Astronomy 101 Exam 2 Form Bkey

Name: ______________________________

- This exam form is for you to keep. Circle your answers on it for your records; all you will turn in this time is the Scantron.
- If you fill out your Scantron in pen and make a mistake, ask us for a new form. It is better if you use pencil so you can erase.
- Exam time: one hour and twenty minutes
- Please put bags under your seats to allow proctors to move around the room.
- You may use only pencils and pens for this exam; **no cellphones, calculators, or smart-watches** are allowed.
- If you have a question, raise your hand, and a proctor will assist you.
- You may use a single-sided 8.5x11 inch page of notes you wrote yourself
- Do not attempt to communicate with anyone other than teaching staff during the exam

Good luck!

Reference

Kepler's three laws of orbital motion, as he described them, 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 $T^2 \propto A^3$. *(The symbol $\propto$ means "proportional to".)*

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

Newton's three 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 $a = F/m$.
- If object A exerts a force on object B, object B exerts an equal force in the opposite direction on object A

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.

`(Question formid)`

1. What form is your exam?
   (A) Form A
   (B) Form B
   (C) Form C
   (D) Form D
   (E) Form E

`(Question earth-change-1)`

2. Suppose that Tycho's pet moose Bullwinkle weighs 1,000 pounds when he is standing on the surface of the Earth. In the next few questions, we'll change a few things as our adventurous moose explores different planets.

   First, let's take him to a new planet Plumbia, which is very dense. It has the same mass as Earth, but since it is so dense it is much smaller; it has only one-quarter the radius. How much would Bullwinkle weigh on the surface of this planet? *(Remember, "weight" means "the force of gravity".)*
   (A) 1,000 pounds (the same amount)
   (B) 4,000 pounds (4 times as much)
   (C) **16,000 pounds (16 times as much)**
   (D) 62.5 pounds (1/16 as much)
   (E) 250 pounds (1/4 as much)

`(Question earth-change-2)`

3. Now Bullwinkle goes to the planet Alce, which has has twice the mass of Earth and has twice the diameter. How much would Bullwinkle weigh on the surface of Alce?
   (A) 1000 pounds (the same as on Earth)
   (B) 4,000 pounds (four times as much as on Earth)
   (C) 2,000 pounds (twice as much as on Earth)
   (D) 250 pounds (one-quarter as much as on Earth)
   (E) **500 pounds (half as much as on Earth)**

`(Question earth-change-3)`

4. Bullwinkle now flies home to Earth. Before he lands, though, he wants to search the Earth's surface for his friend Rocky. He flies around the Earth in his spacecraft at an altitude of 6,000 km above Earth's surface. *(The radius of Earth is about 6,000 km.)*

   How much does Bullwinkle weigh when he is in his spacecraft, 6,000 km above the Earth's surface?

   (A) **250 pounds, one-quarter what he weighs on the surface**
   (B) 500 pounds, half of what he weighs on the surface
   (C) 4,000 pounds, four times his weight on the surface
   (D) 1,000 pounds, the same as his weight on the surface
   (E) 2,000 pounds, twice his weight on the surface

`(Question third-law)`

5. Here are some data concerning the inner planets that you will use for the next few questions.

	Mercury	Venus	Earth	Mars
Aphelion (AU)	0.47	0.73	1.02	1.67
Perihelion (AU)	0.31	0.72	0.98	1.38
Orbit long axis (AU)	0.78	1.45	2.00	3.05
Eccentricity	0.21	0.007	0.017	0.09
Mass (Earths)	0.06	0.82	1	0.11

   Which one of these planets will take the longest amount of time to go around the Sun?

   (A) Mercury
   (B) Earth
   (C) Venus
   (D) **Mars**
   (E) In order to determine this, you'd need another piece of information that's not in the table

`(Question planet-difference-2)`

6. Which of the inner planets experiences the *greatest percent change* in its kinetic energy as it travels around the Sun? *(Reference the table in the previous problem.)*

   (A) Venus

   (B) **Mercury**

   (C) Earth

   (D) Mars

   (E) In order to determine this, you'd need another piece of information that's not in the table

`(Question surface-gravity)`

7. If an astronaut stands on the surface of each of the inner planets, which of them would apply the greatest gravitational force to them? *(You will need to consult the table from two problems ago.)*

   (A) Venus

   (B) Earth

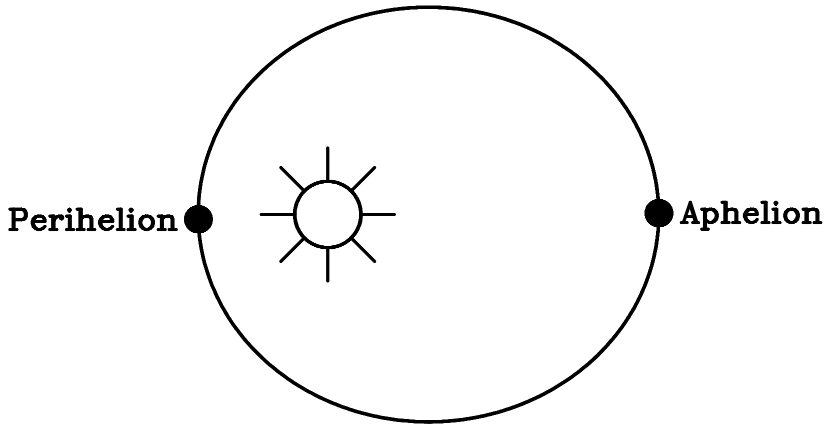
   (C) Mars

   (D) Mercury

   (E) **In order to determine this, you'd need another piece of information that's not in the table**

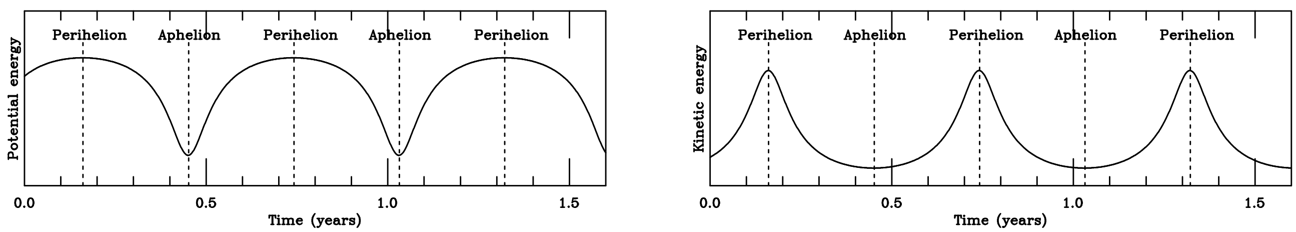
(Question energy-1)

8. Here is an orbit with the perihelion and aphelion points labeled.

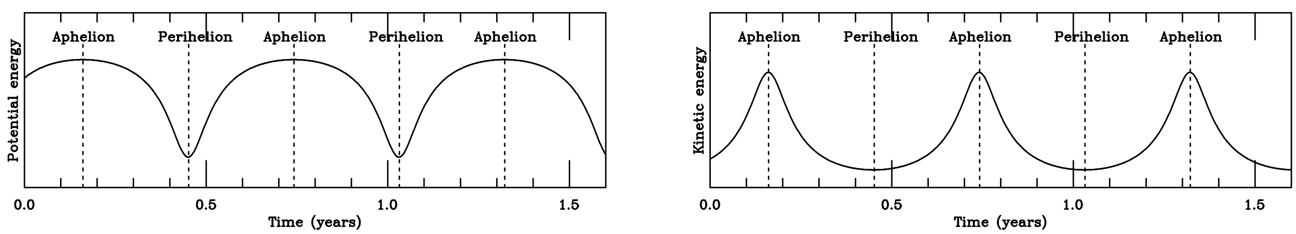


Which of the following pairs of plots correctly shows how the gravitational potential and kinetic energy of this planet vary during the course of its orbit?

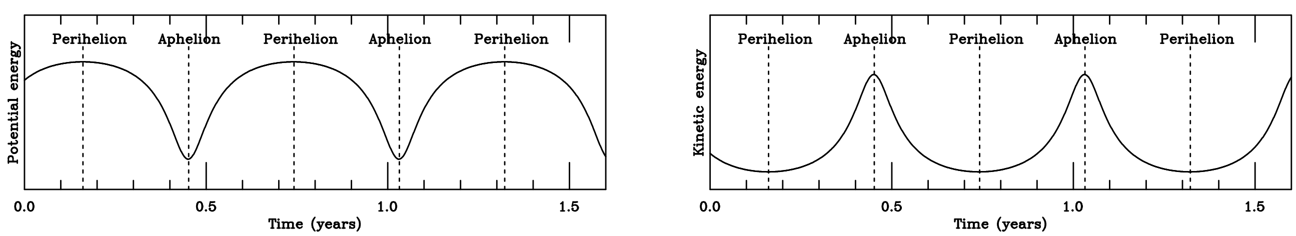
(A)



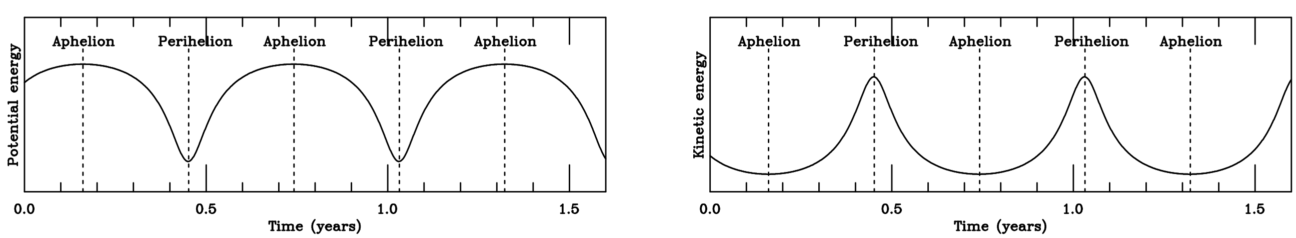
(B)



(C)



(D)



(E) None of the above are correct.

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(Question regions)
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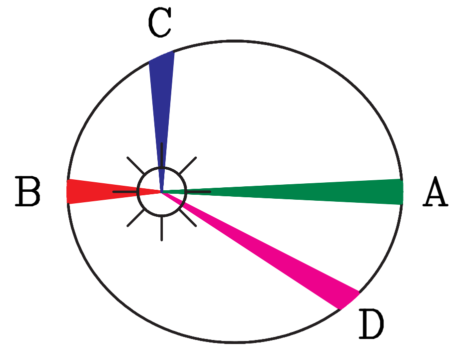
9.

Here is a diagram of the orbit of an asteroid with four highlighted regions.

Note that these four regions *do not have* the same area. Instead, the distance along the outside of the orbit is the same.



Which region will take the asteroid the *least time* to travel through?

(A) Region A

(B) **Region B**

(C) Region C

(D) Region D

(E) Each of these regions will take the same amount of time to pass through.

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(Question two-rocks-moon)
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10. What is true about the gravitational forces that act on the Earth and Mars? *(Modified from a question from A. Yoon; thanks!)*

(Note that the mass of Mars is about 1/9 the mass of the Earth.)

(A) **The Earth's gravitational force on Mars is equal to Mars's gravitational force on the Earth**

(B) Planets don't exert gravitational forces on each other; only the Sun does that

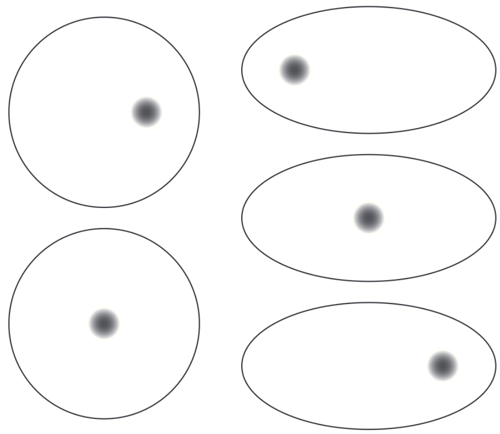
(C) The Earth's gravitational force on Mars is **less than** Mars's gravitational force on the Earth

(D) The Earth's gravitational force on Mars is **more than** Mars's gravitational force on the Earth

(E) When Mars is in retrograde its gravitational force on the Earth is much larger than when it is in prograde

(Question orbits-legal)

11. How many of the following orbits obey Kepler's first law of planetary motion? The grey dot is the Sun.



(A) **Three**
(B) All five
(C) Two
(D) Four
(E) One

(Question conservation)

12. Quanta the dog jumps up on the table trying to grab a sausage, but knocks it off the edge instead; the sausage falls to the ground. *(Modified from a question by Colin B.; Ohana insists that her dogs appear on the exam somewhere!)*

At what point in its motion will the sausage have the greatest *total* energy? (Ignore air resistance for this problem.)

(A) It will have the most energy right before it hits the ground
(B) **It will be the same everywhere**
(C) The change in its energy depends on the height of the table
(D) It will have the most energy right after Quanta bumps it

`(Question conservation-of-energy-derivation)`

13. Which principle of orbital mechanics can be very easily deduced from the conservation of energy as applied to planetary orbits?

    (A) All objects near the Moon's surface accelerate at the same rate in response to its gravity, as we saw demonstrated in class (in a vacuum rather than on the Moon)

    (B) Planets that are further away from the Sun will take longer to orbit it, as described by Kepler's third law

    (C) Planets move in elliptical orbits with the Sun at one focus, so long as the planet is much lighter than the Sun, as described by Kepler's first law

    (D) **A planet in an eccentric orbit moves faster when it is closer to the Sun and slower when it is further away, as described by Kepler's second law**

    (E) None of the above can be deduced from the conservation of energy

`(Question apple-drop-moon)`

14. Suppose a person on Earth and a person on the Moon both drop identical apples from a height of one meter. Which of the following is true?

    (You may not need this information, but the mass of the Earth is 96 times the mass of the Moon, and the radius of the Earth is 4 times the radius of the Moon.)

    (A) **The apple dropped on the Moon will take longer to hit the ground, and the force of gravity on it will be less**

    (B) The apples will take the same amount of time to fall, and they will experience the same gravitational force.

    (C) The apple dropped on the Moon will take the same amount of time to hit the ground, but the force of gravity on it is less

    (D) The apple dropped on the Moon will take longer to hit the ground, but the force of gravity on it will be the same

`(Question escape)`

15. 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 escape from the Sun's gravity and fly away forever**

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

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

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

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

`(Question ptolemaic-epicycles)`

16. How did the Ptolemaic geocentric model explain retrograde motions of the planets as seen from Earth? *(Thanks to Reed W. for the question!)*

    (A) By having the celestial spheres of the planets stop their motion and rotate backwards periodically

    (B) By the relative motion of both the other planet and the Earth as they both move along their orbits

    (C) The influence of their moons' gravity pulls them forwards and backwards

    (D) **Through epicycles, which are smaller circular motions overlaid on the large orbit of the planet around the Earth**

    (E) By using elliptical orbits for the planets

`(Question universalism)`

17. The ancient Greek philosopher Aristotle argued that motion on Earth followed one set of rules, and motion in space followed a different set of rules.

    As part of the scientific revolution, it was discovered that motion in space actually follows the same set of laws as motion on Earth. Which property of scientific thought is this an example of?

    (A) **Universality**

    (B) Self-skepticism

    (C) Objectivity

    (D) Empiricism

(Question neutrinos)

18. The aspiring mad scientist Dr. Horrible builds his newest superweapon: a particle accelerator that projects an intense beam of neutrinos at its target.

    Dr. Horrible fires this superweapon at his nemesis, Captain Hammer. What will happen to him?

    (A) Nothing will happen immediately, but the radiation will likely give him cancer years later

    (B) Captain Hammer will be blown backwards by the force

    (C) Both Captain Hammer *and* Dr. Horrible will be blown backwards by the force, by Newton's third law

    (D) Captain Hammer will absorb the kinetic energy of the neutrinos and will be cooked from the inside out

    (E) **None of the above will happen**

(Question ptolemaic-model)

19. Which of the following is true about the ancient Ptolemaic geocentric model?

    (A) **It explained retrograde motion of the planets with "epicycles", in which the planets traveled in looping motions as they moved around their orbits.**

    (B) If the phases of Venus were known to the ancient Greeks and Egyptians, it could have accurately predicted them.

    (C) Its predictions of the motions of the planets in the night sky were not very accurate.

    (D) It described the motions of the planets in elliptical orbits.

    (E) All of the above are true.

`(Question copernican-advance)`

20. In what way did the heliocentric model of Copernicus represent an advance over the ancient geocentric Ptolemaic model?

    (A) It explained why stellar parallax can't be observed with the eye alone

    (B) It provided more accurate predictions of the motions of the planets in the night sky than the Ptolemaic model

    (C) It described the motion of the planets as ellipses, rather than as circles, and thus its predictions matched Kepler's laws

    (D) **It explained retrograde motion without needing the complicated mechanism of "epicycles"**

    (E) It aligned more closely with the dominant religious and political forces in its time and place (early Renaissance Europe)

`(Question tycho-empiricism)`

21. Tycho Brahe, along with his assistants, made detailed measurements of the motions of the planets. These data guided his assistant Kepler to the correct conclusion about their motions.

    What feature of the process of science does this demonstrate?

    (A) Objectivity (the notion that our study of the laws of nature shouldn't be biased by our personal perspective or identity)

    (B) Self-skepticism (the notion that scientists should be their own strongest critics and look for flaws in their own work)

    (C) **Empiricism (the notion that the highest authority is what we observe)**

    (D) Universality (the notion that the laws of nature are the same everywhere and at all times)

(Question kepler-laws)

22. Johannes Kepler looked at the data collected at Tycho's observatory on the motions of the planets and found that it always disagreed slightly with Copernicus' heliocentric model. He concluded that a particular feature of Copernicus' model must be changed to make it match his data.

    How did Kepler change Copernicus' model to make it fit the data?

    (A) **The planets orbit in elliptical paths, not circular ones**
    (B) The planets move more quickly when they are far from the Sun, in order to explain retrograde motion
    (C) He accounted for the gravitational force that the planets exert on each other, not just the gravity from the Sun
    (D) The Sun, not the Earth, is at the center of the Solar System

(Question cake)

23. 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 a student named Haylee in 2017 – I am not making this up! – for the question!)*

    (A) **The piece where Halley's comet would be closest to the sun (the perihelion).**
    (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 farthest from the sun (the aphelion).
    (E) The cake is a lie!

`(Question mooncycle)`

24. If the Moon were twice as far away on average from the Earth as it is now, but still moving in an orbit with the same eccentricity, how would the length of the cycle of moon phases change? *(Thanks to Robert R. for the question!)*

    (A) It would be about twice as long as it is now

    (B) Its length would be about half as long as it is now

    (C) **It would be more than twice as long as it is now**

    (D) Its length would not change

    (E) The Moon could no longer orbit the Earth at this distance

`(Question baseline)`

25. 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? *(Thanks to Xinning for the question!)*

    (A) **About 2 AU**

    (B) As far as we can run/walk/drive before the stars set each night

    (C) About 1 AU

    (D) About 12,000 km (the diameter of Earth)

    (E) About 30 AU

`(Question galileo-observations)`

26. Galileo observed four moons orbiting Jupiter using a telescope. What was the significance of these observations?

    (A) **It demonstrated that not everything orbited the Earth**

    (B) The shapes of their orbits provided Kepler the data needed to determine that orbits were ellipses, not circles

    (C) It allowed him to deduce the fundamental law of mechanics, $F = ma$

    (D) It allowed him to determine the parameters of the epicycles in the Ptolemaic model of the solar system

    (E) None of the above are true

`(Question newton-kepler)`

27. Which one of the following is true about the relationship between Kepler's laws of planetary motion and Newton's discoveries about mechanics? *(Thanks to Emma M. for the question!)*

    (A) Kepler relied on Newton's laws of mechanics to deduce the correct shape of the planets' orbits from his measurements

    (B) Kepler's laws of orbital motion apply to objects like comets that do not follow $F = ma$ exactly

    (C) **Kepler's laws describe how the planets move, but Newton's mechanics explain** ***why*** **they move in this way**

    (D) Both Kepler's laws of planetary motion and Newton's law of gravity only apply to motion in space

    (E) None of the above are true

`(Question tycho-parallax-fooled)`

28. After making his observations in Uraniborg, Tycho Brahe did not observe any parallax in the stars.

    He concluded from this that the Earth does not move, since if it did, the baseline would have been able to observe parallax.

    What flaw in Tycho's scientific process caused him to settle on this false conclusion?

    (A) He should have made observations from many other places on Earth, not just his castle at Uraniborg

    (B) **He should have been skeptical of his first idea and been open to the idea that he might have been wrong, by considering other reasons that he did not observe parallax in the stars**

    (C) He should have allowed himself to be guided by empirical data rather than only using logic

    (D) He had a mathematical error, since he considered only circular orbits for the Earth

    (E) He should have realized that the principles of geometry that dictate stellar parallax work differently in deep space than they do on Earth, since the geometry used is only valid when the distances involved are less than about 100 AU

`(Question exoplanets)`

29. In 1995, astronomers pointed their telescopes at the star 51 Pegasi and saw that it was wobbling back and forth a little bit – moving away from us, then toward us, then away from us, changing direction every few days. This star is very much like the Sun.

    (They won the Nobel Prize this year for their discovery.)

    What did they conclude from this?

    (A) 51 Pegasi is reaching the end of its life, and is about to explode
    (B) 51 Pegasi has a large planet that is about 1 AU away from it
    (C) 51 Pegasi has a black hole orbiting it, and that black hole's gravity is causing it to wobble
    (D) 51 Pegasi is very close to us, and it is showing a large amount of parallax as our observing position changes
    (E) **51 Pegasi has a large planet that is very close to it, much closer than 1 AU**

Scratch Paper

Scratch Paper

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