Workbook for Introductory Mechanics Problem-Solving

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To the Student

The *Workbook* should help you to learn how to think about physics problems before you try using equations. The format is designed to carefully build each level of your problem-solving ability before moving you to the next level. So instead of working one problem at a time, you will work several problems at once. Here is advice on how to use this *Workbook*.

1. After printing, place these materials in a binder before beginning work. (If possible, use double-sided or duplex printing.)

2. Attempt to answer every question by drawing or writing before looking at the answer.

3. *Warning*: Simply reading the questions, the answers, and the discussion without doing the work is a complete waste of time.

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Acknowledgments

Students have provided invaluable assistance in word processing, and in creating graphics for this workbook. Thanks go to Andrick Anderson, Kyle Herbert, Tyesia Pompey, Tarryn Reeves, and Keilah Spann. Professors Theodore Hodapp and Dave Maloney are thanked for their criticism and suggestions. Clip art is taken from the *Art Explosion* collection published by the Nova Development Corporation, Calabasas, CA.

I have had the pleasure of teaching and tutoring at South Carolina State University and Northeastern University, and in the process I have learned much from students about their difficulties in solving physics problems. Those who wish to further my enlightenment may send comments to dsmith@scsu.edu.

Chapter 2 B

MOTION IN ONE DIMENSION

Wilson/Buffa Chapter 2: Kinematics

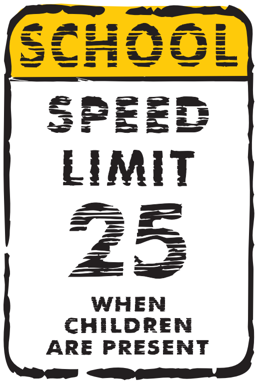
Unit 1
Vector representations of velocity and acceleration

Unit 2
Estimating answers

Unit 3
Interpretation of data and symbols

Unit 4
Setting-up equations

Unit 5
Solving the equations



While driving along at 20.1 $\frac{\text{m}}{\text{s}}$ (45 $\frac{\text{mi}}{\text{hr}}$), you enter a school zone whose speed limit is 11.2 $\frac{\text{m}}{\text{s}}$ (25 $\frac{\text{mi}}{\text{hr}}$). You hit your brakes quickly to slow down at the rate of 4.2 $\frac{\text{m}}{\text{s}^2}$. (a) After hitting the brakes, how much time is needed to slow down to the speed limit? (b) How far does the car travel in this time?

2.161

Make sketches of the car for the important events of the problem, i.e. sketch the car at the instant you hit the brakes, and at the instant the car is at 11.2 $\frac{\text{m}}{\text{s}}$. If drawing is difficult for you, just draw rectangular boxes to represent the car at the important positions. Next, draw two vectors above each sketch, one representing the velocity (use $\rightarrow$ or $\leftarrow$), the other the acceleration (use $\Rightarrow$ or $\Leftarrow$). Write out reasons for the way your vectors have been drawn.

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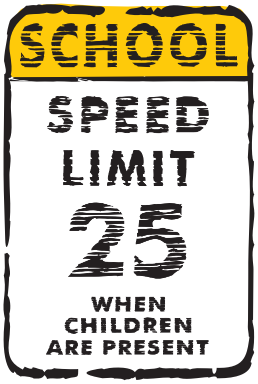

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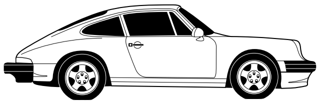
2.162

Velocity vectors (→) form the top row, acceleration vectors (⇐) the bottom row.

Whether the car is moving to the right or to the left in your diagram is unimportant. What is important is that the velocity vectors point in the direction of the car's motion and that they become progressively shorter to represent the slowing-down. Then the constant acceleration vector causing the slow-down must point in a direction *opposite* to that of the car's motion.



A driver stops at a traffic light. After the light turns green, she steps on the gas pedal to give her car a constant acceleration of $1.7\,\frac{\mathrm{m}}{\mathrm{s}^2}$ as it passes through two intersections. The second intersection is 75 m away from the first and she passes it 7.2 s after passing through the first. (a) What is the car's velocity when it passes through the first intersection, and (b) when it passes through the second?

2.163

Sketch the car for all of the important events in the problem. If drawing is difficult for you, just draw rectangular boxes to represent the car at the important positions. Draw two vectors above each sketch, one representing velocity (use $\rightarrow$ or $\leftarrow$), the other acceleration (use $\Rightarrow$ or $\Leftarrow$). Justify your vectors.

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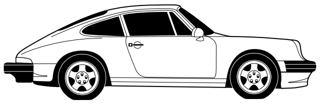

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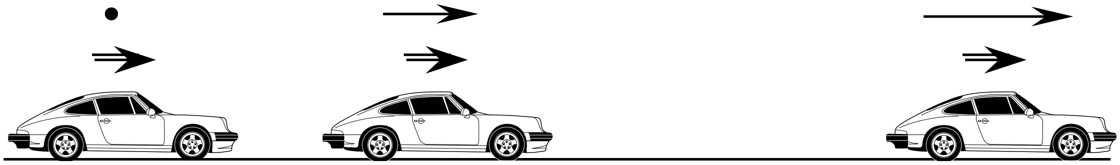
2.164

The car starts from rest, so $\vec{v} = 0$ initially, then $\vec{v}$ increases, but the acceleration is constant. Velocity vectors (→) form the top row, and acceleration vectors (⇒) form the bottom row.



2.165

Is the traffic light at the first intersection?

❑ Yes ❑ No ❑ Cannot be determined

2.166

From the problem statement, the answer to this question cannot be determined. We are not told where the traffic light is in relationship to the first intersection.

While standing at the edge of the roof of a 7.3 m tall (two story) building, a student tosses a ball upward at a velocity of 11.2 $\frac{\text{m}}{\text{s}}$ (25 $\frac{\text{mi}}{\text{hr}}$). He fails to catch the ball on its way down, so it strikes the ground shortly after the toss. The ball experiences a gravitational acceleration of 9.8 $\frac{\text{m}}{\text{s}^2}$. Neglecting air resistance, (a) how high above the roof does the ball rise? (b) How much time lapses before the ball strikes the ground? (c) What is the ball's velocity as it strikes the ground?

2.167

When would you say that the ball's velocity is 11.2 $\frac{\text{m}}{\text{s}}$?

☐ While the ball is being tossed, still in the student's hand.
☐ The instant the ball leaves the student's hand.

At the start, when is the ball's velocity zero?

☐ While the ball is being tossed, still in the student's hand.
☐ The instant the ball leaves the student's hand.
☐ Undetermined, and irrelevant to the problem solution.

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2.168

The ball's velocity is 11.2 $\frac{\text{m}}{\text{s}}$ at the instant the ball leaves the student's hand. While the ball is in contact with the hand, we should assume that the velocity is changing. When, at the start, the ball's velocity is 0 cannot be determined and is irrelevant to the problem solution. We are interested in the ball only after it leaves the student's hand.

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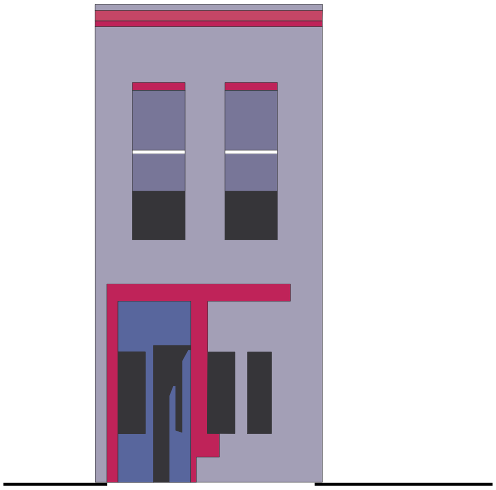
2.169

Decide what the important events are for this problem, then make sketches of the ball to represent each of these events. Draw two vectors alongside each sketch, one representing acceleration (use ⇑ or ⇓), the other velocity (use ↑ or ↓). Justify your vectors.



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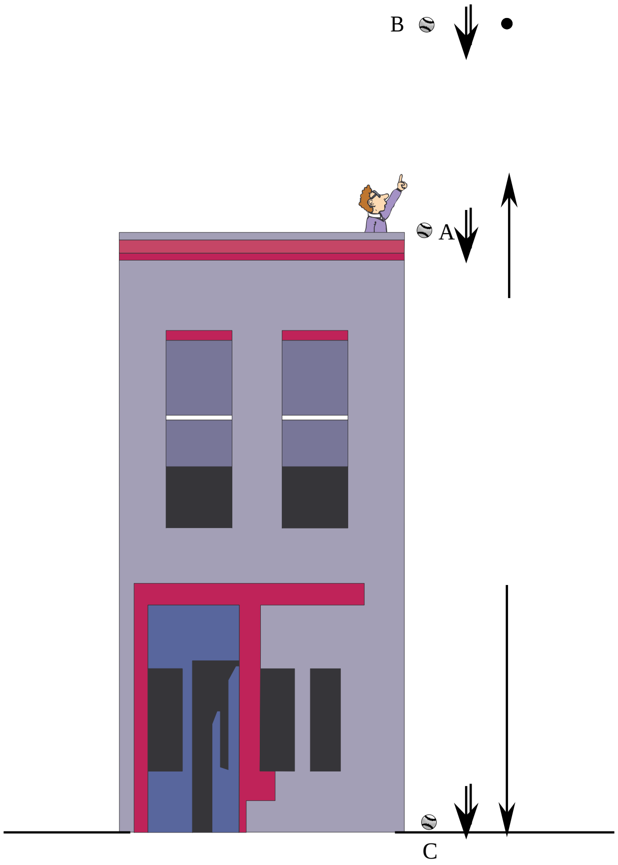
2.170

Events of importance are the toss, labeled A, the ball reaching its apex, B, and the ball striking the ground, C.

At the instant it leaves the student's hand (A), the ball is moving upward; this is the direction of the velocity vector. But the gravitational acceleration is downward, directed towards the ground as always. Gravitational acceleration slows the ball until its velocity is reduced to 0; its motion upward ceases, so it has reached its maximum height (B). Because the ball slows down to reach B, and speeds up to leave B it is accelerating at B.

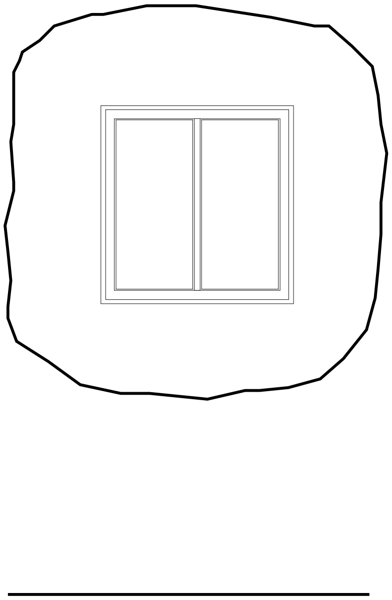
At C the ball has been speeding up since leaving B. At C the ball has just touched the ground, it's still moving and still speeding up.



An office worker looks out of the window just in time to see a rock moving upward, passing the bottom of the window. The worker looks away for 1.7 s. When he looks back he sees that the rock is now at the top of the window and moving downward. The bottom of the window is 9.0 m from ground level, and the window is 1.2 m tall. (a) How high did the rock rise? (b) What is the rock's velocity when it strikes the ground?

2.171

Sketch the rock at all of the important events for this problem. Draw two vectors alongside each sketch, one representing velocity (use ↑ or ↓), the other acceleration (use ⇑ or ⇓). Justify your vectors.



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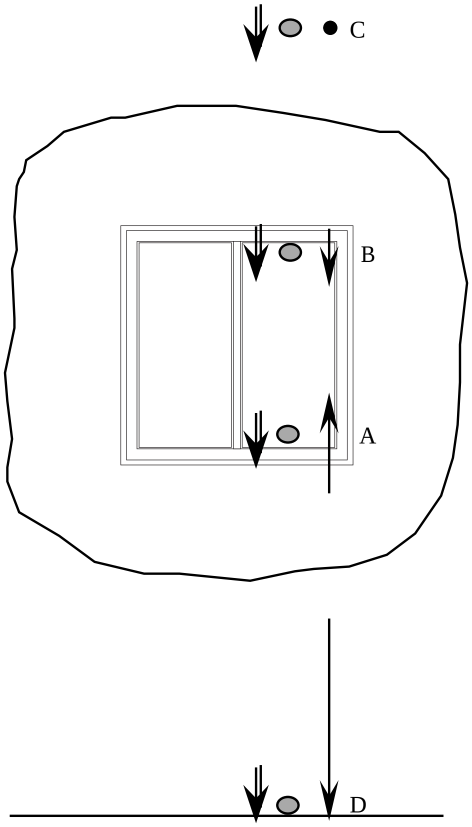
2.172

In the diagram below, the velocity vector is at the right of the rock, the acceleration vector at the left of the rock. Because the rock is moving upward when first seen (A), the velocity vector points upward. When the rock reaches its maximum height (C), it stops moving so its velocity is zero.

At B, the rock is moving downward, so the velocity vector points downward. When the rock reaches D, it is moving faster than at B, so the velocity vector is longer.

In all cases the gravitational acceleration vector points downward. The rock is slowing as it leaves point A moving upward; this implies acceleration in a direction opposite to velocity.



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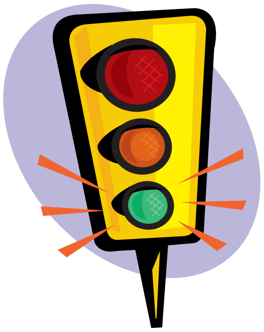
2.173

Why is the velocity of the rock at D *not* equal zero?

An office worker looks out of the window just in time to see a rock moving upward, passing the bottom of the window. The worker looks away for 1.7 s. When he looks back he sees that the rock is now at the top of the window and moving downward. The bottom of the window is 9.0 m from ground level, and the window is 1.2 m tall. (a) How high did the rock rise? (b) What is the rock's velocity when it strikes the ground?

2.174

The rock has just touched the ground at D. It is still moving, so its velocity cannot be zero.



A car is stopped at a traffic light, while a truck a half-block behind the car approaches that same light at a constant speed of $8.9\,\frac{\text{m}}{\text{s}}$ ($20\,\frac{\text{mi}}{\text{hr}}$). The light changes to green, and 0.8 s later the car's driver steps on the accelerator at the same instant that the truck passes the car. If the car undergoes a constant acceleration of $1.7\,\frac{\text{m}}{\text{s}^2}$, and the truck's speed remains constant, (a) how far must the car travel to catch the truck? (b) How much time is needed for the car to catch the truck? (c) What is the car's speed when it catches the truck?

2.175

Are events preceding the passing of the car by the truck important for solving the problem? Is the 0.8 s important? Write a reason for your answer.

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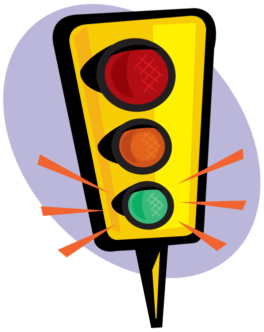

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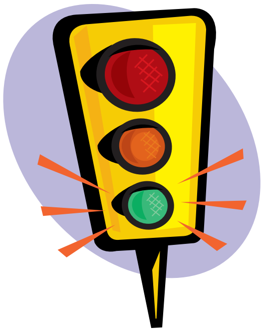
2.176

No, the 0.8 s is unimportant. Imagine, for example, that the car stalls at the light while the truck is still 5 blocks away. Then just as the truck approaches the car, the car starts and the driver steps on the accelerator just as the truck passes. The questions are all the same as before, and none of them depends upon what happened before the truck passed the car.

2.177

Given the previous discussion, sketch the car and truck for the important events in the problem. Draw vectors to represent both the velocity and acceleration for both the car and the truck.



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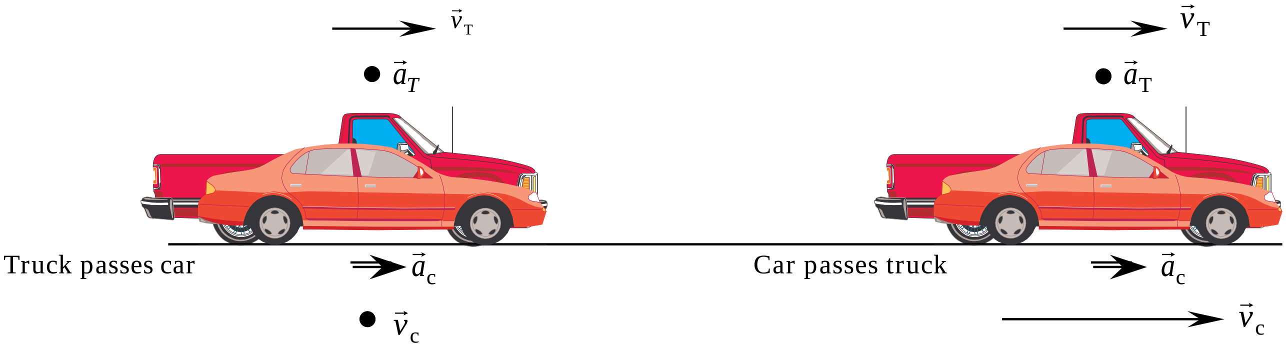
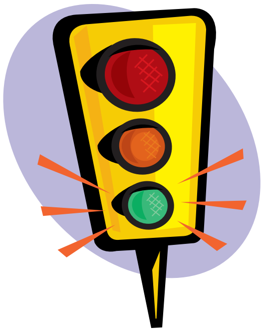
2.178

Important events in the problem are (1) the truck passing the car, and (2) the car catching the truck.



Check that your vectors are similar to those shown here. Vectors $\vec{v}_T$, $\vec{a}_T$, and $\vec{a}_c$ should be the same for the truck passing the car as for the car passing the truck.

When the car passes the truck, why is the magnitude of $\vec{v}_c$ larger than the magnitude of $\vec{v}_T$? Write your answer.



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2.179

If the car is to catch and pass the truck, its speed (magnitude of $\vec{v}_c$) must become greater than that of the truck.

2.180

To say that the car has caught the truck in the language of physics means that (choose one, then complete the sentence)

(a) the time ____

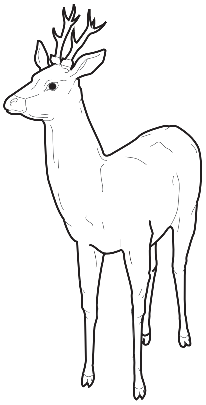
(b) the position ____________________________________

(c) the velocity _____________________________________

(d) the acceleration __________________________________

2.181

In the language of physics, the position of the car's front bumper is equal to the position of the truck's front bumper at the time that the car passes the truck.



A deer walks onto a highway in front of a car which is traveling at 26.8 $\frac{\mathrm{m}}{\mathrm{s}}$ (60 $\frac{\mathrm{mi}}{\mathrm{hr}}$). The driver first sees the deer when it is 84.0 m ahead, and 0.6 s later he applies the brakes so that the car slows at the constant rate of 5.8 $\frac{\mathrm{m}}{\mathrm{s}^2}$. If the deer freezes in fear, (a) does the car hit the deer? (b) If not, how many meters separate the car and the deer after the car stops?

2.182

Choose the important events in the problem, and make a sketch of the car's position for each one. Draw vectors to represent the velocity (use → or ←) and acceleration (use ⇒ or ⇐) of the car for these events. Justify your vectors.

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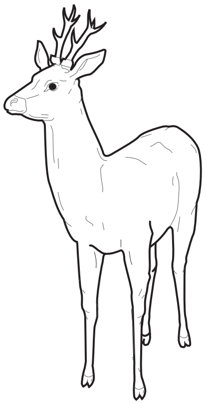

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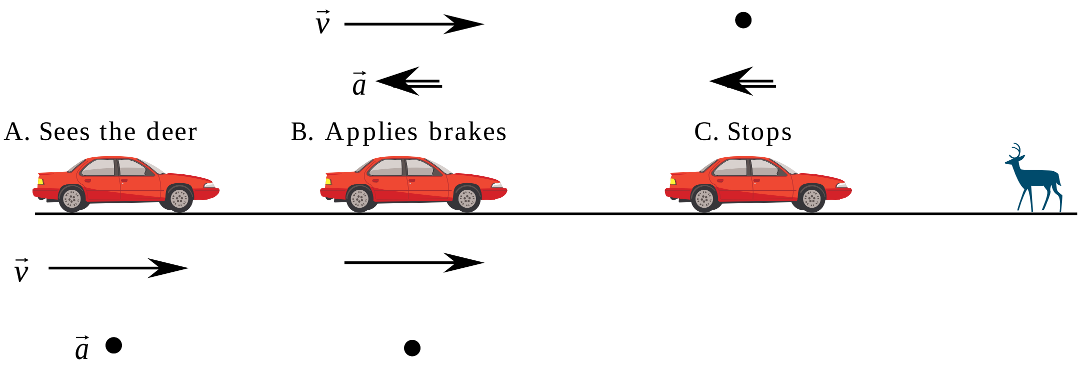
2.183

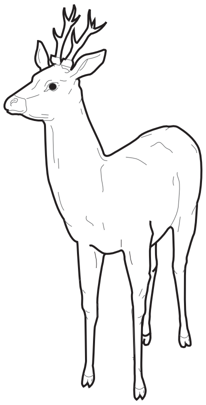


Velocity vectors form the top row, acceleration vectors, the bottom row.

We have optimistically assumed, in the diagram, that the car stops before hitting the deer although we are not yet certain that it will. Did you select the three events A, B, C above? If not then correct your diagram.

For event A (driver sees the deer) the acceleration is 0 because the driver does not hit the brakes immediately; his reaction time is 0.6 s. For event C, the car has just stopped moving so its velocity is 0. Because the car is slowing as it approaches C, it must have acceleration in the direction shown above the car (really deceleration), opposite to the direction of motion.

Why are there two sets of vectors (above and below the car) at event B? Write your answer.



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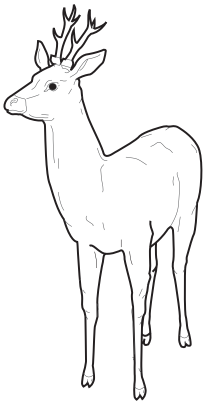
2.184

Event B is both the end of the constant velocity motion (vectors below) and the beginning of the accelerated motion (vectors above).



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