**Newton’s Laws of Motion Review**

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**Part A: Mass, Inertia, Weight, and Newton's First Law of Motion**

1. Which of the following statements are true of **inertia**? List all that apply.

1. Inertia is a force.
2. Inertia is a force that keeps stationary objects at rest and moving objects in motion at constant velocity.
3. Inertia is a force that brings all objects to a rest position.
4. All objects have inertia.
5. A more massive object has more inertia than a less massive object.
6. Fast-moving objects have more inertia than slow-moving objects.
7. An object would not have any inertia in a gravity-free environment (if there is such a place).
8. Inertia is the tendency of all objects to resist motion and ultimately stop.
9. In a gravity-free environment (should there be one), a person with a lot of inertia would have the same ability to make a turn as a person with a small amount of inertia.

2. Which of the following statements are true of the quantity **mass**? List all that apply.

1. The mass of an object is dependent upon the value of the acceleration of gravity.
2. The standard metric unit of mass is the kilogram.
3. Mass depends on how much *stuff* is present in an object.
4. The mass of an object is variable and dependent upon its location.
5. An object would have more mass on Mount Everest than the same object in the middle of Lake Michigan.
6. People in Weight Watcher's are really concerned about their mass (they're mass watchers).
7. The mass of an object can be measured in pounds.
8. If all other variables are equal, then an object with a greater mass would have a more difficult time accelerating.
9. If all other variables are equal, then it would require less exerted force to stop a less massive object than to stop a more massive object.
10. The mass of an object is mathematically related to the weight of the object.

3. Which of the following statements are true of the quantity **weight**? List all that apply.

1. The weight of an object is dependent upon the value of the acceleration of gravity.
2. Weight refers to a force experienced by an object.
3. The weight of an object would be less on the Moon than on the Earth.
4. A person could reduce their weight significantly by taking an airplane ride to the top of Mount Everest.
5. Two objects of the same mass can weigh differently.
6. To gain weight, one must put on more mass.
7. The weight of an object can be measured in kilograms.
8. The weight of an object is equal to the force of gravity acting upon the object.
9. When a chemistry student places a beaker on a balance and determines it to be 84.3 grams, they have weighed the beaker.

4. Which of the following statements are true of an object that experiences **balanced forces** (or **unbalanced forces**)? List all that apply.

1. If a person is moving to the right, then the forces acting upon it are NOT balanced.
2. A balance of forces is demonstrated by an object which is slowing to a stop.
3. It would take an unbalanced force to keep an object in motion.
4. If an object is moving with a constant speed in a circle, then the forces acting upon the object are balanced.
5. If an object is accelerating at a constant rate of acceleration, then the forces acting upon the object are balanced.
6. It is NOT possible for just three forces to be acting upon an object and they still balance each other.
7. A free-falling object experiences a balance of forces.
8. Balanced forces cause stationary objects to remain at rest and moving objects to come to rest.
9. Unbalanced forces cause objects to move.

5. Consider **Newton's first law of motion** to determine which of the following statements are true? List all that apply.

1. Newton's first law of motion is applicable to both moving and nonmoving objects.
2. If a football is moving upwards and rightwards towards the peak of its trajectory, then there are both rightwards and upwards forces acting upon it.
3. It would take an unbalanced force to keep an object in motion.
4. If an object is at rest, then there are no forces acting upon the object.
5. It would take an unbalanced force to keep an object in motion at a constant velocity.
6. It is the natural tendency of all objects to eventually come to a rest position.
7. A pendulum bob is set into its usual back-and-forth periodic motion. After some time (perhaps 10 minutes), the pendulum bob comes to a rest position. This is best explained by the idea of inertia - all objects eventually resist motion.
8. If a 3-kg rock is thrown at a speed of 2 m/s in a gravity-free environment (presuming one could be found), then an unbalanced force of 6 N would be required to keep the rock moving at a constant speed.
9. It would take an unbalanced force to cause an object to accelerate from rest.

**Part B: Force, Acceleration and Newton's Second Law of Motion**

 6. Which of the following statements are true of the concept of **force**? List all that apply.

1. A force is a push or pull exerted upon an object that results from the interaction of that object with its environment.
2. Bubba approaches Billie and gives him a swift shove. Timid little Billie keeps his hands in his pocket during this interaction. Subsequently, while Bubba places a force upon Billie, Billie does not place a force upon Bubba.
3. A quarterback throws a football down field. Once thrown, the force from the quarterback persists upon the ball to cause it to continue on its upward trajectory towards its peak.
4. A sled slides down the hill and reaches the bottom where it gradually slows to a stop. Once on the level ground, the force of the hill persists upon the sled to allow it to continue its forward motion.
5. Forces always cause objects to move.
6. An object can experience two or more forces and not accelerate.
7. A contact force results from the physical contact between two objects.
8. A field force results from the action of two objects which are positioned some distance away.
9. Spring and tension forces are examples of field forces.
10. A force is a vector quantity; there is always a direction associated with it.
11. Force can be measured in kilograms or Newtons depending upon the system of measurement (metric or otherwise).

7. Consider **Newton's second law of motion** to determine which of the following statements are true? List all that apply.

1. If an object is accelerating to the right, the net force on the object must be directed towards the right.
2. If an object is moving to the right and slowing down, then the net force on the object is directed towards the left.
3. Accelerating objects are either slowing down or speeding up.
4. The acceleration of an object is directly dependent upon its mass and inversely dependent upon its net force.
5. An object has an acceleration of 8 m/s/s. If the net force acting upon the object is increased by a factor of 2, then the new acceleration would be 10 m/s/s.
6. An object has an acceleration of 8 m/s/s. If the net force acting upon the object is increased by a factor of 3, then the new acceleration would be 11 m/s/s.
7. An object has an acceleration of 8 m/s/s. If the mass of the object is increased by a factor of 2, then the new acceleration would be 16 m/s/s.
8. An object has an acceleration of 8 m/s/s. If the mass of the object is increased by a factor of 4, then the new acceleration would be 2 m/s/s.
9. An object has an acceleration of 8 m/s/s. If the net force acting upon the object is increased by a factor of 2 and the mass of the object is decreased by a factor of 2, then the two factors would offset each other and the acceleration would still be 8 m/s/s.
10. An object has an acceleration of 8 m/s/s. If the net force acting upon the object is increased by a factor of 2 and the mass of the object is increased by a factor of 4, then the new acceleration would be 4 m/s/s.
11. An object has an acceleration of 8 m/s/s. If the net force acting upon the object is decreased by a factor of 2 and the mass of the object is increased by a factor of 4, then the new acceleration would be 1 m/s/s.
12. An object has an acceleration of 8 m/s/s. If the net force acting upon the object is increased by a factor of 4 and the mass of the object is increased by a factor of 2, then the new acceleration would be 16 m/s/s.
13. A 2-kg object accelerates from rest to a final velocity of 6 m/s in 3 seconds. The magnitude of the net force acting upon the object is 12 N.
14. A 10-kg object slows down from 24 m/s to a final velocity of 9 m/s in 3 seconds. The magnitude of the net force acting upon the object is 80 N.

**Part C: Forced Choice and Short Answer**

8a. Big Bubba has a mass of 100 kg on the earth. What is Big Bubba's mass on the moon where the force of gravity is approximately 1/6-th that of Earth's? \_\_\_\_\_\_\_\_ Explain or show your work.

8b. Little Billie weighs 360 N on Earth. What is Little Billie's mass on the moon where the force of gravity is approximately 1/6-th that of Earth's? \_\_\_\_\_\_\_\_ Explain or show your work.

9. **TRUE or FALSE:**

An object that is moving rightward has a rightward force acting upon it.

a. True b. False

10. The amount of net force required to keep a 5-kg object moving rightward with a constant velocity of 2 m/s is \_\_\_\_.

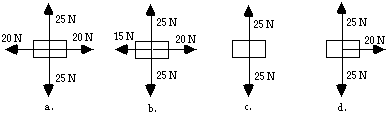
a. 0 N b. 0.4 N c. 2 N d. 2.5 N e. 5 N

11. **TRUE or FALSE:**

For an object resting upon a non-accelerating surface, the normal force is equal to the weight of the object.

a. True b. False

12. Which one(s) of the following force diagrams depict an object moving to the right with a constant speed? List all that apply.



13. According to Newton's third law, every force is accompanied by an equal and opposite *reaction* force. The reason that these forces do not cancel each other is \_\_\_\_.

a. the action force acts for a longer time period

b. the two forces are not always in the same direction

c. one of the two forces is greater than the other

d. the two forces act upon different objects; only forces on the same object can balance each other.

e. ... nonsense! They do cancel each other. Objects accelerate because of the presence of a third force.

14. As you sit in your chair and study your physics (presuming that you do), the force of gravity acts downward upon your body. The *reaction force* to the force of the Earth pulling you downward is \_\_\_.

a. the force of the chair pushing you upward

b. the force of the floor pushing your chair upward

c. the force of the Earth pushing you upward

d. the force of air molecules pushing you upwards

e. the force of your body pulling the Earth upwards

f. ... nonsense! Gravity is a field force and there is no such reaction force.

15. A golf pro places a ball at rest on the tee, lines up his shot, draws back his club, and lets one rip. During the contact of the golf club with the golf ball, the force of the club on the ball is \_\_\_\_ the force of the ball on the club and the acceleration of the club is \_\_\_\_ than the acceleration of the ball.

a. greater than, greater than b. greater than, equal to

c. greater than, less than d. less than, less than

e. less than, equal to f. less than, greater than

g. equal to, equal to h. equal to, greater than

i. equal to, less than

For **Questions #16-#21**: Each one of Newton's Laws can play a role in any one particular situation. However, one of the laws is often most obviously dominant in governing the motion of a situation. Pick which of Newton's laws **most** governs the situations described below.

a. First Law (inertia)

b. Second Law (F = m•a)

c. Third Law (action-reaction)

16. A helicopter must have two sets of blades in order to fly with stability.

a. First Law (inertia) b. Second Law (F = m•a)

c. Third Law (action-reaction)

17. If you were in an elevator and the cable broke, jumping up just before the elevator hit the ground would not save you. Sorry.

a. First Law (inertia) b. Second Law (F = m•a)

c. Third Law (action-reaction)

18. You usually jerk a paper towel from a roll in order to tear it instead of pulling it smoothly.

a. First Law (inertia) b. Second Law (F = m•a)

c. Third Law (action-reaction)

19. A student desk changes the amount of force it puts on other objects throughout a school day.

a. First Law (inertia) b. Second Law (F = m•a)

c. Third Law (action-reaction)

20. Heavy objects are not easier to move around in a horizontal fashion on the Moon than on the Earth.

a. First Law (inertia) b. Second Law (F = m•a)

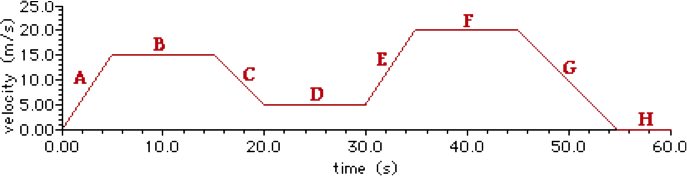
c. Third Law (action-reaction)

21. The stronger, heavier team in a tug-of-war does not create a larger tension in the rope than the weaker, lighter team.

a. First Law (inertia) b. Second Law (F = m•a)

c. Third Law (action-reaction)

For **Questions #22-#26**: Consider the velocity-time plot below for the motion of an object along a horizontal surface. The motion is divided into several time intervals, each labeled with a letter.



22. During which time interval(s), if any, are there no forces acting upon the object? List all that apply.

23. During which time interval(s), if any, are the forces acting upon the object balanced? List all that apply.

24. During which time interval(s), if any, is there a net force acting upon the object? List all that apply.

25. During which time interval(s), if any, is the net force acting upon the object directed toward the right? List all that apply.

26. During which time interval(s), if any, is the net force acting upon the object directed toward the left? List all that apply.

For **Questions #27-#31**: Consider the dot diagram below for the motion of an object along a horizontal surface. The motion is divided into several time intervals, each labeled with a letter.



27. During which time interval(s), if any, are there no forces acting upon the object? List all that apply.

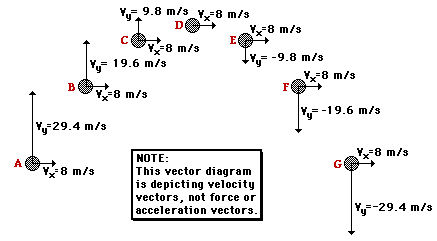
28. During which time interval(s), if any, are the forces acting upon the object balanced? List all that apply.

29. During which time interval(s), if any, is there a net force acting upon the object? List all that apply.

30. During which time interval(s), if any, is the net force acting upon the object directed toward the right? List all that apply.

31. During which time interval(s), if any, is the net force acting upon the object directed toward the left? List all that apply.

For **Questions #32-#36**: Consider the trajectory diagram shown below for a **projectile** thrown at an angle to the horizontal. The vector arrows represent the horizontal and vertical components of the projectile's **velocity**. Several points in the trajectory are labeled with a letter. Use the trajectory diagram to answer the next several questions. (Consider air resistance to be negligible.)



32. At which point(s), if any, are there no forces acting upon the object? List all that apply.

33. At which point(s), if any, are the forces acting upon the object balanced? List all that apply.

34. At which point(s), if any, is there a net force acting upon the object? List all that apply.

35. At which point(s), if any, is the net force acting upon the object directed toward the right? List all that apply.

36. At which point(s), if any, is the net force acting upon the object directed upward? List all that apply.

**Part D: Drawing and Interpreting Free-Body Diagrams**

37. Construct free-body diagrams for the following physical situations at the instant in time for which they are described. As is always done in free-body diagrams, label the forces according to type and draw the arrows such that their length reflects the magnitude of the force.

|  |  |
| --- | --- |
| a. A book is at rest on top of a table. | b. A book is being pushed to the right across a table surface with a constant velocity. (Neglect Fair.) |
| c. A book is being pushed to the right across a table surface and accelerating in the direction of the push. (Neglect Fair.) | d. A student is pushing lightly upon a large box in an attempt to push it to the right across the floor, but the box fails to move. |
| e. A rightward-moving box (which was previously set into rightward motion across the floor) gradually slows to a stop. | f. An air track glider is gliding to the right at constant velocity. |
| g. A ball is dropped from rest from the top of a building. (Neglect Fair.) | h. Several seconds after being thrown, a football is moving upwards and rightwards towards the peak of its trajectory. (Neglect Fair.) |
| i. Several seconds after being thrown, a football reaches the precise peak of its trajectory. (Neglect Fair.) | j. A falling skydiver is speeding up. |
| k. A falling skydiver has reached a terminal velocity. | l. After reaching a terminal velocity, a falling skydiver has opened her parachute. |
| m. A car is moving to the right at a high speed across a level roadway surface; the driver's foot remains on the gas pedal. | n. A car is skidding to a stop (with wheels locked) while traveling to the right across a level roadway surface. |
| o. An elevator (held by a cable) is moving upwards at a constant velocity. (Neglect Fair.) | p. An upward moving elevator (held by a cable) slows down. (Neglect Fair.) |
| q. A downward moving elevator (held by a cable) slows down. (Neglect Fair.) | r. A picture hangs symmetrically by two wires oriented at angles to the vertical. |

**Part E: Force-Mass-Acceleration Relationships**

Construct free-body diagrams for the following objects; label the forces according to type. Use the approximation that **g = ~10 m/s2** to determine the magnitude of all forces and the net force and acceleration of the object.

|  |  |
| --- | --- |
| 38. A 2-kg box is at rest on a table. | 39. A 2-kg box is free-falling from the table to the ground. |
| 40. A 2-kg box equipped with a parachute is falling at a terminal velocity after being dropped from a plane. | 41. A 2-kg box is sliding to the right across a table. The force of friction upon the box is 5 N. |
| 42. An 8-N force is applied to a 2-kg box to move it to the right across the table at a constant velocity of 1.5 m/s. | 43. An 8-N force is applied to a 2-kg box to accelerate it to the right across a table. The box encounters a force of friction of 5 N. |
|  |  |
| 44. A 500-kg freight elevator is descending down through the shaft at a constant velocity of 0.50 m/s. | 45. A 500-kg freight elevator is moving upwards towards its destination. Near the end of the ascent, the upward moving elevator encounters a downward acceleration of 2.0 m/s/s. |
| 46. A 150-N rightward force is applied to a 20-kg box to accelerate it to the right across a rough surface at a rate of 2.0 m/s/s. |  |

**Part F: Problem-Solving**

For the following problems, draw free-body diagrams and solve for the requested unknown. Use **g = 9.8 m/s/s**.

47. A 0.250-kg ball is thrown upwards with an initial velocity of 12.0 m/s at an angle of 30.0 degrees. Determine the acceleration of the ball when it has reached the peak of its trajectory. Assume negligible air resistance. **PSYW**

48. A 72-kg skydiver is falling from 10000 feet. At an instant during the fall, the skydiver encounters an air resistance force of 540 Newtons. Determine the acceleration of the skydiver at this instant. **PSYW**

49. A 72-kg skydiver is falling from 10 000 feet. After reaching terminal velocity, the skydiver opens his parachute. Shortly thereafter, there is an an instant in time in which the skydiver encounters an air resistance force of 1180 Newtons. Determine the acceleration of the skydiver at this instant. **PSYW**

50. A 5.20-N force is applied to a 1.05-kg object to accelerate it rightwards across a friction-free surface. Determine the acceleration of the object. (Neglect air resistance.) **PSYW**

51. A 5.20-N force is applied to a 1.05-kg object to accelerate it rightwards. The object encounters 3.29-N of friction. Determine the acceleration of the object. (Neglect air resistance.) **PSYW**

52. Determine the applied force required to accelerate a 3.25-kg object rightward with a constant acceleration of 1.20 m/s/s if the force of friction opposing the motion is 18.2 N. (Neglect air resistance.) **PSYW**

53. A 921-kg sports car is moving rightward with a speed of 29.0 m/s. The driver suddenly slams on the brakes and the car skids to a stop over the course of 3.20 seconds with the wheels locked. Determine the average resistive force acting upon the car. **PSYW**

54. A 0.250-kg rightward moving air track glider decreases its speed from 0.872 m/s to 0.798 m/s over the length of a 1.71-m long air track. Determine the average resistive force acting upon the air track glider. **PSYW**

55. A 1250-kg small aircraft decelerates along the runway from 36.6 m/s to 6.80 m/s in 5.10 seconds. Determine the average resistive force acting upon the plane. (Assume that its engine/propeller makes no contributes to its forward motion). **PSYW**

56. A tow truck exerts a 18300-N force upon a 1210 car to drag it out of a mud puddle onto the shoulder of a road. A 17900 N force opposes the car's motion. The plane of motion of the car is horizontal. Determine the time required to drag the car a distance of 6.90 meters from its rest position. **PSYW**

57. A 4.44-kg bucket suspended by a rope is accelerated upwards from an initial rest position. If the tension in the rope is a constant value of 83.1 Newton, then determine the speed (in m/s) of the bucket after 1.59 seconds. **PSYW**

58. A 22.6-N horizontal force is applied to a 0.0710-kg hockey puck to accelerate it across the ice from an initial rest position. Ignore friction and determine the final speed (in m/s) of the puck after being pushed for a time of .0721 seconds. **PSYW**

59. A train has a mass of 6.32x104 kg and is moving with a speed of 94.3 km/hr. The engineer applies the brakes that results in a net backward force of 2.43x105 Newton on the train. The brakes are held for 3.40 seconds. How far (in meters) does the train travel during this time? **PSYW**

60. A shopper in a supermarket pushes a loaded cart with a horizontal force of 16.5 Newton. If the cart has a mass of 33.8 kg, how far (in meters) will it move in 1.31 seconds, starting from rest? (Neglect resistive forces.) **PSYW**