Physics 1250
Laboratory Activities & Worksheets

Fifth Edition, 1st Rev.

Department of Physics
The Ohio State University

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 978-0-7380-7642-3

Hayden-McNeil Publishing
14903 Pilot Drive
Plymouth, MI 48170
www.hmpublishing.com

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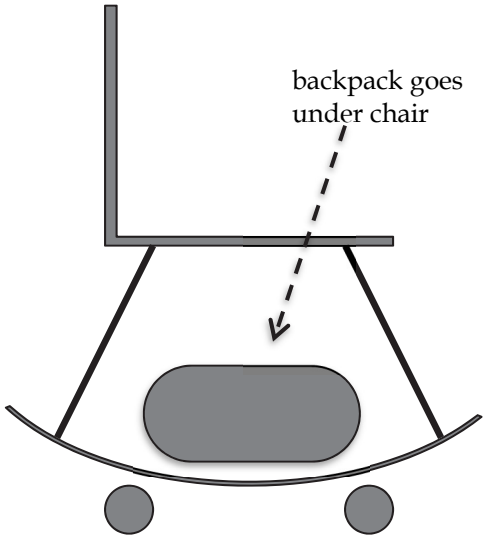


COURSE INFORMATION: PHYSICS 1250 – 1251

Complete course policies are available at the course web site:
http://www.physics.ohio-state.edu/phys1250

Only the course manager has the authority to grant excuses.

Dr. Michael Ziegler, ziegler.2@osu.edu, SM 1036A, 614-292-2067.

University Required Statement

Physics 1250 – 1251 (1240, 1241) are Physical Science courses in the Natural Science category of the GEC. The goals and objectives for this category are:

Goals/Rationale: Students in natural sciences gain understanding of the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

Learning Objectives for Physical Science:

1. Students understand the basic facts, principles, theories and methods of modern science.

2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.

3. Students describe the inter-dependence of scientific and technological developments.

4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

How the Learning Objectives are Met:

1. Student preconceptions and alternate conceptions of physical law are addressed head-on in P125x and P124x. This is a necessary component of any contemporary introduction to physics, and is addressed in all components of the courses.

2. Students learn the scientific theories that have developed from the 1600s to the present day. They learn different modes of approaching the same phenomena, such as force and energy methods in mechanics.

3. Students understand that P125x and P124x introduce the basic physical laws that underlie all engineering applications. Examples of applications are provided in the textbook and in demonstrations in lectures.

4. Students understand that the social implications lie in the applications, and that in the case of physics the social implications are taken up more appropriately in the engineering courses that teach the applications. The reason for this is that physics does not go into details of how to build instruments or devices.

Assignment sheets: Assignment sheets are distributed in the first lecture session of the semester; thereafter, they are available on-line at the P125x and P124x websites, and in a rack next to room SM 1011V. Assignment sheets include information about required textbooks, specific course policies, and grading.

Students with Disability: Please contact the course supervisor at the start of the semester so that arrangements can be made to accommodate you. Students needing the services provided by the Office for Disability Services (ODS) will need to be certified by that office. The ODS is located in 092L Baker Hall, 113 W. 12th Avenue; 614-292-3307, VRS 614-292-0901; http://www.ods.ohio-state.edu/. **ODS sets deadlines to be certified and to register for its services. Failure to meet the deadlines will result in delayed access to ODS services. The physics department has no control over the deadlines.**

Tutoring: A free tutoring service is available in SM 1011A and B – see the schedule posted there for times. A private tutor list is available at http://pgsc.physics.osu.edu/tutors.

Academic Misconduct: Not to report academic misconduct is itself regarded as academic misconduct. Everyone in the university community has a duty to report suspected academic misconduct.

Academic Misconduct in Lab: Students are not always aware of what constitutes proper academic conduct in a laboratory situation. As a general rule, one should not bring into the lab any material with data taken at other times, or with any sort of answers written in ahead of time, whether in the lab report or in the lab manual or on any sort of substance, paper or not. The presence of any such material in the lab will be considered evidence of intent to commit academic misconduct. Any such materials used for study prior to the lab should be tucked away where they cannot be retrieved easily, in a backpack or other such carrying case. To receive credit, the lab report must be handed in or checked off at the end of the period. If it is removed from the lab, in fairness to other students it cannot be accepted. In no case may a lab report be taken home and be handed in later.

Academic Misconduct in Lecture: When credit is given for use of "clickers", use of another student's clicker to obtain credit for that student must be reported to the Committee on Academic Misconduct.

Academic Misconduct in Recitation: The procedures of the Ohio State University Committee on Academic Misconduct include the following in the definition of academic misconduct: "Providing or receiving information during quizzes and examinations such as course examinations...". The Physics Department refers all suspected cases of academic misconduct to the Committee on Academic Misconduct and usually follows the committee's recommendations, but there can be exceptions. Exams and quizzes may be photocopied for comparison with exams handed in for regrading. All homework handed in for grading must be your own work. If an exam states that no notes or books may be used, you must demonstrate to your recitation instructor that your calculator memory is clear before the exam begins.

Students are permitted to work constructively with other students, and to obtain help from instructors when solving on-line homework problems. Study by cooperative or collaborative methods is an excellent way to learn and retain understanding. Use of a complete solution or final equation provided by another student, a paid tutor, or any form of web site or consultation defeats the purpose of the homework assignment, and must be reported to the Committee on Academic Misconduct by instructors and other students. Posting of or provision of a complete solution or final equation by any form of transmission to other students, including, but not limited to, those listed above also defeats the purpose of the homework assignment and must be reported to the Committee on Academic Misconduct.

FAST FACTS

Time Conflicts: By university rules, no excuses are granted to miss your regular final exam, midterm, quiz, or lab for an exam, or lab, or any other activity in another course. The other class must offer you an alternate time.

There are no makeup quizzes and labs in this course.
Every student is excused for missing two quizzes for any reason including illness, family emergency, an interview, representing the university, etc. Therefore, no documentation is needed for the first two missed quizzes.

Quiz Excuse: Two missed quizzes, or two lowest quizzes, are dropped automatically; missed quizzes are dropped first, regardless of reason. If you miss more than two quizzes, contact the Course Manager with documentation within two weeks, or by the first day of exam week, whichever is first.

Lab Excuse: NO DROPS. If you miss a lab, contact the Course Manager with documentation within two weeks of the missed lab, or by the first day of exam week, whichever is first.

HW Excuse: HW is typically not excused because at least a week is given to complete each homework assignment. Deadline extensions are not granted for last minute illnesses or computer failures. A request for a homework excuse must be made to the Course Manager within two weeks of the missed homework, or by the first day of exam week, whichever is first.

Missed Midterm: No Make-ups. If a student misses a midterm, the student must seek permission from the Course Manager to be excused for missing the midterm. If the student's absence is excused, a grade for the missed midterm will be replaced by a prorated final exam grade. **The absence must be excused within two weeks of the midterm.**

Missed Final Exam: Permission is required for a makeup exam. A makeup final exam will be given, if missed for a valid documented reason. Please contact the Course Manager by the last day of exam week to request permission to take a makeup final exam.

Early Final Exam: **FINAL EXAMS ARE NEVER GIVEN EARLY.**

Only course supervisors have the authority to grant excuses.

COURSE MANAGER: Dr. Michael Ziegler, (ziegler.2@osu.edu), SM 1036A, 614-292-2067.

Regrade Requests: These must be submitted within one week of the return of an exam to you, and no more than two weeks after the exam has been returned to the rest of the class, but the last day to summit a request is the first day of exam week. **Regrade requests are not possible for the final exam.** Request forms are available on the P125x websites, and in the rack next to room 1011V Smith Lab. See the document **GENERAL COURSE POLICY AND INFORMATION** for more detailed information.

1/17/19

On-Line Homework Instructions

Homework will be submitted and graded via the on-line software package WebAssign. Go to https://www.webassign.net/osu/student.html and use your Ohio State name.# and password to log in.

A registration access code is required to use WebAssign, but at the beginning of the term there is a grace period of about two weeks in which an access code is not required. An access code is included as part of the valuepack with the textbook when a new textbook is purchased from the local bookstores or can be purchased through WebAssign's online store.

Problems with WebAssign access: Contact the WebAssign Administrator in the Physics Department, Dr. Bolland (bolland.1@osu.edu, 614-292-8065). Contact Dr. Bolland ONLY if you believe there is a problem with WebAssign itself; consult your recitation instructor or lecturer or a tutor for help with the homework.

You may submit answers to part or all of the assignment at any time before its due date. You get more than one try at most problems, and your goal is to eventually get it right. The number of tries you have used and may use are shown at the upper left of each problem (click the +).

Responses should be either in decimal numbers or the "E" format for scientific notation. For example: Enter "0.5" NOT "1/2" or "1E-3" rather than "10^-3".

WebAssign checks your answer to see if it is within 1% of the correct answer. As you calculate, you should keep at least 4 significant figures in intermediate steps and enter your answer to at least 3 significant figures, even if there are fewer significant figures in the problem.

WebAssign records the grade for the LAST answer submitted, even if that answer is incorrect and a previous answer is correct.

You may work on any assignment up to its due date/time. NO EXTENSIONS will be granted for online homework assignments. You may be excused from an online homework assignment ONLY in the following special cases:

- enrolling late in a course
- hospitalization or extended illness of the student --- (requires a physician's note stating that the student should be excused from school for that week)
- death of a parent or sibling
- military duty for the entire week.

Should one of the above special cases arise, contact the course manager with appropriate documentation in order to obtain an excuse. Also, if you find that you are not in the database and fail to contact the administrator, you will receive zero for your homework grade.

Lab Instructions

The two-hour lab session lies at the heart of this course. In it a combination of problems and laboratory activities is worked in small groups with the assistance of the instructor. These sessions are where you can best learn the material, in order to be able to complete the homework assignments and be prepared for the quizzes and exams that will determine your grade. The following are answers to questions you might have.

Typically, you and your group will be given a combination of problems and laboratory activities to do in a set order. The problems and some of the laboratory activities are not graded, but some of the laboratory activities may be graded. The graded activities, indicated clearly in this manual, together constitute the "lab score." Your lecturer will explain how the lab score combines with other course elements to determine your grade.

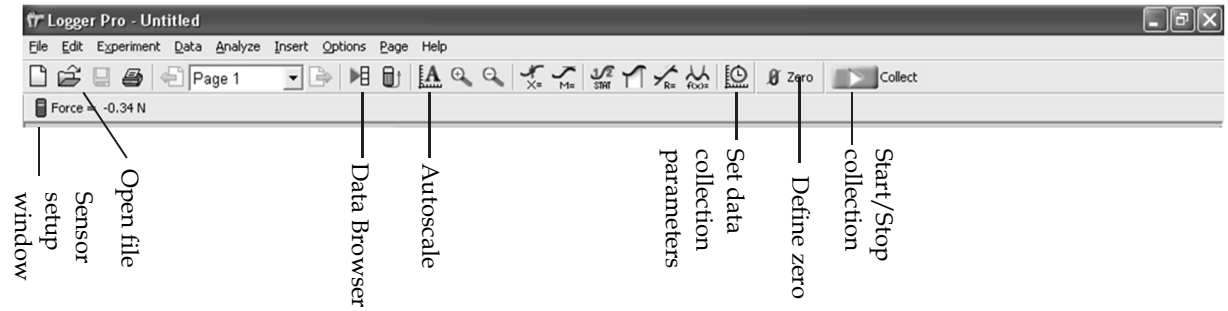
Your group is not expected to finish every problem! We would rather that you work a few problems well with complete understanding than a large number using guess-work.

You should record all measurements and calculations in your individual lab manual. (The other members in your group are expected to do the same.) Your instructor may ask to examine it at any time. You are encouraged to ask for help from your instructor at any time. You are welcome to use your textbook and class notes. Also, do not forget that you are part of a group. Bring this manual and a scientific calculator to class.

Be on time. If you come late, you may not be allowed to perform the lab.

Academic Misconduct: (These considerations are in addition to the general University rules.) All laboratory work will be done during the laboratory period. Do not bring completed lab work to the laboratory. The presence of completed material in the lab book can be considered evidence of intent to commit academic misconduct. Do "graded activities" only when your instructor is watching. Do not mistreat the laboratory equipment -- in particular, do not write on the apparatus. If you are uncertain what is permitted while doing a given graded lab activity, ask your instructor before proceeding.

Introduction to Logger*Pro*



To start data collection, click the green "Collect" button on the tool bar. There is a delay of a second or two before data collection starts, so don't try to time clicking the button with your actions.

Many parameters in the software are adjustable, like the sample collection time. Adjusting them is done through the menus, but some common commands and parameters are available through the toolbar. For example, click the clock icon to change the sample rate or time.

Often you will be told to load/open a file. Such files will set all the relevant parameters for the experiment.

Graph parameters can be changed by clicking on the graph to select it and using the menus, or by right-clicking on the graph. Common graph commands include *zoom* and *autoscale*.

If you can't see your data (the graphs appear blank) or the data is a flat line at zero you probably need to adjust the graph scaling. Start with "Autoscale from 0", then zoom-in or adjust the axes.

If the "collect" button is gray and can't be clicked then there may be a problem with the sensor hardware. Make sure the cable to the sensor is snapped in place and likewise with the cables going to the interface box. (The cable from the sensor goes to the interface box; just follow it.) If the button is still gray, the problem might be the software. Quit out of Logger*Pro* and restart it.

If all else fails, ask your lab instructor for help.

Experiment I – 1-D Kinematics

The data collection for this and many other labs use Logger*Pro* software operating a variety of sensors connected to a LabPro interface. This week's sensor is a Vernier Motion Detector 2. It measures position by emitting pulses of sound and measuring the time until the reflected sound returns (like radar but with sound waves).

- You will hear a clicking sound when data collection begins.
- The detection zone extends about 15-20° to either side of the axis of the beam's centerline. If some other object or body part gets inside this "cone" it will be detected instead of the target. A sharp change in the position data may be due to this.
- The position detector can measure an object only within the range 15 cm - 6 m.
- The detector folds open so that the detector can be aimed. Opening the detector reveals a sensitivity switch with cart and normal (person/ball) settings. Selecting the appropriate setting will give better data.
- The default is for the position detector to be the origin or the zero point of an axis with the positive direction away from the detector.
- The only thing that is directly *measured* is position with respect to the detector as a function of time; the Logger*Pro* software calculates the velocity and acceleration from the position data. This increases the noise in derived values like acceleration.

Activity 1 Put the detector into the first setup: measuring the cart on the track. Open the file "1-D Kinematics #1"; this file will initialize some parameters and prepare graphs. Level the track so that the cart remains motionless or nearly motionless on the track.

Try understanding the graphs for some sample motions. In particular, make sure you can explain the features of the $v(t)$ graph and how it relates to the $x(t)$ and $a(t)$ graphs.

The following are examples of situations you can try:

- The cart rests motionless at some distance from the detector.
- After data collection starts, tap the cart so that it moves slowly away from the detector. Can you identify when the tap started and when it ended?
- Push the cart steadily to get roughly constant acceleration (difficult).
- Push the cart back and forth to get oscillatory motion. Can you identify the sign of the acceleration as it changes simply by looking at $x(t)$? At $v(t)$?

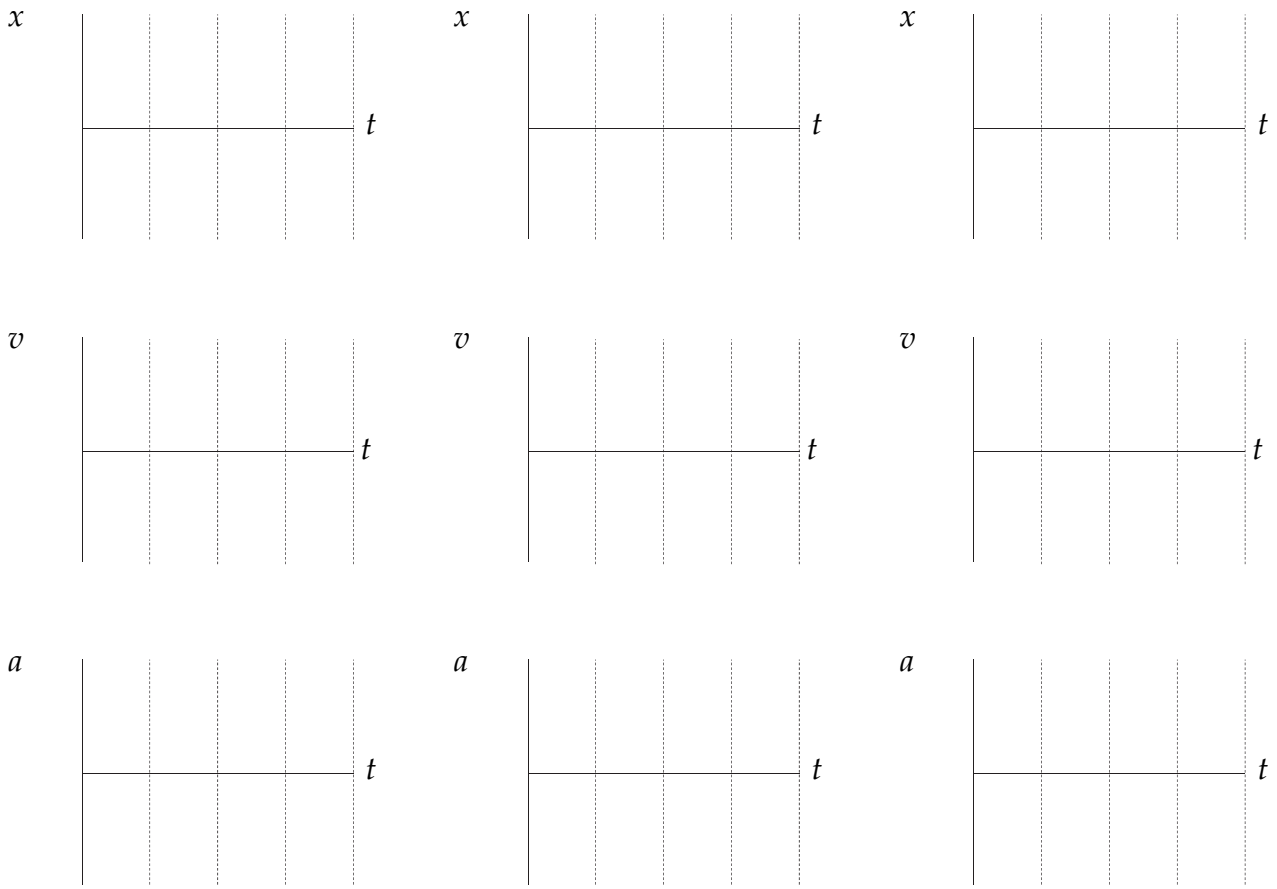
Activity 2 For each case below, (1) sketch your best guess for the cart's motion on the graphs, then (2) perform the experiment, ideally recording the experimental results in a different color and (3) reconcile any differences.

1. Raise one end of the track to be about 6 cm above the other. Place the detector at the lower end and the cart near the higher end and release the cart.

2. Put the detector at the higher end, with the cart also near the higher end, and release the cart.

3. With the detector at the higher end, start with the cart near the lower end and tap it so that it rolls towards the detector, stops before hitting the detector and then rolls back. You may need to practice a few times before performing the measurement.

(1) (2) (3)

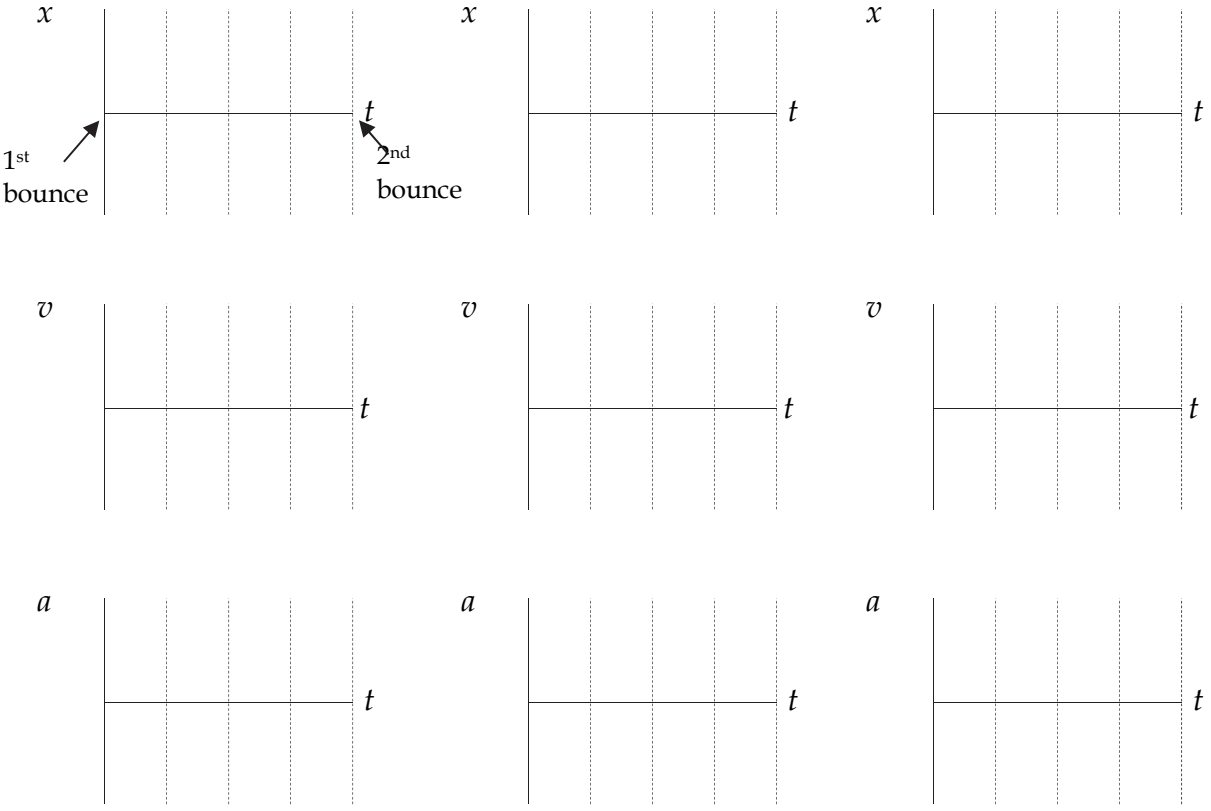


Activity 3 Predict the motion of the dropped basketball. The position detector will measure the ball's motion after you drop the ball. The ball will fall and bounce a first time and then bounce a second time while still under the detector. Your job is to predict the motion starting immediately after the first bounce and continuing until just before the second.

Open the file "1-D Kinematics #2". Hold the detector over the floor, pointing downward. Which way is the positive direction?

Make your prediction on the leftmost graphs. Once you are ready to do the experiment, wait for your instructor. Do not drop the basketball with the computer taking data until you have your instructor's attention. Sketch the results using the middle graphs below. Sketch only the portion of the motion between the first and second bounces.

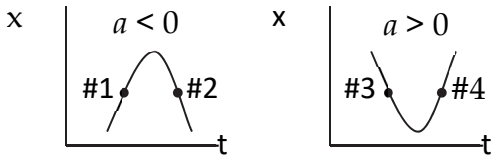
Prediction **Measured** **Use these graphs for scratch work.**



Instructor Initials: _____ Date: _____

1-D Kinematics

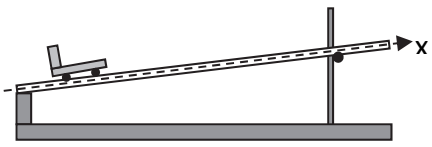
(1) Consider the graphs below. Fill in the table whether v is positive or negative and whether the object is speeding up or slowing down.



Point	Sign of a	Sign of v	Speeding up or slowing down?
#1	-	+	
#2	-	-	
#3	+	-	
#4	+	+	

(2) You can't use the sign of the acceleration alone to determine if a particle is speeding up or slowing down. Using the table that you just filled out, develop a rule to determine if a particle is speeding up?

(3) In front of you are a rail sloping upwards and a cart. Let's use the coordinate system shown in the figure. Tap the car so that it rolls most of the way up before rolling back down.



To answer these next two questions, use what you see before you but, also, use the rule that you established above.

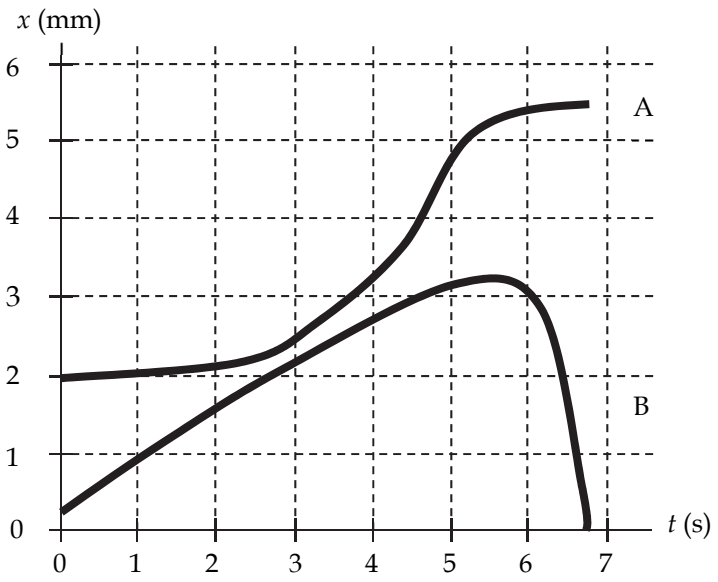
During the upward journey, what is the sign of the velocity and the acceleration?

v _____ a _____

How about the downward journey?

v _____ a _____

(4) The position-versus-time graph shows the motion of objects A and B moving along the same axis.



a) At t = 1s is the speed of A greater than, less than or equal to the speed of B?

At t = 5s?

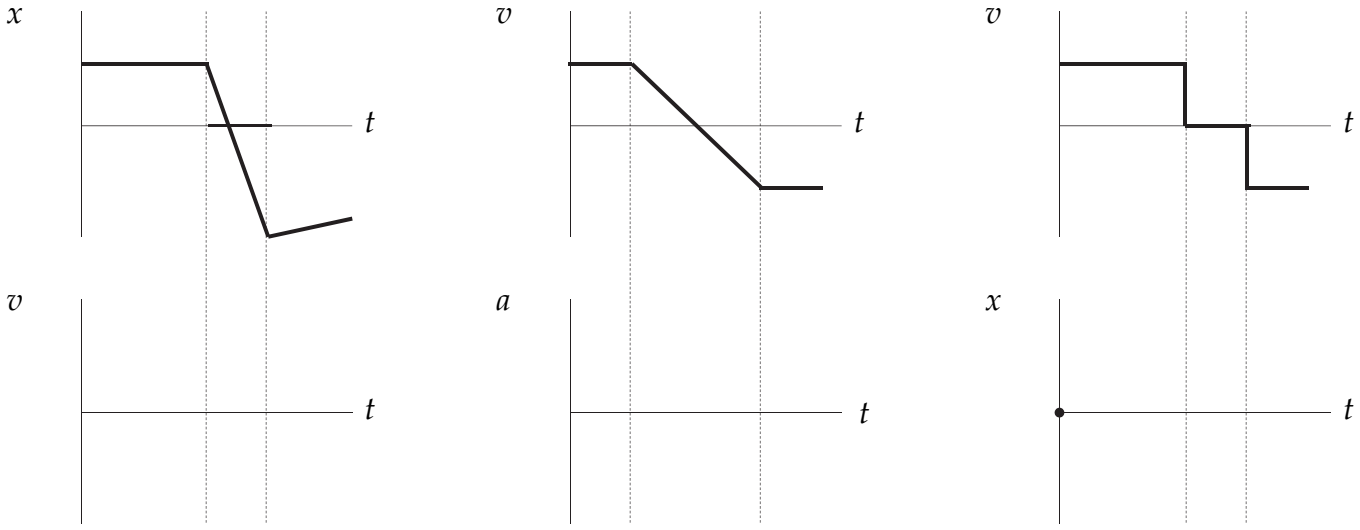
b) At t = 4s is the acceleration of B negative, zero or positive?

At t = 6 s?

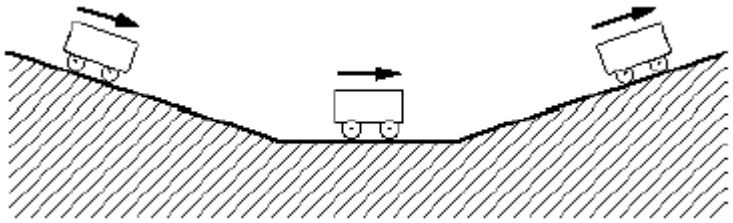
c) At what time (roughly) are they closest to each other?

d) Does A ever turn around (reverse direction)? Does B?

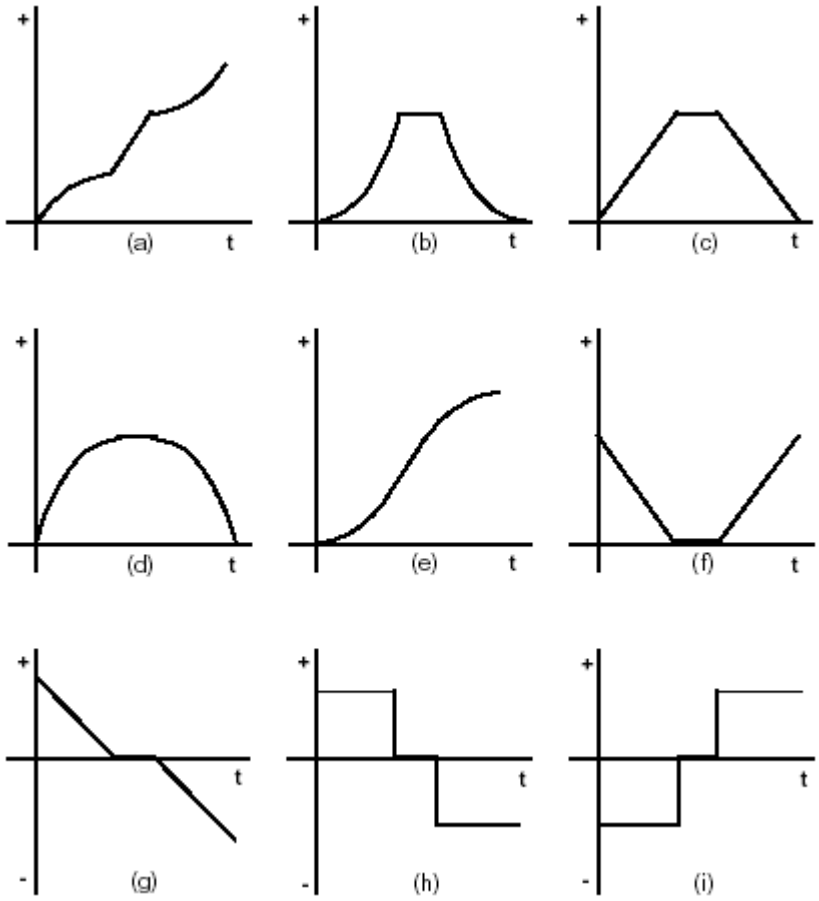
(5) Each of the following pairs of graphs shows a kinematical quantity (x or v or a) versus time on the top graph. Sketch a plot of the indicated kinematical quantity versus time on the bottom graph. The dashed lines are given for your convenience to help you line up important features in the graphs.



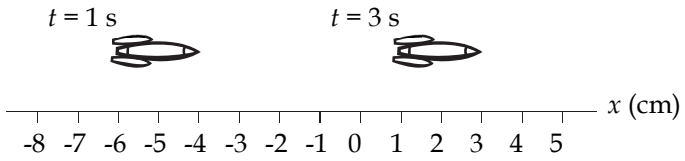
(6) A mining cart starts from rest at the top of a hill, rolls down the hill, over a short flat section, then back up another hill, as shown in the diagram. Assume that the friction between the wheels and the rails is negligible. Sign convention: For each section of track, let the direction shown in the figure above be taken as positive.



a) Which graph below best represents the position-versus-time graph?
b) Which graph best represents the instantaneous velocity-versus-time graph?
c) Which graph best represents the instantaneous acceleration-versus-time graph?



(7) Imagine a rocket ship that moves in one dimension along the x-axis according to the equation:



$$x(t) = -6.0 + 1.5\,t + 0.50\,t^2$$

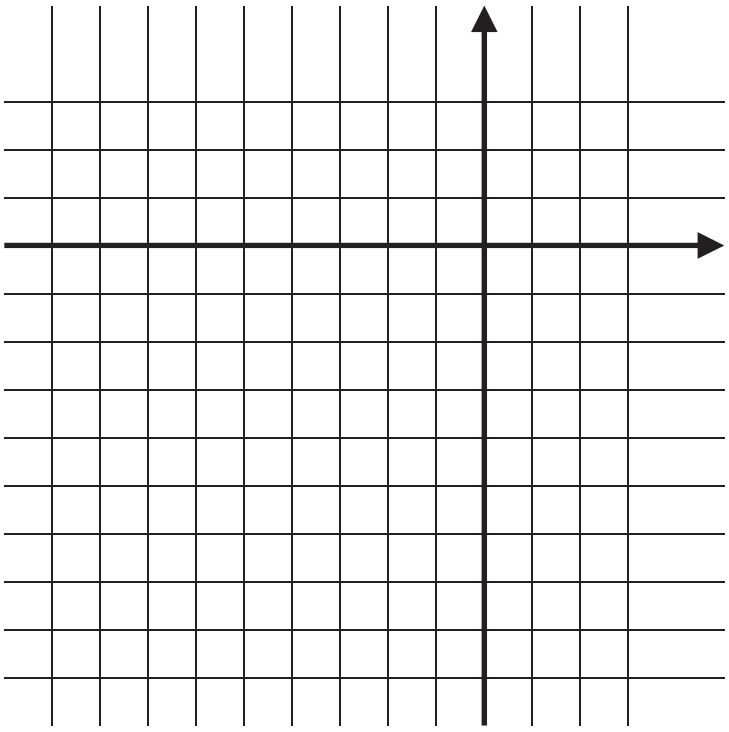
Here $x(t)$ is given in cm and t is in seconds. All equations must obey certain rules or they are meaningless. Two important rules regarding units are [1] both sides of an equation must have the same units (i*t makes no sense to say 2 meters = 4 seconds)* and [2] any two terms that are added together must have the same units (i*t makes no sense to evaluate 2 meters + 4 seconds)*.

a) These rules tell us that, for the above equation to make sense, the numbers in it are not pure numbers but are physical quantities with units. Find the units:

-6.0 _____
1.5 _____
0.50 _____

Note that if, for example, $x = t$, then there is an implied "1" multiplying the t that has units.

b) Sketch the graph of the position of the rocket ship between t = -3 s and t = 3 s.



c) Find the displacement of the rocket ship between t = 1 s and t = 3 s.

d) Find the average velocity between t = 1 s and t = 3 s.

We do not define $v_{ave} = (v_i + v_f)/2$. This equation might yield the same result for the average velocity as the one above, but in general it does not.

e) Find the velocity $v(t) = dx/dt$ at time t = 1 s.

Physicists have a precise definition for the word "speed" that might be different from what you have in mind.

speed =	the magnitude (or absolute value) of the velocity
average speed =	total distance traveled divided by time interval

If you run to the left and then back to the right, stopping where you started, your average speed is non-zero and positive, but your average velocity is zero.

f) Find the speed at time t = -1 s.

g) Find the average velocity between t = -3 s and t = 0 s.

h) Find the average speed between t = -3 s and t = 0 s.

i) Find the acceleration at time t = -1 s.