Astronomy 101 Exam 2 Form A

Name: _____

Lab section number: _____

(In the format "M0**". See back page; if you get this wrong you may not get your exam back!)

- Exam time: one hour and twenty minutes
- Please put bags under your seats to allow proctors to move around the room.
- Please choose the **best** answer to each question.
- You may use only pencils and pens for this exam; no notes, **or cellphones** are allowed. You do not need a calculator; this exam requires no complicated calculations.
- 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

Day	Time	Section	Instructor
Monday	8:00-9:20 AM	M024	Scott Bassler
Monday	9:30-10:50 AM	M003	Scott Bassler
Monday	11:00 AM - 12:20 PM	M004	Lindsay DeMarchi
Monday	12:45-2:05 PM	M005	Lindsay DeMarchi
Monday	2:15-3:35 PM	M006	Jiaxin Sun
Monday	3:45-5:05 PM	M007	Jiaxin Sun
Monday	5:15-6:35 PM	M008	Manu Mannattil
Monday	6:45-8:05 PM	M009	Manu Mannattil
Monday	8:15-9:35 PM	M010	Manu Mannattil
Tuesday	3:30-4:50 PM	M027	Scott Bassler
Tuesday	5:00-6:20 PM	M028	Scott Bassler
Tuesday	6:30-7:50 PM	M029	Ohana Benevides Rodrigues
Tuesday	8:00-9:20 PM	M030	Ohana Benevides Rodrigues
Wednesday	8:00-9:20 AM	M025	Manu Mannattil
Wednesday	9:30-10:50 AM	M011	Manu Mannattil
Wednesday	11:00 AM - 12:20 PM	M012	Ohana Benevides Rodrigues
Wednesday	12:45-2:05 PM	M013	Ohana Benevides Rodrigues
Wednesday	2:15-3:35 PM	M014	Ohana Benevides Rodrigues
Wednesday	3:45-5:05 PM	M015	Nouman Butt
Wednesday	5:15-6:35 PM	M016	Nouman Butt
Wednesday	6:45-8:05 PM	M017	Jiaxin Sun
Wednesday	8:15-9:35 PM	M018	Jiaxin Sun
Thursday	5:00-6:20 PM	M019	Lindsay DeMarchi
Thursday	6:30-7:50 PM	M020	Lindsay DeMarchi
Thursday	8:00-9:20 PM	M031	Lindsay DeMarchi
Friday	8:00-9:20 AM	M026	Nouman Butt
Friday	9:30-10:50 AM	M021	Nouman Butt
Friday	11:00 AM - 12:20 PM	M022	Nouman Butt
Friday	12:45-2:05 PM	M023	Jiaxin Sun

Reference

Kepler's three laws of orbital motion state:

- Planets orbit in ellipses with the Sun at one focus
- The line connecting a planet to the Sun sweeps out equal areas in equal times
- The time T required for a planet to orbit the Sun is related to the orbit's semimajor axis A by $T^2 \propto A^3$.

These laws are equally valid for other gravitationally-bound orbits.

Newton's first two laws of motion state:

- An object with no net force acting on it travels in a straight line at a constant velocity.
- If a force acts on an object, this creates an acceleration on it, with that acceleration given by $F = ma$ or equivalently $a = F/m$.

Newton's law of universal gravitation states:

- The force of gravity between two objects is given by

$$F_g = \frac{Gm_1m_2}{r^2}$$

  where m_1 and m_2 are their masses and r is the distance between their centers.

1. Which of the following was *not* a significant advantage of the Copernican heliocentric model?

   (A) It explained the retrograde motion of the planets in a simple way

   (B) It explained the phases of Venus seen by Galileo

   (C) It correctly represented the essential structure of the Solar System and the movements of the objects in it

   (D) It provided more precise predictions of the motions of the planets than anything that had come before

   (E) The Copernican model did all of the above (i.e. all of them are advantages of it)

2. A chemist claims to have discovered a novel chemical form of carbon. She wrote down the steps in its synthesis very carefully, and has taken detailed data about its properties. However, no one else has been able to synthesize it using the same steps that she took.

   Other people might react skeptically to this as a scientific claim because it lacks...

   (A) Naturalness

   (B) Universality

   (C) Non-anthropocentrism

   (D) Reproducibility

3. The gravitational attraction between two objects with masses of a few kilograms held close to each other is:
   (If you don't remember the answer but would like to calculate things, G is around $10^{-12}\mathrm{N}\cdot\mathrm{m}^2/\mathrm{kg}^2$. However, you don't need this to do the problem, if you remember the history.)

   (A) Measurable, but only by very sensitive instruments built for this purpose

   (B) Measurable in space, but not here on Earth

   (C) Measurable using ordinary laboratory scales if you are very careful

   (D) Not measurable at all

4. Perihelion is the spot in an orbit closest to the Sun, and aphelion is the spot in an orbit furthest from the Sun.
Which is true about the *potential energy* of an asteroid in an eccentric orbit around the Sun?

   (A) It is largest at perihelion and smallest at aphelion

   (B) It is equal at aphelion and perihelion

   (C) It never changes, since energy is conserved

   (D) It decreases as the asteroid is moving away from the Sun, and increasesas the planet is moving toward the Sun

   (E) It is largest at aphelion and smallest at perihelion

5. 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 the weight of the rock? ("Weight" means "size of gravitational force.")

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

   (A) II and III

   (B) I only

   (C) I and III

   (D) I, II, and III

   (E) I and II

6. Galileo made many discoveries with the use of a telescope that he used to support a heliocentric model for the Solar System. Which observation was *not* one of these? *(Thanks to Caroline for the question!)*

   (A) Mountains on the Moon

   (B) A distant supernova

   (C) The phases of Venus

   (D) The moons of Jupiter

7. Which of the following is **not** true regarding Newton's laws of motion? (Or, if all of them are true, choose option E.)

   (A) They apply in space in the same way that they apply on Earth

   (B) They describe the response of objects to forces that act upon them

   (C) Kepler's laws of orbital motion are a consequence of Newton's laws of motion

   (D) When combined with mathematics, they can explain why the planets move in elliptical orbits

   (E) All of the above are true.

8. 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 in orbit around the Earth

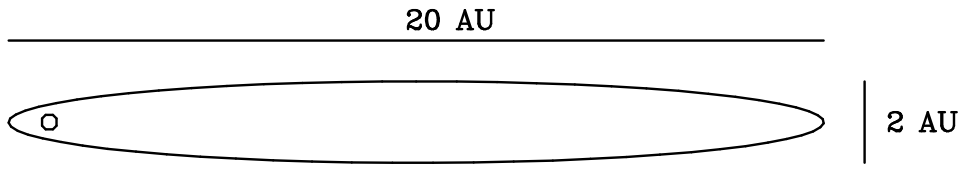
   (B) Because the centrifugal force from the Moon's rotation holds the astronauts down

   (C) Because the Moon is also smaller than the Earth

   (D) Because the Earth's gravity provides the other 14 percent

   (E) Because the Moon is more dense than Earth

9. Consider the following eccentric orbit of a comet:



   Earth's orbit has a diameter of 2 AU; Saturn's orbit has a diameter of 20 AU. Note that Earth takes one year to go around the Sun, and Saturn takes 30 years.
   Will this comet's orbital period be:

   (A) Significantly more than one year

   (B) Around 30 years, like Saturn

   (C) Around one year, like Earth

   (D) Around 15 years

   (E) Significantly less than one year

10. 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?

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

11. What was the significance of Galileo's discovery that Venus shows all phases from new to full? *(Thanks to Elizabeth for the question!)*

    (A) It proved that Venus has an atmosphere
    (B) In the geocentric model, only some phases are possible
    (C) It allowed him to find Venus' distance from the sun
    (D) It proved to other astronomers that his telescope was working correctly

12. If the Earth were moved so that it were 3 AU from the Sun, how would the gravitational force exerted on the Earth by the Sun change?

    (A) It would become 1/9 as large
    (B) It would become three times as large
    (C) It would become 1/3 as large
    (D) It would become nine times as large
    (E) It wouldn't change

13. Here is a table showing the orbital distances, orbital periods, and masses for the six planets known in Kepler's time.

Planet	Semimajor axis (AU)	Orbital period (years)	Mass (in units of Earth's mass)
Mercury	0.38	0.24	0.06
Venus	0.72	0.61	0.81
Earth	1.0	1.0	1.0
Mars	1.52	1.88	0.11
Jupiter	5.20	11.86	318
Saturn	9.54	29.46	95.2

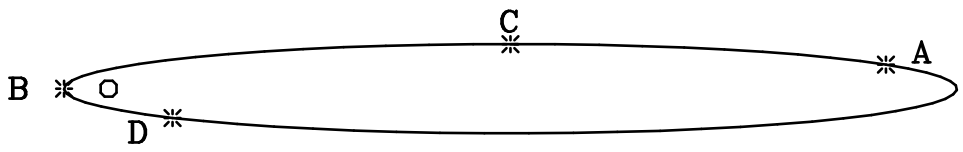
Suppose a new planet was discovered that completed one circular orbit around the Sun in six months. What would its distance from the Sun most closely be?

(A) 0.72 AU
(B) 0.5 AU
(C) 1.52 AU
(D) 2 AU
(E) 0.63 AU

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

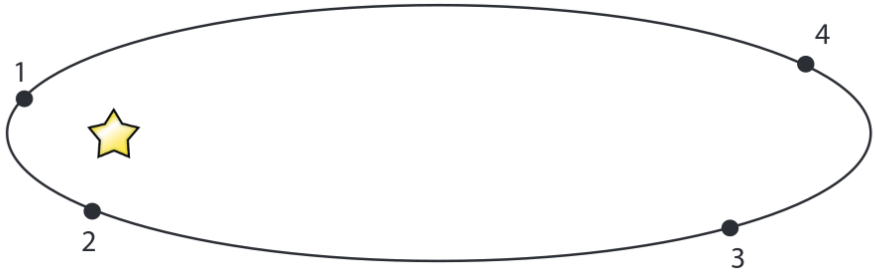
(A) Ganymede, one of the moons of Jupiter
(B) A spacecraft with a rocket engine that is turned on
(C) Halley's comet
(D) Earth's Moon
(E) Kepler's laws of orbital motion apply to all of these

15. Consider the highly eccentric orbit shown here. The comet in this orbit travels counterclockwise around the star.



At which labeled point is the comet speeding up? If it is speeding up at more than one of the labeled points, choose answer (E).

16. Which of the following is true about the orbit of the comet shown below? (Assume that the comet orbits counter-clockwise.)



(A) It is moving faster at position 1 than at position 4, because its total energyis conserved, and some of its gravitational potential energy has been convertedinto kinetic energy.

(B) As it moves from point 2 to point 3, it will be slowing down because the force of gravity pulls it backwards.

(C) It will take longer to travel from point 1 to point 2 than it will take to travelfrom point 3 to point 4.

(D) It is moving faster at position 1 than at position 4, because the law of conservation of momentum requires that it move more quickly when it is closer to the Sun.

(E) All of the above are true.

17. Perihelion is the spot in an orbit closest to the Sun, and aphelion is the spot in an orbit furthest from the Sun.
Which is true about the *kinetic energy* of an asteroid in an eccentric orbit around the Sun?

(A) It increases as the asteroid is moving away from the Sun, and decreases as the asteroid is moving toward the Sun

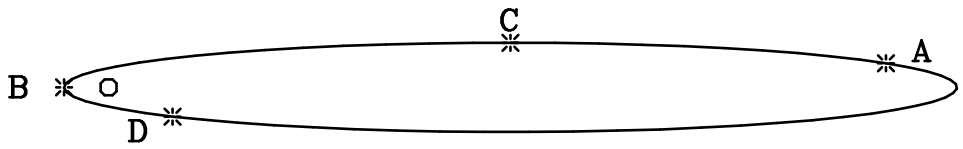
(B) It is equal at aphelion and perihelion

(C) It is largest at perihelion and zero at aphelion

(D) It is largest at aphelion and smallest at perihelion

(E) It decreases as the asteroid is moving away from the Sun, and increases as the planet is moving toward the Sun

18. Consider the highly eccentric orbit shown here. The comet in this orbit travels counterclockwise around the star.



At which labeled point is the comet moving *slowest*? If there is more than one point at which it is moving equally slowly, choose (E).

19. Which object do Newton's laws of 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) Newton's laws of motion apply to all of these

20. Perihelion is the spot in an orbit closest to the Sun, and aphelion is the spot in an orbit furthest from the Sun.
Which is true about the *total energy* of an asteroid in an eccentric orbit around the Sun?

(A) It is largest at aphelion and smallest at perihelion

(B) It is largest at perihelion and smallest at aphelion

(C) It never changes, since energy is conserved

(D) It is equal at aphelion and perihelion

(E) It decreases as the asteroid is moving away from the Sun, and increasesas the planet is moving toward the Sun

21. 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? *(Thanks to Haylee – I am not making this up! – for the question!)*

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

22. 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

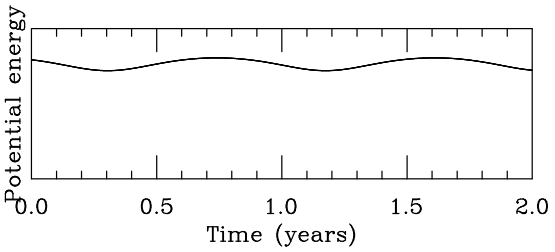
    (A) I and III
    (B) I, II, and III
    (C) I only
    (D) I and II
    (E) II and III

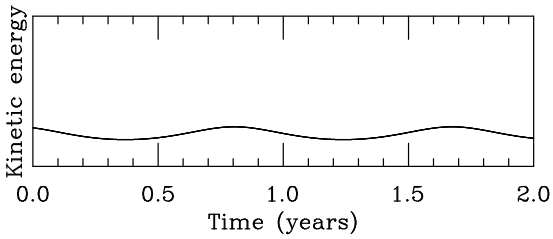
23. Suppose the planet Twilo has twice the diameter of Earth, and has four times the mass. If a person weighs 200 pounds on Earth, how much will they weigh on Twilo? *("Weight" describes the size of the force of gravity acting on something.)*

    (A) 50 pounds
    (B) 200 pounds
    (C) 100 pounds
    (D) 1600 pounds
    (E) 400 pounds

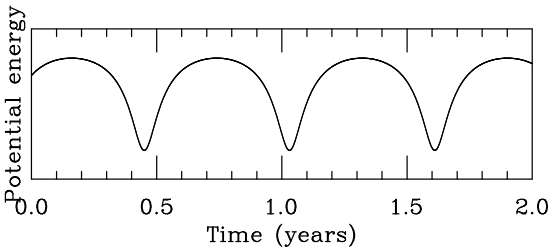
24. Here are some pairs of plots for kinetic and gravitational potential energy. Which one represents the fluctuation of KE and GPE for a planet in a slightly eccentric orbit, like Earth?

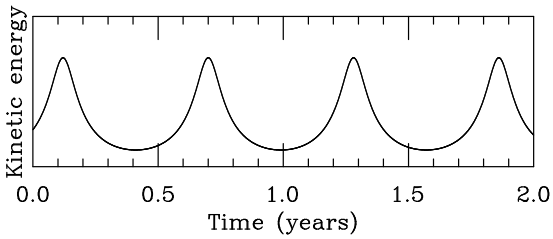
(A)



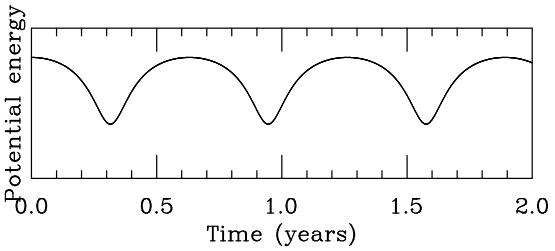


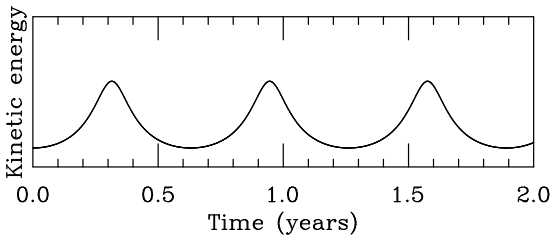
(B)



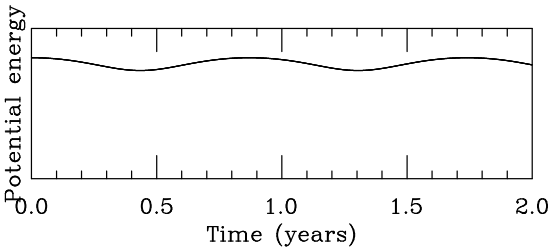


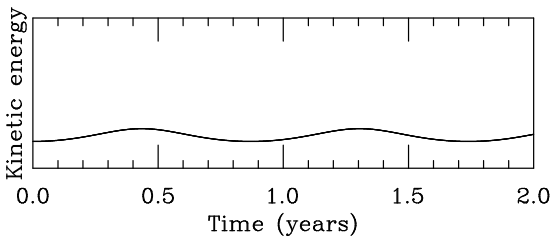
(C)





(D)





25. What was the most significant contribution of the ancient Greeks to astronomy?

(A) The innovation that the Sun, not the Earth, lay at the center of the Solar System

(B) The idea that the motions of the planets could be understood via a model, and this model's predictions could be found using geometry

(C) The development of algebra, and its use to solve the equations that appear in predicting the motions of the planets

(D) The realization that celestial objects travel in elliptical orbits, not circular ones

(E) The use of sophisticated equipment, like a telescope, to make measurements of the motions of the heavens

26. The Moon is about 400,000 km from the Earth, and orbits it once every month in a circular orbit. If we wanted to put it in a new orbit such that it orbited the Earth once every two months instead, what would that orbit look like?

(A) A circular orbit of radius around 200,000 km

(B) An elliptical orbit, in which the Moon's distance from the Earth varied between 400,000 km and 200,000 km

(C) A circular orbit of radius around 800,000 km

(D) A circular orbit of radius around 600,000 km

(E) A circular orbit of radius around 280,000 km

27. Which of the following is true about Copernicus' model of the solar system, proposed in the 1500's?

(A) It allowed astronomers to predict the motions of the planets with more precisionthan anyone could before

(B) It explained the retrograde motion of the planets in a simpler way than the Ptolemaic model did

(C) For the first time, it included the fact that the Earth is round

(D) It explained the retrograde motion of the planets, while its predecessor (the Ptolemaic model) was not able to

(E) None of the above are true

28. The LIGO Scientific Collaboration announced what discovery yesterday? *(This question is extra credit.)*

I. The detection of gravitational waves coming from two neutron stars colliding
II. The detection of gravitational waves coming from two black holes colliding
III. The observation of gamma rays, radio waves, and/or visible light coming from the same event as gravitational waves (an "optical counterpart")

(A) II only

(B) I and III

(C) I only

(D) I, II, and III

(E) II and III

29. If I drop a solid steel ball and a feather from one meter above the ground, the steel marble will fall faster than the feather. Why is this?

(A) Because the Earth's gravity exerts a larger force on the steel ball

(B) The steel ball and the feather will actually fall at the same rate

(C) Because air resistance hinders the motion of the feather more than the steel ball

(D) Because the radius of the steel ball is smaller than the radius of the feather, causing its gravity to be stronger

(E) More than one of the above is true.

30. Suppose that the mass of the Moon were doubled, without changing the shape of its orbit. Which of the following would happen?

- I. The force that the Moon exerts on the Earth would double
- II. The force that the Earth exerts on the Moon would double
- III. The time that it would take to orbit the Earth would double

(A) Only I

(B) Only II

(C) I and II

(D) I, II, and III

(E) I and III

31. What was the Nobel Prize in Physics awarded for this year?

(A) The discovery of the Higgs boson

(B) The discovery of gravitational waves

(C) The discovery of the structure of graphene

(D) The discovery of the structure of neutron stars

(E) The acoustics of why Bob Dylan can't sing in tune

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

(A) It provided a confirmation of Kepler's second law, since we could see them speed up and slow down

(B) It showed for the first time that not everything orbited the Earth

(C) It allowed for confirmation of Kepler's third law, by comparing their orbital periods

(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

33. A spacecraft is launched from Earth toward the Moon.

Note that the Earth's mass is about 81 times greater than the Moon's mass.

Somewhere between the Earth and the Moon, there is a point where the gravitational forces of the Earth and the Moon on the spacecraft cancel out, since they pull in opposite directions and equal strength. Where is that point?

(A) 9 times closer to the Moon than to the Earth

(B) 81 times closer to the Moon than to the Earth

(C) 9 times closer to the Earth than to the Moon

(D) 81 times closer to the Earth than to the Moon

(E) Equally distant from the Earth and the Moon

Scratch Paper

Scratch Paper

Scratch Paper

Scratch Paper