Astronomy 101 Exam 2 Form A

Name: ____________________ Lab section number: __________

(See back page for lab schedule; if you omit this you may not get your exam back!)

Multiple Choice	Gravitation	Orbits	Process of Science		**Total**
/ 39	/ 12	/ 12	/ 12		**/ 75**

Instructions:

- Exam time: 80 minutes
- Please put bags under your seats to allow proctors to move around the room.
- You may use one page of notes that you handwrote yourself, or wrote with a stylus and printed. No electronic devices or things written by others are allowed.
- This exam has thirteen multiple-choice questions worth three points each, followed by three free-response questions worth 12 points each.
- We will award substantial partial credit for free-response answers if you show valid reasoning or insight, even if your answer is not correct.
- If you have a question, raise your hand, and a proctor will assist you.
- Do not attempt to communicate with anyone other than teaching staff during the exam.

Good luck!

Lab Schedule

Section	Time	Instructor
M024	Monday 8:00-9:20	Sierra
M003	Monday 9:30-10:50	Keisi
M004	Monday 11:00-12:20	Keisi
M005	Monday 12:45-2:05	Nada
M006	Monday 2:15-3:35	Sierra
M007	Monday 3:45-5:05	Sierra
M008	Monday 5:15-6:35	Nada
M009	Monday 6:45-8:05	Sierra
M010	Monday 8:15-9:35 pm	Dylan
M027	Tuesday 3:30-4:50	Byron
M028	Tuesday 5:00-6:20	Byron
M029	Tuesday 6:30-7:50	Chad
M030	Tuesday 8:00-9:20 pm	Chad
M025	Wednesday 8:00-9:20	Nada
M011	Wednesday 9:30-10:50	Keisi
M012	Wednesday 11:00-12:20	Keisi
M013	Wednesday 12:45-2:05	Byron
M014	Wednesday 2:15-3:35	Byron
M015	Wednesday 3:45-5:05	Lindsay
M016	Wednesday 5:15-6:35	Lindsay
M017	Wednesday 6:45-8:05	Dylan
M018	Wednesday 8:15-9:35 pm	Dylan
M019	Thursday 5:00-6:20	Chandler
M020	Thursday 6:30-7:50	Chad
M031	Thursday 8:00-9:20 pm	Chad
M026	Friday 8:00-9:20	Chandler
M021	Friday 9:30-10:50	Lindsay
M022	Friday 11:00-12:20	Chandler
M023	Friday 12:45-2:05	Chandler

1. An astronaut travels to another planet (with no air), holds a rock a meter above the ground, and drops it. Which of the following things affect how long it takes the rock to hit the ground?

   - I. The mass of the planet
   - II. The mass of the rock
   - III. The size (radius) of the planet

   (A) I and III
   (B) II and III
   (C) I, II, and III
   (D) I only
   (E) I and II

2. If we are trying to determine the distance to things in the sky using parallax, what is the largest baseline that we can make use of without leaving the surface of the Earth?

   (A) About 1 AU
   (B) About 2 AU
   (C) About 30 AU
   (D) About 12,000 km (the diameter of Earth)
   (E) As far as we can run/walk/drive before the stars set each night

3. Astronomers use parallax to measure the distance to the stars, just like people use parallax to measure distances to things on Earth.

   Which of the following would *increase* the parallax angle seen by an observer? *(The parallax angle is the displacement of an object compared to a distant background as seen from two different observation points; the distance between those points is called the baseline.)*

   There may be multiple correct answers to this question; indicate them all.

   (A) Observing a physically larger object (for instance, a star rather than a planet)
   (B) Decreasing the size of the baseline
   (C) Moving the object further away from the observer
   (D) Moving the object closer to the observer
   (E) Increasing the size of the baseline

4. Suppose we look at a star and see it periodically wobbling in its orbit every few years. For one year it is moving toward us very slightly, for the next year it is moving away from us very slightly, and so on.
   What might we conclude from this? *(Recall what you did in the first orbit simulator lab.)*

   (A) This star is actually a neutron star
   (B) This star has a very massive planet in orbit around it
   (C) There are living things living on at least one planet in this star's solar system
   (D) Kepler's laws of orbital motion do not apply in exactly the same way in this star's solar system
   (E) None of the above

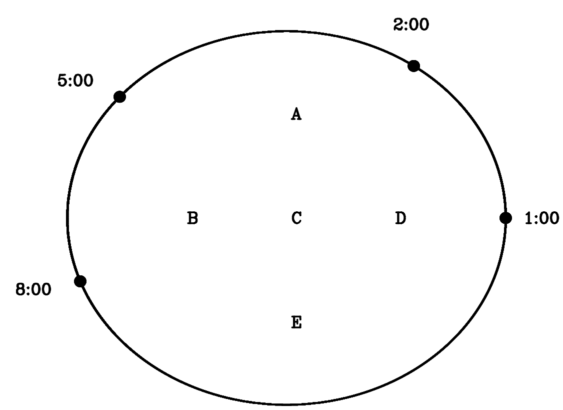
5. Which object do Kepler's laws of orbital motion *not* apply to?

   (A) Halley's comet
   (B) A spacecraft with a rocket engine that is turned on
   (C) Ganymede, one of the moons of Jupiter
   (D) Earth's Moon
   (E) Kepler's laws of orbital motion apply to all of these

6. You are the captain of the starship *Enterprise* when you pick up a radio distress beacon coming from a ship in orbit around a distant planet. This ship has broken down – it has no engines, no way to maneuver, and is running out of air.

   You want to go rescue the people on the distressed ship, but your navigator (Mr. Sulu, naturally) tells you that you need to find out where the planet is in order to safely use your warp drive to get there in a hurry.

   The only trouble is that the planet is too far away for you to see with your ship's instruments. Your ship's computer works out the shape of the ship's orbit, but doesn't tell you where the planet is. You have an idea, though: you've gotten four pings from the distress beacon, at 1:00, 2:00, 5:00, and 8:00. From this, you are able to figure out where the planet is and safely warp to the ship to rescue its crew.



   Which locations could the planet possibly be at? (Indicate one or more of the five marked locations.)

7. If the Earth's velocity were suddenly changed to ten times its current value – that is, if it became around 60 AU/year instead of its current value around 6 AU/year – what would happen? *(Hint: Think about what you did in the Orbit Simulator lab.)*

   (A) The Earth would now orbit the Sun in a highly eccentric orbit, with a perihelion distance around 1/10 AU

   (B) The Earth would now orbit the Sun in a highly eccentric orbit, with an aphelion distance around 10 AU

   (C) Nothing would change about the Earth's motion around the Sun

   (D) The Earth would escape from the Sun's gravity and fly away forever

   (E) The Earth would now orbit the Sun in a nearly circular orbit, with a radius of around 10 AU

8. Which object do Newton's laws of motion *not* apply to?

   (A) Ganymede, one of the moons of Jupiter

   (B) Halley's comet

   (C) Earth's Moon

   (D) A spacecraft with a rocket engine that is turned on

   (E) Newton's laws of motion apply to all of these

9. Saturn is in a nearly circular orbit with a diameter of about 20 AU. It takes about 30 years to go around the Sun.

   Earth is in a nearly circular orbit with a diameter of about 2 AU. It takes one year to go around the Sun.

   Suppose that a comet is in a highly elliptical orbit. Its short axis is 2 AU across, and its long axis is 20 AU across. How long will it take to go around the Sun?

   (A) It depends on the mass of the comet

   (B) About one year

   (C) Less than one year

   (D) About 30 years

   (E) Between one year and 30 years

10. What was the significance of Galileo's observation of the moons of Jupiter through his telescope?

    (A) It allowed for confirmation of Kepler's third law, by comparing their orbital periods
    (B) It showed for the first time that not everything orbited the Earth
    (C) It provided a confirmation of Kepler's second law, since we could see them speed up and slow down
    (D) It allowed for better observations of the elliptical nature of orbits, since we could observe them from a distance
    (E) All of the above

11. Your younger cousin Halley loves astronomy, so on her birthday, you decide to make her a cake in the shape of Halley's comet's orbit around the sun (a very eccentric elliptical orbit).

    You are a very fair person, so you even cut the pieces from where the sun would be (one focus) to the edge of the cake, such that each slice has the same amount of cake. Halley requests that she get the piece that has the longest curved edge, because she really likes the tasty crust. Which piece should you give her?

    (A) The piece where Halley's comet would be farthest from the sun (the aphelion).
    (B) The piece where Halley's comet would be going the slowest around the sun.
    (C) The piece where Halley's comet would be closest to the sun (the perihelion).
    (D) The piece where Halley's comet would be in between the aphelion and perihelion.
    (E) The cake is a lie!

12. The Moon has only about 1/100 the mass of the Earth.
    However, astronauts on the Moon don't experience gravity that is only 1 percent of Earth's; instead, gravity on the Moon's surface is about 15 percent as strong as on Earth's surface. Why is this?

    (A) Because the Moon is also smaller than the Earth
    (B) Because the Moon is in orbit around the Earth
    (C) Because the Moon is more dense than Earth
    (D) Because the centrifugal force from the Moon's rotation holds the astronauts down
    (E) Because the Earth's gravity provides the other 14 percent

13. Which is true about Copernicus' heliocentric model of the solar system, in which the planets including Earth orbit the Sun in circles?

    (A) It made accurate predictions of the motions of the planets, but was unable to provide a simple explanation for retrograde motion because it did not take into account the effects of gravity

    (B) It made accurate predictions of the motions of the planets, but did not accurately describe the motion of the stars because it did not take into account the large distances they are from Earth

    (C) Its predictions for the motions of the planets were not very accurate, because it used the wrong shape for the planets' orbits

    (D) Its predictions for the motions of the planets were not very accurate, because it did not take into account the effects of gravity

    (E) None of the above are true.

Free-Response Question 1

Suppose an astronaut weighs 100 pounds while on Earth's surface. *(This means that the force on them from Earth's gravity is 100 pounds; this will change as they travel to other worlds.)*

1. First, they travel to the planet Baryos. This world is very dense; it is the same size as Earth, but has twice the mass. What will our astronaut weigh on Baryos?

2. Then they travel to the giant world Cryos. It is larger than Earth and more massive, but less dense (since it is mostly made out of ice). Specifically, Cryos has 25 times the mass of Earth, and is five times larger than Earth. What will our astronaut weigh on Cryos?

3. Then they come back to Earth, but make a stop on the Moon to repeat the famous experiment and drop both a feather and a hammer at the same time.

   Explain briefly what will happen. Which object hits the ground first, and why? In your explanation, make sure you discuss how the force on both objects relates to the way they move.

This problem continues on the next page.

4. Finally, they return to Earth. However, before they come back to the surface, they fly above Earth's surface taking pictures of the beautiful Blue Planet to post on Instagram at an altitude of 6,000 km above Earth's surface. *(The radius of Earth is about 6,000 km.)*

   While flying 6,000 km above the Earth's surface, what is the force of Earth's gravity on them?

Free-Response Question 2

In late 1919, Robert Goddard, an American scientist, proposed using rockets to travel to the Moon as part of an article for the Smithsonian Institution. At this time, nobody had built large rockets.

The *New York Times* published a strongly critical editorial early in 1920. They asserted that rockets do not work in vacuum, and that Goddard's claim that they *would* work in vacuum was foolish. They wrote the following:

> [A]fter the rocket quits our air and and really starts on its longer journey, its flight would be neither accelerated nor maintained by the explosion of the charges it then might have left. To claim that it would be is to deny a fundamental law of dynamics, and only Dr. Einstein and his chosen dozen, so few and fit, are licensed to do that.
>
> That Professor Goddard, with his "chair" in Clark College and the countenancing of the Smithsonian Institution, does not know the relation of action to reaction, and of the need to have something better than a vacuum against which to react–to say that would be absurd. Of course he only seems to lack the knowledge ladled out daily in high schools.
>
> *(Clark College refers to Clark University, a small university where Goddard was chair of the physics department. The Smithsonian Institution is a large foundation that supports the sciences and arts in the USA.)*

Translated into modern simple English, this reads:

> After the rocket leaves the atmosphere, it would not be able to propel itself by burning its remaining fuel. Goddard's claim that rockets work in vacuum violates the laws of physics; only Albert Einstein and people as celebrated as he is are allowed to change the laws of physics, but Goddard is just a professor at a small university.
>
> It is absurd that the Smithsonian Institution is backing Goddard in these claims. Goddard seems to lack even a knowledge of basic high school physics, like Newton's third law of motion.

1. The *Times* is highly critical of Goddard's claim that rockets would function in vacuum. Is the *Times'* criticism of Goddard valid, or is it fallacious? Briefly describe why.

2. The *Times* also makes a claim about Einstein – that he and esteemed physicists like him are uniquely "licensed" to change the laws of physics. Is this claim valid or fallacious? Briefly describe why.

3. There is a competing set of claims here:

   - Robert Goddard claims that rockets function in vacuum
   - The *New York Times* writer claims that they do not

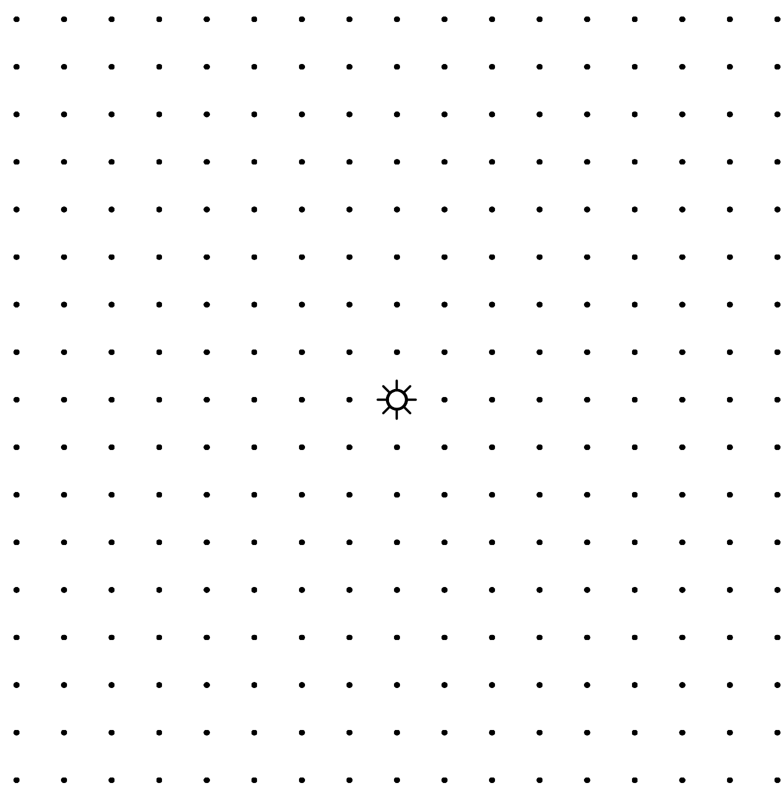
   How should the scientific process decide which claim about rockets is correct? *(Note that you do not need to know how rockets work to answer this question, nor is it important which claim is correct. The question is getting at how science should proceed when faced with competing claims.)*

Free-Response Question 3

A distant star is orbited by the planet Twilo and a comet.

Twilo has a moderately eccentric orbit. It is about 2 AU from the star at its closest point and 3 AU from the star when it is furthest away. Because of this, its seasons *are* determined by its changing distance from the star: it is summer when it is close to the star, and winter when it is further away.

1. Draw Twilo's orbit around its star below, and label the "midsummer" and "midwinter" points. (I have given you a grid here: the dots are 1 AU apart.)



2. On Earth, summer and winter are the same length. Is this true on Twilo? If not, tell how you know and which season is longer.

3. The comet comes very close to the star; at its closest point, it is only 1 AU away. However, the comet takes longer to orbit the star than Twilo does.

   Draw a possible orbit for the comet above.