Name: ____

PHYSICS: Unit 3 HONORS
GRAVITATIONAL ATTRACTION
& APPLIED FORCES

1. Uniform Circular Motion Vocabulary. Fill in the blank. Neatly print the vocabulary words into the paragraph on the lines.

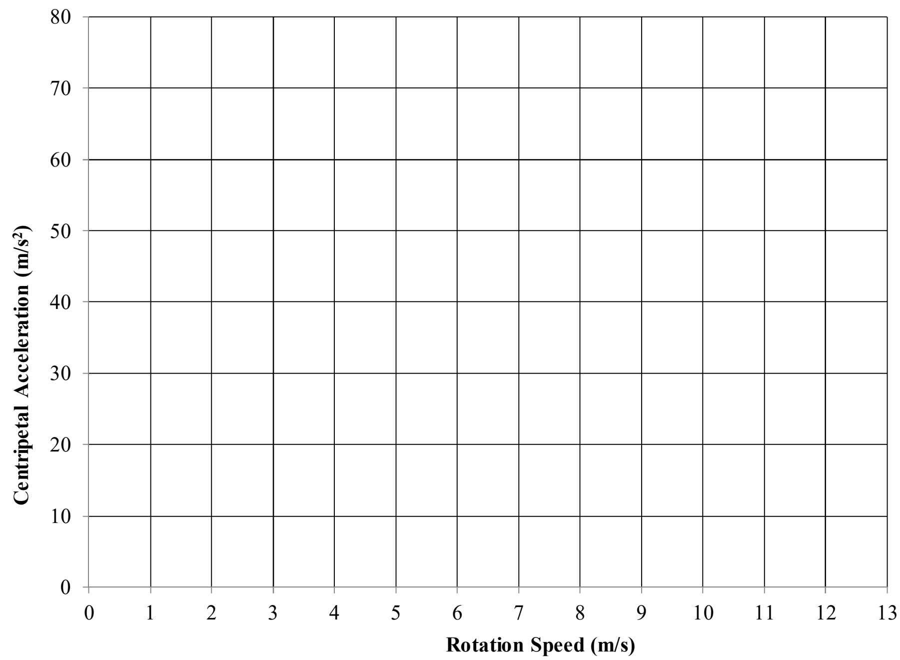
Acceleration	Direction	Radius	Rotate
Center	Force	Revolution	Rotation
Circular	Orbit	Revolves	Speed

Uniform __________________________ motion is the motion of an object moving in a continuous curved path or in a circle. When an object has ___________________________, the object spins around its center of mass. For example, the Earth ___________________________ one time every 24 hours, that is why the Earth experiences a day-night cycle. When an object undergoes ___________________________, the object moves around another object. For example, the Earth ___________________________ around the Sun in 365.24 days, or one calendar year. An ___________________________ is the physical path in which a planet revolves around a star or a moon revolves around a planet. When an object moves in a circular path, the object is constantly changing _______________________, therefore the object's velocity is constantly changing. This constant change in direction and velocity is called centripetal ______________________. The direction of centripetal acceleration is toward the ______________________ of the circular path. Centripetal ________________________ causes the object to change direction or to move in the circular motion. How fast at which an object moves with uniform circular motion is called the rotation or revolution ________________________. Centripetal acceleration and centripetal force is proportional to the square of the rotation speed and inversely proportional to the turn __________________________ of the circle in which the object is moving.

2. Circular motion and Centripetal Acceleration. Calculate the centripetal acceleration of the object moving in linear circular motion. Plot your data as points on the graph. Draw one curving best-fit line through the data points.

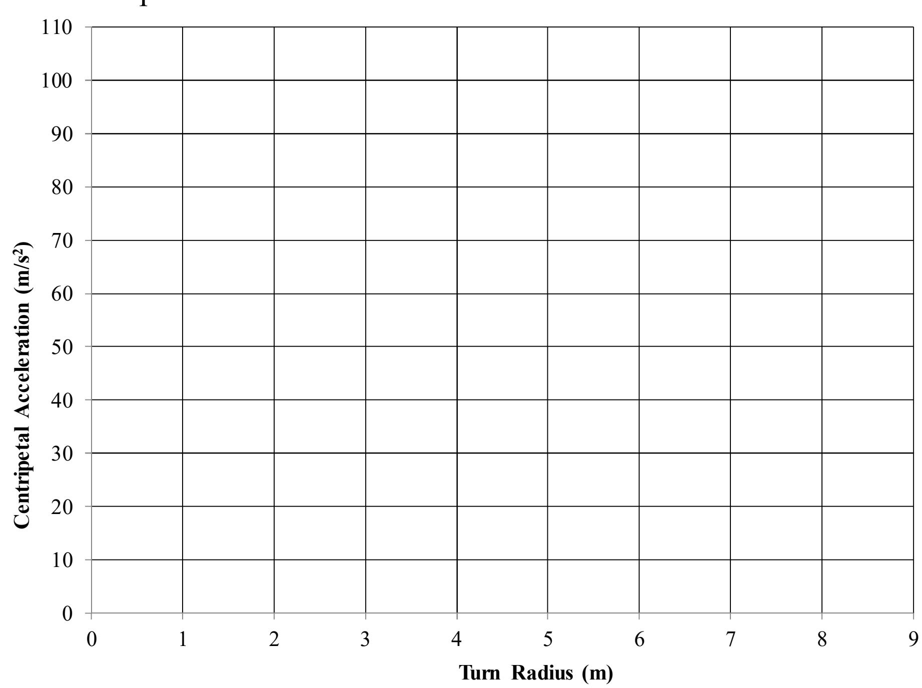
Constant turn radius, increasing linear rotation speed.

Turn Radius, r (m)	Rotation speed, v (m/s)	Centripetal acceleration a_c (m/s^2)
2.0	1.0	
2.0	2.0	
2.0	4.0	
2.0	6.0	
2.0	8.0	
2.0	10.0	
2.0	12.0	



Increasing turn radius, constant linear rotation speed.

Turn Radius, r (m)	Rotation speed, v (m/s)	Centripetal acceleration a_c (m/s^2)
1.0	10.0	
2.0	10.0	
3.0	10.0	
4.0	10.0	
5.0	10.0	
6.0	10.0	
7.0	10.0	
8.0	10.0	



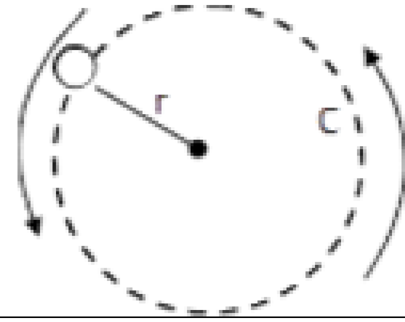
Part 3: Calculate the parameters of uniform circular motion. Show all calculations in the boxes next to each step of the problem.

$C = 2 \cdot \pi \cdot r \qquad v = \dfrac{n \cdot C}{t} \qquad a_c = \dfrac{(v^2)}{r} \qquad \omega = \dfrac{n \cdot 2 \cdot \pi}{t} \qquad F = m \cdot a_c \qquad L = m \cdot r^2 \cdot \omega \qquad \pi \approx 3.1416$

1. A merry-go-round has a turn radius of 10 meters. It rotates 6 times per minute. A boy rides the hobby horse at the edge of the merry-go-round. The boy's mass is 30 kg.

a. Calculate the circumference of the merry-go-round. Report your answer in m.	
b. Calculate the rotation speed of the merry-go-round. Report your answer in m/s.	
c. Calculate the angular velocity. Report your answer in radians/s.	
d. Calculate the centripetal acceleration affecting the boy riding on the merry-go-round. Report your answer in m/s^2.	
e. Calculate the centripetal force affecting the boy riding the merry-go-round. Report your answer in N.	
e. Calculate the angular momentum of the boy riding the merry-go-round. Report your answer in $kg \cdot m^2/s$.	

2. Julio attaches a ball to the end of a string. The length of the string is 0.75 meters. The mass of the ball is 1.2 kg. Julio swings the ball around in a circle 20 times in one minute.



a. Calculate the circumference of the circle made by the ball's motion. Report your answer in m.	
b. Calculate the revolution speed of the ball on the string. Report your answer in m/s.	
c. Calculate the angular velocity of the ball on the string. Report your answer in radians/s.	
d. Calculate the centripetal acceleration affecting the ball on the end of the string. Report your answer in m/s^2.	
e. Calculate the centripetal force affecting the ball on the end of the string. Report your answer in N.	
f. Calculate the angular momentum of the ball on the string. Report your answer in $kg \cdot m^2/s$.	

Part 4. Torque and Static Equilibrium. Solve for torque, perpendicular force, or lever length. Show all calculations.

$$\Gamma = F_{\perp} \cdot l \qquad\qquad (m \cdot g \cdot l)_{LEFT} = (m \cdot g \cdot l)_{RIGHT}$$

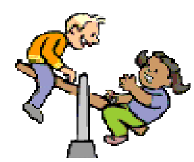
1. Plumber Joe tightens a bolt with his wrench. The length of the wrench is 0.50 meters. He uses a perpendicular force of 8 N to tighten the bolt. Calculate the torque required to tighten the bolt.

2. Plumber Joe tightens a bolt with his wrench. The length of the wrench is 0.70 meters. He uses a perpendicular force of 12 N to tighten the bolt. Calculate the torque required to tighten the bolt.

3. Plumber Sue tightens a bolt with her wrench. She applies a torque of 16 Nm to the bolt using her 0.4 m long wrench. Calculate the applied perpendicular force she used.

4. Plumber Sue tightens a bolt with her wrench. She applies a perpendicular force of 22 N to generate a torque of 9 Nm. Calculate the length of Sue's wrench.

Jimmy and Theresa are siblings. Jimmy is older and is bigger than Theresa. Jimmy has a mass of 50 kg. Theresa has a mass of 30 kg. They are playing on the seesaw at the park.



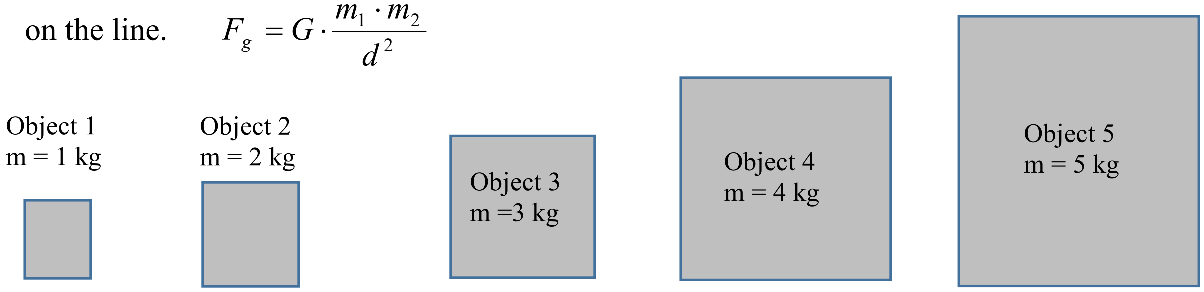
5. On Monday, Theresa sits on the left side of the seesaw, 2.0 meters from the pivot. How far away from the pivot must Jimmy sit to balance the seesaw?

6. Calculate the torque that Theresa creates in problem 5. The perpendicular force is equal to her weight.

7. On Tuesday, Theresa sits on the left side of the seesaw, 1.5 meters from the pivot. How far away from the pivot must Jimmy sit to balance the seesaw?

8. Calculate the torque that Jimmy creates in problem 7. The perpendicular force is equal to his weight.

Part 5. Gravitational Attraction Force. Identify which combination of objects has the strongest gravitational attraction force. Use the gravitational force equation to assist you. Write the correct letter on the line. $F_g = G \cdot \frac{m_1 \cdot m_2}{d^2}$



__________ 1
A. Object 1 and Object 2, 1-meter apart
B. Object 2 and Object 3, 1-meter apart
C. Object 3 and Object 4, 1-meter apart
D. Object 4 and Object 5, 1-meter apart

__________ 2
A. Object 1 and Object 2, 1-meter apart
B. Object 1 and Object 2, 2-meters apart
C. Object 1 and Object 2, 3-meters apart
D. Object 1 and Object 2, 4-meters apart

__________ 3
A. Object 1 and Object 5, 1-meter apart
B. Object 1 and Object 4, 1-meter apart
C. Object 1 and Object 3, 1-meter apart
D. Object 1 and Object 2, 1-meter apart

__________ 4
A. Object 1 and Object 5, 1-meter apart
B. Object 2 and Object 5, 2-meters apart
C. Object 3 and Object 5, 3-meters apart
D. Object 4 and Object 5, 4 meters apart

__________ 5
A. Object 1 and Object 5, 5-meters apart
B. Object 1 and Object 4, 4-meters apart
C. Object 1 and Object 3, 3-meters apart
D. Object 1 and Object 2, 2-meters apart

__________ 6
A. Object 1 and Object 2, 2-meters apart
B. Object 3 and Object 5, 3-meters apart
C. Object 2 and Object 4, 1-meter apart
D. Object 3 and Object 4, 2-meters apart

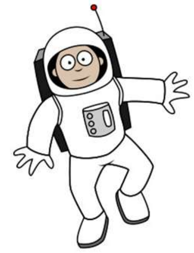
__________ 7
A. Object 1 and Object 2, 1-meter apart
B. Object 2 and Object 3, 1-meter apart
C. Object 3 and Object 4, 1-meter apart
D. Object 4 and Object 5, 1-meter apart

__________ 8
A. Object 5 and Object 1, 1-meter apart
B. Object 5 and Object 3, 2-meters apart
C. Object 4 and Object 4, 2-meters apart
D. Object 5 and Object 5, 3-meters apart

__________ 9
A. Object 4 and Object 3, 2-meters apart
B. Object 4 and Object 5, 2-meters apart
C. Object 5 and Object 3, 2-meters apart
D. Object 3 and Object 3, 2-meters apart

__________ 10
A. Object 2 and Object 2, 1-meter apart
B. Object 2 and Object 4, 2-meters apart
C. Object 3 and Object 4, 2-meters apart
D. Object 5 and Object 5, 3 meters apart

Part 6. Mass and Weight on Earth and Other Solar System Bodies. Calculate the mass and the weights of astronauts and spacecraft on the Earth, Mars, and on the moon.



$g_{Earth} = 9.8\frac{m}{s^2}$ $\quad g_{Moon} = 1.62\frac{m}{s^2}$ $\quad g_{Mars} = 3.71\frac{m}{s^2}$ $\quad w = m \cdot g$

1. Danielle is an astronaut. She has a mass of 50 kg on Earth. Calculate Danielle's weight on Earth. ____________________

2. Danielle travels to the moon in a spaceship. Calculate Danielle's weight on the moon. ____________________

3. Calculate Danielle's mass on the moon. ____________________

4. Darrell is also an astronaut. Darrell's weight on Earth is 880 N. Calculate Darrell's mass on Earth ____________________

5. Darrell traveled to the moon. Calculate Darrell's mass on the moon. ____________________

6. Calculate Darrell's weight on the moon. ____________________

7. Danielle and Darrell traveled to the moon in large spacecraft that has a mass of 30,000 kg on the moon. Calculate the weight of the spacecraft on the moon. ____________________

8. The spacecraft returns to Earth. Calculate the weight of the spacecraft on Earth. ____________________

9. Calculate the mass of the spacecraft on Earth. ____________________

10. An alien spacecraft landed on Mars's surface. The spacecraft's weight on Mars was 24,000 N. Calculate the mass of the alien spacecraft on Mars. ____________________

11. The alien spacecraft landed on the moon to abduct Danielle and Darrell. Calculate the weight of the alien spacecraft on the moon. ____________________

12. The alien spacecraft landed on Earth in front of the White House. "Take me to your leader". Calculate the weight of the spacecraft on Earth. ____________________

Part 7. Gravity and Effects of Gravity. On the line, write TRUE or FALSE as your answer to the question. Answers of T and F will be ignored.

________________ 1 Gravity exists in outer space.

________________ 2 The gravitational attraction force of the Sun pulling on the Earth is greater than the gravitational attraction force of the Earth pulling on the Sun.

________________ 3 The gravitational attraction force of the Earth pulling downward on a person is greater than the gravitational attraction force of the person pulling upward on the Earth—that is why the person falls down.

________________ 4 High tides result from the gravitational attraction between the Sun and the surface of the oceans.

________________ 5 High tides result from the gravitational attraction between the moon and the surface of the oceans.

________________ 6 The greater the masses of the objects, the greater the gravitational attraction force between the objects.

________________ 7 The lesser the masses of the objects, the greater the gravitational attraction force between the objects.

________________ 8 The greater the distance between two objects, the greater the gravitational attraction force between the objects.

________________ 9 The lesser the distance between two objects, the greater the gravitational attraction force between the objects.

________________ 10 Only solids have a gravity field.

________________ 11 The acceleration due to gravity on Earth is greater than the acceleration due to gravity on Earth's moon because the Earth has a greater radius than Earth's moon.

________________ 12 According to Newton's law of gravitation: the attractive force due to gravity is proportional to the product of the masses and inversely proportional to the square of the distances.

________________ 13 The mass of a man on the moon is lesser than the mass of a man on Earth because the moon's gravity field is weaker.

________________ 14 The weight of a man on the moon is lesser than the weight of a man on Earth because the moon's gravity field is weaker.

Part 8: Use the masses, radii, and distances to calculate gravity field strength, escape velocity, and gravity attraction force.

$g = G \cdot \frac{M}{r^2}$ $F_g = G \cdot \frac{m_1 \cdot m_2}{d^2}$ $v^e = \sqrt{\frac{2GM}{r}}$ 1 km = 1000 m

1. The planet Wheeler 424 has a mass of 4.50×10^{25} kg. Wheeler 424's radius is 8,000 km. Calculate the acceleration in Wheeler 422's gravity field (g).	
2. Wheeler 424's largest moon, Giles Beta, has a mass of 3.7×10^{21} kg and a radius of 950 km. Calculate the acceleration in the moon's gravity field (g).	
3. Calculate the escape velocity required by a rocket to break free of Wheeler 424's gravity field.	

4. Two large buildings sit on opposite street corners. Building #1 has a mass of 10,000,000 kg. Building #2 has a mass of 20,000,000 kg. They lie 50 m apart. Calculate the gravitational attraction force with which they pull on each other.	
5. The Earth has a mass of 5.98×10^{24} kg. Earth's moon has a mass of 7.35×10^{22} kg. The average distance between Earth and Earth's moon is 385,000 km. Calculate the gravitational attraction force with which they pull on each other.	
6. Earth's moon orbits the Earth once every 27 Earth days. The mass of Earth's moon is 7.35×10^{22} kg and the average distance between Earth and Earth's moon is 385000 km. Calculate the centripetal acceleration and the centripetal force acting upon the moon. 1 day = 24 hours 1 hour = 3600 s 1 km = 1000 m	

Part 9. Freefall. Calculate the freefall velocity, freefall distance, or time of freefall.

$$v_f = v_0 - g \cdot t \qquad \Delta y = v_0 \cdot t - \frac{1}{2} \cdot g \cdot t^2 \qquad g_{Earth} = 9.8 \frac{m}{s^2}$$

1. Fabian drops a quarter from a bridge. The quarter falls for 5.5 seconds before impacting with the road below.

Calculate the freefall speed of the quarter when it impacts the road below. __________________

Calculate the distance that the quarter fell from the bridge to the road. __________________

2. Elizabeth drops a pebble from the roof of her apartment building. The rock falls for 2.7 seconds before impacting the sidewalk below.

Calculate the freefall speed of the pebble when it impacts the sidewalk below. __________________

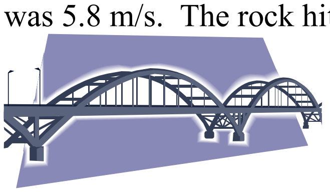
Calculate the distance that the pebble fell from the top of the apartment building. __________________

3. Marquis throws a quarter downward from the bridge's deck with an initial speed of -7.2 m/s. The quarter impacts the road below the bridge in 1.8 seconds.

Calculate the downward velocity of the quarter when it impacted the road. __________________

Calculate the distance that the quarter fell from the bridge deck to the road. __________________

4. Mary threw a rock up over the deck of the bridge. The rock's initial upward velocity was 5.8 m/s. The rock hit the river below in 3.8 seconds after it was thrown.



Calculate the downward velocity of the rock when it impacted the river. __________________

Calculate the distance that the quarter fell from the bridge deck to the road. __________________

5. Floyd three a penny up over the railing on top of his apartment building. The penny's initial upward velocity was 3.3 m/s. The penny impacted the street in 3.1 seconds after it was thrown.

Calculate the freefall speed of the penny when it impacted the street. __________________

Calculate the distance that the penny fell from the top of the apartment building. __________________

Part 10: Gravity Vocabulary. Fill in the blank. Neatly print the vocabulary words into the paragraph on the lines.

Attraction	Fall	Mass	Orbit
Decreases	Gravity	Moon	Sun
Distance	Increases	Newton	Tides

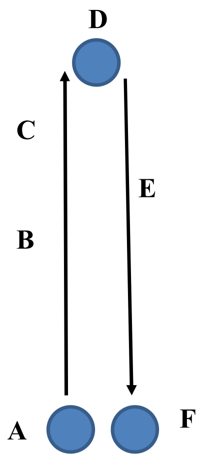
The English scientist Sir Isaac __________________________ developed the universal law of __________________________. This law states that gravity is a force of __________________________ between every object in the universe. This law also states that the force of attraction between two objects depends on two things: the __________________________ of the objects and the __________________________ between the objects. As the mass of the objects increases the force of gravity __________________________ As the distance between the objects increases the force of gravity__________________________. Gravity can be used to explain many of the things we observe in the universe. For example, gravity explains why objects __________________________ to the ground when you drop them. This is because the Earth's gravity is pulling on the object. Gravity also explains why the oceans have __________________________. They are caused by the gravitational pull of the __________________________ and the __________________________. Gravity combined with the law of inertia can even explain why the planets __________________________ the sun.

Part 11. Air Resistance. Circle the objects that would be most affected by air resistance.

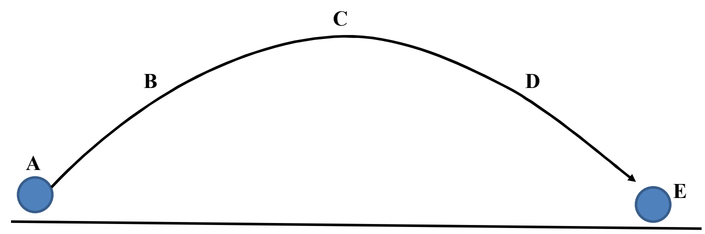
SNOWFLAKE	FEATHER	BASEBALL	CLOTH
RAIN DROP	PAPER	PENCIL	FLAG
ROCK	FOOTBALL	PAPER CLIP	BULLET
PARACHUTE	ARROW	BRICK	PENNY

Part 12. Review of Projectile Motion. The three diagrams show the three types of projectile motion. The letters are specific positions along the projectile's path of motion. The solid black lines are the paths of motion moved by the projectile. The arrow shows the direction of motion. Write the letter of the correct answer on the line.

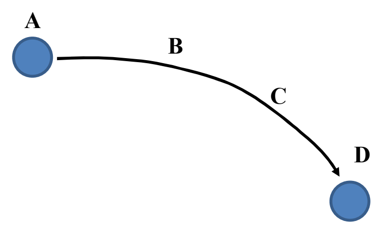
Vertical projectile



Parabolic Projectile



Horizontal Projectile



Answer questions about vertical projectile motion

__________ 1. At which position is the projectile moving the fastest in the up direction?

A. Position A C. Position B & C E. Position E G. All positions
B Position B D. Position D F. Position F H. None

__________ 2. At which position is the projectile moving the fastest in the down direction?

A. Position A C. Position B & C E. Position E G. All positions
B Position B D. Position D F. Position F H. None

__________ 3. At which position is the projectile's velocity decreasing?

A. Position A C. Position B & C E. Position E G. All positions
B Position B D. Position D F. Position F H. None

__________ 4. At which position is the projectile's velocity increasing?

A. Position A C. Position B & C E. Position E G. All positions
B Position B D. Position D F. Position F H. None

__________ 5. At which position is the projectile not moving?

A. Position A C. Position B & C E. Position E G. All positions
B Position B D. Position D F. Position F H. None

__________ 6. At which position is the projectile being accelerated in the up direction?

A. Position A C. Position B & C E. Position E G. All positions
B Position B D. Position D F. Position F H. None

__________ 7. At which position is the projectile being accelerated in the down direction?
A. Position A   C. Position B & C   E. Position E   G. All positions
B Position B   D. Position D   F. Position F   H. None

__________ 8. At which position is the projectile changing direction?
A. Position A   C. Position B & C   E. Position E   G. All positions
B Position B   D. Position D   F. Position F   H. None

Answer questions about parabolic projectile motion

__________ 9. At which position is the object moving with the fastest upward motion?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 10. At which position is the projectile moving with the fastest downward motion?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 11. At which position is the projectile moving with zero upward motion?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 12. At which position is the projectile not moving?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 13. At which position is the projectile moving with only horizontal motion?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 14. At which positions is the projectile moving the fastest in the horizontal direction?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 15. At which position is the projectile's downward motion getting faster?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

__________ 16. At which position is the projectile's upward motion getting faster?
A. Position A   C. Position C   E. Position E   G. None
B. Position B   D. Position D   F. All positions

Horizontal projectile motion

__________ 17. At which position is the object moving with the fastest upward motion?
A. Position A
C. Position C
E. All positions
F. None
B. Position B
D. Position D

__________ 18. At which position is the projectile moving with the fastest downward motion?
A. Position A
C. Position C
E. All positions
F. None
B. Position B
D. Position D

__________ 19. At which position is the projectile moving with the fastest horizontal motion?
A. Position A
C. Position C
E. All positions
F. None
B. Position B
D. Position D

__________ 20, At which position is the projectile moving with only horizontal motion and no vertical motion?
A. Position A
C. Position C
E. All positions
F. None
B. Position B
D. Position D