1. What distinction did Aristotle make between natural motion and violent motion? Ans. Natural motion is straight up and down, light things went up and heavy things went down. Violent motion is imposed: collisions, pulling, and pushing.

2. What was Copernicus reluctant to publish his ideas? Ans. To escape religious persecution which considered the earth the center of the universe.

3. What is the effect of friction on a moving object? Ans. It slows them down.

4. The speed of a ball increases as it rolls down an incline and decreases as it rolls up an incline. What happens to its speed on a smooth horizontal surface? Ans. It remains constant. There is nothing to accelerate/decelerate it.

5. Galileo found that a ball rolling down one incline will pick up enough speed to roll up another. How high will it roll compared with its initial height? Ans. Without friction it will get to the same height everytime.

6. Does the law of inertia pertain to moving objects, objects at rest, or both? Support your answer with examples. Ans. Both. Things that are at rest want to stay at rest such as boulders and stubborn mules. Things moving want to keep moving such as a charging elephant or a linebacker for the L.A. Rams.

7. The law of inertia states that no force is required to maintain motion. Why, then, do you have to keep peddling your bicycle to maintain motion? Ans. There is a force, called friction, which is slowing down the bike. If you want to overcome one force, you must apply another.

8. If you were in a spaceship and fired a cannonball into frictionless space, how much force would have to be exerted on the ball to keep it going? Ans. None, according to Newton’s First Law. An object will continue moving unless acted on by an external force. There is no friction in space.

9. Does a 2 kilogram rock have twice the mass of a 1 kilogram rock? Twice the inertia? Twice the weight (when measured in the same location)? Ans. It has twice the mass, inertia, and weight.

10. Does a liter of molten lead have the same volume as a liter of apple juice? Does it have the same mass? Ans. A liter is a liter so they have the same volume. A liter of lead would have much, much more mass than a liter of apple juice because its density is much greater.

11. Why do physicists say mass is more fundamental than weight? Ans. Weight varies depending on the distance you are from the center of the earth. The farther away you are the less you weigh. Mass doesn’t change because of location.

12. An elephant and a mouse would both have zero weight in gravity-free space. If they were moving toward you with the same speed, would they bump in to you with the same effect? Explain. Ans. Nope! The elephant, which has a larger mass, would apply more force to you than the mouse. It has greater inertia and so it will continue to move while the mouse, with smaller inertia, would stop faster when colliding with you.

13. What is the weight of 2 kilograms of yogurt? Ans. Remember the jingle: To go from mass to weight multiply by nine point eight. \[ 2 \times 9.8 \text{ m/s}^2 = 19.6 \text{ N}. \]

14. What is the net force or, equivalently, the resultant force acting on an object in equilibrium? Ans. The forces in opposite directions cancel out and the net/resultant force is zero.
15. Forces of 10 N and 15 N act in the same direction on an object. What is the net force on the object? Ans. $10 \text{ N} + 15 \text{ N} = 25 \text{ N}$

16. If forces of 10 N and 15 N act in opposite directions on an object, what is the net force? Ans. $15 \text{ N} - 10 \text{ N} = 5 \text{ N}$

17. How does the tension in your arms compare when you let yourself dangle motionless by both arms and by one arm? Ans. If you split your body weight among both arms, they will each hold up half your weight. If you hold all your weight by one arm, then it will hold all your weight.

18. A clothesline is under tension when you hang from it. Why is the tension greater when the clothesline is strung horizontally than when it hangs vertically? Ans. If you are in equilibrium (not moving) while you are hanging from the clothesline then the force of tension upwards must equal the force of weight downwards. See how large the arrows are in each rope below to maintain equilibrium and you will see how much more tension there is in the horizontal situation than the vertical one.

19. If you hold a coin above your head while in a bus that is not moving, the coin will land at your feet when you drop it. Where will it land if the bus is moving in a straight line at constant speed? Explain. Ans. At your feet as well. When the bus is still, the coin is still. When the bus is moving forward, the coin is moving forward at the same speed as the bus the whole time. Everything in the bus is moving forward: driver, passengers, seats, wallets, etc. This is why when you are in a car it is not advisable to leave something in the “cubby” (the space behind the back seats where the car speakers often are). If the car stops suddenly, these things will become projectiles and shoot forward at the heads of the passengers/driver. They are all moving at the same original speed of the car.

20. In the cabin of a jetliner that cruises at 600 km/hr, a pillow drops from an overhead rack into your lap below. Since the jetliner is moving so fast, why doesn’t the pillow slam in to the rear of the compartment when it drops? Ans. Again, everything has inertia on the plane and so moves forward with the same velocity of the plane. Even the air inside the plane is moving forward. Now if the front of the plane didn’t have a window, the wind would blow in through the hole and if you threw a pillow up, the strong wind would blow it towards the back of the plane. What is the horizontal speed of the pillow relative to the ground? Ans. The horizontal speed of the pillow would be the same as the speed of the
plane. Relative to you inside the jetliner? Ans. The horizontal speed relative to the inside of the plane would be zero.

Ch. 5, REVIEW QUESTIONS, p. 71 ANSWER KEY

1. Distinguish between the relationship that defines acceleration and the relationship that states how it is produced. Ans. Acceleration is the change of velocity over time. Acceleration is produced when a force is applied to a mass.

2. What is meant by the net force that acts on an object? Ans. The net force is the sum of the forces acting on an object, the resultant of those forces.

3. Suppose a cart is being moved by a certain net force. If the net force is doubled, by how much does the cart’s acceleration change? Ans. The acceleration will double.

4. Suppose a cart is being moved by a certain net force. If a load is dumped into the cart so its mass is doubled, by how much does the acceleration change? Ans. The acceleration will be cut in half.

5. Distinguish between the concepts directly proportional and inversely proportional. Support your statement with examples. Ans. Directly proportional quantities both increase or decrease together, such as force and acceleration. Inversely proportional quantities move in opposite directions: as one increases, the other decreases. Ex: mass and acceleration.

6. State Newton’s Second Law in words and then in the form of an equation. Ans. The acceleration of an object is directly proportional to the force applied to it and inversely proportional to its mass. \( F = m \times a \).

7. How much force does a 20,000 kilogram rocket develop to accelerate 1 m/s\(^2\)? Ans. \( F = m \times a = 20,000 \text{ kg} \times 1 \text{ m/s}^2 = 20,000 \text{ N} \)

8. What is the cause of friction and in what direction does it act with respect to the motion of a sliding object? Ans. Friction is caused by the contact force between two objects and the irregularities between the surfaces of the objects. It always acts opposite to the direction of motion.

9. If the force of friction acting on a sliding crate is 100 N, how much force must be applied to maintain a constant velocity? Ans. 100 N must be applied to cancel out the frictional force. What will be the net force acting on the crate? Ans. Zero net force. What will be the acceleration? With zero net force, the object will not accelerate. It will move at a constant velocity and the acceleration will be zero.

10. Distinguish between force and pressure. Ans. Force is a push or a pull and is measured in Newtons. Pressure is force per unit area and is measured in N/m\(^2\) or Pascals. Pressure is how much force per square meter, for example.
11. Which produces more pressure on the ground, a person standing up or the same person lying down? Ans. The person standing up is putting all his/her weight on top of his feet. The person lying down is putting all his/her weight over the entire surface of his body touching the ground. The person standing up has more weight per unit area and so has more pressure.

12. The force of gravity is twice as great on a 2 kg rock as on a 1 kg rock. Why does the 2 kg rock not fall with twice the acceleration? Ans. The two kilogram rock also has twice the mass/inertia as the one kg rock. It needs twice the force because it has twice the mass. The 2’s cancel out.

13. Why do a coin and feather in a vacuum tube fall with the same acceleration? Ans. Gravity pulls down on all objects with the same acceleration in the absence of air resistance. Both objects will acceleration downwards at 9.8 m/s².

14. Why do a coin and a feather fall with different accelerations in the presence of air? Ans. Although gravity pulls down on both objects at the same rate – 9.8 m/s² – the force of air resistance is greater on the feather than the coin because of its shape.

15. How much air resistance acts on a 100 N bag of nails that falls at its terminal speed? Ans. If the bag of nails is falling at terminal speed/velocity, this means by definition it is not accelerating anymore. That means the force upwards (air resistance) must equal the force downwards (force of weight). So \( F_a = F_w = 100 \text{ N} \).

16. How do the air resistance and the weight of a falling object compare when terminal speed is reached? Ans. They must be equal so the net force on the falling object is zero. Then no acceleration happens.

17. All other things being equal, why does a heavy sky diver have a terminal speed greater than a light sky diver? Ans. All other things being equal means that the two divers’ profiles are the same. They both fall with the same amount of surface area exposed to the air and so the only thing determining fall rate is their weight. Since the heavier sky diver has more weight, it will take longer for the air resistance upwards to catch up and equal the weight downwards. Until this happens, the heavier skydiver will continue to accelerate. When \( F_a \) finally = \( F_w \), the diver will reach terminal velocity \( (v_t) \) and continue to move downwards at this \( v_t \) until his parachute opens. The lighter diver’s weight is less so \( F_a = F_w \) much quicker and so the lighter diver’s terminal velocity is much less than the heavier diver’s. What can be done so that both terminal speeds are equal? Ans. The lighter skydiver must change his falling profile and fall straight down with his arms by his sides to make up the difference and become more aerodynamic. The heavier skydiver can also increase his air resistance by spreading his arms and legs out.

18. What is the net force acting on a 25 N freely falling object? Ans. The net force is 25 N downwards, which is the object’s weight. What is the net force when the object encounters 15 N of air resistance? Ans. If the object encounters 15 N of air resistance his net force downwards would be 25 N – 15 N = 10 N. When it falls fast enough to encounter 25 N of air resistance? Ans. When the object reaches terminal velocity, 25 N – 25 N = 0 N.