**Astronomy Assessment and TPS Questions:**

**Galaxy Rotation Curves and Dark Matter**

Answer the next three questions using the 4 graphs shown below.

Distance

Orbital Speed

Distance

Orbital Speed

Distance

Orbital Speed

Distance

Orbital Speed

A.

B.

C.

D.

1. If we were to make a curve that shows how all the mass of the Milky Way Galaxy is distributed *based only on the rotation rate of matter in the galaxy*, the curve would look like which of the following?
2. If we were to make a curve that shows how all the mass of the Milky Way Galaxy is distributed based only on the light that we can observe over all wavelengths, the curve would look like which of the following?
3. Which graph best represents orbital speed versus distance for objects throughout the disk of our galaxy?
4. The graph of the orbital speed of stars throughout the disk of the Milky Way Galaxy implies the existence of
	1. the distribution of globular clusters.
	2. dark matter.
	3. spiral arms.
	4. gas and dust.
	5. dark energy
5. The idea of dark matter is provided to explain which one of the following?
6. the location and shape of the arms in the disk of spiral galaxies
7. the location of the maximum in the distribution of globular clusters of stars in the halo of the galaxy
8. the nearly uniform rotation speeds of objects in the Milky Way Galaxy
9. that a spiral density wave moves through the disk of spiral galaxies triggering star formation
10. that spiral galaxies slowly evolve into elliptical galaxies
11. How do we know where we are in the disk of the Milky Way Galaxy?
12. by determining how much dark matter exists in the galaxy
13. by measuring the size and speed of the spiral density wave in the disk
14. by determining the distribution of globular clusters in the halo
15. by measuring the redshift of stars in the galaxy

Star A is located 45,000 light years from the center of the Milky Way galaxy and orbits the center of the galaxy at a rate of 200 km/s. Star B is in a solar system very similar to ours located 100 light years away from the Sun. Use this information to answer the next two questions

1. How fast is Star B orbiting the center of the Milky Way galaxy?
2. Faster than 200 km/s
3. Slower than 200 km/s
4. Approximately 200 km/s
5. Which of these stars has the greater amount of mass contained interior to the circle of its orbit of galaxy?
6. Star A
7. Star B
8. They would enclose the same amount of mass.

Speed

Distance

**Rotation Curve A**

Speed

Distance

**Rotation Curve B**

Speed

Distance

**Rotation Curve C**

At right are three different hypothetical rotation curves (A, B and C) for a spiral galaxy. Use this information to answer the next three questions.

1. Which rotation curve shows a galaxy where the stars speeds continue to increase the farther they are away from the galactic center?
2. Which rotation curve could show the orbital speeds of stars in the disk of a spiral galaxy if dark matter did **not** exist?
3. Which rotation curve shows the orbital speeds of stars in the disk of a spiral galaxy with dark matter?
4. Which of the following components of an elliptical galaxy has the most mass?
	1. Stars
	2. Gas and Dust
	3. Dark Matter
	4. There is insufficient information to determine this.
5. Which of the following components of a spiral galaxy has the most mass?
	1. Stars
	2. Gas and Dust
	3. Dark Matter
	4. There is insufficient information to determine this.
6. What is the dominating mass of the solar system?
	1. The planets
	2. The Sun
	3. Dark Matter
	4. All of the above contribute equal mass
7. What is the dominating mass of the universe?
	1. The planets
	2. Dark Matter
	3. The stars
	4. The galaxies
8. Which of the following do not emit light?
	1. Black holes
	2. Dark matter
	3. Black dwarves
	4. All of the above
9. Which of the following is evidence for the existence of dark matter?
	1. The rotation curve of the solar system
	2. The rotation curve of the galaxy
	3. The bending of space and time
	4. More than one of the above
10. Is Earth’s own mass part of the mass inside its orbit?
	1. Yes, along with Mercury, Venus and the Sun
	2. Yes, Earth’s mass is the only thing included in Earth’s interior mass
	3. No, but Mercury’s mass, Venus’ mass, and the Sun’s mass are
11. In Newton’s Law of Gravitation, FG= (G x M x m)/ r2, what does the variable r stand for?
	1. the radius of the larger object
	2. the distance from the center of one object to the center of the other object
	3. the mass of both objects
	4. the gravitational constant
12. In the Milky Way Galaxy, the orbital speed of stars \_\_\_\_\_\_\_\_\_\_\_ as the distance from the center of the galaxy increases.
	1. Increases
	2. Decreases
	3. is constant
	4. increases to a point and then is constant
	5. none of the above
13. Which of the following best describes the orbital speed of objects in our solar system?
	1. Objects closer to the center of mass orbit faster
	2. Objects further from the center of mass orbit faster
	3. More massive objects orbit faster
	4. Less massive objects orbit faster
	5. All of the objects throughout the solar system orbit at the same speed
14. Which of the following best describes the orbital speed of objects in the disk of the Milky Way Galaxy?
	1. Objects closer to the center of mass orbit faster
	2. More massive objects orbit faster
	3. Objects closer to the central bulge orbit faster
	4. All of the objects throughout the disk orbit at the same speed
15. What is the evidence for the existence of Dark Matter?
	1. The rotation curve of the solar system is the same as the rotation curve of the galaxy
	2. The orbital speed of the outermost objects in the galaxy is equal to that of the innermost objects closest to the bulge
	3. The orbital speed of the outermost objects in the solar system is equal to that of the innermost objects closest to the sun
	4. None of the above
16. How would you describe the galaxies rotation curve?
	1. The speed increases as distance decreases
	2. The speed increases as distance increases
	3. The speed increases as distance decreases than remains constant
	4. The speed increases as distance increases than remains constant

Distance

Orbital Speed

Distance

Orbital Speed

Distance

Orbital Speed

Distance

Orbital Speed

A.

B.

C.

D.

1. Use the above graphs to answer the question. Which rotation curve represents the orbital speed of stars in the disk of the Milky Way Galaxy?
2. Use the above graphs to answer the question. Which rotation curve would be accurate of the Milky Way Galaxy did not contain dark matter?
3. Use the above graphs to answer the question. Which rotation curve would be true if the mass of the solar system was dominated by dark matter spread throughout the solar system?
4. Which of the following could increase the orbital speed of an object?
	1. Adding mass inside the object’s orbit
	2. Adding mass outside the object’s orbit
	3. Increasing the distance of the object from the center of its orbit
	4. Decreasing the distance of the object from the center of its orbit
	5. More than one of the above
5. In terms of Newton’s Law of Gravitation, FG= (G x M x m)/ r2, the difference between the orbital speed of Mercury and the orbital speed of Neptune is mainly caused by:
	1. the larger (M x m) when calculating the force of gravity on Mercury.
	2. the larger (M x m) when calculating the force of gravity on Neptune.
	3. the smaller (r) when calculating the force of gravity on Mercury.
	4. the smaller (r) when calculating the force of gravity on Neptune.
6. We assume that dark matter must exist because:
	1. the light given off by the Milky Way is actually much more than we originally thought, so there must be more mass in the galaxy.
	2. the mass of every known thing inside Neptune’s orbit is still not enough to explain Neptune’s orbital speed.
	3. dark matter often comes between Earth and other stars in our galaxy, obscuring our view of the Milky Way.
	4. the orbital speeds of stars far from the center of the galaxy are much greater than we expected – there must be more mass inside their orbits.
7. Star A and Star B are both in the Milky Way galaxy. If both stars are moving at the same speed, where might they be located relative to each other?
	1. Both are close to each other
	2. Both are far away from each other
	3. You cannot determine from this information
8. Star A is 60,000 light years away from the Sun. If the Sun is moving at a rate of 150km/s. How fast is Star A moving?
	1. Faster than 150km/s
	2. Slower than 150km/s
	3. About 150 km/s
	4. You cannot determine from this information
9. Star A and Star B are both in the Milky Way galaxy. If the Sun is moving at 100 km/s and both stars are moving at 80 k/s, where might they be located?
	1. 20,000 light years from the center
	2. 30,000 light years from the center
	3. 5,000 light years from the center
	4. You cannot determine with this information
10. Star A is 7,000 light years from the edge of the Milky Way galaxy. Star B is 19,000 light years from Star A and is in a large star forming region. How fast is Star A moving compared to Star B?
	1. Faster than Star B
	2. Slower than Star B
	3. About the same as Star B
	4. You cannot determine from this information

**C**

1. Using the rotation curve of Galaxy A shown above, which of the following is true?
	1. Galaxy A’s fastest moving stars are near the edge of the galaxy.
	2. Most of Galaxy A’s mass is located in the center.
	3. Galaxy A’s rotation curve does not resemble the rotation curve of our solar system.
	4. Galaxy A has abundant dark matter spread throughout the disk and halo.
	5. None of the above.
2. Using the rotation curve of Galaxy B shown above, which of the following is true?
	1. Galaxy B has abundant dark matter spread throughout the disk and halo.
	2. The orbital speed of the stars furthest from the center of Galaxy B is slow compared to the other stars in the galaxy.
	3. Most of Galaxy B’s mass is located in the center.
	4. Galaxy B must be more luminous than Galaxy A because it must be more massive.
	5. None of the above.
3. Using the rotation curve of Galaxy C shown above, which of the following is true?
	1. The rotation curve of Galaxy C resembles the rotation curve of our solar system.
	2. The fastest stars in Galaxy C are close to the center.
	3. In Galaxy C, the orbital speed of stars increases at a constant rate as you move away from the center.
	4. Galaxy C is definitely more luminous than Galaxy A.
	5. None of the above.
4. Use the rotation curves shown above to complete the following sentence: The rotation curve of Galaxy \_\_\_\_ resembles what astronomers expected the rotation curve of the Milky Way Galaxy to be, while the rotation curve of Galaxy \_\_\_\_ resembles what observational evidence has shown the actual rotation curve of the Milky Way to be.
	1. A, C
	2. A, B
	3. B, A
	4. B, C
	5. C, B