Worksheet: Newton's Law of Universal Gravitation

Q1: Find the mass of the Sun. Use a value of 152×10^6 km for the average distance between the centers of Earth and the Sun.

Question Video

A 256×10^{18} kg

B 1.37×10^{13} kg

C 2.09×10^{30} kg

D 2.33×10^{23} kg

E 12.3×10^{31} kg

Q2: Evaluate the magnitude of gravitational force between two 5.0 kg mass spherical steel balls separated by a center-to-center distance of 15 cm.

Question Video

A 7.4×10^{-8} N

B 8.5×10^{-8} N

C 8.0×10^{-8} N

D 7.0×10^{-8} N

E 8.9×10^{-8} N

Q3: Astrology makes much of the position of the planets at the moment of one's birth. The only known force a planet exerts on Earth is gravitational.

Calculate the gravitational force exerted on a baby of mass 4.20 kg by a doctor with a mass of 100 kg if they are separated by a distance of 0.200 m.

A 5.90×10^{-7} N

B 1.04×10^{-6} N

C 2.52×10^{-7} N

D 1.53×10^{-6} N

E 7.01×10^{-7} N

Calculate the gravitational force exerted on a baby of mass 4.20 kg by the planet Jupiter. Use a value of 1.898×10^{27} kg for the mass of Jupiter and use a value of 6.29×10^{11} m for the separation between the planet and the baby.

A 5.90×10^{-7} N

B 1.04×10^{-6} N

C 2.52×10^{-7} N

D 1.53×10^{-6} N

E 1.35×10^{-6} N

Q4: Find the orbital velocity of Earth's solar system about the center of the Milky Way. Use a value of 26 550 ly for the distance between the center of mass of Earth's solar system and that of the Milky Way, 99×10^9 solar masses for the mass of the Milky Way, and 1.99×10^{30} kg for the mass of the Sun.

A 23×10^4 m/s

B 93×10^3 m/s

C 13×10^4 m/s

D 32×10^4 m/s

E 78×10^4 m/s

Q5: A spaceship is at a point somewhere between the Earth and the Sun where the net gravitational force exerted on the spaceship by the Earth and by the Sun is zero. How far from the center of the Sun is the spaceship if the mass of the Sun is 333 000 times the mass of the Earth. The mean distance from the Sun to the Earth is 1.496×10^8 km.

A 1.48×10^8 km

B 2.77×10^8 km

C 2.34×10^8 km

D 1.20×10^8 km

E 1.88×10^8 km

Q6: The mass of the Milky Way can be estimated from astronomical observations as being equal to 8.0×10^{11} solar masses. This value can be used to calculate the orbital period of a star that has a circular orbit of radius 8.0×10^4 light-years around the Milky Way's center of mass. Use a value of 1.99×10^{30} kg as the mass of the Sun.

- Find the orbital period of the star.

A 6.2×10^{12} years

B 1.1×10^{16} years

C 9.2×10^{13} years

D 3.2×10^{19} years

E 4.0×10^{8} years

- What would the mass of a galaxy be if a star's orbital period at the same orbital radius was 7.0×10^{7} years?

A 11×10^{22} kg

B 5.2×10^{28} kg

C 7.2×10^{36} kg

D 0.31×10^{50} kg

E 5.3×10^{43} kg

Q7: The center of mass of a mountain is at a distance of 15.0 km from a person. The mountain exerts on the person a gravitational force that is equal to 0.11% of his weight.

What is the mass of the mountain?

A 16×10^{15} kg

B 3.6×10^{16} kg

C 11×10^{14} kg

D 3.9×10^{16} kg

E 86×10^{15} kg

What is the ratio of the mountain's mass to the mass of Earth?

A 5.9×10^{-9}

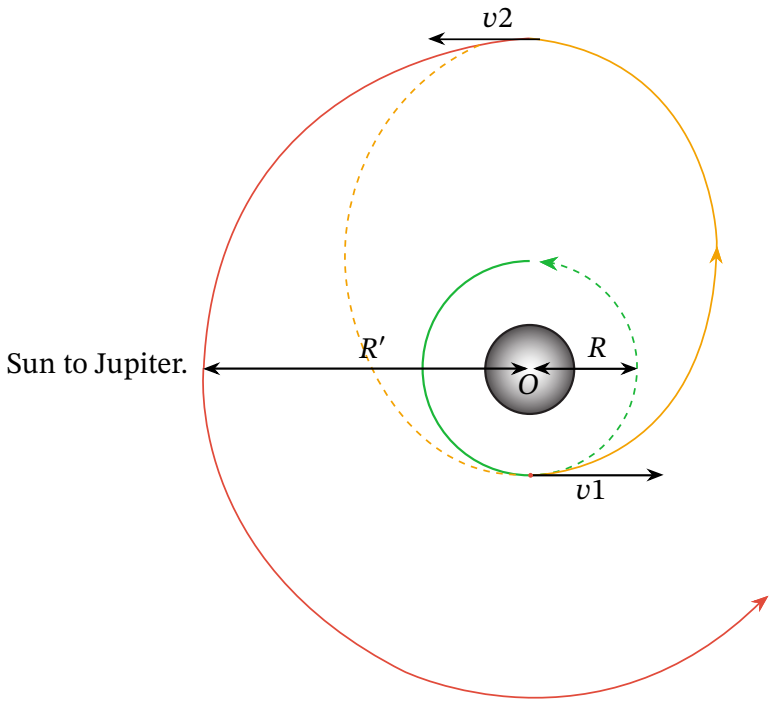
B 6.1×10^{-9}

C 6.6×10^{-9}

D 12×10^{-9}

E 3.6×10^{-9}

Q8: A Hohmann transfer orbit takes a spaceship from Earth's orbit to Jupiter's, as shown in the diagram. Find the magnitude of the change in velocity $\Delta v = |v2| - |v1|$ of the spacecraft between the perihelion and the aphelion of the transfer ellipse. Use a value of 1.500×10^8 km for R, the distance from Sun to Earth, and use a value of 7.780×10^8 km for R', the distance from Sun to Jupiter.



A 85.6×10^6 m/s

B 33.3×10^7 m/s

C 4.10×10^5 m/s

D 3.69×10^4 m/s

E 23.1×10^6 m/s

Q9: Find the mass of Jupiter by considering the orbit of Io, its innermost moon. Use a value of $4\,217.00 \times 10^6$ m for Io's average orbital radius and use a value of $15\,292 \times 10^2$ s for Io's orbital period. Use a value of 6.674×10^{-11} $m^3/kg \cdot s^2$ for the universal gravitational constant.

A 1.897×10^{27} kg

B 6.039×10^{26} kg

C 3.019×10^{26} kg

D 2.900×10^{32} kg

E 9.485×10^{26} kg

Q10: An asteroid has a mass of 4.7×10^{13} kg. The asteroid passes near Earth, and at its closest approach, the separation of the centers of mass of the asteroid and Earth is four times the average orbital radius of the Moon. What force does the asteroid exert on Earth when at its minimum distance from Earth? Use a value of 384 400 km for the average orbital radius of the Moon.

A 7.9×10^{15} N

B 1.2×10^9 N

C 3.6×10^9 N

D 1.2×10^{22} N

E 7.9×10^9 N

Q11: Two sumo wrestlers with masses of 190 kg and 210 kg respectively are grappling each other, at rest while they do so. The distance between their centers of mass is 1.40 m. What is the magnitude of the gravitational force between the wrestlers?

A 2.2×10^{-6} N

B 1.9×10^{-6} N

C 5.1×10^{-6} N

D 1.3×10^{-6} N

E 1.4×10^{-6} N

Q12: The Moon and Earth both rotate about their common center of mass, which is actually a point within the Earth's interior. Find the acceleration produced by the gravitational force of the Moon at the Earth-and-Moon system's center of mass. Use a value of 3.84×10^{8} m for the radius of the circular orbit of the Moon around Earth and use a value of 4 651 km as the distance from the center of mass of Earth to the center of mass of the Earth-and-Moon system.

A 3.36×10^{-4} m/s^2

B 986×10^{-3} m/s^2

C 3.41×10^{-5} m/s^2

D 12.5×10^{-4} m/s^2

E 0.458×10^{-6} m/s^2

Q13: The Milky Way galaxy is accelerating toward the Andromeda galaxy. These galaxies can both be modeled as having a mass of 800 billion solar masses, using a value of 2.0×10^{30} kg for a solar mass, and having a diameter of 1.0×10^{5} light-years. The center-to-center separation of the galaxies is 2.5×10^{6} light-years. What is the magnitude of the acceleration of the Milky Way toward the Andromeda galaxy?

A 2.1×10^{-13} m/s^2

B 9.9×10^{-12} m/s^2

C 1.9×10^{-13} m/s^2

D 2.8×10^{-13} m/s^2

E 1.4×10^{-13} m/s^2

Q14: By using Newton's law of universal gravitation, the mass of Earth can be determined from the values of acceleration due to gravity at Earth's surface and the radius of Earth. The mass of the Moon can be determined from the mass of Earth and the Moon's radius if the Moon is assumed to have the same average density as Earth, and, from this, the acceleration due to gravity on the Moon's surface can be determined. In modeling Earth and the Moon, use a value of 6.37×10^6 m for the radius of Earth and a value of 1,700 km for the radius of the Moon. Use a value of 9.80 m/s^2 for g.

Determine the mass of Earth.

A 5.33×10^{24} kg

B 6.43×10^{24} kg

C 8.32×10^{24} kg

D 5.95×10^{24} kg

E 7.72×10^{24} kg

Determine the acceleration due to gravity on the Moon's surface if the Moon's average density is the same as that of Earth.

A $2.09\ \text{m/s}^2$

B $1.02\ \text{m/s}^2$

C $1.46\ \text{m/s}^2$

D $2.61\ \text{m/s}^2$

E $1.62\ \text{m/s}^2$

Q15: Earth is 1.50×10^{11} m from the Sun. Venus is 1.08×10^{11} m from the Sun. What is the ratio of the acceleration due to gravity caused by the Sun on Venus to that on Earth?

A 2.69

B 2.74

C 1.93

D 1.31

E 2.28

Q16: A recently discovered planet has a masstwice as great as Earth's and a radius twice as large as Earth's. What will bethe size of the gravitational field at its surface?

A 19 m/s^2

B 2.5 m/s^2

C 4.9 m/s^2

D 9.8 m/s^2

Q17: Saturn's moon Rhea has a radius of 7.65×10^5 m and a measured gravitational field of $0.264\ \text{m/s}^2$. What is its mass in kilograms? The universal gravitational constant has a value of $6.67 \times 10^{-11}\ \text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$.

A 2.64×10^{21} kg

B 3.35×10^{21} kg

C 1.72×10^{21} kg

D 2.32×10^{21} kg

E 1.23×10^{21} kg

Q18: In the formula $g = \dfrac{GM}{r^2}$, what does G represent?

A The factor by which you multiply the inertial mass to obtain the gravitational mass.

B A gravitational constant that is the same everywhere in the universe.

C The acceleration due to gravity.

D A gravitational constant that is inversely proportional to the radius.

Q19: Jupiter has a mass approximately 300 times greater than Earth's and a radius about 11 times greater. How will the gravitational acceleration at the surface of Jupiter compare to that at the surface of Earth?

A less

B greater

C not enough information

D about the same

Q20: Jupiter's moon Io orbits Jupiter at an average radius of 4.22×10^5 km, with a period of 1.77 days. Earth's moon orbits Earth at an average radius of 3.84×10^5 km, with a period of 27.3 days. Use this information to calculate the ratio of Jupiter's mass to Earth's mass.

A 52.4

B 24 700

C 1 090

D 316

E 8.91

Q21: The existence of the dwarf planet Pluto was proposed based on irregularities in Neptune's orbit. Pluto was subsequently discovered near its predicted position. But it now appears that the discovery was fortuitous because Pluto is small and actually only has a minor effect on the orbit of Neptune. The universal gravitational constant has a value of $6.67 \times 10^{-11}\ \mathrm{m^3 \cdot kg^{-1} \cdot s^{-2}}$.

Calculate the acceleration due to gravity at Neptune due to Pluto when they are 4.50×10^{12} m apart, as they are at present. The mass of Pluto is 1.40×10^{22} kg.

A 4.61×10^{-14} m/s^2

B 5.71×10^{-14} m/s^2

C 1.64×10^{-13} m/s^2

D 2.25×10^{-15} m/s^2

E 3.42×10^{-14} m/s^2

Calculate the acceleration due to gravity at Neptune due to Uranus, presently about 2.50×10^{12} m apart. The mass of Uranus is 8.62×10^{25} kg.

A 9.20×10^{-10} m/s^2

B 7.90×10^{-10} m/s^2

C 1.60×10^{-9} m/s^2

D 6.90×10^{-10} m/s^2

E 2.10×10^{-10} m/s^2

Q22: Earth has a mass of 5.97×10^{24} kg and the distance between Earth and the Moon is 3.85×10^5 km. Assume that the Moon follows a circular orbit. The universal gravitational constant has a value of 6.67×10^{-11} m$^3 \cdot$kg$^{-1} \cdot$s^{-2}.

Find the acceleration of the Moon due to Earth's gravity.

A 2.68×10^{-3} m/s^2

B 2.77×10^{-3} m/s^2

C 8.41×10^{-4} m/s^2

D 4.07×10^{-3} m/s^2

E 2.12×10^{-3} m/s^2

The Moon takes 27.3 days to orbit Earth. Calculate the centripetal acceleration needed to keep the Moon in its orbit.

A 2.73×10^{-3} m/s^2

B 8.39×10^{-4} m/s^2

C 3.32×10^{-3} m/s^2

D 4.15×10^{-3} m/s^2

E 4.69×10^{-3} m/s^2

Q23: What is the speed of a satellite in an orbit 8.10×10^2 km above Earth's surface? Use a value of 6 371 km for the radius of Earth and 5.97×10^{24} kg for its mass.

A 7.40×10^4 m/s

B 7.91×10^3 m/s

C 560×10^3 m/s

D 9.20×10^3 m/s

Q24: The Andromeda Galaxy is the closest major galaxy to the Milky Way. It has a mass of 1.0×10^{13} solar masses and is at a distance of 0.622 Mpc away from Earth. A gravitational force F from the Andromeda Galaxy acts on an earthbound observer with a mass of 75 kg.

- Find the magnitude of the gravitational force F. Use a value of 1.9898×10^{30} kg for the mass of the Sun.

A 6.2×10^{-10} N

B 4.6×10^{-10} N

C 3.0×10^{-10} N

D 7.5×10^{-10} N

E 2.7×10^{-10} N

Find the ratio of the magnitude of the gravitational force F to the observer's weight.

A 2.8×10^{-13}

B 1.0×10^{-13}

C 2.0×10^{-13}

D 4.3×10^{-13}

E 3.7×10^{-13}