**Circular Motion and Gravitation**

**Question 1:**

aa. Which of the following statements are true of an object moving in a circle at a constant speed? Select all that apply.

a. The object is accelerating.

b. The object is at equilibrium.

c. The velocity of the object is changing.

d. The direction of the object is changing.

e. The net force experienced by the object is 0 Newtons.

**Question 2:**

aa. An object is moving along a circular path. Which one of the following adjectives describes the direction of the **velocity vector**?

a. It is directed tangent to the circular path.

b. It is directed towards the center of the circle.

c. It is directed away from the center of the circle.

d. It is directed in the opposite direction that the object is moving.

e. ... nonsense! There is no predictable pattern for the direction of this vector

**Question 3:**

aa. An object is moving along a circular path. Which one of the following adjectives describes the direction of the **acceleration vector**?

a. It is directed tangent to the circular path.

b. It is directed towards the center of the circle.

c. It is directed away from the center of the circle.

d. It is directed in the opposite direction that the object is moving.

e. ... nonsense! There is no predictable pattern for the direction of this vector.

**Question 4:**

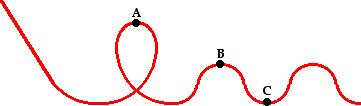
aa. Which of the following adjectives and/or phrases describe the direction of the **net force vector**? Choose three.

a. inwards b. outwards c. towards the center

d. away from the center e. tangent to the circle

**Questions 5-7:**

A coaster layout is shown below. Three points along the track are labeled. Use the diagram to answer the following questions.





aa. Which arrow represents the direction of the acceleration at location A?

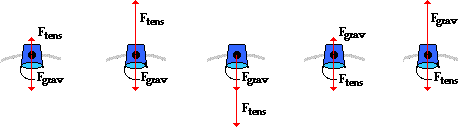
aa. Which arrow represents the direction of the velocity at location B?

aa. Which arrow represents the direction of the net force at location C?

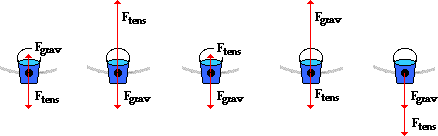
**Question 8:**

aa. A bucket is partially filled with water and whirled in a circle in a vertical plane. There are two forces acting upon the bucket as it travels along its circular path - tension (Ftens) and gravity (Fgrav).

a. Which diagram best represents the force on the bucket when it is at the top of the vertical circle? Click on the appropriate diagram.



b. Which diagram best represents the force on the bucket when it is at the bottom of the vertical circle? Click on the appropriate diagram.



**Question 9:**

aa. A person on a barrel ride has a sensation of being pushed outward against the barrel wall. This sensation of an outward push is explained by the fact that \_\_\_\_\_.

a. the wall provides suction which pulls the rider against it

b. the rider ate too much cotton candy before going on the ride

c. objects which move in circles must be acted upon by a net outward force

d. the rider has a tendency to travel in a straight line but the barrel wall is curved

**Question 10:**

aa. **True**  or **False**:

An object that is moving in a circle at a constant speed is accelerating.

a. True b. False

**Question 11:**

aa. **True**  or **False**:

Circular motion equations do NOT work for planetary motion since the planets' orbits are highly elliptical.

a. True b. False

**Question 12:**

aa. **True**  or **False**:

Objects that move in a circle at a constant speed have an acceleration of 0.

a. True b. False

**Question 13:**

aa. **True**  or **False**:

The centripetal force is a distinctly separate force. It can be added to the list of forces (along with tension, friction, normal, etc.) that might act upon an object.

a. True b. False

**Question 14:**

aa. **True**  or **False**:

The word *centripetal* means "outwards" or "away from the center."

a. True b. False

**Question 15:**

aa. **True**  or **False**:

The value of **G** (in the universal gravitation equation) is an enormously large number. This explains why (at least in part) the force of gravitational attraction between the Sun and the very distant Earth is such a large number.

a. True b. False

**Question 16:**

aa. **True**  or **False**:

As you sit in your chair, you experience the force of gravitational attraction to the Earth. The Earth pulls your body downward. The *reaction force* to this is the chair pushes your body upwards.

a. True b. False

**Question 17:**

aa. **True**  or **False**:

An orbiting satellite is a projectile upon which the only force is gravity.

a. True b. False

**Question 18:**

aa. **True**  or **False**:

Kepler's third law concerning period and orbital radius can be used to understand the period-radius relationship for a satellite of any planet, not just for planets orbiting the Sun.

a. True b. False

**Question 19:**

aa. **True**  or **False**:

The force of gravitational attraction between the Earth and an object located upon its surface is independent of the mass of the Earth.

a. True b. False

**Question 20:**

aa. **True**  or **False**:

All objects on Earth's surface attract each other with the same amount of force of gravitational attraction.

a. True b. False

**Question 21:**

aa. **True**  or **False**:

The acceleration of gravity on the surface of the Earth is dependent upon the mass of the Earth. If the Earth's mass were somehow altered, then the acceleration of gravity would be altered.

a. True b. False

**Question 22:**

aa. **True**  or **False**:

The notion that any two objects attract each other gravitationally is only a theory. There is no empirical evidence for such a notion.

a. True b. False

**Question 23:**

aa. Which of the following adjectives and/or phrases describe the direction of the acceleration vector? Choose three.

a. inwards b. outwards c. towards the center

d. centrifugal e. centripetal ab. away from the center

**Question 24:**

aa. An object is moving along a circular path. Which one of the following adjectives describes the direction of the net force vector?

a. It is directed tangent to the circular path.

b. It is directed towards the center of the circle.

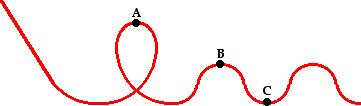
c. It is directed away from the center of the circle.

d. It is directed in the opposite direction that the object is moving.

e. ... nonsense! There is no predictable pattern for the direction of this vector.

**Question 25:**

aa. A coaster layout is shown below. Three points along the track are labeled. Use the diagram to answer the following questions. Click on the proper arrow.

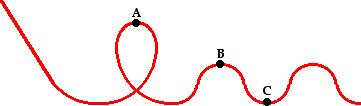


Which arrow represents the direction of the **acceleration** at location A? Circle the proper arrow.



**Question 26:**

aa. A coaster layout is shown below. Three points along the track are labeled. Use the diagram to answer the following questions. Click on the proper arrow.

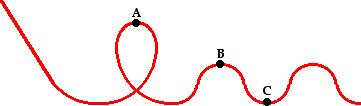


Which arrow represents the direction of the **velocity** at location B? Circle the proper arrow.



**Question 27:**

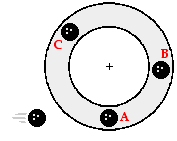
aa. A coaster layout is shown below. Three points along the track are labeled. Use the diagram to answer the following questions. Click on the proper arrow.



Which arrow represents the direction of the **net force** at location C? Circle the proper arrow.



**Questions 28-30:**

A physics teacher is doing a demonstration with a bowling ball and a rubber mallet. A circular course is traced out on the floor. The bowling ball is rolled along the floor tangent to the circular path. Once the ball reaches the path, the teacher periodically hits the ball with a mallet to keep it moving in a circle. Three positions of the ball - **A**, **B** and **C** - are shown in the diagram at the right. The diagram represents a view of the floor from above.

aa. In which direction must the *mallet force* on the ball be directed at location **A**? Circle the appropriate arrow. The "0" indicates that no force is needed at this position.



aa. In which direction is the velocity of the bowling ball at location **B**? Circle the appropriate arrow. The "0" indicates that the ball has no velocity at this position.



aa. In which direction must the *mallet force* on the ball be directed at location **C**? Circle the appropriate arrow. The "0" indicates that no force is needed at this position.



**Question 31:**

aa. A **centrifugal force** is \_\_\_\_\_.

a. an outward force that must be present to move in a circle

b. an inward force that causes objects to travel straight ahead

c. a false force that we make up to explain our feelings of going straight

**Question 32:**

aa. We describe objects to be accelerating for a few reasons. Which statement below is **always** true of accelerating objects?

a. Accelerating objects are having a bad day.

b. Accelerating objects are changing their speed.

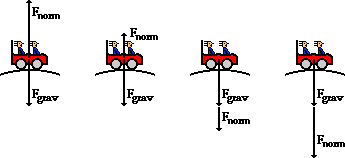
c. Accelerating objects are changing their mass.

d. Accelerating objects are changing their velocity.

e. Accelerating objects are changing their direction.

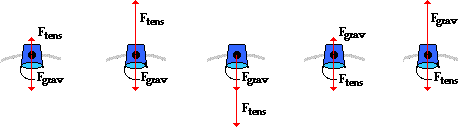
**Question 33:**

aa. A roller coaster rider is at the top of a small hill as shown at the right. The force diagrams below use arrows to show the direction and type of the forces that act upon the rider. A small arrow is for a small force and a large arrow is for a large force. Which diagram best represents the forces on the rider at this location? Circle the appropriate diagram.



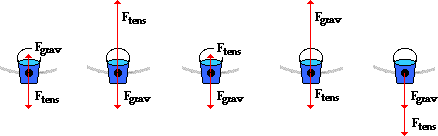
**Question 34:**

aa. A bucket is partially filled with water and whirled in a circle in a vertical plane. There are two forces acting upon the bucket as it travels along its circular path - tension (Ftens) and gravity (Fgrav). Which diagram best represents the force on the bucket when it is at the top of the vertical circle? Circle the appropriate diagram.



**Question 35:**

aa. A bucket is partially filled with water and whirled in a circle in a vertical plane. There are two forces acting upon the bucket as it travels along its circular path - tension (Ftens) and gravity (Fgrav). Which diagram best represents the force on the bucket when it is at the bottom of the vertical circle? Circle the appropriate diagram.



**Question 36:**

aa. Which of the following statements are true of an object moving in a circle at a constant speed?

a. The object is not accelerating.

b. The object is at equilibrium.

c. The direction of the object is changing.

d. The velocity of the object is changing.

e. The net force experienced by the object is 0 Newton.

**Question 37:**

aa. An object is moving along a circular path. Which one of the following adjectives describes the direction of the **velocity** vector?

a. It is directed tangent to the circular path.

b. It is directed away from the center of the circle.

c. It is directed towards the center of the circle.

d. It is directed in the opposite direction that the object is moving.

e. ... nonsense! There is no predictable pattern for the direction of this vector.

**Question 38:**

aa. An object is moving along a circular path. Which one of the following adjectives describes the direction of the **acceleration** vector?

a. It is directed tangent to the circular path.

b. It is directed towards the center of the circle.

c. It is directed away from the center of the circle.

d. It is directed in the opposite direction that the object is moving.

e. ... nonsense! There is no predictable pattern for the direction of this vector.

**Question 39:**

aa. The value of the centripetal acceleration of an object depends upon \_\_\_\_\_. Choose two.

a. the color of the object b. how fast the object is moving

c. how much the object weighs d. how sharply curved the circle is

e. the direction the object is moving

**Question 40:**

aa. Suppose that a car moves in a circle about a fixed point. The **velocity** of the object at any point along its path is directed \_\_\_\_ the circle.

a. tangent to b. towards the center

c. outwards away from the d. outwards at an angle with

**Question 41:**

aa. Suppose that a car moves in a circle about a fixed point at constant speed. The **net force** on the object at any point along its path is directed \_\_\_\_ the circle.

a. tangent to b. towards the center

c. outwards away from the d. outwards at an angle with

**Question 42:**

aa. The force that causes a car to move in a circle when its wheels are turned is the \_\_\_\_\_ force.

a. inertial b. turning c. normal d. friction

e. none of these

**Question 43:**

aa. The path of planets around the Sun can best be described as \_\_\_\_\_.

a. a square b. a parabola

c. elliptical in shape d. circular in shape

e. Nonsense! Very little is known about the shape of the planets' orbits.

**Question 44:**

aa. Kepler's second law of planetary motion is often called the law of equal areas. Which one of the following statements would be an extension of this law?

a. Any given planet will travel fastest along its orbital path when it is closest to the Sun.

b. A planet would move at the same speed at all times during its orbit about the Sun.

c. The longer that the imaginary line from a planet to the Sun is, the greater the speed of the planet will be.

d. When two different planets lie along the same imaginary line from planet to the Sun, their speeds are equal.

e. The length of an imaginary line drawn from a planet to the Sun multiplied by the period is equal to the planet's area.

**Question 45:**

aa. One could reason from Kepler's third law of planetary motion that \_\_\_\_\_.

a. an object that is further from the Sun would have a greater surface area

b. an object that is further from the Sun would have a greater orbital period

c. an object that is closer to the Sun would take a longer amount of time to orbit

d. an object that is closer to the Sun would appear bigger when viewed from Earth

**Question 46:**

aa. The period of an Earth-orbiting satellite depends upon \_\_\_\_\_. Select all that apply.

a. the radius of orbit b. the radius of the Earth

c. the mass of the Earth d. the weight of the satellite

e. the mass of the satellite

**Question 47:**

aa. As the Space Shuttle goes into a *higher orbit*, what happens to the shuttle's period?

a. The period increases. b. The period decreases.

c. The period is unaffected by the change in orbit.

**Question 48:**

aa. Kepler's first law of planetary motion states that \_\_\_\_. Choose one.

a. the Sun is at the center of the solar system

b. gravity provides the force that holds the planets in orbit about the Sun

c. planets orbit the Sun in circular orbits, with the Sun located at the center

d. planets orbit the Sun in elliptical orbits, with the Sun located at one focus

**Question 49:**

aa. Kepler's second law of planetary motion states that a line connecting a planet to the Sun \_\_\_\_. Choose one.

a. is longest in winter and shortest in summer

b. sweeps out the same amount of area regardless of the planet.

c. sweeps out the same amount of area in any two equal periods of time

d. sweeps out more area during a winter month than during the summer month

**Question 50:**

aa. A planet would move \_\_\_\_.

a. at the same speed at all times during its orbit about the Sun

b. at faster speeds when positioned closer to the Sun during its orbit

c. at slower speeds when positioned closer to the Sun during its orbit

**Question 51:**

aa. Kepler's third law of planetary motion states that the ratio of \_\_\_\_.

a. all planets would orbit with the same orbital period

b. the orbital period to the orbital radius is the same for all planets

c. the period squared to the radius cubed is the same ratio for all planet

d. the orbital periods of any two planets equals the ratio of the orbital radii

**Question 52:**

aa. A planet is further from the Sun would take \_\_\_\_\_ time to orbit the Sun compared to planets that are closer to the Sun.

a. less b. more c. the same amount of

**Question 53:**

aa. Which of the following is true of the motion of planets in our solar system? Choose two.

a. The Earth orbits the Sun. b. All planets orbit the Sun.

c. The Sun orbits the Earth. d. All planets orbit the Earth.

**Question 54:**

aa. The path of planets around the Sun can best be described as \_\_\_\_\_.

a. a square b. a parabola

c. circular in shape d. elliptical in shape

e. Nonsense! Very little is known about the shape of the planets' orbits.

**Question 55:**

aa. Which of the following statements are true of orbiting satellites? Select all that apply.

a. Once in orbit, a satellite is acted upon by gravity alone.

b. The mass of a satellite will have a huge effect upon the orbital speed.

c. If an orbiting satellite shuts off its engines, then it will fall to Earth.

d. A satellite falls towards the Earth at the same rate that the Earth curves away from it.

**Question 56:**

aa. Kepler's second law of planetary motion is often called the law of equal areas. Which one of the following statements would be an extension of this law?

a. A planet would move at the same speed at all times during its orbit about the Sun.

b. Any given planet will travel fastest along its orbital path when it is closest to the Sun.

c. The longer that the imaginary line from a planet to the Sun is, the greater the speed of the planet will be.

d. When two different planets lie along the same imaginary line from planet to the Sun, their speeds are equal.

e. The length of an imaginary line drawn from a planet to the Sun multiplied by the period is equal to the planet's area.

**Question 57:**

aa. The speed of an Earth-orbiting satellite depends upon \_\_\_\_\_. Select all that apply.

a. the radius of orbit b. the radius of the Earth

c. the mass of the Earth d. the mass of the satellite

e. the weight of the satellite

**Question 58:**

aa. More massive satellites have \_\_\_\_\_\_ orbital speed than less massive satellites.

a. the same b. a greater c. a smaller

**Question 59:**

aa. More massive satellites have \_\_\_\_\_\_ orbital period than less massive satellites.

a. the same b. a longer c. a shorter

**Question 60:**

aa. Two planets - planet A and planet B - are orbiting a star. If Planet A has an orbital radius which is four times as large as Planet B, then the period of Planet A's orbit is \_\_\_\_ times larger than the period of Planet B's orbit.

a. 1.33 b. 1.59 c. 2.67 d. 4.00

e. 5.33 ab. 8.00 ac. 16.0 ad. 21.3

ae. 32.0 bc. 64.0 bd. None of these are even close.

**Questions 61-62:**

aa. According to the Law of Universal Gravitation, the force of gravitational attraction between two objects is directly proportional to the \_\_\_\_\_ ...

a. product of the objects' masses

b. the square of the masses of the objects

c. the product of the radius of each object

d. the square of the average radius of the objects

e. the square of the separation distance between the two objects

aa. (continuing from previous problem) ... and inversely proportional to the \_\_\_\_\_.

a. product of the objects' masses

b. square of the masses of the objects

c. product of the radius of each object

d. square of the average radius of the objects

e. square of the separation distance between the two objects

**Question 63:**

aa. Newton's law of universal gravitation was capable of explaining Kepler's third law of motion and showing that it could be applied universally to any situation involving satellite motion. Newton was able to show that the period of a satellite orbiting some central body is dependent upon \_\_\_\_\_. Select all that apply.

a. the radius of orbit b. the mass of the satellite

c. the speed of the satellite d. the radius of the central body

e. the mass of the central body

**Questions 64-66:**

Consider the equation for gravitational field strength – **g**. Use the equation to answer the next few questions.

aa. If the Earth were twice as massive but had the same radius, then what would happen to the strength of the gravitational field upon Earth's surface?

a. It would be double the size. b. It would be one-half the size.

c. It would be quadruple the size. d. It would be one-fourth the size.

aa. If the Earth were four times as massive but had the same radius, then what would happen to the strength of the gravitational field upon Earth's surface?

a. It would be double the size. b. It would be one-half the size.

c. It would be quadruple the size. d. It would be one-fourth the size.

aa. If the Earth had twice the radius but the same mass, then what would happen to the strength of the gravitational field upon Earth's surface?

a. It would be double the size. b. It would be one-half the size.

c. It would be quadruple the size. d. It would be one-fourth the size.

**Question 67:**

aa. Which of the following factors affect the force of gravitational attraction between the Sun and a planet? Select all that apply.

a. The mass of the Sun.

b. The mass of the planet.

c. The period of orbit of the planet.

d. The distance between the Sun and the planet.

e. The speed at which the planet moves along its orbital path.

**Question 68:**

aa. The significance of the word *universal* as used in Newton's Law of Universal Gravitation is that \_\_\_\_\_.

a. the law existed since the universe began.

b. the law explains how the universe is held together.

c. the law explains the motion of all large objects in the universe.

d. the law applied universally to all objects, not just to planets and the sun.

**Question 69:**

aa. According to Newton's **Law of Universal Gravitation**, which of the following pairs of objects would NOT experience a mutual force of gravitation. Select all that apply.

a. The Earth and the moon b. Two electrons in an atom

c. You and your lab partner d. The Earth and another planet

e. Nonsense! All objects experience a mutual force of gravitational pull.

**Question 70:**

aa. Newton's law of universal gravitation was capable of explaining Kepler's third law of motion. Newton was able to show that the period of a planet orbiting the Sun is dependent upon \_\_\_\_\_. Select all that apply.

a. the radius of orbit b. the mass of the sun

c. the mass of the planet d. the speed of the planet

e. the radius of the planet

**Question 71:**

aa. The value of **G** is \_\_\_\_\_\_. This explains why \_\_\_\_\_\_.

a. large; the planets are as massive as they are

b. small; people are at rest on Earth instead of in orbit about the Earth

c. small; two nearby students do not exhibit a significant gravitational attraction

d. large; a planet with as much mass as the Earth can still be held in orbit about the Sun

**Question 72:**

aa. Orbiting astronauts on the space shuttle do not have weight in space because \_\_\_\_\_.

a. there is no gravity in space

b. there is no air resistance in space

c. the food is terrible and they work all the time

d. there are no scales in space to weigh themselves

e. ... nonsense! The astronauts do have weight in space.

**Question 73:**

aa. A person will feel weightless whenever \_\_\_\_. Select all that apply.

a. they are in a free-fall environment

b. the air resistance acting upon their body is negligible

c. they weigh nothing due to reduced gravitational forces upon their body

d. there is no support force to balance the force of gravity upon their body

e. they drink large quantities of soda pop and the carbonation makes them float

**Question 74:**

aa. As an object moves further and further from the surface of the Earth, the weight of the object \_\_\_\_\_.

a. decreases b. increases c. remains unchanged

**Question 75:**

aa. Consider the equation for gravitational field strength – **g** - to answer this question. If the Earth were twice as massive but had the same radius, then what would happen to the strength of the gravitational field upon Earth's surface?

a. It would be double the size. b. It would be one-half the size.

c. It would be quadruple the size. d. It would be one-fourth the size.

**Question 76:**

aa. Consider the equation for gravitational field strength – **g** - to answer this question. If the Earth were four times as massive but had the same radius, then what would happen to the strength of the gravitational field upon Earth's surface?

a. It would be double the size. b. It would be one-half the size.

c. It would be quadruple the size. d. It would be one-fourth the size.

**Question 77:**

aa. Consider the equation for gravitational field strength – **g** - to answer this question. If the Earth had twice the radius but the same mass, then what would happen to the strength of the gravitational field upon Earth's surface?

a. It would be double the size. b. It would be one-half the size.

c. It would be quadruple the size. d. It would be one-fourth the size.

**Question 78:**

aa. An object with mass is thought of as being surrounded by a gravitational field. The concept of the gravitational field becomes useful in explaining \_\_\_\_\_.

a. why gravitational forces can be so large

b. why the universal gravitation constant (**G**) is so big

c. why the universal gravitation constant (**G**) is so small

d. why the direction of the force of gravity is always downward

e. how objects can attract despite the fact that they are millions of miles away

**Question 79:**

aa. An object of mass **M** creates a gravitational field. The strength of the gravitational field at a certain location from the mass **M** is measured by \_\_\_\_\_.

a. placing the object with mass **M** on a balance

b. placing a second object on its surface and measuring its weight

c. determining the speed at which another object would be moving at that location

d. measuring the ratio of the force per mass on a second object which is placed in the field

**Question 80:**

aa. A Newton per kilogram (**N/kg**) is a unit of \_\_\_\_\_. Choose two.

a. mass b. force c. weight

d. acceleration e. gravitational field

**Question 81:**

aa. The gravitational field strength on the surface of the Earth is \_\_\_\_\_.

a. approximately 9.8 N/kg

b. equal to the weight of the Earth

c. zero for any object which is at rest

d. directed tangent to the Earth's surface

e. dependent on the mass of the object placed on the surface

f. indeterminable since such a location is too close to Earth's center

**Question 82:**

aa. The gravitational field is a vector that has a direction. The gravitational field direction at any given location is directed \_\_\_\_\_.

a. towards the Earth's center b. every which way but lose

c. away from the Earth's center d. tangent to the Earth's surface

e. in the direction which the object is moving

f. in the opposite direction which the object is moving

**Question 83:**

aa. The evidence that stimulated Newton to propose the law of universal gravitation emerged from a study of \_\_\_\_.

a. the fall of an apple to the Earth

b. the gravitational interaction of smaller objects upon the Earth

c. the motion of the moon and other celestial or heavenly bodies

d. ...nonsense! There was no evidence; it was just proposed as a theory.

**Question 84:**

aa. According to Newton's law of universal gravitation, the force of gravitational attraction between object 1 and object 2 depends upon \_\_\_\_. Choose all that apply.

a. the mass of object 1

b. the mass of object 2

c. the volume of the objects

d. the distance of separation of the two objects

e. the location in the universe (on Earth, on the moon, etc.)

**Question 85:**

aa. The mathematical form of Newton's law of universal gravitation is

Fgrav = G•m1•m2/d2

The symbol **G** stands for

a. gravity b. the gravitational constant c. the acceleration of gravity

**Question 86:**

aa. As the distance between two objects increases, the force of gravitational attraction would \_\_\_\_\_.

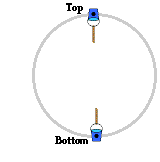
a. decrease b. increase c. not be altered

**Calculations and Long Answer**

**Question 87:**

aa.Dizzy Blaunde (m = 53.8-kg) stands on a merry-go-round platform, 5.49 m from the center. If her speed is 3.71 m/s, then what is the force of friction required to maintain this motion in a circle?

**Question 88:**

aa. A bucket is filled partly with water such that its combined mass is 1.94 kg. It is tied to a rope and whirled in a circle with a radius of 1.06 m. The speed at the top of the circle is 4.98 m/s and the speed at the bottom of the circle is 6.5 m/s.

a. Determine the acceleration, net force and tension force at the top of the circle.

a = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ m/s/s

Fnet = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

Ftens = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

b. Determine the acceleration, net force and tension force at the bottom of the circle.

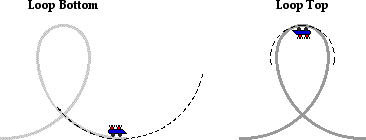
a = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ m/s/s

Fnet = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

Ftens = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

**Question 89:**

aa. A 456-kg roller coaster car is traveling through a roller coaster loop. The car is moving with a speed of 14.3 m/s at the top of the loop and 33.3 m/s at the bottom of the loop. The radius of curvature of the top is 12.4 m and the radius of curvature of the bottom is 23.6 m.



a. Determine the normal force acting upon the car at the top of the loop.

b. Determine the normal force acting upon the car at the bottom of the loop.

**Question 90:**

aa. A rider of a barrel ride at a carnival is moving in a circle with a speed of 5.0 m/s. The acceleration of the rider is 5.1 m/s/s. The speed of the object is somehow increased to 10.0 m/s (i.e., doubled). The new acceleration would be \_\_\_\_\_ m/s/s. (Assume that the radius of the circle is not changed.)

**Question 91:**

aa. A rider of a barrel ride at a carnival is moving in a circle that has a radius of 5.0 meters. The acceleration of the rider is 5.1 m/s/s. The radius of the circle is somehow increased to 10.0 meters (i.e., doubled). The new acceleration would be \_\_\_\_\_ m/s/s. (Assume that the speed of the object is not changed.)

**Question 92:**

aa. A car of mass 1330 kg makes a circular turn of radius 16.7 m along a level roadway. The coefficient of friction is 0.841 between the tires and the road. How fast (in m/s) can the car go without skidding off the turn?

**Question 93:**

aa. A bucket of water is spun in a vertical circle of radius 1.04 meters. What is the minimum speed (in m/s) that the bucket must have at the top of the circle in order for no water to spill out?

**Question 94:**

aa. A 458 kg roller coaster car (includes mass of occupants) is passing through a vertical loop. The speed of the car at the top of the loop is 13.5 m/s. Riders in the car experience a normal force that is 1/5-th their weight (at the top of the loop). What is the radius of curvature (in meters) of the top of the loop?

**Question 95:**

aa. Determine the acceleration (in m/s/s) of a rider on the Cajun Cliffhanger (a barrel ride at an amusement park) if the rider makes 5.40 revolutions around the 5.45-m diameter circle in 29.0 seconds.

**Question 96:**

aa. An eraser is tied to a string and swung in a circle with a radius of 0.739 meters. The eraser makes 76.2 revolutions in a minute. Determine its speed and its acceleration.

**Question 97:**

aa. An 804-kg roller coaster car starts from the top of a hill and rolls down. It enters a loop for which the radius at the top is 9.11 meters. Determine the minimum speed in m/s (at the loop's top) at which the 804 kg roller coaster car will complete the loop without falling out of the loop. (HINT: This is the speed at which the roller coaster car wheels are just barely in contact with the track; any slower speed would turn the car into a projectile.

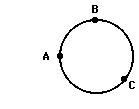
**Question 98:**

aa. A rubber ball is attached to a 1.19-meter string and spun in a horizontal circle. The tension in the string is 3.75 Newton. It takes 0.785 seconds for the ball to complete one revolution. Determine the mass (in kg) of the ball.

**Question 99:**

aa. Irada Inavator is standing in an elevator when it begins to accelerate upward. With a 41.8-kg mass, Irada begins to accelerate upward at 1.15 m/s/s. If Irada were standing upon a Newton force scale as the elevator accelerates upward, then what force (in Newton) would the scale read?

**Question 100:**

aa. An eraser is tied to a string and whipped in a horizontal circle at constant speed. A God's-eye view of the circular path is shown in the diagram at the right. Draw bold vector arrows to show the direction of:

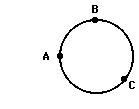
a. the net force at point A

b. the acceleration at point B

c. the linear velocity at point C.

Label each arrow as **Fnet**, **a**, and **v**.

(Assume a clockwise direction of motion.)



**Question 101:**

aa. Consider the diagram at the right. On the diagram, sketch a dashed line to show the *inertial path* of the object at points A, B and C. That is, show the path that the object would move if there was no unbalanced force acting upon it.

**Question 102:**

aa. Rex Things and Doris Locked are out on a date. Rex makes a rapid right-hand turn. Doris begins sliding across the vinyl seat (which Rex had waxed and polished beforehand) and collides with Rex. To break the awkwardness of the situation, Rex and Doris begin discussing the physics of the motion that was just experienced.

Rex suggests that objects that move in a circle experience an outward force. Thus, as the turn was made, Doris experienced an outward force that pushed her towards Rex.

Doris disagrees, arguing that objects that move in a circle experience an inward force. In this case, according to Doris, Rex traveled in a circle due to the force of his door pushing him inward. Doris did not travel in a circle since there was no force pushing her inward; she merely continued in a straight line until she collided with Rex.

Who is correct? Use physics and logic to thoroughly justify your answer.

**Question 103:**

aa. Kara Lott is practicing winter driving in the GBS parking lot. Kara turns the wheel to make a left-hand turn but her car continues in a straight line across the ice. Teacher A and Teacher B had viewed the phenomenon. Teacher A argues that the lack of a frictional force between the tires and the ice results in a balance of forces which keeps the car traveling in a straight line. Teacher B argues that the ice placed an outward force on the tire to balance the turning force and thus keep the car traveling in a straight line.

Which teacher is (A or B) is the physics teacher? Explain the fallacy in the other teacher's argument.

**Question 104:**

aa. Use Newton's law of universal gravitation to determine the force of gravitational attraction between two students of mass 53.4 kg and 70.5 kg if they are seated in their chairs a distance of 1.32 m apart.

**Question 105:**

aa. Neptune orbits the Sun with an orbital radius of 4.495 x 1012 m. If the mass of the Sun is 1.99 x 1030 kg, calculate the orbital period of Neptune's orbit.

**Question 106:**

aa. If a planet were 16.9 times further from the Sun than the Earth is from the Sun, then its orbital period will be \_\_\_\_\_\_ times longer than Earth's orbital period.

**Question 107:**

aa. (Given: G = 6.67 x 10-11 N·m2/kg2; MEarth = 5.98 x 1024 kg; REarth = 6.37 x 106 m) Calculate the speed that a satellite shot from a cannon must have to orbit Earth 168 km (168000 m) above its surface.

How much time in seconds and in minutes would it take for the satellite to complete one orbit?

**Question 108:**

aa. Suppose that a new planet is discovered that orbits the Sun at a distance that is 5 times Earth's orbital distance. How many "Earth-years" will it take the satellite to orbit the Sun?

**Question 109:**

aa. What would be the orbital speed (in mi/hr) of a 312-kg satellite orbiting Earth at an altitude of 1310 miles above the surface of the Earth? (1.0 mi = 1609 m and 1.0 m/s = 2.24 mi/hr) Use planetary data about Earth to assist in your solution.

**Question 110:**

aa. Two students sitting in adjacent seats in a lecture room have weights of 562 N and 636 N. Assume that Newton's law of universal gravitation can be applied to these two students and find the gravitational force (in Newton) that one student exerts on the other when they are separated by 0.808 m.

**Question 111:**

aa. How many Earth radii above the Earth (not from its center) must you be located to experience an acceleration of gravity of 1.32 m/s/s. Express in terms of Earth-radii; that is, express the answer as the number of times greater than 6.37 x 106 m.

**Question 112:**

aa. A planet has a single moon that orbits at a distance of 7.21x106 meters from the planet's center. The orbital period of the moon is in 2.54 *years*. Determine the mass (in kg) of the planet.

**Questions 113-118:**

Express your understanding of the relationship between gravitational force and the variables that affect it by answering the following questions.

Two objects attract with a gravitational force of 32 units.

aa. If the mass of one of the objects is doubled, then the new force of gravitational attraction would be \_\_\_\_\_\_\_\_\_\_\_\_ units.

aa. If the mass of both of the objects is doubled, then the new force of gravitational attraction would be \_\_\_\_\_\_\_\_\_\_\_\_ units.

aa. If the separation distance between the objects' centers is doubled, then the new force of gravitational attraction would be \_\_\_\_\_\_\_\_\_\_\_\_ units.

aa. If the separation distance between the objects' centers is tripled, then the new force of gravitational attraction would be \_\_\_\_\_\_\_\_\_\_\_\_ units.

aa. If the separation distance between the objects' centers is halved, then the new force of gravitational attraction would be \_\_\_\_\_\_\_\_\_\_\_\_ units.

aa. If the mass of one object is doubled and the mass of the other object is tripled and the separation distance between the objects' centers is doubled, then the new force of gravitational attraction would be \_\_\_\_\_\_\_\_\_\_\_\_ units.

**Question 119:**

aa. An apparatus like the one Cavendish used to find *G* has a large lead ball that is 6.3 kg in mass and a small one that is 0.468 kg. Their centers are separated by 0.0553 m. Find the force of attraction between them. (Use *G* = 6.67 x 10-11 N·m2/kg2.)

**Question 120:**

aa. A satellite with a mass of 526 kg is in circular orbit about the Earth at a height above the Earth equal to 1.27 times the mean radius of the earth (REarth = 6.37 x 106 m; MEarth = 5.98 x 1024 kg).

a. Find the satellite's orbital speed (in m/s).

b. Find the satellite's orbital period (in minutes).