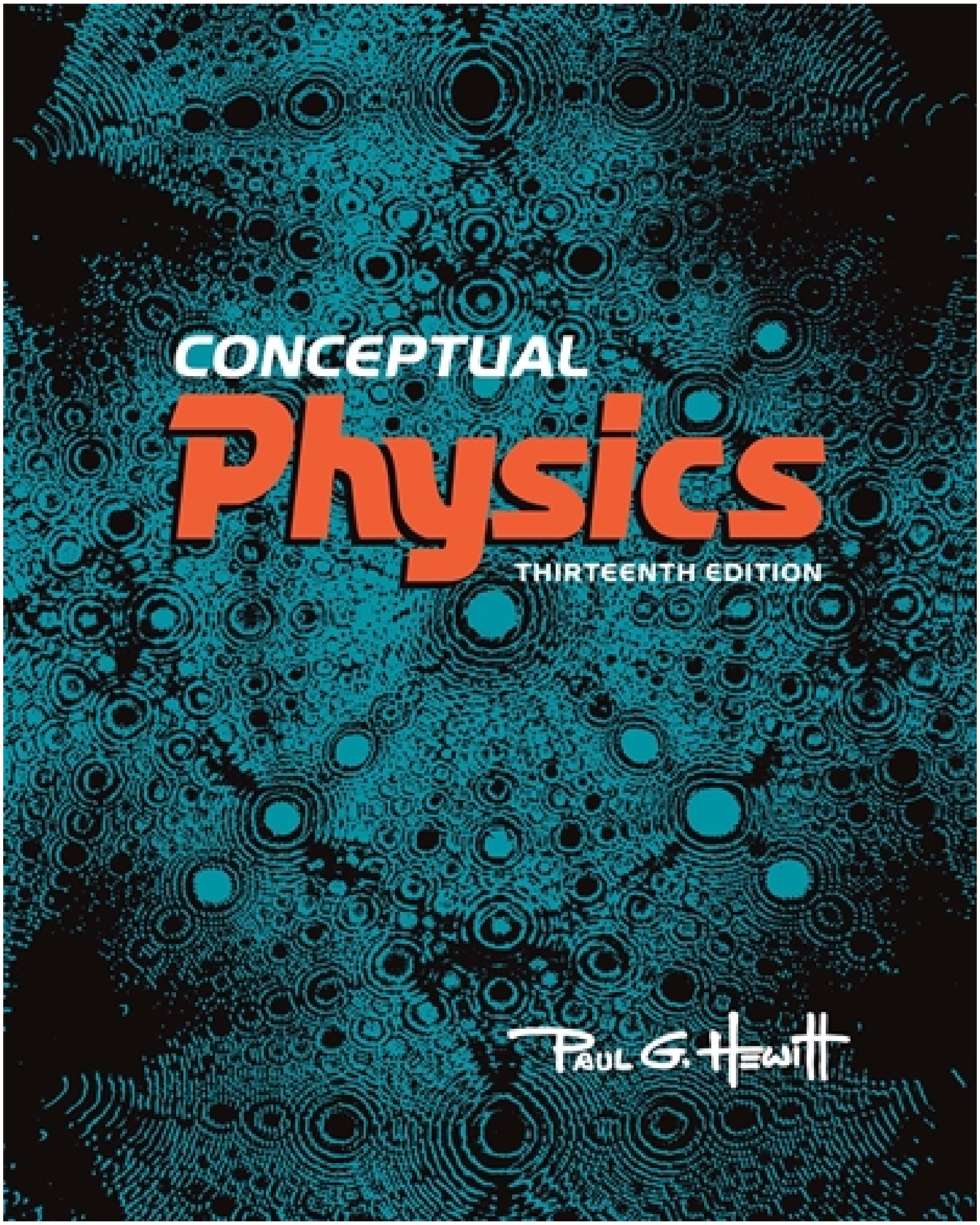
Solutions for Conceptual Physics 13th Edition by Hewitt



Solutions

2 Newton's Second Law of Motion

OPENING PHOTOS AND PROFILE

The little boy with the Newton's cradle apparatus in the Part One opener is Ian Evans, son of Bart and Jill Evans, both featured in chapter-opening photos (Chapters 23 and 25). Bart is the workshop coordinator at the Mission Science Workshop, a mini-Exploratorium, devoted to hands-on learning in San Francisco. Jill is a physics instructor at CCSF, my teaching heaven. Photos of Jill appear throughout the book.

Chapter opener photos begin with Swedish friends Cedric and Anne Linder investigating rope tensions for the suspended red block. Photo two shows a demonstration of inertia with a blacksmith's anvil resting on my body, and friend Will Maynez swinging the sledgehammer. Newton's law of inertia is again illustrated by Ana Miner in photo three. Photo four is of Karl Westerberg of CCSF showing one of my favorite demos with the ball suspended on a string. This is the best demo I know that clearly distinguishes mass and weight.

The profile is of Cedric Linder, the first Professor of Physics Education Research in Sweden at Uppsala University.

INTRODUCTION

Whereas the study of mechanics customarily begins with kinematics, I begin with a much easier concept for your students—*force*. In my experience I've come to see kinematics as the "black hole of physics instruction"—sucking up class time better devoted to physics. It may be fun to teach, but know that there are NO laws of physics in kinematics. Examples of force provide a better initial hook for student interest than speed and acceleration. So forces in Chapter 2, and motion postponed a bit until Chapter 3.

What I hope will be of particular interest to students is the Personal Essay, which relates to events that inspired me to pursue a life in physics—my meeting with Burl Grey on the sign-painting scaffolds of Miami, Florida. Relative tensions in supporting cables are what first caught my interest in physics, and I hope to instill the same interest in your students with my story—also featured on the first of the many Hewitt-Drew-It screencasts, Equilibrium Rule, which nicely introduces vectors.

The distinction between mass and weight will await the following chapter, when it's needed in Newton's second law. I see the key to good instruction as treating somewhat difficult topics only when they are used. For example, I see as pedagogical folly spending the first week on unit conversions, vector notation, graphical analysis, and scientific notation. How much more sensible that the first week in your course is a hook to promote class interest, with these things introduced later if and when they are needed.

SUPPLEMENTS

Practicing Physics

- Static Equilibrium
- The Equilibrium Rule: $\Sigma F = 0$
- Vectors and Equilibrium

Next-Time Questions

- Ball Swing
- Pellet in the Spiral
- Falling Elephant and Feather

Hewitt-Drew-It! Screencasts

- Equilibrium Rule
- Equilibrium Problems
- Net Force and Vectors
- Nellie's Rope Tensions
- Nellie's Ropes
- Force Vector Diagrams
- Force Vectors on an Incline

Laboratory Manual

- Walking the Plank—*Equilibrium Rule* (Experiment)

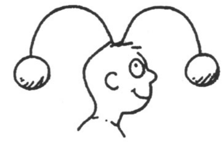
SUGGESTED PRESENTATION

Newton's First Law

Begin by pointing to an object in the room and stating that if it started moving, one would reasonably look for a cause for its motion. We would say that a force of some kind was responsible, and that would seem reasonable. Tie this idea to the notion of force maintaining motion as Aristotle saw it. State that a cannonball remains at rest in the cannon until a force is applied, and that the force of expanding gases drives the ball out of the barrel when it is fired. But what keeps the cannonball moving when the gases no longer act on it? This leads you into a discussion of inertia. In the everyday sense, inertia refers to a habit or a rut. In physics it's another word for laziness, or the resistance to change with regard to motion. To demonstrate, I use a 10-cm diameter solid steel sphere, actually a huge ball bearing. I roll the ball along the lecture table to show its tendency to keep rolling. Inertia was first introduced by Galileo—a result of his inclined-plane experiments.

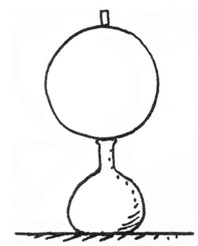
> DEMONSTRATION: Show that inertia refers also to objects at rest with the classic ***tablecloth-and-dishes demonstration.*** Be sure to pull the tablecloth slightly downward so there is no upward component of force on the dishes! I precede this demo with a simpler version, a simple block of wood on a piece of cloth—but with a twist. I ask what the block will do when I suddenly whip the cloth toward me. After a neighbor check, I surprise the class when they see that the block has been stapled to the cloth! This illustrates Newton's zeroth law—be skeptical. Then follow up with the classic tablecloth demo. Don't think either of these demos is too corny. Your students will love both.

Of course when we show a demonstration to illustrate a particular concept, there is almost always more than one concept involved. The tablecloth demo is no exception, which also features impulse and momentum (Chapter 6 material). The plates on the table experience two impulses; one that first involves the friction between the cloth and dishes, which moves them slightly toward you. It is brief and very little momentum builds up. Once the dishes are no longer on the cloth, a second impulse occurs due to friction between the sliding dishes and table, which acts in a direction away from you and prevents continued sliding toward you. This second impulse brings the dishes to rest. Done quickly, the brief displacement of the dishes is hardly noticed. Is inertia really at work here? Yes, for if there were no friction, the dishes would strictly remain at rest.



DEMONSTRATION: Continuing with inertia, fashion a wire coat hanger into an m shape as shown. Two globs of clay are stuck to each end. Balance it on your head, with one glob in front of your face. State that you wish to view the other glob and ask how you can do so without touching the apparatus. Then simply turn around and look at it. It's like the bowl of soup you turn only to find the soup stays put. Inertia in action! (Of course, like the tablecloth demo, there is more physics here than inertia; this demo can also be used to illustrate rotational inertia and the conservation of angular momentum. In the interest of "information overload," it may be best that you don't discuss this.)

CHECK QUESTION: How does the law of inertia account for removing snow from your shoes by stamping on the floor, or removing dust from a coat or rug by shaking it? When your foot moves downward, the snow on it tends to continue moving downward when your foot is brought to a sudden halt by the floor. Likewise for shaking dust from a garment.



DEMONSTRATION: Do as Marshall Ellenstein does and place a metal hoop atop a narrow jar. On top of the hoop balance a piece of chalk. Then whisk the hoop away and the chalk falls neatly into the narrow opening. The key is grabbing the hoop on the *inside*, on the side farthest from your sweep. This elongates the hoop horizontally and the part that supports the chalk drops from beneath the chalk. (If you grab the hoop on the near side, the elongation will be vertical and pop the chalk skyward!)

Units of Force—Newtons

I suggest not making a big deal about the unfamiliar unit of force—the newton. I simply state it is the unit of force used by physicists, and if students find themselves uncomfortable with it, they should simply think of "pounds" in its place. Relative magnitudes, rather than actual magnitudes, are the emphasis of conceptual physics anyway. Do as my influential pal Burl Grey does in Figure 2.11 and suspend a familiar mass from a spring scale. If the mass is a kilogram and the scale is calibrated in newtons, it will read 10 N (more precisely, 9.8 N). If the scale is calibrated in pounds it will read 2.2 pounds. State that you're not going to waste good time in conversions between units (students can do enough of that in a follow-up course). Plus any conversion they might want is instantly available on the Web.

Net Force

Discuss the idea of more than one force acting on something, and the resulting net force, which in vector notation we call the *resultant*. Figure 2.6 captures the essence.

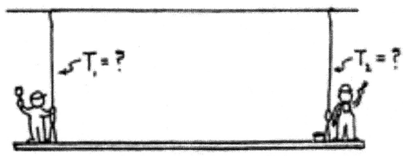
The Equilibrium Rule

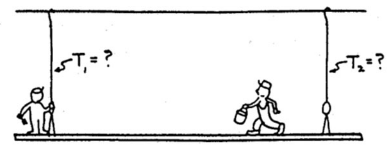
This is the gist of Newton's first law. It is a rule to guide the answers to many questions, especially about structures. The rule is simple: $\Sigma \boldsymbol{F} = 0$. The symbol Σ stands for "vector sum of." A vector sum takes into consideration positive and negative directions. For example, if a scaffold is in equilibrium, then the vector sum of the forces acting on it "add to" zero. If only upward rope tensions and gravity act on the scaffold, then the combination of upward forces, minus the combination of downward forces, will add to zero. Ups is equal to downs, and the scaffold hangs at rest. For any object in equilibrium, the net force on it must be zero.

Sign Painter Skit

From my Personal Essay on page 31 in the textbook.

Step 1: If both painters have the same weight and each stands next to a rope as shown to the left, the supporting force of the ropes will be equal. If spring scales were used, one on each rope, the forces in the ropes would be evident. Ask what the scale reading for each rope would be in this case. The answer is each rope will support the weight of one man and half the weight of the rig—both scales will show equal readings.





Step 2: Suppose one painter walks toward the other as shown to the right, which you draw on the board (or equivalent). Will the tension in the left rope increase? Will the tension in the right rope decrease? Grand question: Will the tension in the left rope increase *exactly* as much as the decrease in tension of the right rope? You might quip that is so, but how does either rope "know" about the change in the other rope? After neighbor discussion, be sure to emphasize that the answers to these questions lie in the framework of the equilibrium rule: $\Sigma \boldsymbol{F} = 0$. Since there is no change in motion, the net force must be zero, which means the upward support forces supplied by the ropes must add up to the downward force of gravity on the two men and the rig. So a decrease in one rope must necessarily be met with a corresponding increase in the other. (This example is dear to my heart. Burl and I didn't know the answer way back then because neither he nor I had a model for analyzing the problem. We didn't know about Newton's first law and the Equilibrium Rule. How different one's thinking is when one has or does not have a model to guide it. If Burl and I had been mystical in our thinking, we might have been more concerned with how each rope "knows" about the condition of the other—an approach that intrigues many people with a nonscientific view of the world.)

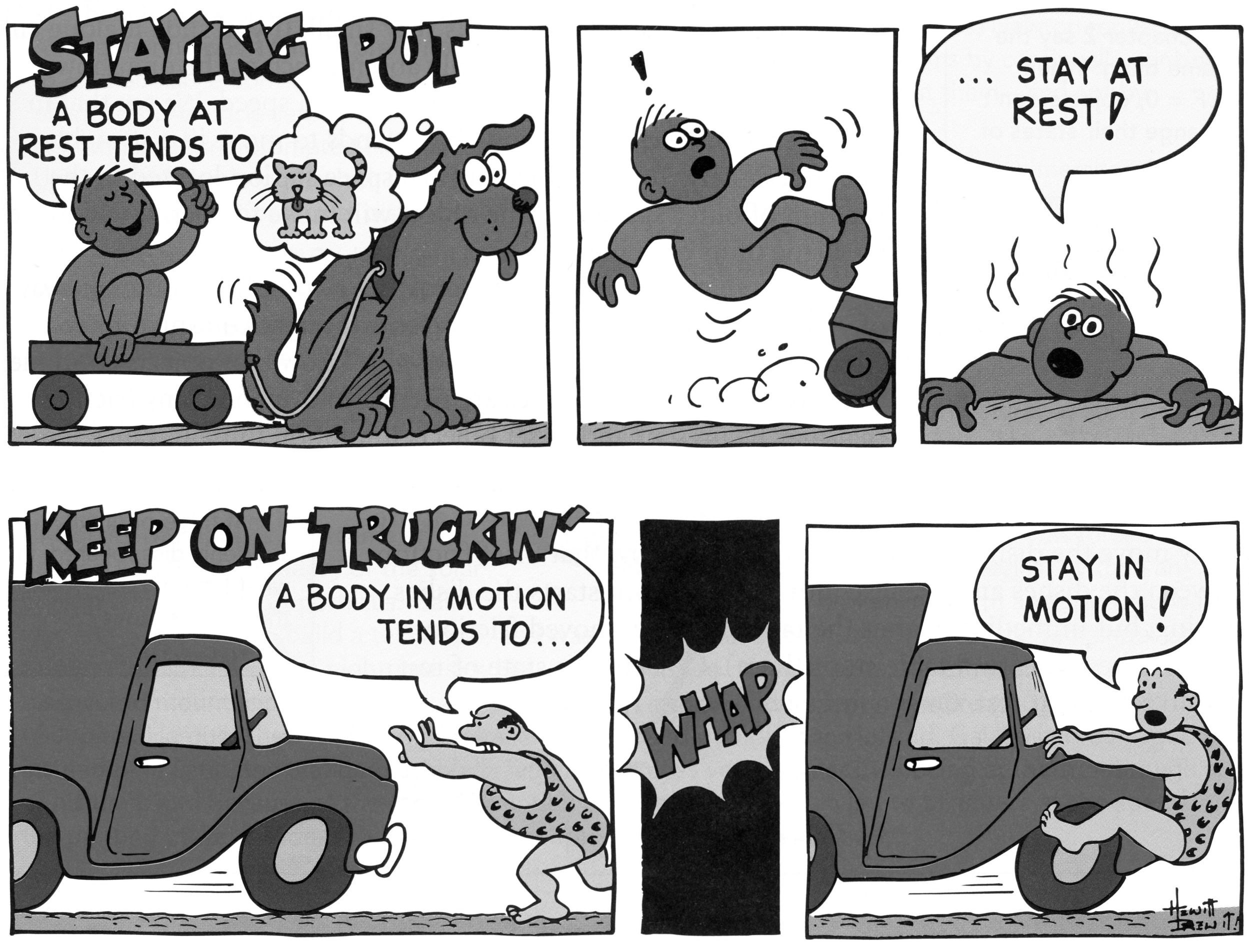
Cite other *static* examples, where the net force is zero as evidenced by no changes in motion. Hold a 1-kg mass at rest in your hand and ask how much net force acts on it. Be sure students distinguish between the 10-N gravitational force on the object and the zero net force on it—as evidenced by its state of rest. (The concept of acceleration is introduced in the next chapter.) When suspended by the spring scale, point out that the scale is pulling up on the object, with just as much force as Earth pulls down on it. Pretend to step on a bathroom scale. Ask how much gravity is pulling on you. This is shown on the scale reading. Then ask what the net force is that acts on you. This is evident by your absence of motion change. Consider two scales, one foot on each, and ask how each scale would read. Then ask how the scales would read if you shifted your weight more on one than the other. We'll return to support force, called *normal force*, in following chapters.

Inertia and the Moving Earth

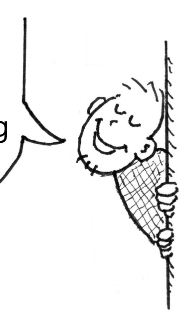
Stand facing a wall and jump up. Then ask why the wall does not smash into you as Earth rotates under you while you're airborne. Relate this to the idea of a helicopter ascending over San Francisco, waiting motionless for 5 hours and waiting until Washington, D.C., appears below, then descending. Hooray, this would be a neat way to fly cross-country! Except, of course, for the fact that-the "stationary" helicopter remains in motion with the ground below. "Stationary" relative to the stars means it would have to fly as fast as Earth turns (what jets attempt to do).

Introducing End-of-Chapter Exercises

After you've assigned exercises, tell your students to be nice to their brains and avoid the easy route of searching on the Web for solutions to Think and Solve and Think and Explain exercises. This is a time for brain exercise. Just as doing pushups strengthens their arms, thinking through solutions strengthens their cognitive skills.



If you want your students to read chapter material *before* coming to class, reward them for doing so. Give them a quickie quiz at the outset of your class—perhaps at unannounced times. The quiz can be one or two end-of-chapter *Reading Check Questions* of assigned chapters. Furthermore, you don't even have to grade the quizzes. Tell your class that you may or may not look at or count their quizzes. The quiz itself is motivation. Nobody wants the indignity of submitting a blank quiz. Not being able to answer simple questions is personally debilitating—enough to motivate students to read assigned material before coming to class. Common sense—reward the behavior you want!



ANSWERS AND SOLUTIONS FOR CHAPTER 2

READING CHECK QUESTIONS (COMPREHENSION)

2.1 Aristotle on Motion

1. Aristotle classified the motion of the Moon as natural.
2. Aristotle classified the motion of the Earth as natural.
3. Copernicus stated that Earth circles the Sun, and not the reverse.

2.2 Galileo's Experiments

4. Galileo discovered that falling objects pick up equal speeds whatever their weights.
5. Galileo discovered that moving objects continue in motion without the need of a force.
6. Inertia is the *name* for the property of matter resisting a change in motion.

2.3 Newton's First Law of Motion

7. Newton's law is a restatement of Galileo's concept of inertia.
8. In the absence of force, a moving body follows a straight-line path.
9. No force is required for continued motion.

2.4 Net Force and Vectors

10. The net force is 80 N to the right.
11. A description of force involves magnitude and direction, and is a vector quantity.
12. The resultant is $\sqrt{2}$ N.
13. The resultant is 50 N.

2.5 The Equilibrium Rule

14. Yes, although scientists prefer the newton.
15. The net force is zero.
16. The net force is zero.
17. All the forces on something in mechanical equilibrium add vectorially to zero.
18. $\Sigma \boldsymbol{F} = 0$.

2.6 Support Force

19. The support force is 12 N. The net force on the book is zero.
20. Weight and support force have equal magnitudes.

2.7 Equilibrium of Moving Things

21. Yes, straight-line motion of the ball at constant speed is dynamic equilibrium.
22. An object in either static or dynamic equilibrium has a zero net force on it.
23. The force of friction is 120 N.

2.8 The Moving Earth

24. They had no comprehension of the concept of inertia.
25. The bird still moves at 30 km/s relative to the Sun.
26. Yes, like the bird of Figure 2.16, you maintain a speed of 30 km/s relative to the Sun, in accord with the concept of inertia.

THINK AND DO (HANDS-ON APPLICATION)

27. Consider connecting with your grandparents via traditional handwritten notes.
28. This illustrates Newton's first law—the law of inertia.
29. Again, the application of the law of inertia. The inertia of the block and books keeps them from suddenly crushing down on you.

THINK AND SOLVE (MATHEMATICAL APPLICATION)

30. (a) 70 N. (b) 30 N.
31. (a) Zero friction. (b) 100 N. (c) 120 N.
32. Since each scale reads 350 N, Lucy's total weight is 700 N.
33. 400 N on one scale, 800 N on the other. ($2x + x = 1200$ N; $3x = 1200$ N; $x = 400$ N)
34. From the equilibrium rule, $\Sigma \boldsymbol{F} = 0$, the upward forces are 800 N, and the downward forces are 500 N + the weight of the scaffold. So the scaffold must weigh 300 N.
35. From the equilibrium rule, $\Sigma \boldsymbol{F} = 0$, the upward forces are 800 N + tension in the right scale. This sum must equal the downward forces 500 N + 400 N + 400 N. Arithmetic shows the reading on the right scale is 500 N.

THINK AND RANK (ANALYSIS)

36. C, B, A
37. C, A, B, D
38. (a) B, A, C, D (b) B, A, C, D
39. (a) A = B = C (no force) (b) C, B, A

THINK AND EXPLAIN (SYNTHESIS)

40. Aristotle preferred philosophical logic while Galileo preferred experimentation.
41. The tendency of a rolling ball is to continue rolling—in the absence of a force. The ball slows down likely due to the force of friction.
42. Copernicus and others of his day thought an enormous force would continuously push the Earth to keep it in motion. He was unfamiliar with the concept of inertia, and didn't realize that once a body is in motion, no force is needed to keep it moving (assuming no friction).
43. Galileo discredited Aristotle's idea that the rate at which bodies fall is proportional to their weight.
44. Galileo demolished the notion that a moving body requires a force to keep it moving. He showed that a force is needed to *change* motion, not to maintain motion, with negligible force.
45. Galileo proposed the concept of inertia before Newton was born.
46. Nothing keeps asteroids moving. The Sun's force deflects their paths but is not needed to keep them moving.
47. Nothing keeps the probe moving. In the absence of a propelling or deflecting force it would continue moving in a straight line.
48. If you pull the cloth upward, even slightly, it will tend to lift the dishes, which will disrupt the demonstration of dishes remaining at rest. The cloth is best pulled horizontally and slightly downward for the dishes to remain at rest.
49. The inertia of a whole roll resists the large acceleration of a sharp jerk and only a single piece tears. If a towel is pulled slowly, a small acceleration is demanded of the roll and it unwinds. This is similar to the hanging ball and string in Figure 2.5.
50. Your body tends to remain at rest, in accord with Newton's first law. The back of the seat pushes you forward. Without support at the back of your head, your head is not pushed forward with your body, which likely injures your neck. Hence, headrests are recommended.
51. In a bus at rest your head tends to stay at rest. When the bus is rear-ended, it lurches forward and you and your head also move forward. Without a headrest, your body tends to leave your head behind. Hence a neck injury.
52. The law of inertia applies in both cases. When the bus slows, you tend to keep moving at the previous speed and lurch forward. When the bus picks up speed, you tend to keep moving at the previous (lower) speed and you lurch backward.
53. The maximum resultant occurs when the forces are parallel in the same direction—32 N. The minimum occurs when they oppose each other—8 N.

54. The vector sum of the forces equals zero. That means the net force must be zero.
55. No, if only a single nonzero force acts on an object, its motion will change and it will not be in mechanical equilibrium. Other forces are needed for a zero net force for equilibrium.
56. Yes, it's in dynamic equilibrium because the net force on it is zero when sliding at constant velocity.
57. No, because the force of gravity still acts. Net force is not zero!
58. No, because the force of gravity still acts, and the player is in motion. Net force is *mg*.
59. Tension in each rope is half her weight.
60. At the top of its path (and everywhere else along its path) the force of gravity acts to change the ball's motion. Even though it momentarily stops at the top, the net force on the ball is not zero and therefore it is not in equilibrium.
61. Yes, if the puck moves in a straight line with unchanging speed, the forces of friction are negligible. Then the net force is practically zero, and the puck can be considered to be in dynamic equilibrium.
62. You can say that no net force acts on your friend at rest. The key word is *net*. When the net force is zero, your friend is in static equilibrium.
63. The scale will read half her weight. In this way, the net force (upward pull of left rope + upward pull of right rope – weight) = 0.
64. In the left figure, Harry is supported by two strands of rope that share his weight (like the little girl in the previous exercise). So each strand supports only 250 N, below the breaking point. Total force up supplied by ropes equals weight acting downward, giving a net force of zero and no acceleration. In the right figure, Harry is now supported by one strand, which for Harry's well-being requires that the tension be 500 N. Since this is above the breaking point of the rope, it breaks. The net force on Harry is then only his weight, giving him a downward acceleration of *g*. The sudden return of zero velocity changes his vacation plans.
65. Two significant forces act on the book: the force due to gravity and the support force (normal force) of the table.
66. If the upward force were the only force acting, the book indeed would rise. But another force, due to downward gravity, results in the net force being zero.
67. When you stand on a floor, the floor pushes upward against your feet with a force equal to that of gravity, your weight. This upward force (normal force) and your weight are oppositely directed, and since they both act on the same body, you, they cancel to produce a net force on you of zero—hence, you are not accelerated.
68. The gravitational force on you and the scale are a constant. What does fluctuate is the upward support force (normal force) due to your jouncing. Since the reading on a scale is the normal force, your best reading is standing at rest on the scale on a horizontal floor, which matches your weight.
69. Without water, the support force is W. With water, the support force is $W + w$.
70. The friction on the crate is 200 N, opposite to your 200-N pull.
71. The friction force is 600 N for constant speed. Only then will $\Sigma \boldsymbol{F} = 0$.
72. The support force on the crate decreases as the load against the floor decreases. When the crate is entirely lifted from the floor, the support force by the floor is zero. The support force on the workmen's feet correspondingly increases as the load transfers from the floor to them. When the crate is off the floor and at rest, its weight is transferred to the men, whose normal force is then increased.
73. Emily will not be successful, for her speed will be zero relative to the land.

THINK AND DISCUSS (EVALUATION)

74. Aristotle would likely say it stops due to its natural place. Galileo would say it stops due to encountering friction along the way.
75. In both cases the top string supports the weight of the ball. When the lower string is pulled gradually, its tension adds to the top string, and it breaks. But if a pull of the lower string is quick enough, inertia of the ball "keeps it in place" while the snapped lower string breaks.

76. We aren't swept off because we are traveling just as fast as Earth, like moving along in a fast-moving vehicle. Also, there is no atmosphere through which Earth moves, which would more than blow our hats off!
77. Your friend should learn that inertia is not some kind of force that keeps things like Earth moving, but is the name for the property of things to keep doing what they are doing in the absence of a force. So your friend should say that *nothing* is necessary to keep Earth moving. Interestingly, the Sun keeps it from following the straight-line path it would take if no forces acted, but it doesn't keep it moving. Nothing does. That's inertia.
78. You should disagree with your friend. In the absence of external forces, a body at rest tends to remain at rest; if moving, it tends to remain moving. Inertia is a *property* of matter that causes it to behave this way, not some kind of force.
79. The tendency of the ball is to remain at rest. From a point of view outside the wagon, the ball stays in place as the back of the wagon moves toward it. (Because of friction, the ball may roll along the cart surface—without friction the surface would slide beneath the ball.)
80. The car has *no* tendency to resume to its original twice-as-fast speed. Instead, in accord with Newton's first law, it tends to continue at half speed, decreasing in speed over time due to air resistance and road friction.
81. No, if there were no friction acting on the cart, it would continue in motion when you stop pushing. But friction does act, and the cart slows. This doesn't violate the law of inertia because an external force indeed acts.
82. An object in motion tends to stay in motion, hence the discs tend to compress upon each other just as the hammerhead is compressed onto the handle in Figure 2.5. This compression results in people being slightly shorter at the end of the day than in the morning. The discs tend to separate while sleeping in a prone position, so you regain your full height by morning. You can notice this if you find an overhead point you can almost reach in the evening, then easily reached in the morning. Try it!

83. No, if there were no force acting on the ball, it would continue in motion without slowing. But air drag does act, along with slight friction with the lane, and the ball slows. This doesn't violate the law of inertia because external forces indeed act.
84. The normal force is greatest when the table surface is horizontal. It progressively decreases as the angle of tilt increases. As the angle of tilt approaches 90°, the normal force approaches zero. When the table surface is vertical, it no longer presses on the book, which then freely falls.
85. No, the normal force would be the same whether the book was on slippery ice or sandpaper. Friction plays no role unless the book slides or tends to slide along the surface.
86. A stone will fall vertically if released from rest. If the stone is dropped from the top of the mast of a moving ship, the horizontal motion is not changed as the stone is falls—providing air resistance on the stone is negligible. From the frame of reference of the uniformly-moving ship, the stone falls in a vertical straight-line path, landing at the base of the mast.
87. A body in motion tends to remain in motion, so you move with the moving Earth whether or not your feet are in contact with it. When you jump, your horizontal motion matches that of the Earth and you travel with it. Hence the wall does not slam into you.
88. The coin moves along with you when tossed. While airborne it maintains this forward motion, so the coin lands in your hand. If the train slows while the coin is airborne, it will land in front of you.
89. If the train rounds a corner while the coin is in the air, it will land off to the side of you. The coin continues in its horizontal motion, in accord with the law of inertia.
90. Gravitation is a vertical force. On an incline, a component of this force lies along the surface, which produces acceleration if the ball is free to move. But on a horizontal surface, no horizontal component of gravitational force exists, and no change in force occurs.

CHAPTER 2 MULTIPLE-CHOICE PRACTICE EXAM

A distinguishing new feature in this thirteenth edition is the sample multiple-choice practice exams at the end of each chapter. I see these as a must for student learning. Even though answers and explanations are displayed upside down at the bottom of the exam page, consider using class time to highlight the explanations, some of which are explained more fully here. Exams can be learning experiences as well as an assessment of student learning.

1. According to Galileo, inertia is a
(a) force like any other force.
(b) special kind of force.
(c) property of all matter.
(d) concept attributed to Aristotle.
Answer: (c)
Explanation: By definition, inertia is a property of all matter, choice (c). It is not a force or a concept opposite to force. This is a definition of inertia, pure and simple.

2. Galileo's use of inclined planes allowed him to effectively
(a) slow the ball's changes in speed.
(b) reduce the time of the ball's changes in speed.
(c) eliminate major changes in speed.
(d) eliminate friction.
Answer: (a)
Explanation: Galileo lacked suitable time devices (clocks had not yet been invented) so he searched for a pattern to changes in a ball's downward motion by using small-angle inclines. By successively increasing the angle of a plane to vertical, he found acceleration to be that of free fall. Look ahead to the step-by-step stages of Figure 3.6 in Chapter 3. Hooray for simplicity.

3. A space probe flying in remote outer space continues traveling
(a) due to a force acting on it.
(b) in a curved path.
(c) even if no force acts on it.
(d) due to gravity.
Answer: (c)
Explanation: In accord with Newton's first law of motion, a body in motion tends to remain in motion in a straight-line path unless acted upon by a force. This question is a simple example of that. With no applied force, the space probe will move continuously.

4. A hockey puck slides along an icy pond. Without any kind of friction, the force needed to sustain sliding is
(a) none at all.
(b) equal to the weight of the puck.
(c) the weight of the puck divided by its mass.
(d) the mass of the puck multiplied by 10 m/s^2.
Answer: (a)
Explanation: In accord with Newton's first law of motion, a body in motion tends to remain in motion in a straight-line path unless acted upon by a force. With no friction to overcome, the puck will slide indefinitely until it encounters a force. The notion that no force is required for sustained motion, although somewhat accepted by the public today, was historically earthshaking.

5. What is the net force on a box of chocolates when pushed across a table with a horizontal force of 10 N while friction between it and the surface is 6 N?
(a) 16 N (b) 10 N (c) 6 N (d) 4 N
Answer: (d)
Explanation: The net force across the table is simply the sum of the horizontal forces 10 N – 6 N, which is 4 N, choice (d). This simple question should not have been missed.

6. The sum of the forces that act on any object moving at constant velocity is
(a) zero. (b) 10 m/s^2. (c) equal to its weight. (d) about half its weight.
Answer: (a)
Explanation: In accord with Newton's first law of motion, no force is needed for a moving object to continue moving. It will "move of itself." The key here is "constant velocity"—no acceleration.

7. The equilibrium rule $\Sigma F = 0$ applies to
(a) objects or systems at rest. (b) objects or systems in uniform motion in a straight line.
(c) both. (d) neither.
Answer: (c)
Explanation: By definition, the equilibrium rule applies to objects at rest, static equilibrium, or in straight-line motion, dynamic equilibrium—both, so the best choice is (c).

8. The tensions in each of the two supporting ropes that support Burl and Paul on opposite ends of a scaffold
(a) are equal. (b) depend on the relative weights of Burl and Paul.
(c) combine to equal zero. (d) none of the above
Answer: (b)
Explanation: According to the equilibrium rule, the sum of the upward tensions must be equal and opposite to the combined sums of the weights of Burl plus Paul, and the weight of the scaffold. Each rope tension is not equal because the weights of Burl and Paul are not equal, nor do they combine to zero. What *does* combine to zero is the sum of upward forces (tensions in the two ropes) and downward forces of the weights the ropes support.

9. A man weighing 800 N stands at rest on two bathroom scales so that one scale shows a reading of 500 N. The reading on the other scale is
(a) 200 N. (b) 300 N. (c) 400 N. (d) 800 N.
Answer: (b)
Explanation: This is a numerical example of $\Sigma F = 0$. What number + 500 N = 800 N? Simple math tells you that number must be 800 N – 500 N = 300 N, choice (b).

10. If you leap straight up inside a high-speed train while it gains speed, you land
(a) slightly ahead of your original position.
(b) at your original position.
(c) slightly behind your original position.
(d) none of the above
Answer: (c)
Explanation: Unlike the bird that drops from a tree branch to a worm below where no changes in horizontal motion occur, the train *gains speed* while you are airborne. Your horizontal component of speed (velocity) during your jump remains the same as your speed when jumping. While you are jumping the floor below gains speed, which means you'll land behind your original position. Got it?