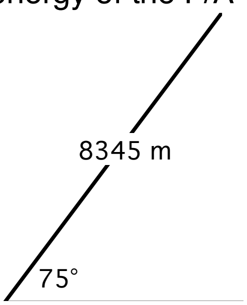
17. A car coasts 62.2 meters along a hill that makes a 28.3° angle with the ground. If the car's mass is 1234 kg, then what is the change in potential energy?



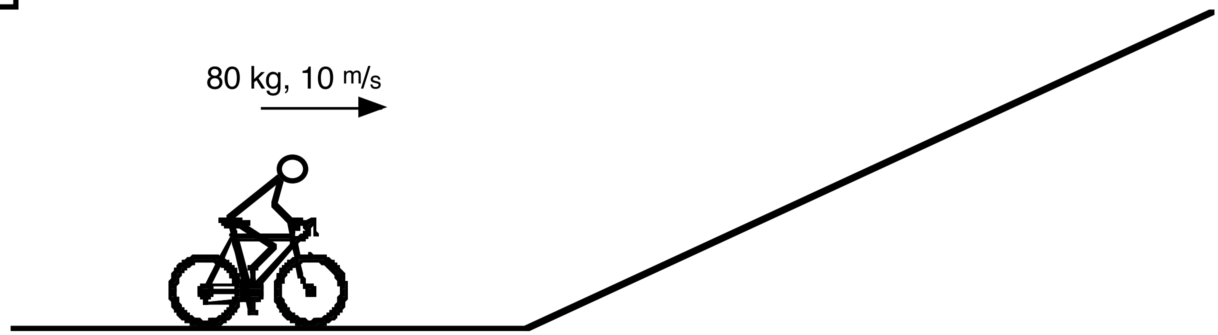
18. A mountain climber scales a cliff that makes a 10.0 degree angle with the vertical. The climber climbs 231 meters up along the cliff. What is the change in potential energy relative to the ground of the 823.2 Newton mountain climber?



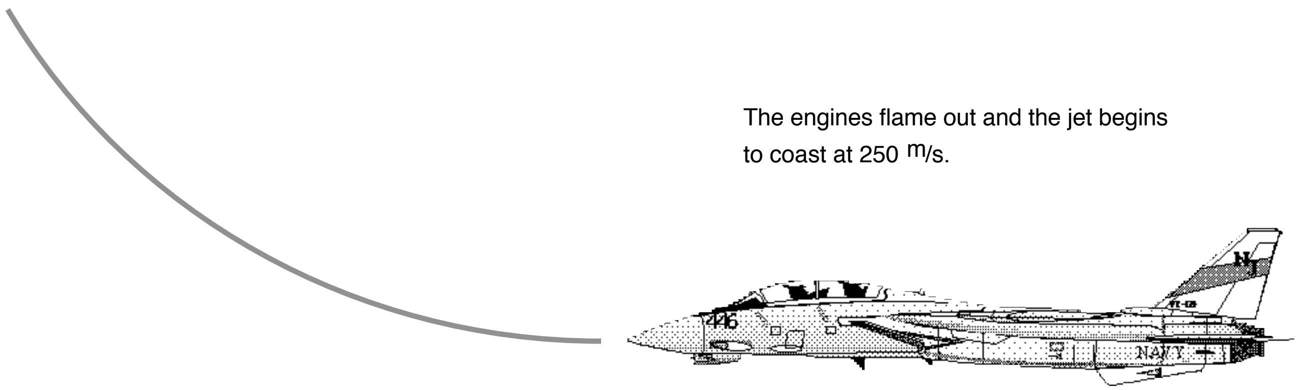
19. An 18,000 kg jet, the F/A-18 "Hornet," climbs up at 75° angle with the ground. The F/A-18 travels a distance of 8345 m. What is the change in potential energy of the F/A-18?



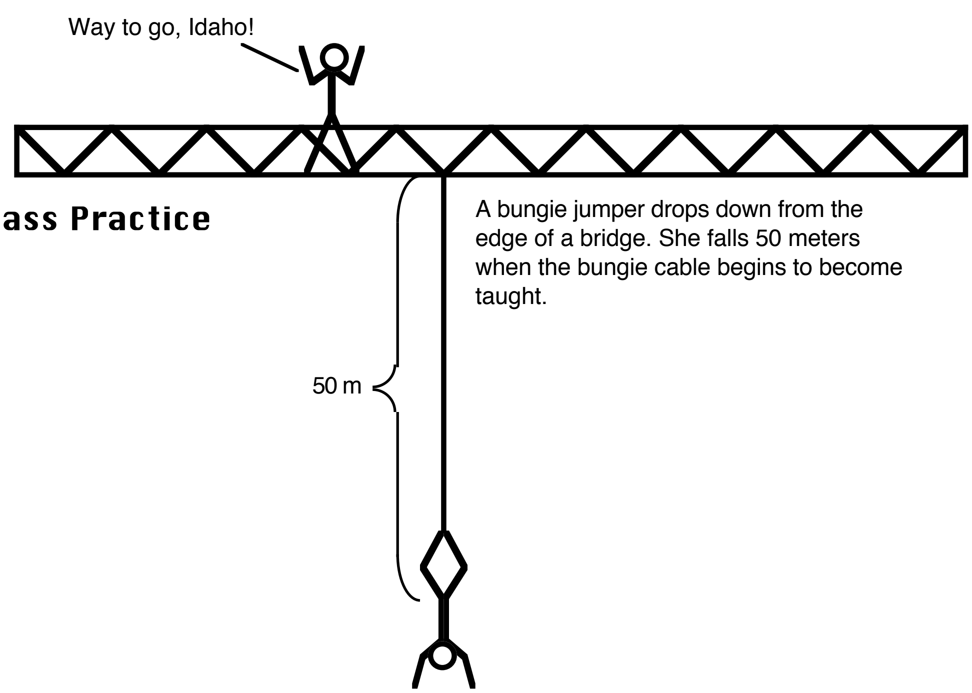
20 Class Practice



21 Class Practice



22 Class Practice

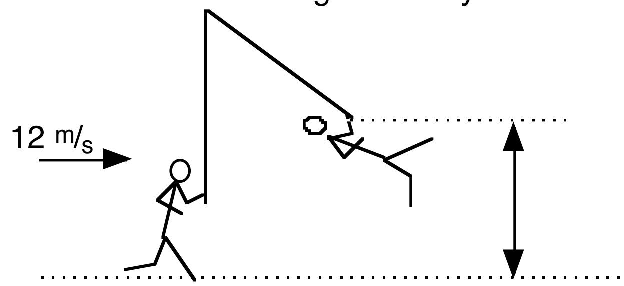


Conservation of Potential and Kinetic Energy

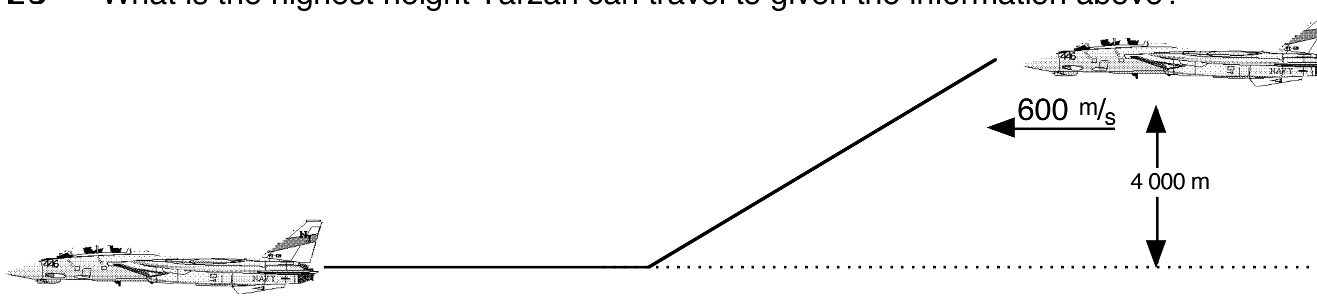
23 How fast is the bicyclist traveling at the bottom of the hill?

24 **a.** How fast is the bicyclist traveling when she jumps off the ramp at 4 m?

24 **b.** What is the maximum vertical height the bicyclist will reach?

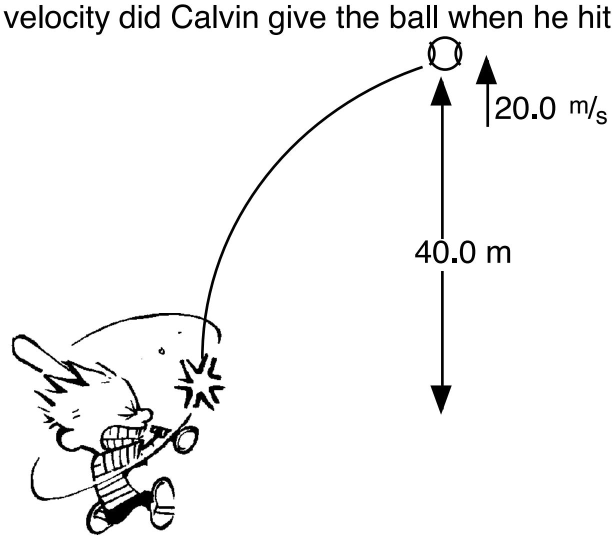


25 What is the highest height Tarzan can travel to given the information above?

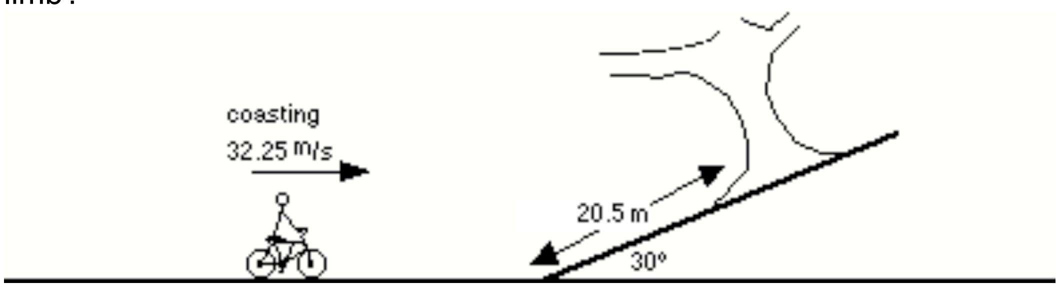


26 What is the jet's new velocity if it coasts to its new, lower, altitude?

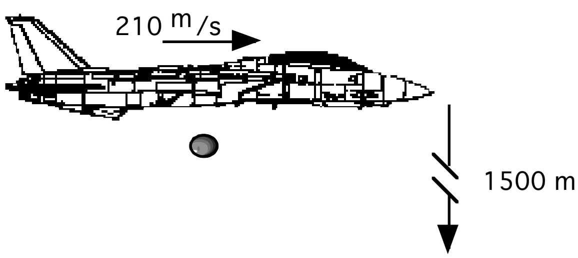
27 How much velocity did Calvin give the ball when he hit it?



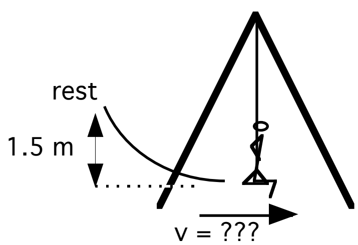
28 A bicyclist is coasting on level ground at 32.25 m/s. The bicyclist coast up an incline and grabs an overhanging tree limb. How fast is the bicyclist traveling when he grabs the limb?



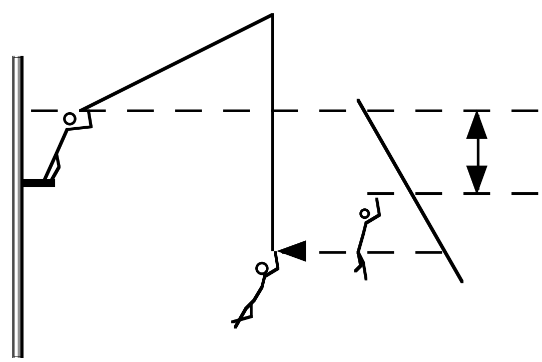
29. What is the velocity of the dropped package after falling 1500 m?



30. What is the velocity of the rider at the bottom of the swing?



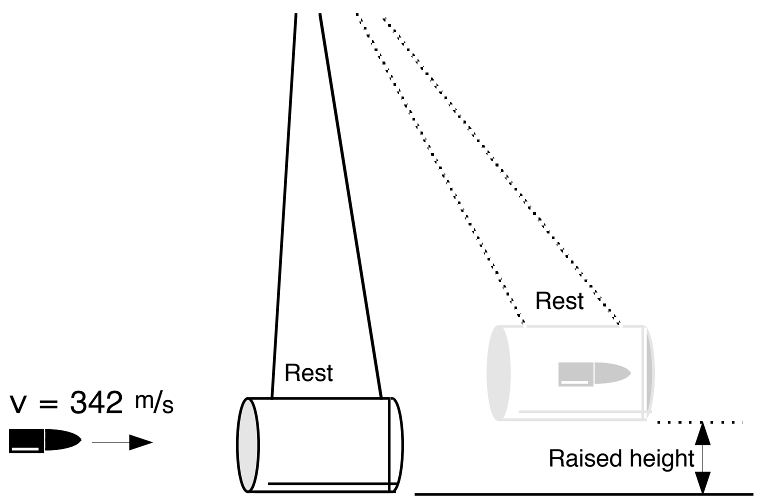
31 A flying trapeze artist starts her swing from rest.
  a. How fast is she traveling at the lowest point?
  b. How fast is she traveling 3.33 meters below the starting height?
  c. If she drops from the lowest point of her swinging motion to a net 22.55 m below this lowest point, how far down will she have traveled, from the lowest point, before reaching a velocity of 15.22 m/s?
  d. How fast will she be traveling when she hits the net below?
  e. In a different acrobatic stunt, the trapeze artist is traveling 2.987 m/s when she is 1.322 m above her starting height. What was her initial velocity?



Conservation of Kinetic and Potential Energy

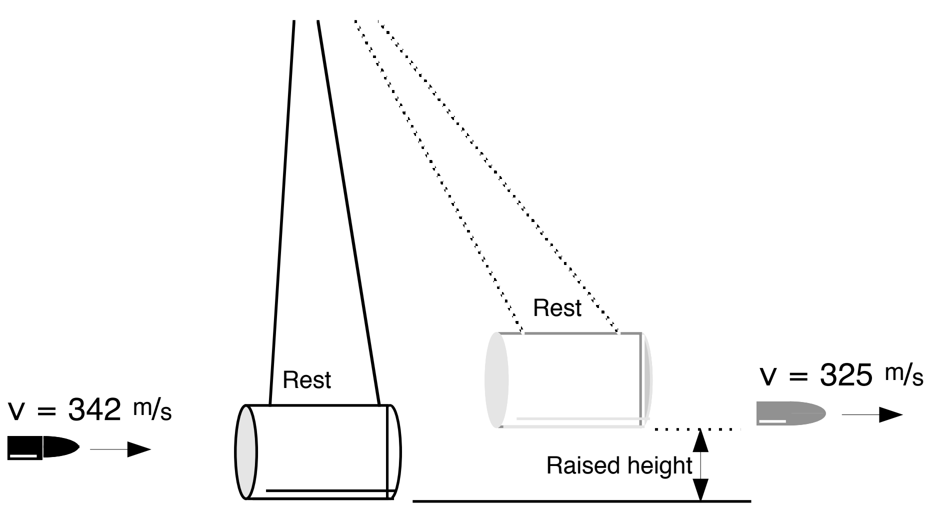
A bullet is shot into a can filled with 19.880 kg of clay. The filled can is tied to the end of a string so that it can act like a pendulum. The bullet (mass = 0.012 kg) is traveling 342 m/s before it impacts the clay filled can.

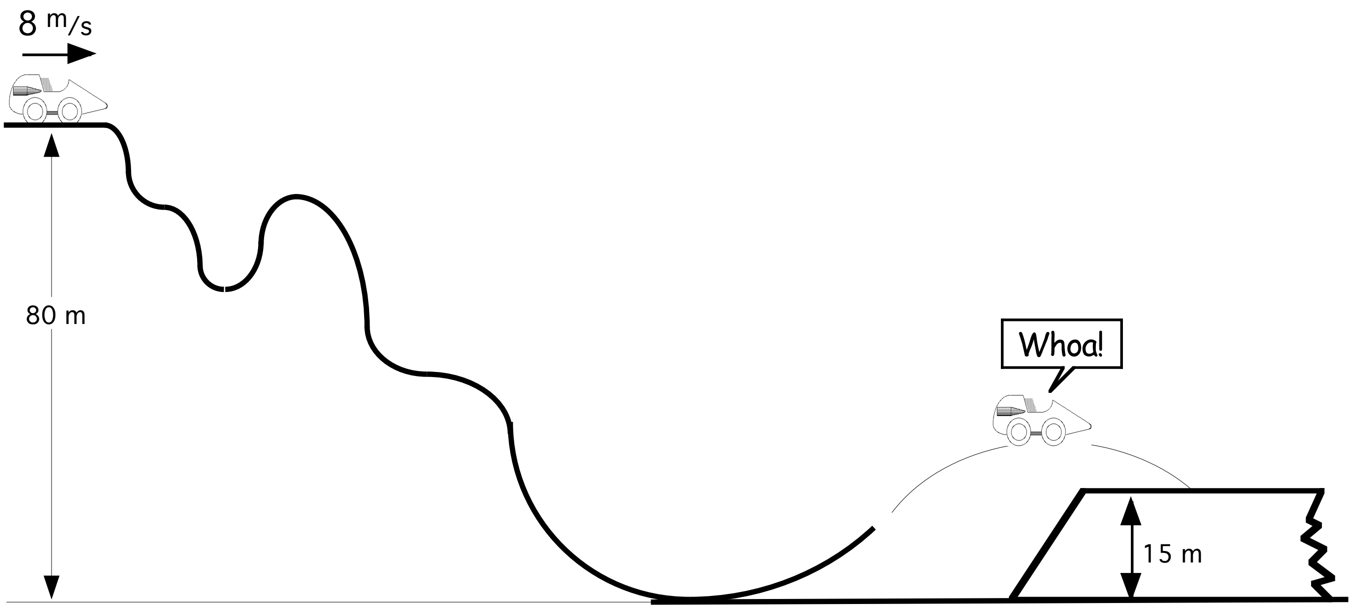
32. What is the mass of the can-bullet combination after the bullet strikes the can?
33. What is the kinetic energy of the bullet before it strikes the can?
34. What is the kinetic energy of the can-bullet when the can is raised to its maximum height?
35. What is the potential energy due to gravity when the can is at its maximum height?
36. What is the maximum height of the can?



A bullet is shot into a can filled with 19.88 kg of clay. The filled can is tied to the end of a string so that it can act like a pendulum. The bullet (mass = 0.012 kg) is traveling 342 m/s before it impacts the clay filled can. The bullet passes through the can. The bullet exits the back of the can at 325 m/s.

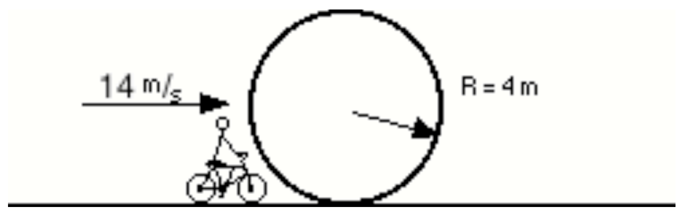
37 What is the maximum height of the can?



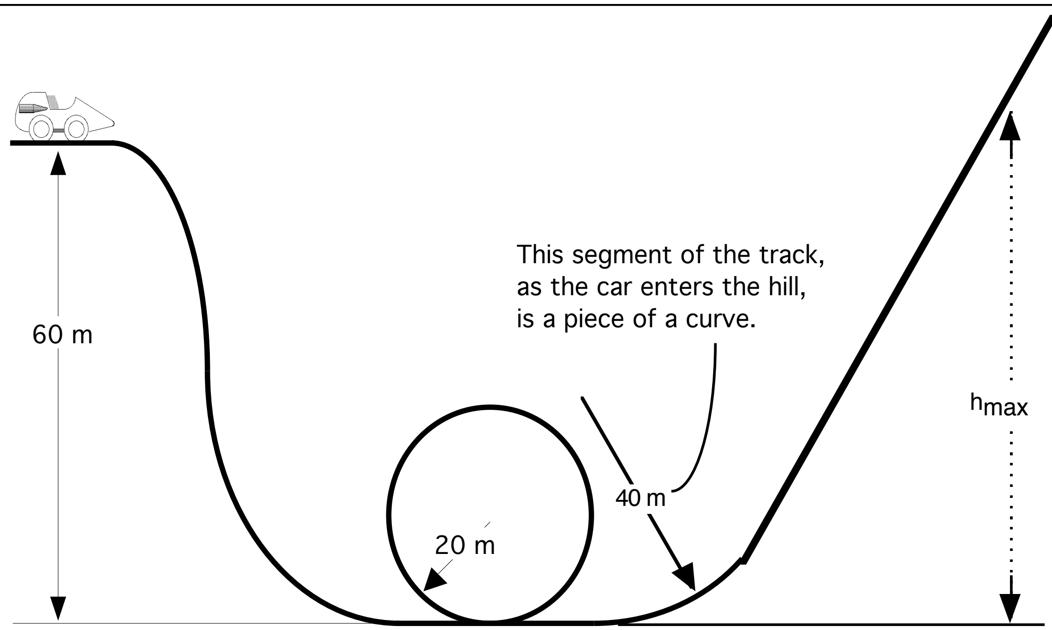


A roller coaster car, 500 kg, is to travel from 8 m/s down a wavy hill. It will coast without friction. Near the end of the ride it will make a death-defying jump.

38. What is the total energy of the system at the top of the hill?
39. What is the total energy of the system at the bottom of the hill?
40. What is the speed of the car at a height of 30 m?
41. What is the speed of the cat at the bottom of the hill?
42. What is the speed of the car after landing on the 15 m hill?

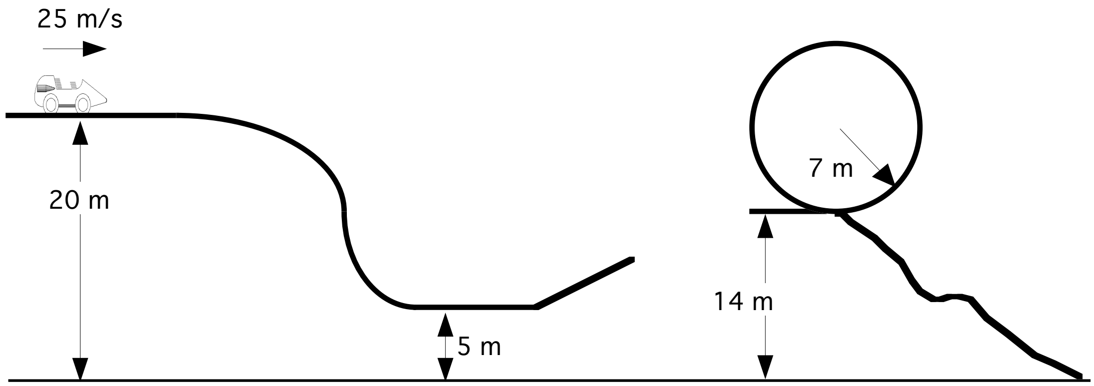


43 How many g's does the rider feel as he enters the loop?
44 How fast is the rider traveling at the top of the loop?
45 How many g's does the rider feel at the top of the loop?
46 Later a different rider travels into the loop at a different velocity. The rider feels 4.5 g's at the bottom of the loop as they enter it. How fast were they traveling?



A roller coaster rolls over the top of a hill with a speed of 10 m/s. The roller coaster's mass is 500 kg. (Ignore friction)

47. What is the speed of the roller coaster car half way down the hill?
48. What is the speed of the roller coaster car at the bottom of the hill?
49. What is the speed of the roller coaster car as it enters the loop?
50. How many g's are felt by the rider as they enter the loop?
51. What is the speed of the roller coaster car when it is 10 m above the ground?
52. What is the speed of the roller coaster car at the top of the loop?
53. How many g's are felt by the rider at the top of the loop?
54. What is the speed of the rider at the bottom of the loop?
55. What is the speed of the rider as they enter the hill's curve?
56. How many g's are felt by the rider as they enter this part of the curve?
57. How high will the roller coaster travel until it comes to a stop?



58. How fast is the car traveling after rolling down the hill to the 5 m mark?

59. How fast is the car traveling after making the jump up to 14 m?

60. How fast is the car traveling as it enters the loop?

61. What is the centripetal acceleration at this point in the loop?

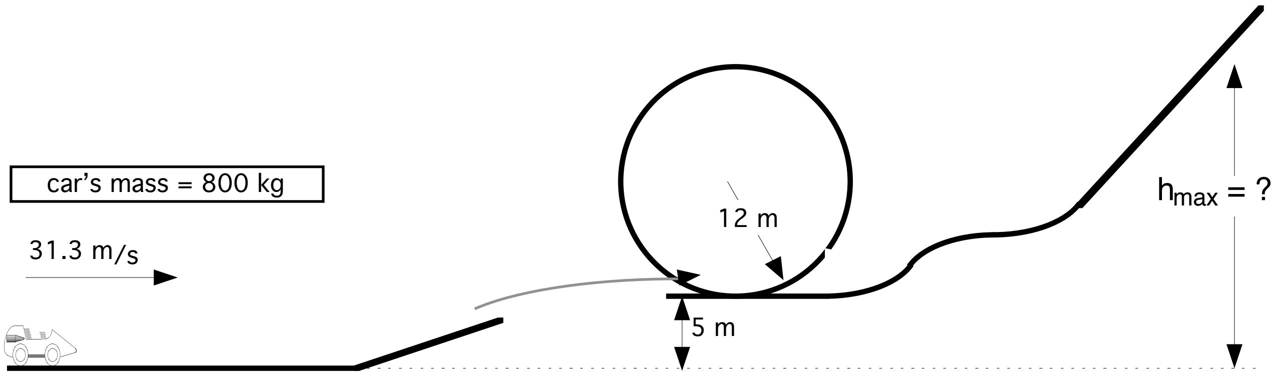
62. How many g's does the rider feel at the bottom of the loop?

63.How fast is the car traveling at the top of the loop?

64. What is the centripetal acceleration at this point in the loop?

65. How many g's does the rider feel at the top of the loop?

66. How fast is the car traveling at the very bottom?



The 800 kg roller coaster car begins the run traveling 31.3 m/s. It makes the jump and travels around the loop before going up the hill at the end. The coaster rolls up the hill until it comes to a rest. From there, it rolls backwards through the ride.

67. How fast is the car traveling after completing the jump?

68. How fast if the car traveling when is enters the loop?

69. How fast is the car traveling at the top of the loop?

70. What is the centripetal acceleration at top of the loop?

71. How many g's is the centripetal acceleration at top of the loop?

72. How many g's does the rider FEEL at the top of the loop?

73. How fast is the rider traveling at the bottom of the loop?

74. What is the centripetal acceleration at the bottom of the loop assuming the car is still barely in the loop?

75. How many g's is the centripetal acceleration at the bottom of the loop assuming the car is still barely in the loop?

76. How many g's does the rider FEEL at the bottom of the loop assuming the car is still barely in the loop?

77. What is the maximum height the car rolls up the hill?

WORK DEFINITION

78 A dog pulls a 40 kg wagon with a force of 300 N over distance of 50 m. How much work was done by the dog?

79 A car exerts a force of 10,000 N while driving on a horizontal stretch of road. How much work is done when the car travels 100 m?

80 A bucket is lifted out of a well by a 200 N force. If the well is 30 m deep, then how much work is done in lifting the bucket?

81 A 60,000 kg jet exerts a force of 1,000,000 N over a distance of 70 m. How much work is done by the jet?

82 A runner exerts 2,000 J of work while traveling 10 m along a horizontal stretch of track. How much force did the runner exert?

83 In order to insert a nerf dart into a toy gun, 50 J of energy needed to be exerted. It the dart was inserted 6 cm, then how much force was required to install the nerf dart?

84 A bicyclist exerted 30,000 J of work while traveling with a force of 10,000 N. How much distance was covered by the bicyclist?

85 A 1200 kg car is pushed by 3 people. Each person pushes with a force of 500 N. If the car is pushed 100 m, then how much work is done?

86 A St. Bernard dog pulls a 20 kg sled 50 meters with a 300 N force. The force act parallel to the ground. How much work does the dog do?

87 A 1500 kg does 20,000 J of work when is travels 200 m. How much force did the car exert, if the force acts parallel to the ground?

88 A model rocket exerted 1200 J of work in flight. If the rocket exerted 2 N of force, what is the maximum height the rocket can reach, without air resistance?

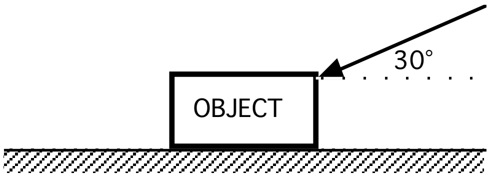
89 How much work is done by pushing a 100 kg box 5 m across a floor by a 20 N force?

90 How much work is done by a 500 N force that pushes a 1200 kg car 50 m if the car is moving 20 m/s when the force is applied? (The force is applied in the direction of motion.)

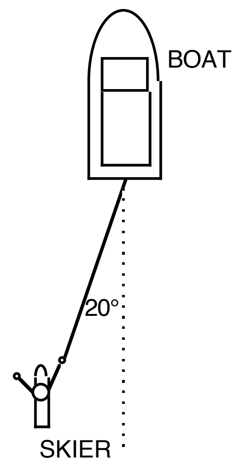
91 2000 J of work is done in running 50 meters. What average force does the runner exert?

92 A bullet penetrates 30 cm below the surface of water. If 2940 J of work is used to stop the bullet, then what is the stopping force? Ignore the effects of gravity?

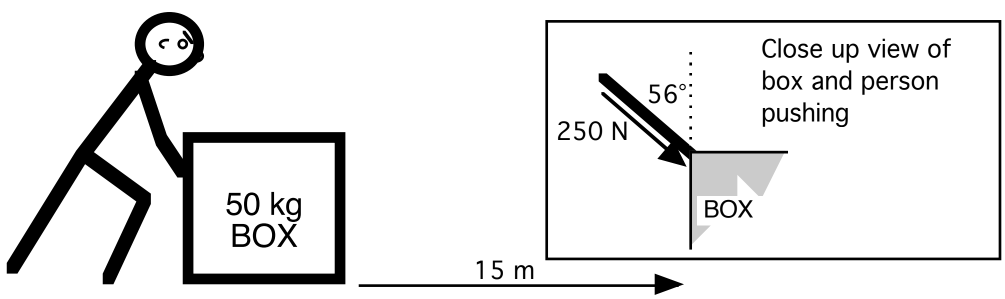
93 A box is pushed by a 600 N force that acts at a 30° angle with the ground. The force pushes a 500 N box 10 meters from rest. How much work is done?



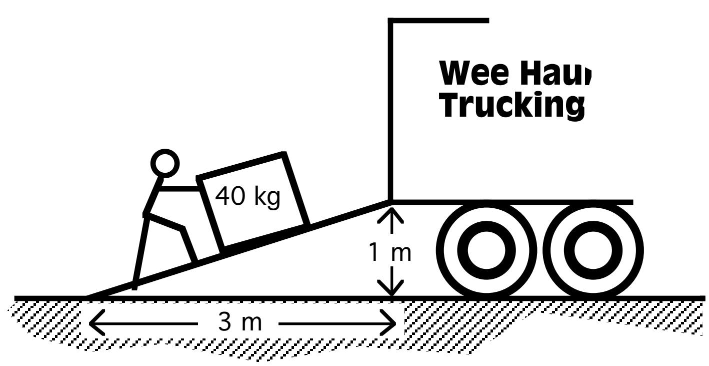
94 An 80 kg water skier is being towed behind a speedboat as shown to the right. The 600 kg boat travels 400 m. At the beginning of the run the boat is traveling 5 m/s. The force in the tether line is 2000 N. The boat travels with a net force of 4000 N. How much work is done by the tether on the skier?



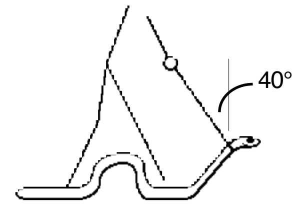
95 A 100 kg dockworker pushes a 50 kg box across a floor. He pushes the box such that his arms are at an angle as shown below. How much work is done by the person on the box?



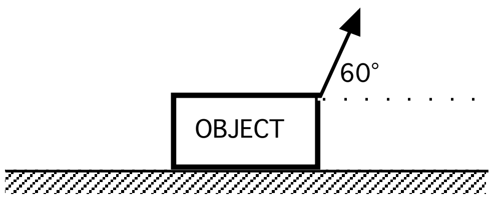
96 An 80 kg trucker loads a crate as shown below. He pushes the 40 kg box such that his arms are parallel to the ground. He pushes with a 100 N force. How much work is done by the trucker on the box?



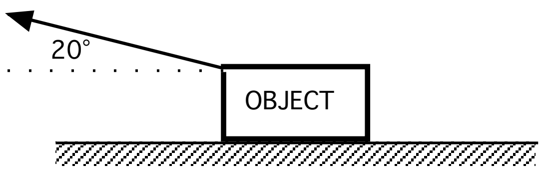
97 Sidney, 60 kg, on a walk-about with his pet snake Cecil. Cecil's weight is 5 kg. Cecil is pulling Sidney with 40 N force. (The two travel a across a distance of 125 m.) They start their trip from rest. How much work is done by Cecil?



98 A 120 N sled & rider is pulled by a 200 N for 100 m. The force acts at a 60° angle with the ground. How much work is done by the applied force?

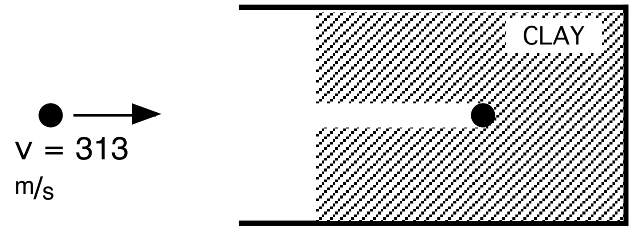


99 A 175 kg bobsled is stopped by a force applied at a 20° angle with the ground. The sled is stopped in 25 m with 800 J of work. What is the magnitude of the force?



WORK AS A CHANGE IN TOTAL ENERGY

A musket ball, 0.20kg, is shot with a speed of 313 m/s into a metal can holding some clay. The musket ball penetrates 13.4 cm into the clay before coming to a stop.



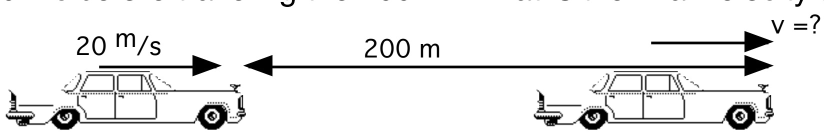
100 What is the kinetic energy of the musket ball before it hits the clay if its mass is 0.20 kg?

101 How much work does the clay do in stopping the musket ball?

102 What average force does the clay exert in stopping the musket ball?

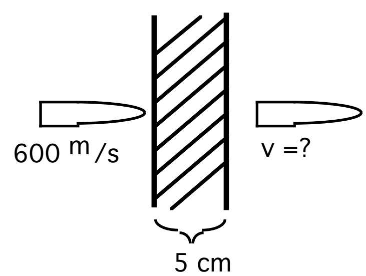
103 Using your answer in the previous problem, calculate the speed of the musket ball when it has penetrated the clay only 4.3 and 9.8 cm.

104 A 1500 kg does 20,000 J of work when it accelerates across 200 m. The car starts from 20 m/s before traveling the 200 m. What is the final velocity of the car?

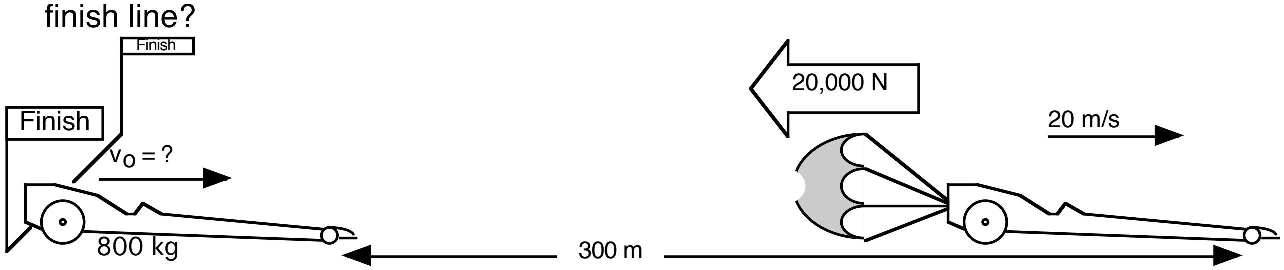


105 A 50 kg runner exerts 500 J of work while accelerating to a final velocity of 10 m/s in 50 m. What was the runner's initial velocity?

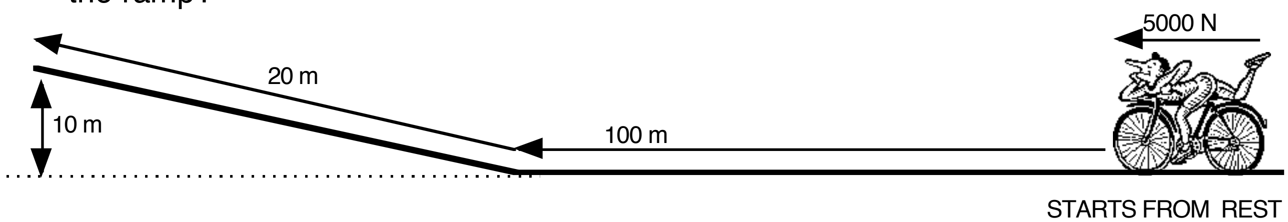
106 A bullet, 10 g, is shot through a piece of wood. The bullet enters the wood at 600 m/s. The wood is 5 cm thick. The wood exerts 10,000 N of force to slow the bullet down. How fast is the bullet traveling when it leaves the piece of wood on the opposite side?

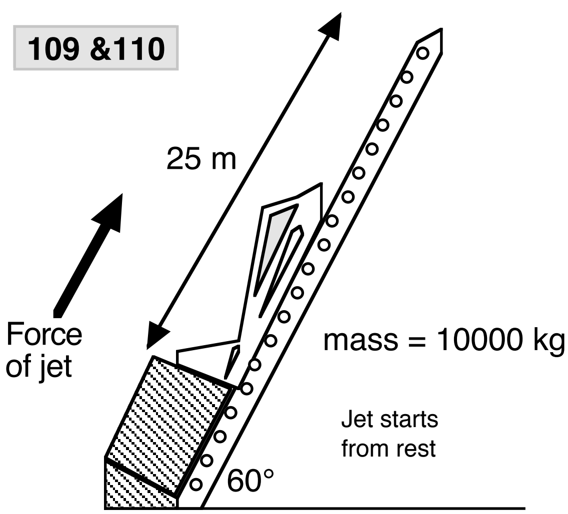


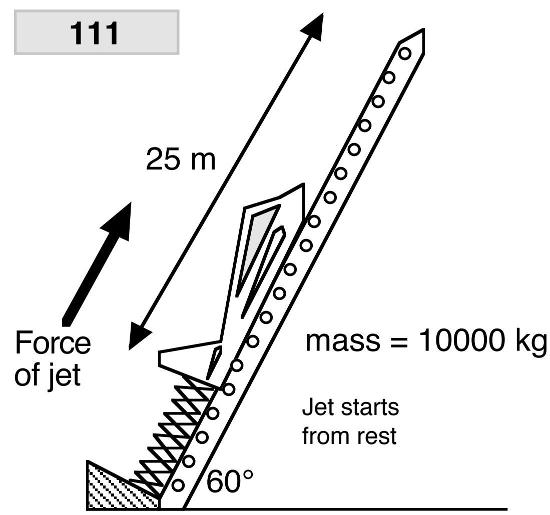
107 An 800 kg dragster finishes the race with some unknown velocity. A parachute is deployed after crossing the finish line and exerts a stopping force of 20,000 N across a distance of 300 m before the dragster slows down to 20 m/s. What was the speed of the dragster when it passes the finish line?



108 A bicycle stunt rider, 100.00 kg, is about to make a great jump over some buses. His bicycle exerts a force of 5,000 N in the direction of motion. He pedals along the entire distance shown. Given the diagram below, how fast will he be traveling when he leaves the ramp?







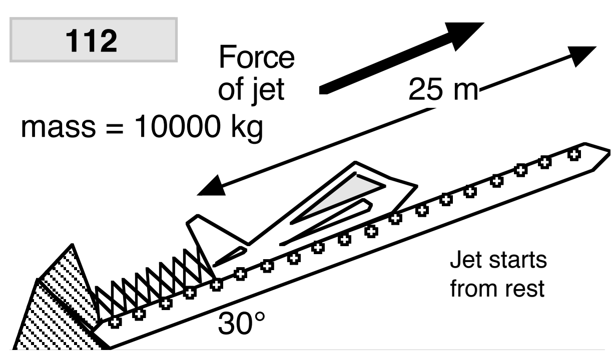
Wile E. Coyote is at it again. This time he is in a rocket boosted glider.

109 How much force is exerted by the boost motor if the glider is to leave the launch tower at 100 m/s?

110 How fast is the glider going to leave the launch tower if the glider's boost motor exerts 5,000,000 J of work?

111 The Coyote is not having much success. So he trades in the glider for a jet. His launcher will now propel him using the spring and the force of the jet's engines. The spring is compressed 25 meters along the launch tower and its force constant is 75,000 N/m. If the engine exerts a constant force of 90,000 N, then what is the velocity of the jet when it leaves the launch tower?

112 Suppose the launcher is at a 30° with the ground and the jet motor exerts the same force. What is the velocity of the plane as it leaves the ramp? (It is using the same spring as stated in the previous problem.)



POWER AND WORK

746 watts = 1 horsepower (hp)

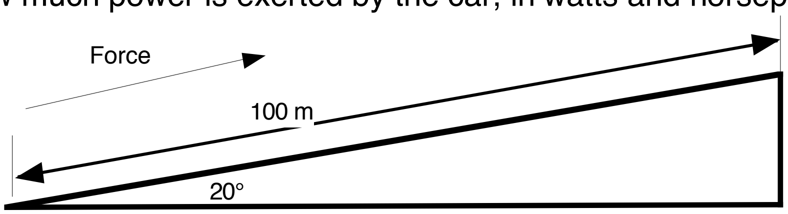
113 A 2800 kg car exerts a constant force of 20,000 N while traveling across 50 m. The car starts from rest.
(a) How much work is done by the car?
(b) How much power is exerted by the car, in watts and horsepower?

114 A student lifts a bucket with a 98 N force in 30 seconds out of a well. If the bucket is lifted 30 m then;
(a) How much work is done on the bucket by the student?
(b) How much power is exerted by the student, in watts and horsepower?

115 A car 2400 kg is traveling down the road at 26.1 m/s. If the car accelerates up to 35 m/s over a distance of 200 m then
(a) How much work is done by the car?
(b) How much power is exerted by the car, in watts and horsepower?

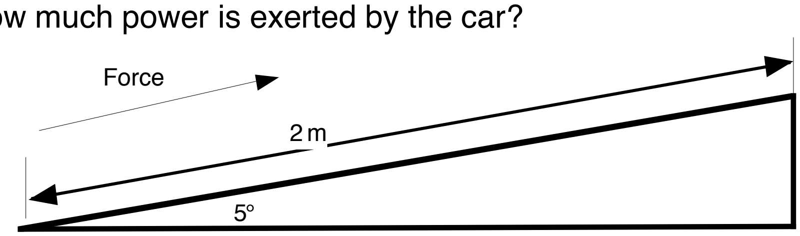
116 After accelerating, the car mentioned in the previous problem now locks the brakes and skids to a stop in 350 m.
(a) How much work is done by the brakes?
(b) How much power is exerted by the car's brakes, in watts and horsepower?

117 A 1400 kg car travels up a 20° incline. The car exerts a constant force of 30,000 N across 100 m. The car starts from rest at the bottom of the incline.
(a) How much work is done?
(b) How much power is exerted by the car, in watts and horsepower?

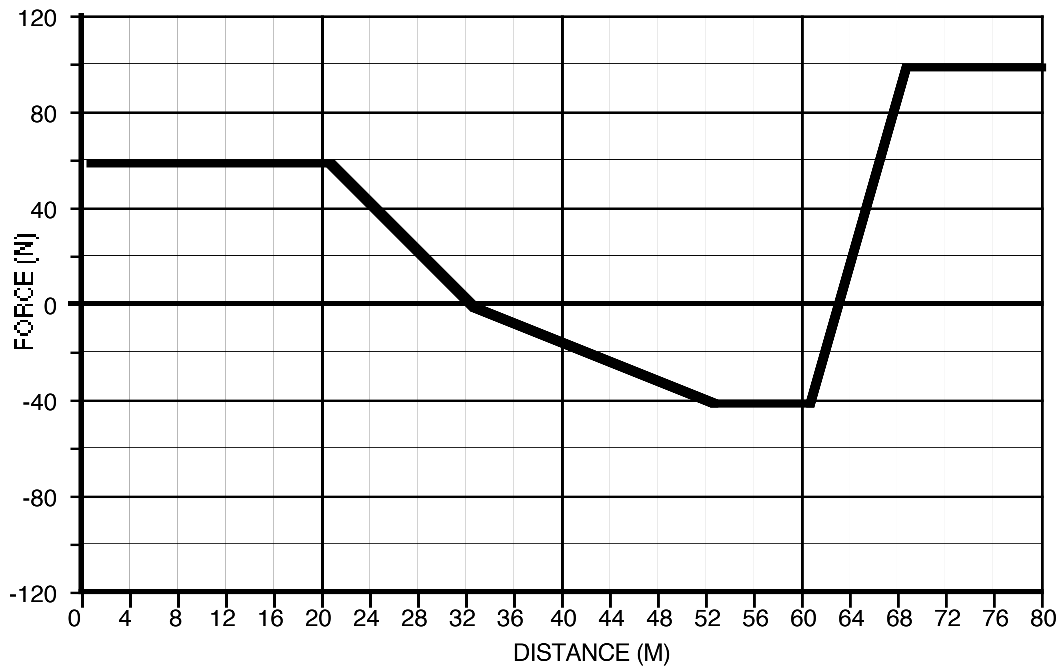


118 A 0.050 kg arrow is accelerated by the bow from rest to a velocity of 140 m/s in 0.60 m.
(a) How much work is done by the bow?
(b) How much power is exerted by the bow?

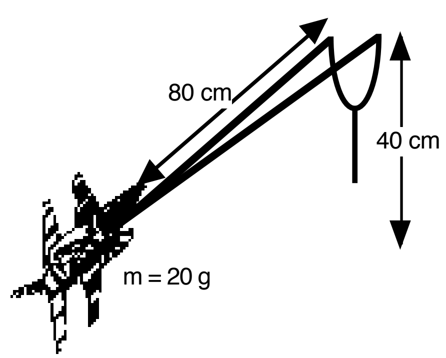
119 A 30 g toy car exerts a constant force of 4 N while traveling over the hill shown below. It starts from rest.
(a) How much work is done by the car?
(b) How much power is exerted by the car?

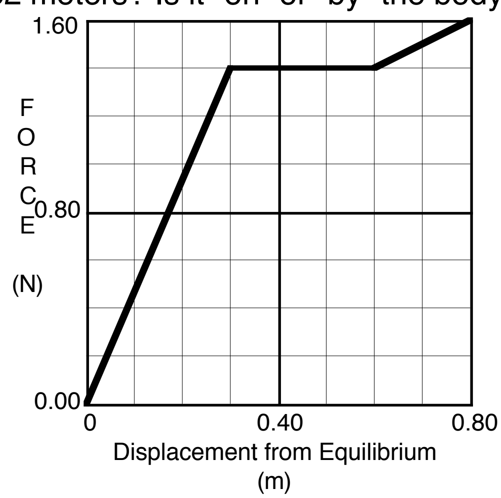


WORK FROM A GRAPH

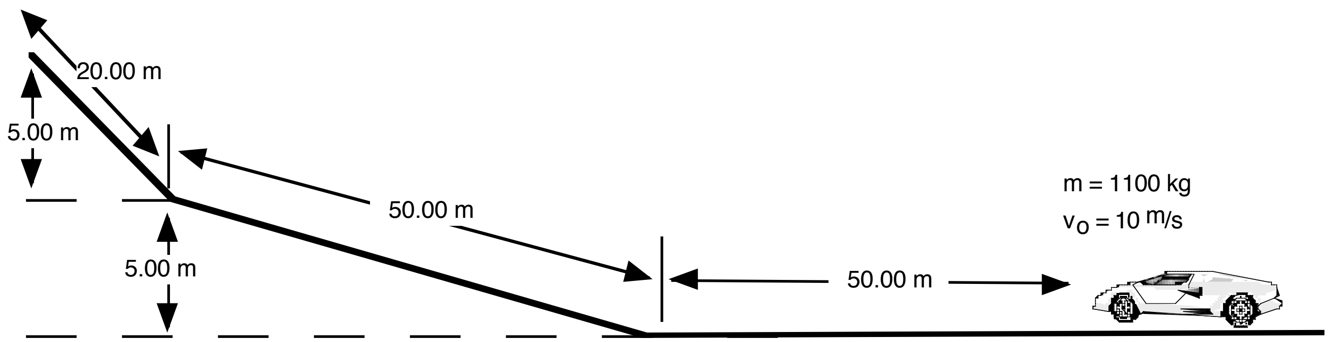


120. What is the work done over the first 12 meters? Is it "on" or "by" the body?
121. What is the work done over the first 24 meters? Is it "on" or "by" the body?
122. What is the work done over the first 32 meters? Is it "on" or "by" the body?
123. What is the work done over the first 52 meters? Is it "on" or "by" the body?
124. How much work is done between 32 and 52 meters? Is it "on" or "by" the body?





125 How much energy is stored in the sling shot launcher when it is pulled back 30 cm?
126 How much energy is stored in the sling shot launcher when it pulled back 60 cm?
127 How much energy is stored in the sling shot launcher when it is pulled back 80 cm?
128 IF the plane was pulled back 80 cm and it held horizontally -not like the above picture – then how fast would it leave the launcher?
129 If the plane were pulled back 80 cm and was held like the picture above, how fast would it leave the launcher?



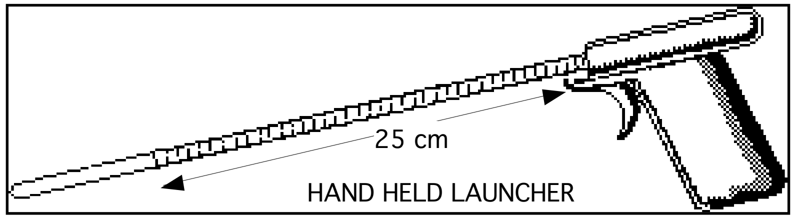
130 What is the car's speed after traveling 30 m?

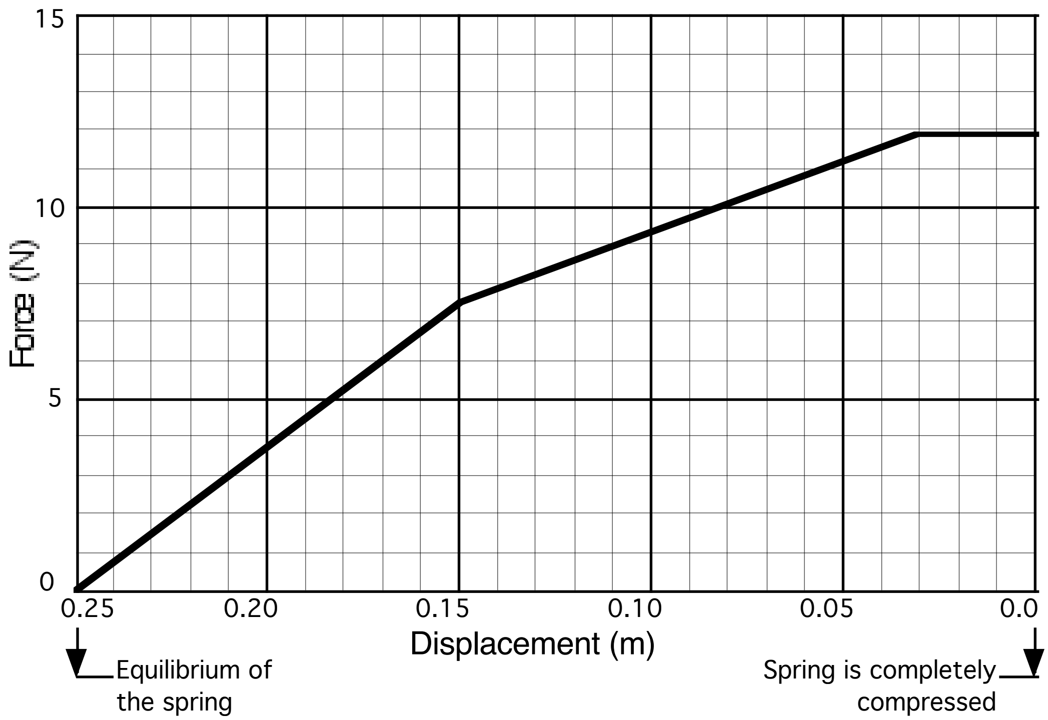
131 What is the car's speed after traveling 50 m?

132 What is the car's speed after traveling 100 m?

133 What is the car's speed after traveling 120 m?

A toy plane of mass is placed on a hand held launcher. The plane is pressed against a spring until it reaches the handle. Below is a force versus displacement graph for when the plane is compressed to the handle.



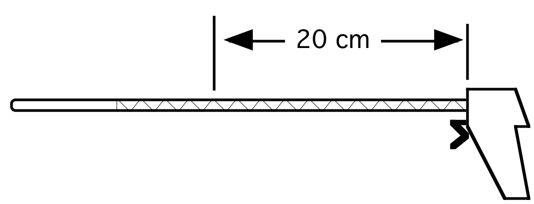


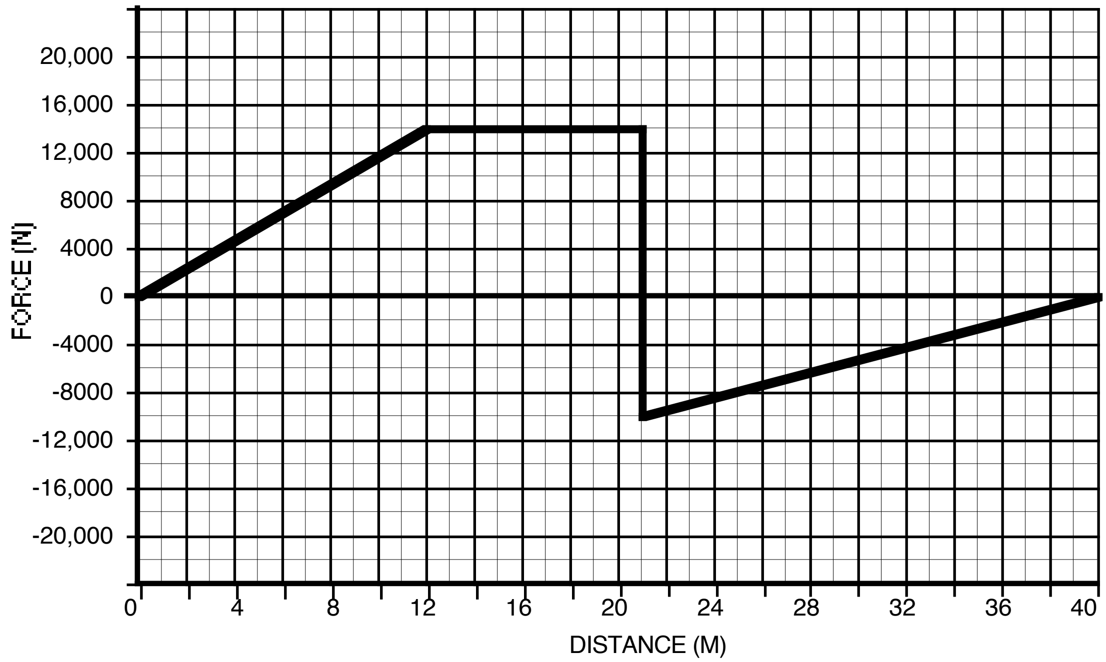
134 How much work is done in compressing the spring all the way back to the handle?

135 If the launcher is held horizontally and the 20.0 gram plane is fired off of it, then with what speed will the plane leave the launcher is the spring is completely compressed (to 0.0)?

136 What is the spring's spring constant across the first 10 cm (from 0.25 to 0.15)?

137 If the launcher is held horizontally and the spring is completely compressed by being pushed back to 0.0 and the plane is fired off of it from rest, then with what speed will the plane be traveling at 15 centimeters from the equilibrium position?





The graph above is a force versus distance graph for a 300 kg Dr. Seuss mobile. The reason for the graph's peculiar nature is due to a wrench left under the hood. The vehicle travels horizontally along the entire time

138. How much work is done between 0 and 16 meters?

139. How much work is done between 16 and 40 meters?

140. How much work is done between 12 and 21 meters?

141. How much work is done between 5 and 12 meters?

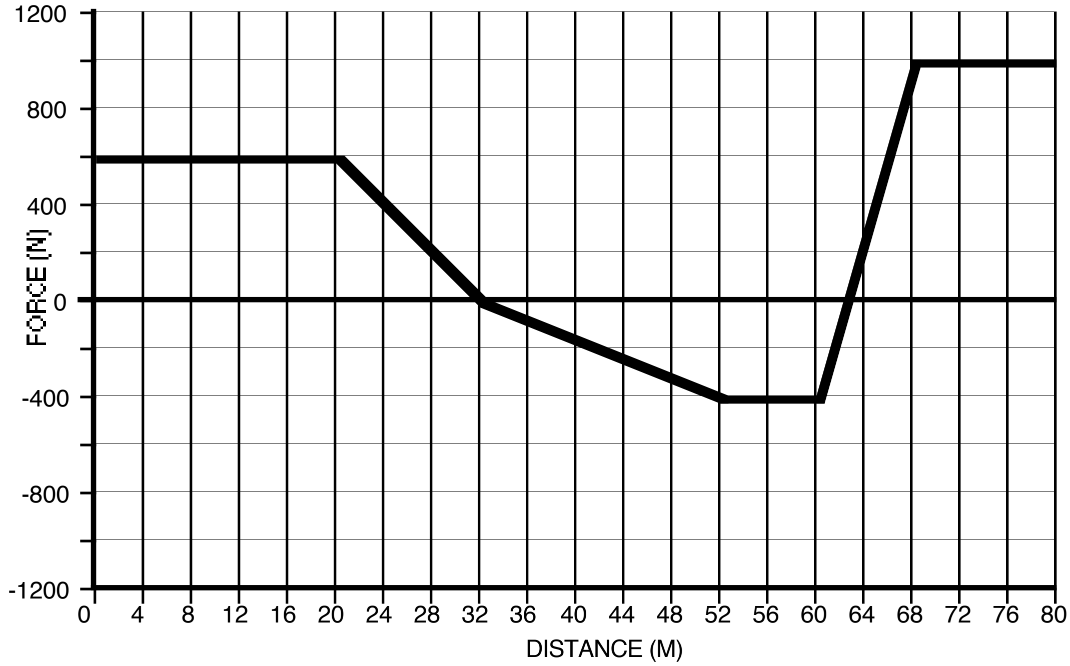
142. How much work is done between 20 and 28 meters?

143. How much work is done between 18 and 32 meters?

144. What is the car's speed after traveling from 0 to16 meters if it started from rest?

145. What is the car's speed after traveling from 0 to 21 meters if it started from rest?

146. What is the car's speed after traveling from 0 to 40 meters if it started from rest?



The graph above is for a bicyclist's ride on level ground. The bicyclist's mass is 90 kg. The bicyclist starts from rest.

147 What is the work done over the first 12 meters?

148 What is the speed of the bicyclist after traveling 12 m?

149 What is the work done over the first 20 meters?

150 What is the speed of the bicyclist after traveling 20 m?

151 What is the work done over the first 32 meters?

152 What is the speed of the bicyclist after traveling 32 m?

153 What is the work done over the first 52 meters?

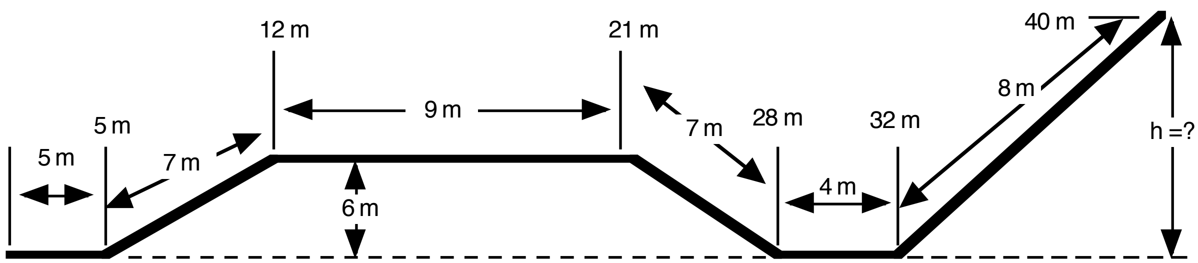
154 What is the speed of the bicyclist after traveling 52 m?

155 How much work is done between 32 and 52 meters?

156 Suppose at 52 meters the bicyclist was traveling 5 meters above the ground. How fast would they be traveling?

157 If the bicyclist drops 10.0 meters below the starting height at 52 meters. Then how fast would they be traveling?

The graph above is a force versus distance graph for a Dr. Seuss mobile. The reason for the graph peculiar nature is due to a wrench left under the hood. The vehicle's mass is 500 kg.



158 How much work is done between 0 and 16 meters?

159 How much work is done between 16 and 40 meters?

160 How much work is done between 12 and 21 meters?

161 How much work is done between 5 and 12 meters?

162 How much work is done between 20 and 28 meters?

163 How much work is done between 18 and 32 meters?

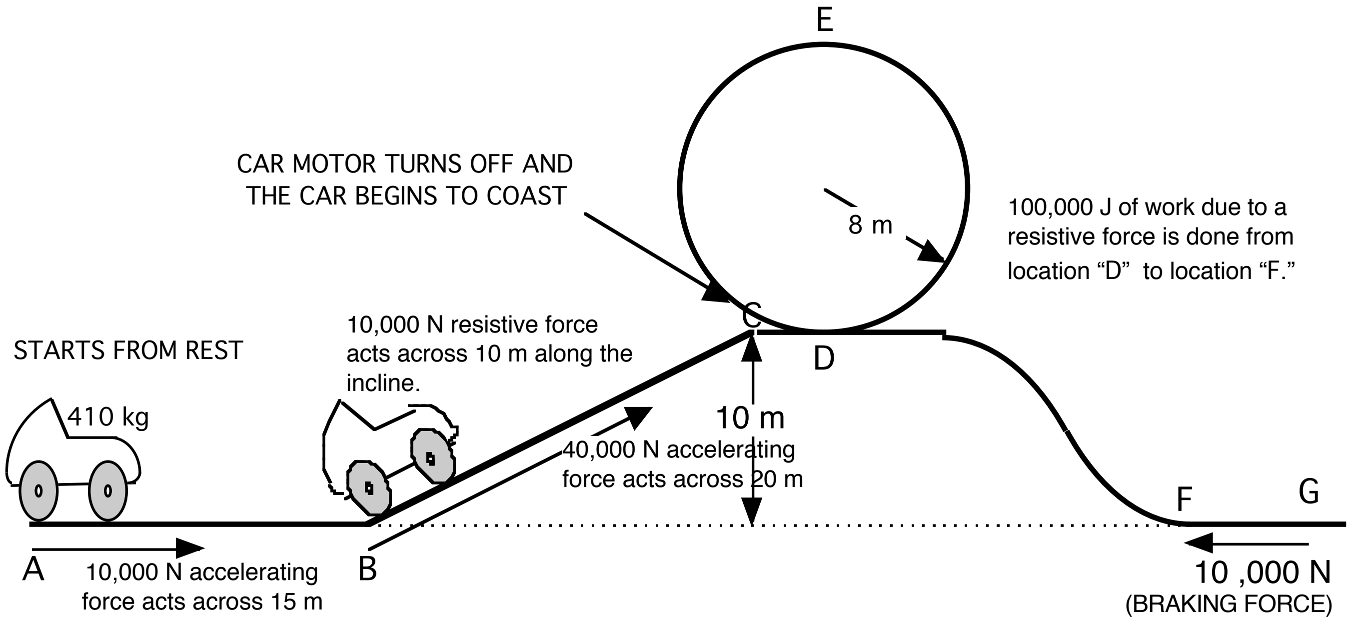
164 What is the speed after traveling from 0 to 16 meters along the diagramed path?

165 What is the speed after traveling from 0 to 21 meters along the diagramed path?

166 What is the speed after traveling from 0 to 32 meters along the diagramed path?

167 What is the maximum height the car will travel to after traveling from 0 to 40 m?

WORK COASTER



168 How much work is done from location "A" to location "B?"

169 How fast is the car traveling at location "B?"

170 How much work is done from location "B" to "C?"

171 What is the velocity of the car at location "C?"

172 What is the velocity of the car cat at location "D?"

173 How many g's are felt by the rider at location "D?"

174 How fast is the car traveling at location "E?"

175 How many g's does the rider feel at location "E?"

176 How fast is the car traveling at location "F?"

177 How much distance is traveled from location "F" to location "G" if the car comes to rest at location "G"

Answers to the "Work Coaster"

168 150,000 J **169** 27.05 m/s **170** 700,000 J **171** 62.85 m/s **172** 62.85 m/s **173** 51.39 g's
174 60.30 m/s **175** 45.38 g's **176** 60.48 m/s **177** 75.00 m

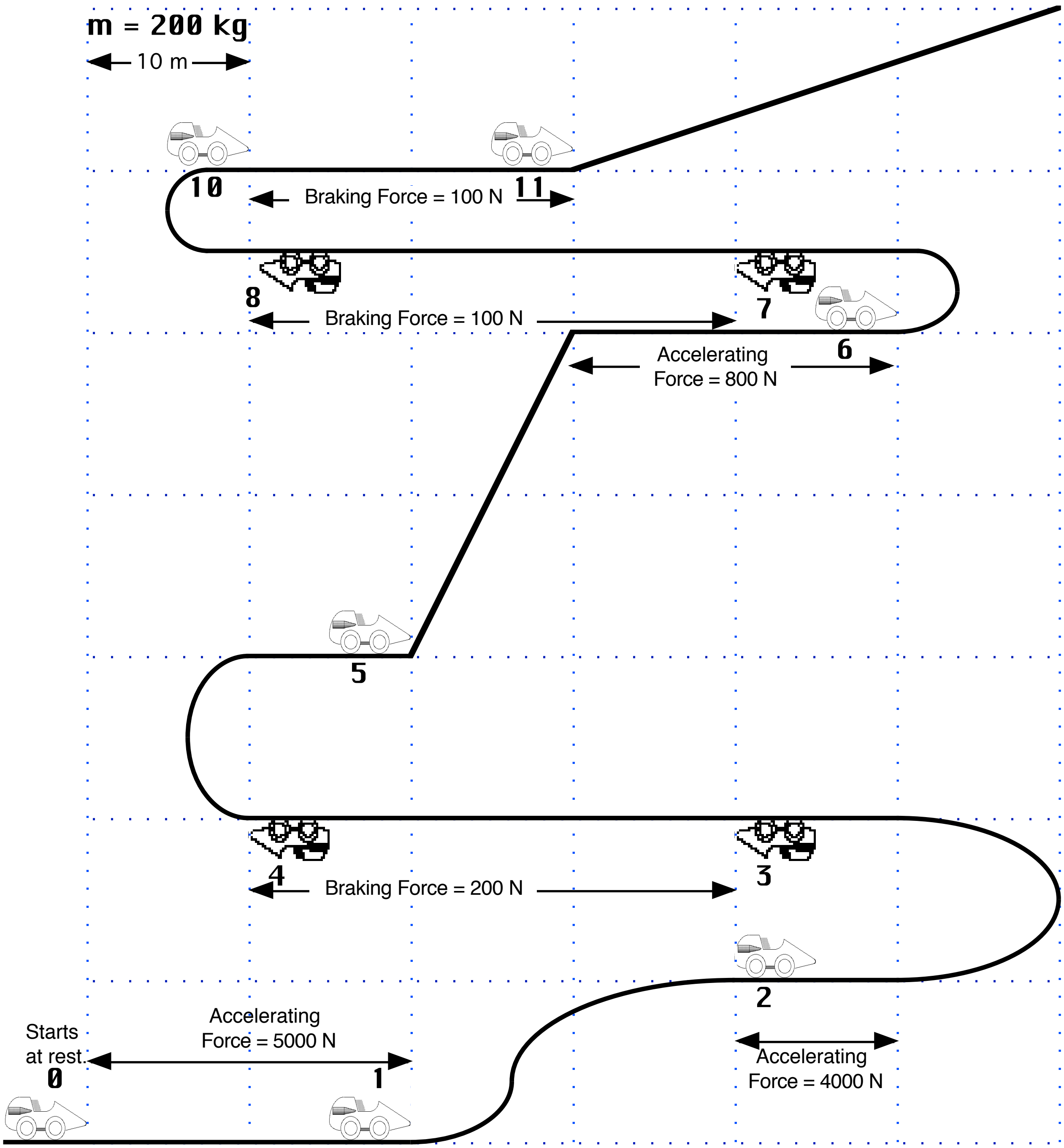
Answer the following based on the coaster shown below.

178 At each number calculate the E_T.

179 At each number calculate the car's velocity.

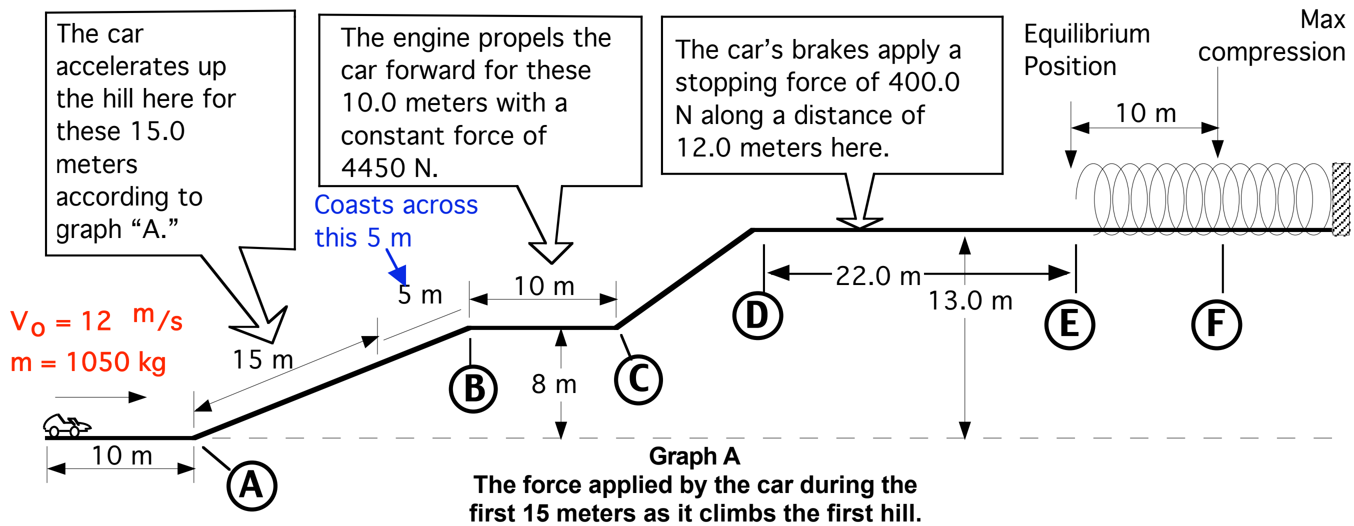
180 Calculate the acceleration due to each force in m/s^2 and g's.

181 Calculate the acceleration felt by the car as it enters each vertical curve.

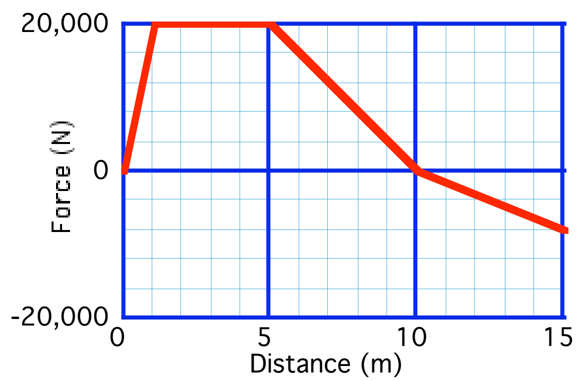


THE JERK

(A roller coaster for the fool in your life.)



Graph A
The force applied by the car during the first 15 meters as it climbs the first hill.



Questions about "*THE JERK*" roller coaster

182 What is the velocity of the roller coaster car at location "B?"

183 What is the velocity of the roller coaster car at location "C?"

184 How much power in watts and horsepower is generated by the car as it travels from location "B" to "C."

185 What is the velocity of the car at location "D?"

186 What amount of power applied to the car to slow it down between location "D" and "E?"

187 What is the spring's force constant?

Spring Questions

189. What is the potential energy of a spring that is compressed 0.53 meters from equilibrium if the spring constant is 219 N/m?

190. What is the spring potential energy of a spring that is stretched 0.23 meters from equilibrium if the spring constant is 12 N/m?

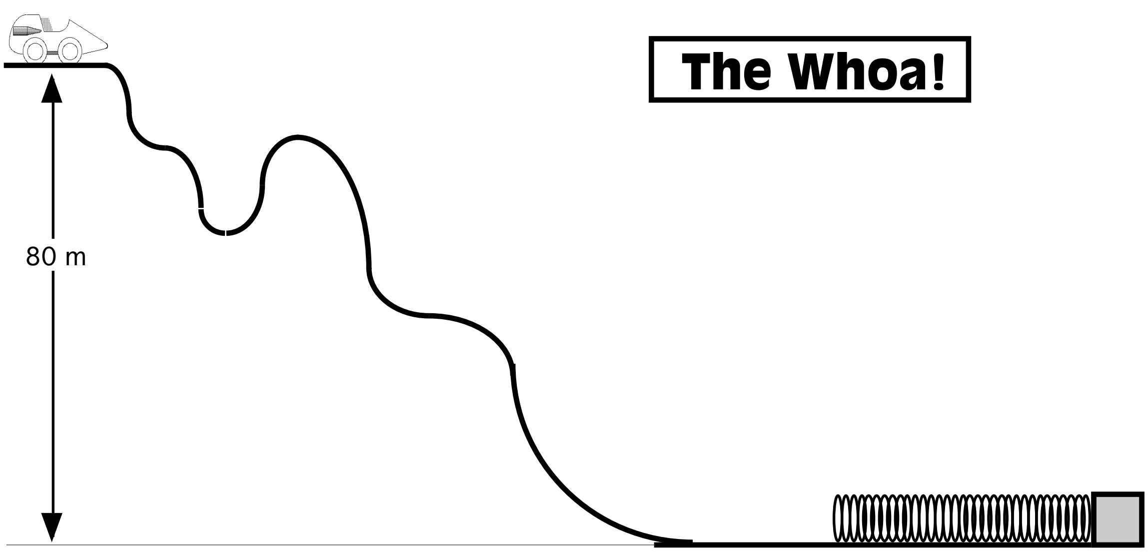
191. What is the spring potential of a spring that is stretched 11.42 centimeters beyond equilibrium if the spring constant is 81 N/m?

192. What is the spring constant of a spring that is stretched 34.2 centimeters if 1298 J of energy is used to stretch the spring?

193. What is the stretched distance of spring with a spring constant of 12.5 N/m if the spring uses 127 J?

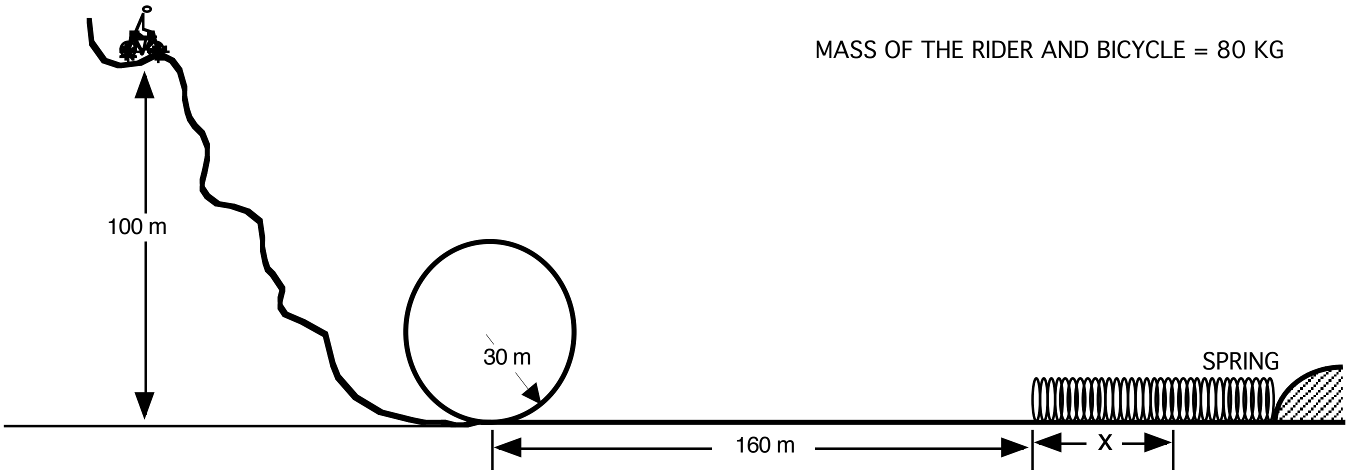
194. What is the spring constant of a spring that is stretched 123.2 cm while storing 93 J of energy in it?

The Whoa!



A roller coaster car is to travel from rest down a wavy hill. Then it will coast without friction into the spring. The roller coaster will compress the spring until it comes to rest. The spring constant is 200 N/m. The mass of the roller coaster is 500 kg.

195. What is the total energy of the system at the top of the hill?
196. What is the total energy of the system at the bottom of the hill?
197. What is the total energy of the system before it hits the spring?
198. What is the total energy of the system when the spring is completely compressed?
199. What is the speed of the car at a height of 30 m?
200. What is the speed of the car at the bottom of the hill?
201. What is the speed of the car before it hits the spring?
202. What is the maximum distance the spring is compressed?



Death-Wish Hershey just finished his design of a new dare devil amusement park ride. The rider coasts down on a special bicycle. The rider starts from rest. This bicycle will not jump off the track. The track is frictionless. The spring constant is 1960 N/m and the mass of the bicyclist and bicycle is 80 kg.

203. How fast is the rider at the bottom of the hill?

204. How fast is the rider traveling halfway up the loop?

205. How fast is the rider traveling at the top of the loop?

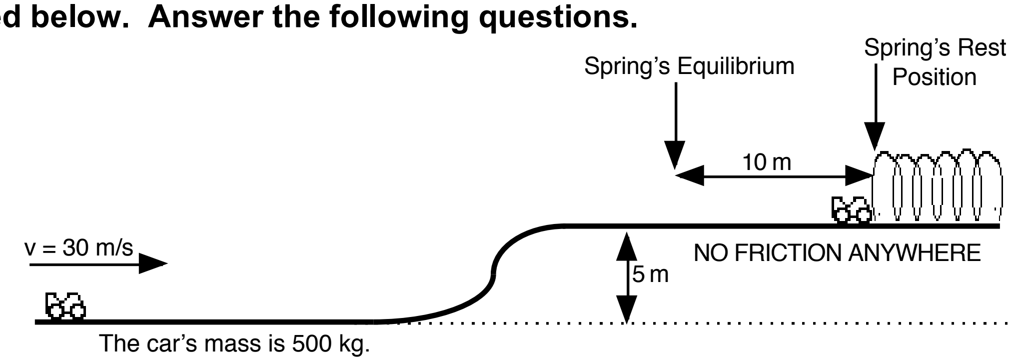
206. How fast is the rider traveling at the bottom of the loop?

207. What is the maximum compression distance of the spring?

208. How fast will the rider be traveling when the spring is compressed 1/3 the maximum distance?

209. After the rider bounces off the spring and starts to roll backwards he applies the brakes. He applies the brakes as soon as the spring is back to its equilibrium position. If he is to come to a stop in the 160.0 meters before reaching the loop again, then what average force the brakes must apply?

Below is a ride at Dr. Seuss's amusement park in "Whoville." Based on the information diagramed below. Answer the following questions.



210. What is the speed of the car at the top of the hill?

211. What is the spring's spring constant?

212. What is the speed of the car when the spring is compressed 5 meters?

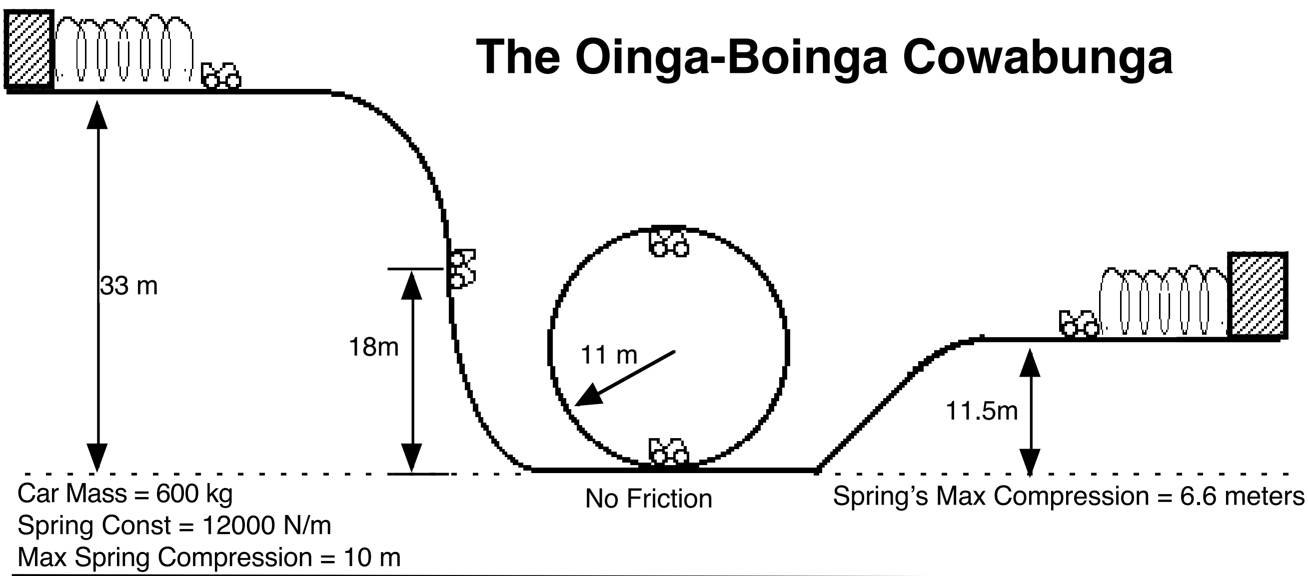
213. At which compression distance of the spring is the speed of the car half of what was at the instant it hit the spring?

214. At which compression distance of the spring is the speed of the car half of what it was at the very beginning of the ride?

215. Suppose, by some weird quirk of Seuss' Science, the spring bounces the car with 3 times the total energy it hit the spring with.

a. What is the velocity of the car when it comes of the spring?

b. What is the new velocity of the car at the very beginning of the ride?



The roller coaster's car starts from rest.
Convert ALL heights to stories -even the ones given in the questions.
Put ALL speeds in m/s and mph.
Put ALL accelerations in m/s2 and g's.
Put ALL powers in watts and horsepower.
(NOTE -It takes 0.1 seconds to blink the human eye)

216. What is the speed of the car after it just looses contact with the spring at the top of the first hill?

217. What is the speed of the car when it is 18 meters above the ground?

218. What is the speed of the car as it enters the loop?

219. How many g's are felt by the rider as the car enters the loop?

220. What is the speed of the car when it reaches the top of the loop?

221. How many g's are felt by the rider at this point loop?

222. What is the speed of the car as the instant before it makes contact with the spring on the right?

223. What is the spring's spring constant?

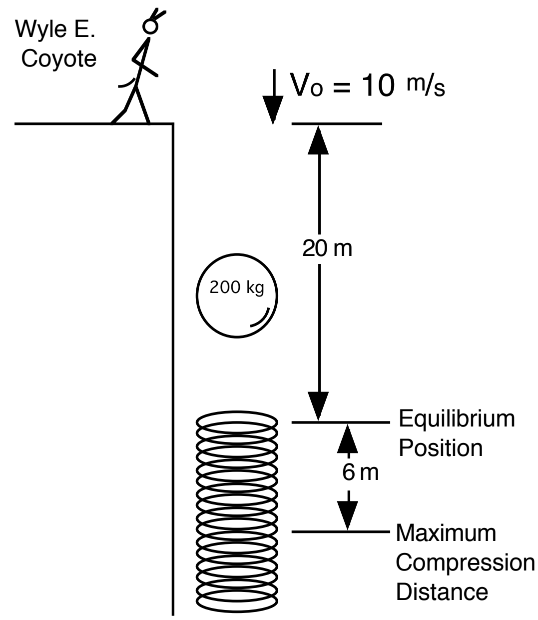
224. What is the speed of the car after the spring has been compressed 4.0 m from equilibrium?

225. What average force did the spring exert to stop the car?

226. How much time did it take to stop the car?

227. How much power was used by the spring to stop the car?

Wyle E. Coyote is still trying to catch that roadrunner -when will he learn? As part of this new ACME trap he throws a ball down on a spring as shown to the right.



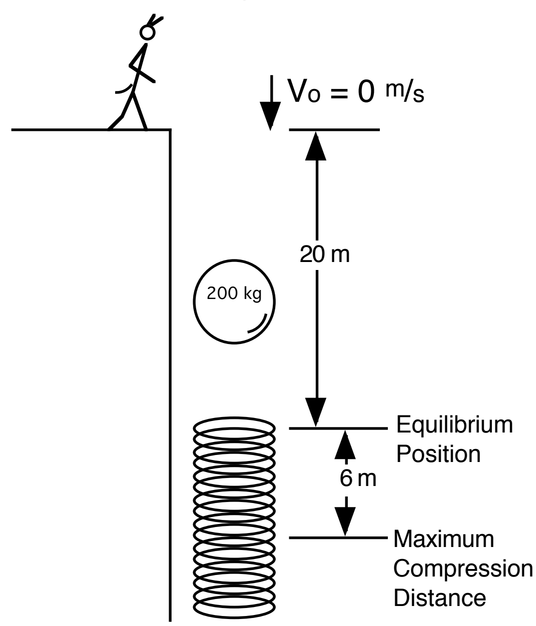
228. What is the velocity of the ball the instant it makes contact with the spring?

229. What is the spring's spring constant?

230. How fast is the ball traveling when the spring is compressed 2 meters from the equilibrium position of the spring?

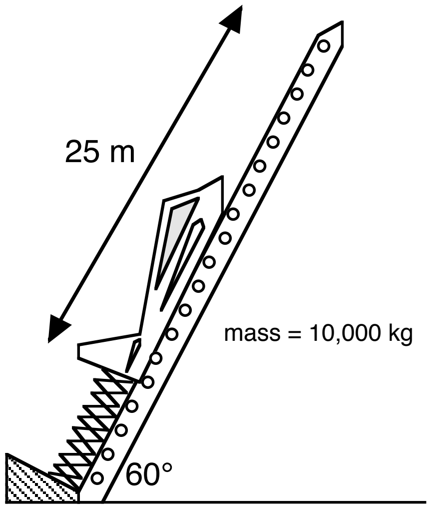
In a later experiment, the coyote drops the ball. A different spring compresses 6 meters.

231. What is this spring's spring constant?

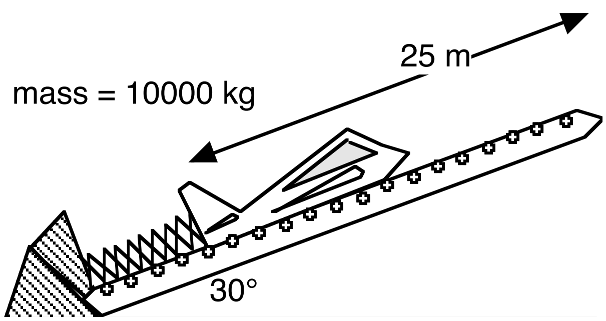


Wile E. Coyote is at it again. This time he is in a rocket boosted glider.

232. The spring is compressed 25 meters. What is the spring's spring constant if the glider is leave the launch tower at 100 m/s?

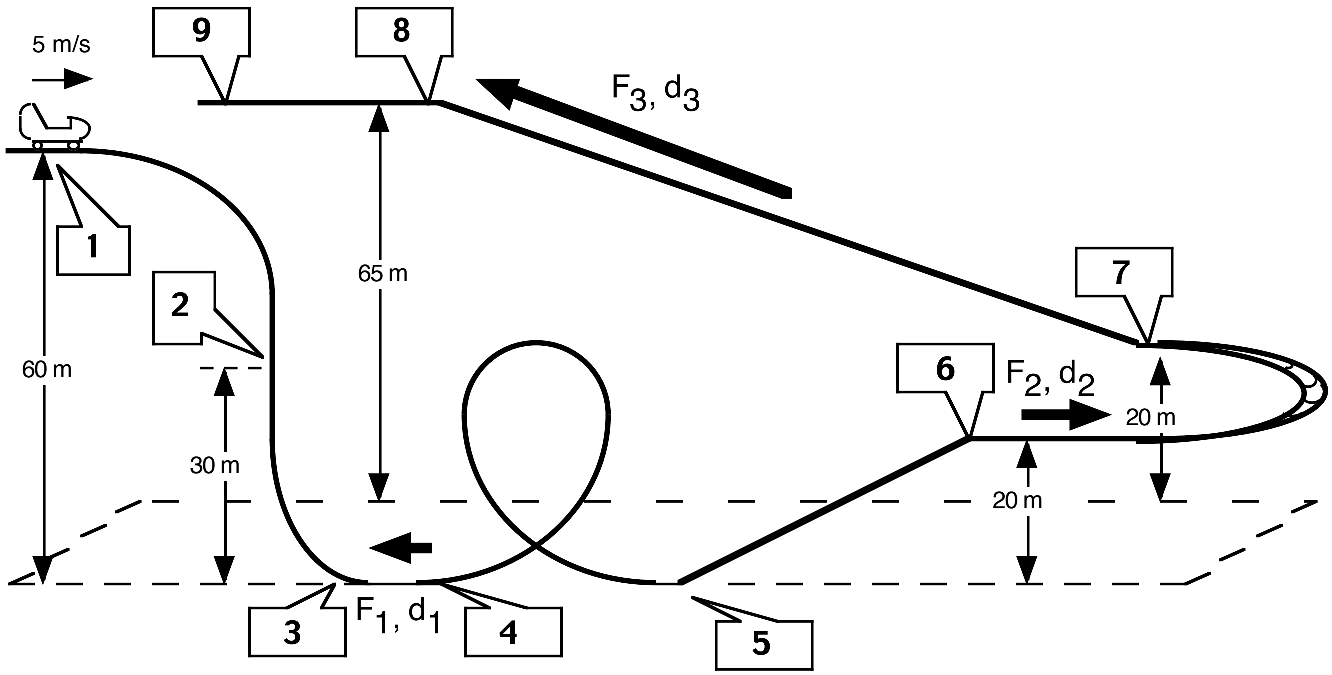


233. The spring is compressed 25 meters. What is the spring's spring constant if the glider is leave the launch tower at 100 m/s?



This diagram is in 3D

The purpose of this worksheet is to help you to identify when to include WORK and how to include it when it is used.



Write the math expression for the total energy relationships between the following locations:
(Leave out an energy if its value is zero.)

1 & 2 **$KE_1 + PE_1 = KE_2$ <--- EXAMPLE ANSWER**

1 & 3

2 & 4

3 & 5

5 & 6

5 & 7

3 & 7

1 & 9

Energy [Some Selected Answers]

1) 2560 J
2) 2 J
3) 5.746 x 1012 J
4) 169,000 J
5) 56.74 m/s, 127.09 mph
6) 40,000 J
7) 4000 m/s
8) Changes by 1/4
9) 16/27 = 0.592 repeating
10) 1/2
11) $\frac{2\sqrt{10}}{5} = 1.26$
12) $\sqrt{6}$
13) $\frac{\sqrt{30}}{2} = 2.74$
14) 127.3412 J
15) 341,775 J
16) 1,258,437.6 J
17) 356,607.75 J
18) 187,270.2 J
19) 1,421,898,840 J
20) Class
21) Class
22) Class
23) 16.025 m/s
24a) 13.357 m/s
24b) 13.102 m
25) 7.347 m
26) 662.118 m/s
27) 34.409 m/s
28) 30.90 m/s
29) 271.11 m/s
30) 5.4 m/s
31a) 10.551 m/s
31b) 8.079 m/s
31c) 6.139 m below the lowest point of 5.68 m
31d) 25.781 m/s
31e) 5.902 m/s
32) 20.000 kg
33) 701.78 J
34) 0
35) 701.78 J
36) 3.58 m
37) 0.486 m
38) 408,000 J
39) 408,000 J
40) 32.31 m/s
41) 40.398 m/s
42) 36.58 m/s
43) 6 g's
44) 6.26 m/s
45) 0 g's
46) 11.71 m/s
47) 26.23 m/s
48) 35.72 m/s
49) 35.72 m/s
50) 7.5 g's
51) 32.86 m/s
52) 22.18 m/s
53) 1.51 g's
54) 35.72 m/s
55) 35.72 m/s
56) 4.26 g's felt
57) 65.10 m
58) 30.32 m/s
59) 27.25 m/s
60) 27.25 m/s
61) 106.09 m/s
62) 11.83 g's felt
63) 21.64 m/s
64) 66.89 m/s2
65) 5.83 g's felt
66) 31.89 m/s
67) 29.69 m/s
68) 29.69 m/s
69) 20.28 m/s
70) 34.27 m/s2
71) 3.50 g's
72) 2.50 g's felt
73) 29.69 m/s
74) 73.47 m/s
75) 7.50 g's
76) 8.50 g's felt
77) 49.98 m
78) 15,000 J
79) 1,000,000 J
80) 6000 J
81) 70,000,000 J
82) 200 N
83) 833.32 N
84) 3 m
85) 150,000 J
86) 15,000 J
87) 100 N
88) 600 m
89) 100 J
90) 25,000 J
91) 40 N
92) 9800 N
93) 5196.15 J
94) 751754.0 J
95) 3109 J
104) 20.66 m/s
105) 8.94 m/s
106) 509.90 m/s
107) 124.10 m/s
108) 108.65 m/s
109) 2,084,870.49 N
110) 8.94 m/s
111) 68.65 m/s
112) 69.95 m/s
113) (a) 1,000,000 J (b) 267261.24 w,? hp
114) (a) 2940 J (b) 98 w, 0.131 hp
115) (a) 652,548 J (b) 99,676.71 w, 133.61 hp
116) (a) 652,548 J (b)73,500 W, 98.53 hp
117) (a) 3,000,000 J (b) 981,980.51 W: (t=3.06 s)
118) (a) 490 J (b)57,166.67 W: (t=1.00857 s)
119) (a) 8 J (b) 46.19 W: (t=0.17 s)
120) 720 J
121) 1400 J
122) 1560 J
123) 1160 J
124) - 400 J
125) 0.21 J
126) 0.63 J
127) 0.93 J
128) 9.65 m/s
129) 9.23 m/s
130) 17.45 m/s
131) W = 128,571-53571.5+25,000 = 99,999.5 J: v = 13.48 m/s
132) W = 599,999.5 J: v = 31.51 m/s
133) 29.92 m/s
134) W from 0 tp 0.03 = 0.354: W from 0.03 to 0.15 = 1.158: W from 0.15 to 0.25 = 0.375 Therefore work = 1.887 J

189) 30.76 J
190) 0.317 J
191) 0.528 J
192) 22.194 J
193) 4.51 m
194) 122.54 N/m
195) 392,000 J

210) 28.32 m/s
211) 4010 N/m
212) 24.53 m/s
213) 8.66 m @ 14.16 m/s
214) 8.48 m
215) a. 51.00 m/s
b. 51.96 m/s
216) 44.72 m/s
217) 47.90m/s
218) 51.45 m/s
219) 25.55 g's felt
231) 2831.11 N/m
232) 166,789.64 N/m
233) 163,920 N/m

Objectives

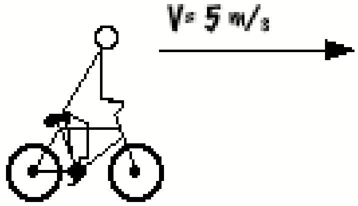
Momentum and Impulse

Students will be able to:

1. Define momentum.
2. Calculate the momentum of an object.
3. Describe the relationship between momentum and concept of inertia.
4. State the law of Conservation of Momentum 2 ways.
   - as Δp.
   - as before and after system p's.
5. Define impulse in terms of
   - Force and time
   - Momentum
   - Mass & velocity
6. Identify the number of impulses in a given situation.
7. Describe the relationship between Newton's 3rd Law and Impulse.
8. Solve impulse momentum word problems using vectors.
9. Use impulse to solve word problems.
10. Calculate impulse from a graph of force versus time.

Momentum and Impulse

A



V = 5 m/s

M_R = 60 kg

M_B = 20 kg

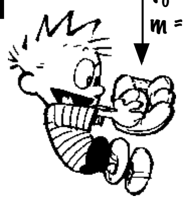
Impulse: ____________

Momentum of the bike: ____________

Momentum of the rider: ____________

11.

B



V_0 = 30 m/s
m = 0.150 kg

Calvin catches the ball

C

BEFORE

V_0 = 20 m/s
m = 0.150 kg

AFTER

V = 35 m/s

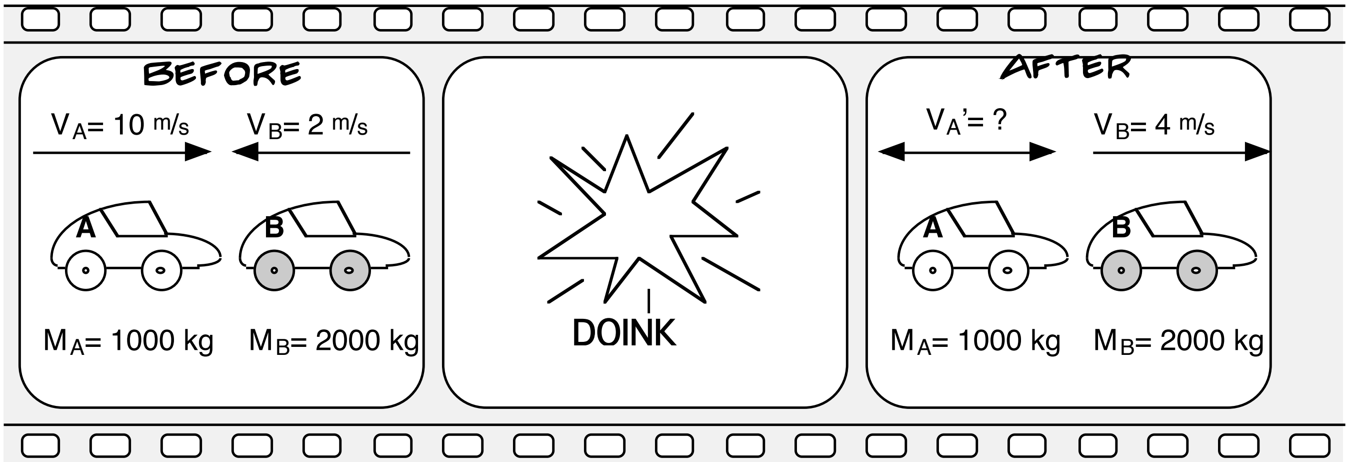
Line drive -straight back at the pitcher.

D

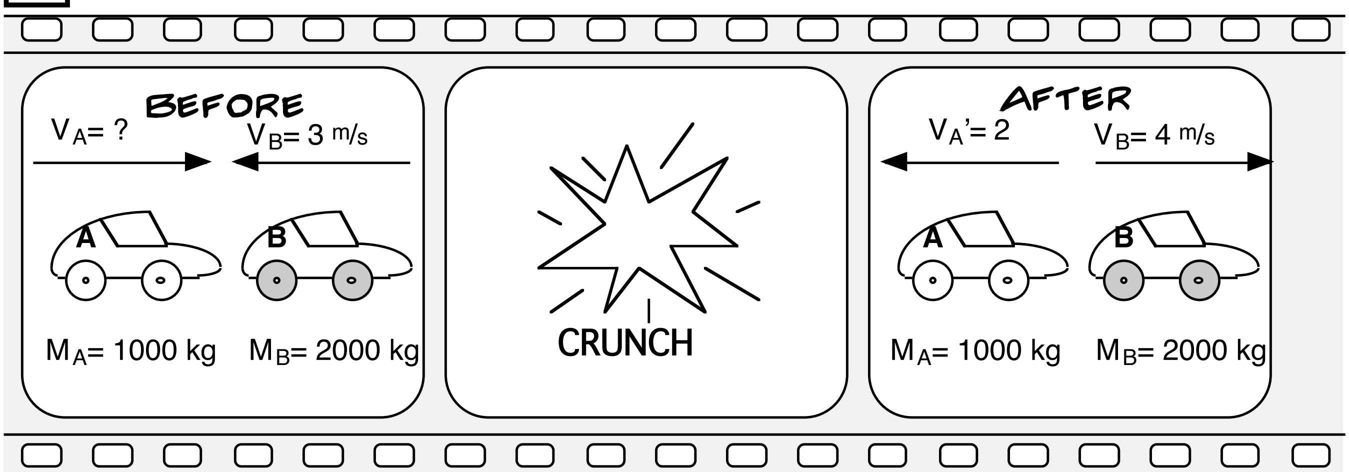
V_0 = 10 m/s
m = 0.1 kg

The snow ball hits Susie on the head and sticks there.

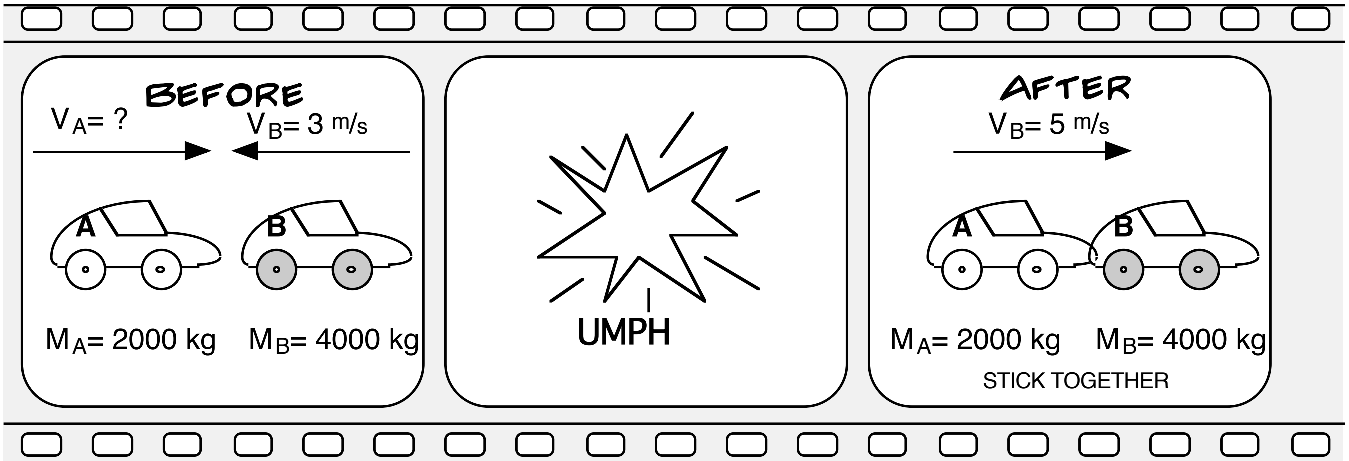
E


BEFORE
VA= 10 m/s
VB= 2 m/s
A
B
MA= 1000 kg
MB= 2000 kg
DOINK
AFTER
VA'= ?
VB= 4 m/s
A
B
MA= 1000 kg
MB= 2000 kg

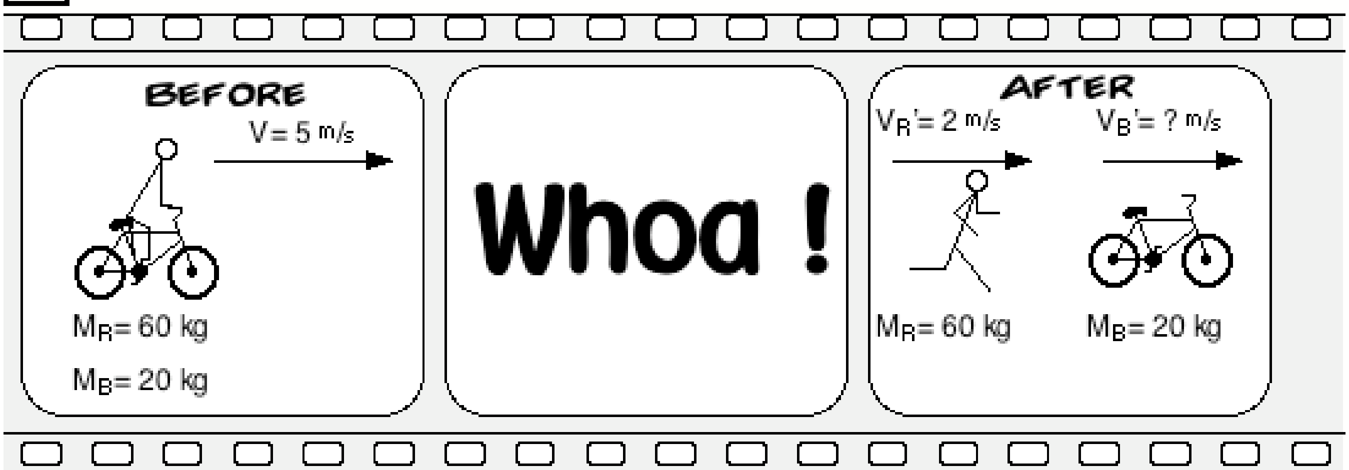
F


BEFORE
VA= ?
VB= 3 m/s
A
B
MA= 1000 kg
MB= 2000 kg
CRUNCH
AFTER
VA'= 2
VB= 4 m/s
A
B
MA= 1000 kg
MB= 2000 kg

G


BEFORE
V_A= ?
V_B= 3 m/s
A
B
M_A= 2000 kg
M_B= 4000 kg
UMPH
AFTER
V_B= 5 m/s
A
B
M_A= 2000 kg
M_B= 4000 kg
STICK TOGETHER

H


BEFORE
V= 5 m/s
M_R= 60 kg
M_B= 20 kg
Whoa !
AFTER
V_R'= 2 m/s
V_B'= ? m/s
M_R= 60 kg
M_B= 20 kg

I

Hobbes, the stuffed tiger, has a mass of 31.8 kg. Calvin, the little boy, has a mass of 25.1 kg. In a game of football, Hobbes runs at Calvin at 11 m/s. Calvin is running in the same direction as Hobbes, away from Hobbes, at 8.33 m/s.

(a) If the two collide and stick together, what is their final velocity?
(b) What impulse is exerted on Hobbes by Calvin?
(c) What impulse is exerted on Calvin by Hobbes?
(d) If the collision occurred in 0.109 seconds, then what force was exerted on Hobbes?

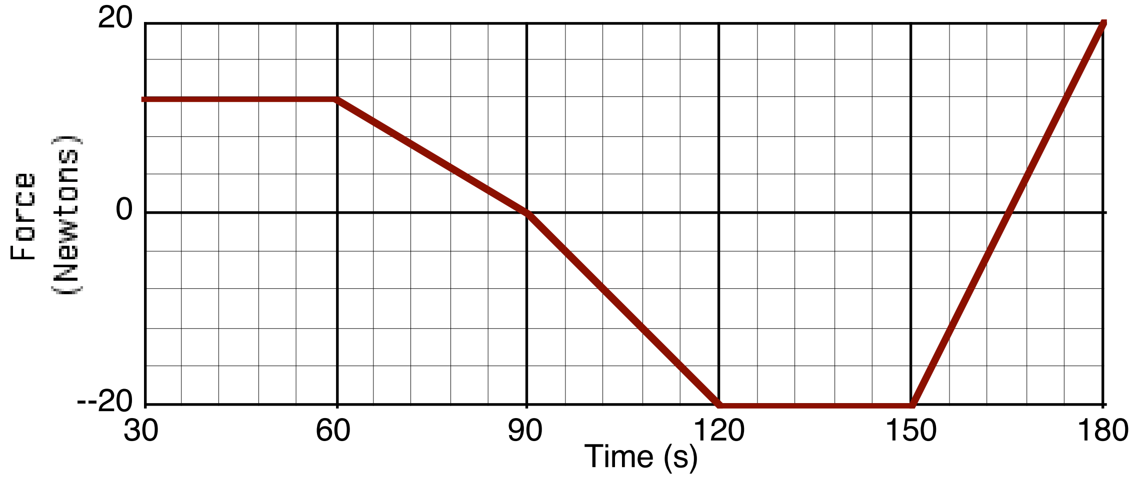
J

Hobbes, the stuffed tiger, has a mass of 31.8 kg. Calvin, the little boy, has a mass of 25.1 kg. In a game of football, Hobbes runs at Calvin at 7.22 m/s. Calvin is running at Hobbes.

(a) If the two collide, stick together, and are then at rest, what was Calvin's initial velocity?
(b) What impulse is exerted on Hobbes by Calvin?
(c) What impulse is exerted on Calvin by Hobbes?
(d) If the collision occurred in 0.0600 seconds, then what force was exerted on Hobbes?

K

Calvin & Hobbes, 45 kg, are sleigh riding down a hill. The hill they are on is irregular shaped, slopes up and down and has snow of varying depths and textures. Below is a force vs. time graph of the force acting on their sled. The initial velocity when they hit the part of the hill depicted on the graph at 11 m/s.



(a) How do you find the impulse from 30 to 60 seconds?

(b) Which 30 seconds time interval contains a net negative impulse?

(c) What is the impulse from 30 to 60 seconds?

(d) What is the impulse from 90 to 120 seconds?

(e) What is the impulse from 150 to 180 seconds?

(f) Using the information from text above combined with the graph; calculate the final velocity **at the 60-second mark.**

(g) Calculate the final velocity **at the 120-second mark**.

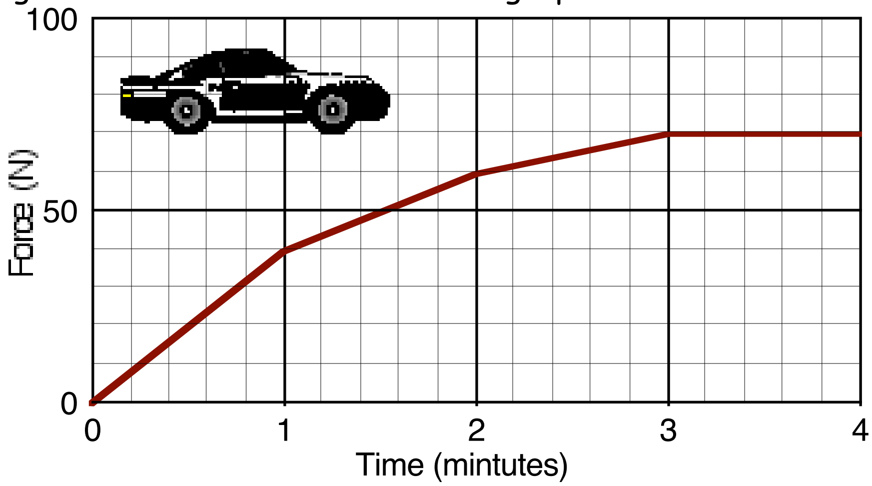
(h) Calculate the final velocity at the end of the ride?

(i) What was the average velocity for the entire ride?

(j) What is the (average) acceleration over the entire ride?

(k) What must the initial velocity be so that Calvin and Hobbes come to a rest at the end of the ride?

A toy car, 3.0 kg exerts the force shown on the graph.



Express all answers in standard S.I. units.

(a) What is the change in speed from 1 to 2 minutes?

(b) What is the change in speed from 2 to 3 minutes?

(c) If the final velocity at 3 minutes is 10 m/s, then what is the initial velocity at 2 minutes?

(d) If the initial velocity is of the car is 5 m/s at 1 minute, then what is the velocity of the car at 2 minutes?

(e) If the car starts from rest at 0 minutes, then what is the velocity of the car after the first 4 minutes?

(f) What is the momentum of the car at 3 minutes if the car started from rest?

Momentum, **p**, is the product of **mv**. The mass and velocity must be put in standard SI units.

1. What is the momentum of a 70 kg runner traveling at 10 $^m/_s$?
2. What is the momentum of a 800 kg car traveling at 20 $^m/_s$?
3. What is the momentum of a 47 gram tennis ball that is traveling at 40 $^m/_s$?
4. What is the momentum of a 120 pound bicyclist that is traveling at 25 mph?
5. What is the momentum of a 1500 pound car that is traveling 5 mph?
6. What is the speed of a 0.050 kg bullet that is to have the same momentum as the car in problem #5?
7. What is the speed of a 60 kg runner that travels with the same momentum as the car in problem #5? (Answer in m/s and mph).

8. What is the momentum of a 453 gram football that is thrown with a speed of 30 $^m/_s$?
9. How fast must a 150 g baseball be traveling to have the same momentum as the football in problem #8? (Answer in m/s and mph)

Changes in momentum, Δp. $\Delta p = mv_{final} - mv_{initial}$.
Direction counts! If the object switches directions then the Δp is added.

10. What is the change in momentum of a 950 kg car that travels from 40 $^m/_s$ to 31 $^m/_s$?

11. What is the change in momentum of a 40 kg runner that travels from 5 m/s to 11 $^m/_s$?

12. A mud blob, 0.350 kg, is thrown at a wall at 10 $^m/_s$. The blob sticks to the wall. What is the change in momentum of the blob?

13. A 0.095 kg tennis ball is traveling 40 $^m/_s$ when it bounces of a wall and travels in the opposite direction it came from. It left the wall with a speed of 30 $^m/_s$. What is the change in momentum of the ball?

14. A baseball, 167 grams, is pitched at 50 $^m/_s$ when is hit by the batter. The ball travels in the opposite direction it was thrown from with a speed of 70 $^m/_s$. What is the change in momentum of the baseball?

15. In a football game a 70 kg player is running at 10 $^m/_s$ when another player hits him. When the other player hits him he bounces off in the opposite direction at 5 $^m/_s$. What is the player's change in momentum?

IMPULSE ($J = Ft = \Delta p$)

16. If the runner, in #11, took 30 seconds to change its speed, then what force caused the change?

17. If the car, in #10, took 2 minutes to change its speed, then what force caused the change?

18. How much time was taken to stop the blob in #12 if the mud blob was stopped by 400 N force?

19. Contact with the ball in #13 lasts for 0.05 seconds. What force caused the ball's change in speed?

20. The baseball in #14 is hit by a 1608 N force. How long is the ball in contact with the bat?

21. When the two players collide in #15, their contact took 0.05 seconds. What force did each player in the collision exert?

22. Baseball pitcher throws a fastball with a 100 Ns impulse. If he applied the force in 0.15 seconds, what force did he apply?

23. A hockey puck is hit by a hockey player at the goalie. The puck is hit with a 1200 Newton force. The stick made contact for 0.1 seconds. What impulse was given to the puck?

    If a goalie stopped it with a force that acts for 0.65 seconds, then what force did he apply?

24. In a lacrosse game a ball is thrown with a force of 2000 N. the throwing force acted for 0.8 seconds. Another player stopped the ball in 0.3 seconds with their helmet. What force did their helmet use to stop the ball?

25. A 1000 kg car crashed into a bearer. The car changed speed from 30 $^{m}/_{s}$ to 20 $^{m}/_{s}$ in 2 seconds. What force did the bearer apply to stop the car?

26. A 60 kg skateboarder accelerated from 5 $^{m}/_{s}$ to 12 $^{m}/_{s}$. She applied a force of 4200 N. How quickly did she accelerate?

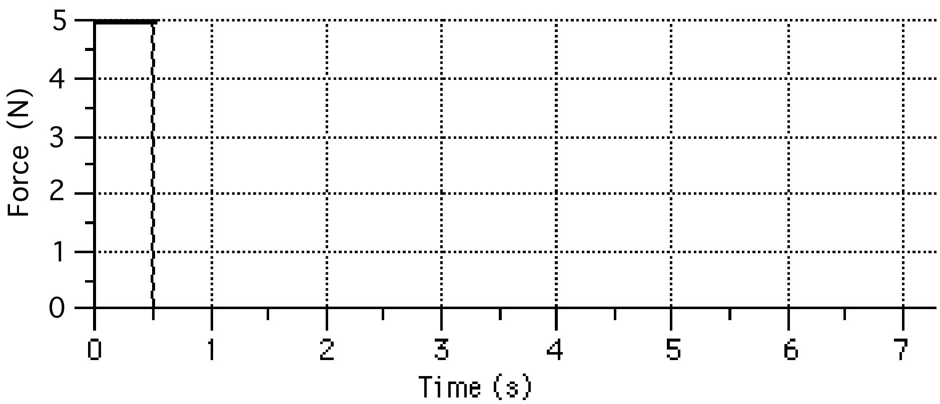
27. An outfielder stops a ball that is originally hit with an impulse of 2000 Ns. The balls mass is 0.25 kg. What was the ball's change in speed when the outfielder stopped it?

Specific Impulse

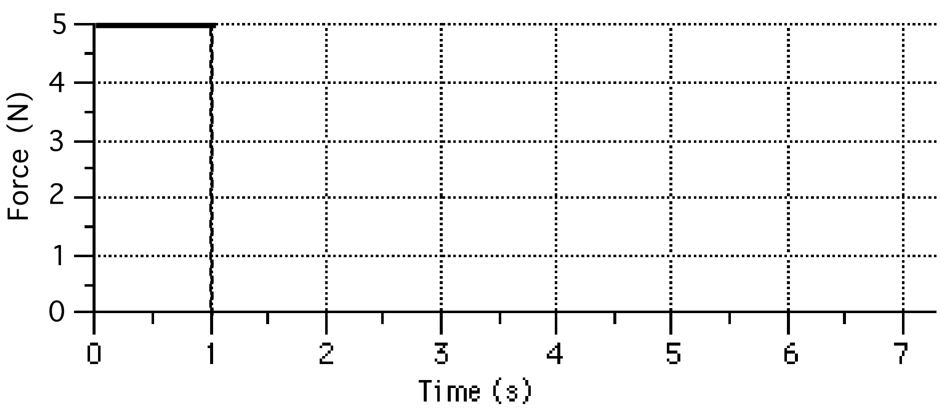
Model rocket engines are marked by a letter, a number, hyphen, and another number. The first number is the thrust of the motor in Newtons, the second is the time delay between when the motor burns out and the ejection charge is ignited. Figure out what the letters stand for.

Calculate the impulse for each of the graphs that represent the rocket motors thrust time curve.

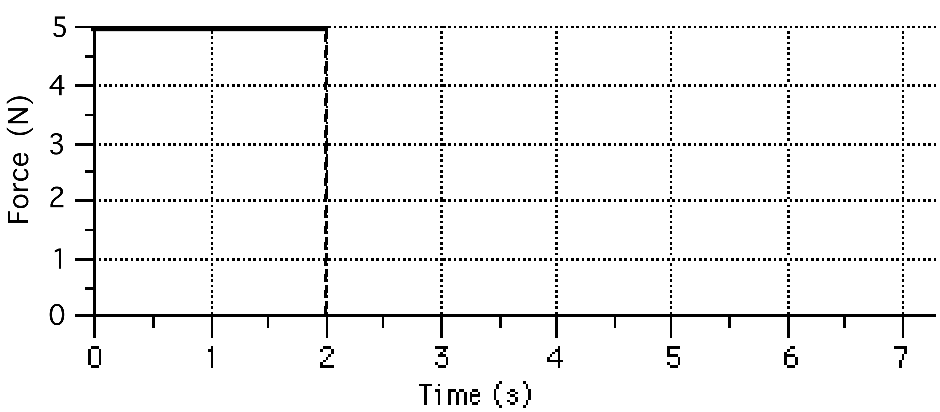
28. THE A5-3



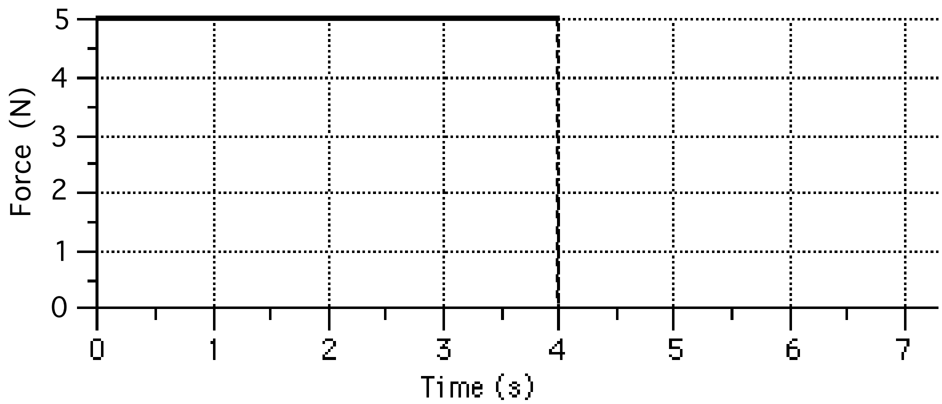
29. THE B5-3



30. THE C5-3

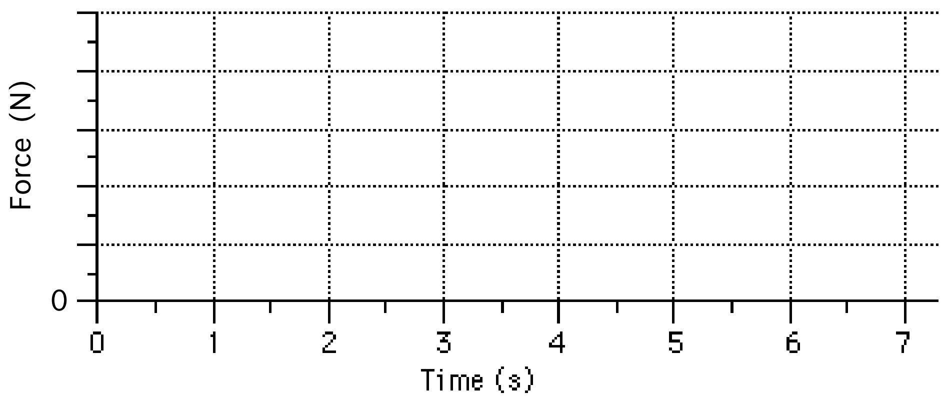


31. THE D5-3

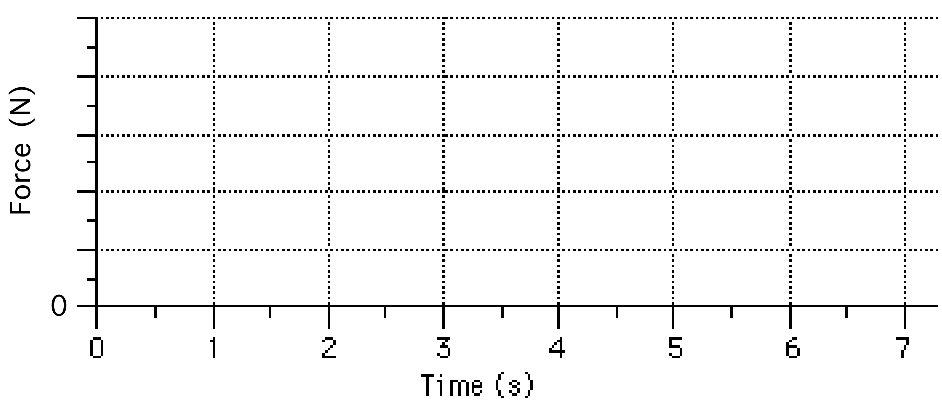


DRAW AN FORCE VERSUS IMPULSE GRAPH FOR THE FOLLOWING ROCKET MOTORS

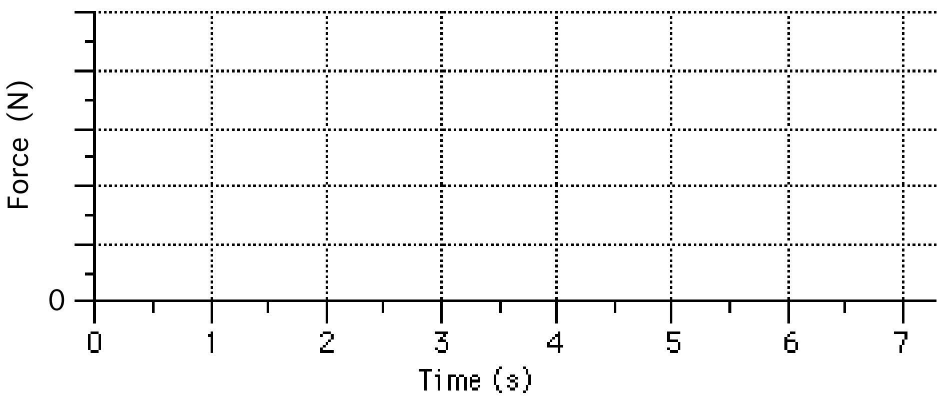
32. THE D12-3



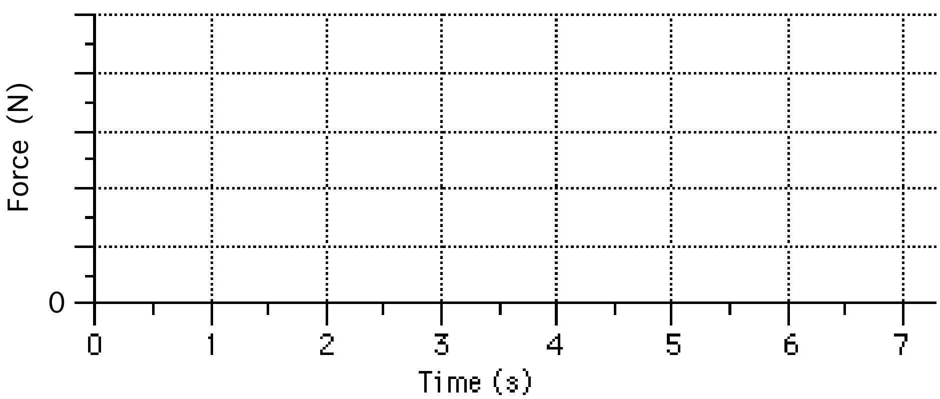
33. THE B6-5



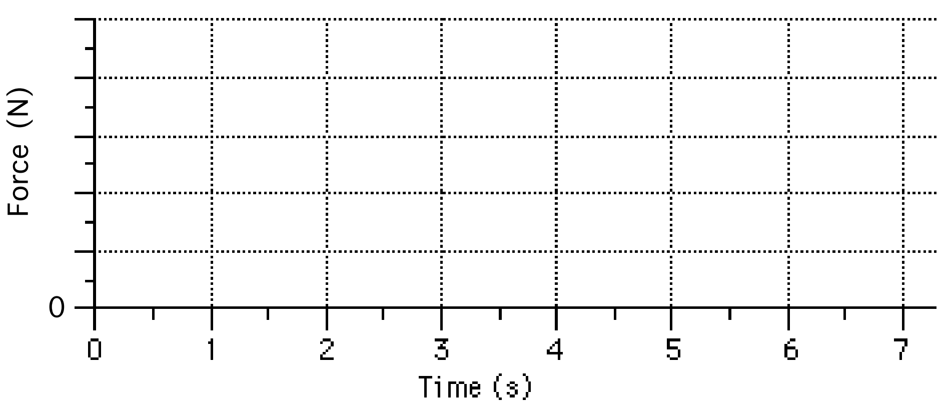
34. THE A8-3



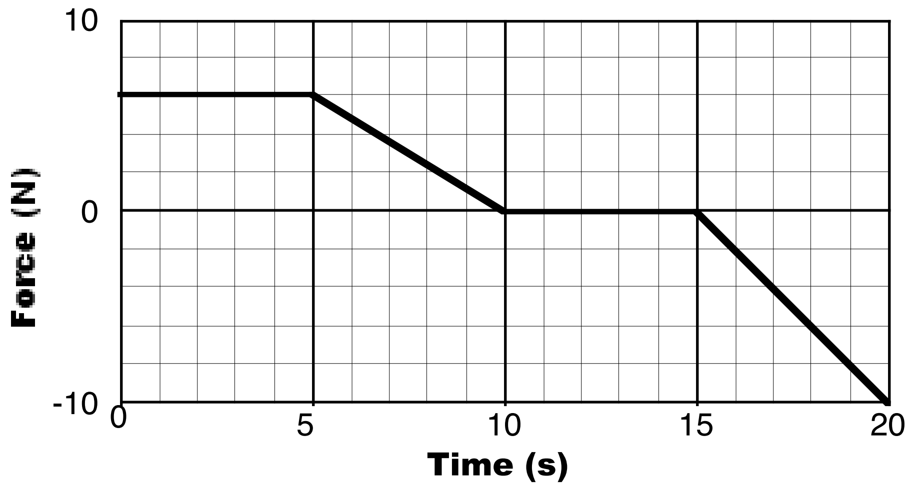
35. THE 1/2A3-4



36. THE B6-6



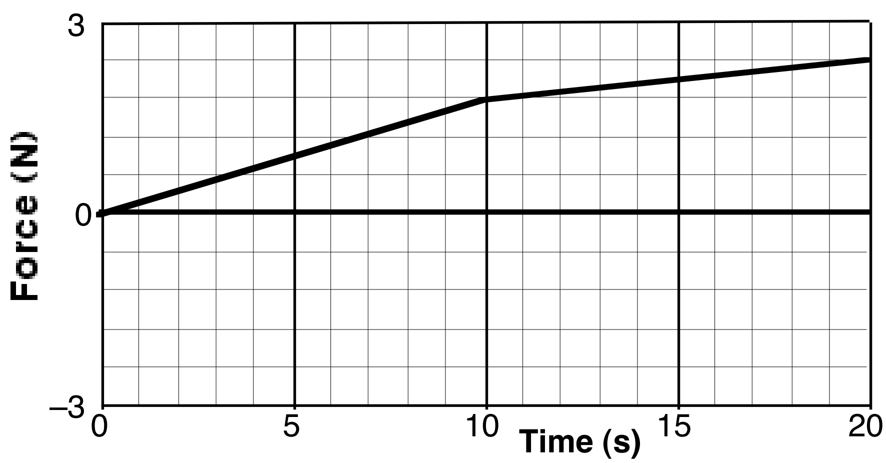
To the right is a force versus time graph for a child's toy car. The toy is malfunctioning and is producing the force shown.



37 What is velocity of the toy car, 0.756 kg, after 20 seconds if it starts from rest?

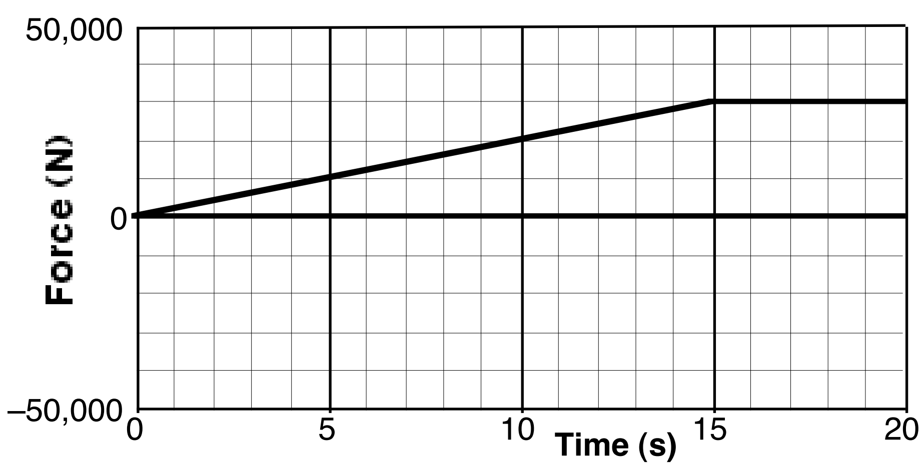
38 What is velocity of the toy car, 0.756 kg, after 20 seconds if it starts from 10 m/s?

To the right is a force versus time graph for a child's toy dart gun. The toy is malfunctioning and is producing the force shown.



39 What is the mass of the dart if the change in velocity is 25 m/s during the 20 s?

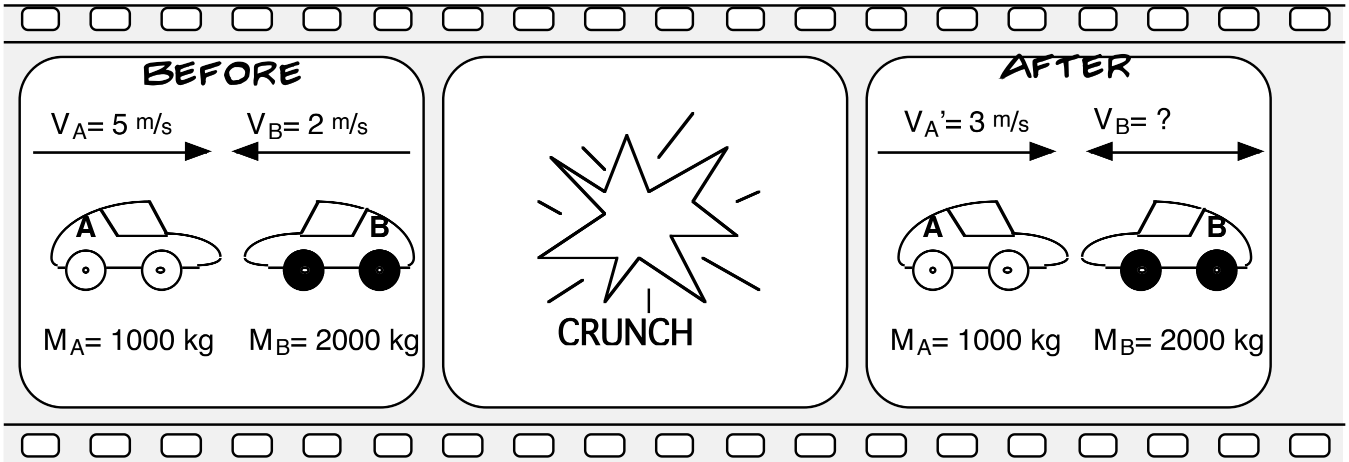
To the right is a force versus time graph for an automobile.



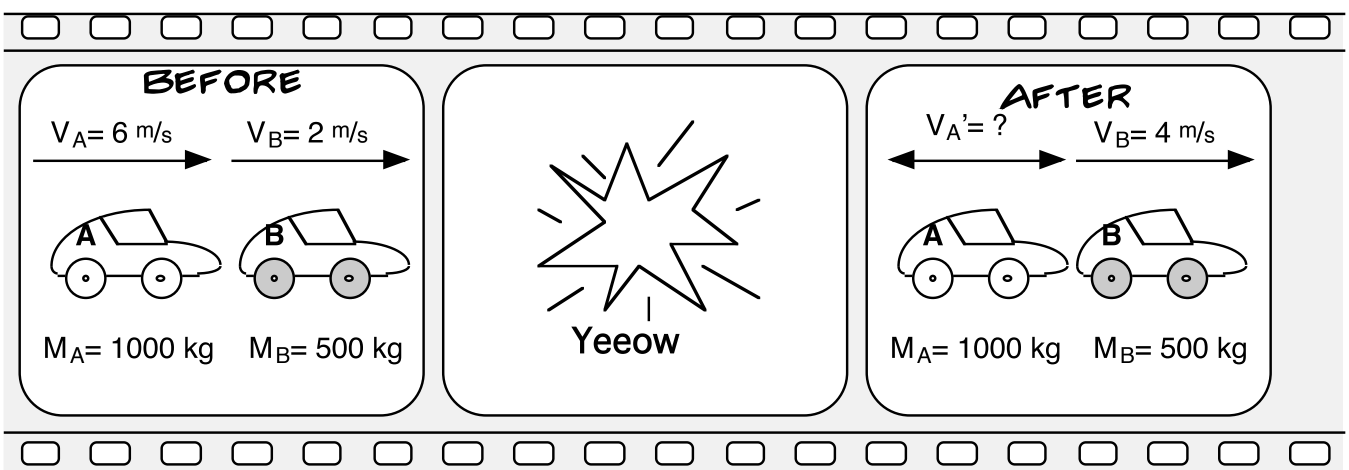
40 If the partially loaded tractor trailer truck is traveling 20 m/s when a force accelerated it to 30 m/s after 15 seconds, then what is the mass of the truck?

ELASTIC COLLISIONS

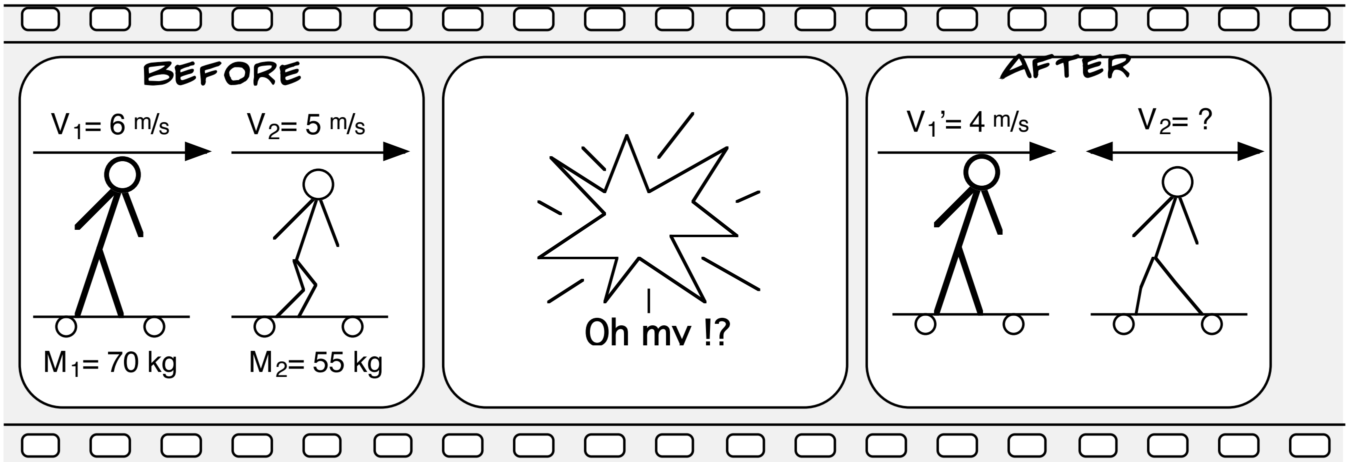
37. Two cars collide head on. Car **A** has a mass of 1000 kg car **B** has a mass of 2000 kg. What is the speed of car **B** after the collision?



38. Two cars bump going the same direction. Car A has a mass of 1000 kg car B has a mass of 500 kg. What is the speed of car A after the collision?



39. 2 skate boarders collide while traveling in the same direction. Skate boarder 1 has a mass of 70 kg and skate boarder 2 has a mass of 55 kg. What is the speed of skate boarder 2 after the collision?



40. Two football players collide head-on. The defensive player has a mass of 100 kg the offensive player has a mass of 90 kg. What is the speed of the offensive player after the collision?

(defense) (offense) (defense)
100 kg------> <--------90 kg 100 kg-->
6 m/s 2 m/s 1 m/s

INELASTIC

41. A loaded train freight car (10 metric tons) rolls at 2 m/s towards a resting car (mass = 2 metric tons). Upon collision, the two cars couple (lock together).
a. What is the speed of the two cars after the collision?
b. Calculate the impulse felt by each car.

42. A loaded train freight car (10 metric tons) rolls at 2 m/s towards another freight car. The second freight car is traveling towards the first at 3 m/s. Its mass is 15 metric tons. Upon collision, the two cars couple (lock together).
a. What is the speed and direction of the two cars after the collision?
b. Calculate the impulse felt by each car.

43. In the previous problem, suppose the initial velocity of the 15 metric ton car was not known. After the collision the two cars came to a rest.
a. What was the speed of the second freight car before the collision?
b. What impulse was felt by each car?

44. Two cars collide in a head on collision. They lock together.

-----------> <-----------
1200 kg 1500 kg
28 m/s 20 m/s

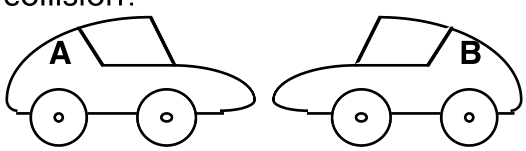
a. What is the speed and direction of the two cars after the collision?
b. Calculate the impulse felt by each car.
c. If the collision lasted 0.7 seconds, what force is felt by each car?

45. Two football players collide. The offensive player, mass = 100, was running at 8.00 m/s. A defensive player catches up to the offensive player from behind. The defensive player was traveling 11 m/s when he tackled the other player.
a. What was the speed of the two players after the collision?
b. What impulse is felt by each player?
c. If the collision lasted 0.05 seconds, then what was the force felt by each player?

46. Two football players collide head-on. The defensive player has a mass of 100 kg the offensive player has a mass of 90 kg. What is the speed of the two players after the collision if they don't separate?

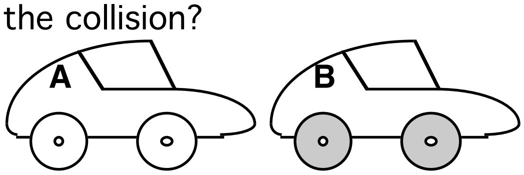
100 kg------> <--------90 kg
6 m/s 2 m/s

47. Two cars collide and then stick together in an accident. Car A has a mass of 1000 kg car B has a mass of 2000 kg. What is the speed of the cars after the collision?



1000kg ------> <------ 2000 kg
5 m/s 2 m/s

48. Two cars bump going the same direction and stick together. Car A has a mass of 1000 kg car B has a mass of 2000 kg. What is the speed of the cars after the collision?



1000kg ------> 2000 kg --->
5 m/s 2 m/s

49. Two vehicles collide as shown below. For each collision calculate:

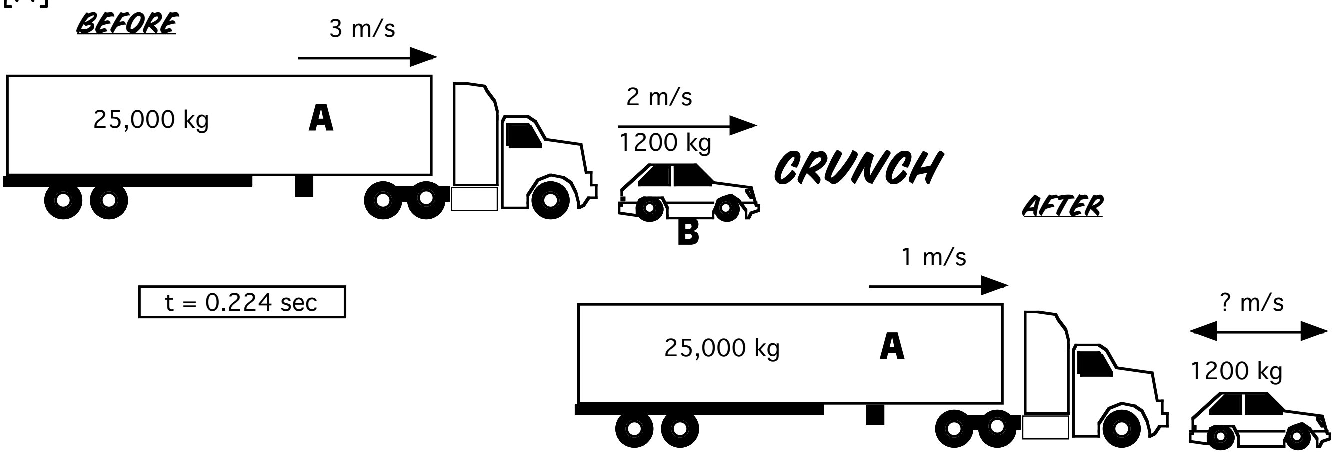
(a) ...the unknown velocity.

(b) ...the impulse on vehicle "A."

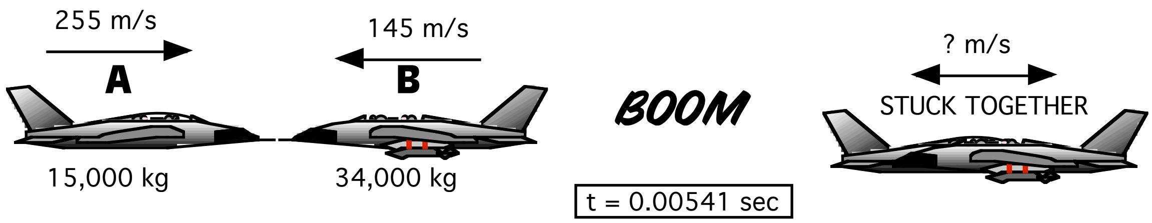
(c) ...the impulse on vehicle "B."

(d) ...the force of the collision given the times shown. -When shown.

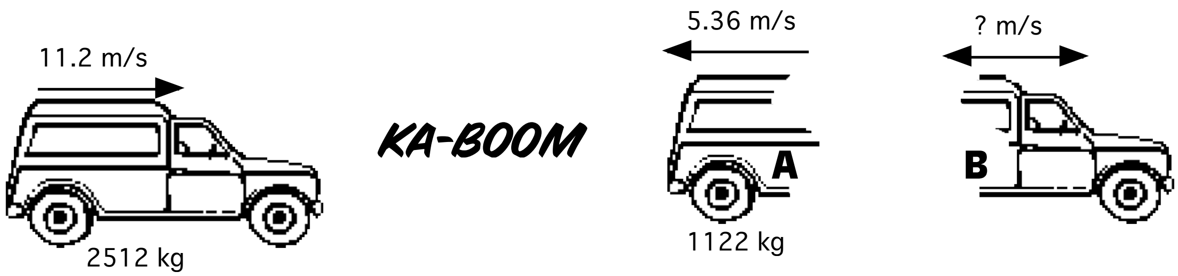
[A]



[B]



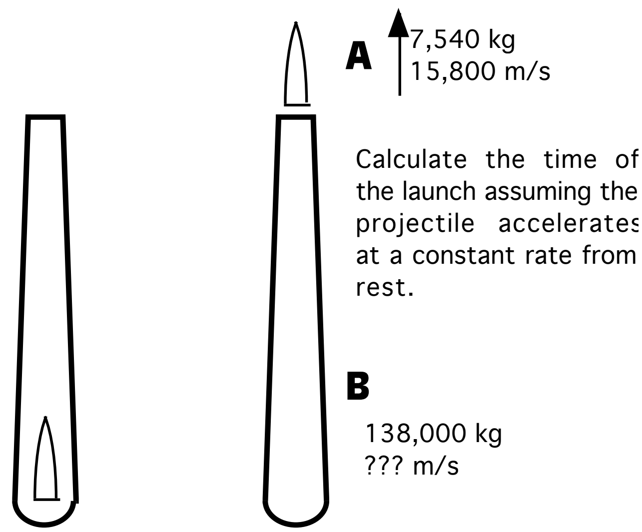
[C]



[D]

[E]

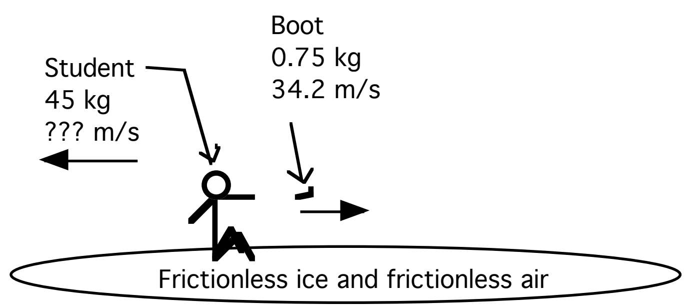
The Baltimore Cannon Club tried to recreate Jules Verne's cannon/ rocket ship. They cast a canon 402 m long to fire the projectile. Given the charge, they calculated a muzzle velocity of 15,800 m/s.



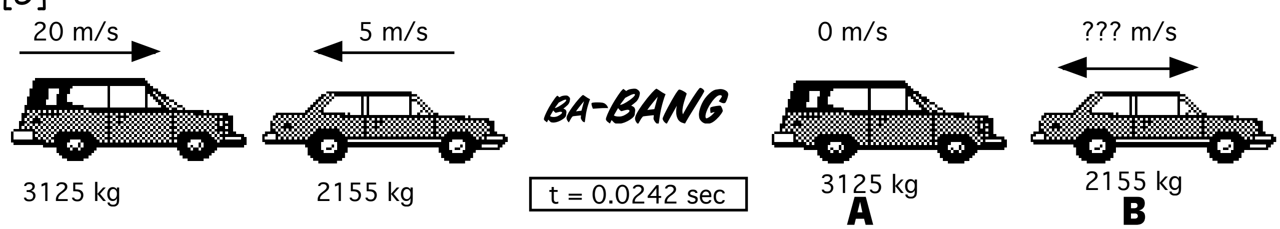
[F]

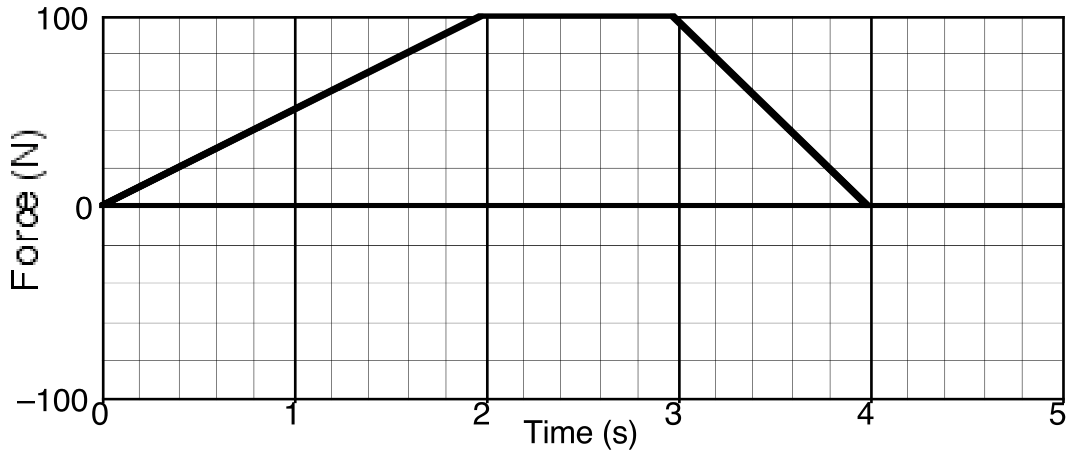
A student is sitting on a lake of frictionless ice at rest. (How he got there nobody knows.) To slide to the other side, he throws his boot.

<u>Additional question</u>: If he has to slide 9.43 m to get to the other side and he slides at a constant velocity, then how much time will it take to reach the shore?

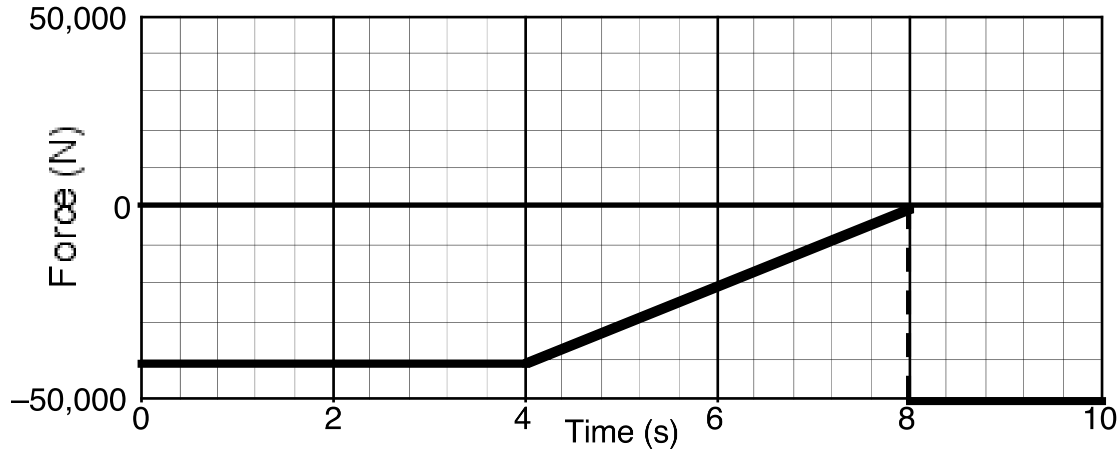


[G]





50. A toy car experience the force graph above as it travels from 2 m/s to 20 m/s during the first 3 seconds of the graph. What is the mass of the car?



51. A large truck slows down according to the force graph above. The car's initial velocity is 35 m/s. After 10 seconds, what is the truck's final velocity if its mass is 11,000 kg?

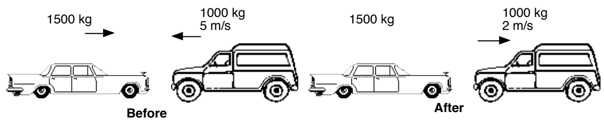
52. What is the magnitude of the average force that slowed the truck mentioned in the previous problem?

53. A device shoots a heavy rock. The device is very dramatic and takes 15 seconds to launch the rock according to the force graph above. If the rock has a mass of 50 kg, then what is the change in velocity of the rock across after the 15 seconds above?

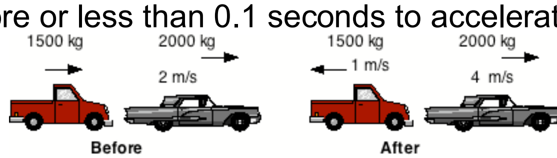
54. How much force did this take?

These problems combine previously taught concepts with impulse and momentum

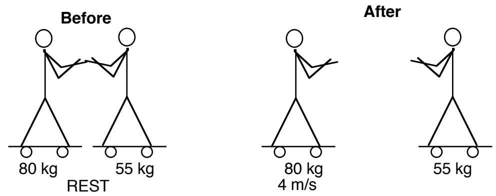
55. A car and a truck collide as shown. But before the collision, the car rolled down a hill from rest. The hill has a height of 0.46 meters. What was the speed and direction of the car after it collided with the truck?



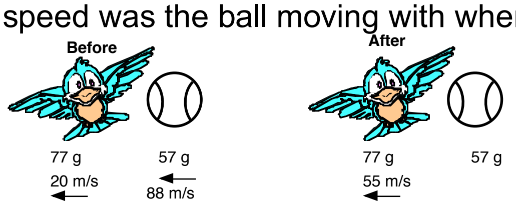
56. In a parking lot, two cars collide as shown. The driver of the red truck says that he was traveling at less than 1 m/s when he hit the car in front of him. He knows this because his truck can accelerate 10 m/s^2 from rest and he only pressed in the accelerator pedal for 0.1 seconds. The truck has been taken back to CSI central and tested. It does accelerate at 10 m/s2 from a rest. Using the information below, and your smarts about physics, determine if it took more or less than 0.1 seconds to accelerate to the collision speed.



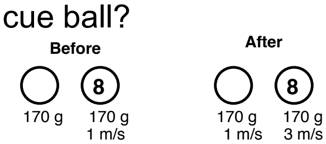
57. A boy and girl on skateboards are at rest touching hands. In one motion they push off of each other as shown below. If the frictional force slowing them down is 200 N, how much does each person travel until he or she comes to a rest?



58. In a tennis match, a ball hits a bird as shown below. After hitting the bird the ball falls 15 m to the ground. What speed was the ball moving with when it hit the ground?



59. A cue ball hits a billiard ball as shown below. The billiard ball was hit by a cue stick. Assuming the billiard ball started from rest before accelerating to the impact velocity, then how much time was the billiard's cue stick in contact with the ball if it moved 0.50 cm while making contact with the cue ball?



60. A 145 gram baseball is traveling at 45 m/s when it collides head on with a 0.92 kg bat moving at 29 m/s. The bat make contact for with the ball for 0.000402 seconds. After contact with the bat the bat is moving at 15.8 m/s. The ball travels straight to the pitcher, 18.288 m. Assuming the ball decelerates at 5 m/s^2, calculate how much time the ball took to reach the pitcher.

ANSWERS

1) 700 kg•m/s	2) 16,000 kg•m/s	3) 1.88 kg•m/s	4) 607.39 kg•m/s	5) 1518.46 kg•m/s
6) 30,369.29 m/s	7) 25.31 m/s	8) 13.59 m/s	9) 90.6 m/s, 202.94 mph	
10) 8550 kg•m/s	11) 240 kg•m/s	12) 3.5 kg•m/s	13) 6.65 kg•m/s	14) 20.04 kg•m/s
15) 1050 kg•m/s	16) 285 N	17) 2 N	18) 0.00875 s	19) 133 N
20) 0.012 s	21) 21,000 N	22) 666.67 N	23) 120 Ns, 780 Ns	24)
25)	26)	27)	28)	29)
30)	31)	32)	33)	34)
35)	36)	37) -1 m/s	38) 5 m/s	39) 9.82 m/s
40) 3.56 m/s	41a) 5/3 m/s	41b) ±3333.3 N•s	42a) -1 m/s	43b) ±20,000 N•s
44a) 1.33 m.s	44b) ± 32,000 N•s	44c) 45,714.29	45a) 9.57 m/s	45b) 154.14
45c) 3142.86	46) 2.21 m.s	47) 1/3 m/s	48) 3 m/s	
49[A]a) 43.67 m/s		49[A]b) 50,000 N•s		
49[A]c)–50,000 N•s			49[A]d) 223,214.29 N	
49[B]a) 22.55 M/S LEFT		49[B]b) 4,163,265.31N•s		
49[B]c)-4,163,265.31N•s		49[B]d) 769,549,964 N		
49[C]a) 24.57 m/s		49[C]b) 18,581.32 N•s		
49[C]c) -18,581.32 N•s		49[C]d) No Answer		
49[D]a) 46.87 m/s	49[D]b) OMIT	49[D]c) OMIT	49[D]d) OMIT	
49[E]a)	49[E]b)	49[E]c)	49[E]d)	
49[F]a)	49[F]b)	49[F]c)	49[F]d)	49[F]Additional)
49[G]a)	49[G]b)	49[G]c)	49[G]d)	

Objectives

Fluid Dynamics

1. Define a fluid, gas, density, and pressure.
2. Give the standard S.I. units for the new concepts above.
3. Define the value in understanding pressure through applications.
4. Define one atmosphere of pressure in Pascals.
5. Explain how a barometer works.
6. Define “Pascal’s Principle.”
7. Explain when to use Pascal’s Principle to solve problems.
8. Explain the various applications of pressure
9. Compare “hydraulics” and “pneumatics”
10. Define “pressure at depth.”
11. Describe what happens to a bubble’s size as is moves about in fluid.
12. Define gauge pressure two ways.
13. Describe what affects the pressure at the bottom of a fluid.
14. Explain application of this pressure at depth.
15. Describe why water towers are made the way they are.
16. Define the continuity equation.
17. Use the continuity equation to solve problems.
18. Define Bernoulli’s equation.
19. Apply Bernoulli’s equation to solving problems.

Fluid Dynamics

1. The circular top pf a can of soda has a radius of 0.0320 m. The pull-tab has an area of 3.80 x 10^{-4} m^2. The absolute pressure of the carbon dioxide in the can is 1.40 x10^5 Pa. Find the force that this gas generates
    a. on top of the can (including the pull-tab's area) and
    b. on the pull-tab itself.
2. High-heeled shoes can cause tremendous pressure to be applied to a floor. Suppose the radius of a heel is 6.00 x 10^{-3} m. At times during normal walking motion, nearly the entire body weight acts perpendicular to the surface of such a heel. Find the pressure that is applied to the floor under the heel because the weight of a 50.0 kg woman.
3. A cylinder is fitted with a piston, beneath which is a spring, as in the drawing. The cylinder is open at the top. There is no friction. The spring constant of the spring is 2900 N/m. The piston has negligible mass and a radius of 0.030 m. When the air beneath the piston is completely pumped out,
    a. how much does the atmosphere's pressure cause the piston to compress?
    b. How much work does the atmosphere to in compressing the spring?
4. The Mariana trench is located in the Pacific Ocean and has a depth of approximately 11,000 m. The density of seawater is approximately 1025 kg/m^3.
    a. If a diving chamber were to explore such depths, what force would the water exert on the chamber's observation window (radius = 0.10 m)?
    b. For comparison, determine the weight of a jumbo jet whose mass is 1.2 x 10^5 kg.
5. A water tower has a vertical pipe that is filled with water. The pipe is open to the atmosphere at the top. The pipe is 22 m high. At the bottom of this pipe is a hole with a cork in it.
    a. What is the pressure at this hole when the cork is in the hole?
    b. What is the pressure when the cork is removed and the water is allowed to squirt onto the ground?
6. A buoyant force of 26 N acts on a piece of quartz that is completely immersed in ethyl alcohol. What is the volume of the quartz? $\rho_{ethanol}$ = 785.06 kg/m^3
7. Oil is flowing with a speed of 1.22 m/s through a pipeline with a radius of 0.305 m. How many gallons of oil (1 gal = 3.79x10^{-3} m^3) flow in a day?
8. A small crack forms at the bottom of a 15.0 m high dam. The effective crack area through which the water leaves is 1.00 x 10^{-3} m^2.
    a. What is the speed of the water flowing through this crack?
    b. How many cubic meters of water per second flow through the crack?
9. An airplane wing is designed so that the speed of the air across the top of the wing is 248 m/s when the speed below the wing is 225 m/s. The density of air is 1.29 kg/m^3. What is the lifting force on a wing that is rectangular and 2 m x 10 m?
10. Water is running out of a faucet, falling straight down, with an initial speed of 0.50 m/s. At what distance below the faucet is the radius of the stream reduced to half of its original radius at the faucet?

ANSWERS		
1) a. 450 N b. 53.2 N	5) ???	9) 1.40 x 10^5 N
2) 4.33x10^6 Pa	6) 3.3 x 10^{-3} m^3	10) 0.19 m
3) 0.097 N b. 14 J	7) 0.356 m^3/kg, 8.12x10^6 gal	

Objectives

Electrostatics

Students should be able to:

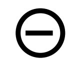
1. Define and list Insulators
2. Define and list Conductors
3. Describe the "charge model"
4. Describe charging due to induction
5. Describe charging due to charge sharing
6. Ben Franklin's Kite experiment.
   a. Describe what lightning was though to be prior to June, 1752.
   b. Describe its importance.
7. Lightning Safety
8. Define a FARADAY cage
9. Give examples of a Faraday cage
10. Solve problems involving charge sharing
11. Describe the ionization of gasses
12. Describe the ionic wind
13. Define an E-Field.
14. Draw an electric field (E-field) between two charged objects
15. Identify the charge of an object based upon its E-field
16. Describe the direction a positively or negatively charged object will travel when immersed in an E-field
17. List the rules for drawing an E-field
18. Describe the relative E-field strengths between two objects based upon their E-fields
19. Define the SI units of an E-field
20. Calculate the magnitude of the force felt on a charged particle when immersed in an E-field
21. Use the relationship F=qE in solving word problems
22. Ratio problems
23. Numerical evaluation problems
24. Draw the symbol for a battery
25. Label the positive and negative terminals on a battery symbol
26. Define what is meant by electrical "current."
27. Give the symbol for current.
28. Describe in physics terms what a dead battery represents
29. Describe the recharging of a battery
30. Calculate how long a battery will last before becoming dead or how long it will take to recharge a battery.
31. Use V=Ed in solving word problems
32. Use the relationship V=Ed in solving word problems
   a. Ratio problems
   b. Numerical evaluation problems
33. Define an "electronVolt" and use it in calculations

DRAWING ELECTRIC FIELDS

Follow the rules of electric fields and draw what the electric fields looks like.

1

4

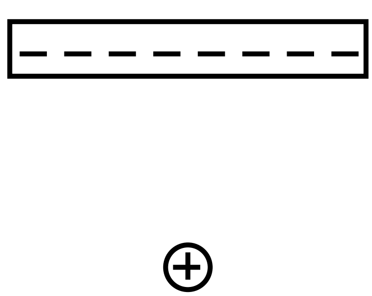


2

5

3 times the charge of the other

3



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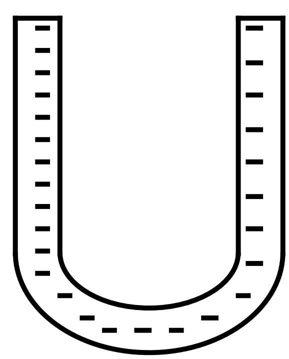


Charging Batteries Worksheet

Recharge units is the consumer unit A•hrs …not Coulombs

7. A battery can produce 1.2 amps for 1 hour before going "dead." What is the battery's charge value?

8. A battery can produce 0.4 amps for 4 hours before going "dead." What is the battery's charge value?

9. A battery can produce 0.2 amps for 6 hours before going "dead." What is the battery's charge value?

10. The batteries for many radio control cars are rated at 1.2 A•hrs. How much current should be pumped into the batteries if they are to be recharged in 15 minutes?

11. In a radio shack catalog a light bulb is rated to draw 0.045 amps at 6.0 Volts. If a 6.0 Volt battery has a charge rating of 2.2A•hrs, then how much time can the light be run by the battery before the battery goes "dead."

12. A toy motor draws 2.4 amps from a 1.5 Volt battery when turned on. If the battery runs the motor before it goes dead, then what is the A•hr rating of the battery?

13. A flashlight will last for 2.5 hours before the batteries go dead. The batteries A•hr rating is 1.2 A.hrs (combined). The flashlight's batteries produce 3.0 Volts. How much current does the flashlight's bulb draw?

14. A cassette player runs off of a batteries. The two batteries put out 3.0 Volts (together) in the player. The player is rated at 5 watts. If the batteries have a charge rating of 1.2 A•hrs then, how long will the cassette player run before the batteries go dead?

E-FIELDS F=qE: V=Ed; W=qV

15. An electron is immersed in an E-field (electric field) of 20 N/C. What force does it feel?

16. A charged particle with the charge of 3 electrons feels a force of 1.6×10^{-18}N. What size is the E-field that it is immersed in?

17. A charged particle is immersed in an E-field of 10^{28} N/C and feels a force of 5×10^{-6}N. What is the charge of this particle?

18. A proton feels a force of 9.5×10^{-21}. What is the strength of the E-field that is in?

19. An electron is immersed in an E-field of 0.067 N/C when place between 2 plates connected to a 4.5 Volt battery. What is the distance between the two plates?

20. What Voltage is connected to two plates that create an E-field of 10,000 N/C that are separated 0.00068 cm?

21 A proton is immersed in an E-field of 32×10^{8} N/C. The plates that create the E-field are separated 0.082 mm. What voltage is connected to the plates?

22. A charged particle feels a force of 9.2×10^{-18}N. The particle is placed between two plates that are separated by a distance of 0.025cm and are connected two a 6.0 volt battery. What is the charge of the particle?

23. A proton is placed between two plates that are separated by a distance of 4.35 m. The plates are connected to a 60.0 Volt battery. What force does the proton feel? And which plate will the proton travel to? (The positive or the negative?)

24. An electron is immersed in an E-field (electric field) of 20 N/C. What force does it feel?

25. A proton feels a force of 8.0×10^{-17}N. What size is the E-field that it is immersed in?

26. A particle with a charge of 11 elementary charges is immersed in an E-filed of 30 N/C. What force does this charged particle feel?

27. A charged particle is immersed in an E-field of 1000 N/C and feels a force of

15 X 10^{-14}N. What is the charge of this particle?

28. A proton feels a force of 1 X 10^{-17}. What is the strength of the E-field that is in?
29. What force does an electron feel when it is immersed in an electric field of 456 N/C?
30. What is the charge on a particle that feels a force of 4.35 X 10^{-16} when it is immersed in an E-field of 10 N/C?
31. What is the force on a particle with a charge of 1 X 10^{6} elementary charges when immersed in an E-field of 1200 N/C?
32. What is the charge on a particle that feels a force of 20.0 N when it in immersed in an E-field of 5.5 N/C?
33. What is the electric field surrounding a particle with a charge of 2500 C that feels a force of 33 N?
34. A proton is placed between two plates that are attached to a 6 Volt battery. The plates are 0.56m apart. What is the strength of the E-field?
35. An electron feels an E-field of 10 N/C when place between 2 plates connected to a 9 Volt battery. What is the distance between the two plates?
36. What voltage is connected to two plates that create an E-field of 1000 N/C that are separated 6.8 cm?
37. A proton is immersed in an E-field of 12 N/C. the plates that create the E-field are separated 8.2 cm. What voltage is connected to the plates?
38. A 12 Volt battery is connected to two plates separated 0.23 m. What E-field is generated between these plates?
38. What distance are two plates separated by if they are connected to a 9.0 Volt battery and generate an electric field of 1258 N/C?
39. An electron feels a force of 10 N while being immersed in an electric field. A distance of 0.57 m separates the plates that create that E-field. What is the voltage of the battery connected to the plates?
40. A charged particle feels a force of 12 X 10^{-14}N. The particle is placed between two plates that are separated by a distance of 25 cm and are connected to a 3.0 Volt battery. What is the charge of the particle?
41. A proton is placed between two plates that are separated by a distance of 4.35 cm. The plates are connected two a 45.0 Volt battery. What force does the proton feel? And which plate will the proton travel to? (The positive or the negative?)
42. What is the distance between two plates that are connected to a 24 Volt battery? An electron placed between the plates feels a force 1.6 X 10^{-16}N.
43. A charged particle feels a force of 8 X 10^{-17}N. The particle is placed between two plates that are separated by a distance of 6.8 cm and are connected two a 9.0 Volt battery. What is the charge of the particle?
44. A charged particle with a charge of 2 protons feels a force of 50N while being immersed in an electric field. A distance of 2.4 cm separates the plates that create that E-field. What is the voltage of the battery connected to the plates?
45. An electron is placed between two plates that are separated by a distance of 0.0076 cm. The plates are connected to a 90.0 Volt battery. What force does the electron feel? And which plate will the electron travel to? (The positive or the negative?) Will the electron go in the direction of the E-field or in the opposite direction of the E-field?

RATIO STYLE PROBLEMS

46. A small particle feels a force when placed in an electric field. By what factor is the force acting on the particle changed if the e-field strength is tripled? (All other factors remain unchanged.)

47. A small particle feels a force when placed in an electric field. By what factor is the force acting on the particle changed if the e-field strength is tripled and the particles charge is halved? (All other factors remain unchanged.)

48a. A small particle feels a force when placed in an electric field. By what factor is the e-field changed by if the particle's charge is tripled? (All other factors remain unchanged.)

48b. An electric field exists between two plates connected to a battery. How is the e-field affected if the battery's voltage is changed by a factor of 2/3? (All other factors remain unchanged.)

49. An electric field exists between two plates connected to a battery. How is the distance between he plates affected if the e-field's strength is tripled and the voltage on the battery is changed by a factor of 6/20? (All other factors remain unchanged.)

50. An electric field exists between two plates connected to a battery. A particle is placed in this electric field. How is the force the particle feels affected if the voltage on the battery is changed by a factor of 4/3? (All other factors remain unchanged.)

51. An electric field exists between two plates connected to a battery. A particle is placed in this electric field. How is the force the particle feels affected if the distance between the plates is changed by a factor of 3/7? (All other factors remain unchanged.)

52. An electric field exists between two plates connected to a battery. A particle is placed in this electric field. How is the force the particle feels affected if the distance between the plates is changed by a factor of 4/3 and the voltage on the battery changes by a factor of 6? (All other factors remain unchanged.)

53. An electric field exists between two plates connected to a battery. A particle is placed in this electric field. How is the force the particle feels affected if the voltage on the battery is changed by a factor of 5/3 and the distance between the plates changes by a factor of 9 and the change on the particle changes by a factor of 2/3? (All other factors remain unchanged.)

54. An electric field exists between two plates connected to a battery. A particle is placed in this electric field. How is the e-field affected if the voltage on the battery is changed by a factor of 5/2 and the distance between the plates changes by a factor of 4? (All other factors remain unchanged.)

55. An electric field exists between two plates connected to a battery. A particle is placed in this electric field. How is the force the particle feels affected if the voltage on the battery is changed by a factor of 2/5 and the distance between the plates changes by a factor of 3/7 and the charge itself is doubled? (All other factors remain unchanged.)

E-field follow-up

56. An electron is immersed in an E-field (electric field) of 20 N/C. What force does it feel? What is its acceleration? How fast will the electron be traveling after 0.001 seconds if it starts from rest?

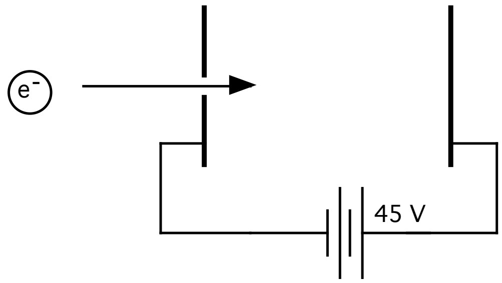
57. A particle with a charge of 11 elementary charges and a mass of 5.0 x 10^{-30} kg is immersed in an E-field of 30 N/C. What force does this charged particle feel? What is its acceleration?

58. What force does an electron feel when it is immersed in an electric field of 456 N/C? What is its acceleration? If it starts from rest how long will it take to reach a speed of 24.6 m/s (55 mph)? How much distance will it need to reach 24.6 m/s?

59. What is the force on a particle with a charge of 1 X 10^6 elementary charges when immersed in an E-field of 1200 N/C? What is its acceleration? If it starts from rest, how much distance will it need to reach 1.0 m/s? How much time will this take?

60. A proton is placed between two plates that are separated by a distance of 4.35 cm. The plates are connected two a 45.0 Volt battery. What force does the proton feel? And which plate will the proton travel to? (The positive or the negative?) What is its acceleration? How fast will the electron be traveling after 0.0010 seconds if it starts from rest? How much distance will it travel in 0.0010 S?

61. An electron is placed between two plates that are separated by a distance of 0.0076 cm. The plates are connected to a 90.0 Volt battery. What force does the electron feel? And which plate will the electron travel to? (The positive or the negative?) Will the electron go in the direction of the E-field or in the opposite direction of the E-field? What is its acceleration? How fast will the electron be traveling after 1.0 year if it starts from rest? How much distance will it travel in 1.0 year?

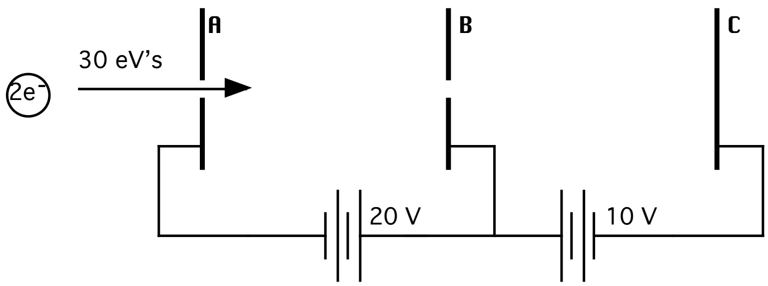


62 How much work is done in traveling across the plates, in joules?

63 Does the electron slow down or speed up?

64 What form of energy does the electron have when it reaches the other side?

65 How fast is the electron traveling when it reaches the opposite plate assuming it started from rest?

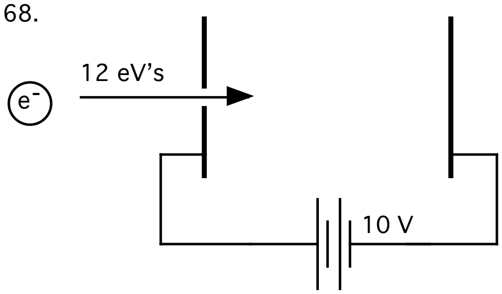


66 How much energy does the particle have when it reaches plate “**B**” in eV's?

67 How much energy does the particle have when it reaches plate “**C**” in eV's?

How much energy, in eV's, will the charge have when it reaches the opposite plate?

68.



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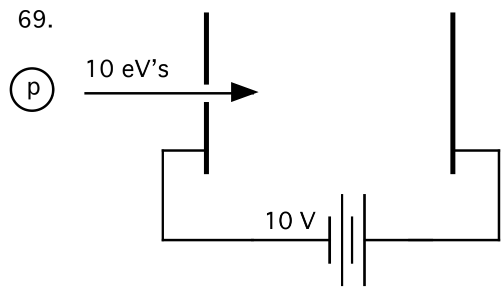

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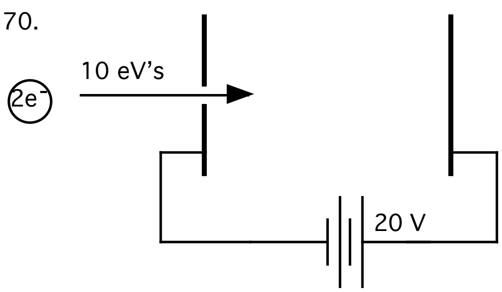

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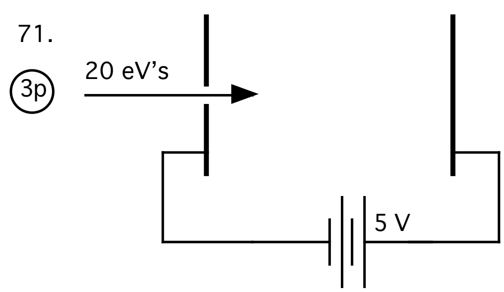

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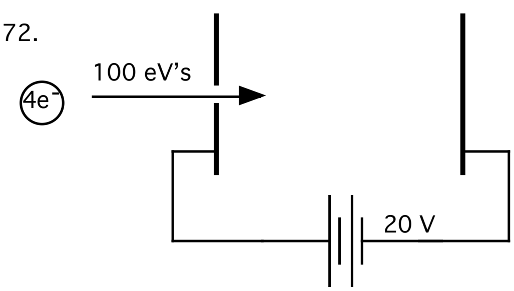

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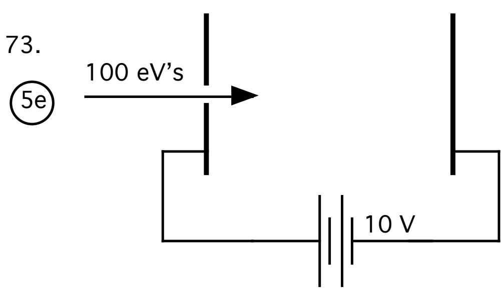
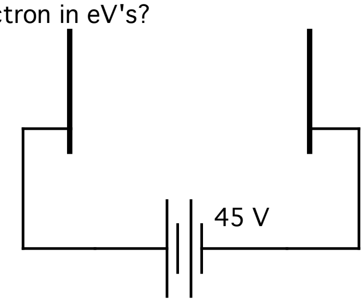
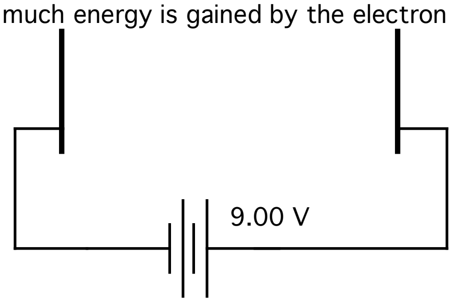


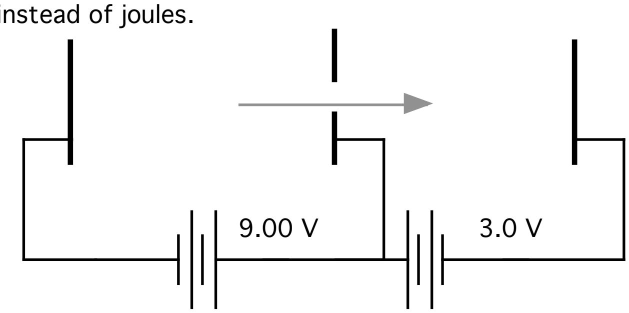
74. Two plates are separated as drawn below. A 45 Volt battery is connected to them. An electron is emitted from the negative plate and is attracted towards the positive plate.
a. How much work is done by the electric field in moving the electron across the plates?
b. How much energy does the electron have when it reaches the opposite plate assuming it started at rest?
c. How fast is the electron traveling when it hits the positive plate?
d. How much energy is gained by the electron in eV's?



75. Two plates are separated as drawn below. A 9.0 Volt battery is connected to the plates. An electron is emitted from the negative plate and is attracted towards the positive plate.
a. How much work is done by the electric field in moving the electron across the plates?
b. How much energy does the electron have when it reaches the opposite plate assuming it started at rest?
c. How fast is the electron traveling when it hits the positive plate?
d. How much energy is gained by the electron in eV's?



76. Three plates are separated as drawn below. A 9.0 Volt battery is connected to the 1st set of plates. A 3.0 Volt battery is connected to the second series of plates. An electron is emitted from the negative of the first series of plates and is attracted towards the positive plate; then passes through a hole in the second plate to the third plate.
a. How much work is done by the electric field in moving the electron across the 1st set of plates?
b. How much work is done by the electric field in moving the electron across the 2nd set of plates?
c. How much work is done by the electric field in moving the electron across all of the plates?
d. How much energy does the electron have when it reaches the middle plate assuming it started at rest?
e. How much energy does the electron have when it reaches the final plate?
f. How fast is the electron traveling when it hits the final plate?
g. Answer (d) and (e) in eV's instead of joules.



7	1.2 A•hr
8	1.6 A•hr
9	1.2 A•hr
10	4.8 A
11	48.89 hr
12	3.6 A•hr
13	0.48 A
14	0.72 hr
15	3.2 X 10^{-18} N
16	3.33 N/C
17	5 X 10^{-34} C
18	0.059 N
19	67.16 m
20	6.8 V
21	262,600,000 V
22	7.36 X 10^{-17} C
23	Negative, 3.2 X 10^{-18} N
24	?
25	500 N/C
26	5.28 X 10^{-17} N
27	1.5 X 10^{-16} C
28	62.5 N/C
29	7.30 X 10^{-17} N
30	2.30 X 10^{16} C
31	1.92 X 10^{-32} N
32	3.64 C
33	82,500 N/C
34	10.71 N/C
35	0.9 m
36	68 V
37	0.98 V
38	52.17 N/C
39	3.56 X 10^{19}V
40	1 X 10-14 C
41	negative, 1.65 X 10^{-16}N
42	0.024 m
43	6.04 X 10-19 C
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	3.2 X 10^{-18}N
	3.51 X 10^{12} m/s^2
	3.51 X 10^{9} m/s
57	mass = 3 X 10^{-29} kg
	5.28 X 10^{-17} N
	1.76 X 10^{12} m/s^2
58	7.296 X 10^{-17} N
	8.01 X 10^{13} m/s^2
	3.07 X 10^{-13} s
	3.78 X 10^{-12}m
59	mass = 1 X 10^{-26} kg
	1.92 X 10^{-10} N
	1.92 X 10^{16} m/s^2
	2.60 X 10^{-17} m
	5.21 X 10^{-17} s
60	1.03 X 10^{9} N
	negative
	6.19 X 10^{29} m/s^2
	6.19 X 10^{26} m/s
	3.09 X 10^{23} m
61	1.89 X 10^{-13} N
	positive
	opposite
	2.07 X 10^{17} m/s
	1.09 X 10^{23} m/s
	2.87 X 10^{28} m

Electrostatics Constant Cover Sheet

Electrostatics Constants Sheet

You will be given a new copy of this sheet for your test. None of the values on this page need to be memorized.

$e = 1.60 \times 10^{-19}$ C (Elementary charge, assumed positive unless noted otherwise.)

$1 \text{ eV} = 1.60 \times 10^{-19}$ J

$C = 6.25 \times 10^{18}$ elementary charges

$1 \text{ J} = 6.25 \times 10^{18}$ eV

electron's charge = -1.6×10^{-19} C

electron's mass = 9.109×10^{-31} kg

proton's charge = 1.6×10^{-19} C

proton's mass = 1.672×10^{-27} kg

constant in coulomb's Law: $k = 2.306 \times 10^{-28} \left(\frac{Nm^2}{e^2}\right) = 8.99 \times 10^{9} \left(\frac{Nm^2}{C^2}\right)$

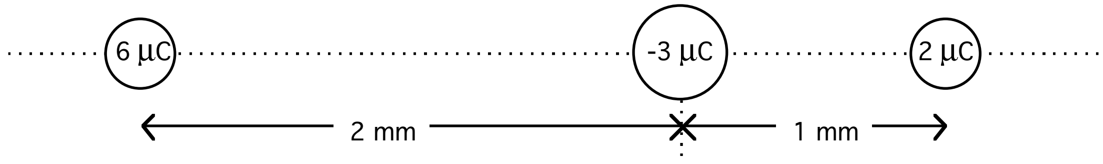
Objectives

Coulomb's Law

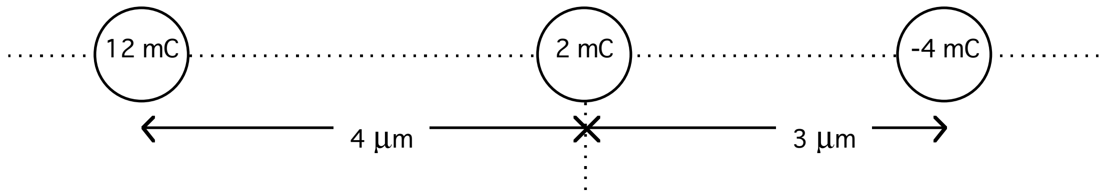
Students will be able to:

1. Identify the correct variables in a word problem.
2. Convert from prefixes such as m, μ, and p to the corresponding powers of 10.
3. Find the electrostatic force of attraction or repulsion between two charges.
4. Find the electrostatic force due to more than one charge on a single charge. (Includes magnitude and direction.)

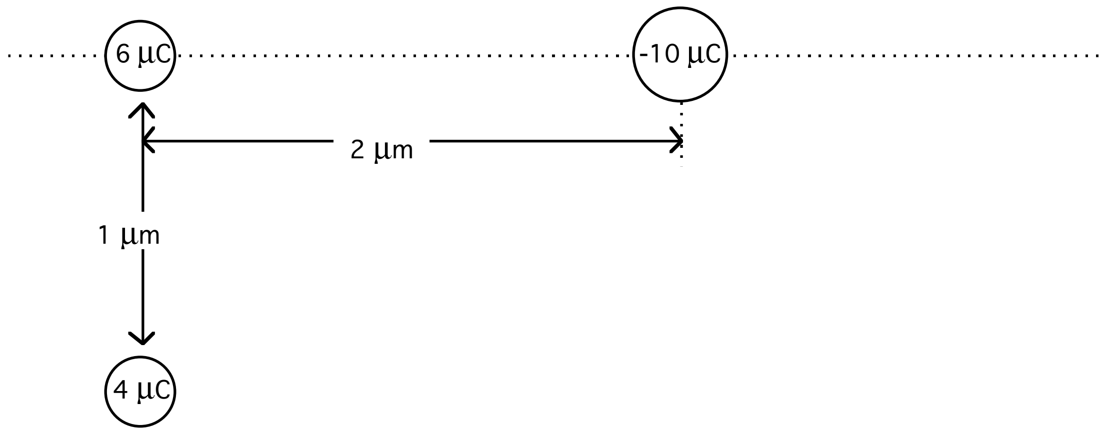
Problem 1



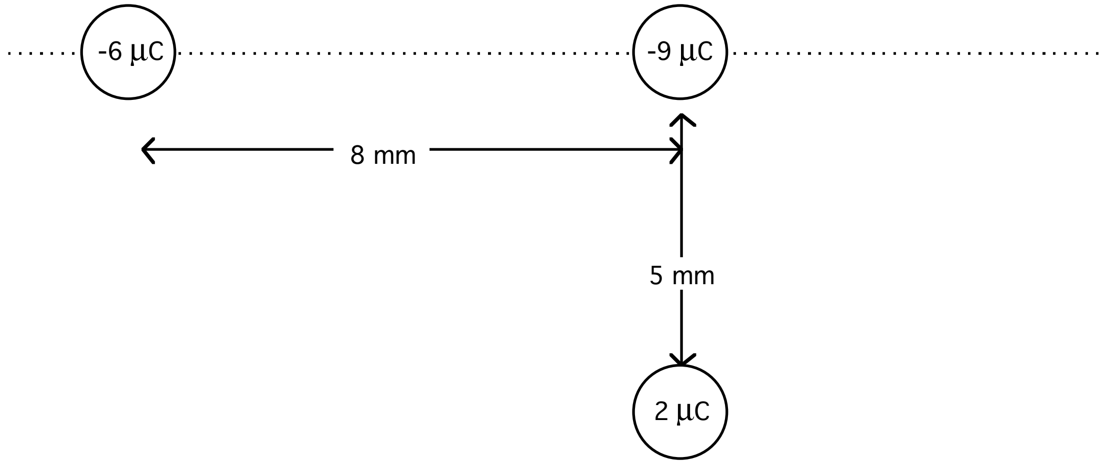
Problem 2



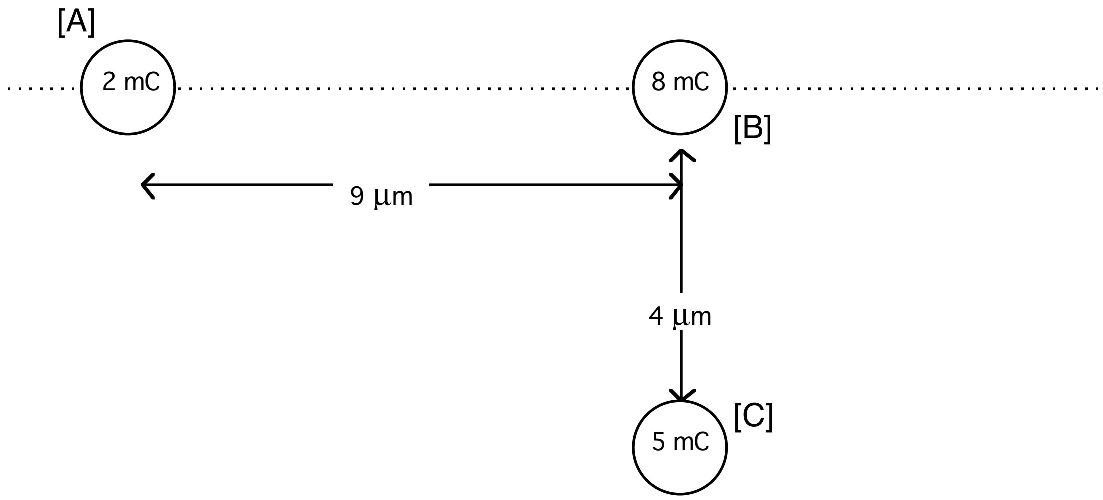
Problem 3



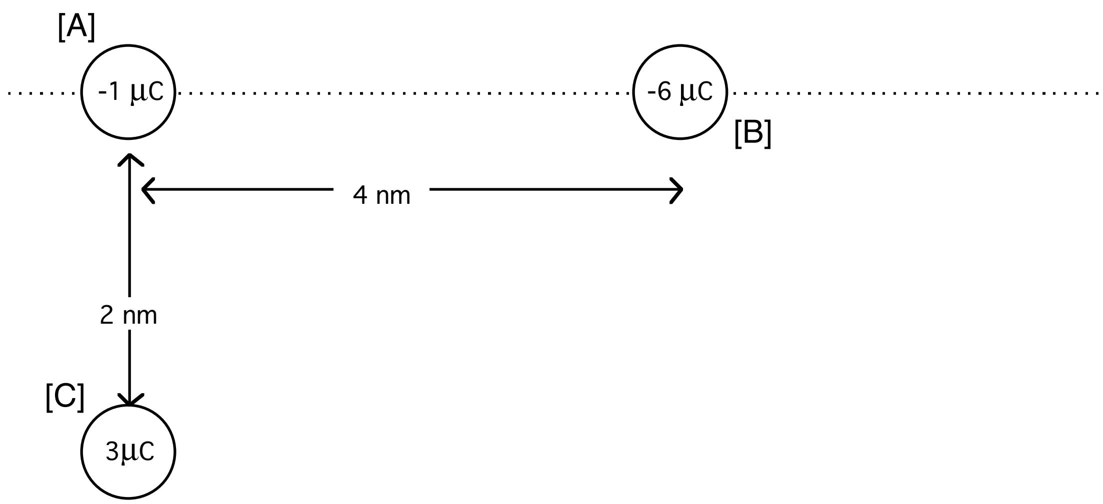
Problem 4



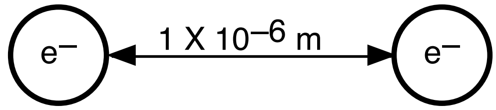
Problem 5



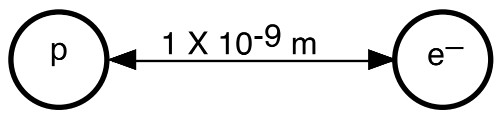
Problem 6



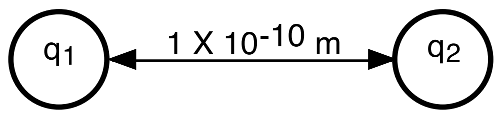
1. Below are two electrons separated by some diagramed distance. What is the net force (DIRECTION and MAGNITUDE) felt on the electron to the right due to the electron on the left?



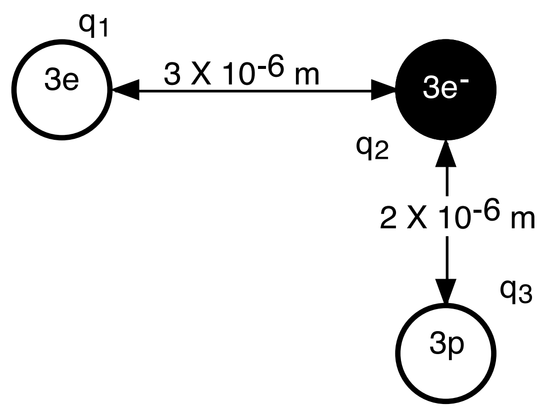
2. Below are an electron and a proton separated by some diagramed distance. What is the net force (DIRECTION and MAGNITUDE) felt on the proton due to the electron?



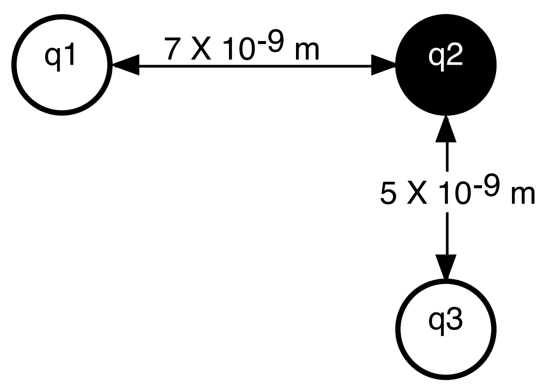
3. Below is a particle q1 with a charge equal to 3 electrons and another charged particle with a charge of 2 protons separated by some diagramed distance. What is the net force (DIRECTION and MAGNITUDE) felt on the q_1 due to the q_2?



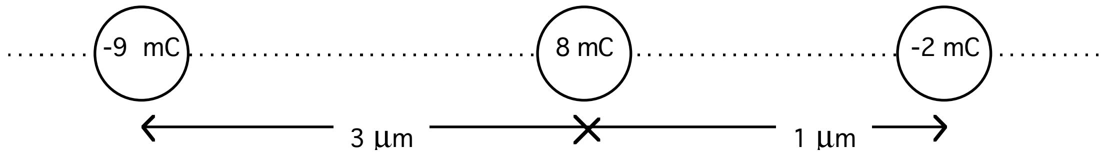
4. Below are three charges. q1 has a charge of 3 elementary charges. q2 has a charge of 3 negative elementary charges. q3 has a charge equal to 3 protons. What is the net force (DIRECTION and MAGNITUDE) felt on the charge containing 3 negative elementary charges?



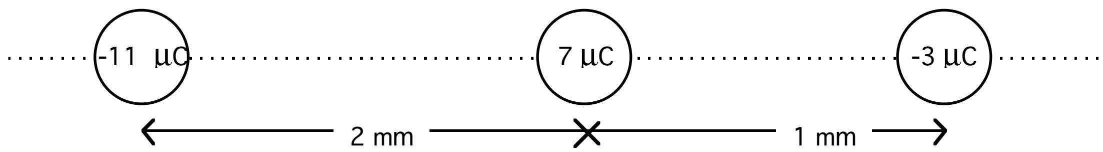
5. Below are three charges. q1 has a charge of 6 elementary charges. q2 has a charge of 2 electrons. Q3 is a proton. What is the net force (DIRECTION and MAGNITUDE) felt on q2?



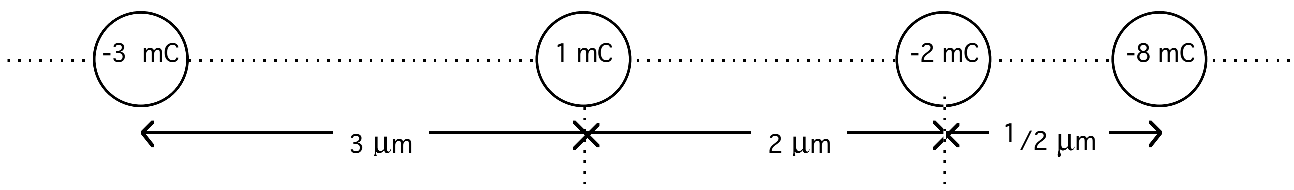
5 Find the net force on 8 mC.
6 Find the net force on -2 mC.



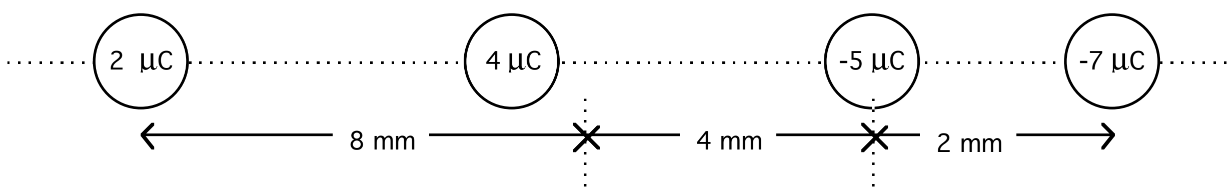
7 Find the net force on -11 μC.
8 Find the net force on -3 μC.



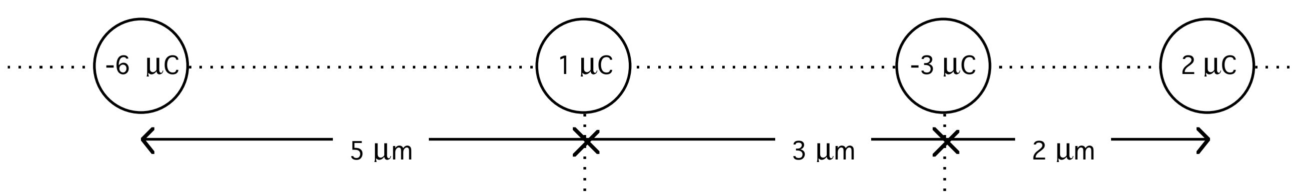
9 Find the net force on -8 mC.
10 Find the net force on 1 mC.



11 Find the net force on 4 μC.
12 Find the net force on -7 μC.



13 Find the net force on 1 μC.
14 Find the net force on 2 μC.



Objectives

Electricity Basics

Students should be able to:

1. Write all the chapter's formulae
2. Define all the S.I. units of each variable.
3. Define Ohm's Law
4. Calculate the power used by an appliance.
5. Use the power relationships to solve problems.
6. Define a.c. and d.c. and give examples of each.
7. Identify the current graph associated with an a.c. or d.c. current.
8. Select the appropriate AC/DC battery adapter.
9. Describe what happens to an adapter or the appliance it is plugged in to if the adapter's voltage is greater than, equal to, or less than the batteries voltage.
10. Describe what happens to an adapter or the appliance it is plugged in to if the adapter's current is greater than, equal to, or less than the appliance's current.
11. Describe what happens to an adapter or the appliance it is plugged in to if the adapter's polarity does not match the appliance's polarity.
12. Describe, simplistically, what a battery is.
13. Calculate the charge value of a battery.
14. Calculate the life of a battery when it is connected to an electrical device.
15. Calculate the cost of running a certain appliance that is plugged into the standard a.c. outlet.
16. Calculate how long an appliance needs to run to use up a specified amount of money.
17. Describe how a household circuit works in relation to a circuit breaker or fuse.
18. Describe how a replaceable fuse works.
19. Describe what each "hole" in a household outlet "does" or means.

Current Definition

1. 3.00 C of charge pass a point in a wire in 3.0 ms. how much current is this?

2. $3.00 \text{ X } 10^{12}$ electrons pass a point in a wire in 0.0060 seconds. What is the current in the wire in amps?

3. How many electrons pass a point in a conductor in 1 second if the wire's current is 0.05 amps?

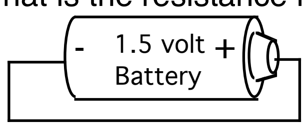
Ohm's Law

4. The fuse for a car radio is a thin wire. The wire is made to burn apart is the current is too high? What is the resistance of a fuse if it is to burn apart when 2.00 amps pass through it at 240 volts?

5. A light bulb is plugged into a wall outlet. It uses 0.68 A. What is the light bulb's resistance?

6. A flash light bulb is labeled to uses 1.77 A. Its resistance is 1.60 Ω. What voltage is the light bulb rated for?

7 A 1.5 volt battery is has a wire connecting its positive side to its negative side. The battery draws 0.10 amps of current. What is the resistance in the battery to create this current?



8 A flashlight light bulb is rated to take 2.83 Volts and use 0.300 amps. What is the resistance of the filament?

9 Another flash light bulb is rated to use 0.300 A and has a resistance of 4.0 Ω. How much voltage does this bulb use?

10 A stereo speaker has a resistance of 8.00 Ω. When it is operating at full power (exactly100 watts) it uses 35 volts of electricity. What is the current drawn by the speaker?

11 A 100 Watt light bulb draws 0.83333 amps from a wall outlet (120 volts). What is the resistance of the light bulb's filament?

12 A toaster plugged into the wall, (120 volts), uses 14 amps of electricity. What is the resistance of the toaster?

13 The thermostat in a house turns on and off the air conditioner and furnace using 24 volts. What is the current in the thermostat when it is turned on it if draws 0.100 amps?

14 A motor in a radio control car uses 7.2 volts and draws 14.4 amps of electricity. What is the resistance of the motor?

15 The volume knob on a radio varies the resistance on a line that goes to the speakers. At a low volume the resistance is 10,000 Ω. At a high volume the resistance is 10 Ω. If the stereo maintains 35 volts into the speaker then, what are the two currents going into the speaker?

16 When a battery "dies" the resistance inside the battery rises while the voltage it can produce almost always remains the same. A new 1.5 volt alkaline battery has a resistance of 0.15 ohms. An older battery may have a resistance of 15 Ω. how much current is drawn by a new and old battery?

17 The resistance of dry human skin is about 500,000 Ω and wet, sweaty, human skin is about 1000 Ω. How much current passes across someone's fingers if they touch the leads of a 9 Volt battery when their skin is wet or dry?

18 0.010 A causes involuntary muscle contractions. How much voltage is required to cause involuntary muscle contractions on wet and dry skin?

Power

19 A watch battery produces a voltage of 1.5 volts. How much power is used by the watch if it draws 0.001 A?

20 A high-tension power line carries 1,000,000 volts of electricity. If the line of to carry 200 A's, then how power does the power line carry? What is the resistance of the power line?

21 A battery is rated at 1.5 volts. This battery can produce a maximum of 15 w of power.

- How much current can this battery produce?
- What is the resistance of the wire attached to the battery?

22 A stereo speaker is rated at 8 ohms and 40 watts. A fuse is going to be installed in the speaker. The fuse can only handle a certain amount of current at 240 volts. How much current does the fuse need to handle if it is to "blow" at 40 watts?

23 A radio control car uses 7.2 volts and 14 amps. How much power does the car use?

24 What are the resistances of a 50, 100 and 150 watt light bulb that is plugged into a wall outlet, 120 volts?

25 A shorted out 12 V car battery can generate 4800 amps! (Never do this. a shorted out battery will explode.) What is the battery's resistance and how much power is generated by the battery before it explodes?

26 A hair dyer says it generates 1400 watts. It is plugged into a wall outlet, 120 volts. What is the current drawn by the hair dryer and what is its resistance?

27 On most home each circuit in a house can handle 15 amps at 120 volts. How much power is this? Will a 1400 Watt hair dryer and four 75 Watt light bulbs blow this circuit?

28 The heating element on a stove is connected to a 240 V outlet. The element draws 20 amps when it is turned on. What is the resistance and power of the element?

29 A motor on a band saw can generate 1/2 horsepower on high. If the motor is plugged into a wall outlet, how much current will it require? (746 w = hp)

30 The garbage disposal in a sink can generate 3/4 horsepower. If the disposal is plugged into a wall outlet, then how much current does it draw?

31 A small car can generate 95 hp. An equivalent electric vehicle is to be built such that it can generate the same power as its gasoline counter part. If the electric vehicle's motor uses 12 volts, then what is the resistance of the motor? What is the current drawn by the motor? How many charges are moved by the current if the car runs for 1 hour?

32 What is the current drawn by a household clock radio using 12 watts?

33 A fan draws 0.184 amps while connected to a wall outlet. What is the power rating of this fan?

34 What is the current drawn by a hair dryer using 1500 watts?

35. What is the current drawn by car stereo that is connected to the car's 12.0 volt battery, if the car stereo draws 40 watts?

36. What is the battery voltage of a portable radio that draws 0.500 amps and is rated at 1.5 watts?

37 You've just invented a "Do-Hickie" that uses 3.0 volts and draws 3.0 amps. What is the power rating of your "Do-Hickie?"

38 What is the power rating of a household light bulb that draws 0.60 amps?

39 How much current would it take to burn apart the wire inside of a 5 Amp fuse if it were connected to a 120 Volt or a 12 Volt source?

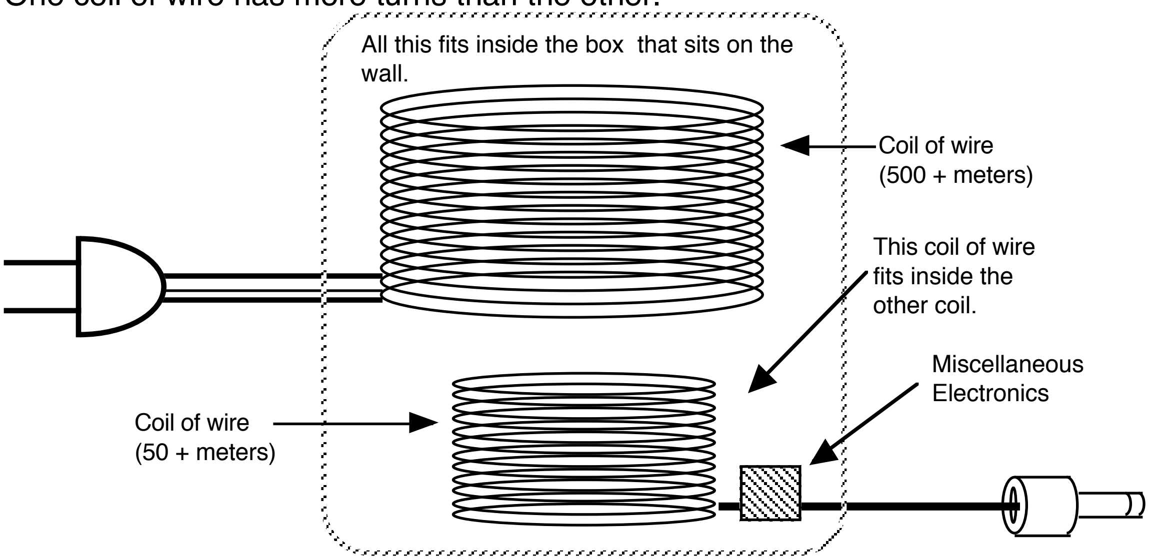
40 Stereo speaker is rated to take 100 watts. If the speaker's resistance is 8 Ω, how much voltage does the speaker use?

41 What is the power rating of a space heater that draws 9.6 amps while connected to a wall outlet?

Choosing the Right AC Adapter

NOTES

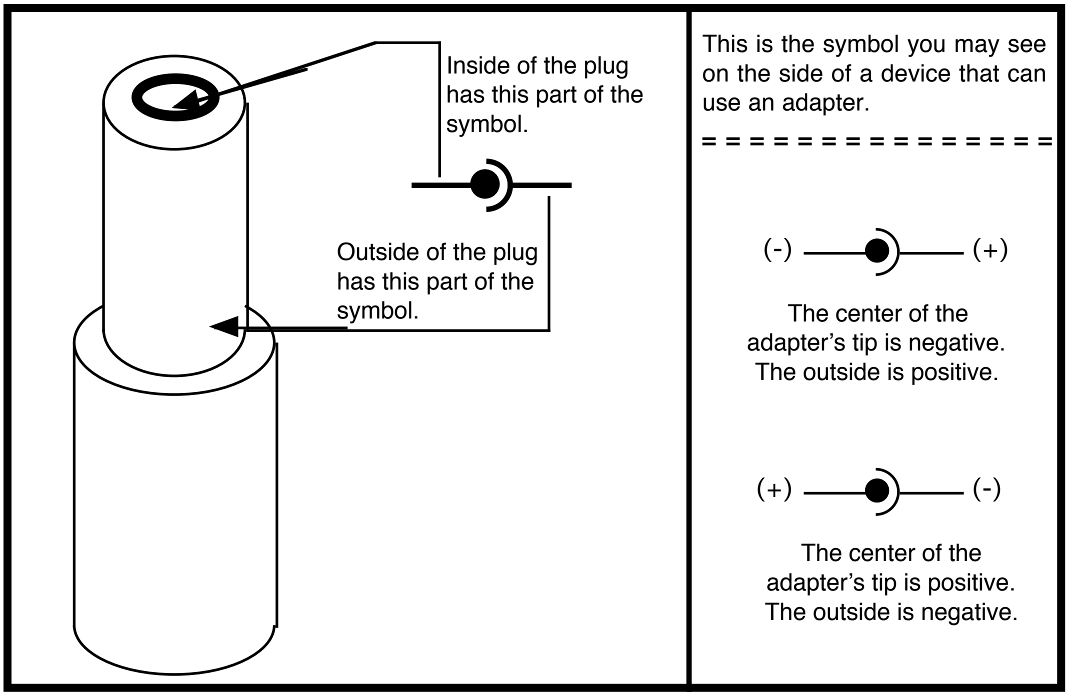
The purpose of an adapter is to adapt the 120 volts from a wall to lower voltage that equals the batteries total voltage. This is done by two coils of wire wrapped around each other. One coil of wire has more turns than the other.



The voltage on the battery side of the adapter is determined by the sum of the voltages of all the batteries. For example; if a radio uses four 1.5 V batteries then the adapter would have to be rated at 6 Volts →(1.5 V + 1.5 V + 1.5 V + 1.5 V = 6.0 V). If the adapter is less than 6 volts, then not enough energy will be supplied to run the radio. If the adapter is rated at more than 6 volts then electronics inside the radio can physically melt. The other variable to take into consideration when choosing an adapter is the current.

This is a question of supply and demand. The radio demands a specific amount of current. The adapter must be able to meet this demand. If the adapter cannot supply enough current then it overheats. This will cause it to do one of two things. (1) Get so hot the case melts -fire is a possibility. (2) The electronics inside the box melt. To summarize, the current rating on the adapter must meet or exceed the current needs of the device it is plugged into.

The plug and the appliance are polarized. The polarization of the device and the adapter must be identical. If they are backwards, it's like putting the batteries in backwards. The device will not work.


Inside of the plug has this part of the symbol.
Outside of the plug has this part of the symbol.
This is the symbol you may see on the side of a device that can use an adapter.
(-)
(+)
The center of the adapter's tip is negative. The outside is positive.
(+)
(-)
The center of the adapter's tip is positive. The outside is negative.

Below are the symbols found on various appliances. Which adapters on the beneath them on this page, if any, will run each device?

42 (-) ●) (+)
Uses 5 batteries
(1.2 volts each)
0.4 A

43 (+) ●) (-)
Uses 2 batteries
(1.5 volts each)
0.8 A

44 (+) ●) (-)
Uses 6 batteries
(1.5 volts each)
0.3 A

45 (-) ●) (+)
Uses 3 batteries
(1.5 volts each)
0.3 A

46 (+) ●) (-)
Uses 9 batteries
(1.5 volts each)
0.4 A

47 (+) ●) (-)
Uses 10 batteries
(1.2 volts each)
0.25 A

48 (-) ●) (+)
Uses 2 batteries
(1.5 volts each)
0.2 A

49 (-) ●) (+)
Uses 4 batteries
(1.5 volts each)
0.1 A

120 v AC 6 v DC/0.5 A [center positive] **-A-**	120 v AC 3 v DC/0.9 A [center negative] **-B-**	120 v AC 9 v DC/0.4 A [center negative] **-C-**	120 v AC 9 v DC/1.0 A [center negative] **-D-**
120 v AC 1.5 v DC/1.2 A [center negative] **-D-**	120 v AC 12 v DC/0.8 A [center positive] **-E-**	120 v AC 9 v DC/0.2 A [center positive] **-F-**	120 v AC 1.5 v DC/0.3 A [center negative] **-G-**
120 v AC 12 v DC/0.8 A [center positive] **-H-**	120 v AC 6 v DC/0.1 A [center negative] **-I-**	120 v AC 4.5 v DC/1.5 A [center negative] **-J-**	120 v AC 9 v DC/0.7 A [center positive] **-K-**
120 v AC 3 v DC/0.7 A [center positive] **-M-**	120 v AC 9 v DC/0.6 A [center positive] **-N-**	120 v AC 3 v DC/0.2 A [center negative] **-O-**	120 v AC 12 v DC/0.6 A [center positive] **-P-**
120 v AC 3 v DC/0.9 A [center positive] **-Q-**	120 v AC 9 v DC/1.2 A [center positive] **-R-**	120 v AC 3 v DC/0.1 A [center negative] **-S-**	120 v AC 9 v DC/0.3 A [center negative] **-T-**
120 v AC 9 v DC/0.3 A [center negative] **-U-**	120 v AC 9 v DC/0.4 A [center positive] **-V-**	120 v AC 6 v DC/0.5 A [center negative] **-W-**	120 v AC 3 v DC/0.5 A [center negative] **-X-**

Notes about battery types

Battery Type	Voltage per Cell	Typical Charge in Amp• hrs	Recharge Notes	Maximum Current Output in amps	Notes
Zinc Carbon	1.5	0.04	Can't Recharge	1	Only good for cheap flashlights
Alkaline	1.5	0.4	Can't Recharge (Except for a few special types)	10	Good for high current uses (walkmans, toys etc)
Ni-Cad	1.2	1.2	Recharge 100-500 times	10	Good for high current uses
Lithium	1.5	1.2	Can't Recharge	10	Longest shelf life (10 yrs)
Lead Acid	2	5-50	Recharge 100's to 1000's of times	2000	Super high current drains, Great rechartable
Nickle Metal Hydride	1.2	1.6	Recharge up to 500 times	10	High current use

BATTERY CHARGING & BATTERY LIFE

50. A 12.6 Volt motorcycle battery can provide 5 Amp-hours of use. The headlight on a particular motorcycle is rated at 75 watts. The headlight on this motorcycle is left on while it is parked. How many hours will pass before the battery is dead?

51. The batteries in a radio control toy are rated at 1.2 Amp-hours (1200 mA•hr). The battery's voltage output is a constant 7.2 volts. If the car's motor draws 7.2 Amps from the battery, how many minutes will it take to completely discharge the batteries? How much power is the car's motor using?

52. A flashlight uses 5 nicked batteries. The ni-cad batteries are rated at 1.2 Amp-hours total. If the light bulb is rated at 6 watts and 6.0 volts, then how much current does the light bulb draw and how long will the batteries last?

53 A battery has a charge value of 1.2 A•hrs. If the battery is connected to a motor that draws 2 amps, then how many hours will the battery last?

54 A 12 Volt motorcycle battery has a charge value of 5 A•hrs. If a light lasts for 25 hours when connected to this battery, then how much current is begin drawn by the battery?

55 A 1.5 Volt rechargeable battery has a charge value of 1.5 A•hrs. If it is connected to a charging source that delivers 4 Amps, then how long will it take to recharge the batteries?

56 What is the value of the charge rating on a 3 Volt battery that takes 1.2 hours to recharge is the charging device delivers 2 amps?

57 What is the charge value on a watch battery the lasts for 1 year is it draws 0.003 amps?

58 A car battery has a charge rating of 5 A•hrs. If the car takes 400 A's to turn the ignition motor on the car, then how many seconds of can the starter be on until the battery dies?

59 The resistance of dry human skin is 500,000 ohms. If a person with dry skin held on to the battery, how long would it take for the 1.5 Volt battery to completely discharge? The charge rating of the battery is 1.2 A•hr.

60 A flashlight is connected to a voltage source of 6 volts. The light bulb has a resistance of 8.5 Ω. If a battery has a charge rating of 1.5 A•hrs, then how long will the battery last?

61 A motor in a radio controlled car can last for 8 minutes of a 7.2 Volt battery pack. The battery pack has a charge rating of 1.2 A•hrs. What is the resistance of the car motor?

62 A cassette player draws 0.10 amps from the batteries. The combined voltage of the batteries is 6 volts. The cassette player lasts for 10 hours before the batteries go dead. What is the charge rating on the batteries?

63 If held between 2 fingers a certain 1.5 Volt battery will last for 170 days before going dead. What is the resistance if this person's skin? (The battery has a charge of 1.2 A•hrs)

64 A package of good alkaline batteries is about $0.40 per battery, on sale. If the charge rating of this 1.5 Volt battery is 1.2 A•hrs, then what is the cost/kW•hr is it is connected to a light bulb with a resistance of 8.5 Ω? What is the cost/kW•hr if it is connected to a light bulb of resistance 17 Ω?

65 An "Indy" racecar can generate 1000 hp. Death Wish Hershey is trying to make an electric racecar. To make this car he is going to use regular 12 Volt car batteries. These batteries can safely produce 14,400 W. How many batteries will is take to create an equivalent horsepower? A car battery has a charge rating of 30 Amp•hrs, how long will one battery last if it produces 14,400 W?

66 A motor can lift a 10.204 kg mass 2 meters in 10 seconds. What is the horsepower of this motor? If the motor is connected to a 12 Volt battery then how much current does the motor draw?

Electrical Work and Power

67 Below is a wire connected to the terminals of a battery? The wire poses no resistance, or friction, to the motion of the charges. The battery has a potential difference of 6.0 volts. 1,000,000 electrons travel from one terminal of the battery to the other in 0.001 seconds. How much electrical work is done on moving the charges between the battery poles?

68 A is wire connected to the terminals of a battery. The wire poses no resistance, or friction, to the motion of the charges. The battery has a potential difference of 1.5 volts. 1,000,000,000,000 electrons travel from one terminal of the battery to the other in 0.02 seconds. How much electrical work is done on moving the charges between the battery poles?

69 Suppose in problem number 3 that the length of wire that the electrons travel through is 10 centimeters long. What average force moves the electron through the circuit?

70 What supplies the force to move the electrons through the wire?

71 How much power is used in moving the electrons through the wire in both problem #1 and #2?

72 A battery bought from the store is rated at 9.0 volts on the side of the battery? What is the potential difference of the battery?

73 A 12 Volt battery is connected to a motor that is connected to motor that is used to lift a ball from rest. The ball's mass is 0.1 kg. When the motor is turned on it will draw 2.4 amps from the battery. The motor is on for 20 seconds.

a. How much power is used by the motor?
b. How much power is used in raising the ball?
c. How much work is done by the motor?
d. How high is the ball raised?

74 A 6.0 Volt battery is connected to a motor that is connected to a motor that drags a block from rest across the ACME friction less surface. (Patent pending by Wiley Coyote). The block's mass is 1.0 kg. When the motor is on it draws 4.5 amps from the battery. The motor is only on for 30 seconds at a time. In "real life" motors are not perfect converters from electrical work to mechanical (lifting, sliding, spinning, etc.) work. In the case of this motor only 40 percent of the electrical work is converted into mechanical work.

a. How much power does the motor use?
b. How much work is done by the motor?
c. If the motor pulls with an average force of 2.5 Newtons, then how far will the block be dragged?
d. What will be the block's final speed?

75 ACME has invented the "Bug's Bunny Buggy." It's an electric car. The car uses 12 Volts. The vehicle's motor draws 20 amps when the car is moving at a constant speed of 24.6 m/s (55 mph). The car has 80 percent conversion efficiency from electrical work to mechanical work. Unfortunately the car only runs for 3 hours at this speed. (HINT: $P=Fv_{avgerage}$)

a. How much power does the motor use?
b. How much work is done by the motor?
c. What average force is applied by the car for it to travel at 55 mph?
d. What distance does the car cover in the 3 hours? (Calculate using work relationships).

Power Smart Tips for Appliance Use

Cooking

- Use your microwave oven whenever possible to reduce cooking time and costs.
- Cook by time and temperature, following cooking instructions. Avoid opening oven door or lifting pot lids, which release heat and wastes energy.
- When cooking on the range, lower the temperature setting once the food has heated. It will continue to steam or boil if you use tight-fitting lids.
- Don't preheat the oven or broiler, except when baked goods require a precise starting temperature.

Clothes dryer

- Dry full loads only. Don't use the dryer for just one or two items.
- Dry loads consecutively. This takes advantage of built-up heat.
- On nice days, consider using a clothesline to dry your clothes.

Clothes washer

- Wash full loads only.
- Use warm water instead of hot for washing whenever possible, and cold for rinsing.

Dishwasher

- Use only for full loads.
- Turn off the dishwasher or use the "energy switch" if you have one, and let the dishes dry naturally.

Refrigerator

- Clean the coils in the back of the refrigerator, or near the floor at the front, at least once a year.
- Do not allow ice to build up more than 6 mm on manual defrost refrigerators.

Electrical Cost and Usage

A wall outlet has a potential difference of 120 volts for these problems.

Cost of Electricity and Electrical Work

For the following problems, electricity costs $\frac{\$0.16}{kW \cdot h} \rightarrow$ (A very high rate)

76. The electric company charges for the electrical work they do in supplying your energy needs. If the electric company charges $0.005 for every watt•second used then how much would it cost to run a 40 watt light bulb for 5 minutes?

77. In reality the unit of electrical work the electric company uses is called a KilloWatt•Hour, (abbreviated kWhr). Virginia Power charges $0.16 for every kWhr used in the winter and early spring. How much does it cost to run a 40 Watt light bulb for 5 minutes? ...For 5 hours? ...For 5 days?

78. You are in charge of analyzing the cost of installing security lighting on a house. The security lights consists of three 150 floodlights. Two options are available: (1) leave the lights on for an average of 12 hrs a night for 30 days. (2) Use a motion detector that runs the lights an average about 36 minutes a night. How much will each increase the household bill of electricity?

79. How much will it cost to run a 75 Watt light bulb, that is plugged into a wall outlet for 12 hours?

80. A hair dryer uses 1250 watts. If electricity costs $0.16 / (kW•hr), then how long can the hair dryer run before it uses up $0.01.

81. A television uses 120 watts. If electricity costs $0.16 / (kW•hr), then how long can the television run before it uses up $0.01.

82. A toaster uses 1400 watts and takes 2 1/2 minutes to cook a piece of bread. If electricity costs $0.16 / (kW•hr), then how many pieces of bread can be cooked for $0.05.

83. A 75 Watt light bulb is plugged into the wall outlet.
- How much current does the light bulb draw?
- How much electrical work is done in 1/2 hour?

84. How much power is used by small black and white TV that draws 0.35 amps at 120 volts <u>AND</u> how much electrical work is done in having the TV on for 3 hours?

85. A 40 Watt curling iron is plugged into the wall.
- How much current does the curling iron draw?
- How much electrical work is done in 1/2 hour?

86. A "35 watt" stereo run at full volume may draw 195 watts from the wall outlet.
- How efficient is this stereo at converting electrical power to "audio" power at full volume?
- What current is the stereo drawing from the wall at full volume?

- How much electrical work is done in running the stereo for 1 hour at full volume?

87. If the stereo in problem #4 is run at "half-volume" it will use 136.5 watts from the wall outlet.

- How efficient is this stereo at converting electrical power to "audio" power at half-volume?
- What current is the stereo drawing from the wall at half-volume?
- How much electrical work is done in running the stereo for 1 hour at half-volume?

The electric company charges for the amount of electrical work they do in moving electrons through the appliances in a house. Instead of using the units of (watt)(second), [Ws], they use the unit of (kiloWatt)(hour), [kW].

For the problems above convert the power rating on the appliances to kilowatts.

For the problems above convert the electrical work rating on the appliances to kW.hr.

If the electric company were to charge (11 cents) per kW.hr used, then how much would is cost to run each appliance above?

88. Fill in the missing information on the table below.

This table calculates the electrical work in kilowatt-hours.
It then estimates the cost for the time period expressed based on the rate of 12 cents per kilowatt-hour.
COST = (power, in kW)(time, in hrs)(price/(kW-hr))

Item	Power in Watts	Time of use in a day (minutes)	Electrical work kWh	Cost for an hour's usage	Cost for a day's usage	Coast for a week's usage	Cost for 30 days of use	Coast for 365 days of use
Alarm Clock	A	1440	0.0020	$0.00024	$0.01	$0.04	B	$2.11
Clock Radio	5	1440	0.0050	C	$0.01	$0.05	$0.22	D
VCR (on)	21	210	0.0031	E	$0.00	$0.03	$0.13	$1.61
Stereo Receiver	F	240	0.0317	$0.02280	$0.05	$0.32	G	$16.68
Light bulb	100	210	0.0146	$0.12000	$0.21	$1.47	$6.31	76.80
CFL bulb	15	210	H					J
Toaster	1776	10	0.0123	$0.21312	$0.02	K	$0.53	$6.50
Refrigerator	1140	680	12.92	L	$1.20	$8.42	$36.09	$439.14