Prolog

1. Science is the accumulation and organization of knowledge.
3. Equations will be used to describe the science in quantifiable terms, so it is unequiviocal.
4. Scientific method
    a. Gather data
    b. Hypothesize an explanation
    c. Make predictions
    d. Test, or investigate the predictions
    e. Revise or reject the hypotheses
5. Fact: scientific knowledge observed by a great number of careful observers
   Hypothesis: educated possible explanation of the organization of the facts
   Law or Theory: accepted explanation that has been subjected to considerable testing
7. A scientific hypothesis is one that has tests that could prove it false.
13. Science, as stated above, is the accumulation and organization of knowledge. Technology is the science applied to a purpose to benefit society.
14. Physics described the motion of things, and the structure of particles. These must be understood to grasp the mechanics of the other sciences.
15. The rules of nature help us better appreciate the beauty of nature.

Chapter 1

3. Galileo determined that the mass of an object does not determine its speed of falling: heavy objects fall at the same speed as lighter weight ones, discounting air resistance. Aristotle has written that heavy objects fall faster than lighter ones. Galileo also determined that forces are not required to keep objects in motion.
4. Galileo spent a great deal of time experimenting to learn the nature of the natural world. This was his way of extending knowledge, in contrast to Aristotle, who spent time in philosophical discussion of the nature of the world.
5. The property by which objects resist change of motion is called INERTIA.
6. Mass is the measure of how much matter is present, it is not dependent on location. Weight is the force of the mass under the influence of gravity, which is dependent upon location.
7. Your mass is the same of Earth and on Moon, however, since the gravity of Moon is so much less, your weight would be considerably less on Moon than on Earth.
8. The unit of mass used in the equations of this unit is kilogram. There are 1000 grams in 1 kilogram. It is abbreviated kg, no period, no capital. Weight is a force: mass X acceleration. The unit of weight is Newton. A Newton, abbreviated N (capital, no period), is a kilogram accelerated by gravity, which has the units of meters per second squared: 1 N = 1 $kg \cdot m/s^2$.
10. There is a net force of 30 N to the right on a box pushed with 50 N to the right and 20 N to the left.
22. Speed is the distance traveled per unit of time. It is a scalar quantity. Velocity is the direction of displacement per unit of time. It is a vector quantity.
24. Speedometers show the instantaneous speed.
25. Velocity is the distance per unit of time. Acceleration is the change in velocity per unit of time.
26. An object with a constant velocity has no acceleration.
27. The acceleration of an object in free fall near Earth's surface is 10 m/s^2

Chapter 2

1. Inertia is the property of an object to stay at rest, or continue in a state of uniform motion, unless acted upon by outside forces. Uniform motion means in the same direction and the same speed.
5. Planets would travel in a straight line, no longer orbiting Sun, if their attraction to Sun did not exist.
6. Newton's second law states that the acceleration of an object is directly proportional to the net force applied to the object, and inversely proportional to the mass of the object.
7. Acceleration is directly proportional to force applied. If twice as much force is applied, the object accelerates twice as much.
8. The vector quantity of acceleration is inversely proportional to mass by Newton's law of $a \sim F/m$. If you double the mass without changing the force applied, the acceleration will be half.
9. Since you triple the mass and triple the force, the acceleration will remain the same.
10. A 10 N freely falling object has the force of its weight: 10 N.
14. If a freely falling object has reached its terminal velocity, it has no acceleration…zero.
17. Force is a push or a pull on an object. This is an action, which has an equal and opposite reaction. These two are the interaction.
21. For every action there is an equal and opposite reaction.
22. The reaction force of the bat hitting a baseball is the baseball's force on the bat. Sometimes it breaks a wooden bat.
23. The relationship of acceleration to force is directly proportional, but inversely proportional to mass. Since it is an action-reaction pair, the forces are the same. If the masses are not the same, which is the case considering the cannon and the cannonball, the lesser mass (the cannonball) will have much greater acceleration than the greater mass (the cannon).
24. Action-reaction pairs are always between different bodies. You might consider the molecular interactions within a solid body, but the bodies of consideration are the molecules, not the object.
30. Newton's first law: law of inertia—an object will remain at rest, or continue moving in a uniform direction and speed, unless acted upon by external forces.
    Newton's second law: acceleration of an object is directly proportional to the net forces acting upon the object, and inversely proportional to the mass of the object.
    Newton's third law: for every action there is an equal and opposite reaction.

Chapter 3

1. A moving skateboard has more momentum than an automobile at rest, because momentum is mass x velocity. Since the velocity of the auto is zero, its momentum is also zero.
3. It requires force exerted over time to change the momentum to zero. This is the impulse. If you are trying to catch a fast-moving baseball, extend your hand forward, so you can recoil from the ball as it hits your hand, increasing the time of slowing the ball to zero. This will reduce the force necessary to stop the ball. If you do not do this, the time the ball goes from moving to stopped will be minimized, and the force the ball imparts to your hand will be greater.
4. If you try to catch a fly ball with your hand against a wall, the time the momentum reaches zero is very short. The result will be the application of great forces to stop the ball. In fact, the ball may bounce off of your hand, increasing the impulse.
7. A baseball that is caught and thrown back undergoes the greatest change in momentum, since a ball that is caught goes from (mv) to zero, thrown goes from zero to (-mv), but one thrown back goes from (mv) to (-mv), twice the change in momentum.
8. When the ball is being caught has greater impulse than one that is thrown, or caught and thrown back, because the amount of time involved. Remember impulse is Force multiplied by time.
11. If two railroad cars are involved in a perfectly elastic collision, and one is stationary, the momentum of the moving one is transferred to the stationary one. The moving one stops. If the two cars are of equal mass, the velocity of the second will be equal to the velocity of the first before the collision.
12. If the two cars stick together, then the velocity of the two cars will be half of the first moving car.
14. If you exert a force on an object, and its frictional force is greater than the force you exert, the object will not move.
15. Work is force moved over a distance. If you lift a mass a certain distance, and half the mass twice that distance, you have done the same amount of work.
16. If you raise a car twice as high, its potential energy is twice as great, in reference to the surface from which you raised it.
17. If you raise two cars the same amount, and one is twice as massive as the other, that car has twice the potential energy compared to the other, in reference to the surface from which you raised them.
20. The net force of the pushing is 30 N = 100 N—70 N. The crate has moved 10 m, so the kinetic energy gained is net force time distance: 300 N·m, or 300 J.
21. A pile driver that possesses 10 kJ of potential energy, it can gain up to 10 kJ of kinetic energy when it

Chapter 4

1. Newton discovered that gravity acts between bodies: they are mutually attracted to one another. The force between them is equal to the product of their masses, divided by the square of the distance between their centers.
4. Newton's law of mutual gravitation is that bodies are attracted to one another, directly proportional to their masses and inversely proportional to the distance between them. $F = \frac{m_1 m_2}{d^2}$

8. You would weigh more at sea level than at the top of the Rockies. This is because you have reduced the diameter between you and Earth, closer to the center of Earth's gravity, increasing the force due to gravity.
9. The springs inside a bathroom scale would be more compressed if you were weighing yourself inside an elevator that was accelerating upward. They would be less compressed if the elevator were accelerating downward.
10. If you are in an elevator that is moving at a constant velocity, the springs inside a bathroom scale would read the same no matter what direction, or if the elevator was at rest. Acceleration would change this; but there no acceleration in the system.
11. In the space station, the occupants have no weight with respect to their surroundings, because they are constantly falling. Everything is also moving in a tangential velocity also, keeping them in orbit. The gravity keeps them from flying off into space in a straight line.
12. Your weight is equal to *mg* when your mass is under the influence of Earth's gravity, *g,* and you have a support force. If you were on another planet, your weight would be equal to *m(gravity of other planet)*.
14. Pluto was demoted to a dwarf planet because it does not dominate its orbital area, has an orbit that is highly elliptical and inclined 17^o to Sun's equator, and travels with a companion satellite of similar size to it. It is the first discovered Kuiper Belt Object.
16. The vertical component of velocity for a projectile changes with time due to the influence of gravity, accelerating, which acts while the object is in moving. However, the horizontal component of the velocity is unchanging, imparted to the projectile when it was fired, and not affected by gravity, which only acts in a downward direction.
17. Because of the reasons cited in the above answer, the stone's horizontal velocity does not change as it rises or falls…until it hits the ground…but then it no longer is falling, is it?
18. However, the stone's velocity decreases as it rises, because gravity acts in a downward direction.
19. If projectiles are launched at complementary angles, they have the same range…if there is no air resistance. We assume this, and if a projectile is launched 75_o, it will have the same range as one launched at 15^o. The one launched at 15^o would arrive downrange sooner, however.
20. A projectile will have the same downward speed at the same altitude as its upward speed was. So when it returns to its initial level , its speed will be the same, in the opposite direction, as when it was launched upward. 100 m/s
21. A projectile moving at 8 km/s (8000 m/s) in the horizontal, straight line direction is falling at $10m/s^2$ This is 5 meters for every second. Since Earth's curvature is 5 meters lower for every 8 km horizontal distance, the projectile falls and moves forward exactly matching Earth's curvature.
22. If this projectile is in Earth's atmosphere, the air would slow it down, and it would not travel 8 km/s in the horizontal direction. This would allow Earth's gravitational acceleration to pull it to Earth's surface.