Phys.12- Q2W1- Qs.Bank- Circular Motion and Gravitation

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. When an object is moving with uniform circular motion, the object's tangential speed
a. is circular.
b. is perpendicular to the plane of motion.
c. is constant.
d. is directed toward the center of motion.

____ 2. When an object is moving with uniform circular motion, the centripetal acceleration of the object
a. is circular.
b. is perpendicular to the plane of motion.
c. is zero.
d. is directed toward the center of motion.

____ 3. What is the term for the net force directed toward the center of an object's circular path?
a. circular force
b. centrifugal force
c. centripetal force
d. orbital force

____ 4. Which of the following can be a centripetal force?
a. friction
b. gravity
c. tension
d. all of the above

____ 5. The centripetal force on an object in circular motion is
a. perpendicular to the plane of the object's motion.
b. in the plane of the object's motion and perpendicular to the tangential speed.
c. in the plane of the object's motion and in the same direction as the tangential speed.
d. in the plane of the object's motion and in the direction opposite the tangential speed.

A child rides a bicycle in a circular path with a radius of 2.0 m. The tangential speed of the bicycle is 2.0 m/s. The combined mass of the bicycle and the child is 43 kg.

____ 6. What is the magnitude of the bicycle's centripetal acceleration?
a. 1.0 m/s^2
b. 2.0 m/s^2
c. 4.0 m/s^2
d. 8.0 m/s^2

____ 7. What is the magnitude of the centripetal force on the bicycle?
a. 4.0 N
b. 43 N
c. 86 N
d. 3.7 kN

____ 8. What kind of force provides the centripetal force on the bicycle?
a. gravitational force
b. friction
c. air resistance
d. normal force

____ 9. When a car makes a sharp left turn, what causes the passengers to move toward the right side of the car?
a. centripetal acceleration
b. centripetal force
c. centrifugal force
d. inertia

____ 10. Tides are caused by
a. differences in the gravitational force of the sun at different points on Earth.
b. differences in the gravitational force of the moon at different points on Earth.
c. differences in Earth's gravitational field strength at different points on Earth's surface.
d. fluctuations in the gravitational attraction between Earth and the moon.

____ 11. Why does an astronaut weigh less on the moon than on Earth?

a. The astronaut has less mass on the moon.
b. The astronaut is farther from Earth's center when he or she is on the moon.
c. The gravitational field strength is less on the moon's surface than on Earth's surface.
d. The astronaut is continually in free fall because the moon orbits Earth.

____ 12. If you lift an apple from the ground to some point above the ground, the gravitational potential energy in the system increases. This potential energy is stored in
a. the apple.
b. Earth.
c. both the apple and Earth.
d. the gravitational field between Earth and the apple.

____ 13. An object's tendency to resist acceleration is measured by the object's
a. gravitational mass.
b. inertial mass.
c. gravitational field strength.
d. weight.

____ 14. The degree to which an object attracts other objects is measured by the object's
a. gravitational mass.
b. inertial mass.
c. gravitational field strength.
d. weight.

____ 15. Which of the following confirms that gravitational mass and inertial mass are equivalent?
a. Free-fall acceleration is the same throughout the universe.
b. Free-fall acceleration is the same at all points where the gravitational field strength is the same.
c. Newton's second law is valid throughout the universe.
d. An object's weight can change with location, but the object's mass remains constant.

____ 16. In this text, which of the following symbols represents gravitational field strength?
a. F_g
b. G
c. g
d. F_c

____ 17. In this text, which of the following symbols represents the constant of universal gravitation?
a. F_g
b. G
c. g
d. F_c

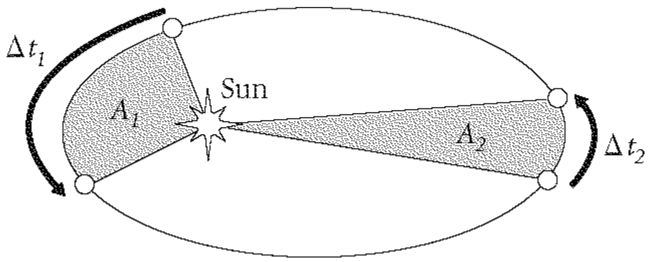
____ 18. Which of the following equations expresses Newton's law of universal gravitation?
a. $F_c = \frac{mv_t^2}{r}$
b. $F_g = \frac{m_1 m_2}{r}$
c. $g = G\frac{m_E}{r^2}$
d. $F_g = G\frac{m_1 m_2}{r^2}$

____ 19. The gravitational force between two masses is 36 N. What is the gravitational force if the distance between them is tripled? ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)
a. 4.0 N
b. 9.0 N
c. 18 N
d. 27 N

____ 20. Two small masses that are 10.0 cm apart attract each other with a force of 10.0 N. When they are 5.0 cm apart, these masses will attract each other with what force? ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)
a. 5.0 N
b. 2.5 N
c. 20.0 N
d. 40.0 N

____ 21. Kepler developed his laws of planetary motion as he tried to reconcile
a. Ptolemaic theory with Copernican theory.
b. Ptolemaic theory with Copernicus's data.
c. Copernican theory with Tycho Brahe's data.
d. Copernican theory with his own data.

____ 22. Until the middle of the 16th century, most people believed ____ was at the center of the universe.
a. Earth
b. the moon
c. the sun
d. a black hole



____ 23. In the figure above, according to Kepler's laws of planetary motion,
a. $A_1 = A_2$.
b. $\Delta t_1 > \Delta t_2$.
c. if $\Delta t_1 = \Delta t_2$, then the orbit is circular.
d. if $\Delta t_1 = \Delta t_2$, then $A_1 = A_2$.

____ 24. Newton's law of universal gravitation
a. is equivalent to Kepler's first law of planetary motion.
b. can be used to derive Kepler's third law of planetary motion.
c. can be used to disprove Kepler's laws of planetary motion.
d. does not apply to Kepler's laws of planetary motion.

____ 25. The equation for the speed of an object in circular orbit is $v_t = \sqrt{G\frac{m}{r}}$. What does *m* represent in this equation?
a. the mass of the sun
b. the mass of Earth
c. the mass of the central object
d. the mass of the orbiting object

____ 26. How would the speed of Earth's orbit around the sun change if Earth's mass increased by 4 times?
a. It would increase by a factor of 2.
b. It would increase by a factor of 4.
c. It would decrease by a factor of 2.
d. The speed would not change.

____ 27. When an astronaut in orbit experiences apparent weightlessness,
a. no forces act on the astronaut.
b. no gravitational forces act on the astronaut.
c. the net gravitational force on the astronaut is zero.
d. the net gravitational force on the astronaut is not balanced by a normal force.

____ 28. Which of the following quantities measures the ability of a force to rotate or accelerate an object around an axis?
a. axis of rotation
b. lever arm
c. tangential force
d. torque

____ 29. Where should a force be applied on a lever arm to produce the most torque?
a. closest to the axis of rotation
b. farthest from the axis of rotation
c. in the middle of the lever arm
d. It doesn't matter where the force is applied.

____ 30. If you want to open a swinging door with the least amount of force, where should you push on the door?
a. close to the hinges
b. in the middle
c. as far from the hinges as possible
d. It does not matter where you push.

____ 31. If you cannot exert enough force to loosen a bolt with a wrench, which of the following should you do?
a. Use a wrench with a longer handle.

b. Tie a rope to the end of the wrench and pull on the rope.
c. Use a wrench with a shorter handle.
d. You should exert a force on the wrench closer to the bolt.

____ 32. A heavy bank-vault door is opened by the application of a force of 3.0×10^2 N directed perpendicular to the plane of the door at a distance of 0.80 m from the hinges. What is the torque?

a. 120 N•m
b. 240 N•m
c. 300 N•m
d. 360 N•m

____ 33. If the torque required to loosen a nut on a wheel has a magnitude of 40.0 N•m and the force exerted by a mechanic is 133 N, how far from the nut must the mechanic apply the force?

a. 1.20 m
b. 15.0 cm
c. 30.1 cm
d. 60.2 cm

____ 34. What kind of simple machine are you using if you pry a nail from a board with the back of a hammer?

a. a wedge
b. a pulley
c. a lever
d. a screw

____ 35. A girl pushes a box that has a mass of 450 N up an incline. If the girl exerts a force of 150 N along the incline, what is the mechanical advantage of the incline?

a. 0.33
b. 3.0
c. 300
d. 33%

____ 36. Which of the following is *not* a valid equation for mechanical advantage?

a. $MA = \frac{F_{out}}{F_{in}}$
b. $MA = \frac{d_{in}}{d_{out}}$
c. $MA = \frac{W_{out}}{W_{in}}$
d. $MA = \frac{\text{output force}}{\text{input force}}$

____ 37. An iron bar is used to lift a slab of cement. The force applied to lift the slab is 4.0×10^2 N. If the slab weighs 6400 N, what is the mechanical advantage of the bar?

a. 1.6
b. 16
c. 6000
d. 6.3%

____ 38. A box weighing 210 N is pushed up an inclined plane that is 2.0 m long. A force of 140 N is required. If the box is lifted 1.0 m, what is the efficiency of the inclined plane?

a. 33%
b. 50%
c. 67%
d. 75%

____ 39. What quantity measures the output force of a machine relative to the input force?

a. torque
b. leverage
c. mechanical advantage
d. efficiency

____ 40. What quantity measures the work done by a machine relative to the work done on a machine?

a. torque
b. leverage
c. mechanical advantage
d. efficiency

Short Answer

1. Two horses are side by side on a carousel. Which has a greater tangential speed—the one closer to the center or the one farther from the center? Explain your answer.

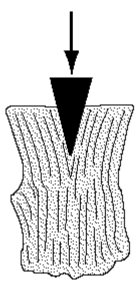
2. What provides the centripetal force for a car driving on a circular track?

3. What provides the centripetal force for a ball whirled on a string?

4. Show how the equation for centripetal force can be derived by substituting the equation for centripetal acceleration into Newton's second law.
5. Is there an outward force in circular motion? Explain.
6. A parent holds a child by the arms and spins around in a circle at a constant speed. If the parent spins fast enough, will the child's feet leave the ground? Explain your answer.
7. Describe briefly how the moon causes tides on Earth.

Earth exerts a 1.0 N gravitational force on an apple.

8. Does the apple accelerate toward Earth, or does Earth accelerate toward the apple? Explain your answer.
9. What is the magnitude of the gravitational force the apple exerts on Earth?
10. What is Kepler's second law of planetary motion?
11. How did Newton use Kepler's laws?
12. Are astronauts in orbit weightless? Explain your answer.
13. How will an object move if it is acted on by a nonzero net torque and a net force of zero?



14. Identify the simple machine in the figure shown above.
15. When a machine decreases the force acting on an object, what happens to the distance the object moves?

Problem

1. What is the centripetal force on the child?
2. A car on a roller coaster loaded with passengers has a mass of 2.0×10^3 kg. At the lowest point of the track, the radius of curvature of the track is 24 m and the roller car has a tangential speed of 17 m/s. What is the centripetal acceleration of the roller car at the lowest point on the track?
3. What centripetal force is exerted on the roller car at the lowest point?
4. A 5.7 kg ball is whirled on a 1.4 m string so that the ball moves in uniform circular motion in a horizontal plane. The tension in the string is 33 N, and the string is at a 31° angle below the horizontal plane. What is the tangential speed of the ball?
5. A satellite in a circular orbit experiences a centripetal acceleration of 8.89 m/s^2. The tangential speed of the satellite is 7.76×10^3 m/s. What is the altitude of the satellite? ($r_E = 6.38 \times 10^6$ m)

6. A 69.8 kg student sits at a desk 1.75 m away from a 78.9 kg student. What is the magnitude of the gravitational force between the two students? ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)

7. Two trucks with equal mass are attracted to each other with a gravitational force of 5.3×10^{-4} N. The trucks are separated by a distance of 2.6 m. What is the mass of either of the trucks? ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)

8. Show how the constant of proportionality in Kepler's third law can be found by equating gravitational force and the centripetal force in a circular orbit.

9. A new planet is discovered orbiting a star with a mass 3.5×10^{31} kg at a distance of 1.2×10^{11} m. Assume that the orbit is circular. What is the orbital speed of the planet? ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)

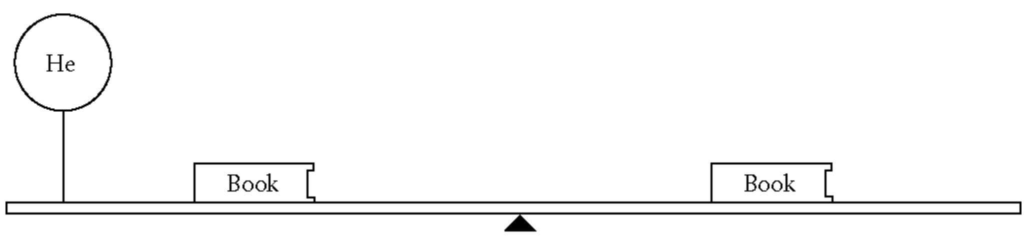
10. What is the orbital period of the planet? ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)

11. Earth's mean distance from the sun is 1.50×10^{11} m. The length of one Earth year is 3.16×10^{7} s. Use this data to calculate the mass of the sun. ($G = 6.673 \times 10^{-11}$ N•m^2/kg^2)

12. A bucket filled with water has a mass of 33 kg and is attached to a rope wound around a cylinder with a radius of 0.043 m at the top of a well. What torque does the weight of the water and bucket produce on the cylinder? ($g = 9.81$ m/s^2)

13. A force of 3.6 N is applied to a door at an angle of 58.4° and a distance of 0.58 m from the hinge. What is the torque produced?

14. To warm up before a game, a baseball pitcher tosses a 0.146 kg ball by rotating his forearm, which is 0.33 m in length, to accelerate the ball. The ball starts at rest and is thrown at a speed of 18 m/s in 0.47 s. While the ball is in the pitcher's hand, what torque is applied to the ball to produce the final tangential speed?



15. A 4.2 m board with a mass of 19 kg is pivoted at its center of gravity. A helium balloon attached 0.24 m from the left end of the board produces an upward force of 7.1 N. A 3.5 kg book is placed 0.74 m from the left end of the board, and another book of 1.7 kg is placed 0.77 m from the right end of the board. Find the torque on the board and the direction of rotation.

16. A force of 271 N is needed to pull a nail from a wall, using a claw hammer. If the resistance force of the nail is 3110 N, what is the mechanical advantage of the hammer?

17. A boy can raise a rock that weighs 95 N by using a lever and applying a force of 17 N. What is the mechanical advantage of the lever?

18. A force of 1050 N is needed to move a crate weighing 3050 N up a ramp that is 3.89 m long. If the elevated end of the ramp is 0.770 m high, what is the efficiency of the ramp?

19. What is the efficiency of a machine that requires 156 J of input energy to do 91.9 J of work?

20. How much energy would be required to do 971 J of work with a machine that was 25% efficient?

Phys.12- Q2W1- Qs.Bank- Circular Motion and Gravitation
Answer Section

MULTIPLE CHOICE

1. ANS: C PTS: 1 DIF: I OBJ: 7-1.1
2. ANS: D PTS: 1 DIF: I OBJ: 7-1.1
3. ANS: C PTS: 1 DIF: I OBJ: 7-1.2
4. ANS: D PTS: 1 DIF: I OBJ: 7-1.2
5. ANS: B PTS: 1 DIF: I OBJ: 7-1.2
6. ANS: B

   Given
   $v_t = 2.0\ \text{m/s}$

   $r = 2.0\ \text{m}$

   Solution
   $$a_c = \frac{v_t^2}{r} = \frac{(2.0\ \text{m/s})^2}{2.0\ \text{m}} = 2.0\ \text{m/s}^2$$

   PTS: 1 DIF: IIIA OBJ: 7-1.1
7. ANS: C

   Given
   $m = 43\ \text{kg}$

   $v_t = 2.0\ \text{m/s}$

   $r = 2.0\ \text{m}$

   Solution
   $$F_c = \frac{mv_t^2}{r} = \frac{(43\ \text{kg})(2.0\ \text{m/s})^2}{2.0\ \text{m}} = 86\ \text{N}$$

   PTS: 1 DIF: IIIA OBJ: 7-1.2
8. ANS: B PTS: 1 DIF: II OBJ: 7-1.2
9. ANS: D PTS: 1 DIF: I OBJ: 7-1.3
10. ANS: B PTS: 1 DIF: I OBJ: 7-2.1
11. ANS: C PTS: 1 DIF: II OBJ: 7-2.1
12. ANS: D PTS: 1 DIF: I OBJ: 7-2.1
13. ANS: B PTS: 1 DIF: I OBJ: 7-2.1
14. ANS: A PTS: 1 DIF: I OBJ: 7-2.1
15. ANS: B PTS: 1 DIF: II OBJ: 7-2.1
16. ANS: C PTS: 1 DIF: I OBJ: 7-2.2
17. ANS: B PTS: 1 DIF: I OBJ: 7-2.2
18. ANS: D PTS: 1 DIF: I OBJ: 7-2.2

19. ANS: A

Given
$F_1 = 36$ N
$r_2 = 3r_1$
$G = 6.673 \times 10^{-11}$ N•m^2/kg^2

Solution
$r_2 = 3r_1$

$$F_1 = G\frac{m_1m_2}{r_1^2} = 36 \text{ N}$$

$$F_2 = G\frac{m_1m_2}{r_2^2} = G\frac{m_1m_2}{(3r_1)^2} = G\frac{m_1m_2}{9r_1^2} = \frac{1}{9}G\frac{m_1m_2}{r_1^2} = \frac{1}{9}F_1$$

$$F_2 = \frac{1}{9}(36 \text{ N}) = 4.0 \text{ N}$$

PTS: 1 DIF: II OBJ: 7-2.2

20. ANS: D

Given
$F_1 = 10.0$ N

$r_1 = 10.0$ cm

$r_2 = 5.0$ cm

$G = 6.673 \times 10^{-11}$ Nm^2 / kg^2

Solution

$$\frac{r_2}{r_1} = \frac{(5.0 \text{ cm})}{(10.0 \text{ cm})} = \frac{1}{2}$$

$$r_2 = \frac{1}{2}r_1$$

$$F_1 = G\frac{m_1m_2}{r_1^2} = 10.0 \text{ N}$$

$$F_2 = G\frac{m_1m_2}{(r_2)^2} = G\frac{m_1m_2}{\left(\frac{1}{2}r_1\right)^2} = G\frac{m_1m_2}{\frac{1}{4}r_1^2} = 4G\frac{m_1m_2}{r_1^2} = 4F_1$$

$$F_2 = (4)(10.0 \text{ N}) = 40.0 \text{ N}$$

PTS: 1 DIF: II OBJ: 7-2.2

21. ANS: C PTS: 1 DIF: I OBJ: 7-3.1

22. ANS: A PTS: 1 DIF: I OBJ: 7-3.1

23. ANS: D PTS: 1 DIF: I OBJ: 7-3.1
24. ANS: B PTS: 1 DIF: I OBJ: 7-3.2
25. ANS: C PTS: 1 DIF: I OBJ: 7-3.3
26. ANS: A

Given
$m_2 = 4m_E$

Solution
$$v_{t_1} = \sqrt{G\frac{m_E}{r_1}}$$
$$v_{t_2} = \sqrt{G\frac{4m_E}{r_1}}$$
$$\frac{v_{t_2}}{v_{t_1}} = \frac{\sqrt{G\frac{(4m_E)}{r_1}}}{\sqrt{G\frac{m_E}{r_1}}} = \sqrt{4} = 2$$

$v_{t_2} = 2v_{t_1}$, i.e., speed would increase by a factor of 2

PTS: 1 DIF: II OBJ: 7-3.3
27. ANS: D PTS: 1 DIF: II OBJ: 7-3.3
28. ANS: D PTS: 1 DIF: I OBJ: 7-4.1
29. ANS: B PTS: 1 DIF: I OBJ: 7-4.1
30. ANS: C PTS: 1 DIF: I OBJ: 7-4.1
31. ANS: A PTS: 1 DIF: II OBJ: 7-4.1
32. ANS: B

Given
$F = 3.0 \times 10^2$ N

$d = 0.80$ m

Solution
$$\tau = Fd = \left(3.0 \times 10^2 \text{ N}\right)(0.80 \text{ m}) = 2.4 \times 10^2 \text{ Nm}$$

PTS: 1 DIF: IIIA OBJ: 7-4.2
33. ANS: C

Given
$\tau = 40.0$ Nm

$F = 133$ N

Solution
$\tau = Fd$

$d = \frac{\tau}{F} = \frac{40.0\ \text{Nm}}{133\ \text{N}} = 3.01 \times 10^{-1}\ \text{m} = 30.1\ \text{cm}$

PTS: 1 DIF: IIIA OBJ: 7-4.2
34. ANS: C PTS: 1 DIF: I OBJ: 7-4.3
35. ANS: B

Given
$F_{in} = 150\ \text{N}$

$F_{out} = 450\ \text{N}$

Solution
$MA = \frac{F_{out}}{F_{in}} = \frac{450\ \text{N}}{150\ \text{N}} = 3.0$

PTS: 1 DIF: IIIA OBJ: 7-4.4
36. ANS: C PTS: 1 DIF: I OBJ: 7-4.4
37. ANS: B

Given
$F_{in} = 4.0 \times 10^2\ \text{N}$

$F_{out} = 6.4 \times 10^3\ \text{N}$

Solution
$MA = \frac{F_{out}}{F_{in}} = \frac{6.4 \times 10^3\ \text{N}}{4.0 \times 10^2\ \text{N}} = 16$

PTS: 1 DIF: IIIA OBJ: 7-4.4
38. ANS: D

Given
$F_{in} = 140\ \text{N}$

$d_{in} = 2.0\ \text{m}$

$F_{out} = 210\ \text{N}$

$d_{out} = 1.0\ \text{m}$

Solution
$eff = \frac{W_{out}}{W_{in}} = \frac{F_{out}d_{out}}{F_{in}d_{in}} = \frac{(210\ \text{N})(1.0\ \text{m})}{(140\ \text{N})(2.0\ \text{m})} = 0.75 = 75\%$

PTS: 1 DIF: IIIB OBJ: 7-4.4

39. ANS: C PTS: 1 DIF: I OBJ: 7-4.4
40. ANS: D PTS: 1 DIF: I OBJ: 7-4.4

SHORT ANSWER

1. ANS:
The horse farther from the center has a greater tangential speed. Although both horses complete one circle in the same time period, the one farther from the center covers a greater distance during that time period.

PTS: 1 DIF: II OBJ: 7-1.1

2. ANS:
Friction between the car's tires and the track provides the centripetal force.

PTS: 1 DIF: II OBJ: 7-1.2

3. ANS:
Tension in the string provides the centripetal force.

PTS: 1 DIF: II OBJ: 7-1.2

4. ANS:

Centripetal acceleration: $a_c = \frac{v_t^2}{r}$

Newton's second law: $F = ma$

$F_c = ma_c = \frac{mv_t^2}{r}$

$F_c = \frac{mv_t^2}{r}$

PTS: 1 DIF: II OBJ: 7-1.2

5. ANS:
No, there is only an inward force causing a deviation from a straight-line path. The tendency to move in a straight line away from the circular path is inertia.

PTS: 1 DIF: II OBJ: 7-1.3

6. ANS:
As the centripetal force increases, the parent's arms must exert a larger and larger force, F, because the horizontal component of this force, F_h, is the centripetal force and this force $F_c = ma_c$. However, if F increases, so does its vertical component. When F is large enough so that its vertical component is equal to the weight of the child, the child's feet will leave the ground.

PTS: 1 DIF: II OBJ: 7-1.3

7. ANS:
High tides occur at points on opposites sides of Earth in line with the moon. On the side closer to the moon, the gravitational force between Earth and the moon is greater than the force between the moon and the center of Earth. This causes Earth to bulge toward the moon. On the opposite side, the gravitational force is less than the force at Earth's center, which again causes a bulge. Two high tides occur each day as points on Earth rotate past these bulges.

PTS: 1 DIF: II OBJ: 7-2.1

8. ANS:
They both accelerate toward each other. Earth’s acceleration is extremely small compared to that of the apple because Earth has a much greater mass than the apple does.

PTS: 1 DIF: II OBJ: 7-2.1

9. ANS:
1.0 N

PTS: 1 DIF: II OBJ: 7-2.2

10. ANS:
An imaginary line drawn from the sun to any planet sweeps out equal areas in equal time intervals.

PTS: 1 DIF: I OBJ: 7-3.1

11. ANS:
Newton used Kepler’s laws to support his law of universal gravitation. More specifically, he derived Kepler’s laws from the law of universal gravitation. This helped support the law of universal gravitation because Kepler’s laws closely matched astronomical observations.

PTS: 1 DIF: II OBJ: 7-3.2

12. ANS:
No, astronauts in orbit are not truly weightless. They experience apparent weightlessness because they are in continual free fall, along with their surrounding environment.

PTS: 1 DIF: II OBJ: 7-3.3

13. ANS:
The object will rotate. It will not move with any translational motion.

PTS: 1 DIF: II OBJ: 7-4.1

14. ANS:
wedge

PTS: 1 DIF: I OBJ: 7-4.3

15. ANS:
The distance moved increases.

PTS: 1 DIF: I OBJ: 7-4.3

PROBLEM

1. ANS:
74 N

Given
$m = 35$ kg

$v_t = 2.6$ m/s

$r = 3.2$ m

Solution

$$F_c = \frac{mv_t^2}{r} = \frac{(35\ \text{kg})(2.6\ \text{m/s})^2}{3.2\ \text{m}} = 74\ \text{N}$$

PTS: 1 DIF: IIIA OBJ: 7-1.2

2. ANS:
$12\ \text{m/s}^2$

Given

$v_t = 17\ \text{m/s}$

$r = 24\ \text{m}$

Solution

$$a_c = \frac{v_t^2}{r} = \frac{(17\ \text{m/s})^2}{24\ \text{m}} = 12\ \text{m/s}^2$$

PTS: 1 DIF: IIIA OBJ: 7-1.1

3. ANS:
2.4×10^4 N

Given

$m = 2.0 \times 10^3\ \text{kg}$

$v_t = 17\ \text{m/s}$

$r = 24\ \text{m}$

Solution

$$F_c = \frac{mv_t^2}{r} = \frac{(2.0 \times 10^3\ \text{kg})(17\ \text{m/s})^2}{24\ \text{m}} = 2.4 \times 10^4\ \text{N}$$

PTS: 1 DIF: IIIA OBJ: 7-1.2

4. ANS:
2.6 m/s

Given

$m = 5.7\ \text{kg}$

$F_T = 33\ \text{N}$

$\theta = -31°$

$r = 1.4\ \text{m}$

Solution

$$F_c = F_T \cos\theta = (33\ \mathrm{N})\left[\cos(-31°)\right] = (33\ \mathrm{N})(0.86) = 28\ \mathrm{N}$$

$$F_c = \frac{m{v_t}^2}{r}$$

$${v_t}^2 = \frac{F_c r}{m}$$

$$v_t = \sqrt{\frac{F_c r}{m}}$$

$$v_t = \sqrt{\frac{(28\ \mathrm{N})(1.4\ \mathrm{m})}{5.7\ \mathrm{kg}}} = 2.6\ \mathrm{m/s}$$

PTS: 1 DIF: IIIC OBJ: 7-1.2

5. ANS:
390 km

Given

$v_t = 7.76 \times 10^3\ \mathrm{m/s}$

$a_c = 8.89\ \mathrm{m/s^2}$

$r_E = 6.38 \times 10^6\ \mathrm{m}$

Solution

$$a_c = \frac{{v_t}^2}{r}$$

$$r = \frac{{v_t}^2}{a_c} = \frac{\left(7.76 \times 10^3\ \mathrm{m/s}\right)^2}{8.89\ \mathrm{m/s^2}} = 6.77 \times 10^6\ \mathrm{m}$$

$$altitude = r - r_E = 6.77 \times 10^6\ \mathrm{m} - 6.38 \times 10^6\ \mathrm{m} = 3.9 \times 10^5\ \mathrm{m} = 390\ \mathrm{km}$$

PTS: 1 DIF: IIIC OBJ: 7-1.1

6. ANS:
$1.20 \times 10^{-7}\ \mathrm{N}$

Given

$m_1 = 69.8\ \mathrm{kg}$

$m_2 = 78.9\ \mathrm{kg}$

$r = 1.75\ \mathrm{m}$

$G = 6.673 \times 10^{-11}\ \mathrm{N \bullet m^2 / kg^2}$

Solution

$$F_g = G\frac{m_1 m_2}{r^2} = \left(6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2\right)\frac{(69.8\ \text{kg})(78.9\ \text{kg})}{(1.75\ \text{m})^2} = 1.20 \times 10^{-7}\ \text{N}$$

PTS: 1 DIF: IIIA OBJ: 7-2.2

7. ANS:

7.3×10^3 kg

Given

$m_1 = m_2$

$r = 2.6\ \text{m}$

$F_g = 5.3 \times 10^{-4}\ \text{N}$

$G = 6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$

Solution

$m_1 = m_2$

$$F_g = G\frac{m_1 m_2}{r^2} = G\frac{{m_1}^2}{r^2}$$

$${m_1}^2 = \frac{F_g r^2}{G}$$

$$m_1 = \sqrt{\frac{F_g r^2}{G}} = \sqrt{\frac{\left(5.3 \times 10^{-4}\ \text{N}\right)(2.6\ \text{m})^2}{6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2}} = \sqrt{5.4 \times 10^7\ \text{kg}^2} = 7.3 \times 10^3\ \text{kg}$$

PTS: 1 DIF: IIIC OBJ: 7-2.2

8. ANS:

Let m_1 be the mass of the central object and m_2 be the mass of the orbiting object. Kepler'

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$F_c = \frac{m_2 v_t^2}{r}$$

The centripetal force equals the gravitational force.

$$F_c = F_g$$

$$\frac{m_2 v_t^2}{r} = G\frac{m_1 m_2}{r^2}$$

$$v_t^2 = G\frac{m_1}{r}$$

Speed equals the distance traveled in a time interval, and the distance traveled in one orbital period is $2\pi r$.

$$v_t = \frac{2\pi r}{T}$$

Substituting,

$$\left(\frac{2\pi r}{T}\right)^2 = G\frac{m_1}{r}$$

$$\frac{4\pi^2 r^2}{T^2} = G\frac{m_1}{r}$$

$$T^2 = \frac{4\pi^2 r^3}{G m_1} = \left(\frac{4\pi^2}{G m_1}\right) r^3$$

s third law states that $T^2 \propto r^3$. The constant of proportionality is $\frac{4\pi^2}{G m_1}$.

PTS: 1 DIF: IIIC OBJ: 7-3.2

9. ANS:

1.4×10^5 m/s

Given

$m = 3.5 \times 10^{31}$ kg

$r = 1.2 \times 10^{11}$ m

$G = 6.673 \times 10^{-11}$ N • m^2 / kg^2

Solution

$$v_t = \sqrt{G\frac{m}{r}} = \sqrt{\left(6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2\right)\frac{\left(3.5 \times 10^{31}\ \text{kg}\right)}{\left(1.2 \times 10^{11}\ \text{m}\right)}} = 1.4 \times 10^5\ \text{m/s}$$

PTS: 1 DIF: IIIB OBJ: 7-3.3

10. ANS:
5.4×10^6 s

Given

$m = 3.5 \times 10^{31}$ kg

$r = 1.2 \times 10^{11}$ m

$G = 6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$

Solution

$$T = 2\pi\sqrt{\frac{r^3}{Gm}} = 2\pi\sqrt{\frac{\left(1.2 \times 10^{11}\ \text{m}\right)^3}{\left(6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2\right)\left(3.5 \times 10^{31}\ \text{kg}\right)}} = 5.4 \times 10^6\ \text{s}$$

PTS: 1 DIF: IIIB OBJ: 7-3.3

11. ANS:
2.00×10^{30} kg

Given

$r = 1.50 \times 10^{11}$ m

$T = 3.16 \times 10^7$ s

$G = 6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2$

Solution

$$T = 2\pi\sqrt{\frac{r^3}{Gm}}$$

$$T^2 = \frac{4\pi^2 r^3}{Gm}$$

$$m = \frac{4\pi^2 r^3}{GT^2}$$

$$m = \frac{4\pi^2\left(1.50 \times 10^{11}\ \text{m}\right)^3}{\left(6.673 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2\right)\left(3.16 \times 10^7\right)^2} = 2.00 \times 10^{30}\ \text{kg}$$

PTS: 1 DIF: IIIC OBJ: 7-3.3

12. ANS:
14 N•m

Given
$m = 33 \text{ kg}$

$d = 0.043 \text{ m}$

$g = 9.81 \text{ m/s}^2$

$\theta = 90.0°$

Solution
$\tau = Fd \sin\theta = mgd \sin\theta = (33 \text{ kg})(9.81 \text{ m/s}^2)(0.043 \text{ m})(\sin 90.0°) = 14 \text{ N} \bullet \text{m}$

PTS: 1 DIF: IIIA OBJ: 7-4.2

13. ANS:
1.8 N•m

Given
$F = 3.6 \text{ N}$

$d = 0.58 \text{ m}$

$\theta = 58.4°$

Solution
$\tau = Fd \sin\theta = (3.6 \text{ N})(0.58 \text{ m})(\sin 58.4°)$

$\tau = (3.6 \text{ N})(0.58 \text{ m})(0.852)$

$\tau = 1.8 \text{ N} \bullet \text{m}$

PTS: 1 DIF: IIIB OBJ: 7-4.2

14. ANS:
1.8 N•m

Given
$m = 0.146 \text{ kg}$

$v_i = 0 \text{ m/s}$

$v_f = 18 \text{ m/s}$

$\Delta t = 0.47 \text{ s}$

$d = 0.33 \text{ m}$

$\theta = 90.0°$

Solution

$$F = ma = m\frac{\left(v_f - v_i\right)}{\Delta t} = \left(0.146\ \text{kg}\right)\frac{(18\ \text{m/s} - 0\ \text{m/s})}{0.47\ \text{s}} = 5.6\ \text{N}$$

$$\tau = Fd\sin\theta = (5.6\text{N})(0.33\ \text{m})(\sin\ 90.0°) = 1.8\ \text{N}\bullet\text{m}$$

PTS: 1 DIF: IIIB OBJ: 7-4.2

15. ANS:
13 N•m counterclockwise

Given

$F_1 = 7.1\ \text{N}$

$d_1 = -2.1\ \text{m} + 0.24\ \text{m} = -1.9\ \text{m}$

$m_2 = 7.1\ \text{kg}$

$d_2 = -2.1\ \text{m} + 0.74\ \text{m} = -1.4\ \text{m}$

$m_3 = 1.7\ \text{kg}$

$d_3 = 2.1\ \text{m} - 0.77\ \text{m} = 1.3\ \text{m}$

$g = -9.81\ \text{m/s}^2$

Solution

$\tau_{net} = \tau_1 + \tau_2 + \tau_3$

$\tau_1 = F_1 d_1 = (7.1\ \text{N})(-1.9\ \text{m}) = -13\ \text{N}\bullet\text{m}$

$F_2 = m_2 g = \left(3.5\ \text{kg}\right)\left(-9.81\ \text{m/s}^2\right) = -34\ \text{N}$

$\tau_2 = F_2 d_2 = (-34\ \text{N})(-1.4\ \text{m}) = 48\ \text{N}\bullet\text{m}$

$F_3 = m_3 g = \left(1.7\ \text{kg}\right)\left(-9.81\ \text{m/s}^2\right) = -17\ \text{N}$

$\tau_3 = F_3 d_3 = (-17\ \text{N})(1.3\ \text{m}) = -22\ \text{N}\bullet\text{m}$

$\tau_{net} = (-13\ \text{N}\bullet\text{m}) + (48\ \text{N}\bullet\text{m}) + (-22\ \text{N}\bullet\text{m}) = 13\ \text{N}\bullet\text{m}$

$\tau_{net} = 13\ \text{N}\bullet\text{m counterclockwise}$

PTS: 1 DIF: IIIC OBJ: 7-4.2

16. ANS:
11.5

Given

$F_{in} = 271\ \text{N}$

$F_{out} = 3110\ \text{N}$

Solution

$$MA = \frac{F_{out}}{F_{in}} = \frac{3110\ \text{N}}{271\ \text{N}} = 11.5$$

PTS: 1 DIF: IIIA OBJ: 7-4.4

17. ANS:
5.6

Given
$F_{in} = 17\ \text{N}$

$F_{out} = 95\ \text{N}$

Solution
$$MA = \frac{F_{out}}{F_{in}} = \frac{95\ \text{N}}{17\ \text{N}} = 5.6$$

PTS: 1 DIF: IIIA OBJ: 7-4.4

18. ANS:
57.5%

Given
$F_{in} = 1050\ \text{N}$

$d_{in} = 3.89\ \text{m}$

$F_{out} = 3050\ \text{N}$

$d_{out} = 0.770\ \text{m}$

Solution
$$eff = \frac{W_{out}}{W_{in}} = \frac{F_{out}d_{out}}{F_{in}d_{in}} = \frac{(3050\ \text{N})(0.770\ \text{m})}{(1050\ \text{N})(3.89\ \text{m})} = 0.575 = 57.5\%$$

PTS: 1 DIF: IIIB OBJ: 7-4.4

19. ANS:
58.9%

Given
$W_{in} = 156\ \text{J}$

$W_{out} = 91.9\ \text{J}$

Solution
$$eff = \frac{W_{out}}{W_{in}} = \frac{91.9\ \text{J}}{156\ \text{J}} = 0.589 = 58.9\%$$

PTS: 1 DIF: IIIA OBJ: 7-4.4

20. ANS:
$3.9 \times 10^3\ \text{J}$

Given
$W_{out} = 971\ \text{J}$

$eff = 25\% = 0.25$

Solution
$$eff = \frac{W_{out}}{W_{in}}$$

$$W_{in} = \frac{W_{out}}{eff} = \frac{971\ \text{J}}{0.25} = 3.9 \times 10^3\ \text{J}$$

PTS: 1 DIF: IIIB OBJ: 7-4.4