Conceptual Physical Science – 5th Edition

# Solutions

## Chapter 1 – Patterns of Motion and Equilibrium

Reading Check Questions:

1. What did Aristotle believe about the relative speeds of fall for heavy and light objects?
   *Aristotle believed that heavier bodies fall faster than lighter bodies.*
4. Which dominated Galileo's way of extending knowledge: philosophical discussion or experiment?
   *Galileo believed that answers to questions about natural phenomena should be attained by experiment.*
5. What name is given to the property by which objects resist changes in motion?
   *inertia*
6. Which depends on location, weight or mass?
   *Weight depends on the location of one body to another because of the universal law of gravitation.*
7. Where is your weight greater, on earth or on the moon? How about your mass?
   *Your weight will be greater near a larger body (earth), whereas your mass does not change.*
8. What are the units of measurement for weight and for mass?
   *Weight is measured in Newtons (N) and mass is measured in kilograms (kg).*
9. A 1 kilogram weighs nearly 10 N on earth. Would it weigh more of less on the moon?
   *A one kilogram mass would weigh less on the moon, about 6 times less.*
11. What two quantities are necessary for a vector quantity?
    *A "vector" quantity has magnitude and direction, whereas a "scalar" quantity only has magnitude.*
12. Name the support force that occurs in a rope when both ends are pulled in the opposite directions?
    *The support force in a taut rope is called "tension."*
15. Why is the support force on an object often called the normal force?
    *When a body rests on a horizontal surface then the support force will be equal to the normal force. Remember that a normal force is at a right angle to any surface.*
22. Distinguish between speed and velocity.
    *Speed has only magnitude (scalar property) and velocity has magnitude and direction (vector).*
24. Does the speedometer on a vehicle show average speed of instantaneous speed?
    *instantaneous*
25. How can you be at rest and moving at 100,000 km/h at the same time?
    *A person sitting on earth is at rest with respect to the earth's surface, but being the earth is in motion around the sun, the person is in motion with respect to the sun.* [*Think of frame of reference.*]

Think and Solve:

40. Find the net force produced by a 30 N force and a 20 N force in each of the following cases:
    a) Both forces act in the same direction.
       *50 N*
    b) The two act in the opposite directions.
       *50 N*
45. A horizontal force of 120 N is required to push a piece of furniture across a floor at a constant velocity.
    a) What is the net force acting on the furniture?

*Because there is friction present, a force must be applied to overcome friction. Any extra force applied beyond that needed to overcome friction will acceleration the furniure forward. Because the velocity is constant in this question there is no acceleration. Therefore, the net force acting on the furniture is that needed to just overcome friction. The net force acting = frictional force.*

b) How much friction acts on the furniture when it is at rest on a horizontal surface?

*On a horizontal surface there are no horizontal forces acting on the furniture at rest. If the is no horizontal force acting then friction does not exist. Friction only appears when an unbalanced force is present.*

c) How much friction (f) acts on the bookcase when it is at rest on a horizontal surface without being pushed?

*There is no friction present. Remember - friction only appears when an unbalanced force is present.*

48. a) Show that the average speed of a tennis ball is 48 m/s when it travels the full length of the court, 24 m, in 0.5 s.

*speed = $d/t$ ---> 48 m/s = $24\ m/0.5\ s$*

b) How would air resistance affect the travel time?

*Friction slows down the speed of moving bodies and will thus increase travel time.*

49. a) Show that the average speed of Leslie is 10 km/h when she runs to the store 5 km away in 30 min.

*30 minutes = 0.5 h  speed = $d/t$ = 10 km/h = $5\ m/0.5\ h$*

b) How fast is this in m/s?

*Must use <u>two</u> conversion factors.  10 km/h ($1{,}000\ m/1\ km$)($1\ h/3{,}600\ s$) = 2.7 m/s*

50. Show that the acceleration is 7.5 $m/s^2$ for a ball that starts from rest and rolls down a ramp and gains a speed of 30 m/s in 4 s.

*acceleration = change in velocity / change in time = 30 m/s / 4 s = 7.5 m/s*

53. A race car races on a circular track of radius (r).

a) Write an equation for the car's average speed when it travels a complete lap in time (t).

*speed = distance of one lap / time = $d/t$*

*What is d?  d = circumference of one lap = $2\pi r$ ----> speed = $2\pi r/t$*

b) The radius of the track is 100 m and the time to complete a lap is 14 s. Show that the average speed around the track is 45 m/s.

*circumference = $2\pi r$ = 628 m  speed = $2\pi r/t$ = $628\ m / 14\ s$ = 45 m/s*

<u>Exercises</u>:

63. A bowling ball rolling along a lane gradually slows as it rolls. How would Aristotle likely interpret this observation? How would Galileo interpret it?

*According to Aristotle the ball slowed because it no longer had a force behind to move it. Galileo's interpretation would be that unbalanced forces were at play. Friction slows the ball.*

67. What physical quantity is a measure of how much inertia an object has?

*Mass!*

81. An empty jug of weight (W) rests on a table. What is the support force exerted on the jug by the table? What is the support force when water of weight (W) is poured into the jug?
*The supporting force is equal to the weight of the jug. This is Newton's 3rd law (action – reaction).*

87. Suppose that a freely falling object were somehow equipped with a speedometer. By how much would its speed readings increase with each second of fall?
*The speed would be increasing by 9.8 m/s every second.*

90. What is the acceleration of a car that moves at a steady velocity of 100 km/h for 100 s? Why is this question an exercise in careful reading as well as in physics?
*If a body is moving at a "steady velocity" then there is no acceleration.*

## Chapter 2 – Newton's Laws of Motion

Reading Check Questions:

5. What kind of path would the planets follow if suddenly their attraction to the sun no longer existed?
*Newton's 1st law of motion indicates the inertia of the moving body would have it move off in a straight line if the unbalanced force of gravity were to end.*

11. Why doesn't a heavy object accelerate more than a light object when both are falling freely?
*Using Newton's 2nd of motion* $a = {}^{F}/_{m}$ *it can be seen that when the mass of a body increases so then does the force of gravity acting on it. Therefore, if the mass is doubled then the force is doubled as well and the ratio remains one unit of acceleration.*

22. Consider hitting a baseball with a bat. If we call the force on the bat against the ball the action force, identify the reaction force.
*The "reaction" force is the force of ball on the baseball bat.*

28. How does a helicopter get its lifting force?
*In accordance with Newton's 3rd law of motion, the helicopter blade pushes on the air and the air pushes on the blade causing lift.*

Think and Solve:

38. A Honda Civic Hybrid weighs about 2,900 lb. Calculate the weight of the car in Newtons, and its mass in kilograms. [Note: 1 kg = 2.2 lb; 1 kg on earth's surface has a weight of about 10 N.]
*Convert pounds to kilograms first, then multiply mass times gravity.*
$2{,}900\ lb\ /\ 2.2 = 1{,}318.2\ kg$ *Wt. =* $mg = (1{,}318.2\ kg)(9.8\ m/s^2) = 12{,}918.2\ N$

## Chapter 3 – Momentum and Energy

Reading Check Questions:

1. Which has a greater momentum, an automobile at rest or a moving skateboard?
*Being momentum (p) = mv, then an automobile at rest has zero momentum, whereas the skateboard in motion has momentum.*

2. When a ball is hit with a given force, why does contact over a long time impart more speed to the ball?
*Using* $F\Delta t = m\Delta v$ *the impulse (J) imparted to a body is equal to the change in momentum of a body. Therefore, if the time the force of contact increase then the impulse given to the ball increase and thus the momentum of the ball increases. Being the mass is constant, then when the momentum increases then the velocity must increase.*

5. In karate, why is a force that is applied for a short time more effective?
*Using* $F = \Delta p/\Delta t$ *if the time of contact is small then the force increases.*

6. In boxing, why is advantageous to roll with the punch?
*Using* $F = \Delta p/\Delta t$ *if the time of contact is larger then the force decreases. Therefore, when a boxer moves in the direction of the punch ("roll"), the time of impact is larger (and decreases the force).*

16. A car is raised a certain distance on a service-station lift and therefore has potential energy relative to the floor. If it were raised twice as high, how much potential energy would it have?
*Potential energy (PE) = mgh. If the height (h) is doubled so will the potential energy of the car.*

19. Compared with some original speed, how much work must the brakes of a car supply to stop a car that is moving four times as fast? How does the stopping distance compare?
*The work-energy theorem states that* $Fd = {}^1/_2 mv^2$. *If the velocity (v) is increased four times then the KE will increase 16 times* ($4^2 = 16$). *Therefore the work (Fd) required to stop this car and the stopping distance will go up 16 times.*

Exercises:

64. Show that 470 W of power is expended by a weightlifter when lifting a 60 kg barbell a vertical distance of 1.2 m in a time interval of 1.5 s?
$P = {}^W/_t = {}^{Fd}/_t = {}^{(60\ kg)(9.8\ m/s^2)(1.2\ m)}/_{1.5\ s} = 470\ J/s$ (or Watts)

75. In terms of impulse and momentum, why do airbags in cars reduce the chances of injury in accidents?
*An airbag will increase the time in which the passenger's momentum changes, and thus reduce the force.* $F = \Delta p/\Delta t$

4. A car crashes into a wall at 25 m/s and is brought to rest in 0.1 s. Show that the average force exerted on a 75 kg test dummy by the seat belt is more than 18,000 N.
$F = \Delta p/\Delta t = {}^{m(v_f - v_i)}/_{\Delta t} = 75\ kg\ (0\ m/s) - (25\ m/s) / {}_{0.1\ s} = -18{,}750\ N$

## Chapter 4 - Gravity, Projectiles, and Satellites

Reading Check Questions:

4. What is the magnitude of gravitational force between two 1 kg bodies that are 1 m apart?
*This force is extremely small because of the small amount of mass in the system. This value was determined by Henry Cavendish in 1796 to be* $6.672 \times 10^{-11}$ *N.*

5. What is the magnitude of gravitational force between the earth and a 1 kg body at its surface?
*According to* $F = ma = mg$ -----> $(1\ kg)(9.8\ m/s^2) = 9.8$ *N.*

7. How does the force of gravity between two bodies change when the distance between them is tripled?
*The force of gravity is a function of the "inverse-square" law* ($I = {}^1/_{d^2}$), *therefore if the distance is tripled, then* $I = {}^1/_{3^2}$ ($= {}^1/_9$). *The force of attraction will decrease 9 times.*

10. Explain why occupants of the International Space Station have no weight, yet are firmly in the grip of earth's gravity.

*Both the ISS and its occupants are continuosly accelerating towards the earth when in orbit. If both are accelerating downward the occupants can not push against the floor they are weightless. This is exactly like being in an elevator that is in free-fall.*

28. At what part of an elliptical orbit does a satellite have the highest speed? The lowest speed?

*A satellite orbits the earth in an elliptical orbit, and will thus have a near point and far point. Therefore the satellite will have its greatest speed when it is closer and least speed when further away.* [*Remember that the force of gravity in inversely related to the distance between the bodies.*]

29. What happens to a satellite close to earth's surface if it is given a speed exceeding 11.2 km/s?

*A body close to the earth's surface is moving at 11.2 km/s then it will "escape" the earth's gravitational field. This 11.2 km/s speed is much grater than the speed to remain in a low-earth orbit, which is 7.9 km/s.*